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Environmental Apocalypse in Science and Art

Designing Nightmares

Sergio Fava

ROUTLEDGE

Environmental Apocalypse in Science and Art

At a time when it is clear that climate change adaptation and mitigation are failing, this book examines how our assumptions about (valid and usable) knowledge are preventing effective climate action. Through a cross-disciplinary, empirically-based analysis of climate science and policy, the book situates the failures of climate policy in the cultural history of prediction and its interfaces with policy.

Fava calls into question the current interfaces between scientific research and climate policy by tracing multiple connections between modelling, epistemology, politics, food security, religion, art, and the apocalyptic. Demonstrating how the current domination of climate policy by models and scenarios is part of the problem, the book examines how artistic practices are a critical location to ask questions differently, rethink environmental futures, and activate social change. The analysis starts with another moment of climatic change in recent western history: the overlap of the Little Ice Age and the "scientific revolution," during which intense climatic, scientific and political change were contemporary with mathematical calculation of the apocalypse.

Dealing with the need for complex answers to complex and urgent questions, this is essential reading for those interested in climate action, interdisciplinary research and methodological innovation. The empirical analyses amount to a methodological experiment, across history of science, theology, art theory and history, architecture, future studies, climatology, computer modelling, and agricultural policy. This book is a major contribution to understanding how we are precluding effective climate action, and designing futures that resemble our worst nightmares.

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Stephen Ingle

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Pauline Johnson

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Joseph Femia

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Edited by Ruth Parkin-Gounelas

76 **Environmental Solidarity**
How Religions Can Sustain Sustainability
Pablo Martínez de Anguita

77 **Comedy and the Public Sphere**
The Rebirth of Theatre as Comedy and the Genealogy of the Modern Public Arena
Arpad Szakolczai

78 **Culture, Class, and Critical Theory**
Between Bourdieu and the Frankfurt School
David Gartman

79 **Environmental Apocalypse in Science and Art**
Designing Nightmares
Sergio Fava

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For Michelle

Contents

Figures and Tables

FIGURES

TABLES

Boxes

Abbreviations

APM	Airborne Particulate Matter
BLS	Basic Linked System of IIASA
CBD	Convention on Biological Diversity
CGIAR	Consultative Group for International Agricultural Research
FAO	Food and Agriculture Organisation
GCDT	Global Crop Diversity Trust
GCM	Global Circulation Models
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GtC	Gigatons of Carbon
IFPRI	International Food Policy Research Institute
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
MER	Market Exchange Rate
NRC	U.S. National Research Council
NWP	Nairobi Work Programme of the United Nations
PPP	Purchasing Power Parity
SPM	Summary for Policy Makers
SRES	Special Report on Emission Scenarios of the IPCC
STEEP	Social, Technological, Economic, Environmental, and Political
TAR	Third Assessment Report of the IPCC
TRIPS	Agreement on Trade Related Aspects of Intellectual Property Rights
TS	Technical Summary
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNU	UN University
WHO	World Health Organisation
WMO	World Meteorological Organisation

Preface

This book is borne out of a lifelong interest and an urgent concern. I have always been intrigued by the paradox of apocalyptic narratives: invariably proven wrong, continually appealing. Whatever keeps these narratives so active as fictions and as truth claims, the diversity of their expressions is hard not to come across: religious, artistic, and scientific; formalised and fuzzy; enduring and fleeting. One might think that with religion's cultural and political ebb, ideas of the end would also fade away. Yet, they remain powerful, and today mostly proposed by science; which brings me to the urgent concern.

Today, arguably aware of the long history of 'the end is nigh' proclamations, we find ourselves at a time in history when, yet again, we are told that global disaster 'is near, even at the doors' (Matthew 24:33), and that *this time* it is real. You might be rightly thinking that 'everyone else in history who believed in some form of apocalypse considered their apocalypse real, and all previous ones fictional, so what's the difference?' The difference is that it is already here. More than a real possibility, it is already an inescapable reality. The insidious giant is still silent for many; many others are already dealing with it, or dying from it.

The important debate, now, is how can we overcome the inertia of climate change mitigation and adaptation. This book hopes to contribute to that most urgent of discussions by examining how the ways in which we peer into the future are preventing effective climate action. It situates the failures of climate policy in the cultural history of prediction, and its interfaces with policy. By tracing multiple connections between modelling, epistemology, politics, food security, religion, art, and the apocalyptic, it shows how the current domination of climate policy by quantitative models and scenarios is also part of the problem. It explores some of the readily available ways of asking questions differently, rethinking environmental futures, and activating social change.

In short, this book argues against the *numerocratic* regime that dominates and mediates our relationship to the world and to ourselves; a regime based on a dated and failed *homo economicus* perception of human existence in the world. The successes of that regime are now revealing the immense dangers of its ignorance. The malaise of representationalism increases inertia in climate change action. The disease now spans representative democracy and climate scientific representation, in what amounts to a *double deficit of representation*. Neither is representational, yet both claim to be.

This book is, to a great extent, fruit of the time I spent researching in sociology at Lancaster University. The intellectual stimulation, collegial environment, and institutional solidity all contributed to making this book possible. I would like to thank, in particular, those who were directly or indirectly involved in its development: John Law and Yoke-Sum Wong for their support, encouragement, ideas, and patience; Elizabeth Shove for the ideas, energy, and friendship that continue to be an inspiration at many levels; Chris Partridge for welcoming me to the religious studies department at Lancaster; Larry Busch, Barbara Adam, Paolo Palladino, Stephen Pumfrey, and Paul N. Edwards for the detailed and extensive feedback.

I am honoured to have received a research grant from the Panacea Society, custodian of Joanna Southcott's Box of Sealed Writings. Their generosity, and their interest in my research, is most humbling. I can only hope that my work is worthy of such distinguished support. The help from the Peel Studentship Trust, part of the Dowager Countess Eleanor Peel Trust, was instrumental in more challenging times.

Bita's example is, always, the foundation. Finally, nothing of what follows would have been possible without Michelle's selfless dedication and peaceful wisdom. In that sense, this is her work.

Introduction

THE END

The end of the world has been expected, throughout history, in many different cultures around the globe. Expectations of planetary cataclysm or cosmic apocalypse have featured prominently in Greek, Amerindian, Nordic, Pacific, Christian, Vedic, Persian, and many other nations, cultures, and belief systems (Cohn 1993; Clifford 2000). These expectations tend to become established alongside foundational narratives (e.g., diasporic, cosmogonic). Apocalyptic narratives do not foresee an abrupt end, a meaningless stop to a developing plot. They forebode a final outcome. As such, they are not self-contained independent narratives, but final, decisive chapters of comprehensive, all-encompassing narratives.

These basic characteristics have generally led to an identification of apocalyptic narratives with religion or religious movements. However, secularisation and the increasing reliance on science to understand and explain the universe have not dictated their demise. Instead, over the last century, many non-religious descriptions of cataclysm or apocalypse have had great cultural import; some have technoscientific origins, such as nuclear winter and climate change.

An apocalypse (from the Greek *apokálypsis*, 'unveiling', 'lifting of the veil', 'revelation') is usually understood as a total destruction of the universe, the planet, or, in some instances, a civilisation. The etymological origin is significant: an apocalypse is, more than the event, its unveiling, *its revelation*, *its narrative dimension*. 'Apocalyptic narrative' has become a fluid term, applicable to total destruction or just overwhelming transformation of the planetary ability to sustain human life. This wider use now encompasses events more accurately described as cataclysmic (from the Greek *kataklysmos*, 'to wash down'), events that do not necessarily entail the end of life on Earth or the physical destruction of the planet.

ALTERNATIVE ENDINGS

With the turn of the millennium, climate change became the most urgent of environmental problems, the most complex apocalyptic narrative, and, most likely, the biggest challenge the human species has ever faced. More than in any other apocalyptic narratives, revealing the risk as real and imminent also depends on scientific disciplines, theories, facts, statements, and people. The sources of danger—and their causal relations with potential consequences—are far less visible than in other scenarios of potential global destruction, as the two following examples indicate. One: when people started dying from Severe Acute Respiratory Syndrome (SARS) in 2003, it quickly became apparent how consequences might spiral out of control, even if the causes were not clear, or clearly understood. Two: meteors belong to the family of celestial bodies that, for a long time, have been part of narratives of both destruction and salvation. They are a discrete source of danger, with calculable trajectories. Their consequences are visible in the craters populating the solar system, and in the magnitude of Comet Shoemaker-Levy 9's collision with Jupiter in 1994 (of which there is a photographic record). In climate change, the sources are invisible, the magnitude and timing of consequences uncertain, and the nexus of causal connections so complex as to be, in cases, intractable. There is nothing anthropogenic about the path of a meteoroid or asteroid, yet climate change has been made inseparable from human agency, with many consequences (from geopolitics to biodiversity) displaying apocalyptic traits. These traits are magnified by their strong resonance with concepts like sin, guilt, salvation, retribution, and so on. Some have proposed the term 'ecosin', noting its resonance with early modern European climatic changes (Behringer 2010: 206).

Why is this important, and why is it important to understand climate change as the latest of a long history of apocalyptic narratives? Far from discarding climate change as another instance of 'crying wolf', the cultural history of climate change is essential to understand our failure to react as the wolf comes into view. Despite the severity of the threat and the multiplication of current consequences, both policies and policy implementation have been far from what is urgently needed.

OBJECTIVITY AND CHANGE

One could assume that science provides sufficient, objective, and neutral evidence, and that policy is the culprit, in its inability to effectively translate it into action. That is, indeed, the usual rhetoric. It is also a misguided view. Scientific statements are not transparent presentations of an independent natural world. Scientific statements are necessarily translations, and therefore *re-presentations*. Because no translation can be transparent or exhaustive, the statements produced by scientific communities necessarily affect the direction of policy. This is especially so when representing the future, an object that does not exist.

I am not arguing against the role of science in understanding climate change. Science is indispensable to understand the civilisational challenge we are going through, and the set of solutions required. I am not implying that scientific objectivity is impossible, or that we should discard science. What I am implying is that objectivity is not the same as neutrality; that the presence of apocalyptic expectations in climate science might also be a function of the human, cultural, and historical dimensions of scientific research, a function of the assumptions upon which its translations are built.

Because effective action is the goal in climate change policy, it is important to understand if the epistemic basis and the methods of climate science enfold assumptions that might work against that goal. Has the power and allure of the apocalyptic found its way from religious doctrine—through the long and convoluted processes of secularisation—into our perceptions of the historical crossroads we are in? Or are we to believe that the eschatologies presented by science are neutral and objective, disconnected from history, pure and untouched by our myths? The answers, whether positive or negative, can help us reinforce or re-evaluate our confidence in our approaches.

It is in this broad context that the book considers how different representations of climate change influence our modes and levels of engagement, how they delimit the range of possible environmental futures, and therefore define what constitutes effective action. Different representations of nature—and its futures—are not approached, here, as true or false, but as different. This is not fence-sitting. The point is to know what does a representation of the future consist of, how do we judge its validity, and what do we do with it. My objective, therefore, in analysing representations of environmental futures is to situate them in the cultural landscape of predictive methods. If mapping this landscape demonstrates that those methods do create the futures they predict, then we must also consider the potential and validity of other modes of representing nature and its futures. By 'creating futures' I mean generating perspectives of the future, working them into a scope of possible futures, focussing attention on that scope, thus promoting the conditions for the fulfilment of its futures.

The hypothesis I present is, therefore, in two parts. First, I propose that methods of predicting or forecasting climatic futures do create the futures they aim to predict. I set out to demonstrate how this happens through the very methods considered guarantors of objectivity. It will also be shown how this affects the design and implementation of climate change policy. Second, I consider how artistic modes of representing nature and thinking futures might embody those same expectations, or undo them, or propose other ways of thinking and making futures.

These other ways exist today and have existed in the past, so we can look in different cultural 'spaces' and different times. The structure of the book is both a function of the above hypothesis, and of exploring different times and spaces. Questions such as "have we always related to the future in this way? If not, what was different and what might be learned from these other ways of engaging with the future?" (Adam and Groves 2007: xiv) have received neither the wider attention they deserve nor the multiple analytical perspectives they suggest. I start by examining a historical moment of climate change as a counterpart to the later analyses of the present moment. Each of those two moments investigates the relation between apocalyptic narratives, the climate, and methods of predicting the future.

I am afraid all this makes a complicated path through different eras and subjects, sometimes in great detail. I will tell you, for example, of biblical interpretation, plant physiology, international agreements, computer programmes, and art installations, to name a few. In the tortuous(ly exciting) connections that make the cultural history of climate change and methods of prediction, I have to appeal to the reader's patience. Because this book is about the importance of devoting more resources to these connections—however difficult and obscure—the difficulty of mapping comes with the terrain.

Ultimately, the book is an experiment in how to ask questions across disciplinary boundaries, in the context of urgent climate action. A large part of what I cover isn't new. There is much taken from established literature. I will, for example, spend much time on models of the world, directly or indirectly. Yet I offer little that is new to understand the ontological status of models, for example. What interests me is to bring debates that have been around for decades to the preeminent problem of climate change. Serious questioning of modernity's love affair with representationalism took place in the seventies, at least. Somehow, the importance of the ideas that coalesced then is still on the margins of discussions about modelling the world and the future.

So, what I try to do is making extant wide connections visible. Not as an abstracting move, but staying close to empirical matter. This mode of exploring is more reliable, but makes for harder navigation. I am driven by a sense of urgency, but also incredulity. How come we are still silencing ideas that are so important? They aren't as uncomfortable to consider as the nightmares that are already becoming true.

HOW TO READ THIS BOOK

You can avoid much of these interdisciplinarity (some would say poststructuralist) issues by reading the sections of the book that are most relevant to your interests, even if the overall intent of the book is largely missed with partial readings. Here's a short version of how you might want to approach it, followed by a longer description of chapters.

Chapters 1 to 3 form the historical section of the book. Those interested mostly in the historical relations between climate change and apocalyptic narratives should find those chapters more relevant. Religion also features more prominently in the historical section. Chapters 4 to 7 form the contemporary section. Those interested in the current relation between climate science and policy can start from Chapter 4. Readers interested in the relation between art and science might want to look more carefully at Chapters 3 and 7. Those interested in the cultural history of mathematical models will find their topic throughout most of the book, with the exception of Chapter 1. A longer description of the chapters might help further.

Chapters 1 to 3 examine a historical nexus of climate change, its interpretations, apocalyptic expectation, mathematical prediction of the future, and artistic representation of the future. Chapter 1 investigates the Little Ice Age (a period of deadly climate change) in early modern England and Scotland. The severe climate had important social, cultural, religious, and political impacts. Apocalypticism and millennialism were heightened by the Reformation, while scientific advances stimulated the secularisation and naturalisation of teleology. Storms, lost crops, and famines encouraged interpretations of the weather[1] and methods to control it. The chapter considers how the weather caused so much destruction and yet was not systematically integrated into the prevailing doctrinal expectation of the End. It suggests that alternative interpretative frameworks—of destruction, of agency (natural, human, and divine), of cosmic order—clashed most times, co-existed sometimes, and sometimes fused partially. In this, I follow Ricoeur's suggestion that "storytellers tell narrative tales with beginnings, middles, and ends. These tales always embody implicit and explicit theories of causality, where narrative or textual causality is presumed to map the actual goings-on in the real world" (1984: 4). In providing initial suggestions of the social, political, and cultural role and function of apocalyptic narratives, the first chapter is the backdrop for the two subsequent chapters.

Chapter 2 examines a prediction of the future during one of the peaks of the Little Ice Age. John Napier of Merchiston (1550–1617) mathematically predicted the day of the End in his exegesis of the Book of Revelation. The analysis searches how Napier's exegesis and development of logarithmic calculation are conceptually and methodologically related. It inspects how logarithms might have inscribed, into methods and tools, the assumption that the future is predictable through mathematical calculation. While Napier is studied in greater detail from primary sources, most of the investigation into his cultural, political, and religious context is derived from secondary sources. Because the objectives of the book lie beyond Napier, this approach is preferred, even necessary.

Some "propose that the nervous system of Modernity is rooted, so to speak, in a millenarian impatience with lingering ends" (Schwartz 2001: 176). I do not establish such direct dependencies. However, it is true that quantification was supremely important in the formalisation and universalisation of apocalyptic expectations, eliminating its geocultural markers, numerologically or mathematically justifying universal applicability of context-specific narratives. Mathematical prediction and apocalypticism are, in this sense, intimately related. The investigation of Napier's work is the counterpart to the exploration of today's configuration of that intimate relation, which starts in Chapter 4. It questions the assumption that quantitative calculation is a guarantor of objectivity that makes knowledge independent from myth, religion, subjectivity, or ideology.

The first historical moment is also the time of the third chapter. Inigo Jones' Banqueting House (today the most important surviving Jacobean building) at Whitehall, in London, and its ceiling canvases by Peter Paul Rubens, were contemporary with the resounding success of Napier's work. The House is a unique confluence of apocalyptic tropes, driven by political motivations, with cosmological hierarchy inscribed into its strictly Pythagorean architecture. The fusion of these elements has provided rich ground for research of the building and its wider sociocultural context, and I follow this tradition, contributing to their interpretation. The analysis emphasises the role of apocalyptic elements in the political objectives of the building, and indeed of the city as the heart of the kingdom then united.

I reinterpret some elements of Ruben's ceiling to reassess the role of the House in the apocalyptic message of British seventeenth-century politics: redemptive culmination of the struggles of the righteous against Rome, with London as New Jerusalem. The House would be the centre of the New Jerusalem. It prefigures its own future function by visually placing the monarch in a redemptive position at the acme of a strictly quantified representation of the cosmos.

Chapter 4 initiates the analyses of the present by looking at mathematical modelling of the climate system as the tool of choice of prediction of the future. Its function is not unlike that of Chapter 1, in the sense that it provides the background for the subsequent chapters. It is different, however, since it investigates more technical matters. It devotes more detail to the practice, procedures, and difficulties of mathematical climate modelling, and less to the wider cultural context of the presently changing climate. The context it examines is, therefore, narrower and more focused. It offers a brief historical introduction to the current state of the science, and introduces the work of the United Nations' Intergovernmental Panel on Climate Change (IPCC).[2]

When the scientific validity of predictions of a 'totality' (as the IPCC calls it in its Assessment Reports) rests on mathematical computer simulations, the main problems are *(a)* working with the complex, infinitesimal, potentially intractable or unknown connections between causes and consequences; *(b)* making a convincing—yet neutral, non–value laden—argument for global, pervasive adaptive change based on a hyper-complex causality chain. Point *(a)* comes up against the recalcitrant, even insurmountable, complexity of the 'system', and the uncertainties it entails. Point (*b)* is no less difficult to deal with, since *climate change democratises global disaster by redistributing agency to a nearly infinitesimal point*. A point close to dissolution, since from infinitesimal causes to infinitesimal decisive action, the urgency of change tends to dissipate. With the following chapters in mind, Chapter 4 foregrounds art, science and religion, as key modes of representing the world and dealing with coherence.

Chapter 5 focuses on the IPCC's Special Report on Emission Scenarios (SRES), and its scenarios of the future. Attention is devoted to the work towards quantification of all relevant factors, processes, and variables; the obstacles and uncertainties this entails; and how objective quantification is also a subjective qualitative process. The chapter investigates, in detail, how the neutral translation of an object of knowledge (which encompasses *everything*), aimed at informing policy, cannot avoid creating the very object it purports to neutrally represent. The Report proposes possible global futures (which include, yet transcend, greenhouse gas emissions) as a result of quantitative scenarios. These, based on mathematical modelling, are the tool to 'imagine' the future, and are said to (in the words of the IPCC) *allow room for intuition, creativity, subjective evaluation, imagination and plurality of views*. This while claiming neutrality and objectivity, and admitting difficulties with non-quantifiable variables. The SRES thus appropriates and sanitises the role of creativity and imagination, and empties *futures thinking* of other creative modes of imagining/inventing futures.

Chapter 6 analyses how this narrowing of valid modes of future thinking have real, present, and identifiable global consequences. As in many apocalyptic narratives, quantification makes disaster objective, and places it on the horizon (i.e., not too far to be irrelevant, not to close to be paralysing). Climate change science, and agricultural mitigation and adaptation technologies and programmes, are being used to redefine climate action as a matter of *genetic control of evolution*. The Svalbard Global Seed Vault (commonly known as the Doomsday Vault) of the Global Crop Diversity Trust (GCDT) was made possible by mobilising climate change as a powerful force, thus shifting food security and agricultural biodiversity away from the debates on Intellectual Property Rights (IPR) towards saving the world from doomsday. By explicitly affirming that agricultural biodiversity is the cornerstone of climate change adaptation, the GCDT recontextualises agricultural biodiversity as an issue of salvation of humanity, and makes the Doomsday Vault a central global configurator of agricultural practices. More, this reframing helps transform food security challenges—through the UN's Nairobi Work Programme—into a question of *downscaling* climate models to the local level as a form of *upgrading* or *surpassing* local knowledge.

Chapter 7 examines Olafur Eliasson's 2003 Weather Project installation. Eliasson's work questions representations of nature, climate, and time through forms of experiential deconstruction. It shows how coherence is created, and what holds it in place. It is also—according to Eliasson—an exercise in thinking about representation. It is a reflexive representation of cosmopolitics; a sensorial, non-linguistic experiencing of the mediated nature of nature. It has offered millions of visitors the chance to critically consider how we define nature and weather.

After the previous chapters' documentation of the *common and spurious expectation that the future will deliver the knowledge we need today*, the last chapter proposes that we have—today—useful forms of knowledge that we overlook, subjugate, or discard. Artistic practices, inherently situated modes of representation, can help think differently about nature and its futures. The arts can be a tool for engagement and critical analysis, neither objectifying cataclysmic events nor resorting to the universalism that is so easily instrumentalised by other interests. Artistic practices can thus interfere with a cosmopolitics of the End that divests local narratives of agency; question the ownership of narratives of the future; help resituate agency in climate change mitigation.

SOME NOTES ON METHOD

Each of the two historical moments (early modern and present) analyses scientific and artistic expressions of apocalypticism. This forms an analytical quadrangle of sorts, with the following four vertices: (1) early modern mathematical prediction of the future; (2) early modern artistic embodiment of the future; (3) contemporary mathematical prediction of the future; (4) contemporary artistic embodiment of nature and its temporalities.

These form a set of confrontations that deserve some preliminary remarks. First, no causal links are proposed. The point is to use the interfering patterns and resonating echoes for a nuanced reading of our current problems, and to challenge the stagnant stability of our current perceptions. I foreground a set of connections, gaps, and contrasts, without claiming that they are *the* connections, or that other historical or disciplinary choices would not yield more insightful results. This book is one exploration of a terrain that has much to discover. It opens one path in that terrain, more than establishing or confirming the way. I am guided by the belief that the apocalyptic is a cultural focal point, continuously changing, but always sharp; and that opportunities for climate action are being missed every day. I would not go as far as Schwartz (above), or state that the modern computer has evolved from Napier's invention of logarithms (Gladstone-Millar 2003: 36). Other times and places could have been chosen as counterparts. The climatology, mathematics, physics, pollution, and cultural developments of the nineteenth century offer immense opportunities for exploration, for example.

Second, I offer little in terms of direct comparison. Sometimes there are suggestions of parallels or partially overlapping patterns. The common element in the confronted or juxtaposed moments is the modelling of the world, how it actively creates the future world it claims to neutrally reveal. The Book of Revelation and earth system models work in the same way, in this sense. Both claim to tells us what we need to know about everything that is relevant. In doing so, both determine the present from the future. In both, the fictional disappears, sinking into claims of truth and transparency. Today's 'gaps in knowledge' rhetoric in climate modelling does not serve as a limiting factor to model everything. On the contrary, it woos decision-makers with promises of soon-to-attain complete knowledge, as will be demonstrated. Connections between fictional and scientific models have started to deserve attention elsewhere. Scientific and cognitive models have been proposed as akin to literary fiction (e.g., Frigg 2010) and Rancière talks about representational entities as fictional entities (2007: 116).

Third, despite these connections, I propose no overarching explanatory framework. Even if one were possible—and I doubt a workable one is—my feeling is that it would end up explaining much in the abstract but offer little help towards the concrete action that is overdue.

What follows is, therefore, a resolutely interdisciplinary methodological experiment across history of science, theology, art theory and history, architecture, future studies, climatology, computer modelling, and agricultural policy. Following these complex connections has been a difficult challenge that has led me to unexpected places, places I did not know before. I have navigated them with science studies and cultural history as references, because these help me not getting lost (too often). The result, I hope, shares my mapping of the connections in an approachable fashion.

The analyses are based on primary sources of the subjects of each vertex of the quadrangle (Napier's writing; IPCC, UN, and FAO documentation; visits to the Banqueting House; Eliasson's work, etc.), aided by secondary sources for the historical developments and contemporary conceptual and theoretical framework. Foucault's *The Archaeology of Knowledge* intended to

> [e]ntertain the claims to attention of local, discontinuous, disqualified, illegitimate knowledges against the claim of a unitary body of theory which would filter, hierarchise and order them in the name of some true knowledge and some arbitrary idea of what constitutes a science and its objects. (1980: 83)

I do take inspiration from Foucault's stated objectives, but have no pretence of attaining them. While I hope I do more than 'entertain', I aim at less than providing answers; my concern is how to formulate questions across disciplines.

Understanding the historical connections of the current climatological and policy mobilisation of apocalypticism helps bring to light the contingent nature of the current configuration. The book aims to contribute to an understanding of what futures we preclude by narrowing the range of methods of representing environmental futures. Do we, in seeking certainty, design a narrow scope of futures that resemble self-fulfilling prophecies? Do we design our worst nightmares?

1 Deadly Weather
Narratives of Nature and Agency During the Little Ice Age

> Perhaps the greatest difference between us and the pagans lies in our different relation to the cosmos. With us, all is personal. Landscape and the sky, these are to us the delicious background of our personal life, and no more. Even the universe of the scientist is little more than an extension of our personality, to us.
>
> D. H. Lawrence, Apocalypse

In October 1637, the earl of Lothian wrote to his father, who was at the court in England, to say,

> The earth hath beane iron in this land (espetially in Lothian), and the heavens brass this summer, til nowe in the harvest there hath beane sutch inundations and floodes and wyndes, as noe man livinge remmembers the like. This hath shaken and rotten and carried away the little corne [that] came up, [so] that certainly they [who] are not blynde may see a judgement come on this land. (quoted in Parker and Smith 1997:13–14)

The letter expressed the difficulty in meeting state tax requirements in the face of financial demands of the Thirty Years' War. This was compounded by the economic hardship caused by crop failures and dearths that were ravaging Scotland and Europe.

His situation was not new; not to him, his country, or even his century. The growth of population in the sixteenth century had increased the pressure on natural resources, at a time when up to 95 per cent of the European population depended directly on crop yields (Fagan 2002; Parker and Smith 1997). Europe was enveloped in changes and events that affected all levels of society. Since Voltaire, a 'general crisis theory' of the seventeenth century has been proposed as a catch-all term for the multitude of crises that affected the world. From the popular revolts of Peru and Russia's first civil war, to the Kyushu Rebellion in Japan and the Turkish–Persian wars, or the widespread riots, revolts, and war in Europe, the world was engaged in change, natural and human, many times violent. The intensity and global reach of the crisis is still a matter of discussion. To many it was a 'general crisis'; others prefer to describe it as a set of loosely related crises.[1]

At any rate, Europe underwent a very troubled period, and the unique contours of the set of crises were commonly framed in the apocalypticism pervading the continent, with acute expressions in Scotland and England.

This systemic, even doctrinal, apocalyptic framework permeated the words of men like James I and VI, Cromwell, the writing of Joseph Mede, John Foxe, John Napier, John Bale, Philipp Melanchton, the accounts of Samuel Pepys, among many others. Alongside it, 'anti-popery' rhetoric spread from pulpits across Protestant Europe. This *apocalyptic interpretative framework* mapped narrative elements from the Book of Revelation (and passages from Daniel, Isaiah, and Mark) to personal, national, denominational, and international events. It was heightened with the Reformation in the sixteenth century and remained acute for a great part of the seventeenth century.

THE LITTLE ICE AGE

An important element in the difficulties faced at this time was the weather, severely affecting crops, livestock, travel, and the price of basic goods, especially grain. The floods and famines claimed many thousands of human lives, and have been factored in the general crisis theory. The climatic variability known as the Little Ice Age (a term first used in 1939 by the French geologist François E. Matthes) was characterised by lower average temperatures and, above all, changeable conditions that made agricultural yields (and therefore stock and cost of goods) unpredictable.

From the early fourteenth century, the number of wet summers, very cold winters, storms, and floods increased with no perceivable pattern, disrupting most sectors of life across Europe. Varying limits have been attributed to this period, with the wider limits set at 1315 and 1850. Whatever the endpoints of the Little Ice Age, the late sixteenth century and early seventeenth century saw its peak (Pfister 1980; Behringer 2010), negatively affected by the earlier stages of the Maunder minimum and by the North Atlantic Oscillation. Brian Fagan notes, in his *Little Ice Age* (2002), how the seventeenth century literally began with a bang: in February 1600, the Huanyaputina (in what today is south Peru) erupted with such ferocity and duration that, today, South Pole and Greenland ice cores bear the evidence. The century was to see an increase in volcanic activity, with climatic impacts. When Mount Parker in the Philippines erupted on 4 January 1641, a "nearby Spanish flotilla lit lanterns at midday and frantically shovelled ash off its decks, fearing in the darkness "the Judgement Day to be at hand" (Fagan 2002: 105).

Overall, the seventeenth century saw some of the coldest years of the Little Ice Age, with 1601 being the coldest year of the millennium (Jones et al. 1998). Loss of life had been great on many previous occasions. Fagan notes how "more than 100,000 people are said to have died in the great storms of 1421 and 1446" (2000: 66). The real problem, more than the cold, was the unpredictable sharp variability of the weather (Grove 1988; Lamb 1995). The Royal Society expects the twenty-first century might be a century of crises: climatic, political, economic, environmental (The Royal Society 2012).

Weather and Apocalypse: A Missing Link?

There is something missing here, at least from a twenty-first-century vantage point. There were instances when the extreme weather, the cold (or seemingly inexistent) summers, storms, the engulfing of villages by glaciers in continental Europe, were interpreted as signs of the last days. Extreme weather events were indeed often interpreted as the wrath of God, punishment for the sins of humankind. But divine wrath is not synonymous with the Last Judgement, and 'a judgement' is not the same as *the* Judgement. Even if we work only the shorter periodisation of the Little Ice Age, when its effects were the strongest, a large number of extreme weather events were not seen as signs of the End. The weather was sometimes said to be bringing about the Last Judgement, but the instances do not show systemic correspondence with the overwhelming political and religious expectation of the impending Last Judgement. There were many explanations for the extreme weather.

At any rate, the severity of the weather did not become a part of the 'apocalyptic tradition', a mixed body of literature—theological, literary, political, artistic, military, or a mix of any of these—with common elements and a significant amount of intertextuality, subtended and sustained by biblical exegesis, and centred on Western Christian texts (see Firth 1979; O'Leary 1994). The 'apocalyptic genre', a related term, has a wider remit, encompassing Persian, Christian, Jewish, Gnostic, and other sources (see Collins 1979). In comparison, 'apocalyptic tradition' is a tighter, more precise term, also because the 'apocalyptic genre' is now also vaguely used to describe secular works, films, video games, and so on. At any rate, what is of interest here is that despite the growing size and influence of the 'apocalyptic tradition' instilling apocalyptic expectations, the changing climate was usually not interpreted through it.

Wolfgang Behringer notes how, on the 3 August 1562, in the wake of a thunderstorm and hailstorm, "a printed newsletter reported that many people feared the beginning of the Last Judgement" (1999: 335). Jankovic (2000) details how some people, under thundering skies, would abandon work and fall on their knees, gaping up at the sky, expecting the immediate End. Many other instances, however, are closer to Lord Lothian's interpretation: 'a judgement'. Friedman (1992) notes that a chapbook titled *A Strange Wonder, or, The City's Amazement*, traced how the flooding of the Thames (on 4 February 1641) was interpreted, in pamphlets (*News from Heaven*, *True News from Heaven*, *News from Hell*) as God's punishment for the rebellions in England. In all, Friedman notes, the flooding was seen as God's punishment either of monarchists or of Parliament. *A* punishment, not *the* Judgement. Extreme weather events were commonly seen as local punishment for local insurrection, sin, ungodly political positions, more than signs of the Last Judgement. According to Friedman,

> [T]he several-score published accounts of such activity during these years [mid-seventeenth century England], seem to indicate that many reader's *imaginations ran wild and saw every storm and peculiar event as a significant expression of God's anger, Satan's power, or the works of demons, angels and witches.* (1992: 426; emphasis added)

These examples only hint at the diversity of interpretations of climatic events. At the same time, there was a systemic and well-established doctrinal apocalypticism, proposed from the pulpits and learned publications of the time (not only religious, but also from political and natural philosophy sources). Not that there wasn't, during the sixteenth and seventeenth centuries, political millennialism in the 'lower classes'. In the case of the Fifth Monarchists, it extended to grocers, cow-keepers, basketmakers, apprentices and servants, as well as ministers and yeomen (Capp 1972: 83). During the height of the Little Ice Age, food riots had a political and social dimension, but were particularly associated with poor harvests (Wrightson 1982). England and Scotland lived obsessed with the Book of Revelation and the Book of Daniel (Reay 1985), and famine and death and riots caused by the weather were common. How is it, then, that the continued climatic hardship and disasters were not systematically related to apocalyptic expectations, after two centuries of destruction and loss of hundreds of thousands of lives, and when the populace did believe in the proximity of the End?

'COMPETING MYTHS'

Alongside divine retribution, the array of imaginative interpretations included witchcraft, as Friedman mentions. While there was no single dominating interpretative framework, apocalyptic or otherwise, witchcraft was consistently linked to weather-making at the height of the Little Ice Age. Research into the relation between climatic change and popular culture has highlighted the connection between climate change and witch hunts, statistically (Oster 2004), in literary and narrative accounts (Behringer 1999; Fagan 2002), climatologically (Pfister et al. 1999) and demographically (Russell 1972; Lamb 1977 and 1988; Grove 1988). Witchcraft was, Behringer tells us, *the* crime of the Little Ice Age (2010: 119), peaking as the Little Ice Age peaked (2010: 130–132). Behring adds, by the way, that the Little Ice Age "may be regarded as a trial run for global warming" (2010: vii).

The decade of 1560, for example, was a time of poor weather, during which the pastor of Stendhal, in the Prussian Alps, commented that there were no distinguishable seasons and crops did not ripen, and "the fruitfulness of all creatures and of the world as a whole is receding; fields and grounds have tired from bearing fruits and even become impoverished" (quoted in Fagan 2002: 90). At this time, witchcraft accusations increased sharply across

Europe, and "witchcraft accusations reached a height in England and France in the severe weather years of 1587 and 1588. Almost invariably, a frenzy of prosecutions coincided with the coldest and most difficult years of the Little Ice Age" (2002: 91). These beliefs and attitudes were older than the sixteenth or seventeenth centuries. Unnatural climatic phenomena were explained as "great conspiracy of witches" since the fourteenth century, despite several councils over the centuries designating weather-making by humans anathema (Behringer 1999: 335). The causes of bad or extreme weather, it seems, were often found closer to the earth than to the heavens, human more than divine. This amounted to a religious doctrinal problem.

Widespread beliefs with animistic traits were part of popular culture (Thomas 1971). Popular belief regularly attributed agency to nature, natural elements, or isolated natural objects (wind, unusual rocks, plants, etc.). Familiarity with scripture was common with ordinary people (see Barbour 1964; also Haller 1957), but also hybridised with non-Christian elements (Reay 1985). Nature's agency was manipulable to varying extents. Material objects, rituals, prayers, and enchantments were efficacious vehicles of mediation or intercession. This way, the relation between humans and the weather had a maximal but not exclusive mediator in the Christian God. This was the doctrinal problem witchcraft presented: affecting the world (natural or human) did not depend wholly on methods of intercession validated by moral and religious authorities. These authorities held the Church, and its figures and deities, as obligatory channels for intercession, influence, or control over natural events. One might pray to saints or the Father in the face of tempestuous weather, but very little else was sanctioned as a form of influencing the weather. An almost infinite number of possible combinations in the construction of a pantheon of gods is possible, when one god is achieving primacy (Weber 1965[1905]: 21). And indeed the peak of the Little Ice Age coincided with times of religious dissent and of struggles for supremacy of different religious positions (some more systematised than others).

In learned circles, the distance between the weather and the End had an obverse dimension to popular culture. The authors mentioned above, from Melanchton to Pepys, understood history as a trajectory from beginning to End, from Adam to the Second Coming, the inexorable progress from Alpha to Omega, and worked in preparation for the certain great day. These were the type of men that developed the apocalyptic tradition. Friedman reports how Ellis Bradshaw wrote, in his *A True Relation of the Strange Apparitions Seen in the Air on Monday, February 25, 1694*, that the two opposing rainbows visible in a clear sky "symbolised the broken covenant or contract between king and Parliament" (Friedman 1992: 428). Notably, it did not symbolise the breaking of the covenant that the rainbow was accepted to symbolise after the biblical Flood; an expectable interpretation, since "it was a common belief in the sixteenth and seventeenth century that the sins of mankind were so heinous that they had damaged the world itself, as they had in the generation of Noah's flood" (Goldish 2004: 9–10). To be precise, this does not intrinsically deny the apocalypticism of such an interpretation, but the apocalyptic dimension rested with politics, not nature.[2] Armies fighting in the sky were common apparitions, with many accounts recorded over the years across England. The dates and details of these occurrences were interpreted in the light of English or British or European politics. Storms were many times interpreted as God's punishment for human actions, as was the case after Charles I's decapitation. In the light of the numerous scenes in Revelation that take place in the heavens, it would not take much effort of the imagination to relate them to these atmospheric events. Instead, these were seen as depicting very earthly, political struggles. Struggles of good versus evil, but earthly struggles nonetheless.

Somehow, the indubitable holy narrative sustaining apocalyptic expectations did not translate the catastrophic weather into a functional element in the apocalyptic tradition. This is the more surprising in the context of Mark 13, also known as "The Little Apocalypse," especially Mark 13:8: "and there shall be famines and troubles: these are the beginnings of sorrows".[3] Theological and natural philosophy apocalypticism did not make systematic use of extreme weather events to sustain its expectations. The reasons, however, were opposite to those found in popular culture: nature was neutral, the passive realm of the material. It had no agency. To say 'from Adam to the Second Coming' is to say 'from the first man to the return of the Son of Man': history as human history. For the religious authorities to accept the efficacy of witchcraft would be to accept mediated human agency over preternatural elements, and allow a breach in the omnipotence of God, or at least allow a form of circumventing the necessary channels (God—and his saints, in the case of Catholicism). A nature with agency could be seen as undermining God's omnipotence.

The Church's slow—and theologically inconsistent—acceptance of weather-making by humans evidences the complications of the matter: recognising weather-making human agency was needed to suppress witchcraft (and replace magical rituals with Christian rituals); but recognising its efficacy also allowed a short-circuit between humans and nature, potentially bypassing God. These confrontations between explanations of the weather lasted the entirety of the Little Ice Age's most severe period. As late as the 1630s, church policies were more about discipline and uniformity than doctrine, and "religious ideas and practices were central to one strand which fed the 'competing myths' which led to war" (Foster 1994: 80). The church vied for strict control of intercession rituals that asked God for weather changes, "culminating in years of crisis in formal processions and pilgrimages" (Fagan 2002: 52).

Witchcraft: Early Modern Anthropogenic Climate Change?

It is not my aim to reassess the origins, contours, and demise of witchcraft. To engage in an analysis of its role in society would lead to familial and community relations, gender roles, and a complex of elements that is beyond the purpose of the present analysis. What is relevant here is the changing climate, how it was interpreted, and how people tried to act upon it. In this, witchcraft was a central element, and its consistent connections to the weather allow us to understand the relative positioning, overlaps, and frictions of different interpretations of human, divine, and demonic agency.

When analysing this contested terrain, one needs to be careful with expressions such as 'competing myths'. In a terrain criss-crossed by popular culture, 'natural philosophy', and theology, explanations for extreme weather events were sometimes opposed, sometimes easily fusing, sometimes part of a clearly defined doctrine. Sometimes they were a melting pot of religious and magic traditions, amalgamated by individuals into their everyday situations. As Weber said,

> [N]owhere was the existence of spirits and demons permanently eliminated. Even in the Reformation spirits and demons were simply subordinated unconditionally to the one god, at least in theory. The decisive consideration was and remains: who is deemed to exert the stronger influence on the individual in his everyday life, the theoretically supreme god or the lower spirits and demons? (Weber 1965[1905]: 20)

To put it simply, divine omnipotence versus magical agency over nature. Those two poles were also in fluid relation with a third, composed of the developing scientific forms of enquiry and explanation. The acutest period of the Little Ice Age coincides with the lifetime of John Napier, a man who—as we shall see—did not dismiss magic and divination, despite his Calvinist beliefs and his mathematical genius. Some even considered him a warlock. During his time, his home country of Scotland suffered the consequences of adverse weather more than most. Famines resulting from harvest failures caused by poor weather resulted, in Scotland, in more deaths than the plague (Lamb 1977). Witchhunts were legalised in Scotland when Napier was thirteen years old. Alongside popular belief and church doctrine, the formation of early scientific practice (and its communities, academies, practices, and axioms) took place not in opposition to magic and witchcraft, but essentially embroiled with it (see Clark 1991; Daston and Park 1998), adding to the flowing set of different narratives of disaster. Why were humans (mostly women) the cause of catastrophic weather, when it was known that God would provide signs of the End through the weather?[4]

The answers cannot be found solely in witchcraft as a popular belief, or in the distance between doctrine and everyday religion. Belief in weather-making by witches was not restricted to peasants, and agricultural yields affected virtually everyone. Those who did not depend directly on agriculture (e.g., artisans and apprentices) depended much on markets and prices. The growth of towns and cities did not decrease urban dependency on rural areas, very much the contrary. With the growth of London from

50,000–60,000 inhabitants in the 1520s to 200,000 in 1600 (doubling to 400,000 in fifty years), and reaching 575,000 by 1700, the capital could not feed itself from its surrounding areas; shipments of grain into London from Kent grew accordingly from 12,080 quarters in 1587–1588 to 71,090 in 1680–1681 (Wrightson 1982: 128–129). Urban populations felt the impact of price fluctuations at least as much as rural populations.

Animism helped belief in witchcraft to spread, and it was common among different social, religious, geographic, and ethnic groups (Friedman 1992; see also Thomas 1971) despite different formulations in different groups (Rossi 1991). In everyday religion, (*Alltagsreligiositaet*) creator gods tended to have a "comparatively minor role" in natural phenomena, and people interacted directly with the forces of nature, without the need of an absolute God, priests or sorcerers (Weber 1965[1905]: 21–22). The weather variability was, in itself, a challenge not only to crops, but to any overarching explanatory framework. If "the process of rationalization favoured the primacy of universal gods" and was influenced by 'professional sacerdotal rationalism' for the sake of the "inviolable sacred social order in terrestrial affairs" (Weber 1965[1905]: 22), how could the sphere of influence of God be convincingly extended to the changeability of the weather, neither a trivial matter nor regular enough for rationalisation? May it be that it couldn't, and so the instability of the contested terrain provided the conditions of possibility for the "radical reordering of the understanding of nature that did in fact take place in the sixteenth and seventeenth centuries" and on which the scientific revolution rested (Westfall 1997: 72)?

Causal Lacuna

Valid knowledge claims, and the methods to achieve them, formed a landscape of shifting boundaries between the natural, the preternatural, and the supernatural. Class wasn't the dividing factor. Causality, determination of relevant variables—and methods of controlling variables in the face of instability and uncertainty—were everyone's concern, from peasants to the gentry. It formed part of everyday life and part of the musings of natural philosophers. Farmers had a variety of divination practices not only for harvests but also for forecasting market trends in grain prices, from observing the flight of cranes or the moon to laying ears of corn on the hearthstone (Wrightson 1982: 135).

Medicine was an area where the fluidity of disciplines seems contradictory. As Thomas (1971) states, medical knowledge was based on the four humours of the body, and while its effectiveness was very limited and its epistemological basis frail, physicians were far from accusations of witchcraft. James VI and I considered medicine a 'mere conjecture' and 'useless'; the poor, unable to afford the services of licensed physicians, relied on 'wise women', herbalists, and empirics (even if their practice had been denounced by Parliament in 1512), an option that Bacon himself found understandable, in the face of the limited success of academic medicine (Thomas 1971: 14). Women, herbalists, popular healing practices, charms, spells—all were susceptible of being identified with witchcraft practices, but physicians were not. To compound the problem, both explanations of proto-scientific methods and witchcraft methods mixed natural causality with mediated agency, and this had been the case since the *Malleus Maleficarum*, according to which only natural causes were capable of achieving real effects, with the all important exception of weather phenomena. Causality, its laws, its control by humans, the methods to achieve that control, and the causality that escaped human understanding and control, configured the problem as one of boundaries, their permeability, and the instruments, entities, or objects which might mediate between our limited powers and the uncertainty of future events.

Church bells, for example, were said to dissipate storms, and the properties of holy water were applied (or applicable) to nearly everything, from the peace of private dwellings to the fertility of fields, because of their essential properties. Along with spells (words) and divination (sometimes with numbers), these practices would be accused of a causal lacuna (Clark 1991) by the Protestant Reformation. It is worth noting that, according to Thomas,

> The implications of the Protestant rejection of magic were slow to affect those areas where a preaching ministry had not yet been established. Sir Benjamin Rudyerd reminded the House of Commons in 1628 of 'the utmost skirts of the North, where the prayers of the common people are more like spells and charms than devotions'. (1971: 73)

While church rituals had been common in the face of harvest failures, and prayer was widely used for petitionary and divinatory purposes, the Reformation challenged the efficacy of those rituals—even if with some important inconsistencies. That challenge was a crucial moment, but not a watershed change: for centuries, the church resisted accepting that humans had the power to bring about the effects supposedly (or more correctly, illusorily) achieved by witches, including weather-making. It had done so strongly since the *Canon Episcopi* made its way into Gratian's *Corpus Juris Canonis* in 1140, but even before (e.g., in Agobard's *Contra insulsum vulgi opinionem de grandine et tonitmis* [Against the foolish opinion of the masses about hail and thunder] of 815). The early church went as far as identifying witchcraft as heresy (Kors and Peters 1973).

During the thirteenth century, the time when the earliest effects of the Little Ice Age were felt, ecclesiastical attitudes were changing. Witchcraft began to be accepted as efficient causation. By 1326, nine years after Northern Europe's catastrophic famine of 1315, its worst ever (Fagan 2002: 81), papal sanction of witchcraft persecutions was accomplished by John XXII's *Super illius specula*. Since Hemmerlin (1388/89–1460?), witchcraft was a mix of natural causes and demonic favours, and around 1380 magic and weather-making gained prominence in inquisitorial trials (Behringer 1999). Large-scale disasters, such as famines, were considered beyond the power of witches. The weather events causing the famines, on the other hand, were commonly attributed to witchcraft (Thomas 1971). Behringer notes that "it can be shown from many individual witch-trials that meteorological events contributed decisively to many individual suspicions and accusations" (1999: 342).

It was the devil who bridged the causal lacuna between the unconnected natural causes and the desired effects—for example, the transfer of the pain between the wax figure and the victim. Or, most interestingly, as argued by Ulrich Molitor in his 1489 *De Lamiis et Pythonicis Mulieribus* (The Witches and Diviner Women), and in Jean Vincent's 1475 *Liber contra artem magicam* (Book against Magical Arts), the devil deluded women into thinking they were efficient cause of the natural events the devil could predict (Broedel 2003: 51 and 78). Prediction was, therefore, a preternatural matter, not supernatural (Rossi 1992). "Although occult properties were in principle as regular in their operation as manifest ones, they were opaque to reason . . . *Because of their complexity*, chance events also escaped the limits of human knowledge" (Daston and Park 1998: 160; emphasis added). Astrological predictive errors in human affairs, on the other hand, were blamed on observational mistakes (Pennington 1989: 161).

Menstrual blood was used in witchcraft, linked to multiples of seven (numbers contained magic properties), said to "avert natural disasters such as tempests, hail and lightning", and it wasn't until the "early eighteenth century [that] many of the superstitions seemed demonstrable nonsense" (Crawford 1981: 60). Crawford's choice of words is interesting, for the difference between that which makes sense and that which does not was to become, during the seventeenth century, a matter of demonstrability. The demonstrability of rare or complex events was especially difficult, as it is today. *As it is today of climate change*, to be more specific. Then, the Bible was the guarantor of the intelligibility of the complexity of the (preternatural realm of the) world.

The 1484 *Malleus Maleficarum* had opened with Innocent VIII acknowledging witches' ability to destroy crops and pastures and includes a chapter on 'How they Raise and Stir up Hailstorms and Tempests, and Cause Lightning to Blast both Men and Beasts'. Human weather making had been anathema since the early Middle Ages but, by the Renaissance, it was widely accepted that demons and the witches at their service were real and effective, even if working within the laws of nature. By the mid-1500s, theologians (Protestant and Catholic) blamed people for the climatic wrath of God. This isn't necessarily a contradiction: while people could be responsible for God's wrath, God alone created climatic events, and effective demonic witchcraft was natural, if *unintelligible*. This is wholly compatible with the apocalyptic tradition, but wholly different. To use today's terminology, climate change was anthropogenic in cause, even if the causal chain was beyond human knowledge. Suicide, for example, was said to cause bad weather (Behringer 2010: 117). Anthropogenic climate change was possible, through God's wrathful intervention.

Felix Culpa

There is another important nuance to the apocalyptic tradition. The apocalypticism of Protestant theology and natural philosophy was not dystopian, in nearly all instances. By postulating a fundamental divide in civilisation between the followers of the Antichristian Rome and its church, and the role played by Protestantism in bringing about the peace of the millennium, it made both parties indispensable to the impending, ineluctable outcome. In early Stuart court, "in the wider context of the polemical contest with Rome, claims to moderation, charity and irenicism were increasingly seen as trumps in the struggle to cast the other side as the innovative, schismatic and disruptive party" (Lake 1995: 57). This shall be an important topic when we examine Inigo Jones' Banqueting House, and it goes hand in hand with a neutral, passive nature: it was the action of humankind that would bring about the end of days. To men like Bacon and Napier (and, among many others in many different ways, John Dee and Joseph Mede) human action was the privileged seat of agency in this world, and would bring about the last and greatest change of all, a change that retroactively attributes dogmatic meaning to history as a whole. "Manie shall gae to & fro, and knowledge shall be increased", John Napier quoted from Daniel 12 (as Bacon would) a central millennial element of the latter's program (Webster 1975). Mankind's work, along with mankind's immorality, brought about the divine redemptive End.

The Baconian philosophy has been characterised as "the second great fundamentalist doctrine of the seventeenth century" (Feyerabend 1970: 155). And like Bacon's, the approach of 'natural philosophy' is "fundamentally historical and eschatological" (Webster 1975: 23; see also Szerszynski 2005). The End would be brought by man's agency in this world, an utopian end that was tightly enmeshed with the powerful trope of a Golden Age, of a lost Paradise, in a teleological process that involved man's redemption of nature, analogical to Jesus' redemption of mankind. Man's agency was thus matched by nature's lack of agency. Nature worked according to causal principles but human work and divine power permeated its passive matter. This did not exclude the terrors of the Apocalypse, including natural catastrophes, for it was necessary for this world to end for the New Jerusalem to be established.

Apocalypse Deferred

The events of 1588 may illustrate the above point. It was a portentously apocalyptic year. Long before, Regiomontanus had counted the years since Christ's birth until 1588, and expected that year to bring total catastrophe or, at least, the whole world to suffer with great lamentation. Calculations from the blazing star of 1572 also left no doubt that it would be a year of apocalyptic portent. When the Spanish Armada gathered in Lisbon towards the end of 1587, and did not sail, it became clear that it would sail in spring 1588, and the apocalyptic expectation increased even further (Mattingly 1959). 1588 was one of the stormiest years on record (Pfister 1980; Behringer 1999) and the storms of that year are closely related to the apocalypticism of that year. But only indirectly. And that 'indirection' leads us not to nature's tempests as the End or signs of the End, but to the Armada's foiled invasion as a clear sign of the End. The chain of causality towards the End was, unequivocally, a function of man's actions, not of natural events. The political, and even commercial, use of these apocalyptic expectations is further evidenced by how prophecies about 1588 were differently interpreted in different countries in Europe: Amsterdam printers, knowing that their almanacs would sell in several regions and to Catholics and Protestants, were more politically impartial and focused on the natural catastrophes: tempests, floods, hail and snow in summer, daytime darkness, rain of blood and earthquakes (Mattingly 1959).

Increasing Knowledge

In the endless game of predicting or determining the future, different narratives and their associated practices ranged from Christian apocalypticism to popular animistic witchcraft. In that range there was an inscrutable spectrum of hybridisation, or permutations (as Reay puts it [1985]). The practice of witchcraft was a function of a particular view of nature (Clark 1991: 224), using its forces for human purposes, in different ways (and objectives) to those of doctrinal apocalypticism. Demons, the true agents of magic, acted according to nature's regularities, but above the understanding of humans. The devil himself worked wonders (*mira*), not miracles (*miracula*) (Daston and Parker 1998: 121). This meant that demonology could be considered an integral part of 'natural philosophy' and "the discussion of witchcraft influenced the emerging science of meteorology" (Thomas 1971: 346). *The preternatural was not considered to be forever outside the scope of human knowledge, it was reachable by man's endeavour, the same endeavour that would lead to Daniel's 'increase in knowledge'*. The preternatural was unknown, but knowable: as early as 1637, Descartes looks for natural causes for climatic processes in his 'Discourse on Method, Optics, Geometry and Meteorology'. "To predict the weather was to predict the harvest; and to predict the harvest was to predict the discontent which would follow a food shortage, and the rebellion which might follow the discontent" (Thomas 1971: 334). The progressive increase in human knowledge would reign in the unknown, reigning in nature towards the glorious, if catastrophic, End.

In an economy dominated by the parish as the cornerstone of social structure (Fagan 2002) with an agricultural economy reliant on rainfall (Restivo and Karp 1974: 131), the state asserted its power through a diversity of narratives (Larner 1983; Gaskill 2001; Oster 2004), enacted through—and because of—a liturgical reform (Rosendale 2001) and through secular justice courts. With the Protestant emphasis on prohibiting Catholic rituals, the obliteration of weather-related rogation ceremonies incited the proliferation of popular practices and rituals outside the control of the church, that it therefore needed to stifle. Yet, the Reformation was also liberating and empowering for the individual believer. It removed the institutionalised and 'rogue' mediators between the individual and God. It then required other boundaries, which it located in social structure, outside the soul-divine axis.

In this light, witchcraft was a space of social disputes that reflected the fluidity and urgency of stability in a world mired with uncertainty. The multiple attributions and displacements of agency and initiative (responsibility, if one wishes) for uncertain catastrophic events to demons, witches, God, or human sin were part of the urgency in determining the limits and possibilities of human action in the face of famine, plague, war, and deadly storms. This concerned every individual, and every individual acted in accordance with their perceived social status, and in accordance to the cultural matrix that configured their practical abilities to predict, determine and control their world. It was not a situation of clearly distinguished competing narratives, but different camps are perceivable, especially through institutional efforts: "salvation supervenes by virtue of the grace which is distributed on a continuous basis by some communal organization that has either divine or prophetic credentials for its establishment" (Weber 1965[1905]: 187).

Witchcraft's power, in contrast, was more socially diffuse (and dispersive of power and authoritative knowledge that yields control) than that of apocalyptic narratives. The spirituality and invisibility of apocalypticism, as well as its focus on a messianic individual figure, enables it to colonise the imagination of the subjects (of crown and church). The palpable reality of natural disasters meant that to assimilate them into doctrinal apocalypticism would lead to rebellion-breeding anxiety levels. Apocalypticism was a narrative aiming to determine present action by colonizing the future. The social chaos that would result from identifying present extreme climatic disasters with the end of the world would work against those objectives. A *future* state of (apocalyptic) exception narrows the horizon of possibilities, reinforcing authority; a *present* state of (apocalyptic) exception makes present possibilities boundless, undermining authority. The successful Apocalypse must therefore always remain tantalizingly close, yet *forever future*.

DEFINING THE APOCALYPTIC

This helps us reconsider some theories on the nature and potency of apocalyptic narratives. Michael Barkun proposes, in *Disaster and the Millennium* (1974), that natural and man-made disasters are the main source of apocalyptic tendencies. If that were the case, then we should expect the Little Ice Age events, and its consequences, to bear more consistent links with the doctrinal and political predictions of the End, if not become the evident proof of what the Little Apocalypse (Mark 13) predicted. Stephen O'Leary (1994) instead argues that apocalyptic discourses contextualise disasters into their rhetorical use of calamity. But neither of these options matches popular understandings of climatic events and apocalypticism, during the height of the Little Ice Age.

O'Leary adds, however, that "apocalyptic discourse [is an] argument that is intended to persuade, focusing attention on specific interpretive practices" (1994: 15). This, he suggests, should be seen in relation to Bernard McGinn's analysis of the apocalyptic as a tradition textually embodied in a community of discourse (see also Szerszynski 2005; cf. Borchardt 1990). Apocalypses focus truth into a single event, a single point in time, a single entity or person, a single regime, a single source of authority to the total exclusion of all others. As Weber says of the power of humans and spirits and gods, "whoever possesses the requisite charisma for employing the proper means is stronger even than the god, whom he can compel to do his will" (1965[1905]: 25).

Apocalyptic narratives thus define present disputes, while temporally displacing them. Those disputes are either over cosmological, moral, or political issues that are already mutually exclusive; or an apocalypse, as a universal event, may be used to make them mutually exclusive. By virtue of their *universal inexorable applicability*, they reduce the number of possible futures: there is but one truth, and the paths of access to such salvific truth are to be found only in what Weber calls *membership in a community of belief*. Stories of the future have their own exclusive representatives. Personal soteriological paths are invalidated. One single source of truth about the future is allowed, and its universal applicability reaches every scale, every individual. O'Leary says that "competing notions of truth exist not only between cultures, but within a single society, and even within a single divided mind" (1994: 23). Institutionalised apocalyptic narratives flatten these differences: Weber says that the personal situation ("religious qualification") of the individual is indifferent (as long as the individual believes), as is the personal situation of the priest or the institution: "salvation is universal" but exclusive to one purveyor of the Truth; therefore *extra ecclesiam nulla salus*, no salvation outside the church (1965[1905]: 187).[5]

Reformation Britain reinforced a univocal truth in a multiplicity of ways. The Preface to the 1611 edition of the Authorised (King James) Version of the Bible asks the reader, "But now what piety without truth? What truth (what saving truth) without the Word of God? What word of God (whereof we may be sure) without th*e Script*ure?" (reproduced in Bray 1994: 419). Methods of in*script*ion of truths about the future became more diverse during the seventeenth century. In their differences, these methods aimed at universality. John Napier of Merchiston was an exemplary figure in these developments.

2 Counting the Days
John Napier's Exegesis and Mathematics

> Our most prevalent notions both about the function of measurement and about the source of its special efficacy are derived largely from myth.
>
> Thomas Kuhn

John Napier lived and worked in a context of heated eschatological political debate and extreme weather, "encircled with savage sights and sounds of civil discord, above which the name of God was howled by those whose hands were red with murder" (M. Napier 1834: 36). In January 1594, he published *A Plaine Discovery of the Whole Revelation of St John* (hereafter *Discovery of Revelation*). Twenty-one years later, in 1614, he published the *Description of the Wonderful Canon of Logarithms* (*Mirificii Logarithmorum Canonis Descriptio* in its Latin original, hereafter *Description of Logarithms*).[1]

The two works, divided by the turn of the century, were also separated by their subject matter. Napier considered the *Discovery of Revelation* to be his most important work, and it became very successful in Protestant Europe, with twenty-one editions in English, French, Dutch, and German. Its five English editions were heavily drawn upon in the writing of prophetic almanacs in the 1640s, when apocalypticism in British politics was at one of its highest points. It was the *Description of Logarithms*, however, that earned him a distinguished place in history. His landmark mathematical work immediately became central to mathematical description and prediction, in astronomy, natural sciences, and later to engineering, probability, cryptography, and so on.

NAPIER'S 'DISTRACTIONS'

His mathematics are often deemed unrelated to the apocalyptic expectation that dominates his religious exegesis. Accounts of the invention of logarithms are sometimes accompanied by biographic detail making anecdotal mention of the *Discovery of Revelation*. Sometimes with a hint of irony: "Napier was working on logarithms in the 1590s, but this fanatic Calvinist was distracted by the religious broils of the day" (Crosby 1997: 237–238). Sometimes with disdain, even from Napier's descendants: "Napier, like Newton, wasted time in endeavouring to discover the mysteries of the Apocalypse" (M. Napier 1834: 181, see also 34). Sometimes with surprise:

> It is very remarkable that, in a country distracted by political, social, and religious feuds of the most serious kind, such as Scotland then was, there should have arisen the first of those great thinkers who in the course of the seventeenth century brought Great Britain to the highest point of achievement in the domain of Mathematical Science. (Hobson 1914: 47–48; on a similar tone, see Glaisher 1915: 63; Thomas 1834: 34; Hume Brown 1915: 34; Edwards 1982: 142)

Conversely, research of post-Reformation apocalypticism in the British Isles examines the *Discovery of Revelation* as a landmark effort at interpreting the Book of Revelation, sometimes mentioning Napier as being more famous for his invention of logarithms. It seems difficult to reconcile Napier's interests: a man capable of brilliant abstract mathematical thinking was also an astrologer and divinator engaged in treasure hunts; a man who created optical and explosive military 'secret inventions' motivated by political and religious opinions; a man who built mechanical, tabular, and chessboard calculation devices was seen by some of his contemporaries as 'a limb of the devil'.

There is a suggestive third position. In a few instances, the connection between the development of logarithms and Napier's apocalyptic thinking is established. Some tell us that "Sir Isaac Newton became a super-expert on the late, late Roman Empire . . . John Napier [had] devised the system of logarithms to help in these difficult calculations" (Popkin and Force 2001: ix), and that "Napier's fame in history rests upon his discovery of logarithms, which he imposed on the existing Genevan teaching to produce a strict chronological framework for his eschatological narrative" (Gribben 2000: 41), or that it was with the number of the Beast in mind (Trevor-Roper 1967; also Hill 1971). Unfortunately, no further examination or explanation is offered in these instances.

John Fauvel goes a little further, stating that the reasoning used in the development of logarithmic calculation and in the calculation of the End is the same. Napier's logarithmic work involves a perfectly clear apprehension of the nature and consequences of a certain functional relationship (Fauvel 2000). Fauvel notes this functional correlation and points to the equivalent functional reasoning in the *Discovery of Revelation* between the "historic timeline from the time of Christ onwards, and the narrative time-line of St. John's vision as presented in the Apocalypse which is being mapped onto it", in a structurally equivalent process, as it uses the known information from one continuum to determine unknown quantities in the other (2000: 24).

This being true, Napier's work deserves a different kind of attention. Besides the fame he earned from the development of logarithms, we should consider the shift from determining the ultimate future of the whole world in a divinatory and numerological fashion, to calculating it mathematically. His is a seminal place in the development of scientific methods of calculating future global disaster. Interestingly, he does it without factoring the deadly climate change surrounding him. But let us leave the weather aside for now.

Consilience in Napier

We might never find direct factual confirmation that Napier's mathematical and exegetic work are mutually derived, or even developed together. Some pieces of the puzzle are forever missing. At the end of the eighteenth century, many of Napier's private papers burned in a chest, where they were placed for safekeeping, at Colonel Milliken Napier's house. Whatever may have been lost, it can be plainly stated that Napier's interpretation of the Book of Revelation is not logarithmic, *strictu sensu*. But it would be further from the truth to say that Napier's logarithms are the real and serious vocation of a man distracted by strange interests, or that the two works do not have significant developmental and conceptual equivalences. It is a misleading assumption that mathematical techniques and devices are independent of the conditions of their development. It is misleading when examining today's calculations of potential disastrous climatic futures (as we shall see later). It is also misleading—in an equivalent way—when considering Napier's motivations to calculate the end of days. To separate his mathematics from his apocalypticism is to perform anachronistic disciplinary divisions, to—as Charles Taylor says—portray processes of secularisation as subtraction stories, whereby "science refutes and hence crowds out religious belief" (2007: 4).

If, instead, we consider the changing conditions of possibility and 'fields of constitution and validity' (Foucault 2002: 5), it is possible to trace the genetic and conceptual connections between apocalypse and mathematical prediction of the future. Understanding secularisation, as Taylor suggests, through the whole context of understanding and the conditions of lived experience can help us see beyond the subtraction stories (or 'distraction stories' in Napier's case). Brian Rotman says, of processes of naturalising mathematical signs, that "what is forgotten, ignored, suppressed—in fact repressed . . . is the original subject, or rather, the agency of this subject, the activity of the one responsible for originating, through the primary meta-sign, the entire system of signs" (1987: 54). To study how mathematical calculation and religion are *made separate* allows us to understand how "alternatives became thinkable" (Taylor 2007: 25), and distant enough to seem distractions. Nowadays, as then, the conditions of possibility (Taylor's 'shape of the background') of our mathematical predictive practices must be taken into account if we are to understand our apocalyptic predicaments.

The questions I shall be investigating of Napier's work also subtends the analysis of current climatic quantitative predictive practices, *mutatis mutandis*: what resources does Napier mobilize in knowledge production, how they are utilised, what epistemic assumptions do they carry and propagate? What political, religious, epistemological, and cultural transformations can we discern in his work? What residual elements might be enclosed in his mathematical legacy, from his motivations, purposes, and beliefs?

A PLAINE DISCOVERY

In dedicating the *Discovery of Revelation* to James VI of Scotland, Napier exhorts the king to "remove all impediments . . . as may hinder that work", towards a reformed country, in readiness for "that great and universall reformation" (Napier 1594: A3–A4r). This call to action was so urgent that Napier abandons the Latin version "to haste out this English present work" (1594: A7r).

The first of two reasons for the hasting of Napier's admonitions was, it has been suggested, avoiding any doubts regarding his royal and religious loyalties, after Sir James Chisolm (Napier's father-in-law) was implicated in the 1592 Spanish Blanks plot to overthrow the Protestant Scottish crown and to instate Catholicism. Napier was eventually among the chosen, by the Synod of Fife, to represent the Protestant cause before the king, but the whole affair was to end in bloodshed, when the king attacked the Catholic earls in 1594 and 1595.

Still a fresh memory in 1592 was the second reason: the battles against the Spanish Armada in 1588 had left a great impression in the British Isles. Napier intended to settle beyond doubt that Rome was the seat of the Antichrist, and that the end of the world was nigh. He aimed to do so

> as neere the *analytick and demonstrative maner*, as the phrase and nature of the holy scriptures will permit . . . that thereby the trueth of God, the history of his Church, and the person of the Antichrist are detected. (Napier 1618: A6r; emphasis added)

To achieve "honest science and godly exercise" (Napier 1594: A5r), his method requires that "explanation and interpretation is proved, confirmed and demonstrated, by evident proof and coherence of Scriptures, agreeable with the event of histories" (1594: A7). His strongly formal Ramistic approach to decoding the text is married to a detailed analysis of dates, periods, proportions in time, based on quantification of the 'metaphorical' and 'metonymical' (in Napier's terminology), to evince proof "as may make that interpretation undenyable" (1594: A6), structured clearly in propositions and in tables, a typical Ramistic method (Firth 1979; Ong 1958).

The first proposition, "proved by appearance, by a law, by practice and by necessitie" sets out the proportions that will be used to measure historical periods, namely, that a prophetical day stands for a year and that a week of years are seven years, a month of years is thirty years, and a year of years contains 360 years, "according to prophetical custom and practice", Genesis and Levitical law (Napier 1594: 1). The second proposition establishes the identity between the trumpets and vials of Revelation. They are "to be one and the selfe same thing" (1594: 19). There isn't much new in these two propositions. The contents of the first were standard in Christian exegesis, and there were recent similar interpretations in Britain, from John Bale, John Knox, and also Calvin. Napier acknowledges that his proportions are in accordance with those of Joseph Scaliger, in the latter's *De Emendatione Temporum* (Napier 1594: 1)

Having thus established the proportional magnitudes, Napier maps them to historical events, creating a proportional scale. Making reference to one of the seminal works of the Protestant apocalyptic tradition, the *Carion Chronicles* of 1532 (expanded by Melanchthon from John Carion's original), to scripture (Vulgate), and to semantic coincidence of translated terms, he identifies the Fifth Trumpet with the "Dominator of the Turks and his armie, who began their dominion, in anno Christi 1051" (Napier 1594: 19). From this initial date, he calculates other dates in the past and in the future (see Figure 2.1).

In the fourth proposition, the Sixth Trumpet is identified with the Ottoman Empire, "which began in anno Christi 1296" (1594: 7). Proposition 5 establishes, with the dates from the previous propositions, that each trumpet or vial equally lasts for 245 years. The quantified "perfect harmonie & analogie betwixt the prophecies and historie" (1594: 7) was a common assumption (e.g., Luther, Knox), and is here confirmed by the regularity of the 245-year-long vials. They are inaugurated by trumpets, like the regular Jubilees in Leviticus (49 years each) and must be a multiple of Jubilees. Of four Jubilees (196 years) and six Jubilees (294 years), Napier says "one shall be so few, and the other shall be so manie, that the historie could not agree thereto: Therefore, five Jubilees, which is 245. years (as the middest between extremities) agreeth exquisitlie" (1594: 8).

The eleventh proposition states that every one of the seven seals that precede the trumpets and vials "must containe the space of seven yeares". The assumption is that the regularity of the world makes it knowable, and quantifiable. All parts of the history of the world have the same quantitative structure: "In every distribution, æqualitie is most apparent and probable", Napier tells us. "Secondlie . . . so the harmonie to bee perfect betwixt these seales and the just historie" (1594: 13).

Overall, this relationship between historical events and prophecies (Revelation and Daniel) acknowledges—but slightly alters—previous Protestant interpretations. He corrects "Carion and other Historiographers" (Napier 1594: 9), but uncritically resorts to Scaliger's *De Emendatione Temporum* as the authoritative source of calendric computation. The six days of creation correspond to the "6,000 years of worldlie trauels and cares, than shall come our eternal Sabboth & rest, in the glorie of heaven, signified by the seventh daies rest" (Napier 1594: 19; cf. Molland 2004).

The regularity of the world and its history render its future predictable. Like others before him, Napier relies on the harmony between prophecy and history, yet he seeks mathematical demonstration, not numerological justification. The absolute, univocal relation between numbers and things which had seen increasing questioning (by Erasmus, More, Bruno, and John Dee, among others) is unable to sustain knowledge claims, for Napier. Such

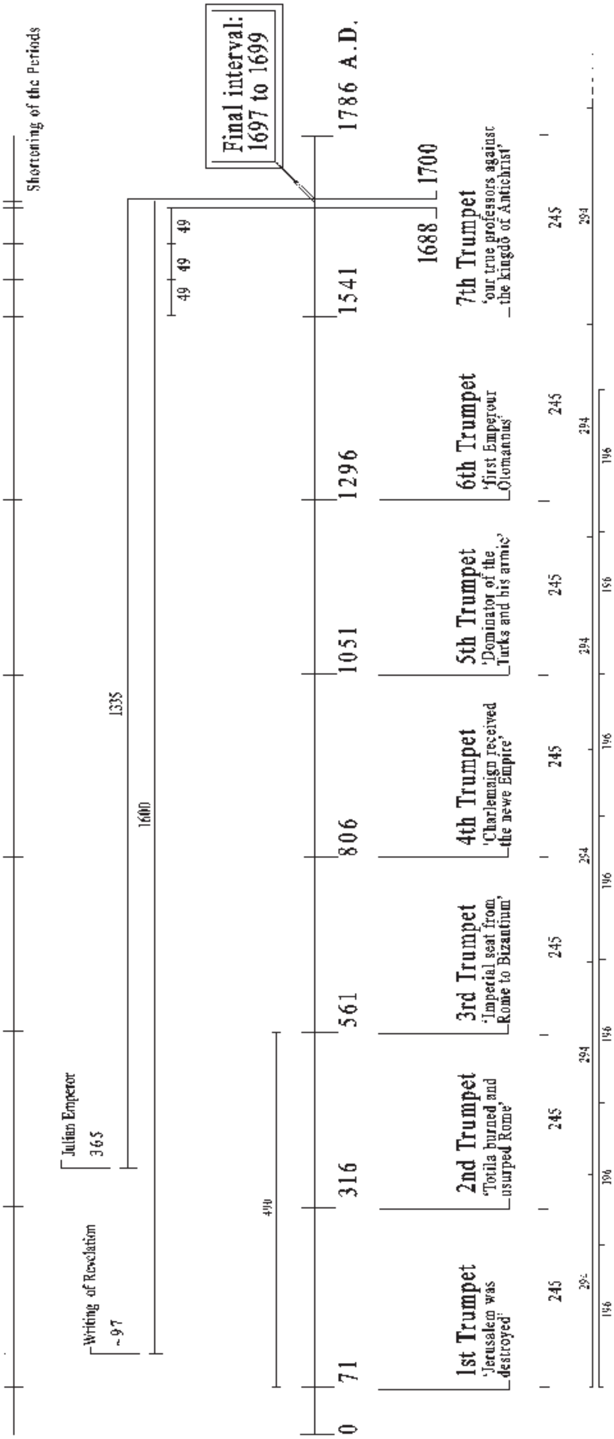

Figure 2.1 Diagrammatic representation of the chronological distribution of prophecies in John Napier's *Discovery*.

relation is no longer an essential unity. It requires demonstration. Numbers no longer have intrinsic power. It is extrinsic, derived from the historical events representable by numbers. Whereas Napier is one among many who use mathematics and Revelation as systematically related, these specificities have special relevance in the development of quantitative methods of predicting the future. The profusion of publications of the *Discovery of Revelation* would make this far from innocuous.

Dating the End

Napier defends the risk of calculating the End, not for fear of being wrong, but because scripture warns against it. He paraphrases Mark 13:32 (see also Matthew 24:36), the passage that stopped many, before and after Napier, deciding on a date:

> the day of the judgement and the houre thereof, none doth know: yea, not the Sonne, but the Father only: yea let none be so base, of judgment as to conclude thereby, that the yeare or age thereof, is also unknowne to Christ, or unable to be known any waies to his servants. (1594: 16)

Here, in proposition 14 (second in length after proposition 26, 'The Pope is that only Antichrist, prophecied of, in particular') Napier needs to justify knowing more than Christ. How can any man have such arrogant aims? His reasoning here is careful, considered, and revealing. God hid knowledge of the long distance to the end from most generations by his providence, Napier says, because knowledge of a distant end would lead them to care too much about earthly matters at hand. Yet, "so soon as the day beginneth to approach, God by his Scriptures, shall make the age and years thereof be manifested" (1594: 17). Because opportunity for repentance is central in Christian doctrine, man receives warnings and signs *and the ability to decode them*. This shall not happen "till the appointed time, [when] manie shall gae to & fro, and knowledge shall be increased" (Napier here quotes Daniel 12:4). Provided with the code (Scripture) and the knowledge of how to map the code to the world (mathematics), we can know the future. Man (I use the word advisedly) will know the future. This is why, Napier says, Daniel and Revelation were given to the Church of God. The code of truth is mathematical; not numerological, as it had been previously thought.

In both the 1616 and 1618 editions of the *Description of Logarithms*, a section 'In the iust praise of this Booke, Authour, and Translator' leaves no doubt that the time of increased knowledge has arrived:

> Arts, in themselves, have such divine Perfection,
> As Human reason cannot alwaies see;
> Yet God all good, to man giveth such direction
> As hidden things sometimes discovered be:

What many men and ages could not find,
Is, at last, by some one brought to mind.
(signed Ri. Leuer[?] in Napier 1618: A10r)

Not only the time of knowledge has come, given by God, but we also see that Napier is the one who finds it. As the End approaches, its hidden time becomes calculable. God grants men the ability to know it. Napier is the man. "Those mysteries are able to be found out, seing that time is expired" (1594: 12), and therefore "*all* these Prophecies of the latter day *shall be known and manifested* . . . let us confer al these prophecies and *prophetical figures* therof together" (1594: 18; emphasis added).

Thus justified, the end of the seventh trumpet would coincide with the year 1786, from the preceding calculations. Napier, however, does not use it as the final date. To calculate the actual date of the End, Napier takes into account that "for the elect's sake those days shall be shortened" (Matthew 24:22). It is at this point that Napier's mathematical thinking comes closest to his development of logarithms. The shortening of the time, from Matthew 24:22, is central to the relation between Napier's mathematics and his calculation of the End.

As Fauvel points out, Napier is trying to establish a function between two continua: history since Christ, and the coded narrative of Revelation. "Once the function is established, from the information about the past which you have, you are then in a position to use the correlation to work out the things you don't know in particular, the date of the last judgement" (Fauvel 2000: 24). But there is more to the connection between apocalypse and logarithms, because 'the days shall be shortened'.

Napier has a function between two continua, and is looking for an unknown quantity, the final date. The question then, is how much are the days to be shortened from 1786. He tries different scales to establish the functional relationship, but they don't work. Trumpets are tested for durations of 196 and 294 years (quoted above; see Figure 2.1), but it is the ratio of the shortening that is the final decider. The time between creation and apocalypse is comparatively easy to calculate. It is the shortening of the days that requires complex calculation.

By dividing the last Trumpet into its five jubilees of forty-nine years each, Napier cannot fit in it the seven thunders (or seven thundering angels of Revelation 14) that he wishes to identify with the five jubilees (see Figure 2.1). He posits, in proposition 13, that the first three thunders correspond to chronological Jubilees, and the following four occur simultaneously. He does so in a convoluted and unconvincing way, detracting from his claims to demonstrative analytical method. His difficulties indicate the effort to creating a demonstrable, calculable ratio, between history and prophecy.

Not only does Napier map history and numbers in what he sees as 'undeniable demonstration'; once he has an arithmetic progression timeline of the history of the world, he can calculate future time and the ratio of the shortening (see Figure 2.1). The aim to calculate justified, the question is how much shall the line from 1541 to 1786 be shortened? Let us now examine how much logarithms are part of the answer.

THE LAST DAYS OF THE EARTH

A logarithm is the inverse operation of exponentiation, allowing us to find the unknown exponent for a certain quantity. As Henry Briggs (1561–1631) explains in the preface to the *Description of Logarithms* and the Appendix of the second English edition, logarithms are useful in finding a number "betwixt any two numbers assigned . . . thus having two extremes given, and the number of mean proportionals betwixt them, we may finde any, for any assigned distance within or without" (Briggs in Napier 1618: A8). Briggs was Napier's best friend. As closest collaborator in the development of logarithms, Briggs took on the task of further developing logarithms after Napier's death in 1617, developing tables of logarithms that transformed the nightmare of calculation into the convenience of consultation. In explaining "another very excellent and admirable use of this Table" that the previous ones did not achieve, Briggs' verbal description of the solution is conceptualised traditionally, and in close proximity to the sixteenth-century developments in arithmetic and geometric progressions: having two numbers as extremes of the distance between them, logarithms are the best way to find any proportional points between them, so that "we see the admirable use of these Logarithmes, not onely in the doctrine of Triangles . . . but also in all our common accounts of ordinary proportionall numbers" (in Napier 1618: A7r). These passages are highly suggestive, in the context of finding an unknown quantity (date of the End) given an interval between two values (1541 and 1786).

Napier's own words show the conceptual equivalence between his logarithmic work and his exegesis. He opens the *Description of Logarithms* by defining and depicting an arithmetic progression: "A line is said to increase equally, when the point describing the same, goeth forward equall spaces, in equall times, or moments" (see Figure 2.2), and provides a corollary: "Therefore by this increasing, quantities equally differing, must needs be produced, in times equally differing" (Napier 1618: 1–2). As an example, Napier states how a point B progressing along such line, moves from A to C in one moment, from A to E in three moments, and A to K in eight equal moments.

Napier then explains a geometrical progression: "A Line is said to decrease proportionally into a shorter, when the poynt describing the same in equall times, cutteth off parts continually of the same proportion to the lines from which they are cut off" (1618: 2), with the corollary "Hence it followeth that by this decrease in equall moments (or times) there must needs also bee left proportional lines of the same proportion" (1618: 3). In the *The Construction of the Wonderful Canon of Logarithms*,[2] a geometrical

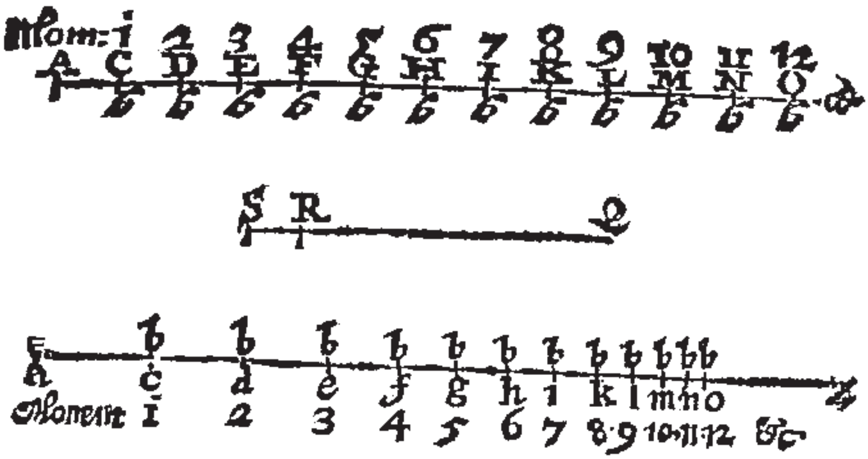

Figure 2.2 Napier's graphical representation of an arithmetic progression (top), and a geometric progression (middle and bottom) (adapted from Napier 1618: 1–2).

progression is defined as "one which advances by unequal and proportionally increasing or decreasing intervals" (Napier 1966[1617]: 8).

So, to return to his apocalyptic calculations: between the two numbers assigned to the last trumpet (to use Briggs' logarithmic terms), Napier wishes to find the unknown quantity resulting from the shortening of the days. Napier is looking for a date within the interval of 1541 (beginning of the seventh trumpet) and 1786 (1541 plus 245-years-long trumpet), the last segment of the arithmetic progression formed by the seven trumpets. This interval itself was found by testing different arithmetic progressions (as we have seen, one of 196 years, one of 294 years, and the 'correct' one, of 245 years). The correct arithmetic progression demonstrated, he can then find how much 'those days shall be shortened', resorting to other scales to discover by what proportion that line (from 1541 to 1786) shall decrease.

Napier brings in scales from different origins for this purpose. Revelation 11:15 provides the lesser limit (to follow Napier's Construction of Logarithms terminology), 1688, and Daniel 12:11–12 brings the greater limit, 1700. The line thus shortened, Napier then introduces the final calculation, based on a quantity (Rev 14:20) that merits an interval, as the date of writing of Revelation is "about the 97. yeare of Christ". This final calculation is wholly independent from the preceding ones, but is subordinated to them.

The final calculation places the end between 1697 and 1699. It defines an interval of time, but is based on a single, independent calculation: the "space of a thousand and sixe hundred stades or courses" (Rev 14:20), "would mean metaphorically . . . a thousande and sixe hundred years, from the time this [Revelation] was written, which was about the 97. yeare of Christ" (Napier 1594: 21–22). But this independent, single and most accurate of all the intervals he defines, is only used "for further confirmation" (1594: 21).

Logarithms and the End

Fauvel's assertion—that the same functional relationship is to be found in Napier's logarithms and Napier's exegesis—is confirmed by a closer look. However, it seems arguable, at least without careful qualification, to state that Napier imposed logarithms onto his received Genevan teaching, or that logarithms were developed to decode the number of the Beast. There is no evidence that his calculation of the end of days is logarithmic. From the above, however, it is also clear that the development and reasoning are related.[3]

There is, finally, an instance in which Napier lays out his arithmetic progression of history in a continuous timeline. In the *Discovery of Revelation*, writing 'To the Godly and Christian Reader', he says that

> there is two drawne lines betwixt the Paraphrastical columne and the Historicall, within which lines there is set downe the dates of times,

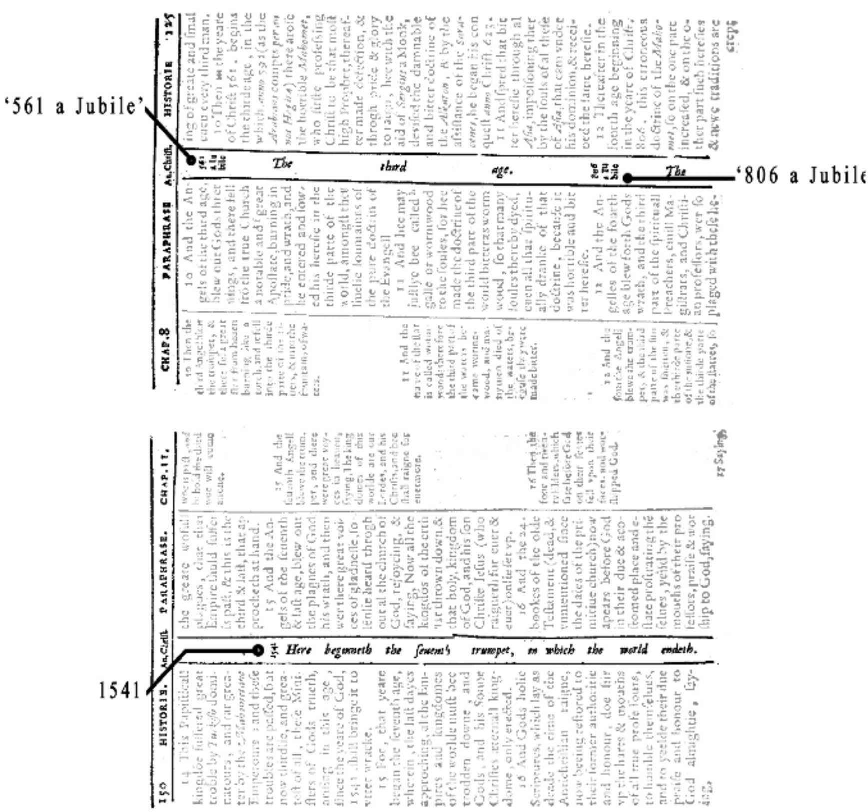

Figure 2.3 Two pages from the *Discovery of Revelation* mapping a chronological progression timeline juxtaposing history with prophecy.

> by seals, trumpets, viols, thunders, and years of God, answering to the precise time, in which every Prophecie thereof was or shall be performed. (Napier 1594: A7r)

Despite the lack of direct documental confirmation, the approach and reasoning—in determining the shortening of the distance to the End, and in developing logarithms—are conceptually and analogically equivalent. The common ground is Napier's belief in the need for change: both his mathematics and his exegesis are sustained by an explicit motivation to remove hindrances; hindrances of calculation and to attain the 'eternal Sabbath'. The *Description of Logarithms* states that "this new course of Logarithms doth cleane take away all the difficultie that heretofore hath been in mathematicall calculations" (Napier 1618: A4r). Having seen how "troublesome to Mathematicall practice" calculations of large numbers are, Napier considered "by what certaine and ready Art I might remove those *hindrances*" of mathematical calculation, "having thought upon many things to this purpose" (1618: A5; emphasis added). Hindrances stand between man and Redemption, and hindrances stand between man and knowledge. If there were any doubts about the relation between apocalypse and knowledge, Napier's insistence on increased knowledge near the End surely removes them. These were not separate matters for Napier, or for his contemporaries, as research has profusely confirmed (e.g., Webster 1975; Funkenstein 1986; Firth 1979; Dear 2006; Fried 2004).

NAPIER IN HIS TIME: THE SHAPE OF THE BACKGROUND

Napier was indeed a man of his time. There is much supporting evidence that logarithms were waiting to be stumbled upon, so to speak. Many had pre-figured them (Michael Stifel, Alvarus Thomas, Caspar Peucer) or even develop them at the same time (Joost Buergi, who published later than Napier). The historical importance of the *Description of Logarithms* and the *Discovery of Revelation* lies in the fact that they are both doubly tributary. Tributary, as subordinate, to the sixteenth-century apocalyptic biblical exegesis, and mathematical work on geometric progressions. Tributary, as subsidiary, to the seventeenth century's deterministic mathematical exegesis of the world and its nascent concept of nature, more knowable the more it is distant from the human realm, the more it is othered (Szerszinsky 2005). It is in this, above all, that Napier is pivotal. Before him, there is no clear bifurcation of the paths of mathematics and religion. Napier is not the bifurcation, but enables its development across the seventeenth century. After enumerating most of the important figures in trigonometry since Hipparchus himself, Briggs characterises Napier's logarithmic work as a dialogue with tradition, but a dialogue in which singularly new answers are enunciated.

According to Trevor-Roper, in the first half of the seventeenth century, when the astronomers and mathematicians had established the measurement of time and the theologians were refining the exact meaning of the Apocalypse—it seemed as if the last remaining problems were solved and the few still unfulfilled events of history could be exactly predicted (1969: 9). Napier's work is both a result of the shape of his own background, and an enabler of changes to the configuration of the background.

An example of Napier's proto-scientific episteme that places him beyond numerology, but only just: he overlooks the conventional nature of calendrical time. Napier would not pay homage to the authority of the Pope in any case, but Pope Gregory XIII's 1582 calendrical reformation deserves no consideration. The fact that a year like 1582 could be ten days shorter by decree appears to have no conceptual or computing consequence. Numbers are arbitrary signifiers, but in some ways they still bear the residue of the fundamental relation to the world. Napier can still consider years as coterminous, if not intrinsically linked with the events and the *historical progression* they compose. Yet, it is this liminal, neither-here-nor-there epistemic location that enables him to see time as an entity computable in absolute accordance with history. *If we know the numbers that define the past, we can know the numbers that define the future, beyond doubt.* Napier's truth is universally valid (Goldish 2004: 20), and numbers make that truth context-independent. The book of nature could, thenceforth, reveal God's truth everywhere, independently from revealed word.

In the period between the Reformation and the end of the seventeenth century, many others exhibited the supposed 'contradictions' or 'distractions', the complexities, hesitations, and disagreements percolating the rise of natural philosophy. Like most, Calvin and Luther themselves, inevitable references at the time, exhibited apparently contradictory ideas. Calvin openly defended a geocentric model of the universe, but said astronomers should not look for answers in the Bible. Luther was categorically against allegory and metaphor in exegesis, but liked alchemy for its secrets and allegories, which he thought related to the apocalypse. Boyle, who thought of scientific enquiry as worship, expected the millennium at any moment, but while he thought that nature had to be divested of spirits and inherent powers, confessed he once was transported and bewitched by Vulcan, and believed in final causes for both living and inanimate things according to God's purpose and design. Francis "Bacon spoke of final causes as barren virgins", but the replacement of divine teleological causes with mechanical explanations in the seventeenth century was not a straightforward affair (Shapin 1996: 54 and 155). Giordano

> Bruno was arguing that divine attributes could be given physical meaning—as Newton was later to do when he reconstructed space in terms of God's omnipresence. Such transformations of metaphysical axioms into prescriptions for the natural world were extremely common in early modern science. (Brooke 1991: 74)

This evolving pattern would continue all the way to Newton's gravitational forces and the criticisms they drew from Leibniz and others. Function, natural structure and divine purpose were to be mixed for a long time. Apocalyptic eschatology, Johannes Fried proposes, opened access to reality and, at the same time, configured it (2004: 7).

Calvinist theology relied on God's strict control of history through prescience and predestination. The history of the world—the whole ensemble of events, people, and objects—behaves according to a cosmic order that is predetermined, mathematically intelligible, revealed in numbers (in the Scriptures) and objectively plotted in history. Like Calvin, Napier sees the reformation as the direct precedent of the end of the world. The Church had to be prepared, because the Antichrist would use mathematical knowledge (Shapin 1996: 59). For Napier numerology has lost the appeal it had to others before him, like Michael Stifel and John Dee. Dee's "search for that divine unity which lay *like a pattern* behind the façade of nature" (Trattner 1964: 34; emphasis added) had been going on for centuries. In his conversations with angels, Dee is told the apocalypse is already upon mankind and that his mastery of natural and supernatural things is according to God's plan (Harkness 1996: 711; see also Harkness 1999). The themes are close to Napier's, but Dee's systemic dealings in magic, cabbalistic symbolism, numerology and access to angels also mark the difference.

During the sixteenth century, not only Dee, but also Robert Barnes, Melanchthon, William Tyndale, and John Frith form part of a political, literary, theological current that identifies Rome with the Antichrist. John Bale, like Andreas Osiander, had interpreted the seven seals as seven historical periods and linked chronology to prophecy and prediction (Firth 1979: 61), but had not been precise in the periodisation. Instead, like Calvin, they refrained from attributing a date to the Apocalypse.

It is from these conditions of possibility that Revelation can become the model of enquiry for the second holy book—Nature—and Napier is at the heart of making that model of enquiry reliable, expedient, efficient, and independent from the original narrative. The assumption remains the same, however: given our special place in the order of things, we can know. We will know. We are destined to know. This, we will see later, hasn't changed much today.

As the emergence of science is characterised by the search for the inner grammar of nature (Szerszynski 2005: 42), the analytical framework is identifiable in the *Discovery of Revelation*: the world is knowable; its unknown elements (preternatural) are ultimately knowable; statements about the world are universal, applicable to all scales and places; and the methods are based on correct interpretation of relevant data, leading to accurate quantification and prediction. In this quantitative determinism, there is a truth in things that is visible only as a whole, and the key to apprehending the whole lies in numbers. During the sixteenth century, it was the ontological relation between *signifier* and referent that sustained numerology as a valid mode of knowledge. To Napier, the power of numbers is in their ability to represent unrelated objects (events, periods, etc.)—not because they have some sort of umbilical connection to what they are supposed to represent. Supported by Scripture, Napier had total belief in human ability to predict the future through a calculable, 'scientific' history of the world (Goldish 2004: 20).

Knowledge as an Instrument to Attain the End

The indigenous peoples of the Americas were identified, both in the sixteenth and seventeenth centuries as the lost tribe of Israel, or as the inhabitants of Gog and Magog (by Joseph Mede), or as the remaining heathens to be converted before the End, or their land as the ground for New Jerusalem or as the Garden of Eden (Webster 1975: 44; see also Ball 1975; Aho 1997). Whichever interpretation was expressed, it meant the Judgement was at hand. Navigating ships, and the measurement and instruments and calculations that directed their route, sought to complete the historical route to the End. Devices and practices developed by men who attentively stated that "many shall run to and fro, and knowledge shall be increased", men who themselves went to and fro, increasing the knowledge of new land and that of getting there, as Edward Wright did in his nautical voyages. From Wright's voyages resulted his Correction of Certaine Errors in Navigation, from 1599, altered and reissued in 1610 as Certaine Errors in Navigation, Detected and Corrected. Six years later, Wright would translate into English the Description of the Wonderful Canon of Logarithms from its Latin original. Columbus believed, in his own flavour of apocalypticism, that he was fulfilling prophecies in preparation for man's return to the Adamic state involved a purification of nature that was fallen with man (Harrison 1998; Webster 1975; Szerszynski 2005). Adam's apple symbolises a long-lost ontological harmony of all creation. Before eating it, Adam had named the beasts and trees. With the Fall, the names became corrupted and only hold the remnants of that lost essential connection. Knowledge is the *revealing* of that original harmony that residually connects all entities.

With the Reformation, the book of nature is perceived in a more utilitarian attitude, as a path to complete knowledge (Harrison 1998: 193 ff.; Jacob 1988). We will see how the completability of knowledge is a basic assumption of climate modelling. In Napier, the access method to the language of nature is validated by the access method to the language of scripture. Artificial numbers (Napier's first name for logarithms) are instruments to access reality. Napier paves the way to what Opper calls the 'fundamental premise of Newton's cosmology': nature is "rational, and reducible to logically quantitative abstraction" (1973: 44). Thus "the disenchantment of nature is the emergence of nature in the modern sense" (Szerszynski 2005: 47; see also Brooke 1991: 71).

If the foundation of quantification is measurement (Wilks 1961), logarithms are a catalyst in formalizing and abstracting quantification, disentangling it from an endless network of eschatological expectations and essential equivalence between things and signs, justified by the gospel, source of all truth. It is this disentanglement, performed by Napier as well as his intellectual heirs, that allows logarithmic calculation to make what John Law calls "unqualified scientific statements about reality" (2004: 36). This is a disentanglement in appearance only or, as Latour would call it, a purification, an instrumental separation between signs and things that becomes the 'unconscious of the moderns' (Latour 1993: 37) and enables us today to label Napier as a 'distracted' man. Apocalypticism was entangled with many, if not most, areas of life. "The ability to represent mathematically expressed physical regularities or laws did not depend on belief in their mechanical causes" (Shapin 1996: 58).

Devising and instituting a stable quantitative abstract universal order, and inscribing it into its instruments, the seventeenth century sees a tremendous increase in calculating devices (Pascal's and Schickard's prominent among many others). Over the following century, men would surrender the nouns 'calculator' and 'computer' to the *machina arithmetica*, the instruments of calculation that 'removed the hindrances' Napier was confronted with. Performing their usage reified the distance to the object of knowledge. Operations and devices (among them, early and famously, Napier's rods) tangibly perform the operations that grant objective access to nature. The widening and clearing of the gap between knower and known is accelerated by calculation devices. These are also access devices, mediators, defining correct access to the world. The context of development of calculation disappears into the mechanisms, invisible entities at work, invisibly translating observation data into theories and vice-versa. The operations of quantification, measuring and calculation become assumed, unsaid but performed in every turn of the crank, dial, and rod. The success and quick routinising of logarithmic calculation helped quantitative modes of knowledge production to subtend a specific ordering of the world and its history (both past and future), and forget its genesis.

Man's Ordering of Nature

Napier's role in the 'disenchantment of nature' is coherent with the lack of extreme weather events in his predictions of the End. If nature is a second book of divine revelation, it is also merely a vehicle to the revealed message. It is the created passive receptacle of God's will and human free will. Demonology further withdrew any attribution of agency to nature, to place it in demons. These acted according to unknown (preternatural) laws of nature, giving the impression to witches that they could indeed control the weather. These laws of nature were divine laws embodied in nature, and not nature's *dictum*. Nature was the book, not the law it bears.

This is not sufficient, however. One could argue that Nature's message did conform to God's decree and therefore its signs could be interpreted as signs of the End. What seems to preclude this possibility is the total unpredictability of the weather. Astronomical events, despite their complexity, were far more predictable than weather events. Mathematics was becoming the tool to predict the future, and successes in astronomy (greatly advanced by the immediate adoption of logarithms in calculations) increased the belief in prediction (Dear 1995).

That regularities were knowable was attested by the Book of Revelation, which has always lent itself to astronomical interpretations. Thomas More had already suggested that 'God would undo that universal coalition of particles'. Or, the Earth, in its increasing dryness, would orbit closer and closer to the sun, until it conflagrated. After Napier, John Ray, Joseph Glanvill, Bishop George Rust, and Thomas Burnett, among others, held similar views. Interestingly, to most of them, there would be (or could be) a reformation of the earth afterwards, with or without mankind, making the process more like a Stoic conflagration and leaning more towards scientific ideals of astronomical stability of mathematical laws than to an absolutely final outcome determined by Scripture. All their considerations on the end of the world involve orbits, the expansion of the sun, the fire at the centre of the earth, and so on. Newton's chosen successor as Professor of Mathematics at Cambridge, William Whiston, stated that after the Fall, the impact of a comet destroyed paradise and changed the orbit and shape of the earth, creating seasons and tides (cf. Schaffer 1977; Schaffer 1993). The Flood was caused by another comet, and the Millennium would start with a near-hit comet and the actual End would be brought about by the impact of another comet. The images of Revelation become more figurative, less literal. The prime mover is still God, the final cause still Redemption, but the End is expected through known natural material causes. The weather, however catastrophic, offered no attestable predictability. It might be seen as signs of God, but to include it in the apocalyptic tradition, so heavily reliant on human ability to predict, would be far more challenging. Meteorology was a wholly incipient affair. Celestial bodies were part of creation, but were traditionally not part of nature in the same way that the ocean or the wind or the earth was. Calculating the End based on quantitative regularities of the Bible and celestial bodies seems to offer little room for the weather events that Napier certainly witnessed.

After Napier

The literary apocalyptic tradition was substantially enlarged during the seventeenth century, with production, expressions and interest subsiding towards the end of the century. But once the apocalyptic assumptions were inscribed into the scientific practices that see the world as knowable through quantification, and predictable through calculation, the subsidence of the apocalyptic is not a disappearance, but an embedding into the shape of the background, an integration into the conditions of possibility. The assumption of a world designed with a definite, inexorable, dogmatic deadline is—to use John Law's terms—enfolded into objective methods, to the point where it may be impossible to undo that reality (Law 2004). Additionally, its universality implies the exclusion of other narratives, other realities.

A reading of the book of nature modelled in the reading of scripture accompanied secularisation and naturalisation of causal relations. While the demise, renewal, or end of the world becomes increasingly explained by natural causes, the end moment remains on the horizon. Halley,[4] Burnet, and Newton all resort to material causes or physical processes bringing about divine purpose and design. Nicholas Mercator published his *Logarithmotechnia* in 1668, further developing the comprehension of the properties of logarithms. In dealing with the hyperbolic areas of logarithmic series, the *Logarithmotechnia* presents the first infinite series in analysis. Isaac Barrow knew the book well. He works on some of its problems with his student, a "Mr. Newton, a Fellow of our College, and very young . . . but an extraordinary genius", he says in a letter mentioning Newton's work on the *Logarithmotechnia* (quoted in Carslaw 1924: 3).

Napier's work is part and parcel of Newton's mathematical, scientific and epistemological inheritance, and the germs of Newtonian fluxions can be found in Napier's work (Thomsen and Zeuthen 1915: 407). Schaffer's affirmation that "ironically, the strictest followers of Newton were the ones most willing to leave miracles an important place in the world" (1997: 19) can thus be characterised not just as ironical, but as "characteristic of this enlightenment that it constantly mentions new and undiluted foundations of knowledge and of the faith at the same time making it impossible ever to identify these foundations and to build on them" (Feyerabend 1970: 151).

3 Drawing the End
Inigo Jones' Banqueting House

thou hast ordered all things in measure and number and weight
Wisdom of Solomon 11:20

In early modern Europe, apocalypticism catalysed scientific discovery, influenced historical interpretation, and sustained political discourse and argumentation, in Parliament and from the pulpit. Its verbal expressions are common, even at the highest political circles. In his interpretation of the Book of Revelation (*A Fruitful Meditation*, published in 1616), James VI and I himself assumed the persona of John of Patmos in delivering the prophecies. He was reminded by influential individuals (John Napier, George Marcelline, and John Gordon, among others) of the vicinity of the End, and that it would be an eminently political affair. In Tudor times, Elizabeth had been similarly reminded by John Knox.

Alongside the written word, the visual arts were a common form of expressing and divulging these narratives. Historically, church art, illuminated manuscripts and painting have been a powerful form of disseminating the biblical message, especially to audiences beyond the reach of the written word. However, religious art isn't just a way of telling stories. Apocalyptic religious visual art has very old and intricate links with theological doctrine, and with quantification; links much older than Napier, and as old as the relation between astronomy and calendric calculations of Easter and of the End (Kühnel 2003). Through the centuries, the development and propagation of its own visual conventions made the links with calculations of the End became looser, but still traceable.

This chapter follows the connections between visual representation, large-scale quantitative models of the world, and political narratives of the future, at the Banqueting House, in London. Nowadays, these topics and their relations are crucial for climate science and policy. At the time the House was designed and built, they were important policy and political tools. The changing climate of the time, however deadly, does not feature in the House as an apocalyptic representation of the world. This chapter does not suggest connections between the House and climatology, historical or current. Instead, it considers how the House is a high-profile example of the belief that representation of the future of the whole world can be attained by rigorous quantification, how claims of precise quantitative representation are a prime candidate for political appropriation, and how even revered artworks can be political instruments.

The House, a sumptuous architectural enactment of political apocalypticism, was created at the time when Napier's logarithmic investigations and biblical interpretations were being rapidly adopted, and widely used. Today, it is the only surviving building of Inigo Jones' (1573–1652) greatest project, a project of cosmic significance. The House wasn't simply a royal building. It was the first element of a larger palatial complex that would restore the whole of London to its rightful glory as New Jerusalem, the city of biblical apocalyptic redemption. Designed to represent the world it was meant to rule, it followed strict principles of scale, proportion, and structure. Ultimately, London would attain cosmic harmony from balanced proportion, surpassing Bountalenti's Livorno in Italy, and Madrid's Escorial. With the House as its Solomonic Temple, it would achieve victory over the antichristian papacy. The Temple of Solomon was considered the model for religious architecture. Augustine considered it the model of the Church itself (Terrien 2005: 151). Jones' London would be "a model Rome" (Summerson 2000: 131) for the true church (cf. Fusco 1985: 227, "at the same time Roman and English").

Jones' purposes are not unrelated to Napier's. The work of both claims, for the king, the rulership of the true church against Rome, seat of the Antichrist. Both place the English and Scottish crown in the plot of biblical apocalyptic narrative. In the House this is done more implicitly, given the nature of visual and architectural representation. Yet, the implicit and associative nature of visual references and motifs is directly related to how—and how strongly—visual communication resonates with audiences. In the House and its ceiling by Peter Paul Rubens, we shall see, the secular(ising) elements are not part of making religion a "free-floating cultural resource" (Beckford 1989: 171–172). Quite the contrary. Like Napier, the House inscribes elements of religious belief into what Foucault called the invisible rules of formation of discursive fields (2002) that underlie scientific and artistic statements.

THE PROJECT FOR THE HOUSE

On 12 January 1619 the old Banqueting House burned down. The building performed such an important role that a new design for a Banqueting House by Inigo Jones, along with an estimate, were ready by 19 April (Summerson 2000: 38). Masques were an important part of the role of the House. Developed in Italy, masques were a type of courtly performance in which the audience often performed alongside professionals. They included lavish costumes, elaborate designs, and complex stage devices. Used since Elizabethan times as social and political allegories, the political element became prominent during James' reign. Masques became elaborate political narratives, at a time when stage performances were recognised by the privy council as instrumental in shaping public opinion. In such a configuration, they were intimately connected with practical achievements, like the integration of England and Scotland. Many of the masques performed in the House were dedicated to the union of the crowns (as is one of the Rubens' ceiling canvases).

Jones already had a well-established relation to the crown. Designer for masques at the old House, he had also executed the plan for a new Star

Figure 3.1 The Main Hall of the Banqueting House.
(c) Historic Royal Palaces.

Chamber, a court of law since Edward II. James turned the Chamber into an instrument of royal power and prerogative, more than previous monarchs. It was, both in function and design, a precursor to the House, mixing sources modern and ancient, Roman and English (Anderson 2006: 170). Kevin Sharpe takes the connections between power and the regal theatrical performances further, when suggesting that “in the light of studies of the Elizabethan and Jacobean stage, we need to think much more about the House of Commons as a theatre” (1999: 861). Inigo Jones had no involvement with the House of Commons. He did design a coffered ceiling that was installed in the House of Lords, following Sebastiano Serlio’s designs.

The masques and the Banqueting House were so important to the Jacobean court that Whitehall was not the only location to have such a stage. In 1625 a small Banqueting House was built at Theobalds, a location of James’ preference. The Banqueting House held masques also on religious dates, in a configuration of stage performance rather distant from our contemporary theatrical practices and audiences. “It was no coincidence that Queen Elizabeth and King James began to speak of monarchs as figures on a stage: theatre was a way of conceiving and articulating social and political life as well as a site of their representation to the people” (Sharpe 1999: 859). Theatre was, according to Sharpe, connected with government from its inception. In the case of the House, the connections were deep. It was “hall of state, audience chamber and place of judgement” (Parry 1981: 153).

THE HOUSE AS AN ESCHATOLOGICAL QUANTITATIVE MICROCOSM

The main hall of the House is a double cube of 110 feet by 55 feet (like the Prince’s Lodging at Newmarket, the Queen’s House at Wilton, and the Queen’s Chapel at St. James, all designed by Jones). “At the core of his architectural thinking is the belief that design is an affair of number” (Summerson 2000: 63). The Pythagorean cube was, in architecture, considered the procreator of all things. The world itself is an ideal cube (and a real sphere), in the same manner that other planets correspond to other ideal solids, something that brings to mind Kepler’s geometrical orbits. These principles were fundamental, because replicating the ideal scales of nature allowed the artist to conquer it. In this, architecture was first and foremost, as it *recreated* the world based on mathematics.

Renaissance Pythagoreanism’s simple mathematical ratios were the building blocks of the cosmos, and the key to unlocking its secrets and mysteries. This belief held mathematics, arts, music, and theology in close contact. To Alberti, one of Jones’ major influences, “for the building to be truly cubic, the numbers must be ‘immediate offspring’ of 1” (Hersey 1976: 28). The mathematical properties of the cube were aesthetic properties, musical properties, but also cosmological and mystical properties.

Vitruvius considered the cube to be divine, and Jones observed in his edition of 'Vitruvius' that "Pythagoras and his followers made their presepts with cubick reason" (quoted in Hart 1994: 140). John Dee, who had translated Vitruvius, considered mathematics to be 'thaumaturgicke' (Smuts 1987: 147). The main hall in the House is bicubic, but also a multiple of ten, the most perfect of Pythagorean perfect numbers. Buildings were harmonious not only in themselves, but represented—or, in fact, embodied—the harmony of the cosmos.

Numbers, more than the arbitrary signs they were becoming (through Napier and others), still had "fixed or predictable geometric, psychological, moral and even personal natures" (Hersey 1976: 7–8; emphasis added). This was a basic assumption of Pythagorean mathematics. So dominant was number symbolism in Vitruvius' architecture that he attempted translating a whole Greek temple into its description, calling his temples 'signifiers' and their descriptions 'signifieds'. Alberti, likewise, sees the cube as the fundamental unity of buildings, and form and numbers as interchangeable. His method, like Palladio's, derived most proportions for variations in size from a cube (the procreator) through arithmetic or geometric proportions. These architects were Jones' foremost influences, above Serlio, Labacco, and Scamozzi.

It is the architect's job to transform matter into cubic forms, a demiurgic role that Jones read in Serlio, and which was in line with Marsillo Ficino's Platonism (whereby a building is a model of the cosmos and man's imposition of mathematics onto formless matter is an imitation of God). Through these precepts, the House can replicate the structure of the cosmos, following the Platonic binomial of macrocosmos/microcosmos. More than mere religiously influenced architecture, the House is an ordered Platonic microcosmos, where the King rises to heaven above his court (in Ruben's Apotheosis of King James, the central painting of the ceiling). This was visible to all during masques, receptions, and other official functions, and was not intended as a metaphorical replication, but was considered a real and literal structuring of the cosmos.

The masques performed at the Banqueting House were structured in accordance with Italian masques, and so included, at the start, an antimasque representing the world of disorder, confusion, and distorted image of the higher spheres, adding an equivalent dimension to the Platonic structure of the House. More than courtly entertainment, stage performance or political propaganda, the Neoplatonism of the masques and their setting constituted a "form of religious ritual actually blessing the Court . . . on days linked to religious calendar" (Hart 1994: 17). Throughout the seventeenth century, the idea of the Apocalypse as the culmination of a man-ordered world gained ground, and was expressed in illustrated views of New Jerusalem as a city of order (e.g., Henry Danver's 1672 *Theopolis, or the city of God new Jerusalem, in opposition to the City of the Nations great Babylon*; a book that also interprets Daniel 12:4 "And many shall run to and fro, and knowledge shall increase").

THE POLITICAL ARCHITECTURE OF THE MICROCOSM

James often portrayed himself in godlike terms. Addressing the Lords and Commons, he says, “Kings are by God himself called Gods . . . Kings are compared to the head of this Microcosme of the body of man” (quoted in Hart 1994: 24). Elsewhere, his written published opinion is consonant. James writes the Basilikon Doron to instruct Henry on monarchy: “God made you a little God to sit on his throne” (quoted in Donovan 1995: 143). In his *Trew Law of Free Monarchies* of 1597, monarchy is considered the true pattern of divinity. During masques, he presented himself as god incarnate (Parry 1981: 34).

The House embodies these views, projecting them onto the physical and social dimensions, as do the performances that take place in it. The divinity of kingship is placed at the top of a stratified architecture, following Palladio. Stone colour varied, from darker at the bottom to white Portland at the top, with rustication of the lower levels, inside and outside. The Palladian orders coincide with Lomazzo’s representation of the social world (Ionic, Corinthian, and Composite, in ascending order). The throne room, where masques took place, opens to a top level—that of the ceiling—featuring panels by Peter Paul Rubens. Throne room and ceiling are separated by a cantilevered balcony, once more following Palladio’s structuring of buildings. “Used metonymically their fragments can become a code. They tell of incidents: a façade expresses a family group in its stratification and individual actors; a theatre is a model of a society, a model in which, during performances, that society literally occupies its proper spheres” (Hersey 1976: 114). Concurrently, Hart states that “in presenting higher truths the masque was viewed not as a theatre of illusion but as a glimpse of reality” (1994: 17). The House is more than a model of the world; more than a working model of the world. It is the real, embodied, living structure of the social world.

For the masques in the House, Jones used an equivalent structure. Medieval motifs and rustication were used at the start, in contrast with the order and perfection of the later stages. On Shrove Tuesday 1634, the masque *Coelum Britannicum*, by Thomas Carew, was performed at the Banqueting House. It started with an antimasque of a Pict martial dance around a broken frontispiece with leaves, branches, and husks, and the lines “Behold the rude And old abiders here and in them view The point from which your [the monarchs’] full perfection grew” (quoted in Smuts 1987: 265). Order increased in time, from origins to perfect monarch, and in space, from subordinates to the ruler, depicted highest in the ceiling panels.

Coelum had a specific historical function: it establishes lineage from Rome to James, via Stonehenge, to complete the Protestant claim to ‘true church’ over the Catholic papacy. At the request of James, Jones investigated Stonehenge in 1620, “from the knowledge he had in mathematical science and history’, as Anthony Wood reports in his *Athenae Oxoniens*. Jones’ theory is that

Stonehenge is a Roman temple to the god Coelum. Based on Palladio's diagram of the Roman theatre plan, derived from Vitruvius, Jones maps an outer circle enclosing four equilateral triangles (the basic shapes of Pythagorean cosmology) to the plan of Stonehenge. Of several reasons to refute earlier theories, Jones writes that the temple was never covered, but built without a roof and the circular nature of the temple replicated the form of Heaven. Equally, the House's ceiling panels portray James ascending to the heavens, among clouds and cherubs. Jones modelled the Banqueting House on a basilica, and modelled the reconstruction of the temple of Stonehenge on a theatre.

To Jones, "Coelum [was] from whom the Ancients imagined all things took their beginning" (quoted in Handa 2002: 112). Such beginnings helped establish the lineage of James, the quasi-God to whom the House is devoted. George Marcelline (in his *Triumphs of King James the First*, published 1610) explicitly joined biblical chronology and Pythagoreanism to interpret the name of James as meaning the chosen of God and the beginning and root of everything (Hart 1994: 48–49). Jones cited sixty authors to provide credibility to his theory, but he was soon after contradicted by John Aubrey. However unrealistic and contrived Jones' theory, his main objective was to place James, London, and Britain at the pivotal centre of history. From Jerusalem (via Rome and Stonehenge) to New Jerusalem, the House takes up the links 'found' in Stonehenge; not to create a story about Britain's past or James' future, but to reinforce James' role in the present by confirming his divinely appointed status.

> Was not the Temple at Hierusalem adorned with the figures of Cherubims, that thereby the Nations of the Earth might know it was the habitation of the Living God? and, why not in like manner this Temple composed by Astrologicall figures, that after Ages might apprehend, it was anciently consecrated to Coelus or Coelum Heaven. (Jones quoted in Hart 1994: 133)

James as Solomon

From first temple (in Jerusalem) to last temple (in London as New Jerusalem), the complete lineage supports the Solomonic persona of James. Masques consistently included metaphors of unveiling of clarity and truth from an obscure initial position, with the elect Court as audience. Vaughan Hart likens this to how "Christ has chosen to speak in parables to separate an obvious meaning from a secret one (Matthew 13:13)" (1994: 20). Jones unlocks that meaning through architecture, painting, and performance; presenting "in stone the British revival that James I advocated in speeches defending Union" (Sharpe 1999: 872): "betwixt this Island of Great Britain, and Rome itself, there's no one structure to be seen, wherein more clearly shines those harmoniacall proportions, of which only the best times could vaunt, that in this of Stonehenge" (quoted in Hart 1994 131).

James was consistently portrayed as Solomon, to the end: the sermon at James' funeral was entitled 'Great Britains Salomon'. The tropes of a coming Golden Age and of James VI and I as Solomon present in Rubens' ceiling canvases are well known and have established clear links with Jones' Pythagoreanism and Neoplatonism. David Howarth (1997), Fiona Donovan (1995), and Vaughan Hart (1994) have indicated how the ceiling paintings bear thematic connections with the Last Judgement. This was not only for internal consumption of the kingdom, but set in the wider European context of the Reformation. One of the strongest mainstream beliefs in both England and Scotland was, in line with Continental Protestantism, that the Pope was the Antichrist, and Rome the seat of the Antichrist. James himself wrote, in his *A Fruitful Meditation* (1597), that "the Pope is Antichrist, and Poperie the loosing of Satan, from whom proceedeth false doctrine & crueltie to subvert the kingdom of Christ". Protestantism widely claimed to be the true church of Christ (e.g., Napier's *Discovery of Revelation*), altering or aiming to alter the power relations between kings and Pope throughout Europe. The divine right of the monarchy became a fundamental tenet of absolutism, and not only in Protestant countries, as exemplified by the reign of Louis XIII of France, contemporary of James.

Jones employs central elements from his Stonehenge theory in the Banqueting House ceiling. The Union of the Crowns panel features James in a Tuscan order rotunda with a semi-spherical dome representing the Heavens. It has been suggested that the two central, yet small and passive, figures witnessing the events depicted in the panel are Charles and Buckingham (Gordon 1975; considered unlikely by Donovan [1995] or Brute and Constantine [Hart 1994], the latter option reinforcing the Jacobean relation to Rome and its claim to being the true church). At the time, claims that Constantine had not just been crowned emperor but had been born in England were not uncommon. Since Geoffrey of Monmouth's eleventh-century *Historiae Regum Britanniae* (History of British Kings) Constantine was considered a British king.

In the prevailing utilitarianism of the age, the ambition to restore Britain to a lost Golden Age (and the world along with it) was dependent on mankind's actions and, in particular, those which redeemed the world by ordering it through mathematical and magical principles. The Banqueting House enacts the religious narrative for that political quest, fusing it with the practical craft of building, directed by a mathematical comprehension of the world. Arthur Williamson observes how Scottish stonemasonry organised secret lodges from the 1590s, to foster and protect the belief in being the holders of ancient prophetic knowledge developed in the days of the Egyptian empire, that many Scots believed to be their ancestors. That knowledge had passed to the Jewish people and Solomon's temple built according to the rules that God had used in Genesis (1994: 206–207). Crafts not merely mechanical, but a *scientia* among the highest.

From all this we see how the House crystallises, in a specific point in time, the whole (relevant) history of human existence, from the origins which grant authority to the present ruler, to an End which confirms the power and sanctity of the present ruler. This is important to us today because it shows how the belief in quantitative models of the world is not exclusive to our time, how it has been intimately related to political action for a long time, including times of climatic change; and so it might afford some critical perspective on today's models of the world which we will analyse later.

The House as a Throne Room

The House, following a Vitruvian and Palladian basilica plan, initially included a niche for a throne. Like other church projects from Jones' hand, the throne was placed under a window. The throne remains, to this day, at the Banqueting House. The niche, having been removed, is still visible in Rubens' canvas known as the Benefits of the Reign of James I. In it, James divides the good from the bad in anticipation of the Day of Judgement (Howarth 1997: 37).

If indeed "virtually all sixteenth-century Protestants believed that they were living in the latter days of the world" (Williamson 1994: 194) and this sense of being on the verge of the End was to increase until the middle of the seventeenth century, it is expectable, from the above, that the ceiling was a statement that the prophecies were being fulfilled and was read accordingly. Williamson adds that "the [Scottish] government itself willingly printed the ancient sayings attributed to Merlin, Bede, Thomas the Rhymer, Gyldas and a great many others which seemed to indicate that James I's new monarchy was fulfilling the hoariest of expectations" (1994: 201). Added to James' own writings on the subject, this made public to the realm that the monarch embraced and encouraged those views. Not that the realm depended on the king's word to believe the End was nigh. Donovan is of the opinion that

> Rubens's image of James would have conjured up a range of biblical, historical and mythological associations for the learned, but the casual observer would also find much to look at. Here Rubens intertwined allusions to James as new Solomon, while also identifying King James with a Christ-like figure sitting in judgement. (1995: 134–135)

The throne is the focal centre of the House. Richard Bauckham tell us that it is the central element of Revelation in its combination of political and cultic images, and a central theme in the apocalyptic tradition, where the apocalypse is revealed to counter false views of reality, usually political and pitted against some unfaithful empire. Bauckham adds that the vision of the final future of the world takes place so that the seer "can see the present from the perspective of what its final outcome must be" (1993: 7). Time and again, statements about the future are—first and foremost—indirect statements about the present: they reveal our current way of thinking more than any future state of affairs, and they often reveal present agendas, more than future events.

Figure 3.2 The ceiling of the Main Hall, with panels by Peter Paul Rubens.
Panels from top left to bottom right: Minerva; Union of the Crowns; Hercules; Procession of putti with peaceful animals (tiger, ram, wolf, birds) and cornucopia; Apotheosis of James; putti with fruitful garland, cornucopia and peaceful animals (lion and bear); Reason; Peaceful Reign of James; Abundance.
(c) Historic Royal Palaces.

This idea of Christ sitting in Judgement—which Donovan identifies in the House—is central to the visual dimension of the apocalyptic tradition. The archetypal image of Christ sitting in Judgement was, for many centuries, the Maiestas Domini (also called 'Christ in Majesty', or sometimes "The One Sitting on a Throne"). The Maiestas was even more common in biblical illuminations than in painting or sculpture or architecture. Until now, the House has not been directly linked to the Maiestas, but I want to propose, from recent evidence, that the link needs to be considered, and that it reinforces the point to which art was used to instil an historical sense of impending apocalypse.

THE ABANDONED PROJECT B FOR THE BANQUETING HOUSE

In 1994, Gregory Martin reported the find, in the papers of Sir John Coke (1563–1644), of two early projects for the ceiling of the House. In them, it becomes clear that the design was not Rubens'—contrary to what was previously thought—but mostly decided by Inigo Jones, since the manuscripts are at least five years older than the commissioning to Rubens. It also becomes clear, from the second project—known as Project B—that the lateral panels showing processions of *putti*, are based on the prophecies of Isaiah*:*

> The wolf also shall dwell with the lamb, and the leopard shall lie down with the kid; and the calf and the young lion and the fatling together; and a little child shall lead them.
>
> And the cow and the bear shall feed; their young ones shall lie down together: and the lion shall eat straw like the ox.
>
> And the sucking child shall play on the hole of the asp, and the weaned child shall put his hand on the cockatrice' den.
>
> They shall not hurt nor destroy in all my holy mountain: for the earth shall be full of the knowledge of the LORD, as the waters cover the sea. (Isaiah 11:6–9) [sic]
>
> In the foure small Ovalls
>
> The fower Evangelists. (quoted in Howarth 1997: 124–125)

This direct evidence of the relationship between the ceiling and the biblical prophecies announcing the End confirms that the House enacts a cosmological view in which the demiurgic action of man brings about the Redemption, redeeming nature by transformation operated by *increased knowledge*. This transformation is crowned by the architecture of the New Jerusalem, and is based on mathematics. To the fathers of the church, numbers were magic keys. Augustine even saw an image of the absolute in numbers. But "without perceptible forms, man would not be able to reach spiritual realities. Visual analogies were necessary for men to approach the divine", Terrien says of numbers in antiquity religious architecture (2005: 153). The significance of all this to interpretation of the House is unproblematic, especially since the discovery of Coke's documents. Yet, the significance of the two lines following the quote from Isaiah has been overlooked.

Figure 3.3 Maiestas Domini. Evangelistar von Speyer, 1220. Christ sits in Judgement over a stylised orb, holding a closed Bible, and surrounded by the Tetramorph, in the usual quincuncial arrangement.
Badische Landesbibliothek, Karlsruhe. Cod. Bruchsal 1, Bl. 1v.

Should Project B have been executed, the ceiling of the Banqueting House would have configured a Maiestas Domini, with James in Christ's place. The Maiestas was, throughout the Middle Ages, for more than a thousand years, the most important visual, geometrical, and "quintessential expression of a central thought in the Christian Middle Ages: expectation of the end, hope for the promised fulfilment of salvation" (Kühnel 2003: 222). As the quintessential apocalyptic diagram, the Maiestas Domini represents the apotheosis of the triumphant church (van der Meer 1938). Far from the obscure reference to Christian medieval iconography it is today, the Maiestas Domini was nothing less than "the grandest, noblest of the images of Christ" and had a strong revival in the North of Europe in the fifteenth century (Murray and Murray 1996: 295).[1] The tetramorph (the four beasts) in Revelation 4:6 are in the centre, around the throne (cf. Isaiah 6:1–4, where God sits "upon a throne, high and lifted up, and his train filled the temple"). Instead, the four ovals in the House portray Minerva (or Heroic Wisdom), Reason (or Wise Govern-

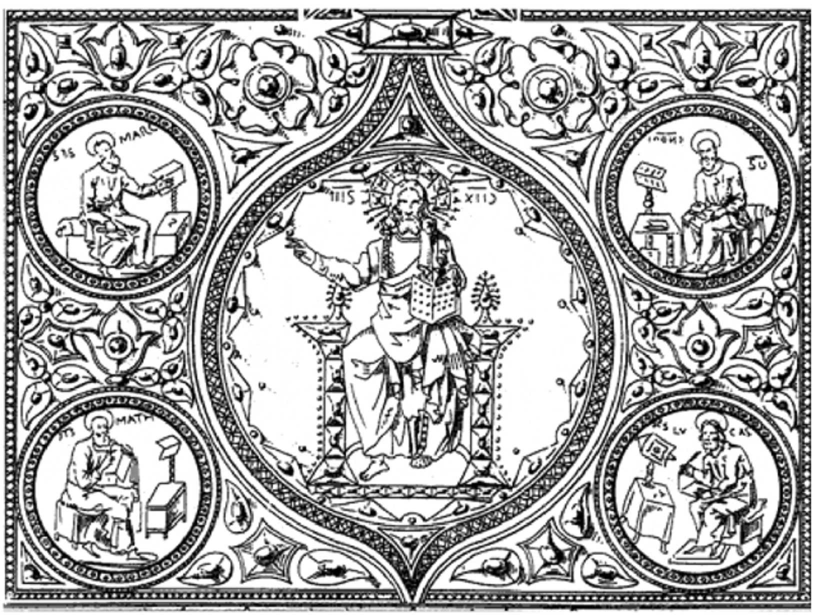

Figure 3.4 The Maiestas Domini at the centre of the Pala D'Oro in St. Mark's Basilica, Venice. Christ sits on a throne over a barely visible orb, holding an open Bible. The four Evangelists are named, and surround Christ in a quincuncial arrangement. Many other Maiestas are found to this day in Venice, in buildings that Jones visited: Santa Maria degli Angeli; the coffered ceiling of the Accademia; the Vision of St John on Patmos, Scuola di San Giovanni Evangelista, where John of Patmos takes the place of Christ; etc.

ment), Abundance (or Royal Bounty), and Hercules beating down Envy (or Heroic Virtue destroying Discord or Rebellion).

It is noteworthy that Donovan mentions James as a Christ-like figure sitting in judgement and finds the four corner ovals have been the most problematic, the greatest challenge to interpret (1995: 9 and 171) and is satisfied that "Project B's suggestion that the four corner ovals show the four Evangelists was probably abandoned as not conforming to the rest of the program" (1995: 250). I expect that Donovan's writing is roughly coincidental with the appearance of Coke's papers, and so these could not influence her analysis. Howarth (1997) and Sharpe (1999) also take the information no further. Anderson (1955) says that in British churches since the fifth century the four beasts were associated with the Evangelists. The earliest British Maiestas Domini, Anglo-Saxon fourth-century carvings, had the bodies of Evangelists with the heads of the four tetramorph beasts. Given the multiple connections between the House and apocalyptic narratives, it seems that the importance of the Evangelists in Plan B has been understimated.

The four beasts of Revelation have been traditionally (almost universally) interpreted as the four Evangelists. Revelation 4:6–7 says, "And before the throne there was a sea of glass like unto crystal: and in the midst of the throne, and round about the throne, were four beasts full of eyes before and behind". This is also, incidentally, Napier's interpretation.[2]

The Quincunx: Astronomical, Apocalyptic, and Artistic Configurations

The Maiestas Domini was related to another architectural feature of many basilicas of Byzantine origin that would not have escaped Jones. The geometrical structure of the Maiestas Domini is the quincunx (see Figure 3.5; cf. Figure 3.2). Architectonically, a quincunx is often divided into nine bays (Krautheimer 1965: 362). In religious illuminations, there are many variations in structure. Since Carolingian times, the basic structure is unchanged and derived, originally, from computistical and astronomical diagrams of reckoning of the times (Kühnel 2003). More importantly, apocalyptic symbols are among the most familiar themes of medieval imagery and were used in church art and architecture well into the fifteenth century, all over Western Europe, either in the form of Doom paintings (with Christ enthroned, in Judgement, depicted according to biblical prophecies of his Ascension, and with New Jerusalem as a common feature) or Maiestas Domini (Anderson 1955).[3]

Bianca Kühnel's research into the quincunx and Maiestas Domini has shown how these are intimately related to computistic calculation and cosmological diagrams, and their history cannot be told separately. In *The End of Times in the Order of Things*, Kuhnel says the first geometrical quincuncial representation of the Maiestas Domini—the Gondohinus Gospel—dates from 754 or 757, with visual digrammatic characteristics that make it close to the appearance of the scientific computistical diagrams, sharing one important element: the quincunx pattern, the basic X-shape of the cross (2003: 76). The changes the Maiestas Domini underwent over the centuries are related to the conceptual and visual impact of illuminated astronomical treatises (2003: 64). Kühnel demonstrates how computistical diagrams and maps developed into the structure of the quincunx, and how these developments were connected not just to mathematical computistic trends, but theological and political developments. Her masterful study of these developments is too detailed for us to follow here, so I will note only a few elements.

The quincuncial form of the Maiestas Domini is not only related to the shape of the cross, but to the astronomical calculation of the pascal cycle of the *rotae computisticae*, and the time of the Second Coming of Christ, the *parousia,* constituting a visual system of time units. The four corners of the Maiestas Domini result from the placing of planets around the central circle, noting the planets' orbits around the Earth. Sometimes there is also visual depiction of tidal regularities, constellations, prognosis, perpetual calendars. In later examples, the four corners sometimes become decorative elements.

Kühnel questions the direction of the influence, asking if it may be the case that the visual style of the Gondohinus Gospel influenced computistical diagrams more than the other way around, because of the interchangeability of motifs within the compositional pattern. Whichever way (and Kühnel's position is that a one-way influence is unlikely), as far as the Banqueting House is concerned, we know that variations and combinations on the Maiestas Domini have always existed, that its apocalyptic origins are found in the calculation of the end of time, and that those origins represented a cosmological ordering of time and world (Kühnel 2003: 229). As late as the tenth century, there is "evidence that at the time the pattern still had a comprehensive computistical connotation" (2003: 224). By the time the Banqueting House was erected, the computistical origins were probably not readily recognised, but the apocalyptic meaning was retained.

Finally, Kühnel adds that the feet of Christ resting on a globe (representing the world), surrounded by the Evangelists, and among clouds, are typical of the Maiestas Domini, and represent his Judgement, as absolute master and creator of the world and of heaven (2003: 229). The open Bible in James' Ascension in the Banqueting House does not show the "ego sum lux mundi" typical of Maiestas Domini, and it is not in James' hands. Instead, it partially shows the first sentence of Genesis in Latin, suggestive of origins and lineage ("In the beginning" of Genesis 1:1).

Kühnel (who makes no mention of the House) remarks that "the main purpose of absorbing cosmological and computistical diagrams into certain biblical compositions during certain periods was to make the latter capable of conveying the certainty of Christ's second coming" (2003: 247). In Rome, St. Paul's Basilica depicts the *parousia* with the Redeemer in a

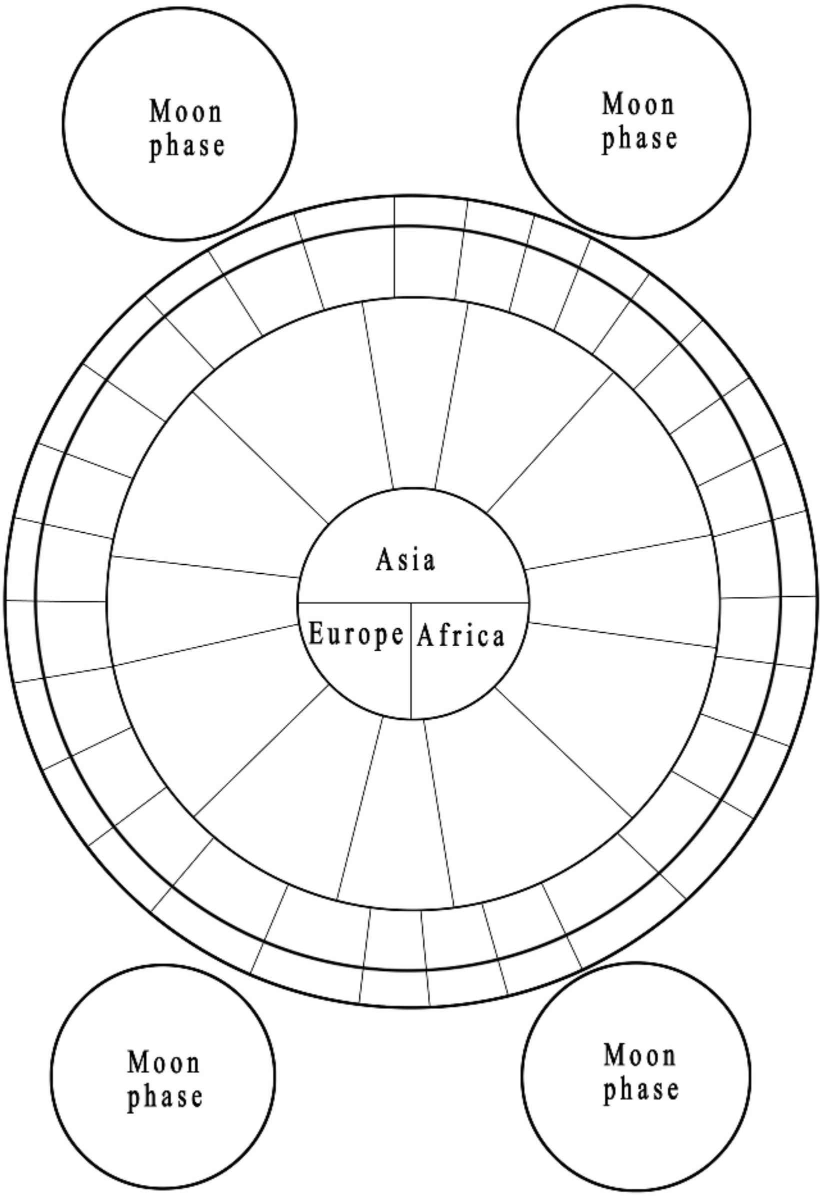

Figure 3.5 Diagrammatic appearance of a typical medieval lunar and tidal calendar, sharing many features with *rotae computisticae*, and other reckoning systems. Used for calculating Easter and the Second Coming, the typical quincuncial configuration would become common in the Maiestas Domini, including the orb derived from the T-O map.

circle surrounded by the four symbols of the Evangelists. Terrien says, of this type of geometrical configuration, that

> the use of numbers and geometrical figures revealed something deeper, more fundamental and more mysterious than visible reality . . . It allows a link to be established between the two levels of cosmic reality, Earth and Heaven (2005:159)

Jones, a keen student of British and European religious architecture, was certainly aware of these connections; and indeed James, who fancied himself an exegete and saw his own role very much in the line of the above quote from Terrien. Church measurements were fundamentally defined, in medieval times, from numerical symbolism derived from Revelation, allowing to bring together heaven and earth in that space (Sunderland 1959).

The Pythagorean meaning of the number five went beyond the quincunx. It was the centre of the most sacred Pythagorean structure, the *tetrakys*. Its relation with the mathematical order of the universe was more than symbolic. Many learned men of the time were familiar with the special properties of the quincunx (e.g., Kepler, Thomas Browne, Giovanni Battista della Porta). To Jones, "from 5 come admiraball things" and "of od numbers 9 is sellibrated ye sfeares of heavne" (quoted in Hart 1994: 147). The importance of the quincunx as a structure with inherent quantitative, spiritual, and supernatural signification was eschatologically determinant in "the ordering of time and the shaping of the modes of its presentation [which] are as much issues of power as are political affairs, the writing of history, and the visual metaphors of rulership" (Kühnel 2003: 67–68).

JAMES PANTOCRATOR

Like Christ, the Apotheosis of King James includes an open Bible, but here held by a female figure representing Religion. James himself was the 'author' of a Bible. The Apotheosis also features the *orbis terrarum*, usually known as 'orb', part of the Crown Jewels. The orb was one of the symbols of kings, and it represents the world. Its origin is related to the Maiestas Domini in two ways: first, Kühnel shows that the T-O map of the world (replicated in the orb) is an important precursor of the Maiestas Domini (see Figure 3.5). Secondly, in the Maiestas Domini, Christ himself sometimes holds an orb in addition to—or instead of—a Bible (see Figure 3.3). In the Apotheosis of James, *putti* carry James' orb, while other *putti* bear palms and trumpets. Palms symbolise the arrival of the Messiah to Jerusalem, and the trumpets feature prominently in Revelation, as we have seen in Napier.

James, the Solomon that brings the Golden Age, divine king of the nation of the true church, rises to Heaven, with his crown, orb and sceptre upheld by *putti*. Salvation is reclaimed from the Roman church, accused by James of being the seat of the Antichrist, to a new temple of Solomon, in the British New Jerusalem, "elevat[ing] James to the place of a God" (Donovan 1995: 161; see also Per Palme [1957] to whom the entire Banqueting House is a temple of monarchical divinity). In the stage where a masque called *The Golden Age Restor'd* had been performed, Sharpe suggests that an active audience must be taken into account in interpreting the stage arts of Elizabethan and Jacobean times. The Banqueting House is an attempt, by an absolutist royal family, to own the most powerful narrative of the time. The House and its ceiling are, at once, a subjugating device and the access to heaven. The apotheosis as a rapture draws in the chosen subjects:

> [T]he look of power in the first sense, representation, entails an idealization of a governing body; the look of power in the second sense, supervision, entails the idealization of a body governed. It attempts to make the subjects of the regime into ideal subjects (Appelbaum 2002: 40)

The reasons why the four Evangelists were excluded from the final plan could have been political. An overly open appropriation of a clearly religious theme might be seen as a blasphemous usurpation of Christ's role, a potential danger because of puritan iconoclasm. Through the seventeenth century, and during the Commonwealth, iconoclasm did not recede. Not even St. Paul's Cathedral was safe. By the time Rubens created the Glynde sketch for the ceiling of the House, it already included the allegorical figures for the corner ovals, instead of the Evangelists. Jones faced serious problems later in his life, finding "himself in the full beam of Puritan hate" and called "contriver of scenes for the Queen's dancing barne" (Summerson 2000: 134). Mythological allegory had been used in Venetian ceilings as a method of state propaganda in the sixteenth century, and it is possible that Jones thought it sufficient and safer to include the Virtues in the ceiling.

The choice might have been historically motivated. Graham Parry notes how, in a tableau, Elizabeth of York had been pictured enthroned with 4 virtues trampling vices, and that Elizabethan propaganda had used the idea of a reinstated Roman Empire in Britain as the return to a Golden Age, a secular counterpart of the millennialism of the day, in the context of the Protestant tendency to see Britain as the new Israel (Parry 1981). However it may be, the House already had, without the Evangelists on the ceiling, many religious and apocalyptic references. In the Maiestas, Christ is sometimes exchanged with other emblems. The Evangelists tend to be a more permanent feature (Reuterswaerd 1991), and this could have made them the first option in secularising the image, assuming there were reasons to do so. But that assumption is not strictly required, since there are examples of the Evangelists not being represented in a Maiestas Domini (an 'alfa et omega' Maiestas Domini in the Codex Vigilanus, at the Escorial, Madrid; or the Church of Sts. Cosmas and Damian, in Rome, from c. 530 (with only Paul and Peter, who present St. Damian and St. Cosmas to Christ)). Some other variations include the twelve Apostles. The variations did not dilute the core apocalyptic message, or the main elements and structure of the composition. Raphael goes as far as replacing Christ with Ezekiel in Vision of Ezekiel (1517), maintaining the tetramorph, as Ezekiel ascends to the heavens.

The Ascension was another variation of the Maiestas Domini that is relevant to the composition of the ceiling of the Banqueting House. Before Raphael's interpretation, "in the fourteenth century, artists in Italy dared to expand the nimbus [of the Ascension of Christ] into a mandorla" (Hughes 1968: 162), somewhat conflating the imagery of Ascension and Second Coming. The Ascension was common in church cupolas, especially in the sixteenth and seventeenth centuries (Brown 1979: 79).

Being close to court and king, Jones' work materialised the ideals professed by James VI and I and Charles I. The Banqueting House, today the sole remaining building at Whitehall Palace, is a spatial configuration of Jacobean doctrine. With the events that it was built to stage and, especially, the addition of Rubens' ceiling canvases, the House became a visual, scenic and architectural cosmogram, a planned point of dissemination of Jacobean ideology and theological doctrine, backed up by practical deeds such as the touching of the King's Evil, whereby sufferers of scrofula were to be cured when touched by the monarch. The House is a model of the world, a representation of the cosmos based on strict quantification principles, built to sustain a political regime.

I am not suggesting Jones used it simply as propaganda. It is more likely that he believed in the vicinity of the End, and in the power of bicubic dimensions. He certainly did not expect visitors to measure the proportions. As we shall see in the next chapters, today we believe in the power of quantified models of the world that claim to include creativity, intuition and imagination, and that are closely related to policy and politics. The sincere belief in the apocalypse, and the role of quantitative representation of the cosmos and its future, have been around for a long time. There is no reason to assume Jones (and others) believed in their truths less than we do ours.

Jones' and Rubens' work fuses magic, mathematics, art, religion and politics into an overarching vector towards the End. With the performance of masques, the House immerses the audience in apocalyptic redemptive expectation. Importantly, it does so experientially, that is, spatially, visually, performatively. Its secularisation of eschatological elements (computational, cosmological, salvific, irenic, redemptive) obscures our ability to understand, today, the implicit modes through which the apocalyptic permeated early modern life and culture, and how they came together to model the world, and cast its future.

4 Assembling the Worldmachine
Mathematical Modelling of Climate Change

> When, therefore, I had long considered this uncertainty of traditional mathematics, it began to weary me that no more definite explanation of the movement of the worldmachine, established in our behalf by the best and most systematic builder of all, was understood with greater certainty by the philosophers, who otherwise examined so precisely the most insignificant trifles of this world.
>
> Copernicus, *De Revolutionibus Orbium Coelestium*

The twentieth and twenty-first centuries have been fertile in apocalyptic narratives, both religious and secular. Loss of human life during World War II was unprecedented, as was the nature and magnitude of destruction. It provided humankind with evidence, for the first time, that we are able to annihilate ourselves. It opened the stage to the Cold War, the Cuban missile crisis, and the widespread cultural awareness that the end can come suddenly, totally, without warning. Without signs.

The Cold War corresponded to the traditional apocalyptic clear-cut 'good versus evil' narrative structure. It also brought about significant changes to its usual precepts. The political adoption of the *mutually assured destruction* doctrine, however, left little or no room for a 'New Jerusalem', paradise on earth, or Christ's millennial reign. As the Cuban missile crisis unfolded, in what was possibly the highest point of the escalation of the Cold War, Rachel Carson's *Silent Spring* (2000 [1962]) introduced most of the western world to the idea of human induced environmental disaster. In *Silent Spring* there was still an identifiable evil—the chemical industry. As environmental and population concerns grew during the 1960s, identifying good and evil became much harder. Malthusian catastrophe disasters gained visibility with studies such as 1968's *The Population Bomb*, by the influential Paul Ehrlich, and the even more influential Club of Rome's *Limits to Growth* (Meadows and Meadows 1972). In all these—Cold War and world wars included—technology and disaster were inseparable. Apocalyptic scenarios are now common cultural currency, to the point where they can be used to illustrate other apocalyptic scenarios. As John Hamre (former United States Deputy Secretary of Defense and current head of the Center for Strategic and International Studies) put it, "[T]he Y2K problem is the electronic equivalent of the El Niño and there will be nasty surprises around the globe" (quoted in CNN 1997).

With climate change something changed; something is new. While the Cold War could be seen as the misuse of science and technology by a few, climate change has democratised apocalyptic agency. To varying extents, everyone is responsible for cataclysm or its avoidance.

The previous chapters examined how models of the world were created by Inigo Jones and John Napier to make statements about the future. The following chapters will examine how models still perform similar functions, and how quantification still has a fundamental role in those models. With mathematics as guarantor of objective representation, Global Circulation Models (GCMs) tell us the apocalypse is still on the horizon, but no longer as a certainty, and no longer as a prerequisite for salvation. Policy informed by mathematical models regards human agency as either taking us down a path towards the disastrous horizon, or as leading us elsewhere, towards salvation. The next three chapters will investigate how nature is still a coded readable realm upon which humans act to determine and decide the future. God has been removed from the narrative, but universal validity—at every scale—is still a *sine qua non* of the narrative.

One difference is crucial: the climatic changes that now affect the lives of many millions of beings around the world are a central factor in the dominant apocalyptic narrative. They are no longer one possible or episodic element in the narrative of an inevitable End; they are the inevitable element of certain disaster of unkown magnitude. Human weather-making is real, as it was (considered) at the peak of the Little Ice Age, but now on a global scale. Our current ability to change the climate still works according to the laws of nature, and there is nothing supernatural about it. Insofar as the influence of greenhouse gases (GHG) works according to a hypercomplex nexus of natural laws, it does not suffer from a causal lacuna, but works preternaturally (i.e., 'beyond our full knowledge'). We shall see how assumptions about the progress of knowledge consistently echo Daniel 12:4 ("and knowledge shall increase"). Since the climate can be modelled to some extent, its changes are considered predictable to some extent. In the past, it seemed too whimsical to be predicted, and therefore found no place in apocalyptic predictions, contrary to the predictability of astronomy (a common and old desideratum in climatological prediction).

Scientific consensus has not prevented climate change from being a contested terrain, in policy and in the media. Adaptation and mitigation efforts are consistently below targets, and the engagement of governments, corporations, and citizens is tentative. The success of climate change adaptation and mitigation is highly dependent on the engagement of as many individuals, institutions, governments, and corporations as possible. To be effective, this engagement depends, first, on the hypercomplex causality chain not being seen as flawed, as a causal lacuna. Second, the relation between awareness and action is not a direct one, so engagement of all the affected parties does not depend solely on scientific understanding of climate change.

It is not realistic to expect that more than a small fraction of all climate mitigation and adaptation (human) agents will understand the causality chains, at least in more than general principles. The causal link between science-informed policy and effective action, sometimes assumed in policy, is far from active, stable, or well defined. Political, economic, and techno-scientific institutions are endowed with power and capacities, but the power of consumers and citizens is much less clear (Wallenborn 2007). The nearly exclusive focus of science and policy is, however, on *objective*, *neutral*, *transparent* science. The problem when apocalyptic agency is democratised—to the point where it is nearly pulverised—is, as Theodore Porter puts it, how

> [t]he modern *canonization* of objectivity implies a kind of openness, but one that is comprehensible only to specialists and that is poorly adapted to express the moral and ethical arguments of an engaged citizenry. Above all, objectivity is a political ideal, one that privileges *universal over local* values and that prefers to invest power in rules rather than persons. (1995: 227; emphasis added)

Scientific knowledge relies on mathematical computer modelling to understand the consequences of GHG emissions and climatic changes. Climate modelling claims to mathematically represent the whole world, the *totality* of the world. This holism, and the universal applicability of the apocalyptic narrative that goes with it, are elements common to the current situation and to early modern apocalypticism. There are connections and similarities between the two periods, and reasons to be tempted to establish more direct relations. The peak of the Little Ice Age in Britain was, chronologically and also geographically, the time when models became widely used in scientific experimentation and simulation and became more formal, complex, and instrumental; a time when "science's line of discrimination between natural and artificial became roughly fixed" (Sismondo 1999: 252).

However, the following chapters do not engage in a comparative historical analysis. Instead, they analyse today's climatic science, and today's artistic representations of the world, nature, and future. The context is not so much historical, but scientific and cultural. Occasionally, historical connections will be made explicit, but I do not wish to make any claims of continuity or direct dependence between the two periods. One does not need to resort to the imbroglios of the 'scientific revolution' to find the current connections between nature, science, and eschatology alive and well. In relatively recent analyses of eschatology—in theological publications—one can find the belief that "one history is of the past; the other, that of the future, is a *science*" (Zubiena 1969: 57).[1]

MAKING KNOWLEDGE COMPLETABLE

When, at the time of the foundation of the Royal Society (1660), systematised weather observations and records started, meteorology was "more an art than a science", based on intuition, local knowledge, and divination (Lynch 2001: 106). By the end of the Little Ice Age and the start of the Industrial Revolution, in the mid-nineteenth century, meteorology was a very different discipline. The work of Joseph Fourier (1768–1830), James Pollard Espy's *The Philosophy of Storms* (1814), Helmholtz's work on chemical thermodynamics, among many others, formed the context from which two of the most influential figures in climate and weather prediction would rise.

The first, Svante Arrhenius (1859–1927) would publish the seminal 'On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground' (1896), estimating that a doubling of carbon dioxide concentrations would lead to a global increase of 5.7 degrees Kelvin. Building on what Fourier had called the 'glass effect' (*effet de verre*, i.e., Earth's ability to trap heat), Arrhenius proposed that the quantity of atmospheric carbon dioxide could significantly warm the earth's climate. At the time, coal was being burnt at an unprecedented rate as it fuelled the Industrial Revolution. Arrhenius' principle states that the atmospheric temperature increases nearly in arithmetic progression as the quantity of atmospheric carbonic acid increases in geometric progression. From this, he estimated that CO_2 doubling would take 3,000 years. Today's estimates put it at about a century.

In Arrhenius' time, it was still far from clear if humans could actually change the weather. Cleveland Abbe, chief scientist at the Army Signal Office, wrote 'Is Our Climate Changing?', in which he states, in no ambiguous words, that

> rational climatology gives no basis for the much-talked-of influence upon the climate of a country produced by the growth or destruction of forests, the building of railroads or telegraphs, and the cultivation of crops over a wide extent of prairie. Any opinion as to the meteorological effects of man's activity must be based either upon the records of observations or on a priori theoretical reasoning. (Abbe 1889: 687)

In 1904, Vilhelm Bjerknes (1862–1951) published 'The Problem of Weather Forecasting as a Problem in Mechanics and Physics'. In it, he says that

> the necessary and sufficient conditions for the rational solution of forecasting problems are the following: 1. A sufficiently accurate knowledge of the state of the atmosphere at the initial time. 2. A sufficiently accurate knowledge of the laws according to which one state of the atmosphere develops from another. (Bjerknes 1904)

With this, Bjerknes adds, "[h]opefully, the *time will soon come* when either as a daily routine, or for certain designated days, a *complete* diagnosis of the state of the atmosphere will be available" (1904; emphasis added). "And knowledge shall increase" (Daniel 12:4).

Bjerknes' 1904 set of seven equations is still the basis of atmospheric forecasting, today. His hope of 'soon to be attained complete knowledge' is also commonly found in meteorology and climatology. Bjerknes' optimism has endured almost without any change. His optimism was derived from the fact that "we already possess the technical tools which will make it possible to fill in these two gaps [maritime and upper atmosphere instrumental records]" (1904). We will come back to this terminology ('gaps in knowledge', 'complete knowledge in the near future', '*in*complete knowledge') often, in the analysis of the assumptions ruling climate change science.

At his 1912 inaugural lecture as director of the Geophysical Institute of Leipzig, Bjerknes chose to contrast meteorological and astronomical methods, with precise prediction in mind. Because "complete observations from an extensive portion of the free air are being published", so that "the problem of accurate pre-calculation that was solved for astronomy centuries ago must now be attacked in all earnest for meteorology". This he defends with the explanation that "there is after all but one problem worth attacking, *viz.*, the precalculation of future conditions" (quoted in Lynch 2001). Of these connections between climatology and astronomy, Naomi Oreskes says (in the context of the predictive and policy-informing limitations of modelling environmental systems),

> The future, by definition, involved the unobservable—the inaccessible—and therefore pushed one beyond the realm of inductive science. Temporal prediction has a religious dimension as well: the future was God's domain. Astronomers had long had the capacity to make accurate temporal predictions of heavenly phenomena, and by the seventeenth century, scientists like Newton and Boyle were extending that capacity to the phenomena of earth as well. (2000: 28–29)

In 1922, meteorological research continued to pursue astronomical precision and accuracy through quantification of necessary and sufficient knowledge, with Lewis Fry Richardson's *Weather Prediction by Numerical Process*. He writes, "The past history of the atmosphere is used, so to speak, as a full-scale working model of its present self" (1965 [1922]: vii). Richardson continues Bjerknes' theme, as Lynch notices, by mentioning the "Nautical Almanac, that marvel of accurate forecasting, is not based on the principle that astronomical history repeats itself in the aggregate". And the optimism was moderated, but still there: "Perhaps some day in the dim future it will be possible to advance the computations faster than the weather advances and at a cost less than the saving to mankind due to the information gained. But that is a dream" (Lynch 2001: 110).

In practice, climate prediction science and systems would have other, more instrumental relations, closer than its connections with astronomy; relations that are closer to the sources of other twentieth-century apocalyptic narratives. Richardson's 1922 work had been developed during

World War I, as he worked as a member of an ambulance unit on the Western Front, in France. He developed the first numerical weather forecast from Bjerknes' equations, a slide rule (originally developed by William Oughtred in 1622, directly from Napier's work), and a table of logarithms. His six-hour forecast was a total failure: the calculations took much longer than the forecast objective (six hours), and with completely wrong results (Hayes 2001). Still, he wholeheartedly believed in the potential and future of numerical weather prediction. In this, he wasn't wrong.

Prediction and Apocalypse: A Twentieth-Century Janus

The close proximity between World War II, systems thinking, and digital computing has been the object of research over the last thirty years (Agrawala 1999; Edwards 2000; Bloomfield 1986). Paul Edwards notes how the 'mutual orientation' of scientific and military research trends, coming out of the war, led to the development of *numerical weather prediction*. These were specially driven by the amassed military experience of engineers, and the amount of funding available from military agencies. Not a hard sell, Edwards says, since weather affects virtually every aspect of battlefield operations, especially air warfare (2000: 223). Richardson's dream of numerical weather prediction was becoming closer to reality, out of the greatest nightmare of the century. And one of Bjerknes' two "especially noticeable gaps" (1904) was 'covered' with the systematisation of upper-atmosphere observations. Radar, aircraft, improved radio transmissions, data networks—all technologies developed or improved during World War II—had an impact on weather forecasting (Edwards 2000).

Today's meteorology and climatology are heirs to these developments, and this thinking. Authors like William Hooke and Robert Pielke acknowledge the debt of modern meteorology to instruments like the telegraph, which "provided the means for scientists to construct a *comprehensive* 'picture' of the weather at regional and global scales" (Hooke and Pielke 2000: 63; emphasis added) and renew Richardson's orchestral view of prediction, in the title of their chapter ('Short-Term Weather Prediction: An Orchestra in Need of a Conductor'). Andresen and Agrawala (2002) have noted the coincidence of the emergence of the Cold War and the concern that CO_2 emissions are a global problem. *Because* it did not fit with Cold War concerns, they say, it was only the *creativity* of Roger Revelle (1909–1991) and Hans Suess (1909–1993) that linked the two in the form of an analysis of the ocean uptake of carbon released by nuclear explosions.

The Electronic Numerical Integrator And Computer (ENIAC) was designed for the U.S. Army's Ballistic Research Laboratory. John von Neumann (1903–1957), better known for his mathematical modelling work in the Manhattan Project, helped establish the Princeton Joint Numerical Weather Prediction Unit to understand how the general circulation of the atmosphere was influenced by external factors. ENIAC conducted the first computer-based numerical weather prediction calculations. von Neumann, one of the great mathematicians of the twentieth century, played a leading role in developing the first form of global annihilation the species has devised. Prediction and destruction have new (but still mathematical) ways of continuing their close relation. After von Neummann, weather and climate forecasting became increasingly reliant on numerical prediction. By the time the 1957–1958 International Geophysical Year (IGY) took place, the connections with the military agencies and research had decreased.

I say that prediction and destruction have continued their relations in new ways, but perhaps they are not so new. Napier was interested in the military use of explosives, and developed explosive devices. Not that Napier's mathematics had any part to play in his explosive experiments. But his politics, his military research, his optimism in knowledge advancement to overcome 'hindrances', his apocalypticism and his predictive techniques were all related. Some authors do explore this type of connection further. Brian Bloomfield opens his *Modelling the World* (1986) by saying that, like past savants and prophets warned about imminent disaster, "in modern times we too have our prophets—the world modellers. Unlike those of earlier periods, these do not 'cast runes' or perform calculations with astrological charts, nor do they examine the entrails of animals: rather, their predictions stem from the use of computers" (1986: vii).

THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Box 4.1 The IPCC's Mandate

The IPCC was established to provide the decision-makers and others interested in climate change with an objective source of information about climate change. The IPCC does not conduct any research nor does it monitor climate related data or parameters. Its role is to assess on a *comprehensive, objective, open, and transparent basis* the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation. IPCC reports should be *neutral with respect to policy, although they need to deal objectively with policy relevant scientific, technical, and socio economic factors*. They should be of high scientific and technical standards, and aim to *reflect a range of views*, expertise and *wide geographical coverage* (IPCC 2004b; emphasis added).

The IPCC's Mandate (see Box 4.1) needs to be understood in the light of its procedures: the "Reports to be accepted by the Working Groups . . . undergo expert and government/expert reviews . . . to ensure that the Reports present a comprehensive, objective and balanced view of the areas they cover" (IPCC 2003: 4.2). In other words, government named experts are part of a neutral, policy-informing scientific process which is aimed at informing governments (see Figure 4.1). There are 155 governments represented in the IPCC. Alvin Weinberg portrays matters as these as trans-scientific issues, since they "hang on to answers to questions which can be asked of science and yet cannot be answered by science" (1972: 209). The authority of science and its advisory committees to address such concerns

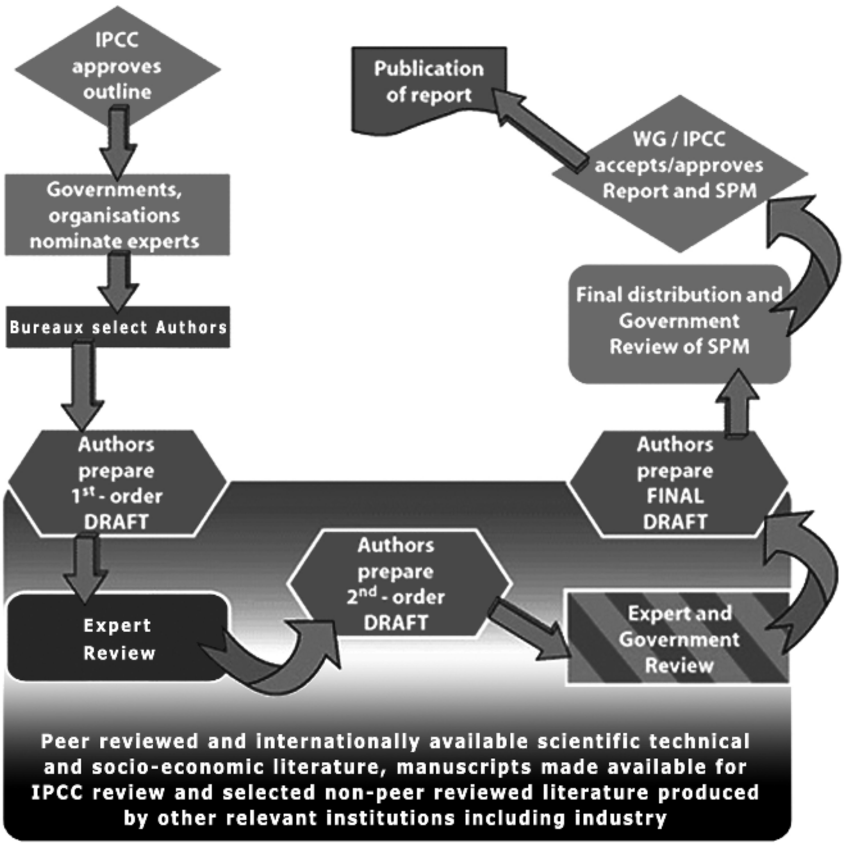

Figure 4.1 IPCC Report Process. "A schematic description of the IPCC process applicable to Assessment Reports, Special Reports and Methodology Reports is provided below. Simplified procedures apply to Technical Papers. Supporting material is prepared to support the assessment process and is therefore not IPCC assessed or approved material" (IPCC 2005b).

is neither intrinsic nor universal. The objective of such institutional structures and procedures is "serviceable truth: a state of knowledge that satisfies tests of scientific acceptability and supports reasoned decisionmaking" (Jasanoff 1990: 250). Science-based predictions, in short, are not politically independent (Brunner 2000). This serviceable truth depends on a performing work that sustains the boundaries between science and policy clearly defined (work rhetorically performed by the IPCC's Mandate and Reports). These boundaries must allow enough permeability for governmental political positions exerting influence. John Napier's dedications to James I and VI show his interest in making his truths serviceable to the King, nation and true church.

Models of the Whole World

The work of the IPCC relies on mathematical modelling, the modelling that has evolved with Bjerknes, Richardson, von Neuman, and others. Models have been described as abstractions or idealisations of reality, decantations of the essential structural properties of the object of study, as heuristic, metonymic tools. Describing them as inherently reductive does not mean that models aren't able to represent relevant features of what is being studied.

In the case of the climate system, the World Meteorological Organisation (WMO) states that models are "the fundamental tool" for predicting climate change (WCRP 2009; see also National Research Council 1987; MacDonald 1989). The IPCC's Fourth Assessment Report defines these models as 'mathematical representations of the climate system' (2007: 600). This 'climate system', in turn, is defined by the UNFCCC as "the *totality* of the atmosphere, hydrosphere, biosphere, and geosphere *and* their interactions" (United Nations 1992; emphasis added). Aiming to model a 'totality' seems to contradict how models work and what they can do, unless we accept that 'everything' constitutes a valid and tractable 'class of events', that we know what the 'totality' is, how to select is relevant features, and that models can mimic all the relevant structural properties of the system. So far, that has not been the case. Far from it, the reports—all reports to date—tell us that substantial uncertainties 'remain' in several important sectors and interactions (IPCC 1992, 1995, 2001, 2007, 2007d).

In mathematical set theory, the universal set includes every set, and itself. A simple, initial example of the impossibility of representing a totality: the calculations of the totality that the IPCC uses do not include the IPCC's scientific work, or its impact. How detailed would the representation of the totality have to be to be able to include specific science and policy initiatives, in their future relevance? I use this example because the level (or time–space resolution) at which socio-economic and policy factors are representable (and usable) is problematic in the IPCC SRES scenarios, as the next chapter will examine. This problem is severely compounded by the largely unknown (or unquantifiable) feedbacks of socio-economic processes. A set of all sets has presented difficulties since Georg Cantor founded set theory, publishing *On a Characteristic Property of All Real Algebraic Numbers* in 1874. And the difficulties have been expressed in the context of prediction for decision-making. Thomas Stewart says "the system that is the focus of predictions is called the external environment *to distinguish it* from the environment in which decisions are made" (2000: 521; emphasis added). Oreskes and Belitz's words add an important dimension to where the 'carving' usually occurs:

> If the purpose of a model is to aid in decision-making, by definition this means that the system is of interest to humans and very likely impinged upon by human behaviour. But it goes against the grain of physical scientists to acknowledge this. We have been trained to study 'natural' systems, and only recently have we begun to assimilate the fact that there is no sharp line between human and 'natural' systems. (2001: 30)

How exactly is the dynamic totality of the atmosphere, and the oceans, and land, and life, and their interactions, translated into mathematic representations, made commensurable, co-calculable? What guarantees that this massive translation is representative of the 'totality', and what validates such representation? Ivar Ekeland denies it is possible to mathematically model a totality, deterministic or not. If determinism means that the future is wholly determined by the past, he says, it can only pertain to reality as a whole, "the total cosmos". Isolating sections of a global reality can lead nowhere, or to randomness. But there is no other choice, Ekeland adds. The whole is out of reach. "What we do is carve out subsystems" (1988: 63) when, in reality (and he speaks of climate forecasting), "everything, absolutely everything, must be taken into account, no perturbation can be deemed too small to have any influence" (1988: 66). The carving is also an absolute necessity, since the continuous infinitesimal changes occurring in nature cannot possibly be observed, recorded, computed, or known. Differential equations are used to represent these continuous variations through discrete points forming a three-dimensional grid, but there are many questions regarding the relevance of processes working below the resolving power of computers and below the resolution level of the grid. How this massive complex totality is simplified, translated, and quantified into mathematical models will be the focus of the next chapter.

The representation of an observable, defined, external entity (the climate system) is projected into the future, offering 'policy-relevant' information when submitted to time-series forecasting. The apparent contradiction between these aims and the above difficulties is part of the arena where continuous rhetorical and institutional negotiations take place. The IPCC aims to offer "an integrated view of the complete cycle of interlinked causes and effects across all sectors concerned" (2001b: 3). Ultimately, this view is again translated, into the English language (and the visual language of the accompanying graphs and tables), in the format of a report. From English, it is translated into several other natural languages. The claim is that, throughout all this process, representation is maintained, and the end result is objective, transparent, and neutral. This is repeated in a large number of IPCC documents. For example, "this chapter provides guidance for reporting complete, consistent and transparent national greenhouse gas inventories, regardless of the method used to produce the data" (IPCC 2006: 8.4). Sismondo remarks that "the agency behind models and simulations is too visible to allow them to easily represent transparent domains" (1999: 253). Merz notes that there is a tendency for users to see models as transparent, since they are (to many users) a blackbox, with internal structure and composition of no particular interest (1999: 309) or completely unknown, as we will see of agricultural commercial forecasting models.

What distinguishes models of the climate system, especially earth system models (which aim to represent everything, including human activity), is that their object is limitless in every direction, spatial and temporal. That makes mathematics the sole common denominator to everything that is relevant, and this assumption about the world determines the process and outcome of predictive practices. It is, possibly, too low a common denominator to represent the totality. Before we get to that, however, it is important to understand how those practices are defined and defended.

The Ingredients of a Modelled Climate

The definition of climate modelling offered by the IPCC adds that models are "mathematical representations of the climate system, expressed as computer code and run on powerful computers" (IPCC 2007: 600). With that, it becomes apparent that representing the future of the totality of the four spheres is made of successive translations, with a large hierarchy of dependences: from climate system to mathematical equations, from equations to FORTRAN (the computer language used in most climate models), all the way to the publishing (and reading) of reports (cf. Kling and Scacchi 1979). The only dependencies visible in the definition are the code and the underlying powerful computers. But that suffices to show that this representing, or this *succession of acts of representation*, isn't accurately described simply as a "mathematical representation". The ramified hierarchy of dependencies extends in many directions. These ramifications overlap, intersect, and merge with the assumptions necessary to the production of knowledge.

First in these assumptions, the climate system. There is no climate system 'out there' to be mathematised (and this not just because a totality includes everything, including modelling). There is, instead of a climate system, a very large array of instruments and records of climatic events, which is both 'out there' (throughout the world) and 'in here' (in databases and in their structure, as designed and corrected by subjective expert preference). Before we (or *in order to*) come to how the system is posited, the instruments and records of their measurements already introduce elements foreign to the wind, the pressure, the heat or the rain. Measuring, reading, comparing, calibrating, selecting, and discarding data are the visible face of the climate. There is nothing wet or hot about them. A climatic event is—in the full extent of its modelling significance—the value of a measurement.

Even before the readings are taken, mathematical models have already defined, in the instrument, the correlation of voltage to numerical scale conversion, for instance. Such correlations are determined by the different companies that manufacture the instruments around the world. Instruments have different resolutions, calibrations, error frequency, and patterns (Harries 2001; Edwards 2000; Edwards and Miller 2001, Humphreys 2004; Beck 2002). IPCC guidance on 'Quantifying Uncertainties in Practice' states that the pragmatic approach is to combine individual source measurements with expert judgement, to generate uncertainty estimates (2000: 6.1). Estimated emissions from individual sources and their uncertainty ranges cannot be solely derived from source-specific measured data, so estimates taken as typical of the sources in question are often considered *representative* (2000: 6.5).

But even before that, even before the instrument is in place to record and transmit its first measurement, models of a coherent world are already at play:

> Despite the complexity and inhomogeneity of urban environments, useful and repeatable observations can be obtained. Every site presents a unique challenge. To ensure meaningful observations requires careful attention to certain principles and concepts. (WMO 2006)

The world is made of heterogeneities and complexities, yet we navigate through them, finding the regular and the repeatable to make sense of it all. A strategy that works most times, as everyone knows and verifies, every day. But heterogeneity (or, in the preferred term, *inhomogeneity*) does not find space in an objective climatic world, however uncertain it may be.

Instruments provide raw data. Raw data are close to meaningless: they are overwhelming, unstructured, partial, unreliable, since "no measurement can be made without error" (Wainwright and Mulligan 2004: 59). This is not to say that measurement is worthless, but that mathematical models are applied to correct the measured data. Data records are patchy and irregular, so models for mathematical interpolation of data are also used, and have been since the days of ENIAC, when data correction and interpolation was conducted by humans (Edwards 2000). This means that *mathematical models are folded into mathematical models*. Edwards calls them 'intermediate models' (2001: 61), but Leigh Star's designation of 'layered representations' (1995) seems richer in conveying how—more than just a step in the translation—they too define the levels of translucence and opacity of the mathematical representation. This is not to say that a critical analysis can dismiss models and data on these grounds. Stephen Norton and Frederick Suppe rightly say that "if one wishes to impeach atmospheric data merely in virtue of their model dependence, consistency demands rejecting all experimental and observational data" (2001: 75).

Interpolated data aren't registered by instruments, they are introduced averaging elements. More data are always possible, yet complete data are never possible. Assumptions and interpolations will always exist. We are still far from computing global models, but already we are distant from the rain and wind, and embroiled in models. Admittedly, this isn't new. Data are theory-laden, regardless of the type of scientific enquiry. But the IPCC elides 'theory' from its final representations of the climate models. In the *Technical Summary of the Report of the Working Group 1* and in the chapter 'Climate Models and their Evaluation' (each seventy-four pages long) of the *Fourth Assessment Report* (IPCC 2007) the words 'theory' or 'theoretical' appear only five times, and each of those times, theory and model are differentiated. The elision of theory makes the "physical science basis" (title of the IPCC 2007 Working Group I report) seem more experimental, a more transparent translation, dealing with things and facts, not theories or hypotheses. The plasticity of models is both their power and their weakness: bridging theory and data, they are neither wholly factual nor wholly theoretical, and "do many things at a time" (Sismondo 1999: 254).

The function of models depends on calculability, and therefore on replacing the intractable with the tractable, the complex with the simplified. The commitment to calculate masks a much more complex backdrop, exemplified by the contrast between the IPCC reports, heavily populated with quantification and discussion of how to quantify all variables, and recent discussions on the matter. These discussions, themselves a 'layer of representation', are masked by the more visible and opaque layers (those of rhetoric of transparency and neutrality). The call for papers for the Semantic Interoperability, Knowledge and Ontologies session of the European Geosciences Union General Assembly meeting that took place in Vienna in April 2008 noted that

> [g]eoscientific information can be both rich and complex, and content is not always readily interpretable by either humans or machines. Interpretation of such information is important if it is to be shared, exchanged, integrated or used by advanced third-party applications as would be required in an interoperable context

and earmarked the session for exploring

> how meaning can be represented using ontologies or other semantic mechanisms [. . . ;] how knowledge can be abstracted, interpreted

> and inferred from semantic representations and data and information repositories. (European Geosciences Union 2008)

Standardising quantification requires qualitative decisions. Another example of how the quantitative drive formats the discussion and the qualitative evaluations: the Summary for Policymakers in the Third Annual Report (TAR) tells us that socio-economic consequences include "tens of millions of people living in deltas, in low-lying coastal areas, and on small islands will face risk of displacement" (IPCC 2001d). Not national collapse, not death, not severe and long-term disruption to social structure and income sources, not anger and violence and looting, not widespread dysentery, not loss of cultural heritage, not generation of tens of millions of refugees that will create pressure on other populations (themselves possibly dealing with changing climate), not trauma, not orphans, not even displacement, but "risk of displacement". Hurricane Katrina created a little more than 'risk of displacement'. So did Cyclone Nargis, as it made landfall on 2 May 2008, over Burma. Much less mediatised than Katrina, the official death toll was above 80,000 (with most estimates well above 100,000) with many thousands more missing (BBC 2008b). The British Red Cross assisted more than 1 million Burmese, in the aftermath of Nargis[2] (Red Cross UK 2009). Models of the totality are necessarily metonymic, but the difficulty in being parsimonious when representing a totality also makes them euphemistic. "For instance, in the case of global warming, predictions of future climate impacts are, in part, based on predictions of future population growth and energy consumption, both of which fall squarely in the realm of the social sciences" (Sarewitz et al. 2000: 16–17).

These distinctions between the quantitative and qualitative are made clearer than they are. The quantitative/qualitative opposition is not clear-cut. There is, in mathematical modelling, qualitative modelling. Richard Levins' loop analysis questions the validity and use in policy environments (as opposed to engineering), of the distinction between qualitative and quantitative modelling. He also questions the perceived superiority of quantitative modelling (2008: 31). The qualitative/quantitative distinction in mathematical modelling is fluid, since there are models which can integrate more quantitative detail in a loop analysis approach, and loop analysis complements quantitative modelling (directly in the type of quantitative modelling called analytical modelling, and indirectly in numerical modelling). Still, loop analysis works—as quantitative modelling does—on the basis of systems thinking as the approach to understand climate change, and human/nature interactions, determining the relative relevance of variables, knowing that all relevant variables are accounted for, and so on (see Hauer and Lamberti 2006; Pilkey and Pilkey-Jarvis 2007).

The final chapter, dealing with non-scientific methods of representation, will establish the contrast between qualitative and quantitative in a different light, that is, between science and art, and how the two have different abilities to create and work with different representations and data. It will be clearer that the distinction is not between the visual and the mathematical (mathematics rely heavily on visual information, and the arts do sometimes work with quantitative data), or between the creative and the scientific.

MODELS: MACHINES TO IMAGINE EVERYTHING?

Models, more than being 'imaginary entities'—as Ronald Giere (1999) defines them—are *imagining entities*, imagining a future and designing a specific scope of possible futures. Their physical embodiment makes them more than imaginary, less than real (in the sense of verifiable experiments). They have become 'embodied entities'—as Brian Rotman (1993) calls them—on a physically massive scale. The significantly named Earth Simulator is the example with the highest international profile.

With full power redundancy, seismic isolation, the Earth Simulator is spread over two floors, each occupying 71x50m, with a total height of 17m, including the Faraday cage that surrounds it (to protect it from electromagnetic interference, including stormy weather). It delivers 35.86 TFLOPS[3] of processing power. In it, the irreducible uncertainties and the unquantifiable variables borne out of climate modelling as a research practice are elided along with theory, dropped from the singular narrative. Some variables are 'poorly understood' and poorly modelled (vulcanicity, cloud coverage, ice sheet cover; IPCC 2007d). Previously unknown variables are brought to light on a frequent basis. Others are of untractable or sub-resolution scale. "Considerable confidence" in quantitative estimates of future climate by models is mostly attributed to continental and larger scales (IPCC 2007: 600; see also IPCC 2007c: 5; cf. Beck 2002). The 'closure assumption', a working assumption in modelling according to which the smaller and sub-resolution processes can be represented by large-scale variables and parameters has become untenable. The IPCC now accepts that this is a source of errors. The Earth Simulator team have a program in place called Macro-Micro Interlocked Simulation (proposed by Tetsuya Sato (2005)). Regardless of the above limitations, the abilities of the Simulator are presented in a striking manner:

> The keyword is "Holistic"
> The Earth Simulator is capable of exploring the evolution and the future. In contrast to existing nonlinear simulations of individual phenomena, what we call Holistic Simulation explores a complex interdependence between micro and macro scale processes. (JAMSTEC 2008)

Holistic representations of the 'totality', of the 'earth system', are in development, as they have been for nearly a century since Richardson's 'Forecast Factory'. 'Knowledge shall increase' (Dan 12:4) . . . are we there yet?

If we believe the scientific community, we are not there yet; but "when ye shall see all these things, know that it is near, even at the doors" (Matthew 24:33). Nearly there, it would seem from all the instances of gaps in knowledge we will encounter over the next chapters. Challenges remain.

One of the enduring challenges of representing the totality is, as recognised in IPCC Reports, modelling cloud cover. Cloud cover is affected by biological processes at the surface (land and ocean) and by sun radiation. The number of feedback processes involved is poorly known. The optical properties of clouds are affected by sulphur-emitting micro-organisms in the upper layer of the ocean as well as by the (better documented, but not completely understood) relation between solar radiation, terrestrial albedo, and other factors. This poorly understood and poorly modelled important element interacts with other components, most of which change at different time scales. The chaotic element of climate prediction is much harder to deal with than 'ordered forcing' components. As recently as 1999, its relative importance was unknown (Rind 1999).

Airborne Particulate Matter (APM) is another poorly understood component with a significant role in climate change. Instrumental measurements of APM can vary around 50 per cent depending on instrument and method, so that correction factors between methods are required (Butterfield and Quincey 2007: 1). Ultimately, "the inclusion of definite PM concentrations in prominent EU legislation leads to political considerations for these measurements, in addition to the scientific ones" (2007: 5). The authors rue the historical choices made in measurement methods and explain how

> even if there are strong scientific grounds for redefining the standard method for PM10, for example, it would not be politically acceptable for the change to be made if it led to significantly different concentrations being obtained, as this would logically mean that the limit values in the legislation would need to be changed, and this would require a major political effort. (2007: 5)

These lines, from a National Physical Laboratory Report, demonstrate how science and politics are inseparable, made through each other. There is no possibility of separation, there is no independent nature for us to model. That impossibility has not ended the continually performed separation of science and policy. The objective is still and always neutral scientific information, despite the rhetoric of transparent representation not surviving scrutiny. As the above APM example shows, science is always grounded in local circumstances, its truths situated, even situated in political decisions. The need for (perceived) objectivity detaches these truths from their context. A model is not only conditioned by the politics of its data measurement, but by its own conceptualisation of the stability and variability of the driving forces of the system (Oreskes and Belitz 2001: 28) which, in the case of climate change, is *no less than everything*.

If measuring is political, how does one objectively and neutrally measure the totality, unless one accepts that politics is part of the totality? If so, how does one measure the political? Or how does one calibrate the political instrumental shift out of measurement techniques? How can one calibrate the political element of historical records, records whose policy and political context is mostly known from *incommensurable sources*? These questions can hardly be answered, but they foreground how the universal set—the set of all sets—includes itself in infinitesimal folds, whichever way we carve it for analysis. The way, and the level, in which everything is folded with everything cannot be measured *and* cannot be discarded. Modelling everything in climate science and policy is inherently paradoxical.

As a consequence, models of the totality are inherently political. The IPCC acknowledges that one of the main outcomes of its work—scenarios of the future—carries many types of uncertainties, and also that "scenario uncertainty is a special case because it is, to some degree, under policy control" (IPCC 2004: 53). If politics is everywhere, from methods to instruments to scenarios, if everything is political, then the modelled totality is indeed infinitely folded onto itself, at many (every?) scales. It is a vast field of agency where our conceptual structures are located (Pickering 1997: 40).

These examples of the impossibility of mapping a totality show how the totality is a narrative of instrumental records, subjective and political choices, artificial values (data smoothing, interpolation, and correcting), and so on. It is produced, and inscribed into the world through 'storylines' (the IPCC designation for the general direction of scenarios) that aim to inform policy. This narrative—or better, a set of multiple, not always compatible narratives—is further simplified and temporally projected, despite some components being much more detailed than others; and despite their relative importance not always being known (it is many times estimated or corrected on the basis of intermodel comparisons and/or testing against past climate records).

Oneness: Holism as Assumption and Objective

In the representation of the totality, a multiplex of incommensurable elements is singularised and sanitised into one single calculable entity, one predictable narrative. We have seen this in Napier's prediction of the End. Avril Cameron says that, since its early days, Christian providence constituted a totalising explanation, a kind of theory of everything, culminating in the Day of Judgement (1993: 121). The belief in prediction assumes, Cameron adds, "that the physical world is controllable, whether by appeal to religious authority or by scientific truth" (1993:122).

Some crucial variables—pertaining to human socio-economic development, examined in the following chapter—are one of the main sources of uncertainty, and are heavily parametrised (cf. Danny Harvey 2004). Bloomfield (1986) states that system dynamics, like astrology, is a belief system based on the *holistic fusion of physical and social reality*. The similarities with astrology are valid, but also limited. The 'holistic fusion of physical and social reality', on the other hand, is a crucial element in the IPCC scenarios of future climate and society, covered in the next chapter. The argument that holism is about the total, the global, or the gestaltian, or fundamental, or spiritual overlooked relations of a system does not hold; at very least in the context of climate change. When the scale, type, and number of relevant components (and especially their relations) are unknown, the whole—as the privileged scale of meaning—is no more than a partial and limited establishing of associations by making them.

Holism as necessarily (and intensely) political is also applicable to the Banqueting House and Napier's *Discovery of Revelation*. Jones' and Napier's work embody universal, all-encompassing models of the world. What Pickering says of modelling today—that it is "the construction of a bridgehead that tentatively fixes a vector of cultural extension to be explored [and that] it marks out a space for transcription" (1997: 42)—is true of those early modern works, with the exception of the 'tentative' fixing of the vector. Then, the vector was not tentative but absolute, omnisciently defined outside time and space, applicable to all time and space, and all scales. Man dis-covered that vector progressively, 'removing hindrances', so that the apocalypse was the culmination of unveiling the order of the world. Nico Stehr and Hans von Storch note, in their study of Eduard Brueckner's (1863–1927) work on global climate variability and its social and economic consequences, how the notion of periodic cycles (which we have seen was determinant to Napier's calculation of the End) as description and explanation for a variety of natural, social, and economic processes was a strong trend in Bjerknes' time. As late as the 1940s, when this belief was widespread, Huntington says, in *Mainsprings of Civilisation*, that "it will be a vast boon to mankind when we learn to prophesy the precise dates when cycles of various kinds will reach definite stages" (quoted in Stehr and von Storch 2000: 9).

Today, the work to overcome the 'incomplete state of knowledge', and achieve holistic completeness, has led to a large-scale increase in the amount of code required to represent the system. In 1997, a global model had 30k to 60k lines of FORTRAN code. Ten years later, the Hadley Centre Coupled Model, version 3, had ~750k lines with ~250k lines changed (Saunby 2007). Change is, in code, both a reliability and stability issue as well as a need. Bugs and bad science become hard to distinguish, and change degrades quality (Dubois 2000: 5). The continuous collective negotiation of what is relevant is a messy qualitative affair that portrays the quantitative as rigorous and transparent. Especially if we also consider that the language of old reliable code is also a legacy from different storytelling practices (Gramelsberger 2006). It bears traces of the collective qualitative changes, negotiations, errors, and assumptions. So, "the craft, art and skill of modelling" (Morgan and Morrison 1999:12) is the craft of coherent storytelling. 'Once upon a future time' kind of storytelling. Ultimately, models, their underlying theories, and the data used are distinguishable, but not distinct.[4]

The power of holism means that areas of ignorance and uncertainty are understood as gaps to be covered, not just by Bjerknes and climatology ever since. This attitude has been mapped to earlier statements on prediction, especially Laplace's (1749–1827) 'demon' proposed in the introduction to the *Essai Philosophique sur les Probabilités*:

> We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes. (1995[1814]: 2)

Quotes of Laplace's words usually stop at this point. His text, however, also includes an important warning: "our efforts will always fall infinitely short of this mark". Sometimes the terminology is found in authors who foreground the limitations of modelling, authors who are critical of the level of dependency and trust placed in models. Oreskes says "the *incompleteness* of our knowledge of natural systems opens the door to systematic errors" (2001: 27; emphasis added).

The Practical Advantages of Ignorance

Uncertainty and ignorance can otherwise be understood as limitations to predicting everything, and indeed that there are both methodological and practical advantages to using ignorance as an epistemologically fruitful condition. This has been the case with the limitations of earthquake prediction. Acceptance of ignorance has informed policy initiatives which lead to a shift from prediction to prevention of damage, resulting in successful policy action (Nigg 2000). "The idea of a prediction as a disembodied number modified by an uncertainty is entirely too abstract to have any meaning in the real world" (Sarewitz and Pielke 2000: 7). It is this very disembodiment, however, this detachment from the conditions and circumstances of knowledge production, that makes it reproducible, stable, believable.

Stanley Changnon makes a supplementary point about flood prediction. Even useful and valuable flood prediction information is not well understood by policymakers, and *a fortiori* the information that might be attained from improvements in prediction. Changnon states that this demonstrates that more or better information does not make the problem go away and, indeed, the opposite might be true. As the amount of information increases, reliability of judgement may decrease "due to information overload, especially in contexts of high uncertainty and high risk" (2000: 75). It is in such a context that Nigg says that "perhaps the wiser course would be for scientists not to predict success at predicting, and for policy makers to respond accordingly" (2000: 135). These critical views of the excessive policy reliance on mathematical modelling are found in case-study reminders of the limited role of modelling, a heuristic role that is based on tacit knowledge methodologies of limited isomorphism with natural events or processes (Stehr 2001; cf. Beck 2002; also Giere 1988; Sarewitz et al. 2000: 2).

Emphasis on predictability is also a function of funding strategies, and a project or institution foregrounding ignorance is highly unlikely to attain funding when pitched against others that suggest 'complete knowledge' (see Sarewitz and Pielke 2000: 6). The IPCC reports buttress certainty and objectivity: "[C]onfidence comes from the foundation of the models in accepted physical principles and from their ability to reproduce observed features of current climate and past climate changes" (2007: 600). Nearly three decades have passed since Knorr-Cetina examined how "the reasons which appear post hoc in a logic of decisions are simultaneously presumptions of the future in a logic of action" (1981: 98), but the climate science on which might hinge the well-being of billions finds strength in establishing well-defined, strong boundaries between itself and policy; and also between itself and the external climate system; between its coherent output and its contingent constitutive parts and persons; between its methods and belief systems; between its methods and qualitative knowledge. All these boundaries make quantification "part of a strategy of intervention, not merely of description" (Porter 1995:13). The future—*a future*—is visible, from the perspective of quantitative intervention.

Asking Questions

If science is "unable to provide certainty in policy recommendations" (Funtowicz and Ravetz 2001: 174) and computer models, simulations, and scenarios are untestable (Funtowicz and Ravetz 2001; Oreskes 2000), or untestable in their lifetime (Williamson 2002) and cannot be validated (Edwards 2000; Oreskes and Belitz 2001), and expectations of complete states of knowledge are unfounded, why the reliance on prediction? Doesn't the exclusive trust in calculation sterilise the policy space that might allow concerted efforts at formulating questions differently? These questions need asking because of other, more fundamental, questions at play.

What if the 'real' story is not understandable? Where does the confidence come for statements like: "There is *still* an *incomplete* physical understanding of many components of the climate system" (IPCC 2007d: 21; emphasis added); "there are some important climate processes that have a significant effect on regional climate, but for which the climate change response is *still* poorly known" (2007d:74; emphasis added); "the TAR does not achieve a fully integrated assessment of climate change because of the *incomplete* state of knowledge" (2001d: 2; emphasis added); "*incomplete* knowledge of feedbacks and timescales in the system " (2004: 53; emphasis added)? These are examples of an ambition Paul Teller calls the Perfect Model Model (2001). It is, Teller argues, gripped by the long standing ideal of exact natural laws, and it should be scrapped entirely because nature may not be 'encodable', and complete knowledge is impossible when initial conditions are far too 'messy', and we are forced to simplify (2001: 393–394).

Could interdisciplinarity be the solution to understanding the 'real story', from various perspectives? Or would that lead to a confrontation of different, incompatible 'real stories'? The multiplicity and diversity of ontologies, concepts, and terminologies in different disciplines related to climate change is sometimes seen as a problem, the source of gross misunderstandings (Ostrom 2008). There have been many propositions for future developments, disciplinary and interdisciplinary, in climatology, scenario building, and a profusion of techniques and methods in future studies. The following chapters will emphasise *the danger of expecting future answers for present problems*, and that *expecting that future knowledge will provide answers needed now* is a flawed strategy, whether in the form of interdisciplinary or highly specialis ed knowledge. It is dangerous hubris, and partly imputable for the current severe inertias. The final chapter will propose that, notwithstanding the power and value of models and scenarios (in their current abilities and in their future developments), it is imperative to consider other *presently extant* strategies, methods, and techniques of representing and imagining weather, nature, and future.

On a smaller scale, a maybe less provocative question: what if not everything that is relevant is quantifiable or expressible in code? Are the limits of knowledge of the totality merely observational and computational? Is the future, and its uncertainties, a matter of more powerful computers running more advanced versions of models? Can we really expect to reach a full understanding of the complete cycle, that is, expect to write a model that is not a version 0.9.*x* but a version 1.0, capable of holistic representation, and therefore *in accordance to the whole* (*kat'holon*)? Or is it the product of a metaphysical conviction shared between system dynamics and structural-functionalism (Bloomfield 1986: 41)? *A propos* the etymon, D'Arcy says that the Fathers of the Church saw Catholicism as the "total world-religion—the kat-holon—into which the partial elements could be fitted after being suitably purged" (1970: 5). Today the purging is quantitative and secular. Napier (not a Catholic, but nonetheless a 'kat'holicist') purged partial elements, both qualitatively and quantitatively.

A more immediate, simpler question, maybe the pressing one: what if telling the whole story takes a little too long? What if reaching the representation of the totality takes a little too long for action to be timely? Are we going to be busy calculating the apocalypse when it arrives? What confidence can we have, and where does it come from, that the story, the full description of the world, the full *dynamic* description of the world, will be ready before it is too late for change? At the 14th Conference of Parallel and Distributed Computing and Systems, David Stainforth said that "the quantification of uncertainty in climate predictions requires of order 1–2 million integrations of a complex climate model. This is beyond the scope of conventional supercomputing facilities" (Stainforth et al. 2002: 32). The Earth Simulator, one of the workhorses on which the IPCC bases its findings has a different approach:

> [W]e seek to overcome the difficulties involved in simulating complex natural and social systems by developing holistic simulation algorithms. *Next-generation* simulations based on holistic algorithms are expected to lead to advances in many research fields involving the study of complex systems such as environmental science. (JAMSTEC 2008b; emphasis added)

In early May 2008, Prof. Julia Slingo, Director of the Centre for Global Atmospheric Modelling at the University of Reading, and IPCC contributor, stated in a BBC interview that it would take computers 1000 times more powerful, and that

> [w]e've reached the end of the road of being able to improve models significantly so we can provide the sort of information that policymakers and business require . . . In terms of computing power, it's proving totally inadequate. With climate models we know how to make them much better to provide much more information at the local level . . . we know how to do that, but we don't have the computing power to deliver it. (BBC 2008)

There are other elements at play. The human element, so difficult to map into predictive models, does influence model-making. Reading the documentation from meetings and communications between working groups, research centres, researchers, government agencies, universities, one finds a tremendous array of negotiations at various levels, negotiations that bear direct impact on what models can do: telecommunications, data compatibility, user-right policies, delays in data transmission, and so on. The THORPE Global Interactive Forecasting System noted that, in its Grand Global Ensemble project, that "a place to develop verification for the multi-model ensemble is not yet identified. Although interest exists in several centres, no centre can already commit workforce" (WMO 2007).

Models represent the 'totality', but also in a wider sense than intended: they represent the model-making world, the code, the mathematics, the theory, the systematisation of the climate, the hardware. Ultimately, they represent themselves, in their limitations, resources, and community organisation, in the "struggle for the imposition, expansion and monopolisation of what are best called resource-relationships" (Knorr-Cetina 1981: 82). They represent the humans who create them, and their preferences. This, however, does not make them representative of the totality. The WMO, for example, wishes "to encourage greater awareness in the research community of the importance of verification as a vital part of numerical and field experiments rather than an "afterthought" (2008). Simon Schaffer states that

> predictors have to move between specialist technical work and public, widely accessible, concerns. One mistake is to suppose that the culture of the wider public has no effect on the specialist predictors; it does. A lesson of the comet stories [which Schaffer's article traces back as far as Kepler and Brahe] is that the most apparently technical estimates of cometary science are very sensitive indeed to public needs and attitudes. (1993: 54)

Some contingent factors in scientific research are recognised, but they tend to be addressed through procedural and disciplinary objectivity (Megill 1994: 5, 10; cf. Porter 1995: 4), as in the WMO example above.

MODES OF COHERENCE

It is not my intention to play a 'Requiem for Large-scale Models'. Douglas Lee wrote a paper with that title in 1973, but the usage of large-scale models has increased sharply since, reaching a situation of dependence. Models are our most powerful learning and research tools in climate science. But the representation of the totality also represents the 'dance of agencies' (as Pickering has called it) practised by global climate modelling. Quantification both bridges and separates nature and society, science and decision-making. Projects and strategies to overcome heterogeneity of time through overarching temporal narratives are signature elements of modernity (Greenhouse 1996). Linear time structures universal narratives, and orders the multiple 'inhomogeneities' of the world into a politically ordered project, with agency distributed according to universal, impersonal, and therefore neutral rules. We will see, in later chapters, how the differentiation of particulars from universal realities is an outcome of universal narratives of climate change, and how it orders/deletes local and situated narratives of time and nature.

That will then bring us to the last chapter, to consider *current* non-universal narratives of nature and time, under the guiding question: How do we represent irreducible multiplicity with action in mind? This question is fundamental because every revealing of the future is an ordering of the future. What strategies, what methods can we use to imagine our futures, if "it might be perfectly appropriate to imagine representation in ways that wholly or partially resist explicit symbolisation" (Law 2004: 87–88)? I am guided by the conviction that there are at least three institutionalised modes of cohering (or dealing with coherence) that have been part of these discussions, in different—and not always separate—ways, for a long time. These are religion, science and art.

Religion (Latin *religiō:* re + *ligāre:* to tie, fasten, to bind) allows/creates an excess of coherence ('excess' in relation to our cognitive and epistemic abilities). The world, our world, coheres with that which is beyond and above and around and within it: everything makes sense together—no exception—and every non-thing makes sense in the same ensemble. Even if (actually, *because*) it exceeds our ability to grasp it, the coherence is total. Theological models, Ramsey says, are judged by their stability over the widest possible range of phenomena and their ability to incorporate the most diverse phenomena not inconsistently (1964: 16).

Scientific knowledge allows/creates coherence that, while not being absolutist, is universalist. Every element, residue or trace that does not fit is a non-thing. In the case of climate change, it makes invisible that which does not cohere or compute. Wynne and Shackley have famously proposed that uncertainty discourses should be understood in this context: they are boundary-ordering devices that "reconcile heterogeneity and cohesion . . . they are 'shorthands' for achieving some understanding among actors involved in highly fluid institutional and epistemic set of relations" (Wynne and Shackley 1996: 280).

Art allows/creates an excess of non-coherence: things fit (sometimes) in some ways, for varyingly transient/stable reasons. They do so in relation to each other, locally; or to each other, remotely; or to the whole, diffusely. Things recede into non-things and vice-versa, through varyingly transient/stable paths. The coherence of the whole can only be proposed locally, sensorially, more or less exposing the process of making (and the imagining that with it forms a dialectical open-ended process).

If indeed "scientific, social and philosophical conditions conspire to create frames of reference that shift the definitions of what is acceptable in the study of experience" (Clandinin and Connelly 1994: 414), then it is important to experiment with alternative forms of making and expressing knowledge, conveying experience, proposing validity, encouraging action. "Can we design our models for the earliest discovery of our ignorance?" (Beck 2002: 4); and if we circumscribe modelling to this role, what spaces do we create, or open, for other modes of coherence to operate in?

There are no clear boundaries between these forms of coherence making (see Box 4.2). Both historically and currently, those boundaries exist where they are enacted. It is very easy to find artistic expressions that serve religious narratives, scientific programmes that are imbued with theological beliefs (Rotman 2000; Bloomfield 1986). The boundaries aren't all that clear between the beauty of art and the formalism and exactness of mathematics:

> Contrary to the conventional impulse to separate the hard zone of the functional and utilitarian from the soft domain of beauty, value and style, in mathematics they are fused at precisely the point where the world—already and ineradicably a mathematized domain—exerts a selective pressure on the mathematics that will best, most aptly, most beautifully, most concisely fit it. (Rotman 1993: 144)

Box 4.2 György Ligeti—BBC Radio 3 Interview (Excerpt)

You said you take a pencil—you still write in pencil? Are your manuscripts tidy or is there an enormous amount of crossing out?
Enormous amount of crossing out. For my piano concerto there are many hundred first pages.

You had twenty attempts to start it, is that right?
Much more. Much more. Maybe more than 100. I never counted, I am not aware. It takes time until . . . it's something which I cannot explain, because it's just a feeling. There is a screw which has to be adjusted very exactly . . . The cogs have to . . .

To mesh.
To mesh, exactly. There is a description of Yeats, in English, about a puzzle which you try, you try . . . in a certain moment, you succeeded. And I think this is a wonderful image for this kind of work. It's not only the free fantasy of the composer or of the artist in general. There is something where things have to have a certain consistency, but don't ask me what this consistency is. In a mathematical deduction, I can exactly show what is consistency. In art there is no such consistency.

But you just have that sense that you have reached the point when it fits, when it meshes?
Yes. So, why I'm so slow in composing and revising all the time and rewriting pieces; until I have the feeling, it's like a mathematical structure, but it's never a mathematical structure, in fact.

A sense of the mathematical may validate it, but it doesn't drive it in the first instance?
Yes. And it's an emotional validation, not an intellectual one and when I imagine music, it's naïve first. But then I am very interested to have a . . . like in a school where the teacher gives you a certain problem, solve this problem (BBC undated [c. 2002?]).

That deterministic reductionism has reigned in the environmental sciences and dominated mathematical modelling (Young et al. 2004: 385) would only contradict Rotman's words if we were to consider the enactment of boundaries to be epistemologically stable, and not rhetorically, scientifically and institutionally performed.

For something that does not exist, the end of the world has changed a lot in the last forty years. Four decades ago, the decisions and actions leading to the destruction of the world (by nuclear warfare) seemed relatively simple. Relative, that is, to today's narrative of destruction. Forty years or so on, the new apocalyptic narrative—climate change—has changed how we perceive the complexity of causality, the decision-making process, and the action leading to destruction or salvation. Our disastrous future now looks very different, the fundamental difference being the current perception that it is up to every single individual and every organisation (large or small)—in the infinitesimal weight of their every decision—to bring about the end, or avert it. The democratisation of the apocalypse distributes apocalyptic agency to a near infinitesimal point, close to dissolution. From infinitesimal causes to infinitesimal decisive action, the urgency of change tends to dissipate with this democratisation of the end. Finding ultimate coherence between these two poles may be an impossible task to impute to quantification alone, assuming ultimate coherence is the case.

It is significant that a famous composer and practising mathematician like Ligeti accepts the messiness of *imagining* and *making* without a clear need for boundary work, and considers the emotional to be a form of validation. Brian Rotman notes how, in mathematics, the subject and the process of making are consistently elided (1993), and Breslau and Yonay note how, in reports of econometric modeling, there is "maximal separation of the author's agency from that of the model" (1999: 319). Acknowledgement of the subjectivity of models and simulations can sometimes be found. As a respondent (inorganic chemistry) quoted by Dowling says, simulation is not strictly science, but "more like an art . . . It's just, you have to have a feel" (1999: 269). Ligeti adds, in his interview, that the audience recognises that form of validation. Does art have potential to *demonstrate* (Latin '*démonstrāre*', to show, point out, derived from '*monstrum*', sign, portent), through the visible messy trail of making and imagining (and the discarding, suggesting, hesitating that go with it), that 'everything conspires'—as Leibniz would optimistically have said; that, simply (in complexity terms), the switching on of a lamp in the office next door did set off a storm in New Orleans?

5 Imagining Futures

The Special Report on Emission Scenarios

> The apocalypse is finished, today it is the precession of the neutral, of forms of the neutral and of indifference. I will leave it to be considered whether there can be a romanticism, an aesthetic of the neutral therein. I don't think so—all that remains, is the fascination for desertlike and indifferent forms, for the very operation of the system that annihilates us.
>
> Baudrillard, *Simulacra and Simulations*

IPCC EMISSION SCENARIOS

The IPCC says, in its Special Report on Emission Scenarios (SRES, or Report), that modelling "very complex, ill-understood dynamic systems" has three main sources of uncertainties: data uncertainties, modelling uncertainties, and completeness uncertainties (2000: Technical Summary [TS] 2). These uncertainties make predicting future GHG emissions impossible, so *a fortiori* the effects of climate change. These depend on emissions, on poorly understood variables and on completely unknown variables (2000: TS 1), so that "information on the relevant variables is so incomplete that they can be appreciated only through *intuition* and are best communicated by *images and stories*. Prediction is not possible in such cases" (2000: 1.2; emphasis added).

The future cannot be predicted. More accurately, there isn't *a* future to be predicted, which leaves us with two options. The first, not even worth considering, is forgetting about the future. The second is to employ non-predictive methods to explore multiple possible futures. Exploring multiple unpredictable futures through limited understanding, limited methods, and limited data requires a plurality of viewpoints. *Exploring multiple futures with action in mind requires methodological plurality.* I suggest we take this as the guiding statement in the present analysis into (a) how the IPCC works to overcome the severe limitations of predicting the future, when it is urgent to know the future consequences of our present actions and choices; and into (b) how this is formulated in the SRES, through words, methods, and outcomes.

The Report indicates that multiple types of data, data sources, and data interpretation are part and parcel of such methodological plurality: narratives, intuition, computers, stories, formulas, subjective preferences, diagrams and charts, tables and graphs, flowcharts, assumptions, standardisation—all are said to belong to a wide array of tools used to explore futures. To *see the multiple through the plural*, the IPCC puts great effort in the participatory nature of the process, in the availability of its data and its findings for scrutiny and feedback from the scientific community, and in the inclusion of a diversity of modelling approaches and interpretations of driving forces and their interactions. When, in 1998, the Bureau of the IPCC made the preliminary scenarios available to modellers in 1998, it recommended that

> the new scenarios be used not only in the IPCC's future assessments of climate change, its impacts, and adaptation and mitigation options, but also as *the basis for analyses by the wider research and policy community* of climate change and other environmental problems. (IPCC 2000: Preface; emphasis added)

As an intergovernmental panel, the IPCC also takes into account, in the elaboration of scenarios, the needs and preferences of its users. The ambitious aim of the Report is to—at the same time—include intuition, imagination, and subjective preference, and to generate results stable enough to be the base of further analyses, to be 'reproducible'.

How many Earths Are There? Making the Object Stay Still

The Report states, in its Summary for Policymakers (hereafter SPM), that "by 2100 the world will have changed in ways that are difficult to imagine" (IPCC 2000: SPM 4). These inherent and fundamental conditions of obscurity (prediction is impossible, imagination is difficult) subtend the work of generating policy-relevant neutral information. The 'cascade of uncertainties' (Kellog and Schware 1981) means that as the timescale increases, so uncertainties increase exponentially. With "an infinite number of possible alternative futures to explore" (IPCC 2000: TS 6), the IPCC has adopted scenarios as a "major tool" to analyse potential long-range developments in emissions and socio-economic developments (2000: TS 1). Others have used scenarios in similar ways. Large international institutions and corporations (famously the World Bank, RAND, the UN, and Shell), and a rapidly increasing number or regional, national, and local bodies and organisations, are using them for economic planning, environmental assessment, integrated assessment, military and corporate strategy, disaster relief, and so on.

An IPCC scenario is "a linking tool that integrates qualitative narratives or stories about the future and quantitative formulations based on different formal modelling approaches" (2000: 1.2),[1] a "plausible future climate that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change" (2001b: 13.1.1). It generates neither predictions nor forecasts, but images of the future, or alternative futures

(2000: TS 2), and it is "an appropriate tool for summarizing both current understanding and current uncertainties" (2000: TS 1). To bring together quantitative and qualitative elements, the IPCC uses scenarios as an integrative method 'allowing' intuition, analysis, and synthesis (2000: 1.3).

The obscurity does not seem to dissipate, at least for now. In short: to work through an infinite number of possible climatic futures, we need integrating and summarising a diversity of views. Needed because we do not know how emissions behave in the context of unknown circumstances; or how they will evolve and how their circumstances will evolve, and why; we do not know all the factors at play and we do not know how to know them (IPCC 2000: TS). Also needed because the infinite doesn't lend itself to being known; because the object of study does not exist, it cannot be adequately circumscribed. Its multiplicity is infinite, in number and mode. Of course GHG emissions exist now, and will exist in the future. But the futures that result in diverse cumulative concentrations of GHGs do not exist. They constitute an *indefinite infinite*, and that does not qualify as an object of systematic knowledge. This is troubling: the obscurity seems to dissipate into intractable multiplicity.

To contrast, the next perihelion of Halley's Comet does not yet exist, in the sense that it has not taken place. But a lot about it can be said with a great degree of certainty. It will occur on 28 July 2061, and we can describe it in greater detail than GHG emissions in, say, three years. Neither those GHG emissions nor the 2061 perihelion exist. But emissions are not defined, its relevant circumstances (and especially their interactions) cannot be fully known, much less described. The 2061 perihelion exists as a discrete—or distinguish*able*—event, because we can determine its relevant variables, and their interactions (for the purpose of prediction). Facing an indefinite infinite is more complicated than facing obscurity: how do we manifest something that does not exist as an external independent object, that resists the stabilisation that would make it 'objective', an object (i.e., circumscribed and describable)? How can we represent something that does not precede its manifesting? If the object will not 'come forth', we must make it manifest. Making the object manifest (by stabilising exploratory arbitrary futures for widespread use) amounts to a *manifest making*.

It is not just the future that is a manifest making. Descriptions of the present are also always partial, something that 'holism' tries—and rotundly fails—to overcome. The past too resists complete knowledge (see IPCC 2000: 5.1 on past emissions; cf. Strathern 2004: 20 on making present choices about the complexities of the past). When the object of knowledge is the totality, its representation is necessarily a manifest making, both 'generative' and 'performative' (Law 2004). This means multiple futures and multiple presents to deal with, to choose from, and not independently. Each model used in the Report presents a distinct present and a distinct past. The formulation of a past and present world involves a great deal of both making manifest and making absent. The objectual existence (i.e., as an independent, external object) of presents and futures is different, but their objectification is inseparable.

This both begs evidence and does not answer the question 'how do we manifest an object of study that does not objectively exist'? A question that is related to the guiding statement proposed above: *representing irreducible multiplicities with action in mind through methodological plurality.* To look for evidence and answers, let us take a look at how the IPCC's integration and summarisation moves from an infinite number of futures to a small number of possible futures. The pertinence of the above question is attested by statements like, "Scenarios offer decision makers an unrivaled methodology to learn from the future before it happens. Yet . . . there is no single approach to developing and using scenarios" (Fahey and Randall 1998: 21).

The Structure of Collective Imagination

The first set of IPCC scenarios was published in 1990 (usually known as SA90), two years after the IPCC was created. The 1992 set—usually known as IS92—became widely used after its publication. A little too widely, as a matter of fact. One particular scenario in the set, the IS92a scenario, became the *de facto* reference case in numerous studies, contrary to the IPCC's intentions, and used as the only reference emissions trajectory. The 1994 IPCC formal scenario review concluded that there was no objective basis on which to assign likelihood to any of the scenarios. Work towards new scenarios began in 1996 at the request of the Plenary, and the Working Group III appointed a writing team in January 1997. This means the current set of IPCC scenarios was sketched more than a decade ago. The IPCC is currently working on a new set of scenarios, to be called '*representative* concentration pathways'.

For the 2000 Special Report on Emission Scenarios, the specially appointed team agreed on elaborating scenarios based on a four-step process, in line with the *modus operandi* of the IPCC (i.e., a body that does not conduct primary research, instead relying on peer-reviewed scientific literature to base its findings, projections, estimates, and scenarios). The first step was a "review of existing global and regional emissions scenarios from the published literature and development of a unique database of 416 global and regional scenarios"[2] (IPCC 2000: 1.1). The second step was an analysis of the database, focusing on main characteristics, their relationships, and driving forces. The third step was the formulation of specific storylines and the development of quantitative prototype scenarios from those storylines. "Four storylines were developed by the whole writing team in an iterative process that identified driving forces, key uncertainties, and quantitative scenario families" (2000: 1.1.6). This is done by "six leading groups representing the main modelling approaches from around the world" (2000: 1.1). Storylines were quantified to generate one marker scenario per storyline. Features of models and preferences of modelling teams were taken into account in creating the four marker scenarios. These four scenarios were posted online for open review and scrutiny by the modelling and scenario-building communities for half a year, with some published in peer-reviewed literature.

The fourth and last step was a review by experts and governments, after the reception of feedback from modelling groups and experts around the world (partially nominated by governments).

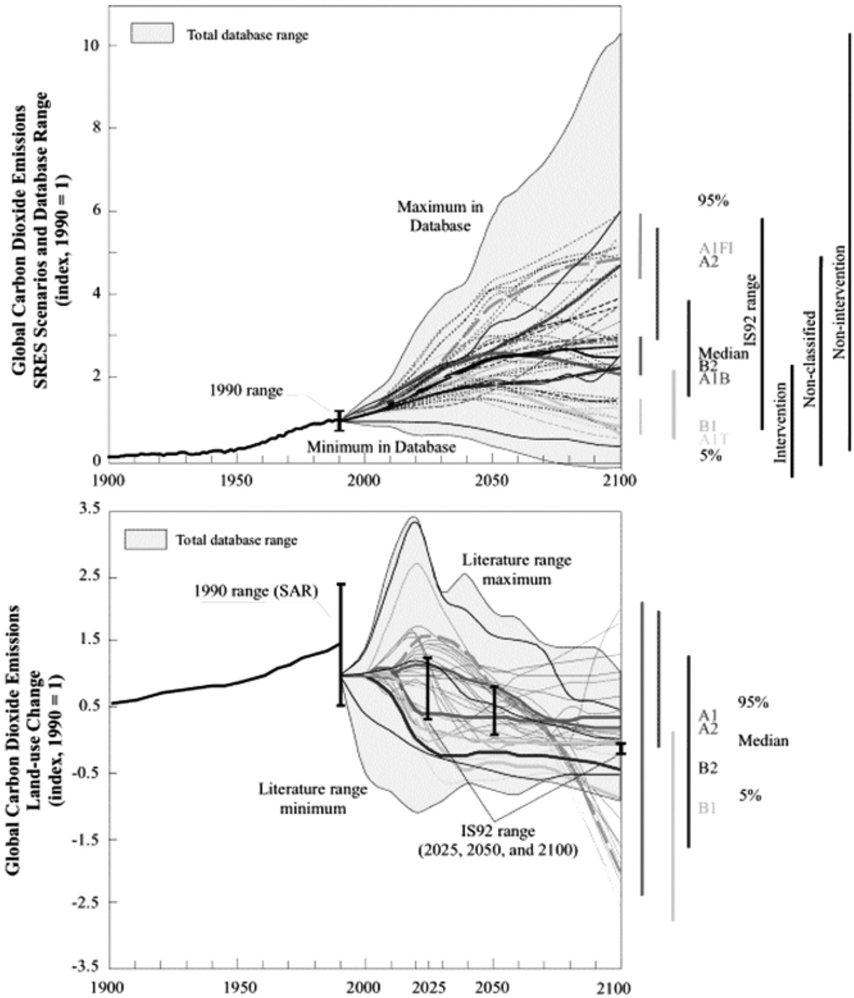

Figure 5.1 Global SRES CO_2 scenarios (land-use change), backgrounded by the database range (light blue area), marker scenarios (coloured thicker lines), each scenario family range (vertical bars on the right), IS92 range, and classification ranges (both in black vertical bars on the right). (IPCC 2000 SPM: 7)

Box 5.1 Driving Forces

Forces that drive GHG emissions are the fundamental factors in constructing scenarios of the future, in the context of climate change. These driving forces, in the case of the IPCC, extend the STEEP framework (Social, Technological, Economic, Environmental and Political) to include Demographic, in what might be called a STEEPD analysis. The driving forces behind the SRES scenarios are population, economic development (economic growth and per capita income), and structural and technological change (divided into energy systems—primary energy use, hydrocarbon resource use—and land-use change. Different assumed trends for these driving forces generate different 'storylines'.

From thousands of scenarios peering into infinite possible futures to a few marker scenarios, what is distilled and what is discarded in the process of scientific review, consultation, and scenario elaboration? How is the diversity of perspectives safeguarded from the pressure of integration and summarisation? From an infinite scope of possibilities, a final set of forty scenarios with no indication of probability was presented. Of what is this set an indication? How is it determined, in a scenario, what results from imagination and creativity and what results from scientific endeavour? What is the difference? This last question does not intend to be cynical, but double.

First, is it different? In a scenario line plotted along a two-dimensional graph, can the formula-based calculations be unravelled from subjective preferences and quantitative assumptions? The simple answer is no. Idiosyncratic features of models and team preferences are invisibly inscribed in graphical displays of future amounts of GtC (Gigatons of Carbon). The stated aim of these scenarios is to integrate qualitative and quantitative, not differentiate. The amount of imagination per future GtC is not seen as undermining the wide use of the IPCC scenarios, but as an integral part of an exploratory process. Second, what difference would it *make*? What is to be gained from the differentiation of the quantitative and qualitative? The quick answer—and the IPCC's answer—is 'nothing', in the current circumstances.

These answers, quick as they are, need more consideration. For complex multiple futures to be grasped, simplification is needed. And making simple futures isn't simple at all:

> Harmonization of important scenario driving-force inputs was neither possible for all scenarios and for all participating modeling teams, and nor was it judged desirable, as the adoption of any harmonization criterion somewhat artificially compresses uncertainty. This is also why simpler harmonization criteria were adopted . . . that focused on global population and GDP growth profiles. (IPCC 2000: 4.4.1)

There is no simple way of summarising an indefinite infinite. A slower evaluation of these answers will also address what brought us here: *how do we manifest an object of study that does not exist* when *representing multiplicities with action in mind through methodological plurality?* The detail of the SRES scenario creation process, the process of making things simple, might render the slower answers, drawn from the complications of creating the simple from the complex, of creating visions of the invisible, of creating meaning from the unknown.

THE KAYA IDENTITY: COMMENSURABILITY AND EXCLUSION

There is a great deal of diversity in the set of 416 scenarios selected from the literature to compose the database. The futures they plot diverge, as do the spatial, geographical, and temporal scales on which they are based. Some are the result of careful, complex, and iterative computational modelling, some "are generated using simple spreadsheets or even without any formal tools at all" (IPCC 2000: 2.4). The greater the diversity of methods, scales and metrics, assumptions, languages, approaches, and objectives, the more possible futures can be considered. Diverse futures call for plurality of methods, but the task of analysing heterogeneity from a unifying framework becomes a very complicated nexus of compromises that demonstrate how the present world is, manifestly, a making.

> Even when the regions are similar or equivalent in terms of this assessment, the names are sometimes different, which hampers comparisons. Such *gaps in knowledge* limit the range and effectiveness of the various policy options that logically follow from the discussion. (2000: 2.3; emphasis added)

Having several names for the same regions is not a gap in knowledge. It is multiple incommensurable knowledge (amounting to excessive knowledge for the purposes of the SRES team). Multiple names are seen as a gap in knowledge because they resist standardisation. This reveals how diversity is seen as something to overcome, a gap to cover, more than something inherently valuable.

Different scenarios also document their assumptions and driving forces to different degrees, or do not specify how they are quantified or made part of the narrative, and have different base years with large discrepancies of values (IPCC 2000: 2.4). Of the 416 scenarios, 230 only report CO_2 as a GHG, and only 20 estimate land-use based emissions, which make up a large percentage of GHG emissions. Like the difficulties with names, classification of scenarios between (policy) 'intervention' and 'non-intervention' faced "many ambiguities". Many simply could not be classified in those terms. Against complexity or complication, they became part of the category of "non-classified" (2000: 1.7.1). This pragmatic classification system results in “considerable overlaps” between ranges. The IPCC goes as far as saying that the typology is arbitrary and often impossible to apply.

It is clear to see, from this, that intuition and subjective preference do play a part in emissions scenarios. There is no other way. But instead of valued, they are a source of difficulties, given that the sole common denominator is quantification. This creates issues in generating usable images of the future. If they are seen as too arbitrary, unreliable, or based on unrealistic assumptions and values, their adoption will be at risk.

The IPCC deals with this *mess* by applying the Kaya *identity*[3] (developed by Kaya and Yokobori in 1990; see Kaya and Yokobori 1997; also Kaya 1990), an application of the IPAT formula, devised by Commoner, Ehrlich and Holdren,

$$I = P \times A \times T$$

where *I* is the environmental impact, *P* is population, *A* is affluence, and *T* is technology. The Kaya identity’s four factors represent main driving forces: population, gross world product, energy consumption, energy intensity (energy per unit of gross world product), and carbon intensity (CO_2 emissions per unit of energy), so that I = P × A × T is converted to

$$F = P \text{ x } (G/P) \text{ x } (E/G) \text{ x } (F/E)$$

where F represents total global CO_2 emissions, P is global population, G is global GDP (and G/P is global per-capita GDP), E is global primary energy consumption (E/G is the energy intensity of world GDP), and F/E is the carbon intensity of energy (CO_2/Energy, as applied in SRES, but other GHGs can be factored). The *identity*, as the ‘=’ sign indicates, is between GHG emissions and the interaction of the other factors. This method of quantification is, of course, not comprehensive. It is followed by a harmonisation of driving forces with the underlying narratives through control parameters. Different model architectures yield different results.

The messy diversity is strained through an identity. By ‘disaggregating’ driving forces, the Kaya identity allows standardisation of scenarios and better comparisons, even if the SRES is cautious in clarifying that this presumes no causal relation. However, this is not without its drawbacks:

> [T]he literature review focused on the documentation and the assessment of quantitative scenarios, for two reasons. First, it was not possible to devise a classification system that would allow the documentation of many different forms of narrative scenarios. Second, the SRES *objective was to develop a set of numeric emissions scenarios for use in the IPCC and other assessments of climate change*. (IPCC 2000: 2.1; emphasis added)

The problems seem to increase. Even the more elaborate qualitative scenarios do not allow “assign[ing] internally consistent values to the various scenario characteristics" (IPCC 2000: 2.1) as quantitative scenarios do. This way, disaggregation results in excision of the incommensurable. Not because of the value of qualitative scenarios, but because of our inability to work with them. This throws up questions about our ability to manifest the multiple, to make it representable as multiple, to use tools to draw things together, or use them to cut off the parts we cannot make commensurable. The Kaya identity turns some variables into tooled excess. Tooling away the unclassifiable, and that which does not match the restrictive identity, does away with the mess of the multiple. Its presence would otherwise make indistinct the shape of the definable. Co-mensurability defines what goes with what, co-existing in coherence, and what is excluded. Higher-level (more general) driving forces permit a wider coverage of uncertainties, but diminish resolution. The level of detail required is both a completeness and modelling uncertainty. The 'totality' cannot be made to manifest itself, but it must be represented. This imperative makes neutrality impossible.

Inscribing Futures

As the above clarifies the relation between *how to manifest an object of study that does not objectively exist* and *representing irreducible multiplicities with action in mind through methodological plurality* (but does not yet provide answers), it raises fundamental questions about scenarios as "major tools" to represent those multiplicities. The exclusion of the qualitative, the incommensurable, and the unclassifiable upholds old boundaries between valid and subjugated knowledges.

That which passes through the strain of the Kaya identity is representable, communicable. It is designed to be shared and used widely, a stable source of further investigation. It can be downloaded, recalculated, tweaked, shared. Printed and pinned to the wall of the research office, I can point at its future values with my index finger. Pointing at a value on a table, indicating CO_2 levels in 2100, I no longer imagine, but indicate, a future that seems anterior to the indexical move (see Table 5.1). Pointing to the SRES scenario chart on the wall of the research office, I put my finger on a sign. It signals a future as it veils a past, an origin which grants the manifestation the stability it requires to no longer be a transient presentation, but a representation. The past it veils is the past of its own constitution, a past of 416 fractions that grants ontological stability to imagined futures; a past path from manifest making to reproducibility. As a sign, the graph is secondary to an origin, and provisional (Derrida 1991)—it stands for it, it is derived from it, a mediation that is a distancing from the origin. The future becomes more objective as it becomes objectualised. The more it is represented, the more stable its past becomes.

The quantification of the Kaya identity awards SRES scenarios the most deferent of deferrals: the numeral. As a mode of writing, its secondarity to

Table 5.1 Global SRES CO2 Scenarios: Distributions of Emissions/Year Variation from Land-Use Change, for All Scenarios Until the Year 2100, Where 1990 Has a Value of 1 (IPCC 2000: 5.3.3)

Global CO2 (MtC) emissions by sector and source category for seven scenarios calculated with the MESSAGE model for 1990, 2050, and 2100. In the SPM, A1C and A1G scenarios are merged into one fossil-intensive A1FI scenario group.

	1990				**2050**										**2100**
		A1B	A2	B1	B2	A1T	A1G	A1C	A1B	A2	B1	B2	A1T	A1G	A1C
Supply Side															
Energy Supply/Transformation															
Electric generation	1773	4783	4875	763	2844	2192	6519	5924	7541	9283	207	5323	293	8854	11166
Synfuels production	0	1162	1613	2207	929	1278	2294	3958	170	7245	2071	2848	441	3619	9788
Other conversion*	680	2277	1312	999	1170	1506	3012	719	2901	2393	735	1394	807	7682	622
Direct Use of Fuels by Sector															
Residential/commercial	880	2782	1618	1361	1494	2362	3606	2458	1402	925	367	973	656	3085	1255
Industry	1289	1540	1515	843	1401	845	987	1165	273	1601	176	1166	503	984	631
Transportation	1310	3823	2952	2669	2587	3445	4513	5587	1881	4524	1135	1845	1577	5924	8640
Feedstocks	303	912	1311	490	891	972	766	768	91	1963	66	398	448	535	422
Non-Energy Emissions															
Cement prod./gas flaring	68	172	192	65	104	141	206	249	136	479	36	187	64	224	462
Land- use change	1010	-139	-104	-902	-436	-139	-139	-139	2	81	-646	-501	2	2	2
TOTAL	7312	16789	15044	8367	10983	12601	21802	21086	14397	28493	4147	13634	4789	30909	32988
Demand Side															
Residential/commercial	1995	7212	4631	3126	4059	4846	10290	7032	9407	7827	1698	5830	1209	14971	10939
Industry **	2784	3916	5734	1975	4042	2996	4388	4434	1471	9165	601	4909	1244	4341	3493
Transportation	1523	5800	4783	4168	3318	4897	7262	9759	3516	11421	2494	3396	2334	11596	18554
Land-use change	1010	-139	-104	-902	-436	-139	-139	-139	2	81	-646	-501	2	2	2
TOTAL	7312	16789	15044	8367	10983	12601	21802	21086	14397	27493	4147	13634	4789	30909	32988
By Source															
Solids	2346	5356	7106	841	2230	2643	7553	12471	6166	22586	565	7765	188	3904	29596
Liquids	2787	5618	4100	3832	4542	5007	7310	4185	2751	933	910	1039	1542	7813	1118
Gases	1102	5782	3750	4532	4544	4949	6872	4320	5342	4415	3283	5144	2993	18967	1810
Others***	1078	33	88	-837	-332	3	67	110	138	559	-611	314	66	226	464
TOTAL	7312	16789	15044	8367	10983	12601	21802	21086	14397	28493	4147	43634	4789	30909	32988

* Includes emissions from district- heat production, energy transmission/ distribution, oil refining, fuel extraction, and other conversion losses.

** Includes emissions from feedstocks, cement production, and gas flaring.

*** Emissions from land- use change, cement production, and gas flaring.

numbers and mathematical objects is assumed and unquestioned (Rotman 1997). If, on the other hand, one attempts

> to put into question these traits of the provisional secondariness of the substitute, one would come to see something like an originary *différance*; but one could no longer call it originary or final in the extent to which the values of origin, archi-, *telos*, *eskhaton*, etc. have always denoted presence—*ousia, parousia*. (Derrida 1991: 62)

As classification produces difference, it produces its own *différance*: 416 futures are too many to point at. The sheer diversity (in number and type) is incompatible with a workable basis for repeatable analysis that is to be coupled with simplicity. A smaller infinity of futures is required.

MINIMUM INFINITE

From a larger than knowable number of available scenarios, the 416 selected for review had a wide array of working assumptions (not always explicit), had substantially different initial conditions (e.g., GDP had a maximum variation of 32 per cent between models), worked with different driving forces, were quantifiable to different extents and in different ways, and so on. Incidentally, not all could be graphically displayed as a total ensemble, due to software limitations. The total number of scenarios that can be worked with, to define a database of quantified values, is progressively funnelled as it becomes compatible with the methods, tools, and objectives of the SRES team.

With the review completed and the database finalised, the third step started with a wholly qualitative construction of the four storylines. Four storylines to avoid the issues raised by IS92, the scenario that became *aurea mediocritas*.

> The writing team consciously applied the principle of Occam's Razor . . . They sought the minimum number of scenarios that could still serve as an adequate basis to assess climate change and that would still challenge policy makers to test possible response strategies against a significant range of plausible futures. (IPCC 2000: 1.7.2)

That defines the number of storylines, and it also tells us directly who their main audience is. Each of these qualitative storylines imagines a future according to different developmental paths of the same driving forces and their interplay (based on what I called the STEEPD framework, in Box 5.1), creating what is "basically a short 'history' of a possible future" (2000: 4.1). Storylines are the starting point for the quantification of scenarios and have *coherence*, *usefulness* and *ease of use* as their main reasons (2000: TS). They are also "designed to facilitate specification and further interpretation of scenario quantifications" (2000: 4.1), making the qualitative ancillary to the quantitative. Not only are the storylines designed for quantification, but "quantitative indicators form an important part of each scenario description" (2000: 4.1). This need to quantify as a means to stabilise and disseminate scenarios undermines the stated 'exclusive role of intuition and the preferable role of images'. In practice, the quantitative is the basis and outcome driving the qualitative work.

Back to Napier

We are already familiar with a similar method, based on equivalent premises. To Napier, Revelation was a narrative code elaborated to be cracked through quantification. Its purpose is to reveal, and it does so if the exegete performs a quantified analysis of *certain* elements in the

Box 5.2 The Scenario Narratives

- The A1 storyline and scenario family describes a future world of very rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into four groups that describe alternative directions of technological change in the energy system.

- The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in high population growth. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.

- The B1 storyline and scenario family describes a convergent world with the same low population growth as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

- The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with moderate population growth, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

(from IPCC 2000: Summary for Policymakers, box SPM-1)

narrative. In other words, the future is revealed if the exegete computes the quantities. Revelation, of course, was considered absolutely originary non-human Truth. From Adam's naming of beasts and plants to Napier's present, the Fall had caused a corruption of knowledge, a breakdown of the chain of reference, a distancing between things and words. The disruption of universal unity it brought about required redemption. The role of man in the redemptive process is the increasing of knowledge. Knowing the disastrous/salvific future depended on increasing demonstrable knowledge, based on the coded quantities of the narrative. This increase of knowledge through human agency would assist the redemption of

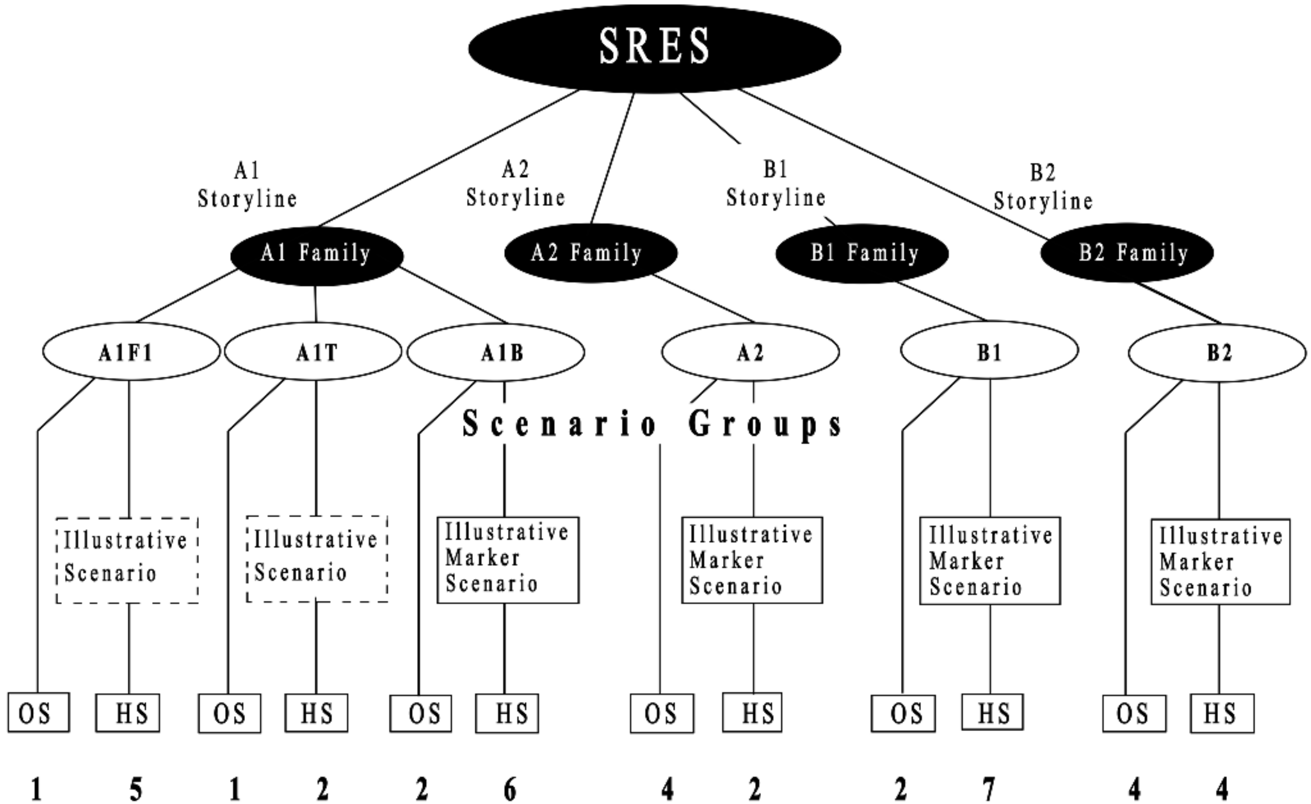

Figure 5.2 Schematic illustration of SRES scenarios. Four qualitative storylines yield four sets of scenarios called "families" (IPCC 2000: SPM 4). 'HS' stands for Harmonised Scenarios.

humankind and nature along with it. No science without the Fall; no re-connecting (re-ligion), no representing, unless "we humans cut our countless ties with reality", as Latour says of the biblical story of the Fall (2004: 16).

Razors for Spaghetti: Applying Occam to the Future

Once each storyline is quantified into a marker scenario, it is then quantified again by each of the six modelling teams. Population and GDP are the Kaya identity 'guidepost' quantifiers (SRES terminology) for each of the storylines and their driving forces. Presented with a future, each modelling team attempts to replicate the marker scenario quantifications in their own models. This generates the alternative quantitative interpretations of each storyline that, with their respective marker scenario, form a scenario family, in a total of four families (see figure 5.2).

Quantified factors are underpinned by a number of wider social, cultural, and educational assumptions "that often cannot be defined in strictly quantitative terms and do not directly 'drive' GHG emissions" (IPCC 2000: 4.2.1). Dropped from the quantification, assumptions nonetheless work as coherence checkmarks in quantification. That is the case with the rate of change of social drivers (usually meaning political stability) or educational development (usually meaning technological innovation). It is *re-present-ability* that is generated, not representations. From each marker scenario, the world can be computed again, represented. It is not a representation, because each new quantification presents a different future. But once there is a *mark, a trace*, it can be retraced or modified. It is not an origin, but a precedent. Other futures can be plotted without referring back to the invisible origin, back to the ineffability of indefinite infinite futures. One can refer/defer back to the mark(er scenario) inscribed, and assume the 'origin'. The future is still an object without an origin, but the opacity of the origin makes the object more stable.

There are some more apparent moves to make the object stand still. The Report states, in a dedicated text box titled "Neutrality of the SRES Scenarios",

> The SRES scenarios are intended to exclude catastrophic futures. Such catastrophic futures feature prominently in the literature . . . In such scenarios GHG emissions might be low because of low or negative economic growth, but it seems unlikely they would receive much attention in the light of more immediate problems. Hence, this report does not analyze such futures. (2000: 4.2.1: Box 4–2)

This does not seem to coincide with concerns on the same matter, expressed by the IPCC elsewhere:

> Extreme events are a major source of climate impacts under the present climate, and changes in extreme events are expected to dominate impacts under a changing climate . . . Methodological issues concerning extreme events in the context of climate change include developing climate scenarios, estimating impacts, evaluating responses, and looking at large-scale effects. (2001b: 116)

Extreme events can occur in non-catastrophic futures, of course, but their occurrence may indicate a(n increasingly) catastrophic future, especially if they dominate impacts. Either way, it is hard to see how this fits with the assertion that "it seems unlikely they would receive much attention in the light of more immediate problems".

The Report describes, in all its scenarios, "future worlds that are generally more affluent compared to the current situation" (IPCC 2000: 4.1). From the stated approach of the IPCC (not attributing probability to any scenario), it would seem that catastrophic scenarios are no less likely than increased affluence scenarios. Limiting the scope of possible futures to the database range does not make the possibilities finite: CO_2 emissions for 2100, across all scenarios, ranges from more than seven times current emissions levels to below current levels (2000: 2.4.1). Not a universal set, but still uncountable. "Unexpected consequences, even the catastrophic ones, never had an impact on the initial definition of the object, with its boundaries and its essence, since they always belonged to a world lacking any common measure with that of objects: the world of unpredictable history" (Latour 2004: 23).

In the A1 storyline, "current distinctions between 'poor' and 'rich' countries eventually dissolve" (IPCC 2000: 4.3.1). All the scenarios assume absolute convergence of per capita incomes (Tol et al. 2005: 8). A major discontinuity in the history of civilisation, but a continuity in the modernist view of history: "[T]his Modernist narrative of progress . . . is beautifully captured in the IPCC Special Report on Emission Scenarios, with its stories of economic growth and technological progress marching on through the 21st century" (Michaelis 2000: 160–161). All the above assumptions are interdependent and also depend on the *ceteris paribus* ('all else being equal') condition.

> The ceteris paribus condition is an important qualifier for the convergence theorem. Evidently, the potential for conditional convergence and economic catch-up cannot be realized in an economy struck by civil war, poor institutions, or even low savings rates. (IPCC 2000: 3.3.4.6)

As Tol, O'Neill, and van Vuuren have stressed (about GDP convergence) in their assessment of the Report, "unsurprisingly, empirical studies have convincingly demonstrated that all else is not equal" (2005: 7). Neutrality is seen, in the SRES, as the non-attribution of negative or positive valuations to scenario developments. Contrary to the literature, where scenarios are often valued as 'negative' or 'positive', the SRES names them A1, A2, B1 and B2. This, the Report says, makes SRES scenarios "neutral" or "agnostic" (IPCC 2000: 4.3). The SRES scenarios also do not include climate policy or emission policy initiatives, as to avoid suggesting that specific climate change policy measures might be better than others. These forms of selectivity leave neutrality in a precarious state, to say the least.

The resulting emission futures are plotted on a graph that is (in instances) backgrounded by the database range. The visual aspect of the graph is designated as "spaghetti curves" (IPCC 2000: 2.4.1; see Figure 5.1). The visual depiction of database and SRES scenarios does not represent past or future emissions, but a sample of futures plotted by past scenario research. The IPCC's application of Occam's razor to the spaghetti of past futures (the scenarios that form the database) cuts scenarios down to a minimum number and forms a workable typology. It then chops the spaghetti of present futures to a minimum: scenarios that include disasters and other discontinuities are among those cut off from the spaghetti of the future.

The SRES team grouped the disparate regions in models into four "macro-regions" common to all the different regional aggregations across the six models" (IPCC 2000: 4.1). The need to find greatest common divisors sometimes leads to post hoc aggregations, which are sometimes also decided for ease of use, as in the case of the combination of scenarios A1C and A1G into one fossil intensive group A1FI during its approval process (see Figure 5.2). The greatest common divisor also resolves the issues raised by different languages. Through lowering resolution, the greatest common divisor (not linguistic diversity) creates gaps in knowledge. Aware of the reductive effect of limited scenario quantification, the modelling teams did not follow, in fourteen of the total forty scenarios, harmonised input assumptions (2000: 4.4.1; corresponding to scenarios marked OS in Figure 5.2).

The IPCC's razor seems too sharp for representation of futures through plural methods. The Report, in both its methodological detail and its findings, offers a wealth of information that merits its claims of openness and inclusion. This information covers mostly matters of consistency of quantification, coherence with assumptions and with driving forces, and internal coherence (e.g., IPCC 2000: 1.5; cf. Tol et al. 2005). Internal consistency is a rule of thumb in the scenario business.[4] To be useful, scenarios need coherence. However, the intuition, stories, images, and other qualitative elements that find space in the outlining of the method have limited application, and end up serving mostly as bounds in the quantification exercises.

This does not yet offer answers to my starting point—*how do we manifest an object of study that does not objectively exist* when *representing multiplicities with action in mind through methodological plurality?*—but it further clarifies it. When the Report makes salient that some variables can *only* be understood through intuition—and in the assumption that this does not mean mathematical intuition—the necessity for methodological plurality is apparent. Ultimately, the qualitative survives in SRES scenarios as it "ensures they do not become an arbitrary numeric combination of quantitative parameters" (IPCC 2000: 4.2.1). This statement confirms the limited role of the qualitative in a methodology that aims to be inclusive. The plurality of legitimate perspectives does not survive the process of quantification.

RECIPES FOR A SCIENCE OF THE MULTIPLE

The discrepancy between the stated importance of the qualitative (in the outlining of the method) and its actual use is a function of boundary conditions. Not the boundary conditions of models, but the institutional boundary conditions of the IPCC. In exploring how these boundary conditions determine the SRES' ability to *represent multiplicities with action in mind through methodological plurality*—and how they shed light on choices like excluding disaster scenarios—I would like to consider Funtowicz and Ravetz's[5] proposition of post-normal science as "a science based on unpredictability, incomplete control, and plural legitimate perspectives" (2001: 173). Their description of post-normal science seems aligned with the needs and objectives of the IPCC. That the methodology requires change in the face of unpredictability, lack of control, radical uncertainty, and ignorance is acknowledged by the IPCC. The institutional boundary conditions of the SRES, however, are indicative of the limitations of some of Funtowicz and Ravetz's more normative suggestions.

While it is true that "forms of knowing other than those fostered by modern Western civilization are also relevant for an exploratory problem-solving dialogue" (Funtowicz and Ravetz 1990: 173), their later conclusions—made in the specific context of global environmental risk—according to which "science will also expand the scope of its concerns" (2001: 194) are problematic. This is evidenced, in the SRES, by the distance between statements on method and methods as practiced. The outcome of scientifically dealing with unpredictability, incomplete control, and plural legitimate perspectives demonstrates the difficulties of making use of other, relevant, forms of knowing. "Science cannot provide certainty in policy recommendations" (2001: 174). Neither can post-normal science, as far as the SRES can be seen as an attempt at a post-normal science (or, at least, as an expansion of the scope of scientific concerns).

As Porter says, objectivity, impersonality and replication of calculations are partly a response to outside pressures (1995). Because the IPCC includes a large number of experts nominated by governments (to provide neutral information back to the same governments, who review and approve its findings), the outside pressures are, in the case of the IPCC, on the inside. It is, in a way, its own audience, sanctioning forms of knowing and acting with which it is familiar: "Why the IPCC was created: Climate change is a very complex issue: policymakers need an objective source of information about the causes of climate change, its potential environmental and socio-economic consequences and the adaptation and mitigation options to respond to it" (IPCC 2006b).

Reproducibility was another reason for 'extreme scenarios' not being considered: they are difficult to reproduce. This, the IPCC says, is compounded by the openness of the process and its usage of several models (2000: 4.2.2). Even within the same language, polysemic terms retain ambiguity that is considered counter-productive: in the TAR, verbal characterisations of uncertainty ranges are accompanied by a quantitative range to confirm that "different users of the *same* language mean the *same* degree of confidence" (2001b: 130; emphasis added). *One language for one world, indivisible, whole.* So, when interpellations are made for "an urgent need for the IPCC to devote more attention to the processes underlying the evolution of cultural traditions and narratives" (Michaelis 2000: 167), one needs to ask if the IPCC is the right body for that attention. The SRES outlook of future scenarios may shed some light on how that urgent need is seen:

> [T]he task of future scenario development entails more than just the adoption of alternative quantitative assumptions. The overall context within which alternative assumptions on productivity growth or energy and materials intensity take place needs to be made explicit. This is *simply because* many key influencing factors (e.g., institutions) cannot be assessed *quantitatively*, or the relationship between factors is known only *qualitatively*. The development of alternative qualitative scenario "storylines" . . . is therefore an important advance over previous IPCC scenario methodologies. (IPCC 2000: 3.3.5; emphasis added)

Is the IPCC, then, the space for the plural to be used *qua* plural? The TAR defined the suitability of each type of scenario for use in policy-relevant impact assessment according to five criteria: consistency (with theory and models) of regional and global projections, physical plausibility and realism, appropriateness of information for impact assessments,[6] representativeness of the potential range of future regional climate change, and accessibility for use in impact assessments (IPCC 2001: 745). This, with the need to find a minimum number of scenarios, does not bode well for plurality. The tendency, or the need, to focus on the quantifiable and to use the qualitative as 'overall context' does not coincide with the extolling of the exclusive virtues of intuition and of the power of images and stories. Or with the calls for a post-normal science, or calls for attention to cultural traditions and narratives. On the contrary, 'key influencing factors' are made contextual, so that those that can be quantified can be dealt with 'objectively'. Because "policymakers require a coherent synthesis of all aspects of climate change" (2001b: 2.4), the question is if the multiple is compatible with coherent synthesis, and how can 'all aspects' be part of such synthesis. The way 'key influencing factors' are seen as recalcitrant, irreducible, and incommensurable with the replicable is symptomatic. Latour goes as far as saying that the "more heterogeneous and dominating the centres [of calculation], the more formalism they will require simply to stay together and maintain their imperium" (1987: 245).

The text of the UNFCCC, which officially frames the work of the IPCC, states that "policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost" (Article 3, Principle 3), a point that the IPCC reiterates (IPCC 2001b: 119; see also 2001c: 75). After "researchers have spent the past decade developing integrated assessment methods to meet these needs of policymakers" (2001: 118), the distinction *made* between the qualitative and quantitative sustains the perception that the qualitative is not neutral, and that it is exterior to mathematical practice, when actually it is "familiar on an everyday basis to mathematicians within their practice" (Rotman 1997: 19). Rotman speaks of imagination, but his overall argument is also about the material, empirical, psychological and semiotic dimensions of mathematics. These are removed with the removal of all reference to agency, Rotman says, a move that upholds mathematical language as a neutral and inert medium. This is a feature of a Platonist view of mathematics; when in fact mathematics is constitutive, it generates meaning.

The boundary work is twofold. Quantification simultaneously enacts the science–nature boundary, and it enacts the science–policy boundary. The boundaries need sustaining because of their permeability: decision-makers have decided that the future shall be cost-effective. Catastrophic futures are not cost-effective. *These futures are made in their manifesting*, and are not *ex nihilo*. Cost-effectiveness is anterior, but not exterior, to the making-manifesting. Quantification is the most important tool in taming the manifest making, in stabilising the inscriptions that translate an imaginative manifesting into "the basis for analysis by the wider research and policy community" (IPCC 2000: Preface). Neutrality ends up being the cathartic narrative device of an audience performing to itself.

The narratives are made rewritable by the performing audience, "through the detour of the sign", the sign that takes the place of the future, to make it present (Derrida 1991: 61). Signifying a (not yet re)presentation is an act of creation, and creativity is sanitised, but present. The mathematical signifier, however, gives the future the anteriority it needs by a deference to its numeral writing system, until its *nth order inscription* (Latour 1987) renders invisible the manifest making of the origin. The future gains an origin that is diffuse in deferral, but also more stable and more transportable (rewritable, recalculable, representable). Graphocentrism (which Rotman proposes as the inverse to Derrida's logocentrism) sustains the "idealized imaginings of mathematics"; it is the vehicle of a deeper, absolute desire, a desire for the stamp of eternity on mathematical objects (Rotman 1993:

156) that makes their embodied apparatus—and its technical choreographies—unproblematic and unqualified.

In developing his argument about the embodied nature of mathematical practice and the efforts at a disembodied writing of mathematics, Rotman partially bases his semiotic account of mathematics on Charles Sander Peirce (1839–1914). While he rejects Pierce's view that reasoning is always a form of disaster avoidance, he is clear in characterising the elimination of certain phobias as "reigning supreme in mathematics". These phobias are "ambiguity in the form of cognitive oscillation or irresolution, blurring or shifting of boundaries, imprecision, or any departure from the clarity and determinateness of either/or logic" (1997: 21). The unpredictable, unknowable, hard-to-imagine futures are represented for iterative representation as clearly as possible, with an array of 'disclaimers' about uncertainties. These futures are meant to be descriptive and not normative, "possible, rather than preferred, developments", because normative scenarios are "explicitly value-based and teleologic, exploring the routes to desired or undesired endpoints (utopias or dystopias)" (IPCC 2000: 1.2). Isn't a range of non-catastrophic scenarios explicitly value-based? Doesn't cost-effective GHG emission reduction subtend the whole of the work of the SRES as a desired endpoint? The IPCC's futures result from circumscribing areas of uncertainty into conquerable terrain ('gaps in knowledge'). These circumscribed realms also become the repositories of the phobias Rotman identifies: the uncertain is the gap inhabited by the 'undetermined', the 'unclear' and 'imprecise', while science can continue to be the realm of the clear and distinct.

The efforts continue, at present, to bring together the quantitative and the qualitative, while upholding the same boundaries. These efforts also confirm Rotman's assessment of Peirce's position, in Rotman's semiotic analysis of mathematics as 'the everyday doing of mathematics'. Beyond establishing the direct and simple connection between disaster-avoidance, phobias, and the excision of catastrophe scenarios from the SRES database and assumptions, I would like to present a number of examples (different in nature and detail) of how the science of climate change gives direction to research, in the face of the potential disasters the IPCC admits as more than likely, and in the face of the need to embrace a plurality of methods.

LOSING PERSPECTIVE: MER VS. PPP AND OTHER STRANGE DIRECTIONS

In an editorial of the journal *Climatic Change*, Pittock (2002) calls for multi-disciplinary work that is open to new ideas and alternative explanations as the only way to develop appropriate policies. The author notes the great progress of the SRES, but rues its mostly *qualitative* conclusions, partly due to the infancy state of truly integrated studies.

In a paper titled 'Using Base-Year Data with Empirical Scenario models' (an important matter in SRES scenarios), Kemp-Benedict questions the narrow focus on quantification as it "misses the richness that can be brought to light in a searching narrative exercise" and explores a role for models that supports "a primarily narrative exercise in a way that makes good use of both qualitative and quantitative methods" (2008). The paper then wholly consists of mathematical techniques to make use of the discrepancy between observed base-year values and a model. It is of significance how the continued call for appreciation of qualitative factors is met with advances in quantitative techniques.

While the IPCC pushes scenarios forward as a method by considering multiple and long-term futures, the discussion about the merits of the SRES scenarios that has followed the publication of the Report completely overlooks the SRES statement about the need for plurality. The most widely debated point of contention (some would say the criticism of the SRES scenarios that has generated the most discussion) started with Castles and Henderson (2003) disputing the use of market exchange rates (MER) instead of purchasing power parities (PPP), when converting regional GDP into a common denominator, saying that it artificially widens the perceived gap between wealthier and poorer nations. With the estimated gap in income being reduced over time in SRES scenarios, estimates for economic development are consequentially exaggerated, and GHG emissions in the scenarios become overestimated. IPCC SRES authors replied to the charge (Nakicenovic et al. 2003). Holtsmark and Alfsen (2005), among others, also disputed Castle and Henderson's claim. Some agree with it (e.g., Mckibbin et al. 2004). The Stern Report weighed in and the discussion expanded, in journals, online, and in the press, with *The Economist* (2003) accusing the IPCC of the "seriously flawed methods it has followed in making its estimates", on the basis of the arguments of what became known as the Castles and Henderson affair.

Schenk and Lesink (2007) accuse Castles and Henderson of "apprear[ing] not to understand the concept of scenario analysis in general and SRES in particular" (2007: 294), a charge that can be extended not only to *The Economist*, but the whole affair: the number and magnitude of uncertainties the SRES mentions, the stated claim of exploring futures without attributing probability, the importance of the qualitative, and all the methodological challenges the world faces in dealing with climate change become secondary to matters of detail, matters of quantification.

Castle and Henderson may be right. As before (Kemp-Benedict example), the question here is not whether their analysis is right or wrong: when the IPCC calls its own SRES driving forces 'coarse' (IPCC 2001b: 115), the question is whether Castle and Henderson's effort is misplaced, and "large problems and broad scientific questions are brought down to issues of detail" (Porter 1995: 219). With a limited number of coarse driving forces, the cascade of uncertainty (Kellog and Schware 1981; also Schneider 1983) easily subsumes the variation caused by methodological options such as MER vs. PPP: "Different modeling approaches and different specifications of other scenario assumptions overshadow the influence of the main driving forces" (IPCC 2000: 6.3.1.1).

One example of this coarseness of the driving forces is the detail with which energy intensity is treated in the models that quantify the SRES scenarios. Because energy intensity cannot easily be disaggregated into its constitutive elements (of which the SRES lists "structural change, price effects, technological change, etc." as examples (IPCC 2000: 4.4.5)), some models differentiate only between 'price effects' and 'everything else' (another interesting classification and nomenclature, used interchangeably with 'autonomous energy intensity improvements' (AEEI)). The SRES recognises that, in the long term, 'everything else' is likely to outweigh price effects. That is relevant in providing the wider context to the MER vs. PPP debate, especially because 'everything else' is "one of the model calibration parameters frequently used to replicate existing scenarios or to standardize inter-model comparison projects" (IPCC 2000: 4.4.5.1). The class of 'everything else' in energy intensity is vague enough to become a calibration parameter, a standardisation mechanism, when its real importance (qualitative and quantitative) is much greater. At the time of the TAR, the Working Group II chapter on 'Methods and Tools' considered, as final concluding remark, that the recent methodological developments in decision analysis were encouraging, but modest.

A rather different example, now. One coming from the opposite direction, so to speak, to reach the same endpoint, or at least an equivalent one. In 2007, Zerefos et al. found a "statistically significant correlation coefficient (0.8) between the measured red-to-green" values in 554 climate proxy data sources. The authors used a

> radiative transfer model . . . to compile an independent time series of aerosol optical depth at 550 nm corresponding to Northern Hemisphere middle latitudes during the period 1500–1900. The estimated aerosol optical depths range from 0.05 for background aerosol conditions, to about 0.6 following the Tambora and Krakatau eruptions and cover a period practically outside of the instrumentation era. (2007: 5146)

The proxy data sources? Paintings by Turner, Degas, Bosch, Durer, Raphael, Titian, Klimt, Rubens, Caravaggio, Poussin, and Tintoretto (to name only a few) representing sunsets from the year 1500 to the year 1900.

The claim—a coherent, well-presented translation of pigment colour to graphical format which corresponds to volcanic events—is that the mathematics of a paintbrush sunset yield a(n objective) representation from a (subjective) representation, a re-representation of sorts. The claim is that from the colours of all those skies, all those artists had commensurable optical depth perception; had a commitment to realistic depiction of atmospheric colour temperature; had calibrated pigment mixing techniques (internally consistent independently of the source of the pigments and of the optical density offset between pigment and the colour temperature of the light in each of those skies); and had consistent physiological colour depth perception, independently of their variable visual acuity over the years—the chemical make-up of the pigments, water or oils, canvas was consistent then, and consistent in chemical degradation over centuries, and so on, all the way until our high resolution, high-density scanners of today read the hues on the canvases, and allow us to extend the network of reinforcing statements all the way to painting.

The claim might hold. It is internally coherent and has been peer reviewed. But what is deleted? Law says that representation is allegory that denies its character as allegory (Law 2004). This particular denial, achieved by quantification, allows distilled numerical values to circulate, like currency, in the network of climate research. And sustain, by their very circulation, that network. As Latour put it,

> If inventions are made that transform numbers, images and texts from all over the world into the same binary code inside computers, then indeed the handling, the combination, the mobility, the conservation and the display of the traces will all be fantastically facilitated. (1987: 228)

One last example, from the Report. Driving forces in the Kaya identity are interdependent. The coarseness of two of them—'energy intensity of world GDP' and 'carbon intensity of energy'—screens their interdependence, and how their causal dependencies ramify to factors that are not calculable. Among these is technological change. Technological change is, of course, not an uncaused cause. The Report states that 'innovations are highly context-specific; they emerge from local capabilities and needs, evolve from existing designs, and conform to standards imposed by complementary technologies and infrastructure" (IPCC 2000: 3.4.5) This future ground of technological innovation is, no doubt, only imaginable. Not only that, but technology changes from the

> messiness, or complexity, of innovation processes . . . But even if the innovation process is messy, at least some general features or "stylized facts" can be *identified*
>
> - The process is *fundamentally uncertain*: outcomes cannot be predicted.
> - Innovation *draws on underlying scientific or other knowledge.*
> - *Some kind* of search or experimentation process is usually involved.
> - Many innovations depend on the exploitation of "*tacit knowledge*" obtained through "learning by doing" or experience.

- Technological change is a *cumulative process and depends on the history* of the individual or organization involved. (2000: 3.4.5; emphasis added)

So, a fundamentally uncertain and cumulative process that occurs through ‘some kind’ of events, and is history dependent. A history that is, of course, unknown to us, as are its decisive underlying knowledges, tacit or not, and its imponderable institutions and individuals. This is what can be *identified* in the *mess*. How does one work with this, when “technological improvement is a critical element in all the general mitigation scenarios” (2001c: 131)? But the difficulties with this driving force do not lead to its exclusion, contrary to the difficulty in *reproducing* extreme scenarios:

> Given the nature of the SRES open process and its multi-model approach, as well as the need for documented input assumptions, published scenario extremes are difficult to reproduce using alternative model approaches or insufficiently documented input data. (2000: 4.4.2)

Safety in Numbers

These examples allow us to return to Funtowicz and Ravetz’s concept of ‘post-normal science’. By suggesting that science (normal or post-normal) is the space where expansion of concerns can be achieved, ‘post-normal science’ perpetuates the othering of Western forms of knowing, knowledge production practices (‘problem solving activities’ in their terminology), that do have acceptance in Western life and culture, corresponding largely to situated forms of knowing and making. How do we make use of the incommensurable as incommensurable? What knowledge, what wisdom are we excluding by looking for colour temperatures in the work of masters? Does that knowledge say something of consequence (i.e., transportable) in its incommensurable elements? If it is true that scenario learning is ‘only effective if integrated’ into the decision-making progress (Fahey and Randall 1998) then, in the light of the above examples, what hope have we of *representing multiplicities with action in mind through methodological plurality*? Can the IPCC heed calls like Michaelis’ (2000) and provide its audience with unstable and non-combinable inscriptions? What can ‘post-normal science’ look like when climate change research turns Turner and Rubens into elements in a series of inscriptions of optical depth, when “mathematics and quantification are of course not uniquely responsible for the increasing uniformity of knowledge, but their contribution has been impressive” (Porter 1995: 223)? What is methodologically plural about using many models?

This protracted search for answers to the question—how to *neutrally represent multiple futures with action in mind, through methodological plurality*—has led to more questions than it has found answers. At this point we can go back to the quick answers tentatively provided above, and see if—and how—they still hold. The double question 'What is the difference?' asked if 'the formula-based calculations can be unravelled from subjective preferences and quantitative assumptions' and also asked 'what is to be gained from the differentiation of the quantitative and qualitative'. The quick answers were, respectively, 'no' and 'nothing'.

The slower answers can be found in the tensions patent in the SRES: the tension between the imaginative and the quantifiable, and the tension between the infinite and the minimal multiple. This second tension, between the unfathomable, ineffable, unwritable infinite and the summarised, workable, writable, *partial minimal multiple* is patent in the introduction to the Report, when it emphasises openness, documentation, "pluralism and diversity of groups, approaches and methods", comparability and harmonisation, as guidelines in scenario development (IPCC 2000: 1.6). "The use of different models reflects the SRES Terms of Reference call for methodologic pluralism " (IPCC 2000: 4.1; also in the TAR, e.g., IPCC 2001c: 10.3.4.2)

This presents a problem, and the sketch for a first slower answer. If I aim to create something to be reused extensively, and this something is made of 'images of the future', how do I convince my users that I know the future, that I can make valid statements about it? Well, I can't. I can't say that 'anything can happen', for that provides no new information. I can't say 'this is what will happen', because I don't know. I cannot know. And I can't just tell stories. I need something my audience can hold on to (without it dissipating) to manipulate, replicate, mutate; 'reproduce', as the Report says. If I am writing a story to make it a success, it needs to be shared, it needs to appeal to what is common with my audience's imagination and knowledge, and it needs to be shareable in my audience's language. But why will my audience reproduce my story if I have told them I made it up because I can't know and have to imagine it? Why would they reproduce it as a valid story? This matter is also related to the previous chapter's point about funding: projects claiming (near-)predictability are more likely to gain funding than projects which do not. As long as predictability is the measure of success, the circulation of the currency (funding) depends on exchange for something which also circulates and amounts to a form of currency (stable prediction statements). It has been more than one hundred years since Bjerknes' cornerstone of weather forecast optimism was published. We have been 'nearly there' for more than a century.

If I can't validate the story with certainty, I can validate it through plurality of methods. The story may not be true, but it is plausible, believable. This is the tension that permeates the work of the SRES teams: to generate "comparable, comprehensive emissions scenarios" (IPCC 2000: 1 1.6) through methodological plurality. And it permeates it by being continuously enacted in the differentiation between the qualitative and quantitative (see Figure 5.3 and Box 5.3); a differentiation the Report makes real every

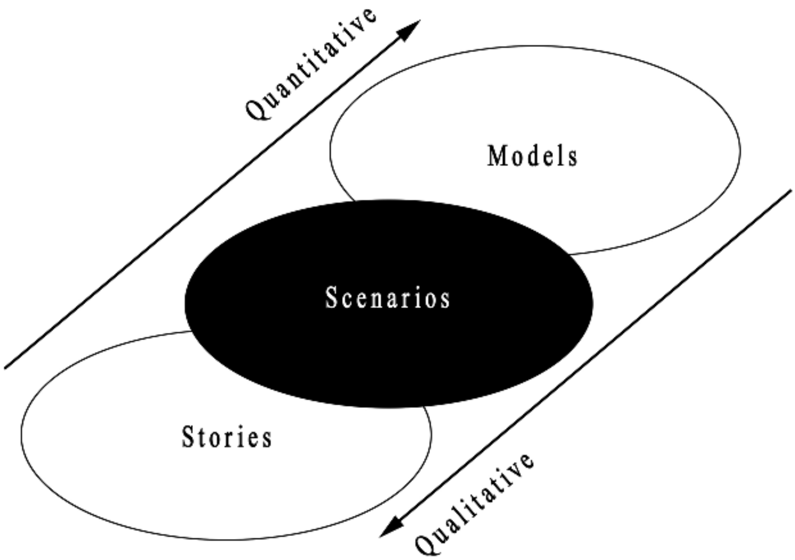

Figure 5.3 Positioning scenarios in relation to stories and models in a quantitative vs. qualitative scale (from IPCC 2000).

time it tries to find ways to overcome it. In the same way, speaking of intuition and analysis as complementary makes them separate. The work that led to the Report actually shows us how they are inseparable.

So, to the first part of the question 'What is the difference?', or in detail, 'Can the formula-based calculations be unravelled from subjective preferences and quantitative assumption?', the answer would be 'no, *they can't*; but yes, *they are*'. They can't be separated, as the work of the IPCC shows, at various levels (even within strictly quantitative matters, intuition and preferences are important, and the role, nature and use of numeric writing systems shows that assumptions about the world are at play). But yes, they are: they are presented as separate, even competing—if not contradictory—avenues of exploration. Sometimes they can be made compatible, commensurable, sometimes not. And when not, the qualitative is deemed largely unusable.

Methodological plurality is a given we tend to hide, more than an objective we aim for. We work in messy ways, especially with messy problems. Our methods aren't pure things tainted by use. It is the distilling process that makes them appear pure. *Only that way can we then claim a need to mix things up.* Only that way can science keep the boundaries up and working; 'working' meaning not just keeping things from passing, but deciding what does permeate the boundaries, and how. The African Environmental Outlook of the UNEP makes the same distinction between the qualitative and quantitative and adds, as a further distinction in its concluding remarks, that it "used both imagination and science as ingredients for generating effective scenarios" (Kakuyo et al. 2002).

In all these instances the distinction is presented as unproblematic in itself, and it is its use that needs some negotiation, as if imagination were essentially unscientific and science essentially unimaginative, and the mess were caused by human inability to articulate them, or make them complementary. The usefulness of these two camps is sometimes assumed, as is visible in the language used: "*Although* these relationships are often based entirely on qualitative analysis, they might *nonetheless* yield insights about the relationships between some dimensions, especially those that are difficult to quantify, and emissions" (IPCC 2001c: 137; emphasis added).

We can have, it would seem, either a qualitative perspective of the world (providing limited insight and validity), or a quantitative perspective of the world (never comprehensive, but controllable, valid and verifiable). We can also try to use them together, as complements or through integration, and this requires a complicated (and continued) balancing act.[7] The expectation is that putting these two perspectives together would expand our horizons. But not only have they never been divided, their complementary use is yet another perspective. Using several modelling teams does not amount to methodological plurality, instead it points to another enacted division, maybe the underlying one: method is not singular or plural. So shows the *modus operandi* of the SRES teams. Their division of qualitative and quantitative does not occur in their work as much as it is made in their statements and the presentation of their findings. So, while I have been following these distinctions, it is wise to drop them if they are only made real at some levels.

APPROPRIATING THE PROBLEM SPACE

Forty scenarios derived, by six modelling teams, from four scenarios that have qualitative assumptions chosen for their quantifiability amount to "similar ideas disguis[ing] themselves by appearing as ideas about dissimilarities" (Strathern 2004: 25). They are different ways of telling the same story, not plural methods of peering into the future. Or, if we want to call them different narratives (since they represent different global outcomes), they are still different narratives derived from the same scientific and discursive practice. *The SRES aims for plurality where it cannot achieve it, it hides it where it is inevitable*. Its method is neither plural not singular but, caught between what Strathern calls the atomistic and the holistic (2004: 26), it seeks to overcome the singularity (and therefore the limitations) of the quantitative mode by harnessing the power of the qualitative.

This helps to attempt an answer to the second part of the question ('What is the difference?'; in detail, what difference would it *make*? What is to be gained from the differentiation of the quantitative and qualitative?).

The early, quick answer was 'nothing, in the current circumstances', and I said this was also the IPCC's answer. Nothing, because the SRES aims at integrating the qualitative and the quantitative, and summarising both. But it is exactly because the qualitative and the quantitative are *seen as* requiring integration that this nothing is something. Once the Report creates the difference between the qualitative and the quantitative, it needs to work to integrate them. In reality, every step of the way, the qualitative is in the quantitative, and in every step of the way the quantitative has directed the qualitative (e.g., cost-effectiveness; quantifiability subtends the imagining of storylines, etc.).

"Any scenario necessarily includes subjective elements and is open to various interpretations" (IPCC 2000: SPM), the Report acknowledges. But more than "each scenario represents a specific quantitative interpretation of one of four storylines" (2000: SPM), each scenario actually represents a specific quantitative interpretation of qualitative storylines chosen based on quantifiability. This choice is qualitative, but based on the experience that modellers have of quantification. The chain of interdependence between the qualitative and quantitative never ends, and isn't linear. Scenarios nonetheless 'enhance our understanding of how systems behave, evolve and interact' (IPCC 2000). The IPCC is doing what Funtowicz and Ravetz (2001) and Michaelis (2000) propose, and doing it well, to the extent it can. And that is the very core of the problem: it does as much as it can in integrating qualitative and quantitative in an explicit way, and it shows a lot more integration in non-explicit ways, which gain resilience and value from being multidimensional in their technical imprecision (Wynne et al. 1998; see also Demeritt 2006). In this, its conclusions are laudable:

> Perhaps the most important conclusion from the SRES multi-model, open process, and the large number of scenarios it has generated is the recognition that there is no simple, linear relationship between scenario driving forces and outcomes or between emission outcomes and scenario driving forces. (IPCC 2000: 4.6)

But there is a problem. The SRES (and the IPCC) claims an important role for intuition, creativity, imagination, and subjectivity. It then uses them in very specific and restricted explicit forms because their usability is seen as limited (as in the '"although" qualitative "nonetheless" maybe useful' quote above). The problem is that it defines the usability of qualitative elements for decision-making. Ultimately, this defines both the usable power of imagination and creativity, and reinforces a specific view of decision-making. To put it simply, the problem is the colonisation of imagination and intuition and creativity. As the SRES puts together futures to be used extensively by decision makers, by making them transportable, reusable, highly visible templates, and adding that they are imaginative and creative, *other forms of creativity and imagination are pushed out of the scope of* *methodological plurality*. So, it colonises and clears. The UNEP (United Nations Environment Programme) Vital Graphics series, created to generate wider awareness of the environmental challenges the world faces—or, in the UNEP's words "an ideal tool for mainstreaming environmental issues, in other words, for preaching to the 'non-converted'" says, in the section 'Back to the Future: The Science of Building Scenarios',

> We cannot anticipate everything, but we try to assemble as many of the pieces as possible in order to predict the future. The science—or the art—of building scenarios requires a degree of control over a wide range of factors, all intricately linked. It is like a game, where we have to guess how changing one thing will affect the whole. (UNEP/GRID 2008)

The future does not arrive, we make it in advance. Our images of the future define policy options and generate absences. They create spaces of opportunity, open directions, and generate blindspots, ignorance, and inertia.

If all perspectives are always mixed up together, then what of complementarity? What of clear, neutral, reproducible communications? A kaleidoscopic chain of interdependence made of the qualitative and quantitative (already, always and infinitesimally bound together) is not compatible with perspectival systems of 'seeing' the world and our knowledges of it. This unsettling vision of complexity (or at least much less comfortable than a perspectival view) is proposed by Marylin Strathern (2004), who mentions a *post-plural* perception of the world, one that ceases to be perspectival. In our context, the SRES cannot overcome the limitations imposed by its mandate and the UNFCCC, it cannot be post-plural, it cannot—by virtue of its audience, mandate, and objectives—be kaleidoscopic, acknowledge that "there are only nature-cultures" (Latour 2004: 40). So, it can't be post-plural, but it is. For, despite its insistence on dividing the qualitative and the qualitative (to then claim to mix them), its procedures and methods are a mesh of pluralities. Admitting it amounts to tainting the purity of the quantification that its communications rely on.

How does one summarise or integrate a plural view and maintain the multiplicity of its object(s)? It cannot be a matter of more perspectives, of widening scope. To Strathern, "pluralities have their own configurations" (2004:21). As recently as 2007, six years after the publication of the Report, some SRES authors (Gruebler et al.), say that "interest [in climate change] in itself needs to be complemented by *new* analytical and methodological perspectives" (2007: 874; emphasis added). The interdisciplinarity is pursued by *extending* the existing 'integrated assessment framework'. This approach is based, the authors say, on the 1970s' global modelling which developed in response to perceived "limits to growth". And on coupled energy-economy models which "have structured much of the climate change policy debate to date" (2007: 874). In an introduction to a Special Issue of the journal *Technological Forecasting and Social Change*, the authors state that the papers published in it "extend the methodological paradigm of integrated assessment models into a broader interdisciplinary integrated assessment based on coupling detailed models of energy and industrial systems, agriculture, and forests" (2007: 874). The programme is still looking for ways to extend the current methods.

If incompleteness is irrevocable, how do we work with it? The root of the problem is that we cannot know with certainty. We are blind to the future. And to centre the quest for decision-making information in finding the right telescope for the blind does not solve the problem:

> It is thus not surprising that assumptions about economic development constitute among the most important determinants of emissions levels in the scenarios. However, economic growth prospects are among the most uncertain determinants of future emissions. (IPCC 2000: 2.4.5)

Not that a kaleidoscope would be of any use to the blind. But if we might be future-blind, we are not necessarily blind to the kaleidoscopic nature of our present knowledge-making practices. Strathern further considers these difficulties by resorting to Haraway's 'view from nowhere', that resonates with the global computational modelling efforts perpetuating Bjerknes' optimism. The IPCC is imputed with two tasks: to imagine the indefinite from somewhere, and to communicate the definite from nowhere. Present Table 5.1 to another audience—almost any other audience—and say, "This is what the future may look like". How far will that carry, how much currency does it hold? How universal is that knowledge? How reproducible will that information be to most audiences or constituencies?

These questions—'what of the futures in the blindspots?'; 'how can universally reproducible knowledge depend on a specific set of skills?'—have an even more basic counterpart. What if not everything makes sense together? To define mess, as Ackoff does (1974), as a system of problems, still assumes that mess is analysable. Only in a system can 'everything conspire', fit together, so that ignorance can be transformed into 'gaps in knowledge' and from there into new knowledge.

What has been the net result of marking spaces where coherence bears fruit and becomes an obligatory passage point, and the spaces where non-coherence can be played with? Are these spaces just mental or epistemic locations? Are they made stable enough for a visit? What would a method of the non-singular and non-plural look like? John Law says these two options are still borne out of a perspectival world (2004: 60) and suggests that we look for other ways of thinking about them. Among those possibilities, he suggests *fractional objects*. If the operative space of the IPCC points to fractionalities (that compose it but) that necessarily exceed its knowledge statements, can we follow the directions it points to? What other spaces already exist that work (also in their own limited ways) with fractionalities in our understanding of climate changes?

The next chapter explores spaces that bear the consequences of quantitative or, indeed, *numerocratic*, formulations of futures. The objective is to understand how far the IPCC's method of 'futuring' does travel, how it is mobilised to sustain and develop other networks, how it makes them more mobile and stable. The last chapter will bring us to forms of fractional, fragmented and kaleidoscopic representation, and to how being unsettled by kaleidoscopic views of complexity can help.

Box 5.3 Separating the Qualitative and the Quantitative

"Scenarios can draw on both science and imagination to articulate a spectrum of plausible visions of the future" . . . The term "scenarios" appears in two distinct streams of inquiry, one based on qualitative narrative and the other on mathematical models. Qualitative scenarios are primarily literary exercises, aimed at holistic and integrated sketches of future visions and compelling accounts of a progression of events that might lead to those futures. Quantitative, formal models seek mathematical representation of key features of human and/or environmental systems in order to represent the evolution of the system under alternative assumptions, such as population, economic growth, technological change, and environmental sensitivity. Qualitative scenarios have a greater power to posit system shifts, to explore the implications of surprise, and to include critical factors that defy quantification, such as values, cultural shifts, and institutional features. On the other hand, qualitative scenarios may appear arbitrary, idiosyncratic, and weakly supported. Model-based scenarios are useful for examining futures that result from variations of quantitative-driving variables, and they offer a systematic and replicable basis for analysis . . .

Scenario studies have begun recently to synthesize the modelling and qualitative approaches, in order to blend structured quantitative analysis with textured and pluralistic scenario narratives."

(from IPCC 2001c: 120–121)

6 Creating One Future
The Doomsday Vault

It isn't necessary to imagine the world ending in fire or ice—there are two other possibilities: one is paperwork, and the other is nostalgia.

Frank Zappa, *The Real Frank Zappa Book*

We breathe background noise, the taut and tenuous agitation at the bottom of the world. Through all our pores and papillae, we collect within us the noise of organization, a hot flame and a dance of integers.

Michel Serres, *Genesis*

The Doomsday Vault—officially known as the Svalbard Global Seed Vault—was built inside a mountain, under permafrost, in the island of Spitsbergen, in the remote archipelago of Svalbard. Opened in February 2008, it is the remotest location in the world accessible by daily commercial flight, at a distance of roughly 1000km from the North Pole. It is a seedbank established by the Global Crop Diversity Trust (GCDT, or Trust). Unlike other seedbanks, the Vault does not have a geographical or single crop protection ambit. It serves as a worldwide secure backup for regional seedbanks. These form, with the Vault, a global network of seedbanks and agricultural technology research centres, run by the Consultative Group for International Agricultural Research (CGIAR). Seedbanks safeguard the world's agricultural biodiversity, and therefore have a unique role to play in food security,[1] especially when the world needs to adapt to climatic variations.

This chapter examines how the Vault mobilises climate change, climate models and climate scenarios to advance non-neutral agendas. To portray imagined futures as neutral, as "policy-relevant but not policy-prescriptive information" (originally in the TAR, and recently reiterated *verbatim* in preparation for the Fifth Assessment Report; IPCC 2009b) is to sanction present action that is far from neutral. Such information is co-optable by special interest groups with very specific futures in mind.

THE ROLE OF THE VAULT

It has always been true that the climate decides, to a large extent, what we eat. The Vault has been placed at the centre of an *inversion of the terms of that proposition*. The inverted statement claims that what we eat decides the climate:

> The Trust is creating an efficient and effective system required for the conservation of crop diversity which is the biological foundation of all future crop varieties. Crop diversity is therefore the cornerstone of successful adaptation to climate change . . . Crop diversity has a significant role to play in mitigation efforts. (GCDT 2006: 2,3)

Nowadays, we know that the causality between agriculture and climate is mutual. A vegetarian diet, for example, generates much less CO_2 emissions than an omnivorous diet. But the inversion performed by the Vault proposes to change our diet to change the climate in far more complex ways. The distributed nature of other seedbanks and seedbank databases makes the overlaps and gaps of current seed classifications largely unknown, so the Vault is also the centre of a global taxonomic reclassification of agricultural biodiversity. The inversion's ultimate claim is that *'the basis of the foundations' of decision-making in climate change policy depends on a worldwide reformulation of agricultural practices*. Such reformulation includes, at its core, the dissemination of crop varieties developed by agricultural biotechnology, implemented with information from climate models and scenarios. This reformulation, we shall also see, actively, explicitly, globally, and programmatically proposes the obsolescence of many forms of indigenous agricultural knowledge. The future is designed today, and expectations of global disaster help implement the design.

Historical Climate and Historical Hunger

Agriculture is one of the areas where climate change has significant consequences, and where anthropogenic climate change is expected to have severe consequences. Changes in climatic patterns and increased climate variability disrupt crop feasibility and yields; change the incidence and distribution of pests, diseases, and extreme climatic events; change availability of soil nutrients, CO_2 absorption capacity, soil moisture, and so on. These events potentially (and usually) increase malnutrition, hunger, and starvation.

Historically, climate-induced environmental change has been one of the main causes of loss of sources of food. Solving hunger by changing the climate has not been a feasible approach. The reverse—addressing hunger to change the climate—would have seemed an absurd suggestion. In the first chapter we explored one such historically situated nexus of climate, hunger, and human agency. During the Little Ice Age in Europe, thousands died from starvation or disease brought about by famine—and thousands migrated too—but those with uninterrupted access to food (and shelter) were not moved by the poor weather. One would change diet because the incessant rain destroyed crops which, in turn, caused the price of bread to spiral. Suggesting a change in diet to stop the rain would seem absurd. If a storm destroyed a European village's livelihood, the villagers' route of intercession—beyond local earthly powers—were saints, god(s), or magic and spells.

To change the weather, Christians used forms of indirect control over it. In this sense, prayer, charms, rituals, and magic influenced nature in the same manner: intercession as mediated control over the causes of events.

While some of the fundamentals of that configuration are still actively in place, something has changed. Actively changing the weather to combat hunger has been seriously proposed, and then largely abandoned. Now, changing diet to change the weather makes sense, in more ways than we might expect.

Present Climate and Present Hunger

Recently, the Millennium Development Goals—set by the United Nations at their 2000 Millennium Summit—have, as their first goal, the eradication of extreme poverty and hunger by 2015. The month before the Millennium Summit, on 24 August 2001, the meeting on Nutrition Transition and its Implications for Health in the Developing World—held at the Rockefeller Foundation's Centre in Bellagio, Italy—resulted in the Bellagio Declaration. Participants included the World Health Organisation (WHO), Food and Agriculture Organisation (FAO), other UN representatives, ministerial representatives, and scientists from medical, agricultural, and nutrition research backgrounds. The Declaration stated, "Phenomenal social and economic changes, on a scale and at a speed unprecedented in history, have resulted in an epidemic of nutrition related chronic diseases that must be contained" (the Authors 2002). It asked for urgent and immediate action through an integrated response based on multidisciplinary and intersectoral partnership action from governments, industry, health professions, the media and civil society, and international agencies.

The size of such task seems beyond imagination. How can such a wide array of diverse actors be immediately mobilised, especially in an integrated manner? If we are to take these calls for action seriously, then we must think how deep and wide the changes need to be. They ask for changing the world, and doing it now. And yet, such a gigantic investment of time and resources (considered necessary to address the world's hunger, malnutrition, and their derived problems) is neither a request exclusive to the Bellagio declarants, nor a new request. The current United Nations Secretary General, Ban Ki-Moon, has issued a statement calling for 'combined efforts', in very similar terms and scope. The matter has been *urgent for decades*, and a global integrated approach has been pursued for several decades.

> In 1974, governments attending the World Food Conference had proclaimed that "every man, woman and child has the inalienable right to be free from hunger and malnutrition in order to develop their physical and mental faculties." The Conference had set as its goal the eradication of hunger, food insecurity and malnutrition within a decade. For

> many reasons, among them failures in policy making and funding, that goal had not been met. (FAO 1996c)

From the early 1970s to 2001, it seems the problem and its urgency have not been met successfully, "for many reasons", as the FAO says. Or because the problem *has* so many reasons, and therefore it requires integrated global action by many actors. Calls for large-scale urgent action have been common throughout this period (see Lappe and Collins 1980: 80). At the same time, the global number of undernourished has increased steadily. FAO statistics put the number of undernourished in 2006 at 840 million (FAO 2006), 923 million in 2007, 963 million in 2008 (FAO 2008d), and since increasing to 1 billion (UN 2010). The 1996 pledge was for 'no later than 2015', a deadline confirmed in the 2000 Millennium Goals.

The magic of numbers has helped make things seem better. Initial calls for hunger reduction used absolute numbers. Now, percentage of world population is used. The change from absolute to relative makes the failure seem smaller. Percentages do not feed the hungry, or change the fact that never, in the history of the species, has there been so much food, and so many dying without it.

Future Climate and Future Hunger

Over the last twenty years, climate change has helped accelerate initiatives to stimulate and integrate action to end hunger. More precisely, mobilising and integrating the actors listed in calls like the Bellagio Declaration has been greatly aided by enlisting a new, different, and very powerful actor: climate change. Scientific statements about the predicted effects of climate change have been used, by organisations like the FAO, to strengthen the case for combating hunger on a worldwide basis.

Climate change has serious implications for hunger and food security. One such implication is that it is impossible to eradicate hunger by 2015. Hunger is a problem that the world can forever address, but never 'eradicate'. Especially given the uncertainties inherent to climate change, only continued action well beyond 2015 can address the problem. GHG emissions are increasing, and the rate of increase is accelerating. As the future is now presenting itself with emissions increasing at the highest rates described in SRES scenarios (some say above[2]), and expected to continue to increase until 2050 (Marchal 2011), the balance between adaptation and mitigation keeps changing. This makes the Vault an important piece of preventative adaptive action.

But that is not its whole story. The Vault's role has immediate global consequences. Its present role is also justified by future climate change. The Trust's claim—that it is creating the biological foundation of all future crop varieties and that these are the cornerstone of successful adaptation to climate change—obscures the origins of the Vault and its present role. The Vault was not proposed, initially, because of climate change adaptation or mitigation. Even after climate change became recognised as a serious threat, it took roughly two decades for it to be claimed as the main reason for the Vault. For decades, agricultural biodiversity was a valuable resource for adaptation, but adaptation meant a large number of environmental variables. The climate was not the driver for establishing a central global backup. The adaptive potential of agricultural genetic resources did make them an important commercial commodity and research subject, but the climate was seldom mentioned. Commercial interests and related ownership of agricultural genetic resources were the main issues. Before we look at those origins of the Vault, what made it possible and what delayed its inauguration, let us go inside it and see what is in it.

Inside the Vault

The Vault's security and redundancy are as high as possible. It has one single secure entry point. Despite being under permafrost, a refrigeration system keeps three separate seed rooms at–18 degrees C. Energy can be procured in the form of coal from local mines. If even that were to fail, the closed Vault would preserve seeds for decades or centuries, depending on the longevity of different varieties. A thick layer of plastic-fibre reinforced concrete further insulates the facility from the sandstone that encases it. The level of security is such that, according to Cary Fowler, Executive Director of the GCDT,

> if there was a huge explosion in front of the Seed Vault, for instance, or someone was really trying to attack it, shooting a projectile or missile down here, it wouldn't go in to any of the Vault rooms, it would hit this solid stone concave structure and the blast force would then be directed back out of the tunnel, outside, rather than going in to the Vault. (in CBS 2008)

Asked if it is a Doomsday Vault, he adds, "It probably is one. At least we think that if there are any big problems on the outside, this is going to survive" (in CBS 2008).

None of the four dimensions of food security[3] is directly addressed by the Vault. Not for the present. The Vault is as remote as possible, and will be closed for most of the time. The seeds in it will not be used for distribution or germination, and are only a backup for those present in other seedbanks across the world. Only in a long-term or catastrophic perspective does the Vault address food security. Climate change adaptation is urgent, according to the IPCC. Eradicating hunger is urgent, according to the Bellagio declarants, and the UN. Yet mobilising uncertain climatic futures pushes the problem into the future.

A New Equation?

The above isn't inherently problematic. The FAO has programmes addressing hunger and food security today, and a long- or very-long-term solution for crop diversity is growing in importance. However, there are some surprises in the FAO's approach. In a *FAO at Work* report, the FAO says that there is "a new equation":

> Food, energy and climate. For the first time in history, these three are closely linked. Without an understanding of this new reality, countries and the international community *lack the basis for the most fundamental policy decisions*—decisions that affect access to food for millions of people. (2008: 2; emphasis added)

It is hard to see how this equation is new. Biofuels might change the values of the equation, but climate, food, and energy have always been linked, in human history. The equation is new to the FAO, who—for decades—was conservative in reflecting climate change in its work and publications.

The scientific understanding of the relations between climate, food, and energy improved significantly, from the early 1970s and during 1980s. As late as 1989, climate change still didn't play a significant role in food security policy at the FAO. Its report on Forestry and Food Security describes itself as drawing "on many different sources, it pieces together a picture of the complex interactions between people, trees, forests, agriculture and food production" (1989). It briefly mentions the climate as a poorly understood factor, but does not include it in its Research Priorities. "The 'greenhouse effect' has become a cause of widespread concern", it says, but 'global climate' is poorly understood. It is covered in less than a page, while there is one whole chapter devoted to socio-economic aspects, including diet, fuelwood, disease, employment, gardens, land tenure, and common property. It further recognised that

> the nutritional well-being of people depends not just on food production; if that were the case then no-one would go hungry, since total food production is more than enough to feed the world's population. Food security is also crucially dependent on the reliability of production and on people's access to supplies. It thereby encompasses questions both of sustainability and equity.

Likewise, in the 1986 *World Food and Agriculture Situation* report, agro-climatic conditions had been barely mentioned, and only in relation to sub-Saharan Africa. The report was largely devoted to international trade (FAO 1986).

The climate/food/energy equation is new in the sense that our scientific understanding now allows it to become part of institutional agendas. In 1989 it was clear that access to food plays, at present, the crucial role;

not food production. By 2008, however, there is 'a new reality'. *This new reality shifts food security from equitable access to future yields*. Future climate change modifies present and future hunger. Cary Fowler, director of the Vault, stated that

> "these resources [seeds in the Vault] stand between us and catastrophic starvation . . . You can't imagine a solution to climate change without crop diversity." That's because the crops currently being used by farmers will not be able to evolve quickly enough on their own to adjust to predicted drought, rising temperatures and new pests and diseases, he said. One recent study found that corn yields in Africa will fall by 30 percent by 2030 unless heat-resistant varieties are developed, Fowler noted. "*Evolution is in our control*," he said in an interview. "It's in our seed bank. You take traits from different varieties and make new ones". (GRIST 2009; emphasis added)

Current food production is more than enough to feed the world's population, but we are told that avoiding catastrophic starvation requires development of new crops. With 1 billion hungry now, is the real catastrophe in the future?

In the light of the continued yearly increase in total GHG emissions (globally, regionally, and by sector of activity) how can a 'solution' depend so much on a *long-term* repository of crop diversity? If the 1974 FAO global hunger statistics were 'unacceptable', how far from catastrophic are the current numbers? As a long-term repository, how does the Vault address hunger in 2030, if not by genetic research? To suggest that one should change what one eats to change the weather no longer seems absurd. Solutions for hunger are made into an essential strategy to address climate change. Calling it an inversion of order of statements does not suggest that the claims are untrue. It means that this truth hasn't always existed.

In statements such as Fowler's, changing what one eats means creating new food. And 'solution' does not distinguish between adaptation and mitigation. There are instances where this lack of distinction between adaptation and mitigation—in the context of the Vault—isn't just an omission, but a conflation. Addressing the conference at the opening of the Vault, Jacques Diouf, the director-general of the FAO said that, in the common future we all share, the Vault is "one of the most innovative and impressive acts in the service of humanity", and added that "the seeds that will be housed in the Seed Vault will be *essential* for increasing crop productivity, *mitigating environmental stress such as climate change*, pests and diseases, and ensuring a genetic resource base for the future" (Norwegian Ministry of Food and Agriculture 2008b). At the same conference, Cary Fowler was quoted as saying,

> Diversity is threatened by climate change. On the other hand we're going to have to be making some *major changes in the nature of the crops we have in the fields*, which is going to require diversity. If ever

> there was a moment in history when conserving this diversity was worthwhile and yielded a great cost-benefit ratio, it would be now," he said. In referring to the threat to the viability of seed collections currently held in gene banks as well as to diversity of crops growing in the field, he called it "*more than an apocalypse*". (Norwegian Ministry of Food and Agriculture 2008b; emphasis added)

Catastrophic hunger brought about by climate change, and the 'more than apocalyptic' situation of seedbanks and crops in fields, justify more than just building the Vault. All these apocalypses mean that major changes to existing crops are justified. Beatriz da Costa and Kavita Philip articulate these matters distinctly: "By placing the causes of public health and agricultural problems into the genetic domain, rather than into the political-economic domain, genetic iconography has sensationalized rather than elucidated contemporary bioethical issues" (2008: 41). The IPCC's scenarios excluded catastrophic futures. What allows such strong catastrophic claims by the FAO? The 'essential role' of new crops doesn't cohere with other recent statements. According to the FAO,

> [M]ost of the mitigation is achievable in the forestry sector, with important implications for climate policy options. Importantly, the total mitigation potentially achievable in the land-based sector is quite close to total emissions of the agriculture sector as a whole. If achieved, they would contribute to making this sector nearly carbon-neutral. (2008c: 5)

Although most of the mitigation is achievable in the forestry sector, new crops are deemed essential for mitigation. Although enough food is produced today to feed the 1 billion hungry, it is the future that is catastrophic.

BUILDING THE VAULT

The need for a global backup for agricultural biodiversity was, for a long time, proposed for other reasons than climate change. A set of statements proposing that *genetic control of evolution is the cornerstone of a solution for climate change* is the culmination of a long story with a different plot, a plot of intellectual property disputes. *A Study to Assess the Feasibility of Establishing a Svalbard Arctic Seed Depository for the International Community* (Noragric and NordGen 2004) established the overall plan for what was to become the Svalbard Global Seed Vault. The Study was drawn "to plan for the worst case scenario", and the "facility should be constructed "to last essentially forever" (2004).

> As Professor Jack Harlan, one the most imminent experts in the field stated before his death in 1999, "these resources stand between us and

> catastrophic starvation on a scale we cannot imagine." Our existence on earth rests on how well we care of these seeds; and their existence depends on us. In many ways, it really is that simple". (2004)

Despite the close and multiple links the CGIAR has with modelling and scenario development over decades (including the IPCC), the apocalyptic tone avoided by the IPCC here opens the Vault's feasibility study. On the other hand, the uncertainty and gaps in knowledge reiterated by the IPCC do not temper expectations of catastrophe. The language also does not coincide with past FAO reports on food security. For decades, the FAO considered the *present state* of global hunger 'unacceptable'. Only if we think of the Study as redefining the problem can we understand it without its apocalyptic futures sounding excessive. The FAO has been at the heart of the development of the Vault:

> FAO Facilitates creation of Arctic Seed Vault: In order to safeguard the priceless pool of genetic material used to grow the world's food, Norway has created a Global Seed *Vault* at Svalbard, a frozen Arctic island. Designed to protect 4.5 million seed accessions, the initiative was facilitated by FAO's International Treaty on Plant Genetic Resources for Food and Agriculture. The treaty, *an international legal framework for conserving and accessing crop diversity, has now been ratified* by 116 countries. The Global Crop Diversity Trust, hosted by FAO, provides operating funds for the seed Vault. (2008: 14; emphasis added)

The Second Working Group[4] of the Intergovernmental Panel on Climate Change (IPCC) states, from its review of the relevant literature, that "climate change cannot be totally avoided" (IPCC 2001b: 18.4.1). And since the negative effects of climate change are expected to increase in frequency and scale in the future, and impacting populations that are most at risk, anticipatory planned adaptation is the best answer. It adds that it may yield benefits independently of the uncertainty, nature, magnitude and speed of climatic changes. Anticipatory planned adaptation becomes "a necessary strategy to manage the impacts of climate change" (2001b: 18.4). The Vault's anticipatory planned agricultural adaptation also has present consequences:

> The initiative will also transform communications for plant-breeders and farmers around the world. It will fund an information system that will include 4,000,000 samples of more than 2,000 species of more than 150 crops—amounting to 85 percent of the diversity of all agricultural crops. The initiative will fund development of a state-of-the-art genebank management software system, enter at least 100,000 new samples into the database, and evaluate at least 50 priority collections for 100 different traits—thus uncovering hidden genetic resources. (GCDT 2007; emphasis added)

Of the 5.4 million germplasm samples held worldwide, 2 million had no backup until the Vault came into operation. Once it opened, reclassification started; estimates of worldwide gene bank germplasm redundancy vary from 10 per cent to 60 per cent (Frisvold and Kuhn 1999). Reclassification will lead to a central vision of the total genetic pool of world agriculture. If the Vault is the central point from which the world's crop diversity re-emerges, and if agricultural biodiversity is the cornerstone to adaptation, then the Vault is a powerful place indeed.

On the other hand, the Vault opens to let new germplasm in. It is permeable to the outside, to some extent. The Vault, as a central global point of crop biodiversity, also aims to address the principal problems of seedbanks: the lack of high-quality trained personnel. Education and training will be provided by the Vault to staff from other seedbanks. As it transforms communications for plant-breeders and farmers around the world, it helps the FAO's programme of disseminating information when "rapidly changing climate conditions will require *upgrading local knowledge* with more scientific observations" (FAO 2008b: 5; emphasis added). This is an important detail, related to how knowledge is propagated from the Vault. Not just genebank training, but agricultural adaptation policy. Without upgrading local knowledge, we lack the 'basis for the most fundamental policy decisions that affect millions'.

> We built it to last for as long as we can imagine. I don't know what was in the mind of the people that built the pyramids, maybe they were built to last forever too, but I can't think of anything that has been built in our lifetime that's been built with this kind of time horizon.
>
> . . . Doomsday doesn't have to come in the form of an asteroid. Doomsday can come in the form of an equipment failure, or mismanagement, just human mismanagement, or lack of funding, or a typhoon or something like that. And those kinds of things happen all the time. (Fowler in CBS 2008)

War and natural disasters have affected seedbanks around the world; without a secure backup facility, some agricultural biodiversity might be at risk of extinction in the future. In the present, the Vault will transform communications for plant-breeders and farmers around the world.

This role of the Vault in upgrading local agricultural knowledge today depend on climate modelling and scenarios. Overriding local knowledge to create *the basis for the foundations of decisions* isn't a new discourse. It has a long past. A past of contested ownership of genetic agricultural diversity and IPR. As Kavita Philip has said, only if we ignore how local practices are connected to geopolitical, cultural and economic matters can IPR not be part of historical studies of environmental issues (2008: 252).

Agricultural Biodiversity and Intellectual Property Rights

From the early 1960s until the 1990s, a common and permanent repository for the world's crop diversity was hindered by the divergent interests of the agricultural Intellectual Property battles. Market forces and industry demands led to crop uniformity in the United States, so that the real concern was the almost exclusive U.S. dependency on foreign procured crop genetic diversity. Pests and diseases were the main concern, not the climate, as was evident in the 1972 landmark study Genetic Vulnerability of Major Crops, by the U.S. National Academy of Sciences. It mentions the challenge to "provide a back-up capability comprising diverse genes to be thrown into the breach as needed" (National Academy of Sciences 1972: 2). The breach was not the climate. In the same year, the UN Conference on the Human Environment "highlighted the emerging threats to the ecological foundations essential for sustainable advances in terrestrial and aquatic productivity" (Paroda 2003: 512), but the climate, however close to these issues, wasn't an explicit cause for a safe repository.

In 1976, the U.S. National Research Council (NRC) made the links between climate and food explicit in Climate & Food: Climatic Fluctuation and U.S. Agricultural Production. It used the Little Ice Age as an example of historical changes of climate and food production (NRC 1976: 14), recognising the importance of weather and climate on agricultural production and food reserves.

> Germ-plasm evaluation would be greatly facilitated if all users would assume their obligation to share the information they obtain in growing the collection. Curators of germ plasm of our major crops unanimously complain that too little information comes to them from users. Ways to ensure the two-way flow of data must be identified and implemented. (1976: 74)

These words (obligation of users to share information with curators, two-way flow of data) reveal the assumptions about the nature and implications of germplasm research, and some naivety regarding IPR. The CGIAR—the study expects—would fulfil its goal of "free international germ-plasm exchange", with 'users' expected to share information (NRC 1976: 75–76). The other direction of the *two-way* information exchange is composed of "educational and advisory services to farmers, particularly if new and radically different techniques are introduced" (1976: 163). Today's status quo reflects this background, with very little change, including the now well established use of 'gaps in knowledge' (e.g., Wollenberg et al. 2012: 99). The paradox of users having an obligation to free international germplasm exchange is a simple illustration of a much larger problem. It would take nearly three decades to clarify the *free obligation*, in the 2004 Treaty that made the Vault possible.

Discussions for a long-term repository for Plant Genetic Resources for Food and Agriculture (PGRFA) started at the FAO as far back as 1978 (Debouck 2008). The time it would take until the opening of the Vault, in February 2008, was the lengthy period during which negotiations and disputes both created and tested international agreements on plant genetic resources. In the early twenty-first century, ‘a comparatively stable international IPR framework was attained’ (Norwegian Ministry of Food and Agriculture 2007). Despite some ambiguities remaining to this day, in June 2004, the International Treaty on Plant Genetic Resources for Food and Agriculture overcame the main discrepancies between the 1983 FAO International Undertaking on Plant Genetic Resources (establishing agricultural genetic resources as common heritage) and the 1993 Convention on Biological Diversity (placing genetic resources under the control of national governments).

The 1983 International Undertaking made no mention of the climate, changing or not. It defined “a base collection of plant genetic resources” as “genetic variation for scientific purposes and as a basis for plant breeding” (Article 2) and its clearly stated objective “to ensure that plant genetic resources of economic and/or social interest, particularly for agriculture, will be explored, preserved, evaluated and made available for plant breeding and scientific purposes” (Article 1). The CGIAR is placed, through explicit referencing, at the forefront of seed banks. Unlike the climate, farmer’s rights do deserve attention. The attention is on genetic resources, with no mention of local knowledge, practices, or rituals. Farmer’s rights were defined in a narrow, material, genetic dimension. Today, with the climate centre stage, farmer’s rights and IPR are still a major issue of agricultural biodiversity (Medaglia 2009), but climate change has changed the nature of the discussions.

The 1983 International Undertaking would be challenged by the 1994 Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) of the World Trade Organization, an agreement that would itself be the target of much criticism, for placing the emphasis of the two-way information exchange on users sharing of information, and empowering patent owners, agricultural biotechnology companies and pharmaceutical corporations.

In 1984 the Nordic Gene Bank created an underground safety backup of its seed collection, under permafrost, in a disused mine in the Svalbard Archipelago, close to the town of Longyearbyen. The loss of agricultural biodiversity was a reality then, and the reasons for safeguarding biodiversity were clear and included changes in climate. That location would become the Doomsday Vault, but its global scope was impossible when all those involved were not just misaligned in method, but also objectives. There were no clear access procedures for *ex situ* seed collections until May 1992, when Resolution 3 of the Nairobi Conference for the Adoption of the Agreed Text of the Convention on Biological Diversity was adopted.

In 1996, the FAO convened the International Technical Conference on Plant Genetic Resources, inviting one hundred and fifty states and fifty-four organisations to create a Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. The Plan was adopted by the governments at the FAO World Food Summit of 1996. It was at this very summit that the Rome Declaration deemed the 1996 state of global hunger 'unacceptable', and pledged to reduce it by half by 2015.

When the FAO adopted the International Treaty on Plant Genetic Resources for Food and Agriculture in Resolution 3/2001, it stated that "classical plant breeding or modern biotechnologies . . . are essential in adapting to unpredictable environmental changes and future human needs" (FAO 2009[2001]: V). Climate change was thus coming closer to justifying genetic control of evolution. With the alignment of all parties consecrated in the 2004 International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), a global venture became a possibility, but not yet a reality. Significantly, since then, climate change has been widely used to promote the Vault, and IPR have receded into the background.

DOWNSCALING: TRANSFORMING GLOBAL UNCERTAINTY INTO LOCAL POLICY

A recent publication of the International Food Policy Research Institute (IFPRI, a CGIAR research institute), defines adaptation in the agricultural sector:

> Adaptation to climate change includes a broad range of policies—changes in land use and timing of farming operations, adaptive breeding and technologies, risk management techniques including catastrophic or weather-risk insurance, climate forecast information, irrigation infrastructure, water storage, and water management. Poor farmers in particular may need special help in adapting to climate change. Some steps, like *long-term weather forecasting* and the dissemination of technology and *drought and flood-resistant crop varieties*, will require *national and international planning and investment*. Agriculture's contribution to greenhouse gas emissions may be reduced by *new crop* and livestock breeding and planting technologies. (Islam and von Braun 2008: 5; emphasis added)

The document adds—from the IPPC's Fourth Assessment Report—that the choice of crop and cultivar, as an adaptation measure, is composed of several choices: use of more heat-/drought-tolerant crop varieties in areas under water stress; use more disease- and pest-tolerant crop varieties; use salt-tolerant varieties; introduce higher yielding, earlier maturing crop varieties in cold regions (2008: 44). According to another article in the same document, implementing these choices depends on factors such as existing knowledge, countervailing beliefs, and cultural practices. It calls these factors *impediments*, yet it believes that "farmers and others at risk from climate change can be provided with external help" through "technical information and provision of weather and climate forecasts and warnings" (Yohe et al. 2008: 44). Napier, you might recall from Chapter 2, aimed to "remove all impediments . . . as may hinder that work", towards a reformed country, in readiness for the catastrophe of "that great and universall reformation" (Napier 1594: A3–A4r).

With forecasting providing the *predictions*, the crops that best adapt to a changed climate can be 'shared' with farmers. Once the FAO adopts the findings and methods of the IPCC, its food security programs rely on the *largest-scale images of the world*. But because agriculture is a local activity, downscaling becomes a must if that information is to be used. We have seen, in Chapter 4, how Earth-system models transform incomplete, uncertain knowledge into a representation of a 'totality', following a kind of inductive logic. This is followed by a process of 'downscaling' to local scale, based on the findings pertaining to the 'totality', through a kind of deductive logic. Decision-making at local level is made dependent on the global inductive/deductive perception of the world. The deductive process of downscaling is by no means limited to scientific circles, their findings and statements. It involves institutional programs for propagation of downscaled global knowledge. Downscaling is a fundamental component of the UNFCCC Nairobi Work Programme (NWP).

This is where the Vault—a building that stands at the outermost geographical periphery—is central. The Vault, a remote undisturbed centre, emanates universal germplasm classifications applicable to all locations. "No longer a multiplicity, no longer noisy, it is one, globally, it is a single chorus, it is one locally, the centre, the midpoint, the navel of the vortex: the eye. The eye of the storm" (Serres 1995[1982]: 60). Heterogeneity is reduced to less than inhomogeneity. Making reference to the IPPC's TAR, identifying unanswered questions and important gaps between information providers and users, K. Konneh says,

> The users' knowledge of the uncertainties of the probability forecast is *still* low. The providers of the information need to make further efforts to help decision-makers better understand the uncertainty of the information. The language of the current forecast is too technical and not user friendly. These factors impede the mainstreaming of the information into decision-making and routine regional and national development planning activities. (2007: 76; emphasis added)

Note how users (farmers, local authorities, local agricultural centres) are expected to adopt a probabilistic view of agricultural decision-making.

The uncertainties and epistemological fluidity of modelling examined in Chapter 4 now serve us to understand downscaling, its reliance on climate and crop modelling, and how the limitations of these practices do not temper the usage of downscaling in policy. The limitations of modelling as 'incomplete knowledge' and of scenarios as exploratory exercises do not prevent institutions at the science/policy interface (like the FAO), and policymakers, from accepting such knowledge as valid, holistic, multidisciplinary representations of the 'totality'. The implicit understanding is that technical constraints are temporary and that the message will improve to the point where forecasts will allow various end users and stakeholders to improve their agricultural planning strategies. Even if the contextual environment in which agricultural decisions are made is not well understood in impact assessments (Vogel and O'Brien 2006: 114).

The scientific confidence in covering 'gaps in knowledge' allows calls to go beyond 'mere' mainstreaming and institutionalising of adaptation, but—in FAO documentation—to

> [m]andating adaptation. In certain cases, it is appropriate for governments to require adaptation to safeguard public health and safety. For example, vulnerability to climate change would rise if irrigation agriculture were to expand beyond available water resources. (Yohe et al. 2008: 44)

These calls are the more startling when the same author, in the same article recognises that "there is no single definition of what it means to adapt to a stress, and there are no firm quantitative measures for adaptive capacity" (Yohe et al. 2008: 46).

Napier's universal, inexorable, indubitable applicability of one universal narrative was justified by quantification. The political, economic, cultural power of apocalyptic narratives isn't new, and the historical relations, not being causal, do evidence intriguing patterns. Today, media outlets and its audiences often scorn religious sects in their doom predictions, unaware of the insidious and pervasive forms in which apocalyptic narratives are part of everyone's life.

In a section on 'Adaptation Strategies in Agriculture' of its *Climate Change Adaptation and Mitigation High-Level Conference on World Food Security*, the FAO suggests nine action points that affect farming practices, including "increasing use of climate forecasting to reduce production risk" (2008c: 7), but makes no mention of local knowledge, or of any methods for upscaling it. The subsequent text says

> Climate monitoring efforts and communication of information: *essential to convince farmers that climate changes projections are real* and require response actions . . . Uncertainty about the complex biological and ecological processes in agricultural systems makes investors more

> wary of land-based mitigation options compared to more clear-cut industrial mitigation activities. This barrier can be reduced by *investment in research*. In addition, high variability at the farm level can be reduced by increasing the geographical extent and duration of the project . . . Increasing visibility of food security issues is necessary within the broad climate change community itself, especially for efforts of high policy relevance such as proposing and supporting *development of an IPCC special publication on Food security and climate change* . . . Monitoring: observation networks and data platforms are needed for monitoring both climate and food production systems. These need to be integrated with climate and impact projections, in order to *provide policy-makers and stakeholders with information necessary for understanding adaptation options*. (2008c: 12–15; emphasis added)

Most times, the adaptive measures suggested by the application of downscaling tools largely suggest 'upgrading', if not replacement of local knowledge. Upscaling or bottom-up programmes are usually vague. The FAO states that "climate change will make agriculture even more *unpredictable* than it is today" (von Braun et al. 2008: 18; emphasis added), but there is nonetheless more promise in downscaling (a practice that depends wholly on prediction, as we have seen) than anything like upscaling. The latter, in the context of agriculture and food security, still means—in FAO documentation—expansion of scale or scope of operations or of production or area of implementation of programmes (FAO 2004; von Braun et al. 2008).

> Effective application of good management practices has many requirements:
>
> - Use of indigenous knowledge and local coping strategies as a *baseline and starting point* of adaptation planning. Although there is a large body of knowledge within local communities on coping with climatic variability and extreme weather events, *rapidly changing climate conditions will require upgrading local knowledge* with more scientific observations and establishing collaboration among neighbours and neighbouring countries to transfer knowledge from areas already experiencing these changes. (FAO 2008b: 5; emphasis added)

What I call 'upscaling of indigenous knowledge"[5] has been, so far, highly asymmetrical with downscaling of climate forecast knowledge. 'Users' of downscaled information are assumed to be rational actors, with consistent, well-ordered preferences, complete information from which they maximise expected utility (Laitner 2001: 14; see also Marx et al. 2007). Initiatives to integrate their knowledge into the predictive and adaptive processes follow an assimilative, methodologically narrow mode. Rengalakshmi mentions studying the seasonal climate variations and farmers' traditional coping strategies and knowledge, and of "*evolving* a methodology for downscaling . . . and converting the generic data into location-specific, medium term . . . climate and weather forecasts" (2007: 129) Rengalakshmi and colleagues studied local folklore, metaphors, and proverbs, and held focus groups, to then *translate forecasts into farmer's language*. The inverse is not considered, possibly because "the indicators clearly show that this indigenous knowledge on seasonal rainfall and weather is qualitative in nature" (2007: 132). Science translates selected driving forces into quantitative expressions and values, then translates the quantitative results into qualitative findings. These findings are downscaled. For this second translation (the deductive translation), the language of the target audience is taken into account, but only to deliver knowledge.

Findings show that farmers' opinions consider probabilistic forecasts less dynamic and more deterministic than their more practical approaches. Given the heterogeneity of local situations, farmers follow dynamic strategies and not the single strategy recommended by forecasters (Rengalakshmi 2007: 133). Heterogeneity is—yet again—a problem. While programs for the mainstreaming of global downscaled information are put in place, whole continents are insufficiently understood (e.g., current understanding of African convection; Traore et al. 2007).

The Limits of Downscaling

Downscaling is defined in the IPCC's Fourth Assessment Report glossary as "a method that derives local-to regional-scale (10 to 100km) information from larger-scale models or data analysis". But it is a lot more than that. It is a central element of agricultural forecasting, increasingly important—if not 'critical' (Sun and Ward 2007: 15)—in climate change projections, and it has significant impacts in food security policy. Downscaling of scenarios is also a concern: "inclusion of long-term emissions scenarios for individual countries, when available, would improve the regional coverage" (IPCC 2000a: 2.1).

To downscale is not just to change scale or increase magnification, but to translate to local conditions. This translation faces many challenges, some insurmountable. Local climate variations occur most times at a smaller scale than the resolution of models. The magnitude of these variations is often of the same magnitude as variations in spatial human practices: observation routines, station placement, changes in instrumentation (Alexandersson 2001: 3). Temporal variation creates equivalent issues, and statistical techniques are used to mask or hide 'homogeneity breaks' (Mueller-Westermeier 2001; see also Mestre and Caussinus 2001; WMO 2003). This masking occurs *after* the separation of good from bad data (Petrovic 2001).

'Homogeneity breaks' sounds like 'gaps in knowledge', and little like an artificial construct derived by careful selection from the 'noise that is the law of history' (Serres 1995[1982]). As if homogeneity was the norm, and its gaps identifiable. The natural, real state of the world—as represented by this language—is of knowable homogeneity (e.g., contributions to India and Bonillo 2001). Heterogeneity is not given a positive ontological status, and so completion of knowledge can be achieved through current methods. This way, not only is everything (of relevance) knowable, *it can be manifested, translated, brought in to view with the same tools used for the already acquired knowledge.*

Downscaling introduces statistical and structural uncertainties, to add to the uncertainties it inherits from climate models. Positioned at the end of the climate modelling downscaling process, crop models are also the last stage of the amplifying the effect of the cascade of uncertainty. Even at that level, simplification and parameterisation are needed, introducing yet more uncertainties, even in critical elements like precipitation. Despite this, uncertainty generated by model parameters is often not considered in regional or local impact assessments (Carter 2001; see also Menendez et al. 2001). Model resolution means that some countries fall in the *gaps created by* different model grids (e.g., the case of Moldova: Corobov 2001; see also Sun and Ward 2007: 15).

Because the worst impacted regions are the ones with less observational data and less regional models, the depth and scope of impacts remains unknown (e.g., FAO 2008b). The areas and populations that can benefit the most from prediction are beyond the observational, spatial, and temporal resolution of models. These areas are said to be characterised by 'extreme heterogeneity', restricting the applicability of measures that might have been successful elsewhere (Jodha 1996). In the TAR, "downscaling the global reference scenarios to local socioeconomic and political conditions remains a significant methodological challenge" (IPCC 2001b: 116). Yet, even in East England, an area with much greater historical and present data than most (and greater data precision and accuracy than most), a 2007 study finds that "decisions about managing the environment are plagued with uncertainty" (Dessai and Hulme 2007: 59).

These difficulties are presented in a consistent manner. Back in 1996, a report on the Basic Linked System (BLS) of National Agricultural Models of the Food and Agriculture Program of the International Institute for Applied Systems Analysis (IIASA), by Fischer et al., included the usual caveats: large uncertainties, speculative projections, paucity of data (especially from developing countries), inadequate representations of plant physiology, and so on. The caveats are coupled, as usual, with "projections are *still* considered fairly uncertain", "our understanding of the many interacting processes affecting biogeochemical cycles is *still in*complete" (Fischer et al. 1996: 154, emphasis added; see also Reilly et al. 1994: 178). "Not all adaptation possibilities were simulated at every site and country: the choice of adaptations was made by the participating scientists, based on their knowledge of current agricultural systems" (Fischer et al 1996: 122–123). Nonetheless, the authors conclude by saying that full examination of the tests *will* provide proper evaluation of climate change effects, because "the means exist by which to do this"

(Parry et al. 1996: 482). Bjerknes also thought that we "already possess the technical tools which will make it possible to fill in these two gaps" (Bjerknes 1904). Napier knew that his was the time for knowledge to be completed, with global disaster drawing near.

The BLS was a direct precursor of SRES scenario work (IPCC 2000: Appendix IV.4). In the SRES too, rural growth is 'simply assumed' (IPCC 2000: 3.2.4.2), and agricultural emissions, agricultural goods consumption, and economic growth are all largely uncertain (IPCC 2000: 2.4.5; 9.2.). Population, the 'backbone of emissions scenarios' and an extremely important driving force "is typically either not reported or not well explored in most models" (2000a: 2.4.3; 3.2.1). However, "climate models can be applied usefully to identify a range of uncertainties allowing strategic policy-making for adaptation" (UNFCCC 2009b). Discussions for preparation of the next IPPC Emissions Scenarios devotes substantial attention to downscaling.

> An inescapable conclusion is that while many of these uncertainties are recognised by scientists, they have seldom been treated adequately in the great majority of impact assessments conducted to date. There are opportunities to improve this situation, however, *through intensified research efforts and by enhancing the guidance offered to climate change researchers*. (Carter 2001: 459; emphasis added; see also Sivakumar and Hansen 2007 for another example of this discourse, in the specific remit of climate prediction and agriculture)

These limitations, the uncertainties, the unknowns, and the limits to tractability have never threatened the monopoly of modelling quantifiable variables into future projected scenarios. The 'gaps in knowledge' discourse (an assumptive mode, an institutional normative approach, and a rhetorical device) has colonised the space for representing futures. The correct word is not 'colonised', however. It does not 'colonise' a pre-existing space. It *creates* the space by drawing its boundaries, by defining and reifying the distinction between qualitative and quantitative. From Crosson and Anderson (1996: 57) to current IPCC work, frameworks that do not approach the field with a fundamental qualitative versus quantitative approach have little or no visibility. Other existing modes of representing possible futures are left out of this reconfigured space.

The 'homogeneity/gaps in knowledge' mode of enquiry usually issues calls for further, or intensified, or urgent research. The future high resolutions expected in 1982—when IIASA's work on climate and agriculture commenced—have become today's low resolutions. In 1996, we were told that "interdisciplinary science is coming of age" (Walker 1996: 597). Today, we know that optimism was unwarranted. But it persists: "The climate forecast community is now capable of providing an end-to-end multi-scale (in space and time) integrated prediction" (Sivakumar and Hansen 2007: 2). Concomitantly, however,

> Thornton argues [2006] that no single method is suitable for dealing with all situations, and calls for combining a range of quantitative and quantitative [sic] methods including: economic surplus methods, cost-benefit analysis, various forms of mathematical programming, econometric methods, non-market valuation methods. (Sivakumar and Hansen 2007: 7)

Besides the humorous(ly suggestive) typographical error, this range of methods is very narrow. It closely corresponds to the set that has been typical of scenario development, and of the historical development of scenarios and futures research.

The typical language, seen at least since Rotmans' 1990 publication on IMAGE, is prevalent in downscaling circles:

> [T]ranslating imperfect ENSO-related climate forecasts into information useful for improved farm-level decision-making remains a challenge that needs to be addressed. There is a need to translate the climate information and forecasts in terms of what the corn stakeholders can interpret and use correctly to guide decision-making in corn production system. (de los Santos et al. 2007: 190)

In this instance, the authors add that studies confirm that forecasts are considered inadequate as they don't fulfil farmers needs, but things are expected to improve with more satellite time series improving the quality and resolution of observation data. And that "*predictability* at intermediate intra-seasonal . . . timescales . . . holds *promise* in the short term as it *will benefit* from enhanced representation of continental forcings" (2007: 198; emphasis added).

The Local Totality: The Nairobi Work Programme

The Nairobi Work Programme of the UNFCCC was a five-year programme (2005–2010) of the Subsidiary Body for Scientific and Technological Advice (SBSTA) on impacts, vulnerability, and adaptation to climate change. As the main international climate change adaptation initiative, it was the way the UNFCCC operationalised the findings of the SRES into the basis of local agricultural policy. It is described in the Compendium on Methods and Tools to Evaluate Impacts of, and Vulnerability and Adaptation to, Climate Change (UNFCCC 2008). Its function was assisting its Parties (countries)—in particular the "developing ones"—to "improve their understanding and assessment of impacts, vulnerability and adaptation to climate change" and "make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical and socio-economic basis, taking into account current and future climate change and variability" (UNFCCC 2009). Its expected outcomes include enhancing adaptive capacity at international, national, local, and sector levels; selecting and implementing adaptation actions; enhancing disseminations and use of knowledge of adaptation activities. Access and use of information on projected climate change is part of its scope (UNFCCC 2008).

The Compendium devotes a chapter to downscaling of scenarios and models to regional, national, and local levels, and makes no mention of upscaling local knowledge or of indigenous knowledge anywhere in its 228 pages. It only goes as far as suggesting, in several instances, engagement of stakeholders in the process of adapting, downscaling, and using information (such as scenarios of projected climate change). And yet, it recognises the unique nature of agricultural modelling and its scalar limitations: "[M]any agricultural models are crop specific or are applicable only to particular regions, whereas models in other sectors tend to be more generally applicable" (UNFCCC 2008: 4–1).

The section devoted to 'Complete Frameworks and Supporting Toolkits' for adaptation opens with a listing of the 'IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations', which include scenarios (UNFCCC 2008: 2–2). It is followed by another scenario approach to adaptation policy decision (the U.S. Country Studies Program), and the UNDP Adaptation Policy Framework, which "seeks to integrate national policy making efforts with a 'bottom-up' movement". This movement 'focuses on the involvement of stakeholders at all stages' but still depends on climate forecast information, data that are most likely to be downscaled from models and scenarios (2008: 2–6). The next framework, 'Assessments of Impacts and Adaptations to Climate Change in Multiple Regions and Sectors (AIACC), considers "vulnerabilities and adaptation options in developing countries. AIACC aims to *fill gaps in the current understanding* of vulnerability and opportunities for adaptation" (2008: 2–8; emphasis added).

The 'Cross-Cutting Issues and Multisector Approaches' section starts with the IPCC guidelines addressing *general application of scenarios*, and offers techniques for downscaling climate data or developing socioeconomic scenarios (UNFCCC 2008: 3–1). We have examined the reticence, uncertainties, severe limitations to the applicability of scenarios (and noted how all SRES scenarios underestimated current GHG emissions). Nonetheless, the UNFCCC describes its downscaling techniques as producing

> small-scale climate data of the type often required by impact models and to develop future climate scenarios at local and national scales. Downscaling techniques represent only one particular way of generating climate change scenarios. None of the following approaches provides a "one size fits all" method for developing socioeconomic futures, but should instead be viewed as informing a necessarily ad hoc process. (2008: 3–1)

This is followed by a large number of other software-based downscaling tools, which derive output from numerical climate models and experiments

(Climate Impacts LINK); link data and models to simulate impacts of climatic variations in sectors such as agriculture to assess present and future adaptation measures (SimCLIM); use climate development scenarios (UKCIP02); use climate information and "predictions" for economic and social decision making (WMO CLIPS); generate scenarios from GCMs used by the IPCC (MAGICC/SCENGEN); downscale climatic information through statistical methods from coarse GCMs (SDSM); and region-independent climate models used in the four SRES marker scenarios (PRECIS). It also includes socioeconomic scenario generators consistent with the SRES (UKCIP SES), whose key output is a "description of future worlds in which climate changes might occur" (UNFCCC 2008: 3–27).

The tools range from farm-level crop models using climate change scenarios to "what if" scenarios (CLOUD). Many of the other agricultural sector tools *require a trained agronomist for operation*. Some downscaling tools are specifically directed at the relation between climate forecast and food security, such as CM Box and AgroMetShell. Developed by the FAO, CM Box generates a set of indicators that are relevant for food security, based on weather, satellite, and crop information. This allows assessing current and future climate impacts on crop production and food security (UNFCCC 2008: 4–24). AgroMetShell works with the same principles and objectives, analysing climate risks and performing regional crop forecasting using statistical and crop modelling approaches (2008: 4–19).

The econometric set of models present in the Compendium "are manipulated with climate change scenarios to *predict* the economic costs of adaptation" (UNFCCC 2008: 4–43; emphasis added). Typically, their output is based on estimations from constant relationships between historical climate and agriculture, a problematic assumption (see Wittwer 1995, Carter 2001).

The IMAGE model of the IIASA also features in the Compendium. Developed by the FAO and IIASA, it "enables rational land-use planning on the basis of an inventory of land resources and evaluation of biophysical limitations and potentials" (UNFCCC 2008: 4–108). Another methodology, Agro-Ecological Zones (AEZ) methodology, "provides a means of identifying how natural resources and agricultural production is likely to be perturbed under future climate scenarios and in *identifying suitable crops and locations under future climate scenarios*" (2008: 4–108; emphasis added). Its intended use is "climate change analysis of crop production", based on improved calculation techniques from recent digital global databases of climatic and agricultural parameters, and population distribution (2008: 4–108). The Vault is the central location in the world where crop diversity will be held, registered, classified and entered into a bespoke (proprietary?) database. The Vault's Trust defends biotechnological control of evolution. The source of climate-hardened varieties becomes apparent.

The CGIAR, the institution with the greatest direct role in creating the Vault, started work on climate trends in 1982. Its work directly and indirectly influenced the downscaling tools present in the NWP Compendium. One of its founding members, the World Bank,[6] had an established tradition of working with scenarios. While IPR was still top of the agenda and the FAO said little about climate change in its publications, IIASA was already working on integrated climate assessment in which future food security scenarios were developed. One of these scenarios would become the 1992A IPCC SRES scenario. The approach was described in terms familiar to us: *holistic* and h*earing a multitude of voices* (Rothman and Coppock 1996). The CGIAR's work on growth season prediction started in the same year. Its Oasis Programme used quantitative methods for measuring ecological processes combined with on the ground participatory assessments of community perceptions (Shapiro et al. 2007).

During the 1980s, the World Bank devoted very substantial resources to an intensive training system of delivering information to farmers. Working with the CGIAR, a significant part of the information delivered was derived from scenario and model work. Placing the focus on the extension worker and not the farmer or farming family were considered shortcomings. The farm enterprise and the farm family were not at the centre of agricultural research systems (Ruttan et al. 1996). Ruttan says, in this context, "The global agricultural support system is *still incomplete*" (Ruttan et al. 1996: 623; emphasis added). The two-way system of information sharing wasn't balanced, but the international research agenda was set.

A number of the tools listed and described in the Compendium emphasise how their predictive output is in a format easily read by policymakers. Laitner et al. offer some insights into this attitude:

> Over-reliance on the predictive power of even well specified equilibrium models leads to a specious precision that can mislead those who are unaware of the limitations of the model. More ominously, if *their predictions are accepted uncritically, the models can be used to bolster the positions of special interest groups* who know that they can elicit from the models the kinds of answers they desire simply by manipulation of the assumptions. (2001: 49; emphasis added)

The Body Apocalyptic

The Global Crop Diversity Trust (GCDT), the organisation that oversees the running of the Vault, quotes the Stern Report in asking for more climate-resilient crops and in stating that "international funding should also support improved regional information on climate change impacts, and research into new varieties that will be more resilient to drought and flood" (2006: 2). The mobilisation of climate change for food security is completed, and activated. This strategy dovetails with the GCDT's parent organisation, the FAO:

> Traditional knowledge and local biodiversity are likely to be *surpassed* in a rapidly changing situation in which methodologies, crops and crop varieties need to be developed for future conditions. This requires strong national and international agricultural, forestry and fisheries research and relegates an important role to the CGIAR Centres. (FAO 2008c: 10; emphasis added)

The CGIAR is the strongest international agricultural research institution. The Vault and CGIAR share very close institutional and research links; their work is mutually dependent and they share staff. The institutional alliances are thus concurrent with the automation of choreographies (technical, i.e., forecasting software packages) and institutional (the local authorities and users that adopt forecasting and 'better' crops in the face of their surpassed knowledge). From scenarios that do not include catastrophic futures we have an outcome that anticipates unimaginable catastrophes, and deems preparation necessary. Indigenous knowledge is rarely profiled and given the critical attention it deserves, while climate models are seen as "a promising but underutilized tool for enhancing food security" (Vogel and O'Brien 2006: 114).

The body apocalyptic is formed. Science stands for clergy as the eyes that provide guidance; institutions for nobility, as the hands that operationalise the vision; and farmers for peasants, as feet for agriculture, or hard workers, as we will see them described below. The body's diet is disseminated worldwide; rituals and festivities might change along with crops, as does management, unifying the global narrative of climate change through a unification of agricultural practices centred on a Doomsday Vault.

> The UNFCCC meetings have focused primarily on matters of science and politics, so experts in climatology or in international relations might seem more appropriate than anthropologists to discuss this protocol . . . But the major activity of the protocol to date has been the effort to construct a *shared narrative*, a verbal framework that links specific actors, institutions, and political entities. (Strauss and Orlove 2003: 11; emphasis added)

LOCAL KNOWLEDGE

Local knowledge and local adaptation and coping strategies have received more consideration in recent years, but the level of integration of local or indigenous knowledge into adaptation mechanisms is very low. In contrast to the NWP focus on downscaling and (sometimes mandatory) upgrading of the 'surpassed' local knowledge, other UN institutions recognise a very different level of importance to local knowledge. Their output largely differs from the methods suggested by the NWP.

The UN University (UNU) Traditional Knowledge Initiative has focused on the relevance of indigenous knowledge to climate change adaptation, through its Traditional Knowledge and Climate Change research programme. The programme is based on the recognition that indigenous people hold powerful knowledge about the climate and are key actors in developing adaptive and mitigative policy. Their place-based adaptation strategies are the most important aspect of indigenous knowledge and are examples of developing local adaptation to climate change. The programme description adds that the IPCC recognises this importance, and also recognises that it has been a missing element in its previous assessments.

This recognition, by two UN institutions (IPCC and the UNU) finds little space in the UNFCCC methods and tools for adaptation listed in its Compendium. It is a future prospect, and the UNU Traditional Knowledge Initiative focus "for the next couple of years [2008–2009] will be to bring the experiences and knowledge on indigenous peoples into the IPCC and UNFCCC processes" (UNU-IAS 2009). Until that process bears fruit, knowledge that is local by origin, nature, and definition will be literally 'saved' in databases. Not unlike the Vault. If 'catastrophe beyond imagination' occurs outside, germplasm has its eternal database in the Vault, and indigenous knowledge databases preserve the 'origin'.

Most repositories for indigenous or local knowledge are online searchable databases, such as the UNFCCC Adaptation Planning & Practices Database and the Database of Local Coping Strategies, the FAO Technology for Agriculture (TECA) database, the World Bank Indigenous Knowledge Database, the World Resources Institute Vulnerability & Adaptation Database, the World Overview of Conservation Approaches (WOCAT) online databases, the UK Climate Impacts Programme database. "Traditional knowledge, by virtue of being entered into database fields that fix the 'traditional' as static, is detemporalized in a precise recording at a particular historical moment" (Philip 2008: 257–258).

These databases assume the translatability of local knowledge, whatever its original language (verbal or otherwise) or format. Songs, rituals, traditional division of labour, ways of looking at the clouds, subjective evaluations, skills embedded into daily practices that are transmitted from generation to generation without verbalisation, how do all these translate and fit into databases? Ethnographic studies have shown the importance of the repertoire of these kinds of practices and rituals of observation and forecasting (Sivakumar and Hansen 2007).

And if they were translatable, how are they organised? Who classifies and organises them? Are they like seeds in a Vault, harvested and safeguarded, kept in detached silence, disembedded? Who owns this online knowledge? Who, in other local rural communities has the means (Internet access and literacy, to name just a couple) to access it? How does this change or reinforce local social hierarchies? "A philosophy of communications conceives the message as order, meaning or unit, but it also conceives the background noise from which it emerges" (Serres 1995[1982]: 110). These processes do not 'save' indigenous knowledge, but create a representation of it, and simplify the process of obliterating that which does not fit the format in which information is saved. This isn't, as they say, rocket science; however, the reliance on scenarios and on developing them based on quantifying uncertainties goes on (e.g., Groves and Lempert 2007).

Upscaling

Not that upscaling doesn't exist. It has started to gain some ground. The Technology and Agrarian Development Group of Wageningen University, in the Netherlands, has started its own Participatory Approaches and Up-Scaling (PAU) programme, with support from the Rockefeller Foundation. It "aims at a better understanding of participatory approaches in research and development, with focus on smallholders' agriculture and emphasis in Sub Saharan Africa" (Wageningen University, undated). The IPCC's TAR recognised, in 2001, that "stakeholder-determined thresholds are an emerging area of research in Australia . . . and methods to evaluate stakeholder and institutional learning in response to changing climatic hazards are being developed". In 2008, the focus remained strongly on downscaling, even if, in the IPCC's TAR, "research on discrete climatic events is an area that also needs further research" (IPCC 2001b: 2.3.5.3).

Recent approaches to mitigation in agriculture use the word 'upscaling' in the sense I suggest above. They too tend to be laconic, saying more about local institutional and financial arrangements, farmer learning, large-scale planning, and stakeholder coordination; this while recognising that carbon offset standards are developed for and by data-rich countries and thus of difficult applicability in developing countries (Wollenberg et al. 2012). Upscaling is a mirage.

Community-based adaptation initiatives aimed at enhancing the autonomous ability of communities to exchange information on adaptation strategies is an approach followed by an increasing number of charities and NGOs (e.g., World Wildlife Fund, Oxfam, International Institute for Environmental Development). And the UNFCCC has started concrete events to give more visibility to local adaptive strategies (e.g., the 2007 NWP Rome workshop on adaptation planning and practices). The scarcity of these events and the focus on databases of indigenous knowledge is a sign of the imbalance and the overwhelming focus on downscaling evident in the NWP Compendium.

In a paper by de los Santos et al. on *correct* local usage of climate forecasts, the authors give an account of a project conducted in 2003 (Bytes for Bites: Translating Climate Forecasts into Enhanced Food Security for the

Sahel), and relate how "[t]he authors' expectations of the *future of research* are in line with the general opinion: there is limited predictability but "this will change over the next decade" (2007: 199).

The Double Deficit of Representation

In an opinion paper written for the 2007 UN Climate Change Conference, Diana Cammack criticizes the UN's work as being centred "almost exclusively on the expected developmental impact and the need for financial support to tackle it". This, I have demonstrated, is not a result of some ideological stance that can be addressed by something like elective democratic means. Once the quantification model is the very fabric of the whole process of representing the world, the non-quantifiable becomes under-represented, scientifically and democratically. Cammack further criticizes the UN for its inability to take conflict, movement of refugees, and other transboundary processes into account and says that solutions based on capital and technology transference are "almost naïve in their simplicity". This amounts to a *double deficit of representation*, of 'representative' democracy, and of 'transparent' science.

Can the deficit be attributed to how—according to Shugart (2001: 120)—science 'progresses' through simplification? That the endless heterogeneity of the most complex of objects of knowledge, the 'totality', is to be known this way is highly problematic. Strauss and Orlove (2003; quoted above) note how the work of the UNFCCC has been mostly the construction of a 'shared narrative' to link actors, institutions, and policymakers (the mobilisation that the Bellagio Declaration called for). Achieving this narrative is helped by scientific representations of a 'totality' through GCMs, but I would propose that it is more the case of a universal (than shared) narrative; a universal narrative that makes sense of everything, but finds it hard to grant other narratives, and other narrative formats, the adaptive potential they may have. Scenarios have always worked through the same principle of simplification; they are "a method of simplification" working under the presumption that "one can cover most relevant issues by creating up to four scenarios" (Nordfors 2007: 199). The outcome of these approaches is that neither the changing climate nor people are adequately represented.

The Bellagio Declaration called for urgent and immediate integrated multidisciplinary and intersectoral action. It seems that those with less responsibility for the current emissions aren't only the most affected, but the least heard. The representation of the totality seems to be lacking one of its primary elements: according to the UNU-IAS Traditional Knowledge & Climate Change programme,

> long-term place-based adaptation approaches developed by indigenous peoples provide valuable examples for the global community of low-carbon sustainable lifestyle, *critical* to developing local adaptations strategies in the face of climate instability. (UNU-IAS 2009; emphasis added)

The relation between models of the physical world and models of the social world as representing human and natural reality isn't new. A quick flashback: the Banqueting House performed, in its time, a double role of representation. It represented the sociopolitical stratification of the realm, and it represented the cosmos through strict quantified proportions. But the House, in its pretensions to absolute power, allowed no deficits.

Economies of Downscaling

Downscaling has not only gained scientific momentum, but has reached commercial success:

> Have you ever needed daily met data and found that the nearest met station is 25km away and over a range of hills? That the data are recorded on paper and you'll have to transcribe them all? That they are only available for the years 1945 to 1953? You're in good company! Almost anyone trying to run a crop model or evaluate the probability of frost or drought knows the feeling only too well. Wouldn't it be magic to create a series of 30 years of daily rainfall, maximum and minimum temperatures, and global radiation with the click of a mouse for the very field that you are working in? MarkSim can do that for you. (CGIAR 2006)

> The Decision Support System for Agrotechnology Transfer (DSSAT) is a software package integrating the effects of soil, crop phenotype, weather and management options that allows users to ask "what if" questions and simulate results by conducting, in minutes on a desktop computer, experiments which would consume a significant part of an agronomist's career. It has been in use for more than 15 years by researchers in over 100 countries. DSSAT is a microcomputer software product that combines crop, soil and weather data bases into standard formats for access by crop models and application programs. The user can then simulate multi-year outcomes of crop management strategies for different crops *at any location in the world*. (ICASA 2009; emphasis added)

DSSAT is part of the NWP's agricultural sector-tools, costs US$195, and a training session costs US$1500 (training is required for 'proper use', plus additional costs for hotel, travel and per diem; UNFCCC 2008: 4–31). DSSAT is described, in the Compendium, as "predicting" growth, yield, resource dynamics (including water and carbon) and gross margins.

From drought as unknowable risk (Shapiro et al. 2007) to the future on a screen at the click of a mouse. Once modelling has been blackboxed along with downscaling, how is uncertainty communicated, commercially? Who, looking for commercial success (or funding), communicates limited confidence in their own product? Technology adoption and dissemination by local institutions is further encouraged by scientific publications

> to come together and pro-actively *decide* necessary actions *based on climate forecasts* . . . An effective information flow system from forecasters to agricultural organisations and farmers is feasible within the recently evolved institutional system. However, targeted forecast application can be enhanced through developing an end-to-end institutional feedback mechanism. (Selvaraju and Subbiah 2007: 58–60; emphasis added)

"Control of Evolution" as Salvation

R. S. Paroda, famous agricultural geneticist (and a prominent member of the CGIAR and FAO) stated "We must realize that the only way to address new challenges and harness uncommon opportunities is to continue building excellence in science and technology" (2003: 4). The only way is technoscience. And if one might think that this contradicts the decades-old call for a two-way sharing of information, the farmers of this genetically modified body apocalyptic are only recognised for their hard work, according to Paroda: "Thanks to the cutting edge of science, strong political will coupled with appropriate policy interventions and the hard labour of our farmers, India since independence achieved four-fold increase in foodgrain production" (2003: 4). Such claims, and even stronger ones (such as the 'cornerstone' claim) award powers to the Vault well beyond climate change adaptation. These are related to perhaps the most striking of this group of statements: "evolution is in our control".

As their names suggest (IMAGE, MESSAGE, PRECIS, MAGICC, CLOUD), climate models are seen as images of the world, messengers that do not interfere with the message; they are *magic* and *precise*, or embody entities central to climate change (*cloud* coverage is one of the most problematic and uncertain areas of modelling). Models are neither separable from the nature they claim to represent, nor neutral. But that is what they claim to be. To use Serres' image of messengers as modern-myth angels, they cannot be neutral by virtue of their position in the communications channel (at least not for long) (1993). Models, our new messengers, in translating the message from the absolute (totality) to the relative (local), have taken the place of angels as messengers by virtue of neutral quantification.

It is not only through a long analysis of the relationships between modelling, climate change and hunger that we can see the impossibility of neutrality. The connections between climate change and control of evolution are strong enough today to be referred to, at policy level, without long explanations. On 19 March 2009, the Chief Scientific Adviser to the United Kingdom's Government addressed the GovNet Communications Sustainable Development UK Conference to talk about climate change and food security, "discussing the twin challenges of climate change and food security and the role of agriculture in mitigating and adapting to climate change" (GovNet 2009).

> Professor Beddington said: "We have to address that. We need more disease-resistant and pest-resistant plants and better practices, better harvesting procedures. Genetically-modified food could also be part of the solution. We need plants that are resistant to drought and salinity—a mixture of genetic modification and conventional plant breeding". (BBC 2009c)

These most recent calls for the 'control of evolution' constitute the corollary of the automation of choreographies into both physical spaces and calculating procedures. A *universal narrative*, sustained by quantification and moving towards an assumed complete objectivity, is seen as universally applicable. The long road from agricultural biodiversity as an IPR issue ('obligations to freely share'), through food security as the cornerstone of climate change adaptation and essential for mitigation, comes full circle to justify genetic modification of crops, bolstered by the power of the alliance with climate change. Laitner et al.'s argument that uncritical acceptance of predictive power of models "can be used to bolster the positions of special interest groups" can now be seen in a new light. As in Napier's time, it is still human agency over nature that will bring about salvation. A nature fallen into disrepair by human action can be redeemed, by 'control of evolution'. In the Vault, we now protect nature from humans, the seeds of our salvation from the behaviour of our doom. Like rebuilding Eden, an untouched and untouchable Nature, with fruit that is not to be eaten, a hermetic realm behind blast doors, one we cannot defile. Purity away from danger, as Mary Douglas would put it, or Hotspur in Shakespeare's Henry IV: "I tell you, my lord fool, out of this nettle, danger, we pluck this flower, safety".

Nina Fedoroff, science and technology advisor to the former U.S. secretary of state, an advocate of worldwide adoption of GM foods has recently reiterated (BBC World Service 2009) the need for the world to accept GM foods because of the food security risks posed by population growth and how climate change will affect crop productivity. Upgraded by downscaled knowledge, indigenous knowledge hasn't found a more fruitful or safer haven than being literally saved into databases. If replaced with GM crops, the current genetic pool of agricultural biodiversity has in the Vault its own database, untouchable, beyond defilement. Sygenta, one of the world's largest agricultural biotechnology corporations, is a member of the CGIAR (through its Sygenta Foundation for Sustainable Agriculture; CGIAR 2007) and is a direct funder of the Vault, as is DuPont/Pioneer Hi-Bred, another very high-profile agricultural biotechnology corporation (GCDT 2006b). Katherine Sierra, Vice President for Sustainable Development at the World Bank (one of the institutions that pioneered the use of scenarios) is the chair of the CGIAR. On climate change, she says that "what is needed is a new revolution in agricultural research, built upon the successes of the 'Green Revolution' that helped so many hundreds of millions of people to escape hunger and poverty, and paved the way for economic growth in their countries" (Sierra 2008).

The virtues of the Rockefeller Green Revolution (the same Rockefeller Foundation of the Bellagio Declaration) have been disputed for decades. It delivered higher-yield varieties, and it yielded social tensions in developing nations, with landlords benefiting over peasants, and the latter earning lower wages and being displaced. Biotechnology industry relies increasingly on biodiversity, and this can deplete biodiversity resources (Ragavan 2007). With examples of famines without food shortages in the recent past (Bengal 1943, Bangladesh 1974), and with the number of hungry people in the world having increased as food production increased through the Green Revolution, the focus of food security policies has started to shift to sustained individual access to sufficient nutrients, from the previous concentration on production. The Green Revolution assumption was 'more food means less hunger'. The then chairman of the CGIAR, overseeing Green Revolution research, S. Sahid Husain, went so far as to suggest that the "added emphasis on poverty alleviation is not necessary" because increasing production itself has a major impact on the poor (quoted in Mukherjee 2004: 2).

The uncountable array of objects on a globe-wide orbit around the *Vault* is maintained by the gravitational force of the NWP's calculating tools. Tools which institute the mediation between nature and policy: with modelling and scenarios being neutral, based on well-established, well-understood physical laws, 'we have the knowledge', there is no causal lacuna, and mediation is assured. The totality (i.e., the atmosphere, hydrosphere, biosphere, and geosphere, and their interactions) is made real in its representation. Made real in its application through tools and remote peripheries (the Vault at Svalbard) that are at the centre of adaptation mechanisms (Nairobi Work Programme). The claimed representation of a totality marginalises those most at risk (and less responsible for the status quo). Latour says that "the defence of marginality presupposes the existence of a totalitarian centre. But if the centre and its totality are illusions, acclaim for the margins is somewhat ridiculous" (1993: 124).

The expectations of development of enough predictive power are still only expectations, more than a hundred years later. The ability of modelling to inform policy has not led to significant GHG emission reduction. Does this mean that modelling and scenarios and downscaling are useless? Not in the least. It shows that, contrary to what Serres states (1995[1982]: 3), we have not given up the hope for a unitary knowledge. This does not mean that they have failed, but it suggests that their monopoly in interfacing with policy is indeed failing adaptation, sustained by the shared language of quantification and the effective rhetoric of 'gaps in knowledge'.

The noise of uncertainty grows every time we realise our projections are wrong. The certain outcome of modelling and scenario exercises is the redefinition, redesign, and retooling of agricultural practices via 'upgrading of knowledge' and 'control of evolution'. We make the world from our models. "[T]here is no metalanguage" (Latour 1987: 86). Much more than a patent debate, Philip argues, this is related to "ideological questions that lie at the heart of transnational economies of the growth of the software and biotech industries" and assumptions made about the developmental capacities of "underdeveloped societies/people" (2008: 254; cf. Blench and Marriage 1998; also Lemos et al. 2002; Vogel and O'Brien 2006). Many have argued that the protracted negotiations of ownership, rights, patents, germplasm, and so on, have perpetuated or renewed economic, technological and knowledge colonialism (see Kesan 2007; Bordwin 1985; Lappe and Collins 1980; Philip 2008; Mukherjee 2004; Adams, J. 2005; Agarwal and Narain 1991; Wright 2007; Chen 2007).

This does not wholesale discredit the work of the CGIAR, or the FAO. Independently of the veracity or fantasy or plausibility or possibility of scientific apocalyptic narratives, their objectification through quantification makes the work of such institutions permeable to interests that can range from commercial to immoral. Apocalyptic narratives rely on a universal truth, applicable to all (downscalable), and need a neutral mediator. Now that prophets or angels won't do as neutral messengers, the neutrality of calculation hardly disguises its impersonality and inhumanity.

7 Reclaiming Futures
Olafur Eliasson's Weather Project

> Don't wait for the last judgment—it takes place every day.
>
> Albert Camus

> One cannot write without bearing witness to the abyss of time in its coming
>
> J. F. Lyotard

In the previous chapter, the critical analysis of downscaling—as simulated generation of local heterogeneities from a virtual totality—considered how climate modelling and global IPCC scenarios are limited as tools to inform decision-making, as demonstrated by current emissions, and by hunger statistics. The analysis has also followed the claimed neutrality of this approach and how the standing of the scientific, institutional, and discursive formations depends on it.

This chapter explores other forms of knowing nature, climate, and their futures. What other ways of representing nature are relevant in addressing climate change? Do they claim neutrality of method, and is that a requirement for their validity? Or do they foreground intuition and creativity to question the very possibility of neutrality? Might they understand agency differently, and challenge the type of control of agency exerted by downscaling?

LOOKING BEYOND SCENARIOS

Jean Baudrillard opens his *Simulacra and Simulations* by considering the present 'imperialistic' attempts of simulation to make the real coincide with models of simulation. He defines simulation as the 'generation of reality by models without origin', and emphasizes that it attempts to create all of the real (1994[1981]: 1). In our context, one might also say 'the totality'. He further argues that the hyperreal, "produced from a radiating synthesis of combinatory models," is "henceforth *sheltered* from the imaginary, and from any *distinction* between the real and the imaginary, leaving room only for the orbital recurrence of models and for the simulated generation of differences" (1994[1981]: 2–3; emphasis added). The IPCC SRES' inclusion of subjectivity and creativity conforms to these two related, but different, aspects of neutrality. One is its *performative dimension*: creativity, intuition, imagination, and subjective evaluation are always and already part and parcel of the practice of generating a 'totality', and of the practice of generating diversity from that totality (cf. Jacob 1982: vii). This aspect is largely unrecognised, or its effects minimised through the purifying power of quantitative methods. The other is its *rhetorical dimension*: the IPCC SRES, like the modelling community it works with, recognises creativity, intuition, and so on, as assets *added to* the array of its solid, objective methods.

To use Baudrillard's terminology, this allows the new, post-SRES scenarios to be *sheltered from distinction* between the real and the imaginary, by claiming valid usage of creativity and imagination. And it allows them to be *sheltered from imagination* by rhetorically upholding transparent scientific objectivity. This way, scenarios are both sheltered from the imaginary and indistinguishable from it. The imaginary is, at once, present and absent.

Scenario thinking—like a great part of future studies—has never shed its managerial, corporate, and military origins. Not that it has to. But to scan the future with great emphasis on those methods, and on the thinking of those who develop them, formats the type of solutions possible, it selects 'pathways'. Scenarios are still seen as the "way to harness the power of systemic insight into the continuous unfolding of strategic action", based on an "essentially entrepreneurial mind" (Sharpe and Van der Heijden 2007: 7). In the introduction to Sharpe and Van der Hejden's edited volume (composed of contributions from academics, researchers, and corporate strategists) the authors define, as object of study, the patterns of *behaviour* sustained over time by three types of actors: governments, businesses and people (2007: 6). Non-humans, and the *practices* they are part of, are not mentioned.

When the methodology of scenarios is examined in these circles, the propositions sound familiar to those we have found in the SRES. Peter Schwartz, author of the 1991 landmark *The Art of the Long View*, contributes to Sharpe and Van der Heijden's volume. Schwartz states that "decision makers must be prepared to be engaged with new ways of thinking" (Schwartz quoted in Sharpe 2007: 15), but does not move beyond the assimilation mode that we have witnessed in the SRES. Typically, the details of these programmatic calls are abstract. Schwartz also adds that scenario planning takes time in development, communication, absorption of new possibilities and time from absorption to action. But time is the least known quantity in climate change. Looking beyond the tools we've been relying on for decades makes sense.

Lennart Nordfors says, in his chapter in the same volume, that when dealing with extreme complexity, too many scenarios reflect existing complexity and prevent insight. Nordfors proposes that the important development of aesthetic methods depends on the ability of formal models to assimilate them, or on their illustrative purposes (2007: 200). The chapter is titled 'The Power of Narrative', but nothing else is said about what it calls 'the aesthetic'. These strategies and rhetoric have the pernicious effect of denying other practices any valid creative purpose, in their methods and in their representations. Other chapters in the volume have titles such as ‘Professional Dreamers’ (Cynthia Selin).

Opposing voices have surfaced, calling for *Clumsy Solutions for a Complex World* (Verweij and Thompson 2006). The authors identify the failure of the Kyoto Protocol, including in the nations that did ratify it. The analysis proceeds through a grid-group typological framework, identifying four primary ways of organising, perceiving, and justifying social relations, or ‘four ways of life’. The framework works as an abstraction from which social life can be understood. As such, it differs little from a social scientific form of downscaling. The analysis renders many interesting points in arguing for creativity in climate change, but anything that is not commensurable with the framework risks being lost. That the typology does constrain the analysis, and sounds a little too much like SRES scenarios, is exemplified by passages such as “four straightforward organizational principles can result in an endlessly changing, infinitely varied and complex social world” (2006: 5). Ultimately, it seems contradictory that “the case for clumsiness rests on the idea that a limited number of collective ways of organizing and thinking exists” (2006: 22). This approach would hardly be coherent when exploring ways out of the blindspots created by scenarios. The authors’ defence of their “assumption that human relations tend to be organized in a restricted number of ways” (2006: 6) is a bit perplexing in the context of representing heterogeneity in a hypercomplex system. A *studying-up* approach would offer a safer way of embracing clumsiness than a restricted typological approach.

We’ll return to *studying-up* later, but the analysis Verweij makes of the climate change mitigation and adaptation reveals the limits of ‘top-down’ approaches. In the chapter ‘Is the Kyoto Protocol Merely Irrelevant?’, Verweij proposes cheap, efficient, and sustainable energy sources as the solution to climate change. Technological advancements that are less reliant on formal international cooperation and more reliant on technological innovation make for a clumsy global solution, the author proposes. It recognises that Kyoto and UNFCCC are a bureaucratic top-down approach based on regulation, with very little faith in local voluntary measures (2006: 53). His exploration of the matter largely—if not wholly—misses inertias in social, industrial, and political change. It makes no mention of lock-ins and current patterns of distribution of agency and power when it proposes “an all-out attempt to develop cheaper and cleaner energy resources”. The author assumes that these technologies are not only possible, but timely within grasp (2006: 41). It adds that “right away, governments should vastly increase their expenditures on renewable energy R&D” (2006: 50). The Bellagio declarants too, asked for urgent, immediate, global, multi-sector change (as did the UNEP, a decade before; Tolba 1991). It hasn’t happened. But they didn’t go as far as proposing Verveij’s clumsy solution.

What Kind of Knowledge, for Whom and for What?

Temporality in environmental issues, especially global environmental issues, has been deemed central by several authors. Barbara Adam (1998) offers a hopeful analysis of the need to include temporality in environmental risk assessment and decision-making, forming timescapes (see also Morton 2007: 166). She asks, "Knowledge for whom and what?" (1998: 4)—a most pertinent question, in the light of the managerial, entrepreneurial, and corporate cornerstones of environmental scenario planning. Asking for a move from disembodied, decontextualised, objective, and institutional science, towards forms of explicit engagement, Adam argues the need for change at the centre of taken for granted scientific assumptions and for the questioning of the futility of objective and static truth, to engage with processes marked by "futurity and un/certainty, and *demystify* the capacity of science to provide truth(s)" (1998: 7–8; emphasis added). To do so, she argues for a deep knowledge of temporal complexity, which she opposes to abstract, scientific clock-time. This "newtonian time", she says, "becomes a quantifiable resource that is open to manipulation, management and control" with nature as an external framework (1998: 11; see also Adam 1990). More recently, with Chris Groves, Adam has stated that the elimination of embodied futures from the frame of reference now requires scholarly engagement to shift in perspective and focus towards historical perceptiveness, and a trans-disciplinary outlook (Adam and Groves 2007: 14). A sustainable environmental future can only be achieved, Adam suggests, if farmers reclaim ownership of the means of *reproduction and ownership of time*, to restore them control over agricultural rhythms and futures. In terms that resonate with Adam's, and the previous two chapters in this volume, Peter Weibel's *Chronocracy* states that the real meaning of 'time is money' is 'time is a number' (2000: 152).

Adam's analysis will be useful to us here, throughout this chapter. Reciprocally, my analysis suggests ways of further employing Adam's ideas. I argue that there are non-verbal modes in which they are being expressed, and that reclaiming ownership of time is increasingly difficult. *Reproduction*, we know now, has been safeguarded in a far-away Vault, setting 'control of evolution' against doomsday. *Time*, we now know, has been included in environmental policymaking, and non-quantifiable representations of time have been excluded; or, to be more precise, have been assimilated and emptied. The plan for the rhythm of agricultural life is derived from downscaling, and met with crop varieties to adapt to the changing seasons. The timescape perspective actually implemented in environmental and agricultural policy has not enabled us to deal with our blindspots. On the contrary, it has claimed to represent nature, and it has made farmers invisible. These developments—total control of plant reproduction by a few genotechnological corporations—were anticipated by Adam (1998:

212). This does not contradict the potential of the temporal for "alternative socio-environmental praxis" she proposes (1998: 19), it merely evidences how the multi-dimensionality of complex social systems tends to exceed analytical ability.

It is, therefore, time that we stop pretending we can know everything that matters, to stop pretending that our ignorance is but a gap, instead of the cliff by the chasm it actually has become. In this context, I propose that the vital importance of work like Eliasson's Weather Project is better understood in the terms and configurations proposed by Adam:

> Future making all too easily slips into future taking. The first corrective move therefore would seem to be an effort to re-embed and re-embody the products of progress in their temporal continuum and to understand them as social. (Adam and Groves 2007: 94)

Adam identifies disciplinary knowledge separation as part of the problem. The visible development of timescapes has not decreased the separation, but resulted in assimilation. Timescape perspectives have not resulted in inclusiveness, relativity of positioning, explicit incorporation of absences, latencies, immanent forces; or resulted in moving away from what Adam calls 'the futile need of proof'. Computational climatic futures are prevalent, but have little in common with the timescapes Adam proposed.

Andrew Ross identifies the power of ecology as practical politics in how it "encourage[s] people to make consistent links between the social or emotional shape of everyday actions and a quantitative world-picture of physical causes and effects" (1991: 194). With Ross' suggestion that such politics are made of information and knowledge, Adam's question—knowledge for whom and for what—gains another dimension: what kind of knowledge, for whom, and for what?

Keeping Adam (and proposals for clumsiness) in sight, I want to make the case for the importance of the imaginary (in its artistic modes of expression) and of temporality (in non-chronological modes); the case for the importance, relevance, and validity of representations that are too incommensurable with quantification for translation, or appropriation, by quantitative world-pictures; the case for the vital importance of re-embedding and re-embodying representations. Instead of proposing changes or additions to the approaches currently used by science and policy to represent nature, or proposing future developments to current practices ('yet to reach their full development', as the mantra goes), I want to analyse *existing* representations, the practices that generate them, their power, successes and potential. This chapter is a return to visual representations, artistic visual representations of the world we live in, and visual representations of our processes of representation.

THE WEATHER PROJECT

The third chapter investigated the Banqueting House, at Whitehall, in London, an architectural and visual representation of a nexus of partially secularised narratives, an instance of how "religious paintings offer an excellent testing ground to compare the various kinds of displacements of translations" (Latour 1988:15). It represented, through Rubens' and Jones' visual and spatial translations, a certain order of the world. It placed those who entered it in a Neoplatonic structuring of the social, the political and the religious, reserving the topmost region to the divinely appointed monarch. Audiences were situated in their relative place in the cosmic hierarchy.

Recently, another very large parallelipipedic building in London had its central Hall modified by a high-profile, internationally acclaimed artist. As in the Banqueting House, the audience is invited to consider its place in the order of things, and to look up to see a sky for a ceiling, and ponder on the role of the human figures that are lifted in it, like James I and VI was (and still is) lifted up in his Apotheosis, across the Thames.

The Tate Modern—a London museum and gallery—has housed the Unilever Series since 2000. As part of this programme of yearly commissions of artworks specifically designed for the large Turbine Hall of the Tate Modern, the 2003 commission was awarded to Olafur Eliasson. From 16 October 2003 to 21 March 2004, Olafur Eliasson offered the public his Weather Project (at no entry fee). He has called it a 'machine', and it took up the entirety of the Turbine Hall. The vast space of the Hall—155m long by 23m wide and 35m high—was doubled by the mirror ceiling that was part of Eliasson's machinic installation. On entering the Hall, the visitor faced a large setting sun at the far end, dominating the whole space. The installation gave visitors a feeling of tranquil wholeness, completeness. The calm of a setting sun created the cosy familiarity of a hazy late summer afternoon (see Figure 7.1).

But the audience soon became aware of the construction of the experience, the space, the ambience, the warmth, the haze, *aware of the construction of the atmosphere*. It was not the winter outside that defeated the illusion. The indoor sun readily revealed its building elements: a screen, and an array of orange mono-frequency sodium lamps (similar to those used for urban street lighting), behind the screen, but not completely covered by it. The screen forming the 15m-wide solar circle was only a translucent semicircle, with its flat upper section flush against the ceiling mirrors. The reflection in the mirrors created the top half of the circle and, in their slightly uneven juxtaposition, created the shimmer of a forever setting Sun, as if time was arrested in the present. The mirrors also reflected the whole floor of the Hall, and those that stood on it. The haze was controlled by pumping water vapour into the Hall, creating a mist that dissipated periodically. The sixteen nozzles, the piping, and the pumps were visible, with

Figure 7.1 Olafur Eliasson, The weather project, 2003. Monofrequency lights, projection foil, haze machines, mirror foil, aluminium, scaffolding. 26,7 x 22,3 x 155,44 m. Installation view at Turbine Hall, Tate Modern London (The Unilever Series), 2003. Photographer: Jens Ziehe. Courtesy of the artist; neugerriemschneider, Berlin; and Tanya Bonakdar Gallery, New York. © 2003 Olafur Eliasson.

no attempt to conceal them. Concrete, steel, glass, and electrical wiring, lamps, pipes, artificial temperature and humidity, mirrors, the yellow hue, all become visible as elements in the creation of an experience.

None of this diminished the success of the installation. The Weather Project was a resounding success, with more than 2 million visitors. The installation became famous also through images of the audience reacting to, and interacting with, the installation. Visitors of this microcosm of the weather system engaged with its sun and its sky: they basked in its light, lying down on the floor of the Turbine Hall as if it were a lawn or a beach, however impossible that beach was. Doing this brought them in direct visual contact with their own reflection, high up in the ceiling. Looking up at it—a sky made of mirrors—visitors got a new, different perspective on themselves and others. Many visitors would sit or lie down and absorb the atmosphere engendered by the installation, dramatically different to the usual ambience of the cold and dark Turbine Hall. The large sun, in spite of being artificial, did create a peaceful environment, and visitors enjoyed looking up, finding their image reflected in the 'sky'.

The Weather Project formed a representational inversion of the naturalised order of things. The 'natural world' went indoors, displaced, inverted, so that we can know how it looks inside out, how the building blocks work together; how humans play a major part in the assemblage of coherent knowledge that is stabilised by the selective forgetfulness of pragmatic truth. Bruno Latour's 'world wide lab' is proposed in his essay about Eliasson's Weather Project. Latour tells us that the reversal has occurred permanently and includes us all in a lab experiment usually known as 'global warming'. Nature goes indoors, into the Doomsday Vault and the Weather Project, but for different reasons and with different purposes.

The funding, building, and opening of the Doomsday Vault confirm that the reversal is permanent. Nature is safeguarded from the world wide lab. The Weather Project questions—through a different type of reversal—our ideas of nature and its representations, and the way they are assembled by our perceptual selves, our institutions, museums and galleries, the media, and society in general. It invites us "to step out of ourselves and see the whole set-up with the artefact, the subject and the object" (Eliasson in May 2003: 18). It does not do so by deriding nature, or by undermining our perception of it. Visitors at the Tate did not endure a disconcerting experience. Very much the opposite. And it wasn't (just?) winter blues therapy, it wasn't an escape from the dark, grey, and cold London winter that made it pleasant. Bathed in the light of an indoor sun, one experienced the exposed entrails of the artificiality of the natural. Bringing the sun inside brings out the assemblage of realities, and their naturalisation. The building blocks, the components of knowledge and perception, their unevenness (and how even the uneven can be naturalised) are visible. The heterogeneity of the world isn't abhorred to the point where the very word is avoided. The workings of a coherent image of the weather are exposed without destroying the image.

Eliasson constructs a piece that is, in a first moment, phenomenologically pleasant, coherent, and soothing. In a second moment, it reveals what sustains that experience. The visibility of the technical set-up of the installation makes the shift to the second moment inevitable, but reversible, to a limited extent. One could easily forget about the lamps and just enjoy the 'sunlight'. This strengthened the awareness of the two moments and meant that, conceptually, once the shift had occurred, the second moment interfered irremediably with the return to the first. The return to the first moment had to be a conscious decision. In this way, the multiplicity of layers of (what) the installation (represents) is replicated in the viewer's mind.

Seeing Yourself Seeing

The deconstruction of the narrative is the narrative (see Derrida 2000[1986]: 578 on the positive constructive dimension of deconstruction). It is a narrative about what happens outside Eliasson's machine. The way this is achieved is centred—as is most of Eliasson's work—on the concept of representation. The heterogeneous elements of the Weather Project aren't offered as anterior to their audience. Eliasson's works are "devices for the experience of reality" (Eliasson in Wailand 2000: 127), heterogeneous apparatuses (Birnbaum 2007) where nature isn't pre-given, or seamless, or natural, but—and this is a pivotal point—understood, known, and engaged with, through one's perception of the processes of representation. Eliasson has said that it is the gaze of the spectator that constitutes the piece (in Grynsztejn et al. 2002), and has many times said that his work is about 'seeing yourself seeing'.

So, *the experience of nature as a representation* can be made apparent through visual and spatial means and, simultaneously, the active role of the viewer in the representation can be foregrounded. Eliasson is frequently explicit about this point:

> [T]he reason you [the artist] want to show the machine is to remind people that they're looking. At certain times you can sit in a cinema and become so engaged with the film that you kind of join that level of representation . . . My work is very much about positioning the subject" (Eliasson and Birnbaum 2002: 14)

Eliasson's qualitative and non-verbal representations also appear much harder to translate into the calculable. That does not detract from their efficacy. They work because of the very fact that they don't easily translate, but instead appeal to different (experiential) modes of cognitive processing. "Future ecocriticism must take the phatic dimension of language into account" (Morton 2007: 37).

At first sight, this coincides with Adam's description of timescapes: embodied, inclusive, contextual relation to nature, enabling us to see the invisible, and dismissing futile quantitative proof and objective truth. It says nothing about temporality and the future, so far, and does not yet answer the question 'what kind of knowledge, for whom and for what?' Eliasson invites us to reflect on the perception of nature and on the nature of perception, on the constitutive roles of acts of perception and representation. This way, we are the objects and subjects of this construction. The viewing subject is in the object (conceptually, but also literally, once reflected in the mirrored ceiling). Visitors to the Weather Project often looked up and waved to the ceiling, noticing how many looked at others looking at the ceiling. Some lay on the floor forming shapes or words with their own bodies that could be seen, reflected, by other visitors. This interaction with the piece was only one level of blurring the subject/object divide. Another becomes apparent only when the visitor understands that it is her act of seeing that is being explored, and in that sense it is the viewer that is the object. Far from a passive engagement with the piece, far from the usual rules of presentation in museological institutions and galleries, the viewer actively perceives the constitutive power of perception, and the determinant role of representation. The installation surrounds the central position of the viewing subject, contrary to the usual disposition of object(ive) display at museums.

Eliasson describes his works as 'phenomena-producers'. The Weather Project represents nature or, more specifically, the weather, with no erasure of the ambiguity and incoherence that become visible when the production isn't deleted. They are integral parts of the work. "I think there's a subliminal border where suddenly your representational and your real position merge, and you see where you 'really' are, your own position" (Eliasson and Birnbaum 2002: 11). This way of representing nature is far removed from providing individuals with statistically derived information about their own situation, conditions and options, as downscaling does. Marilyn Strathern says that complex phenomena are produced when stability and instability coexist in correlation, each implicated in the other (Strathern 2002: 93).

DECONSTRUCTING THE WEATHER

In examining the Weather Project in the context of different representations of the climate, I do not intend to make any claims of superiority of Eliasson's work of representation in opposition to all the previous ones. Neither do I attribute a superior epistemological status to art in general and claim its powers of representation to be superior, more transparent, less mediated, more valid or consequential. Nor can I suggest art as *the* cultural catalyst for climate change action. My argument is restricted to the epistemological validity, and importance, of *plural (and relational) ways of knowing objects that are multiple (and relational)*, and to indicate how they might disrupt the stability, stagnancy (and therefore dangers) of currently dominant modes of representation.

If there is a greater ambition in what is proposed here, it is in demonstrating that it is possible to represent something while representing its mechanisms of representation. To push it a little further (or maybe this merely follows from what I have previously argued), it is that both those aims can be achieved while also actively disturbing the subject-object divide.

Instances of this not only exist at present, but are relevant for thinking about climatically changed futures. I believe that this ambition is not excessive, and that its demonstration is in the works here examined, especially the Weather Project, but also how Eliasson's larger body of work helps to situate the Weather Project.

If Eliasson's work is 'seeing yourself seeing', if it reveals the constitutive power of perception, and the determinant role of representation, then is it not post-representational? If our knowledge practices are constitutive of the object of knowledge (inescapably so for a 'totality'), claims that our statements are neutral representations of the world are a form of representationalism, imbued with the ideological precepts of the mirroring of nature. If, on the other hand, our knowledge practices accept that they are constitutive of their objects of study, and work with that cognizance, then we can describe them as post-representational. I use the term from Nigel Thrift in his *Non-Representational Theory* (2008), but 'post-' denotes a position beyond representationalism. Representationalism is indefensible, especially in the context of climate change, so we might as well move the debate forward, and adopt a post-representational stance: we can't mirror the world, so let's work with the constitutive dimension of our knowledge practices. Because science is post-representational in its *performative dimension* (as we've seen of the work of the IPCC), its *rhetoric dimension* can no longer claim neutrality of its findings, or remain in a representationalist stance. It does not survive scrutiny, it is a disservice to itself, and has become part of our inability to address climate change.

Eliasson's work is beyond representation, in Thrift's sense, inasmuch as it moves with objects of knowledge that will not stand still (Thrift's 'onflow of becoming'; 2008: 5) and does so in a playful way. It values what Thrift calls the pre-cognitive (although I prefer the term 'pre-noetic' after Varela, below), the non-linguistic or pre-linguistic (see also D'Alleva 2001: 82). Surpassing the misplaced focus on behaviours found in climate policy circles, it focuses on practices, to take into account the material and performative dimensions of our situation, so important to understand current climate action inertias. Modelling behaviours is still part of the programme of climate science (e.g., Anderson 2007), yet a "view in human 'behaviour' remains conceptually distinct from the workings of devices, buildings, infrastructures and the other socio-technical arrangements involved in energy use" (Wilhite et al. 2000). Climate science knows that, as Thrift puts it, 'things answer back' (2008: 9). The impacts of climate change, for example, alter climate mitigation possibilities in unknowable ways. In Massumi's suggestive wording, "it is time that cultural theorists let matter be matter, brains be brains, jellyfish be jellyfish, and culture be nature, in irreducible alterity and infinite connection" (1995: 100).

Having much that is distinctive, art has nothing metaphysical, 'above-history' or autonomous, as Janet Wolff says (1993). Like other forms of representing, and acting upon the world—be it a scientific practice, a craft, a religious practice—art is not independent of its conditions of possibility. It requires no representationalist claims. Its language, methods, materials, communities, conceptual frameworks are embroiled with discursive formations. As are those of all other knowledge-making practices; but art claims no independence. To say, as I have above, that the deconstruction of the narrative *is* the narrative does not posit artistic expressions or objects as statements made in a meta-language. "At least for the time being, the breaking of the frame is the new frame. It might be perpendicular to the old idea of frame, but it is also a frame" (Eliasson in Eliasson and Irwin 2007: 60). It is, therefore, not a case of a post-representational utopia, or retrieval of a pre-representational state, which Claire Colebrook says often characterises anti-representational post-structuralism (2000: 63). To move beyond representationalism does not mean to issue "a radical homelessness in which thought no longer locates itself within a totality", as Colebrook states (2000: 48). The representationalist totality is not a home we reject. It is the home we have pretended we live in. The climate modelling totality is inevitably non-representational, despite claiming to be representational. We never lived in that home, so we cannot make ourselves homeless from it. What we have been doing, in climate science, is describing the home we live in as something which it is not. We can *demystify* it, give up the representationalist, objectivist totality, and still live—as we always do—in a heuristic totality. One with a fluid and *ad hoc* gestalt. The only holism that works is the holism that knows it is necessarily wrong. That does not make it less useful. Sure, it is no palace. But it is our home. Eliasson's breaking of the frame as the new frame questions the *ism*; it does not deny the representation.

Art, as knowledge, articulates and contributes to social processes (Chaplin 1994). This articulation is twofold: art articulates social processes, that is, it expresses and enacts them (in the sense that articulating a word is bringing to presence something already existing). Secondly, its contribution to social processes is also an articulation: art is able to connect them differently, or to add connections, or make them visible (in the sense that an articulation makes different elements work together; articulation as pivot). Art contributes to social processes by making them more mobile, more fluid or dynamic, more/differently connected. New articulations may stabilize more or less permanently, old implicit ones can become permanently visible (e.g., cubism's disassembling of perspective). This last aspect also points to the very opposite ability: art can, and indeed has, helped stabilize, reinforce, and propagate ideologies (e.g., the Banqueting House). These two forms of articulation are separable only analytically. A statement always stabilizes or undermines the relationalities of an object, or a concept, or a trend. More simply put, social processes influence or determine artistic representation, and are influenced by it. This includes other knowledge modes. Whichever way, representations enfold cultural codes, visual traditions, social norms. Art is never a meta-language.

Art has the power to challenge representational conventions, as other forms of knowledge do. That power in art does not allow to say, as does Bonnie Marranca, that linking ecology and aesthetics permits "search[ing] for newer and deeper kinds of knowledge [that will outline] the biocentric worldview" (1996: xvi). No more than other modes of knowledge, at least. Art isn't *the* answer to climate change, not even ecological art. Seen as double articulation, art is made of, and makes, many manifold relations, always embodied, always in context. This implies that art is never an infra-language.

Holistic trends in art are a case in point. Elinor Fuchs—who, like Marranca, writes on ecological theatre—calls for "a systems awareness that moves sharply away from the ethos of competitive individualism toward a vision of the whole, however defined in a given setting (1996: 107). We have seen how a vision of a systemic whole, however defined, can lead to outcomes that are short of, or different from, what is required. Holistic approaches, narratives and representations have a conspicuous tendency to be instrumentalised as trojan horses for other motivations.

Others have claimed that art's power to challenge holds ecological revolutionary power. "Nature oriented art, and even bio-art, can revolutionise both concepts and practices of nature and art" (Giannachi and Stewart 2005: 33). The Bellagio Declaration comes to mind: calls for urgent and immediate all-encompassing change—a reasonable definition of revolution—are met with inertia, resistance, dismissal, and eventually lose momentum. Otherwise, they force their momentum through (or over) the resistance, with consequences that have filled graveyards and history books. Revolutions have an unfortunate tendency to fail in their promises and deliver unintended suffering, or to become appropriated by other interests. By showing reservation about programmatic and normative calls for new knowledge and/or revolutionary action, I do not aim to propose that the answer is slow and carefully pondered integration between art and other forms of knowledge. The most important factor in climate change mitigation and adaptation is time (mostly the time we may have left for mitigation). And scenarios have demonstrated how integration tends to become assimilation. Ultimately, a programme for integration offers no guarantees of success, timely or not.

My position isn't one of general cynicism or distrust deriving from anomie. There is much to be gained from interdisciplinarity, multidisciplinarity, postdisciplinarity (and from most of the other '*prefix*+disciplinarity' combinations we can collect or invent). Scenarios are useful, the United Nations Millennium Development Goals are useful, the Doomsday Vault is useful. What concerns me is how, by making a zero-sum game of deciding what is useful, we create our own epistemological blindspots.

There is transformative power in art, just as there is in technoscience, in religion, in sport, even in war. Art's ability to radically situate its transformative power in materiality, and generate newness in the familiarity of the material—even when the materials are light and space—holds something unique for cognition and episteme. Not revolution, not assimilation, not complementarity, not deeper knowledge, not promises of complete future knowledge. Thinking and knowing nature through art—in a period characterised by epistemological uncertainty and crisis of representation—is an activity that, as Oron Catts and Gary Cass say (of their Biotech Hands-On Workshop for Artists), "creates cultural meaning and informed involvement that are needed in order for our society to comprehend the very significant changes we are facing" (2008: 143). This power, this ability, is not a given. Eliasson says that the artistic "can make the work more representational, and [that way] lose its ability to question" (Eliasson and Birnbaum 2002: 31). For Eliasson, when a system does not attempt to deceive by illusion but reveals its methods of mediation—from the display of art to its interpretation and promotional strategies—it enables the viewer to see the machinery of the institution and thus distinguish its multiple values, which the artist regards as the social and moral possibility of the museum (May 2003).

When the world becomes a machine context (Eliasson and Birnbaum 2002: 32), a worldmachine, what is diversity when it emanates from the commensurable? And, more important to us here, can art interfere with such Plotinian mathematical emanation of local practices? Speaking of Eliasson's piece Surroundings Surrounded, Grynsztejn notes that the "cognitive tripping-up is deliberate: it disables perception of the world as an uninterrupted continuum" (Grynsztejn et al. 2002: 38). While the 'gaps in knowledge' assume the underlying continuum, in Eliasson, the image of an external world is dismantled through our perceptions, and each perceptual instance is determinant. Eliasson has noted, several times, that the theme or subject of his work is decided by the audience. "With each viewer the readings and the experience are nailed down to one subjective condition; without the viewer there is, in a way, nothing" (Eliasson and Birnbaum 2002: 14). This cognitive tripping-up through art is related to what Jill Bennet describes as "real-time somatic experience, no longer framed as representation" (2005: 23).

Revolution, Deconstruction, and Selling Out

Following Eliasson's work to foreground the act of perception of nature as an act of representation of nature, to "*demystify* some of the background issues" (Eliasson and Birnbaum 2002: 33; emphasis added) as a non-revolutionary, non-complementary mode of representation, I critically follow the deconstructive power of art proposed by Lyotard, namely in *Driftworks* (1984). Critically, because aesthetic deconstructions are not functionally or ontologically located outside the system, contrary to what Lyotard says (1984: 29). To propose, with *Driftworks*, that 'aesthetics' accesses the underground of politics or, indeed, that it is the fracture that allows such access is highly problematic, and would take us back to 'deeper knowledge' claims. Nor would I know how to agree with art being a symptom referable to a primal fantasy (1984: 37). Lyotard's mistrust of art simply as critique, and his preference for art as deconstruction, bears more fruit. In that sense, to say that *demystification* is the "permanent revolution" (Lyotard 1984: 32) might be a more productive stance. Revolutionary art is a contradiction, Lyotard says, because it yields to the powers of political discourse (1984: 28).

Deconstructing from the Inside

Art can demystify through deconstruction, more than revolution, and that is an endless task. Lyotard's defence of art's ability (through its secularisation) to unmask today's pseudo-religions retains some allure, in our context of technoscientific apocalyptic narratives. This points to a detail of Eliasson's Weather Project that must not go unmentioned: the Unilever Series is commissioned and funded by a large corporation. Eliasson has also worked with BMW and Louis Vuitton. He says this work is "a certain type of subversion or self-reflective, introspective quality" (Eliasson 2008: 86). However that may be, it does not do away with questions regarding how that work might encompass a multiplicity of objectives, including corporate objectives. Jaqueline Stevens (2008) reports how a memorandum by Burston-Marsteller (the largest PR firm in the world) "discourages the biotech industry from using traditional PR techniques" and use art and museums to avoid the "killing fields" of rational debate and to use symbols of hope, satisfaction and caring, not logic (2008: 53). Eliasson has always worked across boundaries, but these specific boundaries pose questions about how distant art really is from the calculable world, whether calculation is of abstract quantities or monetary quantities. The Unilever Series has commissioned several installations for the Turbine Hall that deal directly with climate change and its negative or catastrophic consequences: the Weather Project, but even more openly TH.2058 (2008), by Gonzalez-Foerster, and Rachel Whiteread's Embankment (2005).

In his work for the BMW Art Car decades-old series—which has had contributions by Andy Warhol, Roy Lichtenstein, Robert Rauschenber, David Hockney, among other high-profile artists—Eliasson created an undrivable car (if a car at all), going beyond what any of the other artists had ever done, and turning it into a statement about climate change and the automotive industry, having told BMW that he did not want his creation to be used promotionally (Eliasson 2008). The result, Your Mobile Expectations (2007), vaguely resembles a car, covered by several layers of ice. He says, "Of course, BMW is pouring millions into their research; they are so taken with materials that they don't care very much about the role of cars in society. I'm trying to address this and more fundamental questions, such as the political impact of cars" (2008: 88).

Eliasson does not shy away from presenting representation as creation across the largest scale imaginable: in Your Sun Machine (1997; Figure 7.2), Eliasson opened a hole in the roof of the Marc Foxx Gallery, in Los Angeles, to let the sunlight move across the gallery space during the day. However, he explains, it is the viewer that moves with the gallery. The spot of light is the only thing that does not move. The viewer's moving vehicle is the planet (Eliasson and Birnbaum 2002: 22). We easily forget how assumptive our misrepresentations of the totality tend to become, and Your Sun Machine prompts us to review those assumptions.

Opacity, mediation, and their stable boundaries are under scrutiny in Eliasson's work, in the context of our representations of the weather and climate, and he strives to include the art world in this work of mediation. "I think when experience is marketed experience, it's mediated. When I talk about 'responsibility', I'm saying that anybody who makes this mediated experience has to make the mediation transparent. How do you tell people you are telling them something?" (Eliasson in May 2003: 74). Eliasson's engagement with the Tate's personnel (curators, directors, architects, technical staff, engineers, and consultants) shows the extent to which he wants to make the act of representation visible, and to make apparent the ideologies that subtend museological institutions.

Figure 7.2 Olafur Eliasson, Your sun machine, 1997. Aperture cut into existing roof, daylight, variable, ø100 cm. Installation view at Marc Foxx Gallery, Los Angeles, CA, USA, 1997. Courtesy the artist and Tanya Bonakdar Gallery, New York © 1997 Olafur Eliasson.

Eliasson plays with (uses, abuses, questions, blurs, overcomes) the ideology of the museum and the white cube as neutral space. Eliasson's artwork reflects his position that the white cube is culturally encoded, and that there is nothing that is not representational (Eliasson in Eliasson and Irwin 2007: 57). Distorting the white cube, discarding the pedestal, questioning the vitrine, are not actively presented to the passive viewer. Eliasson's work aims to assist the viewers in seeing how *everything is connected through discontinuities*, but does not do that work for them. His work is, like Victor Burgin's, art as "opportunities for interpretation" (Burgin 1986: 138). Eliasson says museums are places to scrutinise society, not neutral and timeless realms, adding that museums claim to do this on our behalf (in Grynsztejn 2007). Neutrality in the IPCC's SRES deletes the contested, negotiated, scaffolded, and subjective work of making manifest, of creating objects that are visible, discrete, and thus objective. The Vault's blast proof doors belie its opaque frozen constitution of food security policy, "generat[ing] relatively stable networks of socio-technical objects that therefore, for a time, exert a disproportionate influence on those around them" (Law and Callon 1995: 301; see also Law 2004b).

In another piece, somehow in between Your Sun Machine and Weather Project, named Double Sunset (1999), Eliasson brings all these issues together: context, boundaries, construction, naturalisation, and unique individual perception. An artificial sun, 38m in diameter, was installed in Utrecht, at the top of a building. In the evening, from a variety of locations in Utrecht, two suns would seem to be setting, at different points on the horizon. Up close, however, the scaffolding was visible, and during the daytime, the sundisc was no more than a white circle on top of a building. This allowed for constant heterogeneous landscape formations, changing with the moving sun disc and the moving point of view of the visitor. In Your Intuitive Surroundings versus Your Surrounded Intuition (2000), we find ourselves in an indoors cloudy day: 150 light sources vary in intensity, closely simulating—in intensity, colour temperature, and variability—how a cloudy day feels outdoors.

Elsewhere (São Paulo, Brazil) another natural element—ice—extends from the inside to the outside of the gallery, through a large, square window (The Very Large Ice Floor, 1998). The piece questions the function of the museum's glass boundary, and suggests the integration of the visitors (those paying to be inside the museum) into the piece. Those outside experience the piece directly, physically, and also experience the piece as a framed ensemble of people in an institutional setting. Boundaries physically and conceptually questioned, those on the outside wondered if those inside had any idea that they appeared as part of the piece. For those outside, this resulted, yet again, in "seeing yourself seeing". The unsettling of physical boundaries decentres the viewing subject. Eliasson "knowingly and explicitly collapses the natural and the artificial, the evanescent and the concrete, the literal and the metaphoric" with "nature, culture and self presented in all their material impurity" (Grynsztejn 2002: 49, 53).

The Weather Project resists what Law and Benschop call the ontological naturalisation that "has proceeded to the point where the conventions of perspective are often treated as a part of the order of things" (1997: 161). It deconstructs ideologies of representation (scientific, artistic, institutional) by exhibiting the articulation of the many levels of representation that compose an object. Or, to be more faithful to the author's intention, it offers the viewers the opportunity to perform their own, unique deconstruction. By offering strategies for deconstruction, Eliasson unpicks truths and their coherences, including the mediated ideological nature of art, always enfolded in its norms and conventions.

The consciously ambiguous relation between Eliasson's work and the museum and gallery space extends to the communication channels that these institutions use for commercial promotion. Eliasson's Weather Project posters are simple black letters on a yellow background, and ask their audience

> "Have you talked about talking about the Weather today?"

> "Does talking about the weather lead to friendship?"

or state,

> "47 per cent believe that the idea of the weather in our society is based on culture. 53 per cent believe that it is based on nature"

> "The weather will affect the attendance of this reception by 27 per cent" [text on the invitation for the opening of the Weather Project]

> "73 per cent of London cab drivers discuss the weather with their passengers"

Eliasson plays openly with the media, and in doing so plays with representation and communication, with the relation between quantification and personal experience and personal relations, be it lasting (friendship) or fleeting (taxi ride). Sentences like "Have you talked about talking about the Weather today?" use a well established mediation support (advertisement poster) to talk about our conversational representations of a constructed concept.

Eliasson is aware of the historical context of his work:

> We are now slowly accepting, if not fully acknowledging, the fact that the post-war energy ideologies of our society have resulted in damaging that which they were supposed to protect us from: the climate. We are occupied with redefining methods of insulating our surroundings and ourselves. (2003)

The role of mediation is an ever-present element in Eliasson's work: "[T]he mini-Skagen in Legoland is more real [than the real Skagen, the northermost point in Denmark] because it's not trying to be an illusion" (Eliasson and Birnbaum 2002: 9).

Some of his work depends entirely on the positioning of the viewer, on the exact moment and place of the viewing act (Eliasson calls it an anamorphic principle (Eliasson and Birnbaum 2002: 17)). In Green River, without any previous warning, Eliasson introduces a non-toxic dye into the flow of rivers (in California and Sweden). This action, which he says (as he does of the Weather Project) is just a *catalyst*, works differently in different cities of the world. They trigger a change of perspective in the viewer, and it up to the viewer to perform the representational shift. Knowing that his own artistic practice is context-dependent and culturally coded, Eliasson has never shown in the 'developing' world, as his work "might seem totally absurd" (Eliasson and Birnbaum 2002:32). If repeated too often, Green River would become 'formalised'. "The content is lost when it's systematized" (Eliasson and Birnbaum 2002:18). Each piece changes with every viewer. Each view is its own piece, a unique act of non-*re*presentation, an act that takes place in the viewer, and not in an object the viewer passively observes. This occurs to the point where it's not important if it is art or not, it's the experience that matters (Eliasson and Birnbaum 2002), but also to the point where the roles are reversed: "[Y]ou're not only a productive, phenomenologically active subject, you're also produced by the piece" (Eliasson and Birnbaum 2002:20). The situated statement—or the metaphor as culturally situated statement—does not change scales easily, if at all. Such upscaling is actually impossible (Gell 1998:3) Is that impossibility the reason why local knowledge is 'saved' by the UN into databases, like dust-gathering cabinets of curiosites?

Eliasson's early work Beauty (1993) consisted of a curtain of small water drops, continuously falling from a perforated hose. All the viewer saw was mist coming off a hose (and all the usual technical paraphernalia which Eliasson insists on making visible). This changed when the viewer, having walked a few steps along the piece, saw a rainbow appear in the mist, as a light beam was refracted by the water. One single position, one single moment, allowed the visitor to see Beauty. A precisely and narrowly situated perceptual aesthetic experience of yet another 'natural' phenomenon, one that the viewer knows as constructed even before she 'sees' it. The Curious Garden (1997) is one of several pieces that use monofrequency lights to bathe the audience in a single colour. It is only when one leaves to the next room of the indoors artificial 'garden' that one understands the objective of the piece, once the complementary colour retinal afterimage makes evident the *constitutive role of vision;* and as the colours one saw from inside the monofrequency room change dramatically when seen from the next room's natural light conditions. Produced by the pieces we may be, the public's decision on what the work is about is "the final aim: giving the subject a critical position, or the ability to criticize one's own position in this perspective" (Eliasson and Birnbaum 2002: 21). His work is about natural phenomena, but "the way we look at nature changes the moment we look at it" (2002: 29).

Modelling in Eliasson

Eliasson asks, "[D]o we build our world on Euclid, or, as I now think is the question, is seeing the object actually seeing a part of yourself?" (Eliasson and Birnbaum 2002:29). He looks for answers interdisciplinarily, frequently working with scientists, mathematicians, architects, and engineers. The investigation of such questions has resulted in working with architect Einar Thorstein, well-versed in mathematics and geometry. They have collaboratively developed work to alter space and move it away from the Euclidian set-up (2002: 25). The resulting pieces, like Doughnut Projection (2000), are "a questioning of the dimensions we're surrounded by, and looking into the basics of spatial conditions. [Eliasson is] not quite sure, since it's more or less an intuitive practice"1 (2002: 25). The most interesting part, however, is that all the exploratory and preparatory work for these pieces becomes a piece in itself. The experimental, intuitive exploration of our spatial perception (which he usually links with 'natural' phenomena) is not deleted, but is shown as that which constitutes our understanding of space, and our spatial practices.

Both Models (2000) and Model Room (2003; Figure 7.3) exhibit the geometrical, material, tridimensional outcomes of the mathematical models Elliason and Thorstein work with. Model Room is very busy, with tridimensional models of abstract data filling the room the visitors walk through with "structures used by scientists and physicists to visualize abstract data" (Grynsztejn 2002: 66). None of those objects are real, but there they are visible, tangible, everywhere. Both pieces take the representation level one step further—as is typical of Eliasson—and reflect taxonomies as constitutive of nature by echoing the display strategies of the *wunderkammer*. In typical boundary-blurring fashion, Eliasson uses them, displays them, invites the audience to ask questions of them. The audience becomes involved in artistic exploratory work, since that stage of work has no reason to be severed from the context of the experience. Is the object just the polished outcome, or also the usually veiled work of construction, exploration, and testing?

Those boundaries aren't, and do not have to be, erected in pre-determined ways. What some propose is art's special status, ability, or positioning, is thus dismantled. Modernist painting dismantled perspective, and dismantled context. Today, art dismantles the boundaries between presentation and the essentially technical dimension of making art. "Things become interesting to me without my knowing why. How can you tell exactly what a green river will look like? It has to be unpredictable to a certain extent, even to a very large extent" (Eliasson and Birnbaum 2002: 25). Exploration

Figure 7.3 Olafur Eliasson, Model room, 2003. Wood table with steel legs, mixed media models, maquettes, prototypes, projectors, DVD players, videos. Installation view at Martin-Gropius-Bau, Berlin, 2010. Photographer: Jens Ziehe. The artist; neugerriemschneider, Berlin; and Tanya Bonakdar Gallery, New York. © 2003 Olafur Eliasson.

and inevitable uncertainty help to shift the divide between nature and culture, between subject and object, (active) author and (passive) audience.

Speaking of exploration of nature and uncertainty . . .

. . . HOW ABOUT THE FUTURE?

Eliasson's engagement with objectivity as decontextualised representation, which he identifies in the white cube and the museum institution, has a temporal dimension. "Inside a museum . . . everything is presented as if it's isolated from its time, history and context" (Eliasson and Birnbaum 2002: 9). In Eliasson's work, the deconstruction of 'nature' includes its temporal dimension. Eliasson says he's interested in the 'now', because our belief in time is a construct, while simultaneously, the timelessness of the static object is a constructed dogma. He expresses this belief both verbally and in his plastic work:

> So, how long is 'now', and where does 'here' end? One frontier of 'now and here' is the weather forecast, with all its people and predictions . . . Like time travellers, weather predictions can draw a small part of the future back to be included in our cultivated sense of 'here and now'. *By turning farmers' needs into a science, the weather—the broadest of all sources of collective awareness—cultivates complexity and unpredictability. If anything is collective, it's the weather map . . . Cultivation of a collective sense of time and space works, as we can see, through representation.* The weather forecast is our mediated experience thermostat letting us know if we are freezing and in which direction the wind is blowing. Through these representational layers, our immediate, tactile sensation of time and space ('now and here') is evacuated, replaced by TV and thermostats. . . . Such mediations can be infinite; *they only form a threat when you mistakenly believe that time and space are objective*. Like when you are elsewhere and assume you are here. Just like [The] Truman [Show]. (Eliasson 2002: 141; emphasis added)

The Weather Project aims to unfold, at various levels of representation, what Eliasson sees as the construction of a collective awareness of time and weather. The static shimmering sun in the Turbine Hall, forever setting, and dominating the whole experience, enacts Eliasson's ideas about the 'now' and how time is constructed and naturalised.

Your Strange Certainty Still Kept (1996), in a darkened New York gallery (Tanya Bonakdar), was a constructed system of artificial indoor rain, audible at all times, but only visible when a strobe light pulsed, making the rain visually perceivable only as a frozen moment in time, a succession of 'nows'.[2] At this point, it will not be a surprise how, in playing with the sense of now as the only existing moment in relation to the constructed weather, the artist left all the apparatuses very much in sight. Not only that, the name points to the viewer, once again, so that one "sees oneself seeing" (Eliasson's repeated mantra, borrowed from Robert Irwin) and experiences the work as one's own experience, not as a passive object under a scrutinizing gaze. The components of the work are clearly visible, showing the 'technics of ideology' (Lee 2007: 47) that can be enfolded in our own perceptual experiences. This is, Eliasson says, the deconstructive potential of his work (Eliasson and Irwin 2007).

The distance between these works by Eliasson (Weather Project and Your Strange Certainty Still Kept) and Schwartz's 1991 The Art of the Long View is revealing. Eliasson says it is not important whether his work is considered art. Indeed, we have seen how he says that calling it art would add a layer of representation that gets in the way. His works are 'projects' or something that foregrounds 'your certainty'. Schwartz not only uses 'Art' for the title of his future studies work, he tells us his view is 'long'. To the (arguable) exclusion of the articles and the preposition in the title, every word in it is charged with meanings that Eliasson, the visual artist, deliberately avoids. Note, however, that Eliasson's plastic bending of concepts does not exclude art. His deconstruction is no privileged position. "Artworks are not closed or static, and they do not embody some kind of truth that may be revealed to the spectator. Rather, artworks have an affinity with time—they are embedded in time, they are of time" (Eliasson in Eliasson and Irwin 2007: 51).

Objectivity, Time, and Art

Eliasson's view extends in a different direction. Well for Villa Medici (1998) engages with historical perspectivalism at the Renaissance garden of the Villa Medici, in Rome. This 1998 piece was a well in the garden, reminiscent of wishing wells. Inside the well, Eliasson fractures perspectivalism with a kaleidoscopic array of mirrors that undoes Renaissance perspective. In the process of engaging with the well by looking into it (as one does with wells), garden dwellers are broken up into an aperspectival confusion of fragments of themselves. This historical vision is a statement against the process Brian Rotman described as "each image within the code of perspectival art thus offers the spectator the possibility of objectifying himself, the means of perceiving himself, from the outside as a unitary seeing subject" (1987: 19).

A time across which we can cast our vision—as Schwartz intends—has to be transparent, neutral. If it were too opaque or distorting or fractured, no long view would reach distant horizons. Objective Newtonian time does not find, but achieves, neutrality. Ermarth tells us how time neutrality is the counterpart to the objectivity of vision that developed with Renaissance painting perspectivalism. Visual neutrality achieves objectivity through perspectivalism, and Newtonian neutral-time is a system of measurement that organizes and rationalises events into one perspective, "one and the same world" (Ermarth 1998: 200). Time neutrality thus approaches the mathematical signs it is dependant on, and approaches the belief that these signs refer to some 'objective eternal domain' (Rotman 1987). Chronological neutrality is inseparable from Western history, as it unifies metaphysics and technics, and connects the spatial and the temporal (Derrida 1991: 44). Eliasson says that

> the way in which the spectator interacts with them [his optical perception pieces, such as the Well], actually changes them, either through time, or their position, or by one's mental play with a particular piece. This is part of the history of how we see nature, which is also where mathematics comes from—from trying to encompass and measure natural conditions. (Eliasson and Birnbaum 2002: 29)

This task is still visible today in the collective efforts at making climatic space and time objective; efforts at making them universally objective, making them the 'broadest of all sources of collective awareness', as Elliason says. "Time is not measurable—it's now" (Eliasson 2008: 14). It is, instead, made measurable. The technical, conceptual, and institutional apparatus through which this objectifying is performed is never at rest. Its negotiations and conflicts, interim resolutions, and partial stabilities make for "collective work that is never concluded" (Callon 2002: 203), gaps always and forever about to be filled. Clark Miller (2004) analyses how the scientific work and organisational development of the IPCC has played a never-ending active part in constructing the climate as a global narrative, spatially and temporally, while asserting its very neutrality. Proposing that "the existing normative and organizational frameworks for making public policy choices are now seen as inadequate for solving the kinds of problems humanity faces" (2004: 47), Miller argues that it is the very ontological unitary status of climate that is being negotiated. The IPCC reinforces the global, systemic understanding of climate into a vision of nature that can only be addressed by global climate politics (2004: 55).

Downscaling, of course, only makes sense from this view from nowhere. Abstract time "devalues temporal becoming, embodied being and contextual difference and it encourages the belief that we can control the future in the present through financial and technological means" (Adam 1998b: 231). This reframes the heralding of the Doomsday Vault, by its director, as endowing us with 'control of evolution'. Eliasson's position is concurrent with Adam's 'recentralisation of temporality': "At the moment, temporality might be the most constructive dimension if you want to create a narrative" (Eliasson 2008: 158), and "cultural institutions need to embrace temporality in a more productive way" (Eliasson 2008: 159).

Writing with Chris Grove, Barbara Adam has stated that

> empty, open future potential has *dis*placed rather than *re*placed embedded, embodied, contextual and individualised futures that were pre-set by nature, fate and god(s) . . . placed outside the modern public frame of reference, relegated to the private realm of contemporary existence where they have been rendered largely invisible. (2007: 79)

Downscaling efforts, such as those in the Nairobi Work Programme, show the extreme reach of these displacements, to the extent that they can actually undermine the private realm, especially where this realm is constituted in relation to nature and its gods. Adam identifies the performative use as being "inextricably intertwined with business and politics" (Adam 1998b: 238) and, in doing so, mentions corporations working in agricultural genetic research (Dupont, Monsanto). The programme of inclusion of temporality into environmental and agricultural future narratives has indeed been drafted and put into action. Managerial, quantitative, neutral methods have been employed to globalize them, while reinforcing boundaries. Agency is attributed to policy, and duty of neutral information is attributed to science. "To the extent that his work inhabits the relationship between humans and nature, he [Eliasson] also inevitably engages the politics of boundaries, borders and transgressions inherited from the Eden fantasy" (Bal 2007: 160).

OWNING THE NARRATIVE

The question, then, is the same I have been examining all along in the context of witch hunts, of Napier's mathematical exegesis, of Rubens' and Jones' ceiling, of the modelling work of the IPCC, of the downscaled food security practices of the GCDT: *who owns the narrative, and how is it claimed?* And who is entitled to own the narrative? How is that entitlement achieved, and how is the ownership exercised, articulated, put into practice? How is it made stable and universal?

The previous chapter explored how the global climate narrative is made to work at every geographical scale, at any point in the (un)foreseeable future, and about how the downscaling of a central/global narrative becomes what Baudrillard calls the "radiating synthesis of combinatory models" (1994: 2). In the present chapter, conversely, I have been looking at embodied, situated, individual deconstructions of narratives of nature and the weather. Choosing to do so through Eliasson's popular art work has another important reason that I haven't directly addressed yet, but has been present throughout. I speak of *experiential engagement*. Engagement is—to put it moderately—an important subject in climate change policy, and is mentioned by some of the authors I have referred to in this chapter (Schwartz, Adam, Eliasson). The Nairobi Work Programme itself is a plan to develop sustained engagement with global climate policies at local and regional levels.

Sabine Marx, Elke Weber, Benjamin Orlove, et al. state that climate information, and specifically climate uncertainty information, is communicated under the assumption that "people process information analytically" (2007: 47). Research into information processing and decision making has also worked under this assumption until recently, they add. Noting that "people also rely heavily on an experiential processing system", they compare the analytical and the experiential modes of processing and how they work together. Using examples of work conducted by the authors (with the Ugandan Department of Meteorology) to understand how Ugandan farmers process information for decision-making, they suggest that "retranslation of statistical information into concrete (vicarious) experience facilitates intuitive understanding of probabilistic information and motivates contingency planning" (2007: 47).

The findings of Marx et al. (2007) are highly informative, also in ways not intended by the authors. Going directly to farmers to learn about them is restricted to an exercise in learning how to teach them. A retranslation will be a further step down the downscaling chain, the imposition of a neocolonial narrative through research (cf. Bishop 2005 on ethnomethodology and neocolonialism). "Communication of climate uncertainty may be improved by better understanding how people learn and reason about uncertainty and how climate-related decisions are influenced by uncertainty" (Marx et al. 2007: 47). Let me reiterate that this approach isn't wrong in itself. Climate forecast information *is* useful. But this translation is necessary because the knowledge in question is mostly a Western construction. As Miller says, the IPCC's TAR was hard pressed to find scientific work from 'developing' countries that met its (Western) criteria (2004: 62). No wonder that climate information needs translating. Western metonymies ('meta-names') are most likely meaningless elsewhere. In short, "the bottom line is that experiential information overwhelms statistical information, unless statistical information is re-expressed (visually, narratively, or otherwise) in ways that can be combined with personal experience" (Marx et al. 2007: 51).

The authors add that there is no sharp separation between experiential and analytical processing; decisions always integrate both. Much work into how people combine the two has been conducted, they say. Nonetheless, the focus remains on translating statistical information to experiential information: another method of downscaling one universal quantitative narrative. Why do we rely on a unidirectional strategy when, as scenario developers recognise, 'our survival might be at stake'? It becomes difficult to agree with Latour (*à propos* Eliasson):

> The sharp distinction between, on the one hand, scientific laboratories experimenting on theories and phenomena *inside* their walls, and, on the other, a political outside where non experts get by with human values, opinions and passions, is simply evaporating before our eyes. (Latour 2003: 32)

Or, if Latour is right (as the existence of a protected realm like the Doomsday Vault suggests) and the distinction is indeed evaporating, there is much work being done to minimise its volatility.

YES: Your Engagement Sequence

Eliasson, on the other hand, works towards the personal ownership of narratives of nature, and does so by appealing (mostly) to the 'experiential processing system'. Not to hack into the one's narratives, but to foreground them at a time when they "tend to be standardized, automated, and otherwise impoverished by a mediating world" (Grynsztejn 2007: 14). Eliasson considers it noteworthy that the weather, despite being in the public domain, "functions as a social organizer" (Eliasson 2008: 110). He identifies the "vast international industry known as weather forecasting" (2003: 133) and says that the real change that comes from feelings has to be seeded so that one acts and makes decisions or judgements (Eliasson and Irwin 2007: 56). Eliasson articulates this 'dimension of engagement explicitly as a matter of temporality (and of 'destabilising the truth') through the Your Engagement Sequence, or simply YES, a series of pieces centred on the viewer's experience.

So far, I have been speaking of 'audience', 'visitor', 'viewer', and restricting 'user' to the meaning intended by the IPCC and FAO and UN (end-user of climate information). Eliasson, in his boundary-blurring style, is interested in the concept of *user* (often utilised, and also criticised, in climate change downscaling information). He says the utilitarian sense of the word should be accepted, otherwise one denies the utilitarian dimension of art, a necessary dimension to engage more directly with society (Eliasson and Irwin 2007: 58–59). Downscaling aims at defining the subjectivity of others through their own communication strategies, their own traditional narratives. Eliasson's work is not just about 'nature' or 'machine' or 'machinic nature', it is about disrupting the continuous upkeeping of global narratives. More than that, it is about heterogeneity as more objective than 'inhomogeneity', and opposed to 'homogeneity'; about heterogeneity as unavoidable, and a source of much needed diversity. Eliasson takes it further: "[I]f you look closely at the Weather Project for the Tate, it has the potential to become a danger to society. Creativity is not about formalization; it's about action, individuality, and believing in things" (2008: 47). Participation, he adds, is fundamental.

The relationality of objects, in their irreducible multiplicity, thus extends to the relationality of subjects, affectively engaging the user in a pleasant experience, almost therapeutic in the case of the Weather Project (the therapy of heterogeneity?). Eliasson's doubts about how his work would be perceived in the 'developing' world still stand. But his awareness of that difficulty evidences his understanding of the multiple layers of context in the creation of meaning, and how the one narrative cannot be translated into every culture and language, be it verbal or visual.

Conflicting Narratives, 'Competing Myths'

There have been multiple examples, over the last few years, of resistance to heterogeneity of narratives, or to alternative accounts of the same narrative. In Eliasson's work Green River, the Swedish authorities and the media, both completely alien to the real source of the greening of the river, quickly released a statement explaining the cause of the strange occurrence. The official, objectifying, but completely false narrative was that the colour was both harmless and had a *traceable origin* (a heating plant upstream). The real origin, however, was that someone

> thought [he] could make the landscape even more real—or hyperreal—through the impact of the colour. In a city, the colour green somehow takes the already representational image of the city and turns it around, making it, strangely enough, very real. (Eliasson 2008: 15)

Eliasson's resistance to coding Green River as art resulted in the answer of the authorities and the media. This point is worth exploring further.

It is not the case that an art piece simulating an unexplained event (natural, disastrous, or both) debunks the hyperreality of official narratives. It might have, in this case. In many others, that is not required. There are many recent examples of political authorities (or the legal system they are entwined with) being unable to engage with artistic practices. A few examples are illustrative of this inability to accept, understand, or engage with other narratives or narrative accounts of the same event.

Assuming as understood (for the sake of economy) the importance of commons, and common heritage, in the context of climate change adaptation (whether it is water, land, genetic diversity, or other resources), my first example is of the perseverant—and so far frustrated—Amy Balkin. In 2003, Balkin purchased a plot of land in California to make it public domain, free to everyone and held in perpetuity. To the present day,[3] Balkin has been researching legal framing options for such an initiative, with no success. A legal advisor said it "would require an individual contract with every person and would be impossible" (Balkin 2006). Other possibilities were explored: a trust, a corporation (an option Balkin mentions with a mix of irony and dismay), General Public Licence, among others. The project underwent several mutations until a conceptual artwork object was designed, to allow the idea behind the initial project to be expressed in the realm of copyright. The search for a solution of how to put land into the public domain continues.

A second example: Alex Hartley, an English artist, participated in the 2004 Cape Farewell expedition that took a number of scientists and artists to the Arctic. On 19 September, in the waters of Svalbard archipelago, close to the island of Spitsbergen (home of the Doomsday Vault), the crew came upon an uncharted island. The island, previously buried in ice, became free due to the recession of a glacier. It was named Nymark ('new land' or 'new ground' in Norwegian).

After following the traditional procedures to claim an island, Hartley wrote to the Norwegian government, to the Svalbard authorities, and to the United Nations, claiming independence for Nymark. The authorities failed to engage positively with the claim (and by this I do not mean granting independence), missing the opportunity created by Hartley, not to add to their territory, but to use the island in the way Hartley intended: a visible sign of how climate change is changing the world. The ensuing communications became legalistic, and the opportunity to use Nymark (among other options, as an event that might have gained media attention) was lost. Not by Hartley, however, who went on to exhibit the array of documentation pertaining to the discovery of Nymark (both Hartley's visual evidence and claim documentation, and governmental response documentation). This exhibition was named Nymark (Undiscovered Land) (2005–2006), and was displayed at the National Conservation Centre in Liverpool, in 2006. The collection of materials was amassed from what followed the discovery of the island. These failures to understand the language of art, and its role and potential, echo another example mentioned in Chapter 5, where paintings by great masters were used as proxy data sources for climatological analysis.

The managerial, political, and scientific discourses on climate change have determined much of its representations in the media and, to a large extent, in popular culture. Artistic representations and interventions have the potential to resist that appropriation of the narrative, as the above examples demonstrate. Andrew Ross says that the "budgetary way of looking at the world . . . is contiguous with the scientific perspective of quantitatively dominating the world" and therefore it is no coincidence that climate change has become (in terms usually reserved for the liberal market economy), "overproduction of CO_2 waste" (1991: 208). Wangari Maathai says,

> When I was awarded the Nobel Peace Price in 2004 the members of the committee wanted to encourage a more holistic way of appreciating the close linkages between the way we manage our limited resources, the practice of good governance . . . and the promotion of cultures and peace. Unless we understand these linkages, we will continue to deal with the symptoms. (Canney and Maathai 2006: 35)

Between a complete future understanding of the totality, and a different present understanding of our engagement, the emphasis on the first is misguided. In saying this I am, however, making the same mistake I've been trying to dissect. It's not between one and the other. Nor is it about consilience between the two (that is a normative description of a possible epistemic future). It is about plural perspectives of multiple realities, compatible or not. I would go as far as proposing the risky idea that incompatibility (or at least incommensurability) is a good sign. What it is about: the kaleidoscope of representations that is enfolded in one's unitary sense of self, and how much individuals trust that sense for decision-making, in these days of pulverised agency where everyone is a decision maker. This is not merely a matter of sociological theories about the nature of time. It is a matter that transcends disciplines; the matter of what kind of knowledge, for whom and for what.

In cognitive science, the future can also be understood as marked by our preconceptual tendencies in the pre-noetic layers of the mind (Francisco Varela in Mulder 2000). "You walk down the street without any sense of the fact that you are walking down the street. But at the moment the car honks the transparency is lost. You have to reinvent your behaviour" (Varela in Mulder 2000: 15). That emotions are intrinsic to pre-noetic layers, as Varela adds, is not irrelevant to approaches considering experiential learning. To Varela, the moment of breakdown of transparency is "the moment the now reconfigures itself, the point at which we see the process of temporality at work (in Mulder 2000: 15). This 'now' Varela explicitly opposes to chronological time, the 'tick-tick-tick discreteness of time', as he calls it. Downscaling earth system models *radiates* chronological time over gendered time, tribal time, seasonal harvest time, over linguistic temporalities, at the same time creating and 'domesticating the other' (Spivak 1985), and deleting the cultural diversity of the world's different temporalities (Rifkin 1987; cf. Gell 1992).

There is increasing agreement that our frameworks and tools are inadequate for the policy decisions required to solve our current problems. Adam says that there has been little effect from efforts, made since the 1970s, at deconstructing dualisms of science especially where scientific proof is required for political action, but unobtainable (1998b). Neutrality is a fiction continuously made true; and unable, on its own, to yield the results required. What other fictions and narratives can we resort to, for engagement? Can we accept multiple valid narratives, a kaleidoscope of futures? Or will too many futures continue to 'reflect complexity and prevent insight' as Nordfors has warned? Why do we put all our hopes in the apparent plurality of narratives (scenarios), all branching out from the same source, the same underlying narrative of quantitative neutrality? Is our 'trust in numbers' (Porter 1995) warranted? If *homo economicus* is not about to be displaced by *homo pictor* (Fyfe and Law 1988: 2), is there any chance they might cohabit productively?

The very development of complex scientific visual models was largely influenced by an architect and illustrator, Irvin Geis, in his famous illustration of a protein molecule for an article by John Kendrew (Kemp 2000). Kemp compares the verbal description of Buckminsterfullerine and its visual modelling: the first, less than one and a half columns of dryly laconic prose in Nature; the second, a world popular charismatic soccerball which, according to 1996 Nobel Prize in Chemistry Winner Sir Harry Kroto "has fascinated scientists, delighted lay people, and has infected children with a new enthusiasm for science" (quoted in Kemp 2000: 125).[4]

Eliasson demonstrates that art is one location where Barbara Adam's ideas have found expression. These practices foster spatially, temporally, and culturally situated knowledge, today. Knowledge to think difference, not determine it; narratives of the complex, understood in the local or individual scale. Eliasson's sometimes radically constructionist views[5] actually make the case stronger. Whether the user agrees with those views or does not, they do not get in the way of the individual experiential moment. This experiential learning is linked, by the user, to their own analytical processing, as much and however they want. The viewer is challenged to think the world, and scrutinize the relations between the artwork (and its technical apparatus) and the kaleidoscope of her own perceptual and representational position and apparatus (physiological, cultural, ideological; see Figure 7.4). This is an important element of the argument against normativity.

Figure 7.4 Olafur Eliasson, Your spiral view, 2002. Stainless steel mirrors, steel 320 x 320 x 800 cm. Installation view at Fondation Beyeler, Riehen, Basel, Switzerland, 2002. Photographer: Jens Ziehe. Boros Collection, Berlin, Germany. © 2002 Olafur Eliasson.

The Turbine Hall and the Banqueting House

Mieke Bal proposes a Baroque understanding of the ability of Elliason's work to engage. It is neither relativist nor nominalist, Bal says, but engaging because the relation between subject and surrounding becomes one of enfoldment (2007). The blurred limits—Bal uses the term 'conflation'—between subject and object result in embodying as a mode of knowing. Grynsztejn calls this feature of Eliasson's work an "epistemology for the present day" (2007: 27). Eliasson himself makes direct comparative references to the Baroque. The viewer's entanglement, which Bal says is central to the Baroque, can lead viewers to see themselves seeing inside the representation, as part of the narrative enacted by the representation. Or to see themselves seeing their own representations, and how these are entangled with the world by reflecting it in their apperception. Bal considers Eliasson a prime example of baroque thought.

At the Turbine Hall "the political work this art performs is attributed as a task to the visitor" (Bal 2007: 178). At the Banqueting House, the visitor is invited to complete the illusion of the narrative, placed in what Bann (1988) calls the enveloping effect of the museum, historically designed around a domed or vaulted hall (Stafford 1999). The myth and machine of the museum ideology (see Bud 1988) are still an ensemble at the Banqueting House, but the Weather Project performs their separation, their *demystification*. The Banqueting House represents a world ruled by metaphysical laws that are translatable into quantified proportion, and represents (speaks on the behalf of) God.

COMPLEX IN ALL DIRECTIONS

The kaleidoscopic dimension of the self in the Weather Project is baroque in the sense that a monad reflects those around it and is aware of its own perceptions. Apperception is "consciousness, or the reflective knowledge of this internal state" in a monad, "representing the universe from a unique perspective" (Leibniz 1989[1714]: 208—§4 G VI 600/AG 208). This is the baroque politics that Bal says Eliasson performs. At the Banqueting House we witness the Baroque of the pre-established harmony, where there is no doubt that the monads (apperceptive or not) are continually produced by God by emanation (cf. Tarde 1893, III: 20–22) Both locations invite architectural, visual, and narrative entaglements in a folded relationality, but in different directions. Bal summarizes the difference when, speaking of Eliasson, she says that his work "emphatically does not offer representations, though his art engages the pervasiveness of representation in our visual surroundings" (2007: 156). It is arguable whether or not Eliasson offers representations. After all, he says the breaking of the frame is still a frame. To say that it is post-representational might be a better option: aware of the inescapability of representation, but without being representationalist. Possibly more accurately, Doreen Massey, writing in the Tate exhibition catalogue for Weather Project, talks—under the heading of 'Multiplicity'—of spatial heterogeneity as the sphere of possibility, of "simultaneity of ongoing stories" (2003: 114). This, as a form of post-representation (there are several simultaneous stories) seems more plausible than not offering a representation (no story). Crucially, Massey adds another dimension. The representations formulated by "hegemonic geographical imaginations" and presented via global mediation, define the relative positioning of nations "along a trajectory imagined as singular". "Their ['developing' nations'] space (quite literally) to imagine an alternative future is constrained by an imagination of space as time". Ultimately, she says, "the future of developing places is already foretold in the developed present" (2003: 115). Gabriel Tarde said that wars and alliances always take place under the aegis of great principles and interests, protected by truths and recognised laws (1895: 57).

The irreducibility of embodied experiences, and spaces of possibility, to the neutral and chronological conception of time is an invitation to engagement. Upscalable or not, the multiplicity of possible worlds becomes irreducible. The multiplicity of irreducible futures might reduce all information to noise. Yet others consider noise to be not only 'the law of history', but the very 'opening to multiple futures': "There are other possible worlds, I know other possible meanings, we can invent other forms of time" (Serres 1995: 25). If "the work of transformation is that of the multiple" (1995: 101) what transformation is achieved when the multiple is a creation borne out only of the commensurable and rational? Serres says that "a crisis is a return to the multiplicities" (1995: 120). And indeed, the word 'crisis' derives from the Greek '*krinein*': to decide, to choose.

John Law, following Chunglin Kwa (2002), suggests that complexity can be understood in two directions, or sensibilities. One, the Romantic, resorts to centralised modelling and control. Looking up, in increasingly general abstraction, is the direction of Romantic complexity: "look up so you can look down" (Law 2003: 4). In our terms: abstracting the impurities of the empirical to the point where everything is subsumed in a totality, so that downscaling is then possible. In this sensibility, when modelling a system that aims to include everything, how much abstraction can one afford before it is too high, up in the weather clouds? Too high to specificate, to particularize, to downscale? Law identifies a temptation in the Romantic sensibility to include more and more in its models, and Kwa explicitly includes GCMs (Global Circulation Models) in the Romantic sensibility.

The second sensibility towards complexity is the Baroque: it looks down, to find how many realities and objects are enfolded (and stabilised) into one description, one concept, one machine. In the Baroque imagination, complexity is in the detail. The Baroque complex offers more certainty that something is at stake, "from the experiential aspect" (Kwa 2002: 47). How can we imagine work of the type conducted by Marx et al., with Ugandan farmers, starting from a Baroque sensibility of the complex, work that starts from the assumption that uncertainty is ontological rather than epistemological (Kwa 2002)?

Baroque complexity is—Law says, in its preference for divergence (opposed to Romantic convergence)—at best partially coherent; there is no final, overall coherence. "There is no system, global order or network" (2004: 9). His conclusion tells us that "if we lose the visions and the hopes of Romanticism we also lose its blind spots. Other realities, questions, and methodological or political possibilities are brought within the conditions of possibility" (2004: 10). This brings us back to the quest for clumsy solutions[6] as a methodological possibility. The baroque approach to complexity, looking down, is a studying-up. If this seems paradoxical, it is only adverbially so. Janet Wolff reminds us of Adorno's description of Benjamin's work as a "micrological gaze", and how "operat[ing] micrologically by paying attention to the detail, the fragment, the small scale [is] a way of illuminating the broader social scene" (2008: 120). If we accept that there is no globally coherent order (or that, if there is something like it, it is made, transient and proto-coherent) we don't even have to question the 'infinities derived from a few simple principles' assumption proposed by Verweij and Thompson. That assumption may be true of many things (e.g., fractal patterns in the vegetable kingdom and in mineral formations), but it is still too close to overarching narratives when assumed as a universal principle to understand the local and its sempiternal(ly renewed), beautiful, creative, messy clumsiness.

Eliasson's complexity is visually and experientially baroque. The Well for Villa Medici invites viewers to look down to see their image fractured, at no other place than the garden of Renaissance perspectivalism. At the Turbine Hall, looking up doesn't send us to heaven, or doesn't show us a representative of a higher order ascending to its natural place in the cosmos. We are, instead, brought back to ourselves, in a process that can, arguably, be called apperceptive. The highest, most distanced reflection of the specific still retains the recognisable human individual. Eliasson reiterates the Baroque complexity of vision with downward vision (Well at Medici Villa), upward reflexive vision (Weather Project), frozen vision (Your Strange Certainty Still Kept), afterimage vision (Room for One Colour, Yellow Corridor, The Curious Garden), perspectival shattered image (Your Spiral View), relative position vision (Your Sun Machine), situated vision (Beauty), hyperreal perspectival image (Remagine), and so on. All these works focus the attention of the viewer on the normativity of perspectival frameworks, the constitutive role of vision. Many of these works, and most of Eliasson's most successful, also have another dimension: instances that demonstrate the constitutive role of vision and experience show how natural phenomena aren't external and anterior to our experience of them. To *each* of our experiences of them, as the titles consistently remind us.

If the Weather Project is indeed a catalyst, does it work? Two million visitors enjoyed the 'impossible beach'. It gave millions an appealing and engaging experiential entry point to the constitutive role of our climatic representations. Did they get it? I am loath to answer a question with another, but those 2 million people, do they get the hypercomplex causality chains represented in the scientific literature? There is no doubt they knew the 'beach' was impossible, but they returned in masses to relax in its sunlight. Maybe it's not just a matter of exploring clumsy solutions for messy problems, it's also a matter of valuing ways to destabilize our stagnant assumptions. The Weather Project is no direct answer to climate change, but it invites viewers to challenge, by themselves, the colonisation of creative solutions operated by those who call themselves 'professional dreamers'. In brief, and with Bauman, we shouldn't look for a way beyond uncertainty; uncertainty can give us a way forward (2003). As Eliasson says (above), the visual appearance of a Green River has to be uncertain, to a large extent.

The matter is, then, what is meant by 'work' in, 'Does the Weather Project work?' In the light of what this chapter has taken as guidelines (neutrality and efficiency), the answer is simple of the first: it is not neutral, it does not have to be, and it works because it does not pretend to be. The beach is always impossible. Of the second (efficiency), the matter is more complicated. It begs the question of criteria for efficiency, and that sends us in a different direction. However, millions did bathe at the 'impossible beach'. Can we accept that chaos and unpredictabilty are also matters of scale, that the whole necessarily exceeds our sum of its parts, and that the parts are more than their sum, more than we can summon? That both these clauses can be true at the same time of the same unit of analysis, and that both point to the limits of our understanding, to the short-sightedness of our "not-yet-complete" modes of enquiry, and how they determine, or even taint, their findings? That more than nature/culture co-production (e.g., Giannachi and Stewart 2005, Jasanoff 2004), the end of that dualism results in a mesh finer, more complex and more multidimensional than our eyes can squint at?

The Weather Project works insofar as it is one extant, real, reviewable, instance of the multiplicity of strategies that is required to generate wider engagement with climate change. More, it is an instance that fosters that multiplicity as a reclaiming of narrative(s). To achieve multiplicity (as opposed to plurality from the singular total), the development of cultural spaces where incommensurable dimensions can develop (and possibly interact) seems far more promising than professionalising dreaming or annexing art into managerial and corporate strategies. If Latour's "belief that we now live in the ruins of Nature—in all the senses of this expression" (2003: 38) is true, and if it is true that it is on those ruins that the future is being created, always from implicit assumptions (O'Riordan and Timmerman 2001: 450), are our assumptions ruined? Is that why we try to hide them? How do we forecast based on ruined assumptions?

Ella Shohat and Robert Stam suggest that aesthetic practices are able to represent a scrambled and palimpsestic temporality, and that this is crucial in overcoming the teleological attitude towards 'develop*ing*' nations, an attitude they state is also visible in art. A 'polycentric aesthetics' can help us realise that all cultures are multiple, hybrid, heteroglossic, and characterised by multiple historical trajectories (2002: 39). If our entanglement is the start of our engagement, is the Weather Project "a kind of a catalyst" (Eliasson 2003: 66) towards plural approaches to climate change? A multiplicity that is not everything but, for that very reason, can be the many, and owned by many?

Might this be one way to address the question 'what kind of knowledge, for whom and for what?' If everything is connected through discontinuities—the discontinuities of ruins, and the partial articulations of art and of language, and the smoothed partial articulations of climate modelling and political speech—then engagement, or "the word 'feeling' becomes very crucial here. Within the plural, you can still feel capable of handling your own life—that your life has consequences" (Eliasson 2008: 156).

MATHESIS APOCALYPTICA

More than one hundred years ago, Gabriel Tarde described the fallacy of the approach of panoramic view of vast ensembles and its general laws can descend onto the social to determine it, in terms that strongly resonate with today's practices of downscaling a 'totality' (1898: 54–55). Modern metaphysic, Lyotard says, inherited not the content of great narratives, but the belief that the future course of history is traceable and conceivable (1991: 68). This has sustained (and many times masked) apocalyptic narratives through the secularisation and questioning of grand narratives.

The Christian Apocalypse, the end of time and of the world, is centred on Christ's return for a final, last judgement. This is commonly called the Second Coming. The biblical and theological terms are *parousia* (from the Greek for 'making present'), or apocalypse (Greek: 'unveiling' or 'revealing'), or *epiphaneia* (Greek: 'apparition', 'manifestation', from the verb *phaínein*, 'to appear'). In all these instances, the terms denote presence, not as a steady state, but as a process, a process of arrival, a process of making present, a manifestation. As Derrida says of terms for origins and ends, "archi-, *telos, eskhaton*, etc. have always denoted presence" (1991: 62).

This book set out to deal with the apocalyptic in climate change. It is now apparent that the link between the end of the world (as always a form of 'unveiling' or 'making present') and scientific representation (as a manifesting, a making present) is essential, and not just sustained by the apocalyptic as a powerful trope or a narrative. Modelling the future, whether mathematically or prophetically, is *parousia*, making present, manifest. And as we have seen, this is always a manifest making. The 'gaps in knowledge' rhetoric is akin to the way religious apocalyptic narratives aim at universality. These are always the product of a situated, context-specific cultural configuration, but the end is always total, making the local truth universal, applicable to all situations and contexts. As Foucault says, "[T]he sciences always carry within themselves the project, however remote it may be, of an exhaustive ordering of the world" (2000[1966]: 74). In the case of climate change, this pushes climate science closer to apocalyptic narratives. Any and every claim to represent, or speak on the behalf of, a totality tends to totalitarianism.

I have made a case against these modes of ordering of the world because they are based on the impossible assumption that we can know everything that matters, and how it matters, and that this can be done with methods of simplification and commensurability. With Law and Mol, my position is that the

> endless mobilization of this single trope, in which simplification figures as a reduction of complexity, leaves a great deal to discover and articulate. We need other ways of relating to complexity, other ways for complexity to be accepted, produced, or performed. (2002: 6)

The juxtaposition of the visual arts to mathematical methods of 'revealing' the future has been, here, an attempt to foreground other ways of relating to the hyper-complexity of climatic changed futures. Law and Mol add that, instead of simplification, we need to make sense of multiplicity and, to do so, "we need to think and write in topological ways, discovering methods for laying out a space, for laying out spaces, and defining paths to walk through these" (2002: 6).

Of the modes of cohering (or dealing with coherence) listed in Chapter 4, I have devoted much less attention to religion than to the arts and sciences. As well as being absolutist at times, religion can also allow room for ignorance. Actually, it sometimes sustains ignorance as a fundamental mode of existence in the world, and in relation to what is beyond it. This is commonly visible in mystical theology, over the ages, and across religious traditions, where knowledge is always and necessarily secondary to humility, openness, and selfless love. Even in instances when mystics consider mathematics to be, more than the science of the world, the only science there is, they still reserve the nearest proximity to God to the fool, as is prominently exemplified in the writing and thinking of Simone Weil, who sometimes was labelled as Gnostic but prayed for mental and physical decrepitude. I have spoken of religion, as mode allowing/creating an excess of coherence, with no intention of devaluing its practical, ethical or spiritual power, or of disregarding its power to engage. Those matters deserve more attention than I can presently devote to them.

This isn't (only) a matter of academic methods, of the social sciences teaching the earth sciences how to make the world manifest, or of sociology teaching theology about some 'true' nature of the apocalyptic. Over the last few decades, attempts to eradicate, or halve, hunger and poverty have failed.[7] I have mapped these failures to the methods which sustain the policies that have allowed world hunger affect more people than ever. This is why Camus' epigraph (above, this chapter) and Frank Zappa's epigraph (previous chapter) aren't just the fanciful words of artists, but relevant in our context. The apocalypse happens everyday to those starving to death. The Doomsday Vault performs a unique irreplaceable function, but as long as it is sustained by the rhetoric of an objective, neutral, apolitical, non-ideological, scientific apocalypse, it is co-optable by interests contrary to those hungry now, and those who will be hungry in the future.

The focus on calculating the end is reminiscent of Lewis Richardson's efforts at numerical forecasting: the calculations took far longer than the future being forecast, and were wrong. As Jameson has noted (1991), we live today in an image culture. However, our ability to use visual representation is not just underutilised, it is sometimes devalued, as D. H. Lawrence states in his *Apocalypse*: "Man thought and still thinks in images. But now our images have hardly any emotional value. We always want a 'conclusion', an end, we always want to come, in our mental processes, to a decision, a finality, a full-stop" (1995[1931]: 93).

Catastrophic time, Lingis has noted (1998), drives us towards rational time, intelligible time, so that our modes of reasoning are shaped by the possibility of our disappearance. The sense of imminent end drives us to the intelligible time, repeatable, measurable. "Sensing the inevitable catastrophe ahead of us, we determine to keep its shadow completely out of the intelligible and productive time of work and reason"[8] and we settle into work practices that we understand, and avoid the limits of mathematics and physics (1998: 22). The disciplinary boundaries are erected well short of those limits, despite the rhetoric of multidisciplinarity. The calculable, controllable, commodifiable, exploitable future derives from its decontextualisation, the emptying of its content (Adam and Groves 2007: 2, 10), from ignoring modes of future construction which are inherently embedded (2007: 139) and therefore inherently intractable through the consecrated methods and disciplines. This works against ways of making sense of multiplicity, against what Guattari calls the "polyphony of modes of subjectivation", which corresponds to a multiplicity of ways of "keeping time" (Guattari 1995: 15–16). The Doomsday Vault and the downscaling proposed in the Nairobi Work Programme define—through this calculable-apocalyptic-time—one way of keeping time, and one way of controlling agricultural work activities, neutralising events through 'complete information'. For Guattari, as for Eliasson, time is actively created, not passively perceived. When a calculable, objective apocalypse defines time keeping, no other forms of time creation are allowed as valid; and harvest time and harvest work no longer belong to those who tend the land.

The *parousia* now manifests no messiah, but is still the universal, univocal calculability of the futures, still allowing only one valid doctrine of the future, to be manifested to all, and all need to change their lives accordingly. There is no 'death of nature' (Merchant 1980), no 'end of nature' (McKibben 1990). We cannot kill it, only renew it continuously. Even the foreseeing of its end is its production, a human performing of nature. There are many ways to create it and its futures, many ways to perform its renewal, to renew the expectation of its end, or to create new beginnings.

Notes

NOTES TO THE INTRODUCTION

1. I make undifferentiated use of 'weather' and 'climate' when the distinction is either historically anachronistic, or when it is dubious or unnecessary. 'Weather' and 'climate' are not the same thing: some definitions put 'climate' as the long-term patterns of weather events, some see 'weather' as the actual events from which we perceive climatic patterns. When the distinction is needed or adopted from elsewhere, it is used.
2. When referencing IPCC documentation, I have chosen the notation '(IPCC [date]: [page and/or section number])', overlooking the editors of the documents in the flow of the text. This choice makes IPCC quotes and paraphrases easier to identify. The corresponding bibliographical entries list the editors/authors (when available).

NOTES TO CHAPTER 1

1. See Trevor-Roper (1967); Parker and Smith (1997); Elliot (1969); Israel (1974); de Vries (1976); Aston (1970); Treasure (2003); cf. Shapin (1996); Webster (1975). Le Roy Ladurie (1971) is one of the main voices in doubting the significance of the weather effects on early modern life.
2. Friedman (1992) offers a large number of well-documented examples of 'sky wars' and to each offers the contemporary interpretation based on real or potential military confrontation between nations. Vladimir Jankovic (2000) gives a different account, to say that 'sky wars' indicated future events, and only a small minority featured political interpretation. The analyses of Durston (1987) and Wittkower (1977) are closer to Friedman's.
3. All biblical quotes hereafter use the King James Version. Napier used the Geneva bible, so his biblical quotes usually employ the latter.
4. Revelation contains many prophecies directly related to natural events: "I heard a great voice out of heaven" (Rev 21:3); "voices, and thunderings, and lightnings, and an earthquake" (Rev 8:5); "the day shone not for a third part of it" (Rev 8: 12); "an angel flying through the midst of heaven, saying with a loud voice, Woe, woe, woe, to the inhabiters of the earth by reason of the other voices of the trumpet of the three angels" (Rev 8: 13); "the sun and the air were darkened" (Rev 9:1); "when the seven thunders had uttered their voices" (Rev 10:4); "and there were lightnings, and voices, and thunderings, and an earthquake, and great hail" (Rev 11:19).
5. *Ecclesia* from the Greek *ekklēsía*: assembly, congregation, community.

NOTES TO CHAPTER 2

1. Published in English in 1616 and 1618, reprinted in Latin in 1620.
2. Napier's 1619 *Mirificii Logarithmorum Canonis Constructio* (hereafter *Construction of Logarithms*), written before the *Description of Logarithms*, was only published posthumously. The book offers the "most amply unfolded the theory of the construction of the logarithms", tells us Robert Napier, second son and literary executor to John Napier (R. Napier in Napier 1966[1619]: A2).
3. The chronological coincidence, during Napier's life, of the development of logarithms and biblical interpretation also suggests a close relation, but the evidence is circumstantial, and offers little that is useful to us in later chapters.
4. Halley published *An Easy Demonstration of the Analogy of the Logarithmick Tangents to the Meridian Line, or Sum of the Secants; with various Methods for computing the same to the utmost Exactness*, and was busy, for years, with finding a natural reason to proving that the world would have an end to quell accusations of atheism (Schaffer 1977).

NOTES TO CHAPTER 3

1. Early developments of the Maiestas Domini have been examined by Martim Werner (1969, 1981, and 1986), van Moorsel (1966); Okasha and O'Reilly (1984); Lawrence Nees (e.g., 1978 and 1987), Poilpré (2005), among others.
2. In his paraphrastical analysis of the Book of Revelation in the *Discovery of Revelation*, Napier analyses Revelation 4, where the beasts are described as making the history of Christ patent to the world and "these Euangels and their professors doe utter this glorie: honour, & thanks to God" who sits on the throne "Holie, holie, holie, Lord God almightie, which was, which is, and which is to come" (Rev 4: 8–9 as paraphrased in Napier 1594: H3r).
3. The Maiestas Domini already had a venerable and renewed presence in the British Isles. The first known Maiestas Domini in the British Isles are as old as the fourth century AD (Murray and Murray 1996), and the four beasts of Revelation (the Tetramorph) were associated with the four Evangelists ever since. The oldest known examples are at Ilkey (Yorks), Sandbach (Chesire) and Wirksworth (Derbyshire). Rochester Cathedral, Britain's second oldest cathedral (AD 604), features a prominent Maiestas Domini. In Canterbury Cathedral, the Maiestas Domini includes towers of New Jerusalem. Further examples include Malmesbury Abbey, Norwich Cathedral and St. Thomas Church in Salisbury.

NOTES TO CHAPTER 4

1. Brian Rotman says mathematics in the twentieth century has been dominated by Platonism, a belief of metaphysical-theological character (2000: ix–x).
2. I am not establishing a direct causal connection between these events and climate change, even if some have. The point is that whether these are caused by climate change or not, events of this type are expected to increase with climate change.
3. Teraflop: *tera+flop*—floating point operations per second; 35 teraflops = 35,860,000,000,000 calculations per second.

4. On related semantic views of models, see Winsberg (1999); Giere (1999); van Fraassen (1980 and 2008). On syntactic views (according to which models are largely autonomous in relation to theory and data) see, for example, Morgan and Morrison (1999). The traditional semantic view postulates a structural isomorphism between models and the systems they represent. This is not without its problems. However, to characterize this view as defending a structural identity, as Suarez does (1999) is a misrepresentation, as demonstrable by Giere's position of partial isomorphism of models (e.g., 1999).

NOTES TO CHAPTER 5

1. Another IPCC definition of scenarios, from the TAR, says, "For the purposes of this report, a climate scenario refers to a plausible future climate that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change" (IPCC 2001b: 13.1.1).
2. Accessible at http://www-cger.nies.go.jp/cger-e/db/ipcc.html.
3. The words 'mess' and identity' aren't used arbitrarily. The second is extensively used in the Report. The first is taken from John Law, in the methodological sense (2004), and from Ackoff (1974) in the sense of complex problems, or as he puts it, 'systems of problems'. It is also used in the Report, in the above context, and when discussing modelling of technological change. Paul Teller also uses it, but less systematically and without a clear definition (2001).
4. Scenario development has always been a business and linked to business. The origins and development of scenarios are indissociable from corporate, consultancy, and military environments (see Ringland 2006; Fahey and Randall 1998; Sharpe and Van der Heijden 2007; Ross 1991; Edwards 2000; OECD 1979; Slaughter 2007; Rome Special World Conference on Futures Research 1973).
5. Authors acknowledged and quoted by the Report.
6. This means "at an appropriate temporal and spatial scale, for a sufficient number of variables, and over an adequate time horizon to allow for impact assessments" (IPCC 2001: 745). What a sufficient number of variables might be is unresolved, if it ever is resolvable.
7. It is not just the IPCC that promotes this complementarity. Kenneth Hammond (1996), in *Human Judgement and Social Policy*, sets up his argument from a 'rivalry' between intuition and analysis, to then call for 'complementarity'.

NOTES TO CHAPTER 6

1. Food security means different things to different people. Two high-profile definitions should suffice us here. The 1986 FAO's Committee on World Food Security defined food security as the "economic and physical access to food, of all people, at all times". The World Bank defines it as "access by all peoples at all times to enough food for an active, healthy life" (1986).
2. This is disputed. After what we've covered in the previous chapter, it should come as no surprise that the dispute gets lost in matters of numbers and their interpretation. See Sokolov (2009), Manning (2010), Ganguly (2009), Anderson et al. (2008), Reichstein (2010).
3. These are, as defined by the FAO: food availability, access to food, stability of food supply, and utilisation of food (2008b).
4. Working Group II (WGII) is devoted to assessing the impact of climate change, as well as adaptation and vulnerability to climate change.

5. I adopt the term 'upscaling' from the Technology and Agrarian Development Group of Wageningen University (more on this later; there are other conceptualisations—see Tainter 2007; Vogel and O'Brien 2006: 116; also Danny Harvey 2004: 78 in the context of mathematical modelling of the climate system). I use 'upscaling' in the sense of increasing the visibility, usage, uptake, fostering, and development of indigenous knowledge. Especially (but not only) by understanding the assumptions, strategies, heuristics, generalisations, modes of transmission, adaptation, and sharing of local knowledge as intrinsically situated forms of knowing and acting. I propose this only as a tentative, hesitant definition of 'upscaling', aware of the risk of enacting a false dichotomy between the 'downscaled global' and the 'upscaled local', which might serve little purpose besides reproducing the current global/local dichotomy that makes the current downscaling trend possible in the first place. For now, I shall not attempt a precise definition, since it is my concern at present what 'upscaling' might mean, and how what it means depends on its usage. In 1996, agricultural upscaling (in the context of CO_2 impacts and global change) did not feature farmers. It meant extrapolating trends "from experimental observations to the real world" (Gifford et al. 1996: 229).
6. The World Bank's Vice President for Sustainable Development also serves as Chair of the CGIAR.

NOTES TO CHAPTER 7

1. Cf. with Ligeti's mathematical confirmation of musical composition (Box 4.2, in Chapter 4).
2. A note on the power of local cultural specificities, and how downscaling misses the power of local semantic connections: in Romance languages, 'time' and 'weather' are homonyms. 'Tempo' in Portuguese and Italian, 'tiempo' in Spanish, 'temps' in French, 'vreme' in Romanian; from the synonym Latin 'tempus', from Sanskrit 'tapas', meaning 'heat'. The etymon is shared with the English 'tepid', but 'weather' and 'time' bear no such connection. If, beyond the semantic, we were to consider the cultural information encoded into pragmatics and prosody, then downscaling is closer to representing its own project than anything else. The same could be said of local practices and material culture.
3. The project is accessible at http://www.thisisthepublicdomain.org/ and, as of access date (10 May 2012), no solution has been found. The project was also covered in Andrews (2006).
4. Cf. Lynch and Edgerton Jr. (1998) on the boundary work between the 'aesthetic' and 'quantitative' in astronomical imaging.
5. "In fact, there is nothing 'real' outside us, only cultural constructs" (Eliasson 2002: 140).
6. Which I understand as solutions that accept the messiness of complexity, and how this requires creativity as a central tenet. This is not the sense intended by Verweij and Thompson.
7. The UN and the FAO have used 'halving' and 'eradicating' inconsistently. The United Nations Millennium Declaration uses 'halving', but for a long time the Millennium Goals' website used 'eradicate'. As of 2012, it says, 'end'. Sometimes, the same document uses several options (eliminating, eradicating, etc.).
8. The first Christian apocalypse—the 'fruitful' Adamic moment of unveiling of knowing—lead to property and labour, the narrative states. Like then, now "cursed is the ground for thy sake" (Gen 3:17; "because of you" in the New International Version).

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Index