Earth System Governmentality. Critical Notes on Science in the Anthropocence

Eva Lövbrand[1], Johannes Stripple[2] & Bo Wiman[3]

To be presented at the Berlin Conference on the Human Dimensions of Global Environmental Change, February 22-23, 2008

Work in progress – please do not cite without permission

[1] Department of Political Science, Lund University & Center for Climate Science and Policy Research, Linköping University, Sweden. Phone: +46 46 222 4762, email:eva.lovbrand@svet.lu.se,
[2] Department of Political Science, Lund University, Sweden.
[3] Department of Pure and Applied Natural Science, Kalmar University, Sweden.

Abstract

Earth System Science (ESS) has in recent years emerged as a holistic super-discipline that tries to embrace Earth and human society as one interlinked system. Building upon a view from space, ESS has been described as a striving to perceive the big picture, to monitor and manage the "coupled human and ecological system". In July 2001 this new approach to global environmental change research was manifested by the inception of the Earth System Science Partnership at the Global Change Open Science Conference in Amsterdam. Central to this partnership is the presumption that we live in the "Antropocene", a geological époque dominated by human activity. While proposed as a response to the daunting Anthropocene imagery, this paper argues that ESS epitomises modern society's firm belief in human rationality and control. We make use of Michel Foucault's notion of governmentality in order to forward a critical reading of the government rationalities embedded in this science-driven vision of planetary management. We study how the various ESS techniques and practices are enmeshed in the political struggle to assign meaning to contested concepts such as environmental stewardship and sustainable development.

Introduction

Since the late 1980s when NASA launched Earth System Science as a structuring concept for its future research activities (see Johnson et al. 1997), a seemingly new way of understanding and studying the Earth and environmental change has gained ground among scientific institutions around the world. Building upon a view from space provided by remote sensing technology, global databases and sophisticated computer models, Earth System Science (ESS) has emerged as a holistic super-discipline that tries to embrace all processes in nature and human society as one interlinked system (Steffen & Tyson 2001, Clifford & Richards 2005). According to Schellnhuber (1999), one of the main advocates of this new scientific approach, the Earth System consists of two main components; the "ecosphere" and its subsystems such as the atmosphere, biosphere and cryosphere, and the "anthroposphere" that accounts for all human activity. Instead of studying each subsystem as a self-contained entity, this new "science of integration" (Steffen & Tyson 2001, p. 23) seeks to put the pieces together and understand the planetary life-support system as an integrated whole. Hence, ESS has been described as a striving to perceive the big picture, to monitor and manage the "coupled human and ecological system" (Schellnhuber et al. 2005, Steffen et al. 2004).

In this paper we forward a critical reading of this new approach to global environmental change research. While proposed as a response to the daunting anthropogenic changes to the Earth's land surface, oceans and atmosphere, we suggest that the many techniques and practices of ESS paradoxically mediate the very mentality that has brought about these changes in the first place. According to advocates of this science of integration, society can only move towards sustainable futures when the activities on Earth are studied and understood in their totality. Although the "coupled human and ecological system" is said to harbour complexity, non-linearity and surprise, and thus points to the limits of human prediction and control, ESS advocates call for a comprehensive scientific mapping and modelling of the Earth System in order to guide society along sustainable trajectories (Schellnhuber et al. 2005, Crutzen 2002). Hence, during the past decades an advanced "Earth System toolkit" (Steffen & Tyson 2001) of methods and techniques has developed in order to render the Earth System governable. Interestingly enough, this science-driven vision of Earth stewardship has been subject to very limited debate and critique. Surprisingly few scholars have questioned the grandiose management ambitions embedded in the Earth System metaphor. Rather, in academic and policy debates alike, ESS has been celebrated as the only adequate scientific approach in the Anthropocene era (UN 1992, Crutzen 2002, Kotchen & Yong 2007). Although social scientists have sought to replace the managerial techniques embedded in ESS with a broader focus on governance practices[4], the Earth System remains a seemingly uncontested unit of analysis (Biermann 2007).

Considering its widespread resonance in the global change research community, we find it timely to initiate a critical discussion on the basic assumptions and political implications of the Earth System metaphor. We do so by drawing upon Michel Foucault's notion of governmentality. Governmentality studies highlight the *how* of government (Dean 2004). By studying the many mechanisms, techniques and procedures through which political authorities realise and enact their programmes, this field of enquiry seeks to understand the underlying logic or mentality that makes certain governing strategies appear rational and natural at given times in history (MacKinnon 2000, Lemke 2002). Our analysis of "Earth System Governmentality" rests upon three analytical categories that also organise our paper. After a general introduction to our Foucauldian analytics of government, we begin by examining the technical aspects of Earth System Science. Here attention is drawn to the practices, instruments and technologies that have produced the "coupled human and ecological system" as a thinkable and governable object. As a second step we explore the system of thought and rationalities underpinning this emerging research programme. What forms of knowledge and ideas are mediated through the practices of ESS and what nature concepts and human

[4] Biermann (2007, p. 4) defines Earth System Governance as "the sum of the formal and informal rule systems and actor-networks at all levels of human society (from local to global) that are set up in order to influence the co-evolution of human and natural systems in a way that secures the sustainable development of human society."

identities do they produce? Finally, we ask ourselves what kind of environmental futures that are assumed when governing the Earth System and what versions of the sustainable society they harbour.

Analytics of Government

As indicated by the semantic linking of the words governing and mentality, the Foucauldian notion of *governmentality* refers to an analytical framework that identifies the modes of thought and political rationalities that underpin government practices at certain times in history. In a series of lectures held at Collège de France in Paris in the late 1970s, Michel Foucault developed this field of enquiry by tracing a number of historically specific rationalities and forms of rule tied to the modern European state (see Foucault's lectures in Burchell et al. 1991). To analyse government in this context is to draw attention to the many practices and techniques that, in a more or less systematic and reflected manner, structure and shape the field of possible action for individuals by defining what their identities can be and do (Dean 2004, p. 14, Darier 1999, p. 17). From a Foucauldian perspective, these practices are all informed by collective modes of thought that help to create a discursive field in which the exercise of power is perceived as rational and natural (Lemke 2002, p. 55). An analytics of government examines the conditions under which this intrinsic logic or mentality comes into being, is maintained and transformed (Dean 2004, p. 23). By focusing on the multitude of contingent practices that mediate such modes of thought, this field of enquiry seeks to show that our taken-for-granted ways of perceiving and organising society and our selves are far from self-evident or necessary. Hence, studies of governmentality reject any *a priori* understanding of the governed reality (Lemke 2002, Jessop 2007). To analyse mentalities of government is to analyse political knowledge; i.e. how thought produces the governed reality and hereby directs the ways we act upon it.

In this paper we make use of a Foucauldian analytics of government to interpret the government rationalities mediated by the practices of Earth System Science. In line with Rose and Miller (1992), we note that objects only can be governed when they are represented and conceptualised in a way that can enter the sphere of conscious political calculation. Hence, by taming the natural reality and making certain aspects of it visible, scientific knowledge represents important "intellectual machinery" for governments (Rose & Miller 1992, p. 182). Miller (2007) refers to the scientific classification of the world as "kind-making" and suggests that this epistemological activity is central for the constitution of social order. "Through their day-to-day conceptual and practical work, scientists classify and reclassify the subjects and objects of nature and society, carving up the world into distinct ontological types and occasionally creating entirely new taxonomic categories" (Miller 2007, p. 338). By subjecting the world into disciplined analysis of thought, science hereby contributes to the ideational framework or the *episteme* that makes the world meaningful. Adler & Bernstein (2005, p. 296) define episteme as "the 'bubble' within which people happen to live, the way people construe their reality, their basic understanding of the cause of things, their normative beliefs, and their identity, the understanding of self in terms of others." By establishing limits to what can be thought and done, epistemes are more than mere social imagining. According to Adler & Bernstein (2005), they both enable and delimit agency and thus represent a fundamental building block of governance.

In this paper we seek to delineate the "episteme of government" (Dean 2004, p. 31) embedded in contemporary environmental change research. In focus is the underlying system of thought that articulates and justifies the Earth System as a natural "kind" and hereby directs our understanding of how it best is governed. We see these ideational aspects of the "Earth System Governmentality" as inseparable from the many methods, instruments, computations and experiments that have brought the "coupled human and ecological system" into being. This multitude of scientific practices or "technologies of government" (Dean 2004, p. 31) represents the operational aspects of the Earth System that make the metaphor susceptible to government deployment. Hence, we argue that the meanings people attach to nature, and the practices through which these meanings are manifested, are equally central for how the environment is governed. However, since Earth System Science still is in the making, our study does not seek to identify one single mentality that informs its practices. In accordance with most governmentality studies (see Lemke 2002), our paper is attentive to inconsistencies and contingencies within this emerging field of enquiry that may open up different fields of possible government action. Our critical reading should therefore primarily be understood as a reflective exercise that seeks to challenge the 'naturalness' and taken-for-granted character of current ESS practices and thus initiate a debate on the environmental futures they may produce. Once perceived, and unless subjected to critique, an environmental future may become a self-fulfilling reality.

Technologies of Government

In the Amsterdam Declaration on Global Change from July 2001[5], the chairs of four international global change programmes – the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP), the World Climate Research Programme (WCRP) and the international biodiversity programme DIVERSITAS – jointly voice concern over the ever-increasing human modification of the planetary life support system. In order to come to terms with the effects of the human-driven changes to the Earth's biogeochemical cycles in the inter-linked terrestrial, aquatic, and atmospheric systems, the declaration contains a discipline-transcending research agenda that draws upon the expanding field of global change research in the natural and social sciences. The Earth System metaphor emerges as the centrepiece of this joint effort formally known as "the Earth System Science Partnership". The declaration defines the Earth System as a single, self-regulating system comprised of physical, chemical, biological and human components. Notably, Earth System dynamics are here said to be characterised by complex and multiple-scale feedbacks, critical thresholds, abrupt changes and large temporal and spatial variability.

This representation of the Earth System is not produced in a void. Rather, it taps into series of scientific methods, techniques, and nature concepts that have evolved over several centuries (Wiman 1991). It draws heavily upon increasingly sophisticated mathematical representations – i.e. models – of ecologically interactive processes in nature (see e.g., Kingsland 1995). When first developed in the late 19th century, such models contained a relatively low number of components. Based on emerging control theory and cybernetics (see e.g., Wiener 1998), the well known Lotka-Volterra equations (Volterra 1926), and several derivatives thereof, represent early attempts to provide decision support for resource management and control. However, over time the natural systems chosen for scientific enquiry became increasingly larger and complex (see e.g., Golley 1993). Already in the early 20th century attempts were made to represent global-scale cycling of elements such as carbon (Lotka 1924, 1956). During the following decades this modelling tradition, assisted by the build-up of analog as well as digital computer technology, was further developed for applications on ecological, biogeochemical, and biogeophysical systems such as grasslands, forests, lakes, the tundra, oceans, weather, and climate (see e.g., Patten 1971, Shugart & O'Neill 1979, Golley 1993, Manabe 1997).

[5] See: www.sciconf.igbp.kva.se/Amsterdam_Declaration.html).

During the International Geophysical Year (IGY), jointly sponsored by the World Meteorological Organisation (WMO) and the International Council for Scientific Unions (ICSU) from 1 July 1957 to 31 December 1958, a systematic series of geophysical studies spanning the globe from North to South fed empirical data into these models. At that point in time, new research technologies such as cosmic ray recorders, spectroscopes, radiosonde balloons and advances in computer technology allowed scientists to collect and process increasingly large data sets on atmospheric, terrestrial and hydrological processes (Fraser 1957). Among the more famous atmospheric measurements introduced during the IGY was the first permanent monitoring station for CO_2 installed on the Hawaiian volcano Mauna Loa. However, this worldwide research effort also marked the beginning of scientific monitoring of atmospheric ozone over the Antarctic, world-wide studies of ocean depths and currents, as well as satellite technology geared to environmental purposes (Fraser 1957). The systematic and global-scale collection of geophysical data initiated in 1957, and the growing technological capacity of storing and processing such data, was central for the emergence of global biogeochemical and biogeophyscial models and their visual representation of an integrated planetary environmental system (see e.g. the Report of the Study of Man's Impact on Climate, 1971). The close feedback between rapidly developing measurement technologies, Earth observation satellites and world data centres also inspired the further build-up of numerical models attempting to capture, on a grand-scale level, basic feedbacks between human society and the global environment.

(In)famous natural resource models from the early 1970s such as "World Dynamics" (Forrester 1971) or "Limits to Growth" (LTG) (Meadows et al. 1972) generated a great deal of debate and controversy when linking human variables such as demography and industrial throughputs with natural resource stocks and environmental pollution levels. These coupled human-ecological models were widely criticised for oversimplifying their system characteristics and dynamics (Colombo 2001), but, in retrospect, clearly had a formative role in framing environmental challenges as global. As seen by Bell (2001), the LTG "encouraged long-term thinking; focused on holistic analysis, both by taking a global perspective and by investigating the interaction and simultaneous effects of many variables; introduced a technique of dynamic trend analysis and projection, including feedback loops; incorporated counter-factual assumptions; advanced computer modelling and simulation". Models such as Limits to Growth hereby paved the way for the substantially more sophisticated and complex models responsible for the contemporary Earth System imagery. In these recent Earth System models the anthropogenic forcing resulting from human population growth, fossil fuel use, land cover changes and dispersal of chemicals, is directly integrated into the numerical representations of atmospheric, hydrological and terrestrial processes (Crutzen & Steffen 2003). The underlying assumption is that human activity in the 21st Century is influencing and, in some respects, even dominating the Earth's biogeochemical and biogeophysical cycles. Hence, the task to comprehend and map "the human component" – or the "Anthroposphere" – is seen as necessary in order to fully understand and predict the "Ecosphere's" complex cycling of carbon, nutrients and chemicals (Dearing 2007).

The panoramic, or bird's eye view, attained by these global "Earth-simulation machines" (Schellnhuber 1999, p. 20) today rests upon a worldwide infrastructure of *in situ* measurement devices, paleoenvironmental data archives and remote sensing technologies. Following the legacy of the IGY, this global-scale data collection has since the late 1980s been coordinated by international research programmes such as the International Geosphere-Biosphere Programme (IGBP), the World Climate Research Programme (WCRP) and the International Human Dimension Programme on Global Environmental Change (IHDP). The space-based capacity of this scientific infrastructure has also grown dramatically since the mid 1990s when NASA launched its Missions to Planet Earth programme and thereby decided to "take the pulse of the planet" via its more than 20 Earth-observing research satellites (King & Birk 2004). Since the Third Earth Observation Summit held in Brussels in 2005, this U.S. initiative has expanded into an international effort organised around a voluntary partnership between 72 governments and 46 intergovernmental and national organisations called the Group on Earth Observations. The aim of this partnership is to build a Global Earth Observation System of Systems (GEOSS) that will coordinate and distribute the data obtained from all Earth observation satellites orbiting the planet. Through a systematic tracking of changes in all physical, chemical and biological systems, this international space effort sets out to monitor the entire Earth, to provide "the full picture" (GEO 2007). Schellnhuber (1999) describes this capacity to observe the Earth from a distance as a complete Earth reconnaissance, a second Copernican revolution; a depiction that draws upon the opening passage[6] in the World Commission on Environment and Development (WCED 1987). Planetary monitoring systems

[6] "In the middle of the 20th century, we saw our planet from space for the first time. Historians may eventually find that this vision had a greater impact on thought than did the Copernican revolution of the 16th century, which upset the human self-image by revealing that the Earth is not the centre of the universe."

such as GEOSS “enable us to look back on our planet to perceive one single, complex, dissipative, dynamic entity, far from the thermodynamic equilibrium – the ‘Earth System’” (Schellnhuber 1999, p. 20).

Mentalities of Government

In a Foucauldian analytics of government, the technologies, procedures, calculations and instruments humans use to engage with the world always embody forms of truth or an underlying mentality. By making certain aspects of reality visible, diagnosed and stable, these material conditions enable thought to work upon an object and thus (re)produce systems of meaning (Rose & Miller 1992). One central idea mediated by the Earth System enterprise is the assumption that we live in “the Anthropocene”, a geological époque dominated by human activity. In Crutzen’s (2002) view, the Anthropocene era started in the latter part of the 18th century when global atmospheric concentrations of carbon dioxide and methane began to rise due to human fossil fuel use. Since this early phase of industrialisation, human exploitation of the Earth’s resources has increased dramatically and is now, according to the Anthropocene logic, so pervasive and profound in its consequences that it is influencing the very functioning of Earth itself. Crutzen and Steffen (2003) argue that the magnitude and rate of human activities currently are approaching or even exceeding some of the great forces in nature, creating a non-analogue state in the dynamics and functioning of the Earth System. This idea – that humankind is changing the face of the Earth – is hard to separate from the range of methods and techniques used to detect such changes. As explained by Lubchenko (1998), the understanding that we live in a human-dominated era is the result of a long series of empirical investigations into human transformations of land and sea (through land clearing, forestry, grazing, mining, trawling), alterations of biogeochemical cycles (i.e. carbon, nitrogen, water and synthetic chemicals), and biodiversity loss via pollution, hunting, fishing and human habitat destruction. The Anthropocene imagery fostered by these studies build upon the legacy of environmental scholars such as naturalist George Perkins Marsh (1874), biogeochemists Alfred J. Lotka (1924, 1956) and Vladimir Vernadsky (1945), ecologists Eugene and Howard Odum (see e.g., Odum E.P 1987, Odum H.T 1987), and geographer Denis Cosgrove (2001) who all carried the image of mankind as a “planetary geological agent” into the 20th Century (Samson & Pitt 1999).

In face of the potentially dire prospects of the human impress on the global environment, Earth System Science sets out to resume control by developing strategies for planetary management (Steffen & Tyson 2001, see also the Amsterdam Declaration on Global Change[7]). In order to safely steer the planet through the Anthropocene crisis, detailed studies of the various components of the Earth System are perceived as necessary in combination with a systemic approach that maps their many inter-linkages and feedbacks. In this planetary monitoring and management project, the Anthropocene logic is not challenged as such. In line with the Enlightenment's scientific episteme (see Reith 2004), Earth System Science harbours an inherent confidence that systematic investigations into the truths of the natural world will foster a more rational human management of the environment. A better understanding the effects of the "human plundering of the Earth's resources" (Crutzen & Steffen 2003) will lift veils of ignorance and thus allow mankind to enter a more mature stage of the Anthropocene (Schellnhuber 1999, Schellnhuber et al. 2005). Mechanistic metaphors such as the "planetary machinery" (Steffen et al. 2004, p. 9), or "the engine room of the Earth System" (Schellnhuber 1999, p. 21), tap into a nature concept born during the scientific revolution when machines became the symbol for the order, certainty and predictability of physical laws. According to the managerial mentality of this early modern period, nature can be controlled by its human operator when fully described and predicted by science (Merchant 1983, p. 230). The optimistic view of human control and self-determination embedded in this "Enlightenment programme of science" (Sarewitz 2000) is closely tied to modernity's break with tradition and the unfolding of political ideals such as individual autonomy and self-realisation, reason and popular sovereignty. Habermas (1998) talks about the French Revolution in the late 18th Century as the symbolic cradle for the emancipated individual called to be the author of his/her destiny.

When steering "spaceship Earth"[8] through the Anthropocene era, advocates of ESS rely upon this revolutionary mentality. Acting as an agent of "humanity as a self-conscious control force that has conquered the planet" (Schellnhuber 1999, p. 22), ESS sets out to make rational and responsible choices on the system's level. Ironically, however, the Anthropocene imagery is at the same time deeply embedded in widespread uncertainty and the retreat of the Absolute. Representations of the Earth System do not only reproduce perceptions of nature as a predictable and machine-like object, stabilising after disturbance (see e.g., Bodin & Wiman

[7] www.sciconf.igbp.kva.se/Amsterdam_Declaration.html

[8] Among the first to apply this concept – and the related one, "econosphere" – was Kenneth Boulding; see e.g., Boulding, K.E., 1971. The economics of the coming Spaceship Earth. In: Holdren, J.P. and Ehrlich, P.R. (Eds.) Global Ecology. Readings Towards a Rational Strategy for Man. New York: Harcourt Brace Jovanovich, Inc.; pp. 180-187.

2007). Tapping into theories of complex systems, the Earth System discourse is also concerned with non-linearity, the existence of bifurcations, flips between multiple unstable equilibriums, and physically chaotic behaviour (see e.g., Wiman 1991). Whilst far less visible in modern science until formulated by Edward Lorenz in the 1960s in terms of mathematics and fluid dynamics (Lorenz 1963), and, in the 1970s, by Robert May in ecology (May 1976), this thought tradition emphasises the difficulties (as implied in physical chaos theory; cf. Mason et al. 1986) with predicting systemic responses to impact and manipulation. This parallel heritage of the Anthropocene concept departs from the certitude of the Enlightenment era and places the Earth System enterprise in a phase of modernity when, according to Beck (1992), the undesired side effects of modernisation challenge the very foundations of human rationality and progress. This reflexive dimension of the Anthropocene is characterised by ambivalence. As argued by Reith (2004, p. 393), "the profound uncertainty generated within a globalized, indeterministic world erodes the basis for decision making, freezes action, and ultimately blocks the possibility of forward movement into the future. Indeed, the future no longer exists as something that is open to 'colonization' by confident, rational action, but rather as a site of anxiety, full of unknowns, that is not amenable to human intervention".

Earth System scientists have responded to the challenge of indeterminacy and risk inherent in the Anthropocene concept by proclaiming a new social contract for science (Lubchenko 1998, Kates et al. 2001, Clark & Dickson 2003). Acknowledging the limits to scientific prediction and control, this contract departs from the hubris of the Enlightenment era and opens up for a sense of scientific humility. As suggested by Walker (1999), the study of the Earth System takes science out of the controlled environment of the laboratory into a more complex and less predictable reality where repeatable experimentation no longer is possible. Rather than aiming to provide straightforward solutions in this complex environment, Lubchenko (1998) suggests that science in the Anthropocene era should be to help understand the consequences of different policy options. Kates et al. (2001) also point to the need to connect the estranged scientific enterprise with lay experiences and knowledges. "(I)n a world put at risk by the unintended consequences of scientific progress, participatory procedures involving scientists, stakeholders, advocates, active citizens, and users of knowledge are critically needed" (Kates et al. 2001, p. 641). While recognised as ethically undeniable to let all those whose well-being is affected by Earth System management participate in decision-making, the motivation for participatory procedures primarily appears to be instrumental. Apart from offering important empirical insights into the complex workings of the "coupled human and ecological system", participatory processes on an Earth System level are portrayed as central for the building of a "global intent and action" (Kinzig 2004) – a "global subject" (Schellnhuber 1999) – that may increase the willingness of all affected parties to comply with Earth System regulation. In contrast to deliberative visions of scientific democratisation and citizenship (see e.g. Leach et al. 2007, Fischer 2005), Schellnhuber et al. (2005, p.19) argue that scientists should have a dominant role in the making of such regulations in order to ensure that the political exigencies of participation do not override the environmental exigencies of the problems addressed. Hence, the new social contract for science seems to harbour an inherent tension between "rightness of procedure" and "goodness of outcome" (*ibid*) that currently tilts towards the latter.

Earth System Governmentalities

To bring writings on governmentality to bear on the Earth System is not that far-fetched as one might think. Already Foucault drew attention to the governed as "a complex" of what he framed as "men and things". "I think it is not a matter of opposing things to men, but rather of showing that what government has to do with is not territory but, rather, a sort of complex composed of men and things. The things, in this sense, with which government is to be concerned are in fact men, but men in their relations, their links, their imbrication with those things that are wealth, resources, means of subsistence, the territory with its specific qualities, climate, irrigation, fertility, and so on … what counts is essentially this complex of men and things; property and territory are merely one of its variables" (Foucault 1991, p. 93). In the quote above Foucault makes a distinction between sovereign power concerned with territorial control, and biopower that seeks to order and organise entire populations conceived in the abstract by, for example, birth rates, infant mortality and longevity (Stephen 2005: p. 139; Crampton & Elden 2007, p. 7). In this paper we argue that Earth System governmentalities are about the making of a new kind of "population", i.e. "humankind" now measured for the first time in history as a major environmental force. Through the technologies and practices of Earth System Science, humanity becomes an aggregate entity comprising not just the activities of those who happen to live on Earth right now. In the Anthopocene era "men" do not just make history — humankind makes *geological* history.

Following Dean (2004), we suggest that Earth System conceptualisations constitute a novel way of naming, coding, appropriating, and populating the world. The making of the Earth System as political space, i.e. a domain to be intervened by experts, bureaucracies and politicians is indeed a significant achievement. However, our study does not point to *one* homogeneous Earth System governmentality. Rather, the practices of Earth System Science, and the mentalities they mediate, open up for at least three broad government programmes for sustainability that we here call “management first”, “governance first”, and “ethics first”. "Management first" focuses on options and caveats for technological fixes and geoengineering. Geoengineering[9] involves direct control and manipulation of the Earth System and invokes notions of hierarchical steering and expert management. According to Crutzen (2002) sustainable management in the Anthropocene: “will require appropriate human behaviour at all scales, and may well involve internationally accepted, large-scale geo-engineering projects, for instance to ‘optimize’ climate”. Among a wide range of propositions – dating back several decades and now being revived – are schemes for curbing global (tropospheric) warming through injecting dust (aerosols) into the stratosphere (see Crutzen 2006; Wiman 1995). In contrast to this managerial approach, "Governance first" offers political strategies for sustainable development that build on traditional government institutions such as the UNEP or a new established World Environment Organisation. This government programme portrays the hierarchical project of “earth system management” as politically infeasible and normatively undesirable (Biermann 2007). Earth System Governance is neither confined to states and governments as sole actors, nor to scientists as the only Earth System experts. As argued by Biermann (2007), it rather involves “a myriad of public and non-sate actors at all levels of decision-making, ranging from networks of experts, environmentalists and multinational corporations, to agencies set up by governments.”

Finally the "Ethics first" approach, stresses the need for a new ethical framework for global stewardship and strategies for Earth System management (cf. the Amsterdam Declaration[10]). The political heritage of Earth stewardship goes back at least to Immanuel Kant and his notion of *globus terraqueus* – i.e. the natural right of all human beings to a share of the Earth that supersedes the juridical division of the planet into separate sovereign states. As put by Dalby (2004), the Anthropocene requires a new ethics since “ecology at the largest scale, that of the biosphere, is the required backdrop for considerations of our interconnected fates”. Litfin (2005) has made a similar argument by proposing that we need to align human purposes with the "function of Gaia". Her vision of “Gaian democracies” oriented towards sustainability and

[9] The term "geoengineering" was perhaps used first by IIASA scientist Marchetti in 1971; see Wiman B.L.B. (2002) Climate Engineering. Concepts, Examples, and Risks. In: Yotova A. (ed) Natural Resources System Challenge: Climate Change, Humans Systems and Policy, in Encyclopedia of Life Support Systems, Eolss Publishers Co., Oxford, UK [http://www.eolss.net].
[10] http://www.essp.org/en/integrated-regional-studies/open-science-conferences/the-amsterdam-declaration.html

justice on global scales implies a clear break with important modern institutions such as the sovereign state and the revolutionary mentality of the sovereign individual. “Hierarchical structures of domination would give way to participatory networks, and symbiosis would displace competition as the defining modality in economic exchange” (Litfin 2005, p. 514). Hence, governmentalities currently underway in the Earth System discourse are ambiguous. The Anthropocene imagery, on the one hand, produces visions of expert-driven planetary monitoring, grand-scale technologies (geoengineering) and “global management” with a World Environment Organisation as coordinating institution. On the other hand, the complexity, risks and indeterminacy of “the coupled human and ecological system” also harbours a more deliberative, decentralised, heterogeneous language for exploring social and political organisation for sustainability.

The concept of governmentality does not tell us whether either of the current representations of the Earth System is true or better. Rather, it allows us to explore the “politics of truth”, i.e. how forms of knowledge and concepts contribute to the government of new domains of regulation and intervention (Lemke 2002). It draws attention to processes of governing that define both the objects (what should be governed) and the nature of government (how the objects should be governed). In that sense it helps us to initiate a debate on the “kind-making” (Miller 2007) of contemporary global change research and the role of science in the Anthropocene era.

References

Adler, Emanuel & Bernstein, Steven 2005. Knowledge in Power: The Epistemic Construction of Global Governance. In Barnett, Michael & Duvall, Raymond (eds.), *Power in Global Governance*. Cambridge: Cambridge University Press.

Beck, U. 1992. *Risk Society: Towards a New Modernity*. London: Sage Publications.

Bell, W., 2001. Futures studies comes of age: twenty-five years after “The Limits to Growth”. Futures 33, 63-76.

Bengtsson, L., 2006. Geo-engineering to confine climate change: is it at all possible? Climatic Change 77, 229-234.

Biermann, F. 2007. Earth System Governance as a Crosscutting Theme of Global Change Research, *Global Environmental Change* **17**, pp. 326-337.

Bodin, P. and Wiman, B.L.B., 2007. The usefulness of stability concepts in forest management when coping with increasing climate uncertainties. Forest Ecology and Management 242: 541-552.

Bulkeley H, Watson M, Hudson R, 2007, "Modes of governing municipal waste" *Environment and Planning A* **39**(11) 2733 – 2753.

Burchell, G., Gordon, C. & Miller, P. (eds.) 1991. *The Foucault Effect. Studies in Governmentality*. The University of Chicago Press.

Clark, W. C. & Dickson, N. M. 2003. Sustainability science. The emerging research program, *PNAS* **100**, pp. 8059-8061.

Clifford, N. & Richards, K. 2005. Earth system science: an oxymoron? *Earth Surface Processes and Landforms* **30,** pp. 379-383.

Colombo,U., 2001. The Club of Rome and ssutainable development. Futures 33:7-11.

Cosgrove, D., 2001. Appollo's Eye. A Cartographic Genealogy of the Earth in the Western Imagination. Baltimore: The Johns Hopkins University Press.

Crampton, J.W., and Elden, S. (2007). Space, knowledge and power : Foucault and geography. Aldershot, England ; Burlington, VT: Ashgate.

Crutzen, P.J., 2002. Geology of Mankind. Nature 415:23.

Crutzen, P.J. & Steffen, W. 2003. How Long Have We Been in the Anthropocene Era? *Climatic Change* **61,** pp. 251-257.

Crutzen, P.J., 2006. Albedo enhancements by stratospheric sulfur injections: a contribution to resolve a policy dilemma. Climatic Change 77: 211-219.

Dalby, S., 2004. Anthropocene ethics: rethinking ‘the political’ after environment. Paper presented at the International Studies Association (ISA) annual convention, Montreal, March 2004.

Dalby, S. 2007. Anthropocene Geopolitics: Globalisation, Empire, Environment and Critique. Geography Compass. 1(1): 103-118.

Darier, E. 1999. Foucault and the Environment: An Introduction. In Darier, E. (ed), *Discourses of the Environment.* Oxford & Malden: Blackwell Publishing.

Dean, M. 2004. *Governmentality. Power and Rule in Modern Society*. London, Thousand Oaks, CA, New Delhi: Sage Publications.

Dearing, J.A. (2007). Integration of World and Earth Systems: Heritage and Foresight. In Hornborg, A. & Crumley, C. (eds.), *The World System and the Earth System. Global Socioenvironmental Change and Sustainability since the Neolithic*. USA: Left Coast Press Inc.

Fisher, F., 2005. Citizens, Experts, and the Environment. Duke University Press, Durham, London.

Forrester, J.W., 1971. World Dynamics. Cambridge, Massachusetts: Wright-Allen Press Inc.

Foucault, M. 1991 in Burchell, G., Gordon, C., and Miller, P., (Eds). *The Foucault Effect: Studies in Governmentality*. London: Harvester Wheatsheaf.

Fraser, R. 1957. *Once Round the Sun. The Story of the International Geophysical Year 1957-1958.* London: Hodder & Stoughton.

Group on Earth Observations (GEO) 2007. The Full Picture. Report Published by Tudor Rose on behalf of GEO, Geneva, Switzerland.

Golley, F.B., 1993. Ecosystem Concept in Ecology – More than the Sum of the Parts. New Haven: Yale University Press.

Habermas, J.1998. Popular Sovereignty as Procedure. In Bohman, J. & Rehg, W. (eds.), *Deliberative Democracy. Essays on Reason and Politics.* Cambridge, London: The MIT Press.

Jessop, B. 2007. From Micro-Powers to Governmentality: Foucault's Work on Statehood, State Formation, Statecraft and State Power, *Political Geography* **26**, pp. 34-40.

Johnson, D.R., Ruzek, M. & Kalb, M. 1997. What is Earth System Science? Proceedings of the 1997 International Geoscience and Remote Sensing Symposium Singapore, August 4 - 8, 1997, pp 688 - 691.

Kates, R.W., Clark, W.C., Corell, R. Hall, J.M., Jaeger, C.C., Lowe, I., McCarthy, J.J., Schellnhuber, H.J, Bolin, B., Dickson, N.M., Faucheux, S., Gallopin, G.C., Grübler, A., Huntley, B., Jäger, J., Jodha, N.S., Kasperson, R. E., Mabogunje, A., Matson, p., Mooney, H., Moore III, B., O'Riordan, T. & Svedin, U. 2001. Sustainability Science. *Science* **292**, pp. 641-642.

King, R.L. & Birk, R. J. 2004. Developing Earth System Science Knowledge to Manage the Earth's Natural Resources, *Computing in Science & Engineering* **6:** 1, pp. 45-51.

Kingsland, S.E., 1995. Modelling Nature – Episodes in the History of Population Ecology. Chicago: The University Press of Chicago.

Kinzig, A.P. 2004. Group Report: Sustainability. In Schellnhuber, H.J., Crutzen, P.J., Clark, C.C., Claussen, M. & Held, H. (eds.), *Earth System Analysis for Sustainability.* Cambridge & London: The MIT Press.

Kotchen & Yong 2007…FIX

Lemke, T. 2002. Foucault, Governmentality and Critique. *Rethinking Marxism* **14:** 3, pp. 4964.

Leach, M., Scoones, I. & Wynne, B. (Eds.), 2007. Science and Citizens. Globalization and the Challenge of Engagement. Zed Books: London, New York.

Litfin, K., 2005. Gaia theory: intimations for global environmental politics. In: Dauvergne P. (Ed.) Handbook of Global Environmental Politics. Edvard Elgar, Northampton. MA.; pp. 502-517.

Lorenz, E.N., 1963. Deterministic non-periodic flow. Journal of Atmospheric Sciences 20: 130-141.

Lotka, A.J., [1924] 1956. Elements of Mathematical Biology [earlier published as: Lotka A.J., 1924. Elements of Physical Biology]. New York: Dover Publications Inc.

Lubchenko, J. 1998. Entering the Century of the Environment: A New Social Contract for Science, *Science* **279:5350,** pp 491-497.

MacKinnon, D. 2000. Managerialism, Governmentality and the State: A Neo-Foucauldian Approach to Local Economic Governance, *Political Geography* **19**, pp- 293-314.

Manabe, S., 1997. Early development in the study of greenhouse warming: the emergence of climate models. *Ambio* 26: 47-51.

Mason, J., Mathias, P. and Westcott, J.H. (Eds.), 1986. Predictability in Science and Society. The Royal Society and the British Academy.

Marsh G.P., 1874. The Earth as Modified by Human Action [a new edition of "Man and Nature"]. London: Sampson Low, Marston, Low, and Searle.

May, R.M.,1976. Simple mathematical models with very complicated dynamics. *Nature* 261: 459-467.

Meadows, D.H., Meadows, D.L., Randers, J., and Behrens, W.W., 1972. Limits to Growth. New York: Universe Books.

Merchant, C. 1983. *The Death of Nature. Women, Ecology and the Scientific Revolution.* Harper San Fransisco.

Miller, Clark A. 2007. Democratization, International Knowledge Institutions, and Global Governance, *Governance* **20**:2, pp. 325-357.

Odum, E.P., 1987. Global stress in life-support ecosystems mandates input management of production systems. The Crafoord Prize in the Biosciences 1987 – Crafoord Lectures; pp. 5-18. Stockholm: The Royal Swedish Academy of Sciences.

Odum H.T., 1987. Living with complexity. The Crafoord Prize in the Biosciences 1987 – Crafoord Lectures; pp. 19-85. Stockholm: The Royal Swedish Academy of Sciences.

Patten, B.C. (Ed.), 1971. Systems Analysis and Simulation in Ecology, Vol 1. New York: Academic Press.

Reith, G. 2004. Uncertain Times. The Notion of ‘Risk’ and the Development of Modernity, *Time & Society* **13:** 2/3, pp.283-402.

Rose, N. & Miller, P. 1992. Political Power beyond the State: Problematics of Government, *The British Journal of Sociology* **43:**2, pp. 173-205.

Samson, Paul R. & Pitt, David (eds.) 1999. *The Biosphere and Noosphere Reader. Global Enviornment, Society and Change.* London & New York: Routledge.

Sarewitz, D. 2000. Human Well-Being and Federal Science. What’s the Connection? In Kleinmann, D.L. (ed)., *Science, Technology and Democracy.* Albany: State University of New York Press.

Schellnhuber, Hans Joachim 1999. ‘Earth system’ analysis and the second Copernican revolution, *Nature* **402,** pp C19-C23.

Schellnhuber, Hans Joachim, Crutzen, Paul J., Clark, William, C. & Hunt, Julian 2005. Earth system analysis for sustainability, *Environment* **47**, pp 11-25.

Shugart, H.H. and O’Neill, R.V. (Eds.), 1979. Systems Ecology. Stroudsburg, Pennsylvania: Dowden, Hutchinson & Ross, Inc.

SMIC, 1971. Inadvertent Climate Modification. Report of the Study of Man’s Impact on Climate (SMIC). Cambridge, Massachusetts: The MIT Press.

Steffen, Will & Tyson, Peter 2001. Global change and the Earth System: A planet under pressure, *IGBP Science* **4.**

Steffen,W., Sanderson, A., Tyson, P.D., Jäger, J., Matson, P.A., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.J., Turner II, B.L and Wasson, R.J. 2004. *Global Change and the Earth System. A Planet under Pressure.* Berlin, Heidelberg, New York: Springer-Verlag.

Stephen, L. 2005. Foucault's population geographies: classifications, biopolitics and governmental spaces. Population, Space and Place. 11(3): 137-156.

United Nations (UN) 1992. *Agenda 21*. Chapter 35:2 Science for Sustainable Development.

Vernadsky, V. I., 1945. The biosphere and the noosphere. American Scientist 33 (1): 1-12.

Volterra, V., 1926. Variazioni e fluttuazioni del numero d´índividui in specie animali conviventi. Memorie della R. Accademia Nazionale dei Lincei 2:31-113. [Translation in Chapman, R.N., 1931. Animal Ecology, pp. 409-448. New York: McGraw-Hill.]

Walker, J.C.G. 1999. Earth System Science and the Western Worldview, *Chemical Geology* **161**, pp. 365-371.

WCED, 1987. Our Common Future. The World Commission on Environment and Development (WCED), p.1. Oxford: Oxford University Press.

Wiener, N., 1998. The history and pre-history of cybernetics. Kybernetes 27: 26-37.

Wiman B.L.B. (1995) Metaphors, analogies, and models in communicating climate-change uncertainties and economics to policy: a note on a pre-UNCED U.S. case. *Ecological Economics* 15, 21-28.

Wiman, B.L.B., 1991. Implications of environmental complexity for science and policy. Global Environmental Change 1: 235-247.