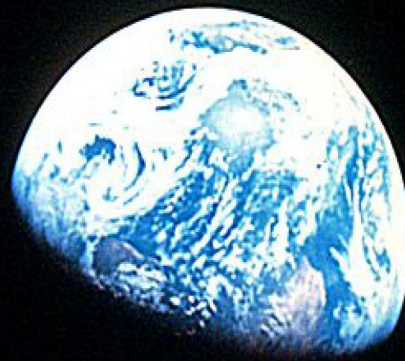


Gaia & Earth System Science

Scientific, historical & philosophical perspectives

24 & 25 March 2016



Donato Bergandi
Laurent Bopp
Sébastien Dutreuil
Jean Gayon
James Kasting
Chunglin Kwa

Catherine Larrère
Bruno Latour
Timothy Lenton
Giulia Rispoli
Ola Uhrqvist
Andrew Watson
Rasmus Grønfeldt Winther

Location:
Institut de Physique du Globe de Paris (IPGP)
Amphitheatre
1 rue Jussieu, 75005 Paris



IH Φ ST GDR SAPIENV

UNIVERSITÉ PARIS 1
PANTHÉON SORBONNE

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Detailed program: <http://bit.ly/1RhAIo6>



web

Gaia and Earth System Science: scientific, historical and philosophical perspectives

IHPST - Université Paris 1 Panthéon-Sorbonne - IPGP - GDR SAPIENV
Organizers: Philippe Huneman (philippe.huneman@gmail.com) and Sébastien Dutreuil (seb.dutreuil@gmail.com)

Location: Institut de Physique du Globe de Paris, 1 rue Jussieu, 75005 Paris, Amphithéâtre.

Thursday, March 24th

13h30 – Welcome of participants

13h45 – General introduction – Philippe Huneman (IHPST) & Sébastien Dutreuil (Université Paris 1, IHPST)

14h00-14h50 – James Kasting (Penn State University) – Long-term stability of Earth's climate

14h50-15h40 – Andrew Watson (University of Exeter) – My voyage round Gaia

Break

16h00-16h50 – Timothy Lenton (University of Exeter) – The evolution of Gaia – and of scientific thinking about the Earth system

16h50-17h40 – Donato Bergandi (MNHN)- The Gaian paradox between ontology, methodology and ethics

Break

18h00 – Bruno Latour (Sciences Po)– Lovelock and Darwin, in which way can Gaia escape being one organism?

Friday, March 25th

9h00 – Welcome of participants

9h10-10h00 – Rasmus Grønfeldt Winther (University of California, Santa Cruz) – Lovelock, Wegener, and maps in scientific controversies

10h00-10h50 – Sébastien Dutreuil (Université Paris 1, IHPST) – Genealogy of Earth System Science: history of the Earth, geochemistry and Gaia

break

11h10-12h00 – Giulia Rispoli (MNHN) – Pre-gaian thinkers: Vladimir I. Vernadskij and the foundation of *Biospheries*

Lunch

14h-14h50 – Ola Uhrqvist (University of Linköping) – Predicting GAIA - a history of the efforts to build one model to fit all.

14h50-15h40 – Laurent Bopp (LSCE) – On the use of Earth System Models in the last IPCC assessment report

break

16h00 – 16h50 – Chunglin Kwa (University of Amsterdam) - The changing logic of Big Science programs in ecology: From IBP to IGBP and how Gaia got lost on the way

16h50 – Catherine Larrère (Université Paris 1) – Gaia ethics : is anthropocentrism back?

break

General discussion – Chair : Jean Gayon (Université Paris 1, IHPST)

Contact: seb.dutreuil@gmail.com

ABSTRACTS OF THE CONFERENCES

Long-term Stability of Earth's Climate

James F. Kasting, Penn State University
(Thursday, March, 24th, 14h00)

Jim Lovelock proposed his Gaia Hypothesis at least partly as a solution to the faint young Sun problem. The Sun has brightened by about 40 percent over its history, relative to its initial luminosity, as a consequence of conversion of hydrogen to helium in its core. To keep Earth's climate within habitable limits, that increase must have been offset by opposing factors, most likely by decreases in greenhouse gas concentrations. Lovelock suggested that atmospheric CO₂ levels were drawn down by photosynthesis at just the right rate to compensate for the solar luminosity increase. More likely, CO₂ was drawn down by silicate weathering followed by deposition of carbonates, as part of the inorganic carbon cycle. The strong dependence of continental weathering on surface temperature creates a negative feedback loop that helps to stabilize Earth's climate over long time scales. Lovelock eventually accepted this assessment, although he argued, with some merit, that this process was also influenced by the biota.

Earth's climate history is too complex, however, to be explained by just one feedback loop or by a single geochemical cycle. Snowball glaciations at the beginning and end of the Proterozoic, around 2.4 Ga and 0.6-0.7 Ga, are thought to be approximately coeval with two separate increases in atmospheric O₂. This temporal correlation is most readily explained if CH₄ was also an important contributor to the Precambrian atmospheric greenhouse, because when O₂ levels went up, CH₄ concentrations could be expected to go down. CH₄ concentrations of 1000 ppmv or more during the Archean are consistent with evidence suggesting that methanogenic bacteria evolved early and with photochemical model calculations which show that methane would have been long-lived in a low-O₂ atmosphere. CH₄ could have remained at reasonably high levels (50-100 ppmv) during the Proterozoic if primary marine productivity was high and if dissolved O₂ and sulfate concentrations in the deep ocean were relatively low, as expected. Because CH₄ in Earth's atmosphere is almost entirely biogenic, this suggests that 'Gaia' may have played an even more active role in regulating Earth's climate during the Precambrian than she does today. Major questions still remain, however, especially about how the control system operated during the 'Boring Billion' years of the mid-Proterozoic.

My voyage round Gaia

Andrew Watson, University of Exeter
(Thursday, March, 24th, 14h50)

I was a PhD student with James Lovelock from 1975 to 1978, and worked with him extensively up until the late 80s. I started out a firm believer in the "strong" version of Gaia having regulated the Earth environment through time, and worked with him (on Daisyworld for instance) to answer to those critics who objected that there was no mechanism for that regulation. However, my view diverged from this version of Gaia through the 80s and 90s. As we learned more about the history of the Earth, it became apparent that it was far from perfectly regulated, and that, while living processes sometimes stabilized the environment, at other times they did the opposite.

My present view is that the longevity of life on Earth owes a fair share to good luck, but that only on such a lucky planet can complex organisms such as ourselves evolve: the extraordinary planet we see is conditioned through "anthropic bias". Though this is very different to the original idea of Gaia, in formulating that idea, Lovelock was the first modern scientist to popularize a "systems" view of the planet. That view remains essential to understanding how the Earth environment and life have interacted and shaped Earth history.

The evolution of Gaia – and of scientific thinking about the Earth system

Timothy Lenton, University of Exeter

(Thursday, March, 24th, 16h00) The Gaia hypothesis was a natural outgrowth of the 1960s space programme and of Jim Lovelock's extraordinary scientific imagination. The proposition that Gaia possesses self-regulation seemed to demand an evolutionary explanation and was deeply provocative for neo-Darwinians – although as Doolittle has recently shown, populations of one can evolve. Over in the Earth sciences, Gaia drew a more muted reaction – several prominent figures argued it was unnecessary to invoke life to explain Earth's continuous habitability – whilst missing the biogeochemical point that life makes this a much more fecund planet by recycling all the materials it needs. The general tenor of argument in the Earth sciences was and still is that life creates both positive and negative feedbacks on its environment with no clear propensity for stability – so only the weak anthropic principle can help us explain our existence and any planetary self-regulation that supports it. In this view the Earth cannot have 'evolved' in any Darwinian sense, yet it was still widely recognised that (shall we call it) the developmental trajectory of our planet, is a stunning anomaly in contrast to its neighbours. Thinking about that historical development, has forced much 'Earth system' thinking as it has come into sharper focus. I will review how our understanding of Earth system history has developed, especially over the last 25 years that I have been scientifically active – and how emerging understanding might inadvertently (for many Earth system scientists) be leading us back to the Gaia hypothesis.

The Gaian paradox between ontology, methodology and ethics

Donato Bergandi, MNHN

(Thursday, March, 24th, 16h50)

The Gaia hypothesis is expression of an organicist metaphor, while the emergentist terminology used is incongruent with the underlying physicalist cybernetics. More generally, the reduction of the Gaia's properties to the laws of physical chemistry render purely formal any assertion about the emergentist and holistic nature of the global ecological systems studied.

Lovelock and Darwin, in which way can Gaia escape being one organism?

Bruno Latour, Sciences Po

(Thursday, March, 24th, 18h00)

Biology and politics have always been permeable to one another trading metaphors back and forth. This is nowhere more blatant than when people claim to talk about "the planet" as a whole. James Lovelock's concept of Gaia has often been interpreted as a God-Like figure. By reviewing in some details a critical assessment of Lovelock's Gaia by one scientist, Toby Tyrrell, the paper tries to map out why it is so difficult for natural as well as social scientists not to confuse Gaia with some sort of Providence.

Lovelock, Wegener, and maps in scientific controversies

Rasmus Winther, University of California, Santa Cruz

(Friday, March, 25th, 9h10)

Famously, Wegener wrote that his first inkling of continental drift occurred to him as he studied a map of the world and noticed "congruences" of the African and South American coasts. Furthermore, mapmaking visualizations pervade his classic text *The Origin of Continents and Oceans*. His arguments for continental drift theory, including isostasy, paleontological data, polar wandering, mountain range and earthquake distributions across the globe, are all secured with detailed maps. Unfortunately, the multidimensional role of cartographic reason here has been downplayed. Wegener's maps are not merely "words or pictures" (Oreskes 1999, 275).

In his classic *Gaia*, Lovelock has a literal map of the continental shelves, which are regions critical for carbon and oxygen cycles. More importantly, he relies on maps metaphorically. That Gaia functions physiologically to stabilize a complex system is a "map or circuit diagram" we can deploy. Moreover, as later captured in Tom Van Sant's iconic composite image or map of the Earth, Gaia's inspiring, holistic "fair face" has been observed by astronaut eyes and orbiting cameras. Gaia thus became self-aware, Lovelock asserts.

Cartographic reason—and maps from literal to analogical—play key epistemic and praxis roles in the Earth Sciences. This is so both for the investigation of the inner anatomy of the Earth (Wegener), and of the chemically active and far-from-equilibrium outer biosphere layers (Lovelock). Analyzing how maps structure

data, channel theory, help formulate bold hypotheses, and launch trenchant analogies and metaphors helps illuminate the logic of the Earth Sciences, and of scientific practices more broadly.

Genealogy of Earth System Science(s): history of the Earth, geochemistry, Gaia

Sébastien Dutreuil, Université Paris 1 Panthéon-Sorbonne, IHPST

(Friday, March, 25th, 10h00)

“Earth System Science” (ESS) is a label which spread rapidly after its introduction in the 1980’s institutional effervescence calling for an entirely new Earth science studying the “global changes” affecting the “Earth system”. The most visible outcome of this effervescence was the initiation of the International Geosphere-Biosphere Program (IGBP) in the late 1980’s, promoting a particular style of scientific research on the Earth system made of modelling and the gathering of massive amount of environmental data to predict global changes in a near future.

Yet, as I will show in the first part of my talk, this contemporary “theory of the Earth”, this “physical approach” of the Earth system, can be contrasted with other versions of ESS which developed outside the IGBP. These versions were more interested in Earth’s history and some were closer to what Rudwick (2005) has called “geohistory”.

In the second part I will argue that an important but overall neglected root of ESSs lies in geochemistry and the study of the chemical history and changes of Earth’s surface. “Global changes”, the stability and history of the Earth are obviously central issues for ESS. I will show that, contrary to what is the case of climate, life and sea-level variation, the idea that the chemistry of Earth’s atmosphere and oceans have a history which can be deciphered emerged only recently, in the mid-20th century. I will pinpoint to two approaches developed in the 1960’s and 1970’s to tackle this question: one historical, another more systemic.

Then I will argue that the Gaia hypothesis, or the research program proposed by Gaia, should be understood as a contribution bringing life on stage of these studies of Earth’s history. I will conclude on the implications of these historical arguments on our understanding of contemporary ESSs and of the concept of “Anthropocene”.

Pre-gaian thinkers: Vladimir I. Vernadskij and the foundation of *Biospherics*

Giulia Rispoli, MNHN

(Friday, march, 25th, 11h10)

The development of a science of the biosphere in Russia is largely the result of a prominent intellectual tradition characterized by unique conceptions of the Earth, space and boundaries. Arguing that this tradition made possible the development of a distinctive systemic approach to ecology and energetics, this paper introduces the work of Vladimir I. Vernadskij (1863-1945), a leading Russian mineralogist considered one of the most innovative pre-gaian thinkers.

Vernadskij is renowned for giving birth at the turn of the 20th century to a new discipline called biogeochemistry. He claimed that the Earth's surface is continuously shaped by the interaction between biological organisms and abiotic components that he identified with the concept of “living matter”. Most importantly, Vernadskij developed a whole comprehension of the biosphere as an integrated system and proposed the idea of the transaction between the biosphere and the *noosphere* – a new evolutionary stage of the Earth that is dominated by human science and technology – long before the theory of the Anthropocene appeared in the 1980s.

In this paper, Vernadskij's work is described as an embryonic, insightful attempt to introduce a cybernetic perspective into the interpretation of the Earth as a self-organizing system. Moreover, placing his research in the framework of the 20th century global ecology, the paper brings into focus the double role of Vernadskij as one of the most interesting exponents of Russian studies on biospherics, and, at the same time, as a persona of international influence, whose work and ideas inspired the whole-earth conception as well as global ecotechnic endeavors during the second half of the 20th.

Predicting GAIA - a history of the efforts to build one model to fit all.

Ola Uhrqvist, University of Linköping

(Friday, March, 25th, 14h)

In the early 1980s research about changes in the global environment went into a new phase where international research programmes embarked on an effort to understand the functioning and future of the co-evolving geosphere, biosphere and atmosphere. A parallel programme engaged with the human dimensions. Found at the heart of the efforts to understand and predict Global environmental change was the use of simulation models to make the different research communities to speak with the same lexicon, if not the same language. This presentation discusses how the efforts to build a “model to fit all” changed the problematizations of the Earth System ontology as well as the rationality for how to design research programmes able to provide knowledge useful to govern in times of global change. Programme publications and newsletters from the International Geosphere-Biosphere Programme and the International Human Dimensions Programme on Global Environmental Change provide an empirical foundation for a discussion about the ideas that guided the arrangement of a research network around the Earth system as a governable object. The results suggest that the practices of simulation modelling has played an important role in increasing the level of complexity ascribed to the Earth system, which in turn has challenged the early hopes for a global environment possible to control and optimise.

On the use of Earth System Models in the last IPCC assessment report

Laurent Bopp, LSCE/IPSL, Gif-sur-Yvette

(Friday, March, 25th, 14h50)

From its inception in 1990, the Intergovernmental Panel on Climate Change relied heavily on the use of climate models in its assessment reports, especially in the chapters on climate projections. The essential part of these climate models corresponds to a coupling of an atmosphere and an ocean general circulation models, thus mostly representing the physical components of the Earth System. Over the last past years, there has been an evolution towards more complex models with for instance interactive chemistry and more explicit biology, to be able to address more complex feedbacks between the different components of the Earth System. One key example is the carbon-climate feedback that necessitates the use of coupled climate and carbon cycle models, and hence a representation of key carbon cycle processes in the ocean and on land. In its last report, the IPCC defines “Earth System Models” as “coupled atmosphere-ocean general circulation models in which a representation of the carbon cycle is included”, and adds that “additional components (e.g., atmospheric chemistry, ice sheets, dynamic vegetation...) may be included”.

In this talk, I will review the history of the usage of climate models / earth system models in IPCC assessment reports. I will in particular focus on the last report, and show how Earth System Models are being used to address the primary issue of feedbacks between the physical climate system and biogeochemical cycles. In addition, I will also show that their use is now being extended to other climate-change related issues, such as geo-engineering and climate impacts.

The changing logic of Big Science programs in ecology: From IBP to IGBP and how Gaia got lost on the way

Chunglin Kwa, University of Amsterdam

(Friday, March, 25th, 16h00)

Ecology's first Big Science programme, the International Biological Program (IBP), ended in 1974 (most of the world) and in 1976 (in the US). The second Big Science programme in which ecology participated started planning in 1986. The period in-between saw the recognition of the importance of global warming and resulted in the shaping of the International Geosphere-Biosphere Programme (IGBP), a program in which ecology played second fiddle. In this paper I want to show that the policy orientation of the IGBP was the outcome of a long and chaotic selection process in which NASA, the US space agency, made most of the choices. A much more Gaia-like approach was considered among several more which did not make it in the end. This paper resurrects the choices not made, against a description of the main thrust of both the IBP and the IGBP.

The period 1965-1980 was marked by a belief among government leaders and officials that science could be shaped and guided by public policy. The U.S. Congress approved the IBP after hearings in 1967 on the “adequacy of technology for pollution abatement.” The US-IBP attempted to elucidate the structure of ecosystems through comprehensive computer models, conceived as physical analogies of ecosystems.

The IBP was a monodisciplinary Big Science ecology program of short duration (1968–1974). At the end of the IBP, only two biome projects were able to complete a comprehensive model, and only one of these had remained true to original mission of the IBP: the grassland biome model (developed at Colorado State University). The model’s (failed) attempt was to specify the conditions for the ecosystem to maintain stability through the mechanical correction of overshooting.

The IGBP was an interdisciplinary program, investigating global climatic change. It became operational in 1990 and lasted until December 2015. Ecology was only one of many participating disciplines. While the ecology program within the IGBP for most of its duration had a sort of standing of its own, it could not (and did not) set itself apart from the larger logic of the IGBP, which was to contribute data of what ultimately would be a physical model of planet earth.

The data orientation of the IGBP had an impact on the research style of ecologists. They were asked: are the observations and outcomes of the field observations generalizable beyond the local features of the ecosystem which they happen to study? The larger context of climate change research makes the basis for this question obvious, and scaling-up of the investigations was a requirement from which no ecologist in the IGBP could escape. In principle, two sorts of generalizations can be made: one from (published) case studies, the other directly from the data assembled for the case studies. The first, while indirect, would leave intact the original context of the data. The data revolution, however, invites the second type of generalization.

Gaia ethics : is anthropocentrism back?

Catherine Larrère (Université Paris 1 Panthéon-Sorbonne)

(Friday, March, 25th, 16h50)

With the globalization of the environmental question and of the environmental sciences, environmental ethics, as well, has been globalized, and, with it, there is no longer any reason to oppose naturalism and humanism : human beings as well as non human ones are threatened by climate change, and must be the objects of moral concern. But if anthropocentrism is back, what kind of anthropocentrism is it? We will rely on Baird Callicott's distinction between moral and metaphysical anthropocentrism first to assess global ethics, and then to stress the importance of locality and diversity.

Localisation : 1 rue Jussieu, 75005 Paris.

IPGP, amphitheatre.

