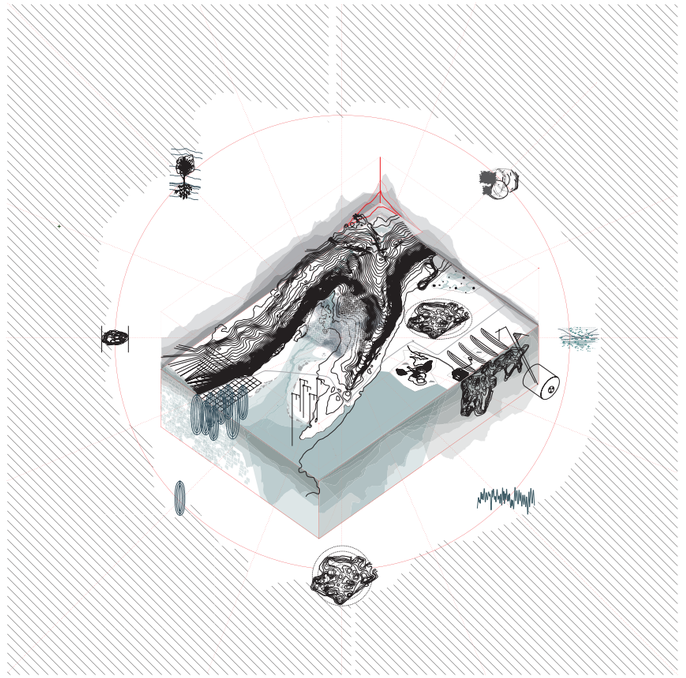
If the Earth is not a Globe, How to Sketch it?

ALEXANDRA ARÈNES & BRUNO LATOUR

The Gaia hypothesis was first developed by the chemist James Lovelock in collaboration with the microbiologist Lynn Margulis in the seventies. Named after the goddess who personified Earth in Greek mythology, the hypothesis proposes that the living interacts with their inorganic surroundings, forming a self-regulating complex system that sets the conditions for life on our planet. Philosopher Bruno Latour has been exploring Gaia for the past several years, giving this complex term a new and critical definition. For him, 'Gaia' as a prefix focuses on the uniqueness of the situation at hand, something that 'geo' seems to downplay.[1] Joining forces with the landscape architect and founder of the Société d'Objets Cartographiques, Alexandra Arènes, the two have set out to create a new map of the globe, starting from the Critical Zone and moving towards representations of events rather than sites. This is a behind the scenes exploration of Arènes and Latour's first-hand experience of Gaiagraphy in a Critical Zone in France.



Watershed equipped with different instruments of each discipline (geochemistry, geomorphology, soils sciences, geophysics, ecology, hydrology)

We started from a simple question: visions of the planet that have been kidnapped by the 'blue marble.' Every time anyone tries to talk about an ecological question, the blue planet comes in. It would not be a problem if this global vision was not so dramatically wrong. We don't live on a globe. No one does. The blue planet is actually a projection made on the older globes invented by cartographers from the 16th century onward to give an outside view, a God like view, of the Earth. But no one lives in this outer space. The view from nowhere, is exactly that, 'nowhere.' So, the paradox is that neither scientists nor citizens have a realistic view of how the Earth is actually spread, nor where humans fit in it. The global view is especially ill adjusted to any representation of Gaia.

Thus, we decided to come up with a better representation. For this, we got in touch with an emerging community of scientists working in "Critical Zone Observatories" (CZO) around the world. These observatories are well instrumented sites (most of the time watersheds) covering a vast diversity of geological, ecological, and land use situations as well as monitoring the Critical Zone. The Critical Zone (CZ) is defined by scientists as the thin veneer at the surface of the planet. This is the zone between the 'rocks and the sky' on which all human activities concentrate. The CZ is not a scientific concept, but rather an appeal from many different, previously disparate, disciplines to concentrate their collective attention on the same zone 'in an interdisciplinary¬–holistic–way.' This zone is 'critical' in the many meanings of the word because it is one of the main interfaces of the planet, still poorly known and also fragile, given the impacts humans have had on it. To our great surprise, we discovered that no matter how many scientific papers they were writing about the dynamics of these Critical Zones, they had no shared visualization to present their work to one another. They too were clamoring for a new representation of the zones that they were trying to describe. Thus, we decided to push them further and see what other visions of the Earth could be offered. What follows is a description of some of the steps taken to shift away from the globe and toward the Critical Zone and more specifically to CZOs.

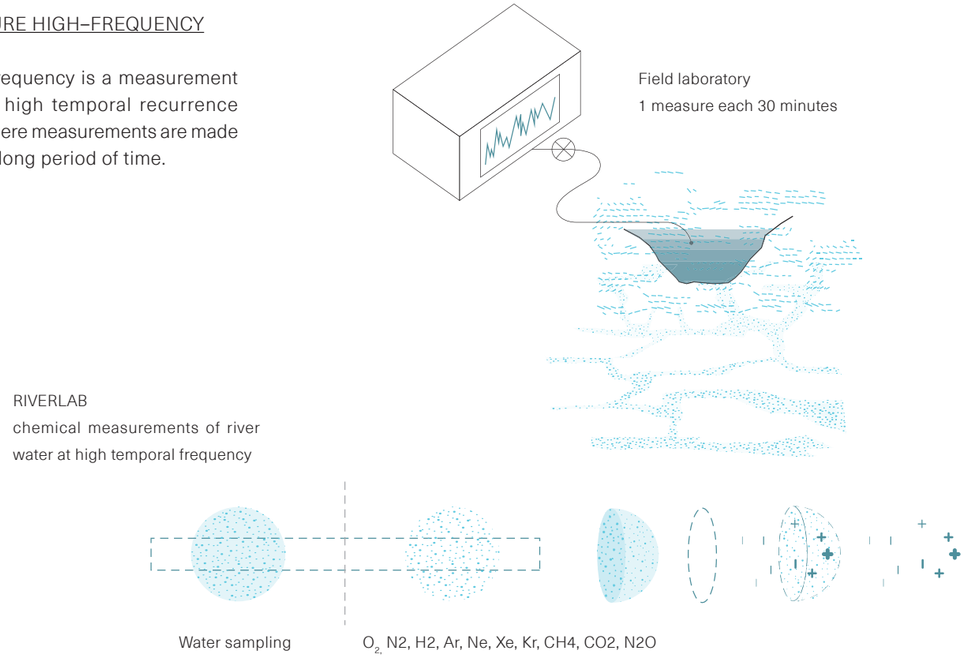
ORGEVAL OBSERVATORY OF THE CRITICAL ZONE, ILE-DE-FRANCE, AGRICULTURAL PLATEAU, MONOTONOUS LANDSCAPE

With our feet in the mud (the most terrestrial sediment of all), we followed a Chinese delegation that came to visit the RiverLab technology. When we got there, there was almost nothing. A green container is installed near a small stream. The interior houses a fully equipped mini-laboratory: computers, measuring tubes, refrigerator, etc. Of course, we do not understand what it is used for or how it works. Scientists present the RiverLab in very technical terms. We

1 Latour, Bruno and Timothy M. Lenton. "Extending the Domain of Freedom, or Why Gaia is So Hard to Understand." 2018. Available at: https://criticalinquiry.uchicago.edu/extending_the_domain_of_freedom/

CAPTURE HIGH–FREQUENCY

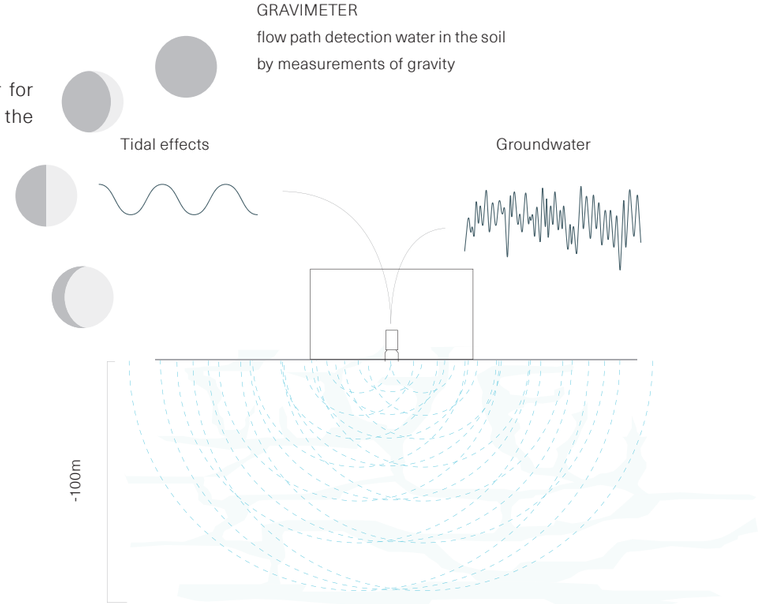
High frequency is a measurement with a high temporal recurrence and where measurements are made over a long period of time.



RiverLab operation (high-frequency multi-chemical analysis of stream water)

WATER PULSATION IN THE CRITICAL ZONE

Water is the preferred vector for flow and energy transfers in the critical zone.



Gravimeter operation

gradually understood that they are measuring the chemical composition of the nearby small river every thirty minutes, which is a challenge and a major breakthrough for understanding chemical exchanges in the Critical Zone. Indeed, these measures allow them to understand, and consequently forecast, the hydraulic regime of the Seine (whose 100-years flood is approaching!). We begin to understand that the Critical Zone is saturated with water, like a sponge that swells, charges, and discharges according to climatic variations. One of us is struck by the precision with which scientists feature the behaviour of the river. They do not use descriptive morphological terms, as can be used in landscape architecture, but they bring the river to life through the use of physiological terms.

First disorientation/change of scenery. At night, the river does not have the same chemical composition as during the day. More ions, less cations (or vice versa). The same phenomena occur in the event of flooding or seasonal change: these events are reflected by the tiny particles that are transported by the river and observed by scientists who are now able to discern them. The RiverLab is a kind of temporal microscope. Scientists capture the movement of a component, such as nitrate leached from the ground, through the ripples appearing on the screens. They can therefore, element by element, reconstruct the composition of the river under scrutiny. Scientists collect data, submit results to colleagues, try to decipher the pathway of the elements in the watershed and their temporalities, and develop the basic techniques to establish their observations. However, their work is not simply data gathering as they must constantly speculate on the composition of agents whose actions terraform the observatory's landscape in one way or another. The Orgeval is a typical multi-layered aquifer system managed by agricultural practices for centuries.

Recently, our contact from the CZO and the scientific mentor of our inquiry, Jérôme Gaillardet, sent us a quote from Alexander von Humboldt, the famous explorer-scientist- botanist-geologist: “every corner of the globe is a reflection of the whole Nature.” This could be translated into: “every observatory of the Critical Zone is a reflection of Gaia.”

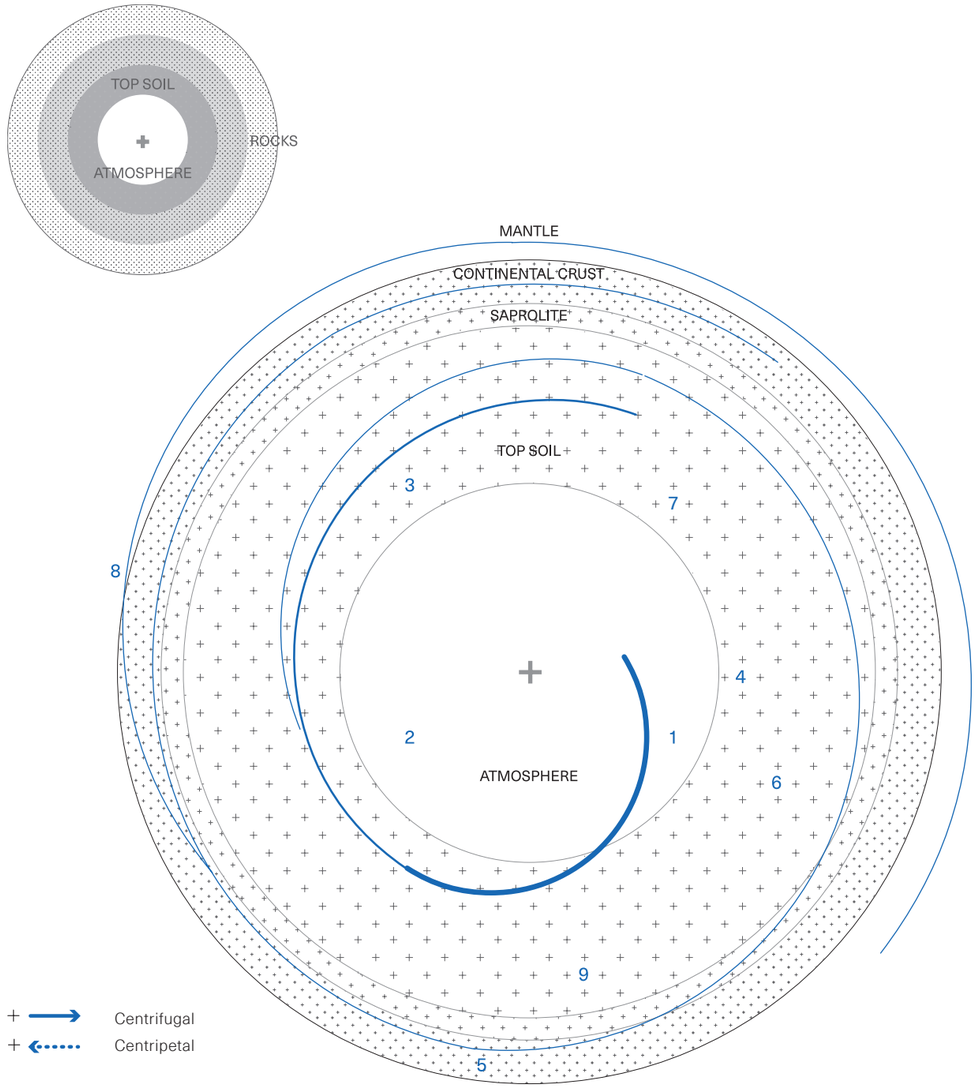
STRENGBACH OBSERVATORY OF THE CRITICAL ZONE, ALSACE, EASTERN FRANCE

It is the beginning of March. We arrive late at night in the heart of the snow-covered Vosges forest. This time, we make up a small delegation: a philosopher accompanied by a journalist who follows him with two other photographers, an American scientist visiting France, Jérôme, and one of his postdoctoral students. We are greeted by the team of geochemists on site, Marie-Claire Pierret and her colleagues who are in charge of this CZO, the mayor, and a small group of residents. The observatory has been operational for thirty years, a time long enough to allow scientists to create close links with area residents. Everyone is worried about their forest. The next day, we wear boots, warm clothes, and backpacks to visit the mountain’s instrumented watershed. We stop at each surveillance point. In these woods, trees perish. The cause: acid rain that washes away the good nutrients from the soil. Without them, the roots can no longer feed. Anthropogenic forcing—the acidity comes from industrial pollutants released into the atmosphere—is recorded by geochemical traces measured in the river.

Second disorientation/change of scenery. Human actions appear as future geo-fossils that disrupt geochemical cycles across all layers of the Critical Zone. The effects of the Anthropocene are materialized by particles barely visible to the naked eye. We finally arrive at the last instrument, on the upper part of the catchment area. The gravimeter measures the mass fluctuations of the ground. These variations are extremely small, and the measure is alone a challenge. The variations of the mass, once corrected from a number of influences, is a measure of groundwater fluctuations, i.e. the water that occupies the pores of the Critical Zone below our feet. Water is a vital resource. However, once again, scientists are not only focusing the conversation on resources. They also want to share with us some hidden dimensions of the Earth that are revealed to them through their instruments and meticulous observations, sometimes almost in an intimate way. Indeed, they are often alone in the middle of the fieldwork, itself in the middle of nowhere! Through their instruments, they acquire an intimate relationship with the landscape—and might offer us a new understanding of nature They care so much about their instruments for this reason: their tools allow them access to the world. This relationship is important, it has in a way guided the design of the model that we will describe below, a tension between microcosm and macrocosm. But let's go back to the moment of the field. Inside a very small shelter where we try to warm up (we have been walking outside for several hours and some of us are not properly equipped for the cold), the screen connected to the gravimeter in the middle of the room displays new undulations, widening, then narrowing. Some of them reflect the water under our feet. Others–third disorientation/change of scenery–are the echoes of the tidal waves that break on the coast hundreds of kilometres from the Vosges forest. The gravimeter is so sensitive and the tidal phenomenon so strong that we are transported in an instant to the ocean shore.

Our eyes shine. The scientists, despite being used to this given the time they have spent looking at these screens, also beam. The next evening, we transport ourselves to the theater in Strasbourg where we replay the Critical Zone, through the performance-lecture “Inside.” The scientists came to see and listen. Their eyes continue to sparkle.

The story that leads to what we call “Gaiagraphy” is not a linear story. There are, of course, significant events on the ground, in observatories, which allow us to enter, sometimes literally, into the instruments and phenomena they report. But discussions with a small group of scientists, in the building of the “Institut de Physique du Globe de Paris” (IPGP) where the Critical Zone has its urban districts, are just as useful to propose a visualization of the Critical Zone. Thus, at the IPGP: the fourth disorientation/change of scenery. Some scientists



1. photosynthesis
2. respiration
3. humidification
4. oxydation
5. C organic or inorganic export
6. oxydation or metamorphism
7. human emissions (fossil energies and cement)
8. subduction
9. volcanism and plutonism

The carbon cycle, taken as an example of cycle. The short-term carbon cycle created by photosynthesis and respiration processes is characterized by bigger fluxes that the subduction of carbon in the mantle. Note the importance of the anthropogenic flux associated with fossil fuels: from deep layers to the atmosphere, rapid injection, and big flux compared to the geological flux of carbon burial.

Fig. 1

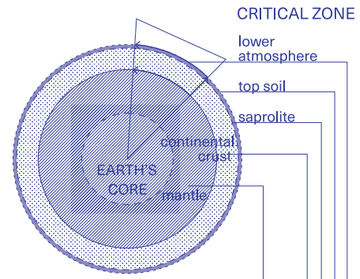
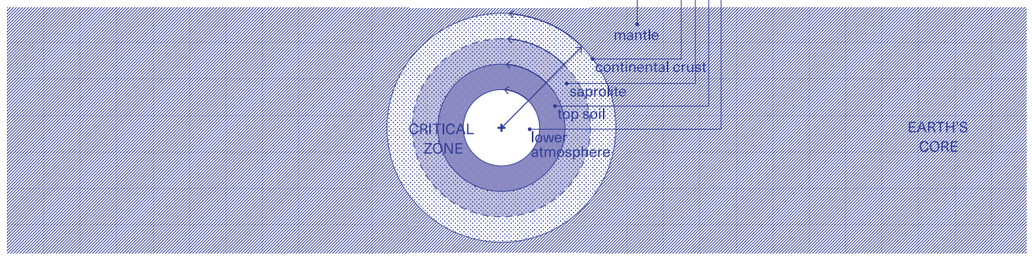
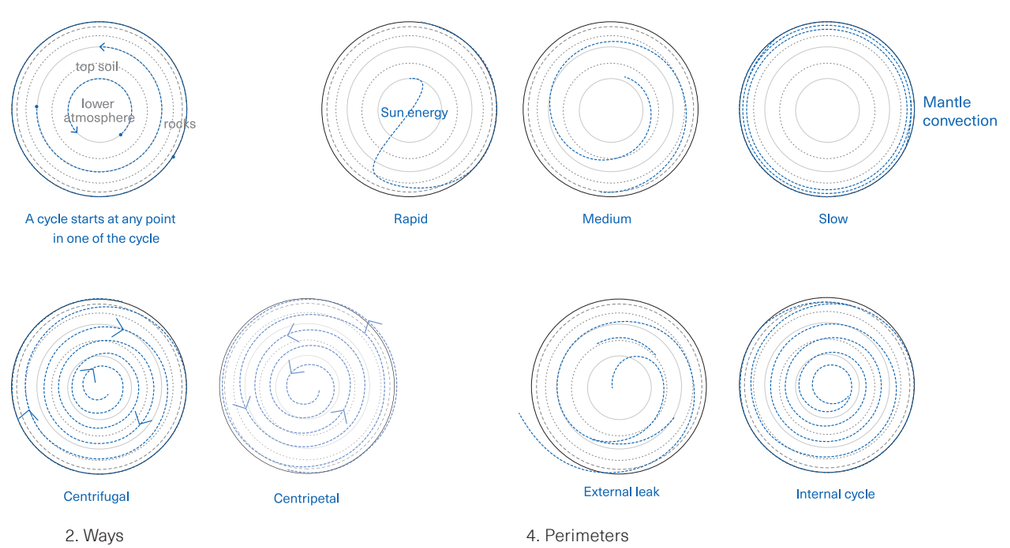


Fig. 2

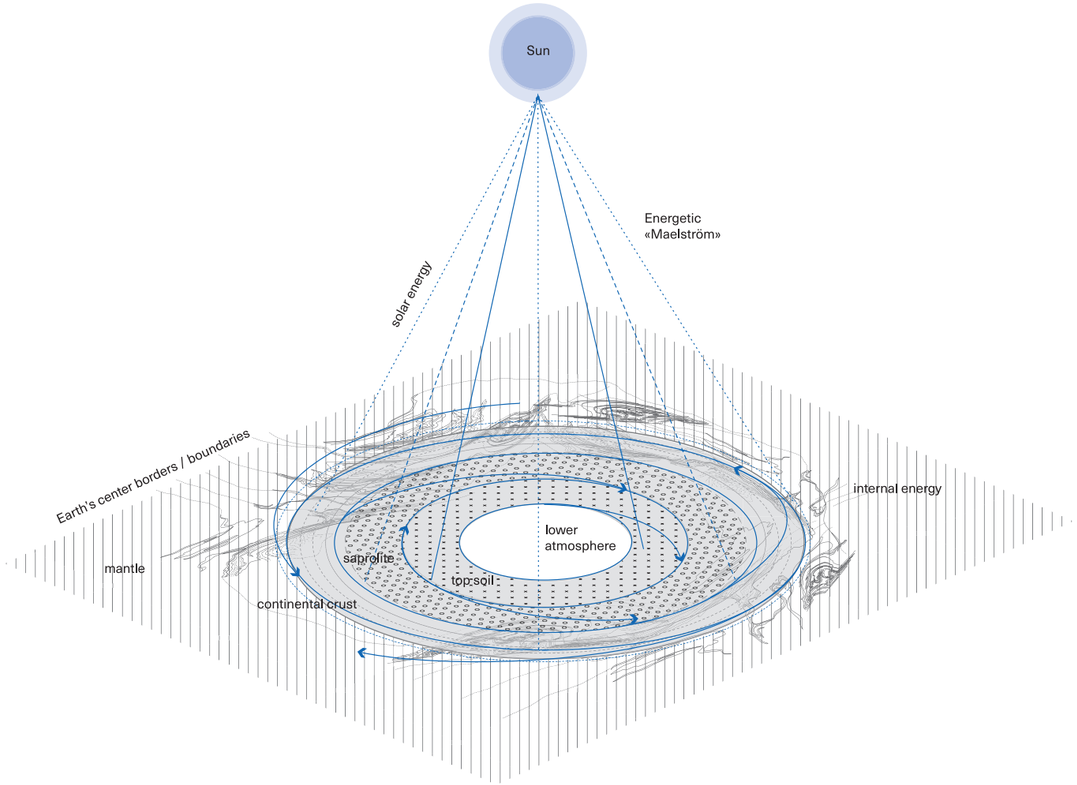


+ reference point (any observatory)

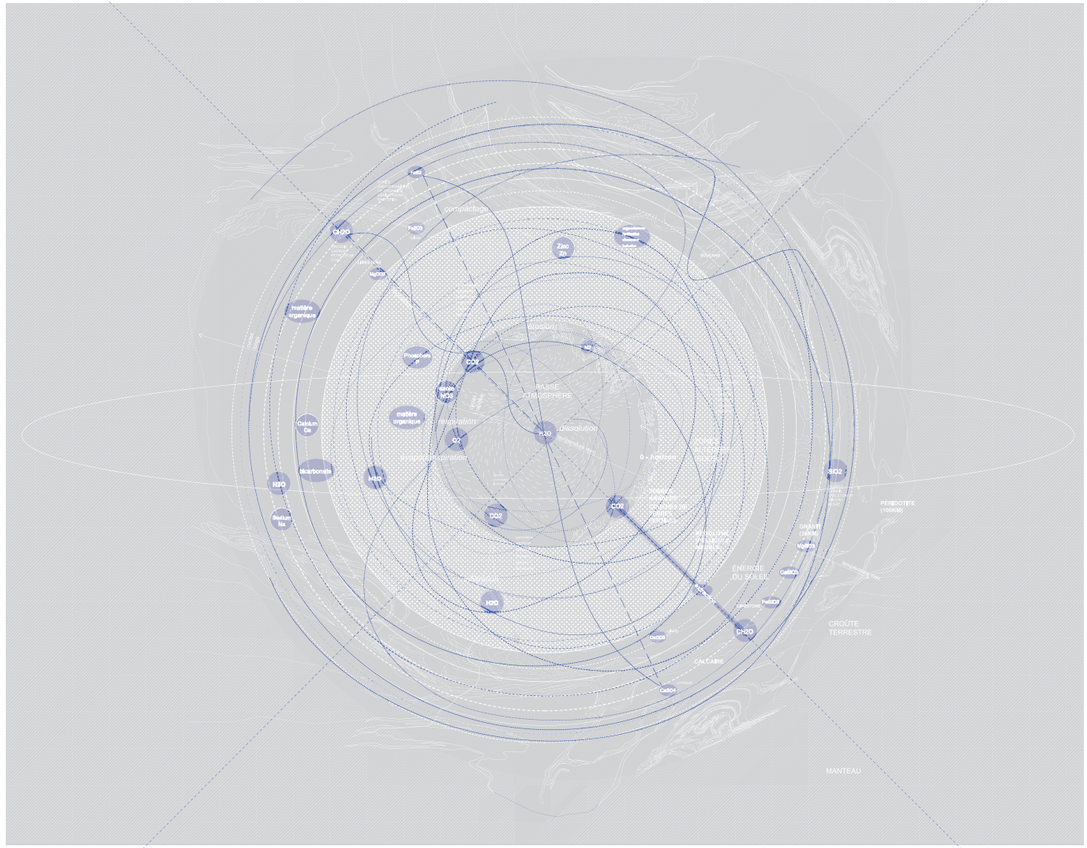
A new conceptual representation of the Critical Zone. The different components of the Critical Zone are deployed in nested circles around a reference point (of any CZO) in a circular plane. This operation is an anamorphosis that places the layers that are really critical for life on earth in the center (Fig.2) instead of being squashed as in the classical representation (Fig.1).



Visual repertoire of mass and geochemical movements (processes) in the CZ in the new system of coordinates. The angle between the spiral's tangent and the radius of the nested circles indicates the velocity. A flat spiral indicates a slow movement and thus a long residence time in the reservoir. A centrifugal arrow means that the element flux is directed from the atmosphere to the deepest CZ layers. A centripetal arrow means that the flux of the element is directed from the deep CZ to the atmosphere.



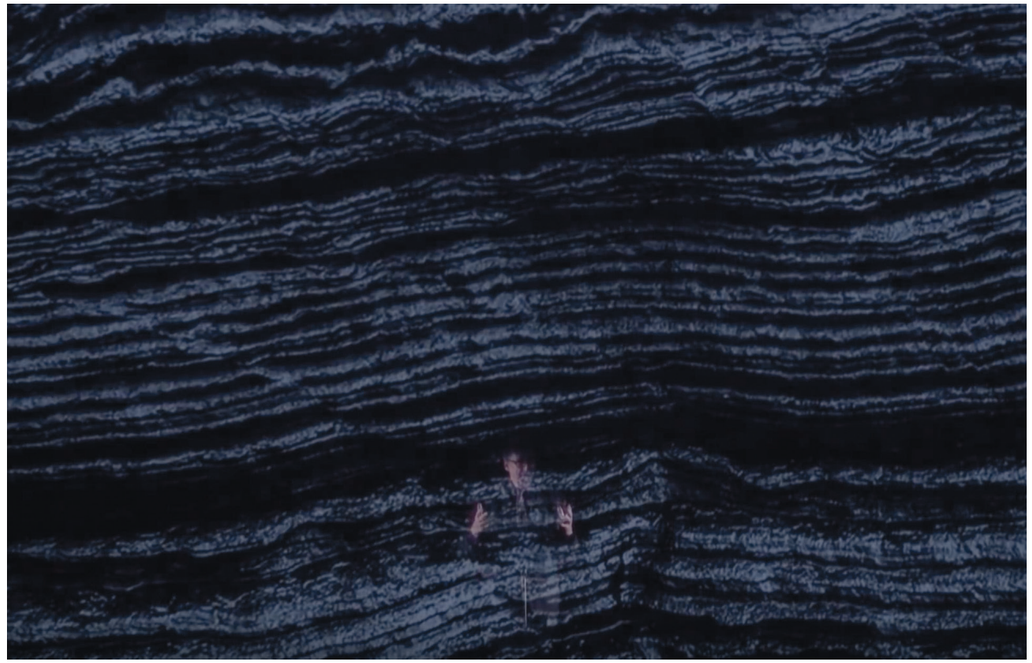
Axonometric view made in order to render visible not only the position of the sun in a cartographic view, but also its role in a dynamic hydrological and geochemical perspective. This view shows that matter and elements are activated by a cosmo-tectonic circulation denoted here as the 'energetic maelstrom.' (Arènes, Alexandra, Bruno Latour, and Jérôme Gaillardet. "Giving Depth to the Surface: An Exercise in the Gaiagraphy of Critical Zones." In: "The Anthropocene Review," 2018.



A new model of the Earth to visualize the dynamics of the Critical Zone (biogeochemical cycles)

Layers of the soil, weathering process – Critical Zone Observatory of the Strengbach in the Vosges forest

Inside the RiverLab, a laboratory for the field



INSIDE – lecture performance of Bruno Latour, staged by Frédérique Aït-Touati. Visuals & videos: Alexandra Arènes, Axelle Grégoire, and Sonia Levy. You can find the video on YouTube: INSIDE - Bruno Latour / Zone Critique (youtu.be/gzPROcd1MuE).

there no longer study the planet 'as a globe' because it does not allow them to face the urgency of the surface situation (territories in ruins or ecologically damaged: pollution, chemical alteration, soil depletion, acidification, increase in CO2)—a situation that leads to hybrid or wild landscapes that are sometimes uncontrollable. Paradoxically, these phenomena, at the surface, are much less explored and understood than galaxies or the Earth's nucleus. Therefore, these scientists are now studying the thin layer on the Earth's surface between rocks and canopy, the Critical Zone where living beings interact and produce biogeochemical cycles. Geochemists do not consider life as an organism. They study it through traces among other abiotic agents and in order to understand how the biogeochemical cycles that make the Earth turn—not around the sun, but around and in itself, under the combined action of the energetic sun and tectonic forces—are formed, regulated or deregulated, balanced or unbalanced.

The scientists asked us apparently simple questions: how can we visualize the Critical Zone? How can we experience it, feel it, estimate it, measure it, represent it? How can we move from the globe to the vision of the Critical Zone, a planet full of life, more local, more complex, and more real? Our first intuition was to turn the seemingly infinite space of the globe upside down and close it around us, to make our position in the Critical Zone more realistic. The problem was also to give depth to the Critical Zone, this thin layer in comparison to the immensity of the globe, an image that we all have still in mind as the representation of planet Earth!

One of us solved this problem by making a fairly simple gesture, which scientists do not hesitate to sketch themselves, and which consists in turning the globe over like a glove to reverse the conventional order and size of the Earth's strata, by placing in the center of the diagram the atmosphere from which there is no escape and where cycles rotate rapidly, then reconstituting the soils, the altered zones, and the earth's crust all around, in as many layers or envelopes, more or less porous, as there are geological times characterized by longer element cycles. The reconstructed interiority traps the atmosphere in its center (after all, the pollution clouds come back to us). The series of envelopes reconstruct upside down the vertical strata of the Critical Zone: the soil, which has been thickened to better qualify and care for it; the altered zone, where water and potentially life still circulate in deep fractures; and the crust, whose mass definitively encloses man's unlimited development potential.

The former space infinity is nevertheless replaced by another kind of infinity: cycles, which constantly circulate between strata. The short times of chemical reactions are visible in the center, while the long processes occur mainly in the periphery. This alternative topology of the terrestrial zone facilitates the visualization of these biogeochemical cycles that cross the Earth and determine its transformations; the map is thus 'cyclocentric.' The topology retains a 'false' circular geometry so that the second movement, the cycles, appears in the drawn model. A new grammar for recording spiral cycles is proposed: direction, velocity, and angle to report on the circulation of the elements from one stratum to another. This grammar makes it possible to visualize the behaviour of the cycle to be studied, on a given site and at a given time, for example that of carbon.

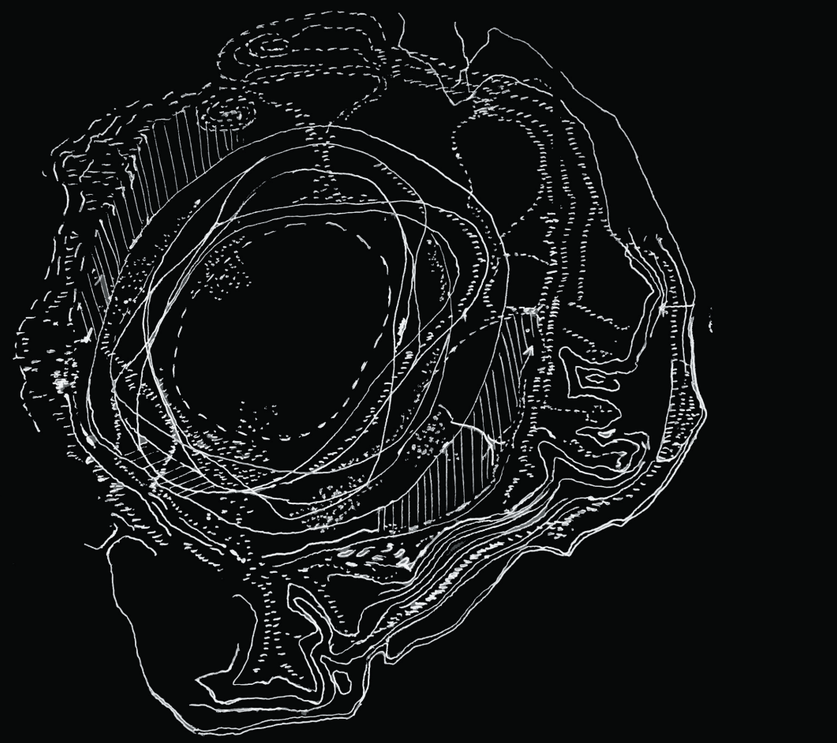
Another location system is also suggested, abandoning the latitude/longitude system, for a location in cycles: at what stage is this territory in relation to its phosphorus cycle, at the moment when I am there? Which agents, identified by the chemical elements they leave behind, disturb this cycle and thus shape this landscape in a particular way? It is this change in the cycle mapping system that is called "Gaiagraphy." The Gaia Hypothesis, elaborated by Lovelock and Margulis, argues that living beings generate or destroy their own living conditions and, ultimately, that it is their actions that terraform the Earth. It would therefore seem necessary to add to 'geography,' understood as an a posteriori reading of Earth's layers, 'Gaiagraphy,' understood as an interpretation of process-induced changes effective in real time.

What may be interesting to conclude our journey into the Critical Zone, and its specific earth science network, are the scientists' varied reactions to this model as it was presented in conferences, discussed in workshops, or read in the Anthropocene Review. Some of them felt their work better represented ("we finally give importance to the surface layers on which I work and push the deep layers towards the periphery"), others better oriented ("we know better where we are"), or reassured ("we no longer float in an infinite space as with the globe"). Others, on the other hand, felt claustrophobic ("but then we are locked in the Critical Zone"), a feeling that was quickly mitigated by a proposal to visualize the infinite movement of cycles. Thus, for the first group, the important thing was to be able to define a new framework. For the second group, the most important aspect was to not lose the dynamics, the 'cosmo-tectonic maelstrom,' i.e. the time scales and the speed of cycles, and especially the ruptures, introduced by human activities.

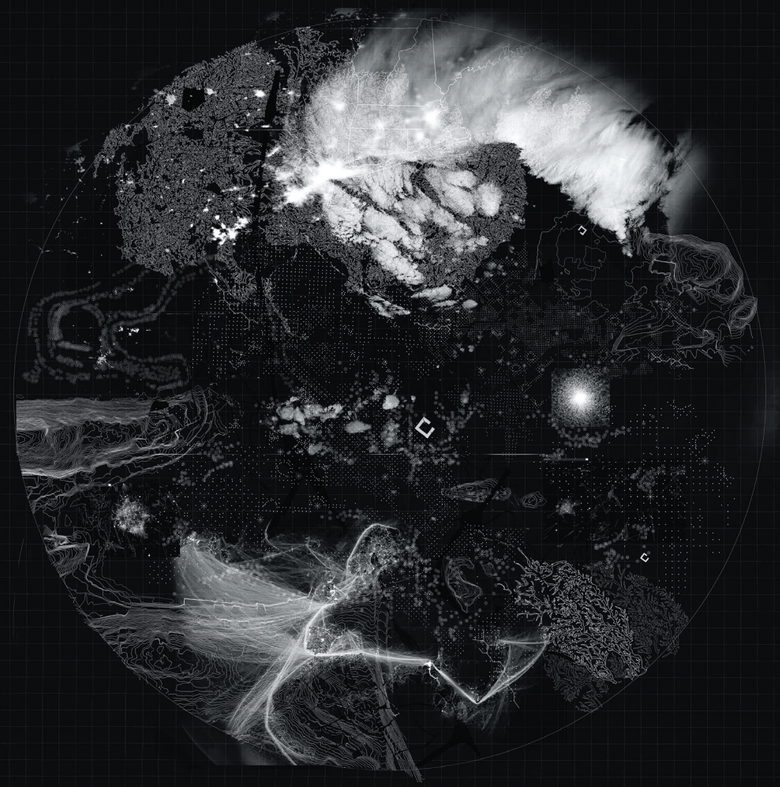
A lot more work is required in order to escape the grip that the global vision of the Earth holds on our collective imagination. What this experience demonstrates is that it is productive for science as well as for the arts to have a geochemist, architect, and a philosopher joining forces to tackle the urgent question of representing the Earth.

BRUNO LATOUR is now an emeritus professor associated with the médialab and the program in political arts (SPEAP) of Sciences Po Paris. Since January 2018, he is a two-year fellow at the Zentrum für Media Kunst (ZKM) and professor at the HfG both in Karlsruhe. Member of several academies and recipient of six honorary doctorates, he is the recipient in 2013 of the Holberg Prize. He has written and edited more than twenty books and published more than 150 articles.

ALEXANDRA ARÈNES is architect and co-founder of SOC (Société d'objets cartographiques/s-o-c.fr), a research and production platform of cartographic tools between arts and sciences. Since 2016, she has been collaborating with the IPGP (Institut de Physique du Globe) on the Critical Zone project. She is now preparing a PhD at the University of Manchester. She co-authored a book "Terra Forma, manual for cartographic tools"(to be published in 2019) which explores Anthropocene landscapes and their potential for resilience through the development of strategic models.



The terraformation of the Earth.



How can we have a better representation of Gaia from the inside of the Earth?