



Integrating The Social Sciences And Humanities In Earth System Science To Address The ICSU/ISSC Grand Challenges

The Planet Under Pressure Requires Institutional Reforms in the Academy

This 11-year transdisciplinary study draws on the physical and social sciences and humanities. The ICSU/ISSC Grand Challenges question has become critical to the study:

How can timely actions be undertaken at unprecedented and multiple geographical and geopolitical scales, where the nature and scale of the issues involved means that the actors have widely differing—and—disconnected values, ethics, emotions, spiritual beliefs, levels of trust, interests and power?

In science there are no absolutes and in social life nothing is certain. When people arrive on the scene, where there is order there is disorder, and while many social events can be anticipated and explainable, most are unpredictable.

At the present time we are not well prepared for extreme weather events, for global economic instability, for the impact of food and water shortages, for public health emergencies, for industrial disasters, for natural disasters, or for the social and political unrest and armed conflict that is often associated with these extreme conditions.

The increasing scale and intensity of these complexly interrelated disasters challenges our capacity to adequately respond, either in the aftermath of the events taking place or in the recovery phase of disasters.

Nevertheless it is imperative that we ask the question, *and* that social scientists and scholars in the humanities work with Earth system scientists to address it. Social scientists and scholars in the humanities cannot stay in the margins of Earth system science, we have to join in.

At the present time social scientists are not even a footnote on the page.

In addition to new collaborative projects it is of critical importance in the vital transdisciplinary configuration that we reflect upon the research we have done and ask how our research findings advance our understandings of people and the planet. "What insights can we share?"

The growing capabilities of Earth system scientists to predict anthropogenic change, provides a nucleus for hope, but only if social scientists and scholars in the humanities find ways to participate in the endeavor.

The institutional reforms advocated by ICSU have the potential to create opportunities for greater understanding of not only the impact of people on Earth system functioning, but also of the impacts on people of the Earth system changes that are taking place. The current organization of research institutions creates, maintains and perpetuates divisions.

At the 2010 Visioning at ICSU in Paris, Johan Rockström spoke of the need for a fundamental change of structure and a stronger engagement in communication and capacity building that is more true to the societal needs in the world. He spoke of "a new effort to serve society," "new institutional frameworks," "greater consolidation," and "an investment in integrated science." Scientists at the forum discussed the large knowledge gaps within and between disciplines, and the need for transdisciplinary research was widely agreed upon—although there was also agreement that basic geo and biophysical Earth science research should be both supported and continued without being impeded by any reorganization efforts.

It is imperative that basic research continues, but within broader frameworks that take into consideration transdisciplinary perspectives. The non linear interrelationships between atmospheric and ecosystem stressors and human activity brings into sharp focus the supercomplexity of the relationships between the physical, biological and social sciences. Any global sustainability efforts will be highly dependent on the ability of all those who participate to take into consideration the professional challenges of working with participants who hold different views of science and, quite possibly, of humanity.

Even the suggestion of such systemic institutional change shakes up the academy. It challenges our understandings of the status quo, encourages us to rethink our positionalities within institutions and our relationships with other scientists, and challenges our conceptions of the endeavor we call "science." Implicit in the conception of transdisciplinary research is the co-production of knowledge.

Transdisciplinary research in Earth system science requires consideration of complementary and contradictory paradigms and metatheories—ideological and theoretical presuppositions—which are philosophically grounded in different views of science with different histories and traditions.

Thus, we will have to reexamination the interconnections between the social, cultural, psychological, biological, and physical sciences, so that new questions can be asked, new understandings gained, and actions taken. To foster collaborative research networks that are truly global in scope transdisciplinary research will require the merger of disciplines and the establishment of research communities which include both physical and social scientists. This will create new conceptual spaces for further scientific thinking beyond the possible perspectives that can be gained from within any single discipline or paradigm.

"We're all working on the edge of our disciplines," a scientist said at the 2010 ICSU Visioning Forum in Paris. Earth system scientists work in the margins, in the spaces between disciplines, centrally dislocated, conducting research while coping with metaworries about metatheories. Many researchers in the social sciences are similarly situated. Inevitably, problems arise from working in complementary and contradictory paradigms, where there are concerns about: (1) reductionism and expansionism (2) questions about the super-complexity of research studies (3) worries about systemic risk.

Colleges and universities are not set up to support them—or to support the participation of social scientists in Earth System transdisciplinary researcher endeavors.

Observations, Models and Epistemic Pluralism in Research on the Planet Under Pressure

In Earth System science an *epistemic problem* is the inherent dualities of "pure and applied science." The idea of "basic and applied research" has long been the received orthodoxy, but in the *quest for new knowledge towards solutions* the allocation of the social sciences to the "applied side" is problematic. "New Perspectives and research are needed to understand the complex relation between global transformations of social and natural systems," Biermann and his colleagues (2010) write. "Innovative research is needed also to analyze political options to govern sustainable development – taking into account not only political effectiveness and efficiency but also global and national justice and equity".

At the 2010 ICSU Visioning in Paris, Rockström emphasized the urgent need for "more deep social science on global change and natural science," and he spoke of the critical imperative for "investment in integrated science." He stressed that global observation is stronger when "all the elements are wrapped up in a more integrated way."

Rockström spoke of the Grand Challenges and of the "bringing two worlds together" as a "potential source for a weakness" inherent in the document – expressed by the participant at the meeting who was concerned by the absence of culture in the presentation of the Grand Challenges. He stressed the need for "clarity of defined research priorities" but then acknowledged that the research priorities included "a mixture in terms of research things," of "action oriented things that aren't environmental but political" that needed "more clarity in defining."

When the dynamic complexity of the planet is combined with the dynamic complexity of human life on the planet even the most advanced Earth System models are questionable. The complex relationships between people and the planet are not static or unidirectional. What we do changes the planet just as it changes us. Both the planet and people are probabilistic and not deterministic, nothing is ever "settled". Thus, in science, even the most dynamic, interactive, non-linear, multimodal models that scientists build are not actual representations of real systems. In the dynamic observational sciences, integral to multiple disciplines, *epistemic pluralism* opens up possibilities for new models to be developed and new insights to be gained.

Owing more to Vico and Montaigne than to Descartes, within the interpretivistic social sciences, *scientific rigor* is highly dependent on disciplined, systematic observations. Clifford Geertz, the renowned Princeton anthropologist, called it "thick description," and such scholarship is a lifetime pursuit for many researchers whose scientific endeavors require close observation of human societies in family, community, institutional, and other organizational settings.

It is in the *situatedness* of human activity, the *embeddness* of social practices, how practices are constitutive of socio-semiotic systems, and events are symbolic of particular discourse communities, which many researchers, across the social sciences, endeavor to observe, document, and explain. The caveat is that observing in the physical world is not the same as observing in the social world. The observations of researchers in the physical sciences are qualitatively and quantitatively different than the observations of researchers in the social sciences. Nevertheless, *epistemic pluralism* expands our understandings of transdisciplinary research, and by so doing changes the possible meanings of the question of questions and our possible responses to it. Once again the **QoQ**:

How can timely actions be undertaken at unprecedented and multiple geographical and geopolitical scales, where the nature and scale of the issues involved means that the actors have widely differing—and—disconnected values, ethics, emotions, spiritual beliefs, levels of trust, interests and power?

Any transdisciplinary response must begin with an examination of the observational data—both physical and social—taking into account the *situatedness* and the *embeddness* of the phenomenological, the functional and the physiological (physical and biochemical) in both the natural and social worlds. Deep Science x Deep Science, it's our only chance to respond to the great acceleration.

Once scientists have collected their observations – whether data from space stations or from human communities—they have to do something with them. In science the *construction of models based on observational data has long been integral to the development of new knowledge, predictions, effective decision making, and action.*

The supercomplexity of this challenge to the Earth System Science is presented in the ICSU Grand Challenges document by the following sentence: *The observation, data preservation and information systems required need to: encompass both natural and social features; be of high enough resolution to detect systematic change; assess vulnerability and resilience; include multiple sources of information (quantitative and narrative data and historical records); provide information about both direct drivers of change and indirect drivers; involve multiple stakeholders in the research process; support effective decisions at global and local scales; be formally part of adaptive decision making processes; provide full and open access to data; and be cost effective.*

We know of the great acceleration through the vast wealth of data and the efforts of thousands of scientists and the models they have developed based upon the sheer genius of their observations. The refinement of modeling capability in Earth System Science is tempered by the dynamic complexity, the *epistemic pluralism*, of the social world. The **QoQ** confounds the modeling process. There is no possibility of algorithmic certainty. Models are vulnerable to too many sociopolitical and socioeconomic kicks. Models can provide useful information – including warnings – but not answers.

"All models are wrong, some are useful," George Box, the renowned statistician is often quoted as saying. Boé, Hall and Qu (2009), in an article which focuses on the rapidly changing Arctic Climate, quote Box, and write, "We could add that many models—each wrong in a different way—can collectively be useful as a nearly perfect one, as long as observations exist to guide interpretations of their predictions".

Responding to the Planet Under Pressure Creates Profound, New, and Historic Possibilities for Physical and Social Scientists to Work Together

At the 2010 Visioning Paris, Johan Rockström said, "There have been great advances in science. As scientists it is fundamental that we move towards institutional frameworks to support research for a more sustainable world." A greater difficulty than changing the organizational structures of universities – if that's possible – is changing the *insularity* of social and physical scientists' disciplinary ways of being –*seeing and knowing* – within the institutions to which they belong.

Rockström talked of "something profound and new" and of an "historic opportunity." What is profound and new *and* historic is the possibilities of finding ways for physical and social scientists to *work together*. But given the inadequacies of social science engagement where do we start? What are social scientists supposed to make of "non-linear social and ecological dynamics, interactions, thresholds and tipping points"? How do scientists in the geobiophysical sciences begin to talk with social scientists about their concerns that will need a very strong emphasis on multiple, multi-layered socio-geographic perspectives?"

The bottom line is that *researchers in the physical and social sciences must talk to each other, read each other's research, and collaborate in research projects so they can imagine science differently* – thus expanding the possibilities of transdisciplinary research. But there's a caveat.

"We see the lives of others through lenses of our own grinding and they look back on ours through ones of their own," Clifford Geertz (1984), the renowned Princeton anthropologist writes, in his seminal article on the vituperative attacks on anthropology by other social scientists.

Another difficulty that must be addressed is the disagreements and dissonance *within the social sciences*. The scientific evidence for the great acceleration is rock solid, but most social scientists remain on the periphery, are not engaged at all, and/or are resistant to any invitation to participate in intellectual activities that stretch them beyond their disciplines, paradigms and favored lines of research, many preferring instead to remain caught up in local squabbles, and lost-in-the-moment contentious arguments.

At the social science conferences there is no mention that what is happening to the planet is outpacing the response. In social science journals there is scant mention that our current path is unsustainable, or that immediate action must be taken to change the global impact of people on Earth System functions. There is no sense of the "urgency" being "so daunting" that the scientific community needs to regroup, reorganize, and restructure to meet the challenge.

Discouraging at best—given we don't have a century to wait. *For social scientists their disciplines are like countries and their scholarly and professional identities are steeped in the ideologies and mythologies of the paradigms to which they belong.* But perhaps it is our propensity for argumentation, *perhaps it is what we argue about – what it means to be human*—that makes the debates so agonistic and antagonistic.

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Perhaps, counter-intuitively, the disarray of the social sciences and the cacophony of positions and dispositions actually create opportunities for the **QoQ** to be addressed.

Before scientists in the physical sciences despair at the ambiguity, indeterminacy and disarray in the social sciences and the cacophony –the noise on the page– the disagreements and dissonance within the social sciences – as well they might– Geertz opens the door to the connections that already exist between the social and physical sciences that provide a way of thinking about possible collaborations in transdisciplinary science. Once again, Geertz is worth the read: *It is, so I think, precisely the determination not to cling to what once worked well enough and got us to where we are and now doesn't quite work well enough and gets us into recurrent stalemate that makes a science move. As long as there was nothing around much faster than a marathon runner, Aristotle's physics worked well enough. Stoic paradoxes notwithstanding. So long as technical instrumentation could get us but a short way down and a certain way out from our sense-delivered world, Newton's mechanics worked well enough, action-at-a-distance perplexities notwithstanding. It was not relativism—Sex, The Dialectic and The Death of God—that did in absolute motion, Euclidean space, and universal causation. It was wayward phenomena, wave packets and orbital leaps, before which they were helpless. Nor was it Relativism—Hermeneutico-Psychedellic Subjectivism—that did in (and has to the degree they have done in) the Cartesian cogito, the Whig view of history, and "the moral point of view so sacred to Eliot and Arnold and Emerson." It was odd actualities—infant betrothals and nonillusionist paintings—that embarrassed their categories (p. 275).*

Geertz writes of old triumphs becoming complacencies, and one-time breakthroughs being transformed into road blocks which are shaken up by odd actualities. It is the gut wrenching experience of being there when catastrophic events take place that will draw them into collaborative work with physical scientists.

For the social scientist "being there" makes Eric Chivian and Aaron Bernstein's *Sustaining Life: How Human Health Depends on Biodiversity* essential reading, but without the research in Steffen and his colleagues' *Global Change and the Earth System: A Planet Under Pressure*, there can be little understanding of what's happening to the planet.

The Humanities are Important to the Development of Models of Non-Linear Dynamics and Thresholds of the Planet Under Pressure

Stories of our mortality run deep in human history – in every culture in every society. Similarly, the human destruction of the planet is a narrative loop that has reoccurred in oral stories and literature through the centuries and millennia.

"Paradoxically, before scientists tell us the sky is falling, we already know what is happening to the planet. It's an old message that our actions can be disastrous and have huge consequences.

In Shakespeare's *A Midsummer Night's Dream*, Titania, the Queen of the Fairies, says to Oberon, the King of the Fairies:

Therefore the winds, piping to us in vain, As in revenge have sucked up from the sea Contagious fogs, which, falling in the land, Hath every pelting river made so proud That they have overborne their continents. The ox hath therefore stretched his yoke in vain, The plowman lost his sweat, and the green corn Hath rotted ere his youth attained a beard. The fold stands empty in the drowned field, And crows are fattened with the murrain flock.

Hurricanes, tsunamis, heavy rains causing rivers to burst their banks, drowning livestock, destroying crops, pollution of contagious fogs, with birds growing fat on the diseased carcasses of dead sheep – it's today's story, an Earth science narrative that continues inexorably.

The human mortals want their winter here. No night is now with hymn or carol blessed. Therefore the moon, the governess of floods, Pale in her anger, washes all the air, That rheumatic diseases do abound. And through this distemperance we see, The seasons alter: hoary-headed frosts Fall in the fresh lap of the crimson rose, And on old Hiems' thin and icy crown An odorous chaplet of sweet summer buds Is, as in mockery, set. The spring, the summer, The childing autumn, angry winter, change their wonted liveries, and the mazed world By their increase now knows not which is which. And this same progeny of evils comes From out debate, from our dissension; We are their parents and original.

In our time, the bewildered (mazed) world no longer knows the difference between winter (old Hiems'), spring, summer and fall. Weather patterns are more erratic and extreme. All life forms – bees, bats, birds, frogs, and children – have become increasingly susceptible to bacterial, viral, and fungal illnesses, some old and some that have not been known before. Common ailments such as rheumatic diseases flourish as do the illnesses caused by toxic stress that change our body chemistry and disorder cortisol metabolism, creating greater vulnerability in children. And, all progeny of evils originates from us, from human activity, from our enterprise, from our debate, from our dissension, the global gathered into the global, involving people of widely differing and disconnected values, ethics, emotions, spiritual beliefs, levels of trust, interests, and power – on a scale so vast it is beyond our capability to comprehend, except in fiction.

A few lines in a Shakespearean play convey the same message as any Earth System heavy tome. Plagues, pestilence, fires and flood, life and death, the struggle against adversity are played out in different ways across the ages. Shakespeare, writing at the time of Vico and Montaigne, reminds us of what we have forgotten, helping us remember, and brings us to the present day and the situatedness of our minds and bodies in the natural world.

In Earth science human experience, philosophy, and literature are intimately connected. In *Daughters of the Moon*, Italo Calvino (2002) connects them directly:

The road petered out in a hilly area with little valleys, ridges, hills and peaks; it was not the contours of the land that created the bumpiness, but rather the layers of things that had been thrown away: everything that the consumerist city expelled once it had quickly used it up so it could immediately enjoy the pleasure of handling new things, ended up in that unprepossessing neighborhood.

Over the course of many years, piles of battered fridges, yellowing issues of Life magazine, fused light bulbs had accumulated around an enormous junkyard of cars. It was over this jagged, rust territory that the Moon now loomed, and the swatches of beat-up metal swelled up as if lifted by a high tide. They resembled each other: the decrepit Moon and that crust of the Earth that had been soldered into an amalgam of wreckage; the mountains of scrap metal formed a chain that closed in on itself like an amphitheatre, whose shape was precisely that of a volcanic crater or a lunar sea.

In the midst of the things that had been thrown away lived a community of people who had also been thrown away, or marginalized, or had thrown themselves away of their own volition, or had got tired of running all over the city to sell and buy new things that were destined to go out of date immediately; people who had decided that only things that had been thrown away were the real riches of the world.

That morning the city was celebrating Consumer Thanksgiving Day. This feast came round every year, one day in November, and had been set up to allow the shops' customers to display their gratitude towards the god Production who tirelessly satisfied their every desire".

The rest of the story is worth reading – the moon is reborn but not the Earth, and Calvino imagines the world as if it could be otherwise, without the junk and wreckage of discarded lives "we realize that now is when life begins," he writes, "and yet it is clear that what we desire shall never be ours".

Reading *The Daughters of the Moon* while studying Earth system science changes the story. But it is not only literature that is changed by science, we are changed, and in that *changing science changes too*—the depth of our understandings, our vision and our insights – lifting the curtain on the dynamic complexities of interrelationships between our social and physical worlds.

Calvino helps us get it. Language is always central to his thinking. "Words," he writes, "like crystals, have facets and axes of rotation with different properties, and light is refracted differently according to how these crystal-words are orientated". He writes of the importance of living in a world where science, philosophy and literature constantly challenge each other. "Literature," he tells us, "breathes philosophy and science but keeps its distance and dissolves, with a slight puff of air, not only theoretical abstractions but also the apparent concreteness of reality". Calvino writes that he is lifting up to "that indefinable region of human imagination" which he, himself, sets free.

Can Science Save Us? The Great Acceleration From Adaptation to Transformation or Annihilation? What Happens When Life as We Know it Ends?

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