The need of tearing down the walls between disciplines and emphasize transdisciplinary approach within a multidimensional framework.

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Mehdi Saqalli[1], Nicolas Maestripieri[1], Melio Saenz[2], Mahamadou Belem[3]

[1] Laboratoire GEODE – UMR 5602 CNRS. France
mehdi.saqalli@univ-tlse2.fr ; nicolas.maestripieri@univ-tlse2.fr
[2] Centre Latino-Américain de Calcul Scientifique et d'Informatique Industrielle. Equateur
msaenz47@gmail.com
[3] West African Science Service Center on Climate Change and Adapted Land use. Burkina Faso
mahamadou.belem@gmail.com

Introduction

« We have not enough data about that ». This is often the answer one modeler may encounter while he/she is asking about one process an issue and by then a model to build needs to construct. The common answer the modeler think about is “ok, but then? We can do something ugly, fuzzy, and not precise but clearly, the mistake will be lower than not putting the process because of the lack of data”. Even more, the “not-enough-data” assertion is theoretically always valid: whatever the issue, data will be lacking. Where to position the limit after which one can say “ok, let us combine what we know to see it has a meaning”, i.e. try to build a theory, a model of the reality for answering a question?

More generally, our purpose in this communication is to argue that asking “how can we model without all the necessary information?” means actually ““how can we model?”.

One may consider that modelling is the last avatar of the less known and less visible and valorizing second part of research: the construction and creation of theories from data and information scientists have previously collected. This demarche, often called “inductive” in the most accepted hypothetico-deductive research approach, i.e. deduction, induction and abduction (Blecic & Cecchini, 2008, p. 539-540), implies to combine altogether “elements”, pieces of science along a plan that may enlighten an issue. This may have been assessed in the past along an intuitive process, such as described by Bergson (1911): he described this capacity of connecting processes, patterns and dynamics along sometimes illogical analogies, comparisons and consistencies as a purely human action, impossible to formalize. Nowadays, modelling tools, especially when implemented to integrate both qualitative and quantitative information and rules, do have this ability if and only if they are used along a formalized and epistemologically relevant methodology. They can then be used as a way to explicit relations along a systemic approach. We do consider that they ***should*** be used as a way to fulfill the second fraction of research: connecting data.

Interdisciplinarity: when do we need it?

Actually, astrophysics is not a scientific discipline that feels an interest for neither interdisciplinarity, nor for instance fundamental chemistry and finally, nor the combination of the two sciences. So, one may ask: "when do we need "interdisciplinarity"? Even more important, how can we characterize it? Better than using a philosophic background we do consider as relevant but beyond our competency and our level of abstraction, let us use the *vox populi* argument: When, where and in what domain can we see a plea for interdisciplinarity?

1. The need facing an "epistemological obstacle" (Bachelard, 1938): This is a necessary but not sufficient condition for an interdisciplinary need. It only means that one scholar from one discipline faces an issue that goes beyond the "normal" science he/she belongs to.
2. The background need: The first criterion is obvious: "when a scientist cannot borrow data and information from other disciplines he/she may need without having knowledge of the mechanisms that create such information. For instance, using prices of goods collected from economic census for better characterizing the needs of a social group into a socio-anthropologic study does not mean it is an interdisciplinary study because some economics is used. It means that each discipline having its own point of view and paradigms on the reality, having the corresponding background that gives access to this point of view and these paradigms is thereby a *sine qua non* condition for interdisciplinarity.
3. The need for a paradigm on dynamics and variables: The second criterion is related to the previous one and come naturally when thinking about interdisciplinarity: it concerns combination of disciplines very different one from one another. Actually, three groups can be considered:
   - The Physics group: It belongs to disciplines where refutation (Popper, 1982) can be assessed with fully controlled experiences, i.e. where the experience is considered as *ceteris paribus*[i] *(*here "considered" means that the related scientific community accepts that it is *ceteris paribus* and has tried to refute it). Relations and dynamics are defined according to a limited range of variables. Full determinism is not reached only because of the principle of Heisenberg and the importance of the knowledge of initial conditions which ignorance leads to chaos. Only quantitative data are considered.
   - The Biology group: it belongs to disciplines where refutation can be assessed with observations and samples, with the support of some controlled experiences. Relations and dynamics are defined according to a medium range of variables. Along the effects of Heisenberg and initial conditions, non-determinism is brought by the lack of information on differential biological functions (for instance, the absorption capacity regarding water or other elements differ from one plant to another) but also emergence, i.e. the property of a phenomenon which is a combination of several elements and which behavior cannot be reduced to each element (Müller, 2002). However, only quantitative data are considered, but dynamics

may be described along qualitative schemes without determinism (for instance, animals do not pilot their fate in absence of self-reflexivity).

- The group of social sciences: Practically, no experiences can be assessed except some well-famous but questionable very controlled behavior experiments such as the one of Milgram. Because it is far more difficult to characterize which variables are **not** part of the studied system (Why social psychology is not fully part of economics?), relations and dynamics are defined according to a large range of variables. Hypotheses are proposed with far more conditions and many anthropologists do tend to avoid theorizations. Refutation can be assessed only with observations and samples. Along the effects of Heisenberg, initial conditions, lack of differential knowledge and emergence, non-determinism is everywhere: no human groups ever behave in the same manner twice. To face the diversity of variables and the structural non-determinism, dynamics are mainly described and characterized along qualitative manners supported by quantitative data. Both qualitative and quantitative tools and data are used.

These three groups do have, because of differences between paradigms, principles, methods and practices large difficulties for inter-dialogue. We do consider that interdisciplinarity is needed if and only if it concerns sciences that belong to at least two of these groups.

4. Finally, another factor does act as an incentive for interdisciplinary: applicability. For instance, the Apollo program did have to include psychology and sociology counter-intuitively for space scientists once the program did raise the application level, i.e. the time when the group of Physics sciences did have to be built, i.e. integrate the oekoumen, the human community.

Interdisciplinarity: Why are socio-ecological sciences its most prominent supporter?

Let us consider a macro-scenario where Nature, Life and Society coexist. This scenario has the three properties which define a system: a universe with elements which have a position and leads to identify the system's structure, a set of properties and attributes on which basis it is possible to assign qualitative and quantitative variables to describe the states of the system and, among its elements we can find or establish a set of relationships which determines the behavior of the system.

1. Socio-ecological systems need a formalism for apprehending a fluctuant, complex system, i.e. a model: We have seen that any system, whatever the discipline it belongs cannot be fully known, observed and described. That is impossible because the quantity of variables needed to do so is infinite and the variability of them in time. Then, we have to choose a subset of relevant variables in agreement with our interest and needs. At this time we are not describing the reality but a part of it. We call this, a model. Value of models can be established by conceptual validation, accurate representation of the reality, stability of the simulation processes and convergence of solutions.

2. *Once the world of academy finds that its own existence is only justified in the measure that it gets community needs, social life would involve a very near and strong relationship with scientific and fundamental knowledge and with solutions which can be provided from research and development. At this moment, the interdependence between Science and Society encounters an amazing growth which is completed with the integration of Nature as the main source of resources for life.*

Reality cannot be explained in terms of an isolated thinking discipline. We must take into account the consequences produced by interactions. Knowledge models need to reflect at least those consequences which are enough to explain the behavior of the macro-system and which will be useful to solve the community problems. Models need to be fed with qualitative and quantitative data which could lead to increment the value of the second step in scientific research: the construction and creation of theories from data and information that scientists have previously collected and qualified.

Nowadays, modelling tools, especially when implemented to integrate both qualitative and quantitative information and rules, have this ability if and only if they are used along a formalized and epistemologically relevant methodology.

They can then be used as a way to establish explicit relations along a systemic approach. We do consider that they should be used as a way to fulfill the second fraction of research: connecting data.

Along with this necessity of a formalization of information as the second mandatory part of the research process, formalizing elements is a cure for self-focusing scientific approaches.

Interdisciplinarity: what for?

Several points are supporting the plea for interdisciplinarity:

- "the better complexity": Because interdisciplinary research objects such as socio-ecological systems include de facto many disciplines, eliminating some (and sometimes because of the lack of data on them, which we deeply deplore as in the introduction) is an important error. More exactly, we consider that taking into account all the components of a socio-ecological system (including society, environment and economy) and simplifying each component is more relevant and less harmful than neglecting some activities by focusing on the one which seems to be the most important.
- Holism: More globally and following Verburg *et al.* (2004) our observations are bound to the extent and resolution of measurement causing each observation to provide only a partial description of the whole multiscale land use system. Beyond the scale of analysis of for instance land use change, it means that

scientists and stakeholders have to tear down the walls of disciplinary approach and cultural context which lead to misinterpretation (subjective interpretation) about these phenomena. For instance, analyzing socio-ecological processes, one of the most complex interdisciplinary scientific objects, combining social and biophysical sciences, the complexity of it must be tackled with the analysis of the holistic character of reality.

- "for the greater good": Indeed, the main quality of social and environmental formalization, and by then a "loud and clear" formalized interdisciplinarity, is to "force" scientists and scholars to represent reality in itself: the need to achieve the model, computerized or not, required for every scholar to sacrifice a portion of the complexity of its own theme on the altar of the combination of disciplines. The importance of encouraging the success of the object as a whole and not its task as oneself is crucial as is the legitimacy of the objective and the people in charge.
- Exactitude: Following the previous point, interdisciplinarity is a test for scientific rigor and more precisely, exactitude. Exactitude is often confounded with precision and precision do have this shiny power of data with several figures after the comma. But what do means such figures for cases such as, for instance, demographic analyses without including migration? It often happens that scientists do present their datasets without justifying the origins of the variables on which the data were collected: why these lasts were chosen and not others? One should then differentiate variables and data and by then characterize the scope of the object of research, i.e. its exactitude before looking after precision. Variables allow getting relationships and dynamics while data parameterize these relationships.
- Epistemological formalism: Again following the previous point, these variables have to be identified and hierarchized according to a paradigm or a principle (local perception? Experts' common agreement?) which legitimizes their selection to the detriment of other variables. We do plea for a formalization of the criteria, the principle on which variables are designated as relevant. Along the go & return flux between induction and deduction, they should be de jure also the criteria for "validation".
- Plausibility: Along with this necessity of a formalization of information as the second mandatory part of the research process, formalizing elements is a cure against self-focusing scientific approaches. Along the traditional self-checking loop mistake (a set of data is used to characterize a function describing a

phenomenon and for "validating this function, it is compared to the very same data which created it), one may consider that "validating" a function coming from one scientific discipline with data from the same discipline has much more risks to create a similar loop. We then plea for "validation" steps that implies using sets from other disciplines to lower the risks of such loops.

The complexity of socio-ecological systems is not inherent to a specific discipline or a domain. Interdisciplinary must avoid all reproduction of domination and should – ideally – transcend frontiers of each discipline. Dawn Youngblood (2007) explains that "*what interdisciplinary studies can therefore learn from the bridging disciplines is the importance of not becoming a domain, as domain creates territory and territory creates niche dominance […]*". As a human animals, researchers act – in a certain way – like non-human animals. Ethological studies talk about social animals in a hierarchic community. We have the alpha, the beta and the omega which interact (and fight) for a social position and/or recognition of liability within a territory. Maybe researchers should think about "a-disciplinarity" which is located elsewhere in another space outside of discipline's boundaries.

One may then ask why, if it is so interesting and relevant, it is not so practiced? The answer may come from this clue: Our own observations support the idea that interdisciplinarity is harmful for scholars (Turner, 2002).

So, why it is so hard and boring?

- Interpreting complex phenomena, especially when one looks after a socio-ecological system, is related de facto to the way it is interpreted, i.e. how it is perceived and what part is seen as interesting and relevant: it does have all to do with notions of subjectivity and objectivity, even in science. We do plea for the inclusion of the affective part of each scientist (why do you like this aspect of the object of research?) not as anthropology dealt with it in the past, with a high level of honesty but with a low efficiency in the dialogue with other disciplines, but more as a factor among others.

  In a way, we find complexity (different scientific point of view and/or approach) inside complexity (socio-ecological systems). It could be "hard and boring" because one phenomena generates various complex questions: where and when ends a complex phenomenon? Consider the whole hypothetical variables would allow optimum accuracy of prediction? (Maestripieri and Paegelow, 2013). Are the limit the same between physical sciences, mathematics and social and human sciences? Deffuant et al. (2015) questioned different visions of complexity and have questions about – among others – time and spatial scales, the relevance of Big Data. What about the cognitive status of the individual, unexpected phenomena, uncertainty, multiplicity and instability of itself?

- Again and pursuing on the emotional part that is often neglected, interdisciplinarity implies that one scholar from other sciences may discuss one's own methodologies and results. However, this may have harmful effects and we also plea for a gentleman's agreement for more clarity. Game theory supports the idea that any group, including scholars, does have conflictual relations. Such conflicts are "sociologically normal" and we consider that open formal oppositions are less harmful than hidden agendas. Such a gentleman's agreement may include the necessity for each scholar to involve a moment in the discipline of others with whom he/she wants to collaborate, the formalization of the research construction along management methods such as ARDI (Etienne et al. 2011) or the use of a model which should "force" the dialogue.

- Following the above statement, the creation of an object is like the establishment of a research project. One seeks to place his discipline to have more assets before the project itself. This is reinforced by the powers that be (who owns the management? The financing? The institutional connections). The interdisciplinary problem lies in the use of method. The methods remaining to build, they are most easily influenced by the context and there is no project that is not "the plaything" of extra-scientific aspects. The interdisciplinary is the least armed, because it is naturally under construction. The use of recognized tools (ZADA, ADM, ARDI, and UML) can reduce this confusion but not make it disappear.

- The principle of « each one at home and the sheep will be well kept » is easy, much more than interdisciplinary. Hence the need to seek a compromise and not a consensus. The latter is becoming more inaccessible as partners include a research project (the more people are, the more emergence of conflict is high). According to Mohamed Nachi (2006) "a compromise is a process that develops between partners seeking to reach agreement at the price of some accommodations, modifications, and reciprocal concessions between competing interests." This relates to the question of domination discussed earlier.

Conclusion

There is a palpable cognitive impasse. Many researchers (reinforced by the media image) see science as a collection of data. Otherwise, they are inventors who press the buttons. We, modelers, seeking to make connections, are seen as technicians. This comes back to the original idea of cultural cognition. According to the Cultural Cognition Project (http://www.culturalcognition.net/) it "refers to the tendency of individuals to conform their beliefs about disputed matters of fact (e.g., whether global warming is a serious threat; whether the death penalty deters murder; whether gun control makes society more safe or less) to values that define their cultural identities".

The difficulty is to build a true transdisciplinary approach beyond the emotional aspect. The latter has an impact on the question of the research question, the subject and the object of research (two different things). In short, to question everything.

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[i] *"All other things remainging equal"*