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2008 : August 2008 - Author Commentaries : Dr. Markus Reichstein

AUTHOR COMMENTARIES - 2008

August 2008

PDF

Dr. Markus Reichstein

A Featured Scientist from *Essential Science Indicators*SM

According to an analysis published on ScienceWatch.com *in May, Dr. Markus Reichstein has been named a* Rising Star *in the field of Environment & Ecology. His current citation record in this field in* Essential Science Indicators *from* Thomson Reuters *includes 26 papers cited a total of 611 times between January 1, 1998 and April 30, 2008. He also has Highly Cited Papers in the fields of Agricultural Sciences and Geosciences.*

Dr. Reichstein is the Leader of the Biogeochemical Model-Data Integration Group at the Max-Planck Institute for Biogeochemistry in Jena. In the interview below, he talks with us about his work involving Earth system dynamics.

SW: Please tell us a little about your research and educational background.

The research I am doing can be considered as part of the current Earth System Science endeavor, where we are trying to understand the dynamics and interactions between the major components ("spheres") of our planet Earth, i.e. atmosphere, biosphere, hydrosphere including oceans, the cryosphere, and the humans (anthroposphere). This field of research is quite young and has been in existence for only a few decades, when the Earth was perceived as a whole system. I think both the satellite observation from space (the first photograph coming from Apollo) as well as the development of the Gaia theory by James Lovelock (the Earth as a self-regulating system with the biosphere as major actor) contributed to this new understanding.

I am particularly looking at the interactions between the subsystems atmosphere and terrestrial biosphere (vegetation and soils). One important diagnostic or test case of whether we understand the interactions within the Earth System is the global carbon cycle, since carbon is resident and processed in large quantities in all spheres and obviously the major element of all living and dead organic material. Moreover, carbon interacts with the climate system by absorbing long-wave radiation as carbon dioxide or methane (greenhouse effect), implying a high significance of the carbon cycle for applied topics such as global climate change.

To be successful in this field a broad interdisciplinary and quantitative natural and geoscience background is very helpful. It is interesting to note that at first glance our field largely relies on physicochemical principles of the 19th century (there are no relativistic or quantum effects to be considered), but the challenge is that we are working with very complex systems that are far from thermodynamic equilibrium. Hence, system-oriented and mathematical education and talent are very important. Last but not least, processes always happen in a spatially distributed way at various space scales, i.e., spatial expertise, e.g., through Geostatistics and Geography, is another critical asset.

I studied Landscape Ecology (often also called Geoecology) with Botany, Physical Chemistry, and Mathematics/Information Science as minors at the University of Münster, Germany, graduated with a soil ecological Diploma thesis, and then continued with my Ph. D. work at the Department of Plant Ecology at the University of Bayreuth.

SW: What do you consider the main focus of your research, and what drew your interest to this particular area?

My current main focus is to analyze how the biosphere/ecosystems react to climate variability, i.e., changes in temperature but particularly in water balance (e.g., drought). One crucial observational tool is the direct observation of carbon dioxide, water vapor, and energy fluxes between ecosystems and the atmosphere, which has been accomplished for roughly the past 10 years in a global flux observation network FLUXNET (cf). We try to link these observations to satellite remote sensing of the terrestrial vegetation, watershed runoff data, and atmospheric CO_2 concentration observations to give a regionally-to-globally integrated picture of the "breathing of the biosphere." Hence, one important aspect of the research is to develop data analysis and numerical modeling approaches, which extract the maximum from this plethora of existing and ongoing observations, which contain complementary information.

"The European heat wave of 2003 not only caused thousands of human casualties, but also strongly stressed the terrestrial biosphere."

One big unknown and "final frontier" is what is happening below ground, i.e., in the soil. Soil contains about four times more carbon than the atmosphere, and annual global soil respiration fluxes are, for example, 10-fold higher than human fossil fuel CO_2 emissions. While these respiration processes are performed by soil organisms operating in a very heterogeneous environment, the representation of the soil in current Earth System models is oversimplified and largely neglects the role of biological mechanisms. Thus, in my group we are dedicating large part of our research to overcoming this "dead-soil paradigm."

In our approach we find it crucial to integrate data-oriented modeling techniques (e.g., data mining techniques, machine learning), which allow almost "assumption-free" exploration of patterns in the data, and process-oriented modeling approaches (reductionistically based on physical and biological theoretical principles), which is also reflected in the name of the research group (Biogeochemical Model-Data Integration Group) that I am currently leading at the Max-Planck Institute for Biogeochemistry, Jena.

SW: One of your most-cited papers in our database is the 2005 *Nature* article, "Europe-wide reduction in primary productivity caused by the heat and drought in 2003." Would you walk our readers through this paper and its findings?

The European heat wave of 2003 not only caused thousands of human casualties, but also strongly stressed the terrestrial biosphere. It can be viewed as a natural experiment that let us better understand the response of vegetation and soils to climate variability and extremes. Using integrated observation and modeling systems as described above, for the first time we could quantify the impact of such a dry summer on the terrestrial carbon balance at continental scale. The main two lessons learned were that water as a factor in limiting vegetation and ecosystem productivity is becoming more and more widespread under such conditions (as opposed to temperature effects mostly discussed so far) and that extreme climate events may easily offset any beneficial effect of warming and rising CO_2 concentrations on vegetation productivity.

In the case of the 2003 heat wave we found that this single event undid five years of carbon uptake by the European terrestrial ecosystems—lag effects like tree mortality were not even accounted for. Given that in the future heat waves will become more frequent according to climate model simulations, one might seriously doubt about a continuation of the carbon absorption by the temperate forest ecosystems, which has previously been inferred from temperature-related prolongation of the growing season.

SW: Another of your highly cited papers, the 2005 *Global Change Biology* paper, deals with algorithms for net ecosystem exchange. Would you please talk a little about this aspect of your work?

This paper is a methodological contribution to the above-mentioned FLUXNET, the worldwide observation network of ecosystem-atmosphere CO_2, H_2O, and energy exchange. Analogous to other observation networks like meteorological or astrophysical networks, one crucial aspect is the generation of standardized data products. In this paper an efficient algorithm is presented to separate the net fluxes of carbon dioxide into the major components of gross photosynthetic assimilation by the vegetation and whole-ecosystem respiration, leading to a better process-understanding of the reaction of the terrestrial carbon cycle to climate and other perturbations. Additionally an algorithm to fill gaps inherent in the flux data is presented there. The content of the paper now builds the basis for the global processing of FLUXNET data that is performed in collaboration with my colleague Dario Papale at the University of Tuscia, Viterbo, Italy.

"Sometimes it strikes me a bit ironic that vast amounts of public money and intellectual capacity is spent for investigating life on Mars, while we still have quite limited understanding about the Living Earth."

SW: Where do you see this research going in five to ten years?

We are just at the beginning of learning about manifold role of the biosphere (vegetation and soils) for global and regional climate, biogeochemical cycles, and the Earth System in general. I hope in five to ten years we will have been able to represent this role adequately in a new generation of Earth system models. I believe we will make particular progress with respect to soil carbon processes by turning the current "dead-soil paradigm" into a "living-soil" paradigm.

Moreover, new observation systems and more intimate integration of current ground-based with satellite remote sensing and paleo-observations will hopefully allow us to get deeper insight into various landsurface and biosphere processes.

SW: What should the "take-away lesson" about your work be for the general public?

There is no doubt that we as humans are globally changing the Earth System (most prominently known the climate), which has led to the term "anthropocene" by Chemistry Nobel Laureate P. Crutzen. We definitely need to know more about the crucial system dynamics within our Planet Earth. Earth System Science is both intellectually challenging, and may be necessary to guarantee continued "sustainable" human welfare. Sometimes it strikes me a bit ironic that vast amounts of public money and intellectual capacity is spent for investigating life on Mars, while we still have quite limited understanding about the Living Earth.

Markus Reichstein
Biogeochemical Model-Data Integration Group (SNWG)
Max-Planck-Institute for Biogeochemistry Jena
Jena, Germany

Dr. Markus Reichstein's most-cited paper with 135 cites to date:

Ciais P, *et al*., "Europe-wide reduction in primary productivity caused by the heat and drought in 2003," *Nature* 437(7058): 529-33, 22 September 2005. Source: *Essential Science Indicators* from Thomson Reuters.

Keywords: earth system dynamics, atmosphere, biosphere, hydrosphere, cryosphere, anthroposphere, terrestrial biosphere, soil, carbon dioxide, climate variability, heat wave, drought, FLUXNET, net ecosystem exchange.