eprecot

Abstracts –

Challenge Talks

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Challenge talk 1

Christian Körner, Universität Basel, CH
Plant and community controls of water relations.

Challenge talk 2

Markus Reichstein, Max Planck Institut, GE

John Grace, University of Edinburgh, UK
Can climate models predict rainfall well enough?

Challenge talk 3

Jake Weltzin, University of Tennessee, US
Research on precipitation change and terrestrial ecosystems: Status, observations, needs, and challenges

Plant and community controls of water relations

Christian Körner, University of Basel

A six-step response of plants to increasing shortage in moisture was introduced, with the first three, physiological responses, becoming increasingly unimportant as the second three, namely stand level adjustments, progress during prolonged exposure of plants to low water supply. The ultimate outcome of community adjustment (species succession) is a new, adapted community at lower land cover, which invests in the photosynthetic machinery in such a way, that this investment is not restricted in returns by stomatal action. One challenge in modelling plant and vegetation responses to drought lies in bridging from initial physiological responses to long term community responses. The latter depend on species specific traits hard to quantify and often misleading, as examplified by Mediterranean Junipers. These prominent members of Mediterranean bush and woodland, are superior in their coping with drought under 'normal' Mediterranean summer conditions. Their reduced foliage development (scale leaves) becomes fatal during extreme drought, when other species shed their leaves, and Junipers are desiccated to death, with their green coat of scales in place, because it cannot be shed. Hence extreme events can revert tolerance rankings among taxa under 'normal' conditions, a further challenge in any predictive attempt. Another challenge relates to distance controls among plants through which even lowest moisture regimes can be balanced as exemplified in many desert plants. The greatest of all challenges is perhaps the unknown water holding capacity of soils and rooting depth at continental scales. It may not need more than a per mille of all roots at great depth to balance marginal moisture losses of the vegetation during drought and thus, permit survival. Since plants differ in rooting strategies and produce overlapping rooting zones, community level consequences are very hard to predict, and observational data may be the best proxy, although often lacking mechanistic explanations. This is where drought experiments can make important contributions. A big unknown is still how elevated CO_2-concentrations in the atmosphere will affect plant water relations and regional hydrology, given the direct effect of CO_2 on stomata. Most CO_2 experiments in the field yield significantly smaller effects compared to predictions based on leaf gas exchange theory, and the effects are likely to diminish further as so far unaccounted atmospheric feedback would come into action. However, reductions of evapotranspiration by only a few percent would still have significant influences on the regional water balance.

Soil: the forgotten mediator of ecosystems' response to climate change?

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

In this challenge talk the strong disparity between the complexity of the soil and the highly simplified treatment in most globally operating vegetation models is highlighted. While it is clearly acknowledged the modeling has to be an abstraction process and that from a scientific standpoint a model only has to be changed when it fails to describe observational data, three themes are identified where both theoretical and empirical evidence already show major challenges with respect to soil biogeochemical modeling in the context of climate change. These themes and associated scientific questions include:

1. Vertical heterogeneity and vegetation-soil feedback
    a. How does the vertical structure of the soil influence the ecosystems' reaction to climate change and extreme events?
    b. Is the feedback from vegetation (=carbon) to the soil in altering soil hydrological properties important?
2. Role of soil (micro-)biota in the carbon cycle
    a. To which extent do microbes 'eat up' the CO_2 fertilization effect?
3. Bio-chemical and physico-chemical limitations of soil processes
    a. Which factors determine the apparent Q10 of soil heterotrophic respiration?
    b. How does respiration respond to changed precipitation and soil moisture regimes?

It is shown that there are a number of untested assumptions in current soil carbon models and that the role of soil microbiota is generally underrepresented, which leads me to the notion of 'dead-soil paradigm models'. The scientifically unsatisfying situation is explained with the example of the temperature sensitivity of soil respiration. Here, quite often relationships taken at the ecosystem level (e.g. temperature sensitivity of soil respiration) are directly transferred to the lower ('process') level of organization (e.g. temperature sensitivity of decomposition rate constants), which does not make sense, since observations at the ecosystem level can be confounded by a number of factors. Instead models and observations have always to be matched at the same level of organization. As an example it is shown that the declining apparent temperature sensitivity of respiration with decreasing soil moisture that is observed at the ecosystem level cannot be mimicked by a typical biogeochemical model, where the opposite behaviour is predicted.

Consequently it is questioned that we are able to understand and quantify the role of soils in the earth system in the context of global change including extreme hydrological events without appropriate treatment of those fundamental processes and properties.

In the context of earth system modelling one can draw the analogue that the treatment of the soil today is in a similar state as was the landsurface and vegetation modelling in the 1970s, where vegetation was rather considered as a static boundary condition. A major effort to advance the biogeochemical soil modeling to overcome the 'dead-soil paradigm' is identified as the major challenge.

Can climate models predict rainfall well enough?

John Grace, School of GeoSciences, The University of Edinburgh, Edinburgh EH9 3JN, UK

Land atmosphere fluxes of carbon and heat are very sensitive to quite small changes in precipitation, and so we need to know how precipitation (as a factor of Global Change) is likely to be affected over the coming decades. In the IPCC's Third Assessment Report, the Global Circulation Models different greatly in their predictions. Almost all of them predict an overall increase in precipitation, but the patterns of drying in some critical regions like the Amazon, the Sahel, and Europe are quite different. The reasons we cannot do better in our predictions of rainfall is that (i) the models have grid squares that are orders of magnitude too coarse to be able to model the process of cloud formation and precipitation (ii) the evaporative feedback from vegetation to atmosphere is not well understood and poorly represented in global models (GCMs especially, also in DGVMs) (iii) the capacity of the vegetated land surface to generate aerosols and therefore to form clouds and affect the radiation balance and is not represented in models. Until these issues can be addressed, the model predictions must be regarded as unsafe.

The GCM modelling community is addressing some of these issues, for example there are plans for high resolution modelling (10-250 km) but the ultimate limitation is on computational power. High resolution models embedded within low resolution models have also been useful.

In the meantime, to advance understanding, it is important to focus on the feedbacks between the vegetation and the atmosphere by numerical experimentation, which will require a set of coupled pant-atmosphere models of a type we have not yet seen. This is a challenge for the modelling community, and for ecophysiologists who must collaborate with, and inform, the modellers.

Revised title: Research on precipitation change and terrestrial ecosystems: Status, observations, needs, and challenges

Jake F. Weltzin, University of Tennessee

At the culmination of this workshop, it seems fitting to review the status our understanding of how changes in precipitation regimes might affect terrestrial ecosystems, to provide some of my personal observations from the workshop, and to describe needs and challenges facing the subdiscipline. I will review our progress since the publication of a state-of-knowledge review in 2003 (in BioScience). I will argue that we need a strong conceptual model for future experimental and model-data integration, and that we should consider the development of standardized methodologies and response variables. I will discuss the need to consider spatial and temporal variation in processes and patterns of interest, not only in terms of the response variables, but the driving variables themselves. I also highlight a number of aspects of natural ecological systems that will greatly control their response to changes in precipitation regimes, but that are relatively understudied within this context, or that were not well-considered in most talks here at the Eprecot meetings. These considerations include the role of soils, species interactions, demographic processes, the use of natural gradients, direct versus indirect effects, the role of feedbacks, the difference between effect and response traits, ecotone versus core areas, genetic variation and adaptation, hydraulic redistribution, antecedent conditions, etc. I argue that we must also consider larger socioeconomic and political environments and contexts such as changes in global patterns of fossil fuel availability and consumption. Finally, I point out the need for continued development of an international research network, including additional international meetings.