

## ***Linking models of human behaviour and decision making processes with land system models***

### **Rationale**

Over recent years, Earth System Models have focussed on linking the atmosphere, ocean and terrestrial components in a way that allows for an investigation of the biophysical and biogeochemical feedbacks in the coupled system (Gregory et al., 2009, Raes et al., 2010, Soden and Held, 2006). Human activities have been considered as an external driver to these systems despite the increasing recognition that anthropogenic activities not only impact on the earth system, but also respond to system changes with a series of feedbacks. Human actions mediated through the global land system are critical in understanding the functioning of the broader earth system and its response to global environmental change (Foley et al., 2005; Turner *at al.*, 2007). The land system plays a fundamental role in biogeochemical and biophysical climate feedbacks (Friedlingstein et al., 2006; Betts, 2000), food security (Brown and Funk, 2008; Fischer et al., 2005; Lobell et al., 2008), biodiversity (De Chazal and Rounsevell, 2009) and fresh water supply (Gerten et al., 2005). Land system change is, therefore, one of the key human dimension issues to be represented in biosphere/atmosphere/climate models.

The biogeochemical and biophysical impacts of land system change were initially simulated in dynamic global vegetation models (DGVMs) by substituting forests with productive grassland or simply by harvesting a fraction of the (natural) productivity (McGuire et al., 2001). Only recently have models of terrestrial biophysical and biogeochemical processes started to incorporate managed ecosystems (forests, pastures and crops) into their process representations for applications at regional or global scales (Bondeau et al., 2007, Kucharik and Twine, 2007, Arneth et al., 2010, Gervois et al., 2008). In doing so, the change in land systems over time is prescribed as an artificial means of exploring the resulting effects on carbon or water balances. To date, no other nutrient cycles (e.g. fertilisation) have been considered.

Land systems exemplify the interactions between people and their environment (Reenberg, 2009) as complex, socio-ecological systems. As human activities across the world become increasingly interconnected, the question arises whether such systems are becoming ever more prone to failure (Finnigan's "The diabolical problem"). In understanding these interconnections, land system research has to cope with the substantial challenge of multi- and inter-disciplinarity to bridge the natural science – social science divide (Lambin and Geist, 2006). Yet, in spite of their complexity, the only methods that seek to treat land systems in a fully coupled way at the global scale have been based on reductionist approaches. Integrated Assessment Models (IAMs) or macro-economic models employ simple equations or optimisation based approaches that lack representation of the diversity of human behavioural and decisional processes. Nonetheless, IAMs are important in informing the global environmental change debate, especially with respect to climate change (Nakicenovic et al., 2000). The new generation of IPCC RCP scenarios, for example, will be strongly dependent on IAMs (Moss et al., 2010). Yet in spite of the known limitations of these models in terms of

representing the human dimensions of land system change there are currently no credible alternatives to address questions of sustainable development in a changing environment.

At the local (landscape) scale level there has been considerable effort in modelling human behavioural and decisional processes based on complex systems principles, e.g. agent-based models (ABM), cellular automata and micro-simulation, supported by empirical evidence from social surveys (e.g. Murray-Rust et al. in press; Parker et al., 2003). Insights from these approaches have yet to be incorporated into global scale analyses. Yet, it seems likely that the application of behavioural models at global scale levels which include the necessary realism could improve our capacity to understand the global coupled human-biophysical land system, and this is the basic premise of this workshop.

### **Research questions**

There is clearly a need to make progress on linking terrestrial and climate system models, with models of human dynamics that reflect behavioural and decision making processes. Important questions arise around the existence of feedbacks in the coupled climate change-land change system that are robustly identifiable, and whether there are thresholds and tipping points in the coupled system that can only be addressed with suitable modelling tools.

The workshop aims to discuss innovative ideas to analyze alternative development pathways under global change by explicitly addressing decision making structures within large scale assessments. The focus will be on how we might develop earth system models in the future that better incorporate human processes by moving away from the traditional top-down strategies of IAM and instead exploring the role of human behavioural and decisional models such as ABM, and how these might link to DGVMs. Thus, the workshop will focus on two primary research questions:

1. How can we better represent the land system in earth system models?
2. How can we improve models of the global land system by representing human behavioural and decision making processes?

### **Workshop audience and expected outcomes**

The workshop is targeted at an audience with interests in improving the scientific tools to support innovative ways of integrating our understanding of the human dimensions of global change within the more physically oriented climate system community. Thus, the workshop will involve a range of participants from across the IGBP projects, notably GLP, AIMES and iLEAPS.

The workshop will pay specific attention to the role that science can play within the design and evaluation of alternative development pathways and governance. The workshop will explicitly discuss the shift needed in our scientific tools and models to support such analysis. It will focus on state-of-the-art developments in large scale models and explicitly address the role of governance and decision making within these. The workshop responds to the main challenges identified within the Global Land Project research plan, and is expected to result in the following outcomes:

- The emergence of a community of researchers (across the IGBP themes) with a common set of research goals in coupled land system and earth system modelling;
- A GLP report with some main workshop outcomes that will be freely available and published online very quickly after the workshop

- position paper on the workshop outcomes, and/or a journal special issue;
- A plan for a follow-up session at the IGBP conference in London 2012.

### Venue and timing

A conference centre/resort hotel in the Australian Snowy Mountains has been chosen as the meeting venue. This location offers a delightful ‘off campus’ setting for an intensive, interactive experience. The workshop dates are 28 November-1 December 2011.

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