BP 48: Physics of Sustainability and Human-Nature Interactions II (joint SOE/DY/jDPG/BP/AKE)

Time: Thursday 17:00–18:30 Location: MA 001

Topical Talk BP 48.1 Thu 17:00 MA 001

Critical Transitions in Socio-econo-ecological Systems—A Global Adaptive Model of the Regional Transitions to Agriculture 8000 BC to AD 500 — •Carsten Lemmen and Kai W. Wirtz — Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

Critical transitions in societies emerge as boundaries between cultural "ages", e.g. the transition from the Industrial to the Information Age, or from the Holocene to the Anthropocene. Societal transitions are believed to emerge from nonlinear feedbacks between environment, economy, and society, but hypotheses have been difficult to test so far.

We propose to employ "numerical experiments in history" and consider one of the major critical transitions in world history—the abandonment of a foraging lifestyle in favor of agriculture and pastoralism. We investigate this transition with a deterministic and dynamic model of society. The global model resolves regional-scale human-environment interactions in space and time, based on only few prognostic adaptive societal traits and their co-evolutionary dynamics with population size.

We successfully reproduced the agropastoral transition as seen in archaeological data; we tested demic and cultural hypotheses about its expansion, finding both equally consistent with the data; we explored the stability of the expansion pattern facing large-scale palaeoenvironmental excursions and found strong resilience of populations and their key traits. Our model enabled us to quantify global and regional emissions of CO_2 and the sustainable population size for the past 10000 years.

BP 48.2 Thu 17:30 MA 001

Evaluating a Socio-environmental Complex Adaptive System: The Case of Self-Organized Socio-environmental Development in State Chiapas. — •Felipe Lara-Rosano[1] and Adriana Quiroga-Carapia[2] — [1]Universidad Nacional Autonoma de Mexico (UNAM), Mexico City, Mexico — [2]Colegio de la Frontera Sur (ECOSUR), San Cristobal las Casas, Mexico

The project "Social and Environmental Innovation for Development in Areas of High Poverty and Biodiversity in the Southern Border of Mexico" was proposed by a research institute: the Colegio de la Frontera Sur (ECOSUR), and financed by the Mexican Research Council. Its central objective: to create opportunities for social and environmental innovation on the southern border of Mexico, seeking to strengthen the local capacity for sustainable management of natural resources and the welfare of its inhabitants. Because of the complex system and environment dynamics the solution of the problem is not a fixed one but it is a process that must be continuously evaluated and adapted based on the standpoint of the complex systems paradigm. The assessment of the socio-environmental development project is performed conceptualizing and organizing the community as a complex adaptive system in interaction with its environment. The system has properties expressed as state variables associated with a value that is changing through the development process. The analysis of the system dynamics is based on the behavior of its state variables. The Colegio de la Frontera Sur (ECOSUR) successfully applied this method in rural development projects in state Chiapas in 2013.

BP 48.3 Thu 17:45 MA 001

Macroscopic description of complex adaptive networks coevolving with dynamic node states — •Marc Wiedermann[1,2], Jonathan F. Donges[1,3], Jobst Heitzig[1], Wolfgang Lucht[1,2], and Jürgen Kurths[1,2] — [1]Potsdam Insitute for Climate Impact Research, Germany — [2]Humboldt University, Berlin, Germany — [3]Stockholm Resilience Centre, Stockholm University, Sweden

When investigating the causes and consequences of global change, the collective behavior of human beings is believed to have a considerable impact on natural systems. Here, we study opinion formation and imitation of nodes on a complex network depending on the state of individual resource stocks that are harvested by each node. Numerical simulations reveal that high interaction rates between nodes cause a likely depletion of the resource whereas low interaction rates ensure their sustainable existence. However, adaptively rewiring the nodes' neighborhood structure with an appropriate frequency guides the system into an equilibrium state where all nodes behave sustainably and a full depletion of the resource stocks is avoided. In order to explain these observations, we derive a consistent macroscopic description of the system, which provides a general framework to model and quantify the influence of single node dynamics on the macroscopic state of a network and is applicable to many fields of study, such as epidemic spreading or social modeling. Our results suggest that with the current trend to faster imitation and ever increasing global network connectivity, societies are becoming more vulnerable to environmental collapse if they remain myopic at the same time.

BP 48.4 Thu 18:00 MA 001

Exploring the safe and just operating space in an inhomogeneous world — •Wolfram Barfuss[1,2], Boyan Beronov[1,3], Marc Wiedermann[1,4], and Jonathan Donges[1,5] — [1]Potsdam Institute for Climate Impact Research, Germany — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [3]Ludwig-Maximilians-Universität München, Germany — [4]Humboldt-Universität zu Berlin, Germany — [5]Stockholm Resilience Centre, Stockholm University, Sweden

The Anthropocene has become reality during the 20th century, meaning that our species is pressuring the Earth's ecosystems on a global scale. In the meantime the challenge of eradicating poverty has not yet come to an end. Effectively dealing with these issues requires us to better understand the driving forces, feedback loops and tipping elements in the whole earth system, constituted from natural and social components. To take a step forward in this direction, we refine an existing conceptual coevolutionary model between social and ecological domains by adding inhomogeneities modelled after real-world data. We then propose an analysis framework, 'the safe and just space'-plot, which aligns with the current debate of simultaneously staying within the Planetary Boundaries and ensuring the social foundations and transforms it into a practical tool for studying socio-ecological models as well as real-world observations. First results from comparing the model outcome with real-world data indicate that the current state of the world is neither particularly safe nor particularly just.

BP 48.5 Thu 18:15 MA 001

Topology of Sustainable Management of Dynamical Systems with Desirable States — •Jobst Heitzig[1] and Tim Kittel[1,2] — [1]Potsdam Institute for Climate Impact Research — [2]Humboldt University Berlin

The sustainable management of systems mainly governed by an internal dynamics for which one desires to stay in a certain region of their state space requires an understanding of the topology of the system's state space in terms of what regions are "safe" to stay in, and to what qualitative degree, and which of these regions can be reached from which others by the internal dynamics or by management.

The paradigm of optimal control on the one hand does not provide sufficient concepts for such a qualitative analysis and on the other hand typically requires quite a lot of structural knowledge about the problem, in particular, some or other form of quantitative evaluation of states.

In this talk, we will derive in a purely topological way a thorough qualitative classification of the possible states and management options of a system with respect to the possibility of avoiding or leaving some given undesired region by means of some given management options. Our results indicate that the sustainable management of a system may require discrete decisions such as choosing between ultimate safety and permanent desirability, or between permanent safety and increasing future options, etc.