SOE 14: Focus Session: Dynamics of Socio-ecological Systems

The focus session addresses work on the complex and nonlinear dynamics arising from interactions between social systems and the Earth system with a specific focus on human-made climate change. This includes topics regarding the risks of tipping cascades in the climate system, implications of social inequality for Earth system stability and resilience, or the impact of extreme weather events on public attitudes on climate change

Organized by Jonathan Donges (PIK Potsdam) and Eckehard Olbrich (MPIMiS Leipzig)

Time: Wednesday 11:15–13:05 Location: MA 001

SOE 14.1 Wed 11:15 MA 001

Humans in the loop? Open questions for modelling the Anthropocene — •Malte Vogl and Gesine Steudle — Max Planck Institute of Geoanthropology, Jena, Germany

The Anthropocene is characterized by the fact that the sphere of socio-cultural-technical evolution and the sphere of natural processes can no longer be clearly separated. This stresses the importance of understanding the dynamics of socio-ecological systems, e.g. when it comes to forecasting the effects of climate adaptation and mitigation and their social impacts. A future prognosis as well as an explanation of past events (or back-casting) for such coupled systems depends on various feedback mechanisms.

In this contribution we will present food for thought on how to address this challenges with agent-based modelling. In particular we investigate what essential memory mechanisms and feedback loops are necessary to describe niche-construction-like effects, for example due to the build-up of infrastructure. Here, infrastructure is seen not only in a technical context but can also refer to knowledge structures.

We present work in progress on projects ranging from modelling mobility decisions to build-up of historical archives and discuss their similarities.

SOE 14.2 Wed 11:35 MA 001

Cascading climate tipping events and can society prevent them? — •Nico Wunderling[1,2,3], Saverio Perri[3], Johan Rockström[1,2], Michael Oppenheimer[3], Amilcare Porporato[3], Jonathan F. Donges[1,2,3], Simon A. Levin[3], Elke U. Weber[3], and Wolfram Barfuss[1,4] — [1]Potsdam Institute for Climate Impact Research — [2]Stockholm Resilience Centre — [3]Princeton University — [4]Transdisciplinary Research Area: Sustainable Futures, University of Bonn

Several climate tipping elements such as the Amazon rainforest or the large ice sheets on Greenland and Antarctica are showing increasing signs of dramatic change in response to human-made global warming. While dangerous tipping risks can be reduced by keeping strict temperature guardrails set by international agreements, so far, such agreements have prompted only moderate emission cuts due to socio-political challenges. Here, we couple a conceptual model of interacting climate tipping elements to a simplified social model outlining an energy-production transition toward clean energy. Using this coupled model, we find that three ingredients are required for a fast sustainability transition, achieving a safe sustainability transition without triggering tipping events or cascades: (i) Strong political incentives to invest in clean energies, (ii) high societal pressure to avoid crossing climate tipping thresholds, and (iii) scientific guidance leading to sufficiently small uncertainties in tipping points. If these conditions are met, we reveal that tipping risks can be reduced strongly in particular when uncertainties in tipping element thresholds are reduced

SOE 14.3 Wed 11:50 MA 001

Low-complexity model of climate change, wealth and energy transition to capture political cost of energy policies — •Diana L. Monroy and Frank Hellmann — Potsdam Institute for Climate Impact Research (PIK)

The energy transition is a pathway toward transformation of the global energy sector from fossil-based to zero-carbon technologies. In this context, devising policies that facilitate a transition to low-carbon energy systems requires an understanding of the political and economic costs of energy and climate policy formulation, both in the short and long-term to contribute to a better description of the challenges and determinants of policy choices that impact energy supplies, markets, and consumption.

This work proposes an alternative approach of modelling environmental and socioeconomic dynamics in presence of policy choices using Complex Systems. The objective is to capture the political and economical cost of energy policies based on the main assumption that there is a high political cost of redistributing economic activity.

The model is based in the AYS low-complexity model of climate change, wealth and energy transition incorporating energy policies to mitigate climate change. In the extended model we propose, the co-evolution of the natural and socio-economic system is effected by two main policies: (i) Research Program for Renewable Knowledge and (ii) Carbon Taxation. We use this model to optimize over time the parameters associated to the CCPs.

5 min. break

SOE 14.4 Wed 12:15 MA 001

A modeling framework for World-Earth system resilience: exploring social inequality and Earth system tipping points — •Jonathan F. Donges[1,2], J. Marty Anderies[3], Wolfram Barfuss[1,4,5], Ingo Fetzer[2], Jobst Heitzig[1], and Johan Rockström[1,2] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden — [3]School of Sustainability and School of Human Evolution and Social Change, Arizona State University, Tempe, USA — [4]Transdisciplinary Research Area: Sustainable Futures, University of Bonn, Bonn, Germany — [5]Center for Development Research (ZEF), University of Bonn, Bonn, Germany

The Anthropocene is characterized by the strengthening of planetary-scale interactions between the biophysical Earth system (ES) and human societies. This increasing social-ecological entanglement poses new challenges for studying possible future World-Earth system (WES) trajectories and World-Earth resilience defined as the capacity of the system to absorb and regenerate from anthropogenic stresses. We develop a framework within which to conceptualize World-Earth resilience. Because conventional system concepts of stability and resilience are hampered by the rapid and open-ended social, cultural, economic and technological evolution of human societies, we focus on the notion of pathway resilience, i.e. the relative number of paths that allow the WES to move from the currently occupied transitional states towards a safe and just operating space in the Anthropocene.

SOE 14.5 Wed 12:30 MA 001

The complex dynamics of collective reinforcement learning — •Wolfram Barfuss — University of Bonn

Cooperation at scale is critical for achieving a sustainable future for humanity. However, achieving collective, cooperative behavior – in which intelligent actors in complex environments jointly improve their well-being – remains poorly understood. Complex systems science (CSS) provides a rich understanding of collective phenomena, the evolution of cooperation, and the institutions that can sustain both. Yet, much of the theory in this area fails to consider individual-level complexity and environmental context — largely for the sake of tractability and because it has not been clear how to do so rigorously. These elements are, however, well-captured in multi-agent reinforcement learning (MARL), which has recently put focus on cooperative (artificial) intelligence. However, typical MARL simulations can be computationally expensive and challenging to interpret.

In this talk, I propose that bridging CSS and MARL affords new directions. By treating MARL as a dynamical system, we can study the complex dynamics of collective cooperation emerging from cognitive agency in a given environmental context.

SOE 14.6 Wed 12:50 MA 001

Complex Contagion in Socio-Ecological Network Systems — •Lukas Röhrich[1,2], Fritz Kühlein[1], and Jonathan Donges[1,3] — [1]Potsdam Institute for Climate Impact Research, Germany, EU

— [2]Humboldt University of Berlin, Germany, EU — [3]Stockholm Resilience Center, Sweden

The acceptance of the Anthropocene as the current geological epoch opens up new areas to our understanding of the influence of a social "world" system on the ecological "earth" system. As a highly evolved species, for example, we humans are capable of especially complex behavioral patterns. Evidently, these behaviors are influenced by and influence the ecosystem around us. A modern tool for investigating this feedback between the world and the earth system is complex contagion analysis on socio-ecological networks. This approach describes social systems as adaptive networks where the vertices, representing households, cities, etc., and edges, representing social circles, cultural exchange, etc., are influenced by their social environment as well as their biophysical environment. In this talk we want to present the tool of complex contagion analysis together with two application examples. First, the general Dodds-Watts model which brings complexity to contagion simulations by incorporating individual memory of exposure, variable magnitudes of exposure and heterogeneity in the susceptibility of individuals (P.Dodds and D.Watts, 2005). Second, the more applied MayaSim model, which aims to identify candidate features of resilient versus vulnerable socio-ecological systems, using the ancient Maya as an example (S.Heckbert, 2013).