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Tipping Points in the Earth System: An introduction to the TiPES project

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There is rising concern that several subsystems of the Earth may respond highly nonlinearly at critical future levels of anthropogenic forcing; these levels have recently been associated with tipping points (TPs). It is paramount to identify safe operating spaces for humanity and the planet in terms of these critical forcing levels, in order to prevent harmful transitions to alternative, undesirable states of the Earth system. The mechanisms leading to such abrupt transitions are only partly understood, and further research in this regard is urgently needed. State-of-art Earth System Models appear to respond too smoothly at TPs and have difficulties in simulating abrupt transitions that occurred in the planet's history. TiPES will address these problems from several angles: 1. The project will identify subsystems that may exhibit abrupt transitions, and couplings between them, by focussing on paleoclimatic records and abrupt transitions therein. Novel methods to detect Early Warning Signals of forthcoming TPs, and to make skilful predictions on their basis, will be developed. 2. The potential shortcomings of models in representing TPs will be evaluated; in particular, TiPES will investigate how Bayesian calibration techniques can help enable these models to simulate past abrupt transitions. 3. TiPES will develop a generalized theory of climate sensitivity that accounts for the presence of TPs and feedbacks across various time scales. 4. To define safe operating spaces. TiPES will focus on dynamical system theory and on global stability notions for non-autonomous systems in order to estimate the stability of desirable states. 5. The results obtained by the project will be communicated to policy makers in a manner that facilitates decisions and their implementation. TiPES will develop formal approaches to define the socioeconomic risks of crossing TPs, and to derive decision strategies to keep anthropogenic forcing below levels where abrupt transitions may occur.