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An extension of SURFER to study tipping cascades on multiple time scales

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Tipping cascades are series of tipping events in the Earth system where transitions in one subsystem can trigger further transitions in other subsystems. In previous work, we demonstrated that the near-linear relationship predicted by GCMs between global temperature and cumulative greenhouse gas emissions for the next century can break up at millennial time scales due to cascades involving slower tipping elements such as the ice sheets. This means that we must consider tipping cascades also from a long-term perspective. Subsequently, we need fast models that encode the relevant physical processes and that we can calibrate on more comprehensive models. In this context, we present an extension of the SURFER model (Martínez Montero et al. 2022) that incorporates sediments and weathering feedbacks in the carbon cycle submodel (Archer et al. 2009), and an additional set of coupled tipping elements. This model may be used both as a surrogate for more computationally expensive models, for example in the context of decision-making problems, and as an exploratory tool to investigate the climate response's sensitivity to specific processes on long-time scales.

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