Extreme sensitivity and climate tipping points

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The equilibrium climate sensitivity (ECS) is widely used as a measure for possible future global warming. It has been determined from a wide range of climate models, observations and palaeoclimate records, however, it still remains relatively unconstrained. In particular, large values of warming as a consequence of atmospheric greenhouse gas increase cannot be excluded, with some of the most recent state-of-the-art climate models (CMIP6) supporting (much) more warming than previous generations of climate models. Moreover, a number of tipping elements have been identified within the climate system, some of which may affect the global mean temperature. Therefore, it is interesting to explore how the climate systems response (e.g. ECS) behaves when the system is close to a tipping point.

A climate state close to a tipping point will have a degenerate linear response to perturbations, which can be associated with extreme values of the equilibrium climate sensitivity (ECS). In this talk we contrast linearized (‘instantaneous’) with fully nonlinear geometric (‘two-point’) notions of ECS, in both presence and absence of tipping points. For a stochastic energy balance model of the global mean surface temperature with two stable regimes, we confirm that tipping events cause the appearance of extremes in both notions of ECS. Moreover, multiple regimes with different mean sensitivities are visible in the two-point ECS. We confirm some of our findings in a physics-based multi-box model of the climate system.

Reference

P. Ashwin and A. S. von der Heydt (2019), Extreme Sensitivity and Climate Tipping Points, J. Stat. Phys. \textbf{370}, 1166–24. http://doi.org/10.1007/s10955-019-02425-x.