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Detection of climate system bifurcations by degenerate fingerprinting

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The question whether thresholds exist in the climate system and under which anthropogenic emission scenarios they might be transgressed, is of vital importance. A method is introduced to estimate the proximity of climate sub-systems to non-linear thresholds. We suggest to measure the smallest decay rate of the system under investigation and to consider its trend [1]. We argue that this is the diagnostic variable most directly linked to the distance from a bifurcation threshold. With the climate model of intermediate complexity CLIMBER2 we demonstrate our method for the North Atlantic thermohaline circulation. It is shown that proper analysis of paleo information could significantly reduce the uncertainty which plagues current estimates of the distance from the shutdown of the thermohaline circulation. was demonstrated only for low-dimensional THC box models and very long time-series. Here, we investigate whether similar indicators can also be constructed for complex natural or numerical systems, and how long the time-series need to be in a more parsimonious approach. We base our approach on the most fundamental, modelindependent property of any bifurcation: the fact that the smallest system-immanent decay rate k for perturbations of the equilibrium vanishes and the variability of the related mode diverges.

[1] H. Held and T. Kleinen, *Detection of climate system bifurcations by degenerate fingerprinting*, Geophys. Res. Lett. **31**, L23207 (2004).