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Tipping Points: Early warning and wishful thinking

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Climate changes and especially the risk of rapid and irreversible changes is of great socioeconomic concern. Abrupt transitions from one statistically steady state to another occur in many complex dynamical systems. Common for these are that crossing a critical threshold can lead to a structural change of the system. This is mathematically described as a bifurcation, which gives the hope that the generic dynamical behavior at bifurcation- or tipping points may be observed even with only imperfect knowledge of the dynamics of the system. It would be especially useful if early warning signals prior to a climate transition could be identified, and perhaps even prevented. The two generic characteristics of the approach to a bifurcation point is increased variance of the observed signal, following from the fluctuation-dissipation theorem and the corresponding increased autocorrelation, related to critical slow down. These two signals are connected, and the detection of only one and not the other, cannot be taken as a sign of an approaching tipping point. This is contrary to what was recently claimed (Dakos et al., PNAS, 105, 14308-14312, 2008; Scheffer et al.,Nature, 461, 53-59, 2009). We shall in the following show this, assess the statistical significance and examine these two signals for the most pronounced observed climate jumps, the Dansgaard-Oeschger events and the termination of the last glacial period. The conclusions drawn is that these most probably are not generated by bifurcations: They are noise induced transitions without early warning signals. This means that it is necessary to understand the full non-linear structure of the climate system, including assessing the influence by an external perturbation (such as increased greenhouse gas concentrations) on the short time scale fluctuations (noise), which might push the system into a different (quasi-)stationary state.