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The role of stochastic forcing in rapid climate transitions

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Even though Moore's law in computing has permitted huge progress in climate modeling, so that more realism in simulating the present climate is achieved, only modest progress has been made in understanding the rapid climate changes documented in the paleoclimatic record. The reconstructions mostly rely on long time series of proxies, representing the climatic variations at a given location. They thus contain signals of both local and global dynamics. The feedbacks in the climate system can lead to non-linear responses to perturbations, even so that the system may undergo bifurcations and thus very rapidly change from one climate state to another. This has been recorded in various paleoclimatic proxies. The causes for and possible predictions of the rapid climate changes are poorly understood. The most pronounced changes observed, beside the glacial terminations, are the Dansgaard-Oeschger events. Present day general circulation climate models simulating glacial conditions are not capable of reproducing these rapid shifts. It is thus not known if they are due to bifurcations in the structural stability of the climate or if they are induced by stochastic fluctuations. By analyzing a high-resolution ice core record in terms of the non-linear stochastic climate dynamics, we exclude the bifurcation scenario, which strongly suggests that they are noise induced and thus have very limited predictability. This questions the possibility of performing predictions of the third kind; defined as prediction of rapid changes in the climate statistics, which may be predictable in the Lorenz' sense of predictions of the second kind.