Geophysical Research Abstracts
Vol. 14, EGU2012-6405, 2012
EGU General Assembly 2012

Characterisation of stochastically-induced climate jumps to other histories paced by the astronomical forcing.

B. De Saedeleer

Université Catholique de Louvain, Earth and Life Institute - Georges Lemaître Centre for Earth and Climate Research, Louvain-la-Neuve, Belgium

The mystery of ice ages induced by a varying incoming solar radiation has drawn ceaseless attention for several decades. A pleiad of paleoclimatic models has been developed in order to have a try at catching the underlying climate dynamics, and their validity is challenged by comparison with typical milestones in paleoclimatic records.

In several published works, the astronomical forcing synchronises the climate to a unique climatic attracting trajectory representing the ice volume evolution. Other studies, though, reported multistability, i.e. the fact that several climatic attracting trajectories could coexist for some given set of parameters, in a deterministic framework. More importantly, it has been illustrated that additional disturbances may cause some 'jumps' from one trajectory to other ones in the climatic history over the last millions years of the Pleistocene. These stochastic effects hence indirectly affect the timing of the glacial inceptions and terminations. The jumping mechanism is closely linked to the widely spread hypothesis that the glacial-interglacial cycles could be primarily triggered by random internal climate variability.

A conjecture has recently been made that these externally triggered jumps are the most likely when the temporary desynchronisation (positive largest local Lyapunov exponent) due to the loss of local stability coalesces with the weakening of the global stability due to the proximity to the basin boundary. No proof of this conjecture has however been provided sofar; it is precisely the aim of the present research to assess the conditions for such a jump to occur.

We uncover the details of the underlying mechanisms by providing a systematic numerical study of the conditions under which these jumps are likely to occur. Extensive Monte Carlo experiments are performed in order to show that the jumps occur preferentially at specific times or locations in the phase space, for a given level of noise. We show how the most critical times are related to those corresponding to a minimum distance between the current attracting trajectory and the boundary of its basin of attraction. The exact role of the magnitude of the perturbation is also investigated in depth.

Our approach relies on several concepts and tools borrowed from dynamical system theory, like attractors (more precisely, attracting trajectories in the non autonomous case),
basins of attraction, global and local stabilities, quasiperiodicity, from modern mathematical theories like the pullback attractor, and also from statistical analysis.

We first use a simple stochastic toy model (a van der Pol-like relaxation oscillator for which reasonable qualitative agreement with ice volume proxies is easily found) in order to illustrate the fundamental mechanisms. The analysis is then extended to other published paleoclimatic models to illustrate the fact that the conclusion could be generalised, with a potential impact on the overall theory of ice ages, as such jumps reduce the predictability of the timing of the glacial inceptions and terminations.