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Simple oceanographic and paleoclimate modeling highlights the same dynamical process: intrinsic variability paced by a deterministic forcing

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Within the climate model hierarchy, simple models usually play the important role of highlighting dynamical processes that can possibly govern climate phenomena. If, in addition, their results are in significant agreement with observations, the processes thus identified are even more likely to regulate the actual phenomena. In this context, the dynamical process of intrinsic variability paced by a deterministic forcing (also called deterministic excitation, DE [1]) is highlighted here by two simple models of different degrees of complexity and set in the different contexts of paleoclimate and physical oceanography. In both cases, despite the simplicity of the models, the results show significant agreement with observations.

The DE mechanism requires the system (i) to possess intrinsic nonlinear relaxation oscillations (ROs) and (ii) to be in the excitable state (i.e., ROs do not emerge spontaneously but can be excited, and therefore paced, by a suitable forcing); moreover, (iii) ROs are excited by a deterministic forcing if a given tipping point is passed.

In the first case [1], the abrupt late Pleistocene glacial terminations are shown by a conceptual model to correspond to the excitation, by the astronomical forcing, of ROs describing glacial-interglacial transitions (e.g., [2]). In the second case [3], ROs describing the Kuroshio Extension low-frequency variability [4] are shown, by a primitive equation ocean model, to be excited remotely by the North Pacific Oscillation. These results show how simple modeling approaches of different complexity advance process understanding and can, therefore, provide theoretical guidelines for interpreting state-of-the-art ESM results.

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