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Coherence resonance in climate dynamics: an oceanic paradigm

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It is well known that adding a noise to the forcing of a nonlinear system can, in some cases, have a constructive effect, with the result of producing a peak in the spectral density of the response. In such a context, "coherence resonance" (CR) is a term referring to those phenomena for which a noise forcing enhances internal modes of a nonlinear system in the absence of a periodic forcing. Such mechanism is very relevant in climate dynamics: for example, CR with bistability and delay feedback has been invoked in order to explain the 100-kyr glacial-interglacial transitions of the Quaternary (Pelletier 2003), and CR in excitable systems is the mechanism proposed to explain the existence of Dansgaard-Oeschger events (Ganopolsky and Rahmstorf 2002). These examples refer to the coupled ocean-atmosphere system, but are there cases in which CR acts in the ocean system alone?

In this communication a case of CR acting in a wind-driven ocean circulation model is presented. A circulation model of the North Pacific Ocean forced by steady winds is shown to produce (in a parameter range just before a homoclinic bifurcation) a Kuroshio Extension (KE) jet that resembles the weak contracted state observed in altimeter data, but no strong elongated KE state arises. However, if a mechanistic noise modeled by an Ornstein-Uhlenbeck stochastic process is superimposed to the wind forcing, then a chaotic decadal KE relaxation oscillation in significant agreement with altimeter observations can be excited. It is shown that a white noise wind is not able to excite the oscillation, while a red noise wind with a decorrelation time larger than 0.1 yr can efficiently excite it. This behavior is likely to be paradigmatic of the low-frequency variability of western boundary current extensions of intrinsic origin, at least in cases in which such variability is in the form of a relaxation oscillation resulting from a homoclinic bifurcation.