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Dynamics and predictability of a low-order wind-driven ocean - atmosphere model

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The dynamics of a low order coupled wind-driven Ocean-Atmosphere (OA) system is investigated with emphasis on its predictability properties. The low-order coupled deterministic system is composed of a baroclinic atmosphere for which 12 dominant dynamical modes are only retained (Charney and Straus, 1980) and a wind-driven, quasi-geostrophic and reduced-gravity shallow ocean whose field is truncated to four dominant modes able to reproduce the large scale oceanic gyres (Pierini, 2011). The two models are coupled through mechanical forcings only.

The analysis of its dynamics reveals first that under aperiodic atmospheric forcings only dominant single gyres (clockwise or counterclockwise) appear. This feature is expected to be related with the specific domain choice over which the coupled system is defined. Second the dynamical quantities characterizing the short-term predictability (Lyapunov exponents, Lyapunov dimension, Kolmogorov-Sinaï (KS) entropy) displays a complex dependence as a function of the key parameters of the system, namely the coupling strength and the external thermal forcing. In particular, the KS-entropy is increasing as a function of the coupling in most of the experiments, implying an increase of the rate of loss of information about the localization of the system on his attractor. Finally the dynamics of the error is explored and indicates, in particular, a rich variety of short term behaviors of the error in the atmosphere depending on the (relative) amplitude of the initial error affecting the ocean, from polynomial $(at^2 + bt^3 + ct^4)$ up to purely exponential evolutions. These features are explained and analyzed in the light of the recent findings on error growth (Nicolis et al, 2009).

References

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