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Statistical and Dynamical Properties of Covariant Lyapunov Vectors in a Coupled Atmosphere-Ocean Model – Error dynamics.

Stéphane Vannitsem (1) and Valerio Lucarini (2)

(1) Royal Meteorological Institute of Belgium, Meteorological and Climatological Research, Brussels, Belgium (stephane.vannitsem@oma.be), (2) Meteorologisches Institut, University of Hamburg, Hamburg, Germany

We study the dynamics of the error in a simplified coupled atmosphere-ocean model using the formalism of covariant Lyapunov vectors (CLVs), which link physically-based directions of perturbations to growth/decay rates. The model is obtained via a severe truncation of quasi-geostrophic equations for the two fluids, and includes a simple yet physically meaningful representation of their dynamical/thermodynamical coupling. The model has 36 degrees of freedom, and the parameters are chosen so that a chaotic behaviour is observed. Furthermore, for some specific coupling strength a Low-Frequency Variability is developing reminiscent of the North Atlantic Oscillation.

Different behaviors of the error were found depending on the specific norm chosen to measure the amplitude of the error. For the L2 norm, a super-exponential behavior is found, inducing a mean error amplification in the stable subspace described by the CLVs dominating the error dynamics within the ocean. This behavior disappears when the logarithmic norm is used, except for a few CLVs in the highly degenerate subspace defined by CLVs 6-10 for which complicate mixing and amplifications arise. Furthermore the long term dynamics of the error considerably changes when the LFV is developing in the system. When the LFV is not developing, the error saturation arises on different time scales associated to the variables under considerations, while once the LFV is present, the error along all variables of the model – and in particular of the atmosphere - is saturating on the longer time scales associated with the dynamics of the ocean. The implications of this error dynamics on the predictability of the coupled ocean-atmosphere system at short, medium and long term are discussed.