Geophysical Research Abstracts
Vol. 18, EGU2016-5560, 2016
EGU General Assembly 2016

Covariant Lyapunov Vectors in a Coupled Atmosphere-Ocean Model - Multiscale Effects and Geometric Degeneracy

Valerio Lucarini (1,2) and Stephane Vannitsem (3)

(1) University of Hamburg, Institute of Meteorology, Klimacampus, Hamburg, Germany (valerio.lucarini@zmaw.de), (2) Department of Mathematics and Statistics, University of Reading, Reading, UK, (3) Institut Royal Meteorologique de Belgique, Brussels, Belgium

We study 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. One finds two positive Lyapunov exponents (LEs), sixteen negative LEs, and eighteen near-zero LEs. The presence of many near-zero LEs results from the vast time-scale separation between the characteristic time scales of the two fluids, and leads to nontrivial error growth properties in the tangent space spanned by the corresponding CLVs, which are geometrically very degenerate. Such CLVs correspond to two different classes of ocean/atmosphere coupled modes. The tangent space spanned by the CLVs corresponding to the positive and negative LEs has, instead, a non-pathological behaviour, and one can construct robust large deviations laws for the finite time LEs, thus providing a universal model for assessing predictability on long to ultra-long scales along such directions. Finally, it is somewhat surprising to find that the tangent space of the unstable manifold has strong projection on both atmospheric and oceanic components, thus giving evidence that coupled modes are responsible for the instability of the flow.