On the use of near-neutral backward Lyapunov vectors to get reliable ensemble forecasts in coupled ocean-atmosphere systems

Stéphane Vannitsem\textsuperscript{1} and Wansuo Duan\textsuperscript{2}
\textsuperscript{1}Royal Meteorological Institute of Belgium, Meteorological and Climatological Research, Brussels, Belgium (svn@meteo.be)
\textsuperscript{2}LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China

The use of coupled Backward Lyapunov vectors (BLv) for ensemble forecast is demonstrated in a coupled ocean-atmosphere system of reduced order, the Modular Arbitrary Order Ocean-Atmosphere sytem (MAOOAM). It is found that the best set of BLvs to build a coupled ocean-atmosphere forecasting system are the ones associated with near-neutral or slightly negative Lyapunov exponents. This counter intuitive result is related to the fact that these sets display larger projections on the ocean variables than the others, leading to an appropriate spread for the ocean, and at the same time a rapid transfer of these errors toward the most unstable BLvs affecting predominantly the atmosphere is experienced. The latter dynamics is a natural property of any generic perturbation in nonlinear chaotic dynamical systems, allowing for a reliable spread with the atmosphere too. The implications of these results for operational ensemble forecasts in coupled ocean-atmosphere systems are discussed.