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# Representation of fine scale atmospheric variability in a nudged limited area quasi-geostrophic model: application to regional climate modelling

H. OMRANI, P. DROBINSKI, and T. DUBOS

Laboratoire de Météorologie Dynamique, Institut Pierre Simon Laplace, CNRS/Ecole Polytechnique/ENS/UPMC, Palaiseau, France

In this work, we consider the effect of indiscriminate nudging time on the large and small scales of an idealized limited area model simulation. The limited area model is a two layer quasi-geostrophic model on the beta-plane driven at its boundaries by its « global » version with periodic boundary condition. This setup mimics the configuration used for regional climate modelling.

Compared to a previous study by Salameh et al. (2009) who investigated the existence of an optimal nudging time minimizing the error on both large and small scale in a linear model, we here use a fully non-linear model which allows us to represent the chaotic nature of the atmosphere: given the perfect quasi-geostrophic model, errors in the initial conditions, concentrated mainly in the smaller scales of motion, amplify and cascade into the larger scales, eventually resulting in a prediction with low skill.

To quantify the predictability of our quasi-geostrophic model, we measure the rate of divergence of the system trajectories in phase space (Lyapunov exponent) from a set of simulations initiated with a perturbation of a reference initial state. Predictability of the "global", periodic model is mostly controlled by the beta effect. In the LAM, predictability decreases as the domain size increases.

Then, the effect of large-scale nudging is studied by using the “perfect model” approach. Two sets of experiments were performed: (1) the effect of nudging is investigated with a « global » high resolution two layer quasi-geostrophic model driven by a low resolution two layer quasi-geostrophic model. (2) similar simulations are conducted with the two layer quasi-geostrophic LAM where the size of the LAM domain comes into play in addition to the first set of simulations. In the two sets of experiments, the best spatial correlation between the nudge simulation and the reference is observed with a nudging time close to the predictability time.