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Interactive comment on "Multiple scale error growth in a convection-resolving model" *by* F. Uboldi and A. Trevisan

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We welcome the reviewer comments that will help clarify some points in the manuscript.

1. The main goal of this paper is to characterize the error growth at various dynamical scales and the introduction of model error would have obscured the interpretation of results. However model errors, which are present in operational systems, constitute an important limitation for all improvements that can be obtained by assimilating observations. In the conclusions of the revised manuscript we will stress that the error reduction obtained for the trajectory with larger initial error by removing the error component on the bred subspace is obtained in absence of model (and boundary) error. We agree that this is necessary, to caution the reader against too optimistic an interpretation of our result.

2. The referee raises a question about the compatibility of the initial error that we used in the experiments with the "present-day analysis error". The only similitude that we claimed is the amplitude of the initial error. If the results of our investigation depended crucially on the spatial structure or the spectrum of the initial error, the referee's objection would be relevant. However it is not so, for the following reasons.

A. We investigate here the predictability properties of error growth as a dynamical property of the model equations, whereas the structure of the analysis error in operational systems not only depends on the model, but also on the observational network and on the assimilation scheme.

B. The memory of the detailed structure of the initial error in the smallest scales of the non-hydrostatic model is lost in a very short time. This is because the lifetime of the convective scales, whose statistical properties are related to the model dynamics, is extremely short. That error growth properties, after an initial readjustment, do not depend on the spatial structure or spectrum of the initial error, but on the instabilities of the model has been discussed in several papers; see for example the work by Tribbia and Baumhefner (2004) and Harlim et al. (2005) and the discussion in Trevisan and Palatella (2011). What is typical of a convection-resolving model is that initial details are lost very quickly.

C. The results shown and discussed in the present paper refer to two experiments that start from different initial amplitudes of the the error. In the second experiment the initial error is obtained by rescaling the amplitude of the first experiment initial error, while keeping the same spatial structure. The rate of growth of the error in the two experiments is very different in an initial period, the one starting with smaller amplitude error being much larger than the other (see Fig. 1 and Fig. 3). This clearly shows that what is important is the amplitude, not the spatial structure of the initial error.

In summary, the results indicate that in the non-hydrostatic model the lifetime of the convective scales is so short that their detailed structure can be considered as noise in the error evolution and their statistical properties are independent of the details of the initial condition.

As a final comment we point out that the procedure used in the experiments is very similar to what is often done in the operational practice, when the state used as the initial condition for a non-hydrostatic model is taken from a hydrostatic model that also provides boundary conditions. This procedure implies the absence, in the initial control state, of small and fast scales typical of a convection- resolving model. These dynamic scales, that are present in reality, are also present in the trajectory of our experiments that we call the "truth" as we chose to give enough integration time for them to develop.

3. Breeding is a consolidated technique, which has been used for over 20 years, and is well documented in literature. In addition to the references provided in the first version of the manuscript, in the revised version we will add a reference to the book by E. Kalnay (2003), which represents an introduction to many topics in data assimilation and predictability, including breeding. Moreover, for a discussion of the perturbative equations relevant for breeding in both an unforced dynamical system and a in system forced by the assimilation of observations, see Section 2.1 of the paper by Uboldi and Trevisan (2006).

REFERENCES

E. Kalnay: Atmospheric Modeling, Data Assimilation and Predictability. Cambridge U.P., 2003.

Harlim, J., Oczkowski, M., Yorke, J. A., Kalnay, E. and Hunt, B.: Convex error growth patterns in a global weather model. Phys. Rev. Lett. 94, 228501, doi:10.1103/PhysRevLett.94.228501, 2005.

Trevisan, A. and Palatella, L.: Chaos and weather forecasting: the role of the unstable subspace in predictability and state estimation problems. Int. J. Bifurcat. Chaos, 21, 3389–3415, doi:10.1142/S0218127411030635, 2011.

Tribbia, J. J. and Baumhefner, D. P.: Scale interactions and atmospheric predictability: An updated perspective. Mon. Wea. Rev. 132, 703–713, doi:10.1175/1520-0493(2004)132<0703:SIAAPA>2.0.CO;2, 2004.

Uboldi, F. and Trevisan, A.: Detecting unstable structures and controlling error growth by assimilation of standard and adaptive observations in a primitive equation ocean model. Nonlin. Processes Geophys., 13, 67–81, doi:10.5194/npg-13-67-2006, 2006.

Interactive comment on Nonlin. Processes Geophys. Discuss., 1, 447, 2014.