Nonlin. Processes Geophys. Discuss., 1, C527–C530, 2014
www.nonlin-processes-geophys-discuss.net/1/C527/2014/

Nonlinear Processes in Geophysics
Discussions
Open Access

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

F. Uboldi and A. Trevisan

uboldi@magritte.it

Received and published: 26 September 2014

We have modified the manuscript, taking into account the remarks of both referees. In particular, both referees raised questions concerning model error and breeding: since a generic reader might also have similar doubts, we introduced a new short section after the Introduction, entitled "Preliminary Remarks", where we explain why we didn't introduce model and boundary error and where we give references for the reader not particularly familiar with breeding.

For the sake of clarity, there we added a short remark concerning the association between different dynamical scales in the main flow and different instability growth rates. On this point, we also added a footnote (N.3, page 10; see also below).

Answers to comments by Referee 1

We think we already gave satisfactory answers to all specific points raised by Referee 1 in the comment we provided during the open discussion phase. Accordingly, we made corrections to the manuscript in the newly introduced Section 2 "Preliminary Remarks" and in the Conclusions (page 16, line 517 of the revised manuscript). Concerning Referee 1 generic comment that our manuscript is "rather speculative", we think that we have fully motivated our discussion, even when, as we say explicitly, we propose a synthesis (Section 7.1, page 14, lines 454 to 467 of the revised manuscript).

Answers to comments by Referee 2

1. Model error

We agree with Referee 2 that the model error issue (as that of boundary error for limited-area models) is important in the general context of NWP and Data Assimilation. However, as we wrote in our public answer to Referee 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". In the revised version of the manuscript, we introduced a new Section, "2 Preliminary Remarks" where we clarified the reasons why we chose not to introduce model (and boundary) error. On this point, Referee 2 says: "In my opinion, the model errors have had major impacts on the results in Figures 1-4 and 8 showing the error growth features as a function of forecast lead time". Since model error is not introduced in our perfect-model twin experiments (model and boundary conditions are the same, only the initial conditions differ) it cannot have any impact on our results.

2. Bred vectors, rescaling and scale selection

Referee 2 states that "When a bred vector is scaled up or down by constant values, the spatial pattern is not changed". This is correct, but the scale selection that is obtained by using different rescaling parameters (amplitudes and time intervals) occurs

when features that are characterized by fast growth and small spatial scale reach their saturation amplitude between renormalization times: convective cells are a good example. The choice of different breeding parameter for selecting the different instability scales was introduced by Toth and Kalnay (1993). In the present paper, the different properties of bred vectors that select different, fast and slow, instabilities is widely documented: Figs. 2-6. In particular, the spectra of Fig. 2 show how the many fast and competing "convective modes" and the small number of slower modes can be selected by respectively choosing small and large rescaling amplitude of the BVs.

In the new Section 2 "Preliminary Remarks" we provide more references for the breeding method.

In the new Section 2 and in the new footnote 3, page 10, we comment on the size of spatial signals present in errors and perturbations (BVs). In footnote 3, speaking of instabilities associated to larger dynamical scales, we say: "In fact they dominate the growth of the whole vector norm, even if small-scale signals corresponding to saturated unstable structures may still be present and, locally, some of them may even still be growing".

Specific points

1. Corrected, thanks.

2. The control state is the state of the unperturbed trajectory. We corrected the text in the revised manuscript in Sections 3 and 4 using "reference" trajectory instead of "control" to avoid confusion with later Sections:

- Section 3, page 4, line 121: "control trajectory" changed to: "reference trajectory"

- Section 4, page 5 line 146: "added to the control state at 00:00 UTC" changed to: "added to the nonlinear model reference trajectory at 00:00 UTC"

- Section 4, page 5 line 159: "by adding, to the control state" changed to: "by adding, to the state of the reference trajectory"

3. The sentence is clear. That of twin experiment is a standard procedure: a model trajectory is taken as the "true" trajectory and a control trajectory, originated from a different initial condition, is compared with it. In our case we considered two control trajectories, with two different initial errors âĂŤ this is why there are two curves in Fig. 1

4. The TUV scalar product is dimensionless because, as we say few lines above, each variable has been normalised with its own variability.

5. It really is an additional set. We modified this sentence in the revised version and added, in a footnote (n.4, page 12): "Since 12 BV was the maximum allowed by computer memory in one run, it has been necessary to save on disk all states (i. e. all T, U, V components on the whole 3-dimensional grid) of the previous 12-vector set at all orthogonalisation times and read them from disk during the new run to perform the Gram-Schmidt orthogonalisation on the 24 vectors".

6. Corrected, thanks.

7. We spell-checked and re-read the manuscript and made corrections.

REFERENCES

Toth, Z. and E. Kalnay, 1993. Ensemble Forecasting at NMC: the generation of perturbations, B. Am. Meteorol. Soc., 74, 2317–2330.

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