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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Technical Note: Description and assessment of a nudged version of the new dynamics Unified Model" *by* P. J. Telford et al.

Anonymous Referee #2

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Technical note by Telford et al.

The paper is a technical note, presenting the implementation of the nudging method in the UM model and demonstrating its results for a simulation "nudged" for 1999/2000. As such it does not present new scientific findings.

General comments:

The paper introduces the nudging method briefly, then presents statistics of the simulations. What is missing is a more careful explanation of the following issues, which are important for the potential user of this method in the UM model, or in other models:

Conservation / sinks and sources: The nudging method was invented to steer the GCM gently along the time trajectory of the analysed atmospheric state, acknowledging that even a perfect model cannot follow the observed time series due to the incomplete knowledge of the atmospheric state. In this ideal case very small "nudging" increments added to the modeled tendencies would be sufficient to keep the model on track. The nudging would not correct for biases. In the real world AGCMs have systematic errors and a plain nudging scheme affects the seasonal means or climatologies of the model. Generally, nudging schemes as presented here introduce net sources and sinks of momentum or energy in the model atmosphere, which modify momentum fluxes (e.g. surface stress) or the energy cycle, with possibly unwanted side effects. For example: AGCMs like the UM are tuned to represent realistically the observed average radiative fluxes at the top of the atmosphere, for given realistic lower boundary conditions. If the nudging scheme corrects biases in the temperature structure of the atmosphere, the radiative fluxes will adjust, and the original TOA radiative balance of the AGCM is changed. Analogous effects may be observed for surface fluxes etc. A priori, it is not clear that the correction of a modeled field with respect to analyses is not deteriorating another field. (Example: assimilating observed tropical moisture in ERA-40 is related to the excess in convective precipitation.) These problems should be addressed in the introduction.

Scale separation: The ERA-40 analysis represent instantaneous states of the IFS model atmosphere including the assimilated observations. Hence, ERA-40 fields may include slowly propagating large scale fluctuations as well as fast and small scale fluctuations, which are often considered as "noise". The nudging method is usually applied with the aim to include the slow and larger scale waves, preferably without the "noise", requiring the filtering of the original analyses for the wanted slow modes of variability. In spectral models, this filtering has been implemented through reduction of the considered wave number space. This issue should be discussed, and it should be explained why no attempt is made here for such a scale separation.

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Diabatic vs. adiabatic heating errors: Temperature (or theta) differences occurring in a nudged simulation can result from inaccurate diabatic or adiabatic tendencies. While nudging the temperature field is useful in the former case, it should not be applied in the latter case, where a dynamic adjustment should indirectly correct the temperature error. The authors should explain this potential problem. In which atmospheric regions could this be relevant? Is this problem the case for the tropical stratosphere?

Specific comments:

Equation 2: As this is a technical report, it should be explained if (2) is implemented explicitly or implicitly. An implicit implementation would provide better numerical stability. Currently (2) does not indicate the time levels of the involved variables. If an explicit implementation is used, this should be justified.

Figure 1: Axis labels are much too small

Evaluation of RMSE, Bias, TC and SC: - This should make use of 6 hourly data, so that the quality of the simulated diurnal cycle has an influence on the results. - Why is April not included in the assessment?

Table 1 and 2: The entries in the Mean and Bias column are not clear. I assume that "Mean" minus "Bias" should result in the mean of the ERA-40 reference field. This seems not to be the case, for example:

Table 1, Theta, level 29: Mean-Bias = 416.2-0.0=416.2K Table 2, Theta, level 29: Mean-Bias = 420.1-3.4=416.7K –> difference of 0.5K

3.1.1. line 4: ... giving evidence ...

Discussion of Figure 2 and 3: The presence of sea ice seems to have an influence on the RMSE. Has ERA-40 used the same sea ice data in 1999/2000 as used here in UM?

p.4, right, line 3: The nudging, as applied here, also introduces small scale "noise"

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from ERA-40, since no filtering has been applied. The UM is nudged also towards small scales, using the same 6 hour timescale. The statement on the nudging of (only) large scale dynamics (line 3) must be revised.

3.1.2: Would it be possible to infer from the bias correction resulting from the nudging the cause of the bias?

3.1.3: What is the expectation value for TC of the unadjusted simulation? Beyond the timescale of predictability of weather, TC is not meaningful to describe the performance of the unadjusted simulation, especially if the diurnal cycle is excluded by using only daily time series.

3.2, above Table 4: The low TC in the tropical omega does imply that the tropical variability in omega500 in UM is not compatible with that in ERA-40, but does not prove errors in the precipitation of the analysis.

Table 5: the ratios are surprisingly high, going beyond the original idea of gently steering the model along the analysed time series. Obviously the UM model requires relatively heave nudging, at least in some regions of the atmosphere (near tropopause, convectively active regions in troposphere ...). Does this have implications for the usefulness of the nudging in the comparison of modeled processes with observations? Should regions with heavy nudging be avoided?

In conclusion the paper demonstrates that the nudging works efficiently in the UM model. The authors should however explain better the limitations and risks of applying the nudging technique.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 17261, 2007.

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