Atmos. Chem. Phys. Discuss., 12, C678–C681, 2012
www.atmos-chem-phys-discuss.net/12/C678/2012/

Interactive comment on "Differences between downscaling with spectral and grid nudging using WRF" *by* P. Liu et al.

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Received and published: 17 March 2012

We thank the reviewer for the thorough, thoughtful and constructive comments. Italicized responses to each of the comments are listed below.

Comments: The authors discussed the spectral versus grid nudging. However, to make the case more complete perhaps they could describe the no-nudging results as well. Another missing information is the procedure in performing both temporal and spatial average to derive Table 1 and 2, and related results. Are these temporal means and standard deviations of domain averages, or otherwise? If it is the former, perhaps the spatial distributions of monthly mean or alike should be provided (similar to Figure 4).

Results from the simulations without nudging are now presented. Table 1 and 2 show the mean and standard deviations of the similarity of certain simulation episode. For every 6 hours, the mean and standard deviation of similarity are calculated (as described in equation 1 on page 1196).A clarification will be added.

In Page 1195, first 6 lines (the last paragraph of Section 2), the authors described to which variables the nudging had been applied. They might want to further indicate whether these decisions are made based on previous study (with reference) or not. Curious about nudging on pressure field, the geopotential field is nudged in spectral nudging, not in grid nudging, could this affect the model performance?

For the grid nudging in WRF, horizontal wind components are typically nudged at all vertical layers and temperature and water vapor mixing ratio are only nudged above PBL. This strategy is based on the studies by Stauffer et al. (Stauffer, D.R. and N.L. Seaman, 1990: Use of four-dimensional data assimilation in a limited-area mesoscale model. Part I: Experiments with synoptic-scale data. Mon. Wea. Rev., 118 , 1250-1277; Stauffer, D.R., N. L. Seaman and F. S. Binkowski, 1991: Use of four-dimensional data assimilation in a limited-area mesoscale model. Part II: effects of data assimilation within the planetary boundary layer. Mon. Wea. Rev., 119 , 734-754). For spectral nudging, same nudging strategy is used within PBL to keep the simulation consistent with grid nudging, and above PBL, temperature, horizontal wind components and geopotential fields are nudged, instead of water vapor mixing ratio, which does not have large-scale features as strong as other fields and would not be nudged in the spectral nudging of WRF.

Nudging geopotential field does not affect the results significantly, since temperature and horizontal wind are always nudged in both grid and spectral nudging for the cases we studied. We tested the spectral nudging without geopotential field. The results of similarity, monthly averaged cloud fraction and monthly accumulated precipitation (as in Fig.4 on page 1211) show little difference compared with the spectral nudging with geopotential field.

It was described in Page 1196 Line 22 that the NCEP/NCAR data was interpolated into WRF's fine-resolution grids, what is the interpolation method? In the next page it was mentioned that these interpolated data would be aggregated again back to coarse resolution for large-scale comparison. Is this really necessary? Can the field back to 2.5x2.5 degree converge to the original field? It seems that only a linear interpolation could reach this but the linear interpolation would not create an ideal fine-resolution field.

To get NCEP/NCAR data with WRF's fine-resolution grids, we used the interpolation methods provided in the WPS (WRF Preprocessing System). The primary interpolation method for temperature, wind and relative humidity is "simple sixteen-point average interpolation", which requires sixteen valid source points to do linear interpolation. If the valid source points are not enough, "Four-point bi-linear interpolation will be used, which requires for valid source points. Otherwise, "Simple four-point average interpolation" will be used, which requires at least one valid points from four source points and average the values of all valid values among the four points.

It is necessary to average the grids back to coarse resolution for large-scale comparison, because otherwise, it would be very difficult to align the simulation results with NCEP/NCAR data.

WRF uses interpolation methods mentioned above to get initial conditions and boundary conditions for the simulation (or other information needed to be updated from the driving fields during the simulation), and the WPS has been specifically designed for WRF to generate fine-resolution data from coarse-resolution. Hence, the aggregation will not skew the properties of original field, although it will not exactly reproduce the original field because of the alignment of grids and minor differences from interpolation.

Page 1197, the second paragraph generally discusses how to use the consistency between NARR and NCEP/NCAR data in large-scale and small-scale to judge the model's performance. However, the consistency between these two datasets at least

in small scale seems irrelevant to the issue. A direct evaluation using NARR and WRF fine-resolution results should be sufficient for the small-scale features.

Instead of the WRF resolution of 36 km, 300km is chosen as the small scale in order to capture features that occur at multiple grids, which are more reliably captured by RCMs than individual grid cells. Therefore, we prefer to use the similarity at the small scales to judge the model's performance, rather than compare NARR with WRF fine-resolution results directly.

The comparison of modeled convective cloud and accumulated precipitation is discussed in the second paragraph in p.1200. The authors made a conclusion that spectral nudging provided better results on both variables in the compared case. It appears not so simple at least for precipitation. Over east costal land area, while both the spectral and grid nudging overestimated precipitation comparing to NARR data, the grid nudging seems doing so to a much lesser extent. By the way, both variables reflect the model performance in handling subgrid scale processes. The authors might want to discuss further the reason behind this result, e.g., why KE nudging in certain method could affect subgrid scale convection and precipitation more effectively, assuming the same convective parameterization along with other relevant schemes were used.

Compared with NARR data (Fig. 4d), spectral nudging (Fig. 4e) generated the similar rainfall region over the east coast, although the rainfall region has not completely moved away from the land to the ocean. Grid nudging (Fig. 4f) did not generate this feature at all; this is attributed to grid nudging being too strong and surpressing the generation of convection at the regional scale. Given the above, we conclude that spectral nudging performed better than grid nudging.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 1191, 2012.