Geoscientific

Model Development

Discussions

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Interactive
comment

Interactive comment on "Adding Four Dimensional Data Assimilation by Analysis Nudging to the Model for Prediction Across Scales – Atmosphere (Version 4.0)" *by* Orren Russell Bullock Jr. et al.

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Comment: Biggest problem I see is that in Figures 10-14 – the RMSE for the NCEP FNL data on its own without MPAS is not included. Is that because it is not a standard output within the NCEP FNL data? If it does exist it should be included in those plots. Otherwise we don't know whether we are actually getting additional value from this product. a. This issue needs to be resolved or at the very least explained before publication. Maybe the RMSEs need to be compared against those from the CMAQ model. b. If this paper is the first step to creating a competitive product it needs to say

so.

Response: While surface values for 2-meter temperature, 2-meter water vapor and 10-m wind are included in the NCEP FNL product, these data are not used in the generation of the FDDA target fields. As with analysis nudging in WRF, the analysis nudging we have developed for MPAS only uses target values defined on vertical layers within the model's computational grid. Also, the NCEP FNL data are only available at 6-hour intervals. But to satisfy our curiosity arising from this comment, we evaluated the NCEP FNL surface data against hourly METAR observations in the CONUS region using linear time interpolation to get the same hourly time resolution we used for the MPAS-A evaluation. The results showed superior accuracy compared to our MPAS simulations. Since METAR observations are used directly in the generation of the NCEP FNL surface values, this finding of superior accuracy is not surprising and comparison of MPAS-A and NCEP FNL regarding their agreement with METAR data is not really a fair assessment of the value added from analysis nudging. Nonetheless, that finding of superior accuracy does gives us confidence that the NCEP FNL product is a good basis for the generation of FDDA target fields, especially near the surface, and that nudging layers near the surface might lead to improved MPAS simulations if it can be done without disrupting the evolution of the simulated planetary boundary layer (PBL). This sort of disruption is why we have avoided nudging in the PBL for air-quality modeling purposes. We see this issue as a prime candidate for future work, but outside the scope of this effort.

Regarding sub-comment (a), we assume this suggests a comparison of MPAS-A with WRF. The physics parameterizations we use in WRF to support CMAQ modeling were designed specifically for air-quality assessment at a finer spatial scale than we used here. For this work, we were constrained to the physics options already available in MPAS-A. As a separate effort, we have begun work to add those special physics options to MPAS-A and will be applying them at 12-km horizontal resolution for comparison to WRF.

Regarding sub-comment (b), we have no intentions to develop a product in competition with CMAQ. Limited-area models will continue to have appropriate applications in both meteorological and air-quality simulations.

Comment: I am struck by the gross similarity between FDDA target and MPAS with FDDA in Figures 2-8. It would be good to see plots where the differences between FDDA target and MPAS with FDDA were presented.

Response: We added difference plots to Figs. 2-5 (now Figs. 2-3 and 6-7) and updated the discussion to describe the results. Adding difference plots to the vertical cross section and wind vector figures has proven to be difficult. We hope the additions we made will be sufficient. If not, additional time will be required for software modifications and new graphics preparation.

Comment: Can you give some theoretical reasoning for choosing the time-scale forcing to be around 55 minutes – it seems to be a bit on the strong side. The weaker forcing for q is around 9 hours. Maybe this exists in the WRF version.

Response: The time scale we adopted in MPAS is the same as the default value in WRF. The theoretical reasoning comes from Stauffer and Seaman (1990) where they equate that nudging time scale to that of meteorological phenomena at the meso-α spatial scale. This is now explained in the revised manuscript at the end of section 2.3. Our use of a longer time scale for moisture nudging in MPAS comes mainly from our experience with WRF where stronger nudging created too much cloudiness, too little downward shortwave radiation and degraded evaluation statistics at the surface. As shown in this work, weaker moisture nudging produces slightly better model accuracy.

Comment: Pg 3 Can the paper be a bit more specific on the details of how the NCEP FNL data is created?

Response: The exact process used by NCEP is continually being modified as their base modeling platform evolves and as new observational data become available (e.g.,

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GOES-Next). The cited web reference for the NCEP FNL product provides a "Documentation" tab where various aspects of the NCEP FNL product are discussed. The availability of this information is indicated in the revised manuscript.

Comment: Throughout the paper the resolution of the NCEP FNL data is described in terms of 1-degree resolution which is around 100km. Given that MPAS resolution is described in terms of km can you mention the FNL data resolution in km to avoid the readers needing to do the conversion themselves.

Response: 1 degree of longitude is variable in physical length depending on latitude. Thus, it is not possible to describe the 1 x 1-degree resolution in terms of specific physical length. But the revised manuscript now mentions that the spatial resolution of the NCEP FNL product approximates that of the coarse portion of the MPAS mesh used in this study.

Comment: What is the timestep of the MPAS model?

Response: We used a timestep of 150 seconds as indicated in Table 1.

Comment: Can you use Figure throughout and not have a mixture of Figure, Fig. and (Fig. 9) on pages 6-10?

Response: With one exception, the original manuscript used the standard convention of "Figure" when starting a sentence and "Fig." otherwise. That exception on page 7, line 5 has been corrected.

Comment: Pg 9 line 11 RMSA -> RMSE

Response: This correction has been made.

Comment: Pg 9 line 30 remove dot: For January 2013

Response: That period was intended to be a comma. This has been corrected.

Comment: Pg 26 and Pg 27 Figures 7 and 8 need to include hyphen between 500 and

300 hPa

Response: These corrections have been made.

Comment: The plots in Figure 16 do not print out well. Can the units be included in the graph?

Response: Figure 16 shows mass values over time scaled to their starting value. Thus, no units are appropriate for these graphs. These graphs could be separated into individual figures for "total moist air mass", "total water vapor mass" and "total dry air mass", thus making the graphs larger and easier to see in print. This seems to be a print-versus-web formatting issue and we will defer to the editor as to whether Figure 16 needs to be expanded into three separate figures.

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