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Geoscientific Model Development Discussions

Interactive comment on "WRF-CMAQ two-way coupled system with aerosol feedback: software development and preliminary results" *by* D. C. Wong et al.

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Dear Mr. Reviewer,

Thank you so much for the positive and constructive comments and here are our responses: (notation: C – Referee's comment, R – Authors' response)

C: Pg. 2420, line 16 (I think you meant Pg. 2419, line 16) What do you mean with "at the science process level"?

R: It just denotes an additional option for user to choose at the top level.

C: Pg. 2420, line 23 Please add Skamarock 2008 to the WRF reference (you can leave

Michalakes et al in there additionally)

R: It has been added.

C: Pg 2421, line 11 "may not be physically realistic". This statement is a bit harsh for this reviewer. You may want to use something like "errors maybe introduced" or such.

R: The following sentence

Without such feedback, the meteorological model may not be physically realistic.

has been replaced with

Without such feedback, errors maybe introduced into the meteorological model.

C: Pg 2422, line 4 "1-30km" You may want to add "1-30km, but WRF is also being used on Large Eddy Simulation Scale (dx 100m or smaller) as well as on global scales" You can probably find references on the NCAR WEB.

R: followed the suggestion and added the following reference

Moeng, C. H., Dudhia, J., Klemp, J., and Sullivan, P., Examining Two-Way Grid Nesting for Large Eddy Simulation of the PBL Using the WRF Model, Monthly Weather Review, Vol. 135, 2295 - 2311, June 2007

C: Pg 2422, line 9 And "may" include turbulent ...

R: done

C: Pg. 2424, line 23 What numerical effects would you see on the WRF domain boundaries and not on the CMAQ domain boundaries? Why is there a difference?

R: The discussion on the domain configurations has been modified to clarify how and why the chemistry-transport calculation domain is specified relative to the WRF domain. The coupler allows the user flexibility in specifying the "relaxation zone" as in WRF, wherein the model is relaxed toward the large scale forecast represented by the boundary conditions. We modified the following two sentences on page 2424 line 20:

Figure 2 illustrates the typical domain configurations of the WRF-CMAQ coupled system; in this the chemistrytransport calculations are performed for a sub-domain of the larger WRF domain to avoid numerical effects associated in the vicinity of the WRF domain boundaries. In general, users can choose how many grid cells to trim off at run time, but five grid cells is the recommended minimum.

Figure 2 illustrates the typical domain configurations of the WRF-CMAQ coupled system; in this the chemistry-transport calculations are performed for a sub-domain of the larger WRF domain. In typical WRF applications, to avoid numerical effects associated in the vicinity of the domain boundaries, a relaxation zone is specified where the model is nudged or relaxed toward the large-scale forecast (Skamarock et al., 2008). The coupler allows the users to specify the size of this zone; users can choose how many grid cells to trim off for the chemistry-transport calculations at run time, but five grid cells is the recommended minimum.

C: Pg 2425 The RSL / RSL-LITE discussion is useless, since RSL-LITE is not used anymore in WRF (since years). If you are not using RSL for CMAQ then you should explain differences better if you want to make a point. This could also be an interesting part of the paper if more detail and attention is given to it. What does using a coupler do to parallel performance. The table 2 would be much more interesting if a comparison would focus on parallel performance (not CAM versus RRTMG), maybe a difference to WRF could be shown (it can also be found on the NCAR WEBsite for the CONUS domain with 12km horizontal resolution !). A speedup of 2.3 when going from 32 to 128 processors on this type of domain is not very good. WRF scales much better, even with fewer computations in general. Where is the bottleneck, and can it be improved. Is the coupler the issue, or is the CMAQ parallelization deficient.

R: We started our work with WRF 2.2 which used both RSL and RSL-lite. RSL and RSL-lite used different decomposition strategies and the our coupler is able to handle both automatically. Even though RSL was dropped starting from WRF 3.3, in this article, we still mentioned RSL so entire development history was provided in a very

brief way. On the CMAQ side, it uses a different strategy to decompose the domain. As a result, one of the tasks for the coupler is to bridge the differences in WRF and CMAQ domain decomposition.

The coupler is an additional code in the twoway model. It is crucial to show that it won't be a substantial burden to the model as well as in the parallel environment. In addition, our direct aerosol effect only implemented with CAM and RRTMG radiative schemes. Hence, we explicitly showed the coupler performance and the parallel performance of the twoway model with CAM and RRTMG schemes in Table 1 and 2, respectively.

We agree that a speedup of 2.3 when going from 32 to 128 processors on the Eastern US domain has room for improvement. CMAQ requires about ten input files and creates about ten output files (files primary are in netCDF format) as well as intermediate run time diagnostic messages from each processors. The I/O depends on a third party package, IOAPI_3 and we are thinking to re-engineering the I/O and hope it will improve the parallel efficiency.

C: Pg 2429, line 19 Those scaling numbers do not look good to this reviewer. (also Pg 2434, line 27)

R: The scaling numbers are not impressive but we believe they are acceptable. Please see the above response for addition information.

C: Pg 2430, paragraph 1 Needs more info on what is done in CMAQ. What physics are diferent, what info is used from

R: replaced the following two sentences

In CMAQ, the CB05 chemical mechanism was used. The same subgrid vertical transport of meteorological and chemical species was used in both WRF and CMAQ following ACM2.

with

In CMAQ, the CB05 gas-phase chemical mechanism and the modal aerosol model known as AERO5 (Carlton et al., 2010) were used. The same subgrid vertical turbulent transport of meteorological and chemical species was used in both WRF and CMAQ following the ACM2 PBL scheme. Note that WRF and CMAQ use different scalar advection schemes that are both monotonic and positive definite for meteorological and chemical species. However, differences in numerical formulations and time steps allow subtile differences in the 3-d mass fields to accumulate over time. Mass conservation and consistency between chemical concentrations and air density is ensured in CMAQ by adjustment of the vertical velocities according to a layer-by-layer solution of the 3-d mass continuity equation at every time step. In this design chemical species are advected in CMAQ by an efficient scheme that has very little numerical diffusion: the piecewise parabolic method (PPM) (Colella and Woodward 1984). A potential drawback of this approach is the inconsistencies between advective transport of microphysical scalars in WRF and advection of gas and aerosol species in CMAQ. While such discrepancies are likely very small they could be important for modeling aerosol indirect effects which result from interactions between aerosols and cloud microphysics. The significance of these inconsistencies will be assessed as implementation and testing of indirect aerosol processes continues.

and two additional references:

Carlton, A. G., Bhave, P. V., Napelenok, S. L., Edney, E. O., Sarwar, G., Pinder, R. W., Pouliot, G. A., and Houyoux, M., Model representation of secondary organic aerosol in CMAQv4.7. Environmental Science and Technology, 44, pp. 8553-8560, 2010

Colella, P. and Woodward, P. R. The piecewise parabolic method (PPM) for gas-dynamical simulations, J. Comp. Phys., 54, 174-201, 1984.

Interactive comment on Geosci. Model Dev. Discuss., 4, 2417, 2011.