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Geoscientific Model Development Discussions

Interactive comment on "Grid-Stretching Capability for the GEOS-Chem 13.0.0 Atmospheric Chemistry Model" *by* Liam Bindle et al.

Anonymous Referee #2

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General Comments

The manuscript describes the advantage of stretch-type grid refinement in atmospheric chemical transport models. The simulation and computational performances of a stretched-grid experiment are evaluated compared to those of a global quasi-uniform grid with similar horizontal resolution. The effectiveness of the more aggressive grid refinement in California with strong pollutant emissions and complex topography was also evaluated by comparing TROPOMI tropospheric NO2 column densities. The methodology is straightforward and the results are concise. However, the manuscript's content looks like a technical note on using the GEOS-Chen model in stretch mode. I could find neither substantial advances in chemical transport modeling nor novel ideas to share with the reader. In my opinion, it requires major revision before ready for publication.

As the authors mentioned in the introduction, one of the advantages of using stretch grids is that down-scaling similar to 2-way nesting can be easily achieved without lateral boundaries. However, there are also side effects when reducing the spatial resolution outside the target region: In Figure 4, there appears to be a systematic bias in the ozone concentration in the free troposphere. It is necessary to investigate whether such a bias is due to changes in ozone precursors' transport pathways outside the focal region. With the recent improvement in computer performance, atmospheric simulations using thousands or tens of thousands of CPU cores are no longer unusual. In terms of time-to-solution, the stretch calculation of C180e-US is only 2.5 times faster than that of C180-global. The authors should consider whether they will tolerate the side effects and reduce computing resource consumption by just a few hundred cores.

In more aggressive stretching experiments, the advantage of high resolution should be examined from multiple perspectives. Many regional chemical transport simulations have already shown that higher resolution emission data can reproduce the tracer concentration distribution near the emission source. The authors should emphasize the advantages of the grid-stretched global chemical transport model that are not present in the regional model. For example, I want to know what advantage there is in keeping the resolution around New York at the same degree as in the non-stretch experiment. Besides, the author should evaluate that they chose a higher resolution than the meteorological field. I recommend adding a stretch calculation experiment with a resolution close to that of the meteorological field. If that resolution gives almost the same results as the 10km resolution in this study's evaluation method, there is no need to use the 10km resolution.

Specific Comments

Introduction: Although it is mentioned in Harris et al.(2016), Tomita(2008) should be referred to, as a previous study of global atmospheric models with stretch grids using the Shumidt transform. The studies of Goto et al.(2015) and Trieu et al.(2017), which simulated atmospheric chemical transport on the stretched grid, should also be cited.

Lines 38-46: It seems to me that almost all the tools to realize stretch calculations were available before this study, and there are no technical problems to be solved to perform chemical transport calculations on a stretched-grid. I would like to see a clarification of what the authors contributed to the implementation.

Lines 65-66: Is the meteorological field re-gridded for both horizontal and vertical, and if so, how is the transformation applied between model grids with different topography?

Lines 66-67: Does the model solve the stratospheric chemical processes, and if not, how is the stratospheric gas (ozone) concentration given?

Lines 135-136: The number of vertical layers and each layer's altitude in the meteorological field is the same as in the GEOS-Chem settings? How much higher is the top altitude for the meteorological field than for the GEOS-Chem simulations?

Lines 136-137: For which time period was this simulation performed?

Lines 154-155: I want to know why the authors did not align the Face center of the hexahedron between the focal region of the C96e-NA and the C96-global.

Lines 163-164, Figure4: 1) In order to clarify the difference in the free troposphere, please show the results for the layer near the surface and the layer above the surface separately. 2) As mentioned in the major comment, the difference in ozone concentration in the free troposphere (left panel) appears to be bias rather than scatter. I would like to see further analysis of this. 3) In the figure for OH, the colors are largely different between the right and left figures. In the left figure, where did the red dot around 0.1-0.2ppt go?

Lines 204-205, Table2: 1) The differences in the number of grid points and the number of time steps (time intervals) between the C180-global and C60-global experiments are not described. Since the relative difference in computational workload can be approximated by the number of grid points and the number of time steps, this information is necessary to evaluate the computational performance. 2) It is not stated how many

months of calculation results were used for the comparison. Recently, the unit "Simulation Year Per wall clock Day (SYPD)" is often used to express the elapsed time of a simulation. This should be added.

Lines 224-225, Figure8: Some people don't even know which is north for LA or SF. I don't know which area is the Mojave Desert. Please add a mark to the figure.

Lines 231-233: 1) I interpreted that the authors upscaled the 0.25degx0.3125deg meteorological data to a grid resolution of $\sim$100 km in the C90-global experiment and interpolated it to a grid resolution of $\sim$10 km in the C900e-CA. Does this mean that a spatial resolution of 0.25degx0.3125deg is sufficient to represent the concentration gradient around LA? 2) To discuss why the concentration gradients were well reproduced, it is necessary to evaluate whether the higher resolution of the emission or the higher resolution of the meteorological field was more effective. Previous researches should be presented. Or sensitivity experiments should be conducted, such as using upscaled, low-resolution emission inventories or meteorological fields in high-resolution experiments. 3) GEOS-Chem is a transport model, and the wind field is a given. I want the authors to show the benefits of usage of higher resolution than the meteorological field for vertical transport, diffusion and chemical reaction in detail. The 10km-mesh simulation provide a better representation of the concentration gradient near the emission source than the 0.25deg-mesh? I would like to see an analysis of the ozone production/dissipation balance, etc.

References

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