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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Introduction to the SPARC Reanalysis Intercomparison Project (S-RIP) and overview of the reanalysis systems" *by* Masatomo Fujiwa et al.

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We thank anonymous referee #2 for their thoughtful suggestions on this manuscript, which helped to identify several important aspects of the reanalysis systems that were either not clearly documented or not documented at all in the initial submission. To address these suggestions, we have added a table (SST and sea ice boundary conditions), added a figure (CO2, methane, and total solar irradiance boundary conditions), and expanded the text in several locations.

There have been previous intercomparisons of reanalyses, including some discussion of the stratosphere. A paragraph mentioning some of these intercomparisons and lessons learned would strengthen the context of the current paper.

In terms of comprehensive intercomparisons, the SPARC Intercomparison of Middle Atmosphere Climatologies is more than 10 years old, and included only two of the reanalysis systems that we consider (NCEP-NCAR and ERA-40). We have added a sentence referencing that intercomparison more explicitly (p.3, l.10–13). Quite a few subsequent studies have looked at certain aspects of reanalysis performance in the upper troposphere and stratosphere, including the 12 papers referenced in the original manuscript (removed at referee #1's suggestion) and several others published between 2004 and 2012. It is difficult to summarize these in a concise way, beyond the current note that "different results may be obtained for the same diagnostic" (p.3, l.14). In this revision, we have instead chosen to prioritize other material that is more specific to reanalysis structure, and is often not as well documented (treatment of model upper layers, horizontal and vertical diffusion, boundary conditions, examples of how the structure of a reanalysis system propagates into the products of that system). Inclusion of a sufficiently comprehensive summary of lessons learned would likely require a more radical reorganization (such as splitting the paper into two; see response to referee #1).

In Section 3, Page 8, it is noted that a key difference between the assimilation systems is the height of the top level of the model and vertical resolution. What is not mentioned in the paper is the treatment of the upper layers of the model. I postulate that the scientific foundation of many of the differences that are revealed will be related to the upper boundary and its treatment. Therefore, it would be useful to tabulate whether or not there is a sponge layer, the depth of the sponge layer and the dissipative methods that are used in the sponge layer – Rayleigh friction, enhanced horizontal diffusion, etc.
A description of the treatment of the upper layers in each model and a brief discussion of associated issues has been added (p.9, l.8–31).

Since one of the applications of stratospheric reanalyses is to understand tracer transport, it would be useful to have a table of how the models, in general, treat

diffusion – second order, fourth order, Rayleigh friction, etc.
A summary of approaches to both horizontal and vertical diffusion (in the free atmosphere) have been added (p.11, l.19 through p.12, l.9). We do not describe parametrizations of vertical diffusion in the boundary and surface layers, which differ more substantially, although we do note that this information is provided in Chapter 2 of the S-RIP interim report (currently under review).

In both the text, Page 8, and the tables, the spatial size in km should be given for all of the models. Presently it is in degrees for some models and km for others. Consistent presentation of technical information should be checked throughout.
We chose this approach because grid sizes are invariant in degrees for regular grids but approximately invariant in km for reduced grids. We have considered including the grid spacing in km at the equator, but opted against it because this calculation is easy to do and we feel that including it in the table could dilute the intended emphasis on what it means for a system to use a regular grid versus a reduced grid.

Coming from a numerical background, the equating of "resolution" with "grid cell size" always bothers me. Generally, I live with my idiosyncrasy. However, the statement in Section 3, Page 8, that the "effective horizontal resolution is . . ." is one I cannot let past. Since, effective resolution of weather and climate models is a topic of some controversy, with several lines of research, this is a term than should be used correctly. This is grid size, not the effective resolution, which will be 6 to 10 times the grid size.
Thank you for pointing this out. References to resolution here and in the column heading for Table 2 have been replaced with "grid spacing".

I would like to see tabulated information on the treatment of CO2 and CH4 (Page 9) and aerosols (Page 10) in the radiative schemes. Since these reanalysis cover a span of time when climate is, definitively, not stationary, the treatment of the greenhouse gases seems fundamental. From the text, the treatment varies greatly from model to model, and I can't differentiate one treatment from another

in the current text. As with the treatment of the upper layers of the model, I would expect the treatment of greenhouse gases and aerosols to have significant impact upon the science-based interpretation of the systems. Hence a quick summary table would be useful.
We have added a figure (Fig. 4) that summarizes the various treatments of CO2, CH4, and TSI, and revised the text to better clarify which aerosol (p.12, l.28–31) and greenhouse gas (p.13, l.14–23) boundary conditions correspond to which systems. We have also added a brief description of the aerosol assimilation used in MERRA-2 (p.13, l.1–7), which was omitted from the original submission.

Similar to previous comment, I would like to see more description, table perhaps, of the sea-ice treatment in the models (Page 10). The changes in Arctic are large. There are trends in area of polar isotherms in the upper troposphere and lower stratosphere; more details of the treatment of the Arctic boundary conditions are needed.
We have added a table (Table 4) listing the sources of SST and sea ice boundary conditions used by the various reanalyses, along with grid sizes, temporal resolutions, and reference information where available. We have also added a reference to Bosilovich et al. (2015), who discussed these differences in more detail and prepared a summary figure that includes most (but not all) of the reanalysis systems examined in this paper.

In the sentences, page 13, the use of the word "attempt" to describe the 3D-Var and 4D-Var assimilation systems is peculiar. I assume that they do, in fact, do the optimization calculation.
The word "attempt" has been removed.

Page 15. Like sea-ice, I could imagine a tabulation of how water vapor (Page 21) is treated in the upper troposphere and stratosphere would be useful for science-based interpretation.
The current text hits all the major points (see also new paragraph from p.25, l.10–17); for the sake of brevity we have chosen not to repeat this information in table form. A

tabular presentation of the same material will be available in Chapter 2 of the S-RIP report.

Just by chance, I just saw that Jim Pfaendtner's name is misspelled in the Helfand reference (Page 31). It is spelled as "Pfaentner," and it should be "Pfaendtner."
This has been fixed, along with other assorted typos and errors.

References
Bosilovich, M., et al.: MERRA-2: Initial evaluation of the climate, NASA Tech. Rep. Series on Global Modeling and Data Assimilation, NASA/TM–2015-104606, Vol. 43, 2015.

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