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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Strong modification of stratospheric ozone forcing by cloud and sea ice adjustments" *by* Y. Xia et al.

Anonymous Referee #1

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General Comments

Using experiments from a single global climate model (CAM3), this study examines the radiative effects of stratospheric ozone recovery. The key conclusion of the study is that, while the radiative forcing of stratospheric ozone recovery is positive (ozone recovery leads to a slight warming of the global-mean surface temperature), the radiative effects become negative when cloud and sea ice adjustments are included (ozone recovery leads to a slight cooling of the global-mean surface temperature). Overall, this is a useful contribution to the literature, and I recommend publication after the following revisions are addressed.

Major Revisions

This paper serves as a converse of the ozone depletion paper of Grise et al. (2013),

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who concluded that, although stratospheric ozone depletion has a negative radiative forcing, the cloud changes due to stratospheric ozone depletion induce a net warming effect on the climate system. Given that both studies use the same CAM3 model and examine stratospheric ozone changes, it is surprising that the authors did not appreciate the strong connection between the two studies. This is especially important because a key shortcoming of the Grise et al. (2013) study was the use of CAM3. The clouds in the newest version of CAM (version 5) have substantially improved from version 3 (see Kay et al. 2012). As a result, subsequent studies have shown that the conclusions of Grise et al. (2013) are likely not robust, at least in terms of Southern Hemisphere mid-latitude clouds and how they respond to tropospheric eddy-driven jet shifts (Kay et al. 2014; Ceppi et al. 2014; Grise and Polvani 2014; Ceppi and Hartmann 2015). So, it is a bit perplexing that the authors of this study have chosen CAM3 for their analysis, as their cloud adjustment in this study is likely quite biased as a result.

It's probably beyond the scope of this paper to ask the authors to run additional simulations using different models, but perhaps the few historicalMisc runs from CMIP5 models that isolate stratospheric ozone depletion could provide some clues about inter-model spread (http://cmip-pcmdi.llnl.gov/cmip5/docs/historical_Misc_forcing.pdf). I would be highly surprised if the results from the CAM3 model are representative of all climate models (or the real world, for that matter). All that being said, this study is important because it shows that this effect occurs in at least some climate models, and the authors perform a much more rigorous diagnosis of the radiative effects of ozone recovery than in previous studies. I would just ask the authors to be very cautious about making any general conclusions about their results (as they do on the top of page 10), until a more comprehensive suite of models can verify them.

Specific (Minor) Revisions

Page 3, Lines 13-17: How does your methodology compare to the COOKIE experiments (http://www.euclipse.eu/downloads/Cookie.pdf) used by previous studies? It sounds similar, but not exactly the same.

Page 3, Line 22: How realistic is the ERA-Interim ozone data compared to more commonly used satellite-derived ozone data sets? For reference, the ozone data used to force the CMIP5 models is provided at http://www.pa.op.dlr.de/CCMVal/AC&CSPARC_O3Database_CMIP5.html.

Page 6, Lines 8-10 (also Page 8, Lines 20-22): As stated above, it would useful to compare your numbers to the cloud-radiative effects for ozone depletion found by Grise et al. (2013) using the same model.

Page 8, Line 9: I don't understand the strong reduction in cloud cover in the Southern Hemisphere stratosphere in Fig. 2e. The absolute value of cloud cover and water vapor in the stratosphere should be very small here to begin with, so the changes seem too large to be physical. More explanation is warranted here. Perhaps this is also a deficiency of CAM3.

Page 9, Line 1: Why would Arctic sea ice increase a comparable amount as Antarctic sea ice, given that most of the ozone recovery should be in the Antarctic? Again, more explanation is warranted here.

Technical Corrections

Page 1, Line 17: Suggest changing "slow increasing" to "slowly increasing"

Page 2, Line 13: sophisticated GCMs

Page 6, Line 11: Reinstalled? Not sure what this means. Consider a different word choice.

Page 7, Line 19: Climatological

Figure 3 is barely discussed in the text. Is it essential to the paper? If so, it should be referenced and described in more detail.

References

Ceppi, P., and D. L. Hartmann, 2015: Connections between clouds, radiation, and midlatitude dynamics: A review. Curr. Clim. Change Rep., 1, 94–102.

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Grise, K. M., and L. M. Polvani, 2014: Southern Hemisphere cloud-dynamics biases in CMIP5 models and their implications for climate projections. J. Climate, 27, 6074–6092.

Kay, J. E., B. Medeiros, Y.-T. Hwang, A. Gettelman, J. Perket, and M. G. Flanner, 2014: Processes controlling Southern Ocean shortwave climate feedbacks in CESM. Geophys. Res. Lett., 41, 616-622, doi:10.1002/2013GL058315.

Kay, J., and Coauthors, 2012: Exposing global cloud biases in CAM using satellite observations and their corresponding instrument simulators. J. Climate, 25, 5190–5207.

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