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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impact of biogenic very short-lived bromine on the Antarctic ozone hole during the 21st century" *by* Rafael P. Fernandez et al.

Anonymous Referee #1

Received and published: 4 November 2016

This study examines the impact of VSL Br on stratospheric ozone depletion in the CAM-Chem model using multiple ensemble members including a coupled ocean. Finding better agreement with observations when the impact is included in the model but not finding any significant delay in the Antarctic ozone return date. Also, this work finds an increasingly important effect of biogenic bromine on the future Antarctic ozone layer. Overall I find the paper clear and well written and of interest to the ACP community, however, I do have strong concerns about the coarseness of the representation of the stratosphere in the model used and would appreciate the authors addressing these concerns or clearly stating the uncertainties that this may cause in their conclusions. I do appreciate the explicit representation of the bromocarbons, interactive ocean, and

multiple ensembles used in this study but they still all rely on confidence in the representation of the stratosphere and its response to the forcing applied.

The CAM-Chem model used in this study has 26 vertical levels and a model top around ∼40km and in fig 1 state the top model level is around 5 hPa. Please add to the model description how many levels are above the tropopause. Typically models of this coarse vertical resolution have less than a dozen or so levels above the tropopause.

Have you done any comparisons to a model with a well resolved stratosphere like WACCM with respect to circulation, mean age, PSC area, or ClOx, BrOx, NOx, HOx concentrations? That might help to quantify uncertainties or to understand the extent that a model with so few stratospheric levels can simulate or properly represent these important quantities.

Recovery of Antarctic October ozone to 1980 levels occurs in the mid 2050s in the CAM-Chem simulations this is significantly earlier than the 4 models used in the WMO 2014 assessment which returned in the 2070s - 2080s (fig 3-15). These models had well resolved stratospheres and were evaluated in CCMVal-2 to have the best representation of stratospheric transport and chemistry. Why should we have confidence in the earlier recovery estimate from CAM-Chem or can you appropriately caveat the conclusions made with this uncertainty?

Page 3 lines 22-24 I couldn't find a figure in Lamarque et al. 2012 that shows reasonable overall stratospheric circulation from including the integrated momentum flux that needs to be in a model with such a low upper boundary. Can you cite or include figures that compare these simulation to observations of mean age or other measures of stratospheric circulation or transport? How is this handled in the future is it interactive or fixed. Is the circulation change over time comparable to models with a well resolved stratosphere.

Could you explain in the paper with a model top at around 5 hPa (from figure 1) how do you represent the 5-8% of total column ozone above the model top?

Can you show or discuss how much Br goes through the tropical tropopause in these two sets of simulations are they consistent with published aircraft and satellite estimates when VSL Br is accounted for. How well is polar BrO columns modeled compared to observations in CAM-Chem.

Figure 3 Why is Spring Aug.-Oct. rather than SON

On Figure 5 there appears to be a significant difference in the early 1980s in ozone hole area between the observations and CAM-Chem simulations but I didn't see this mentioned in the text. Would you expect an underestimation of ozone hole area to be significant to the earlier return date found in CAM-Chem. How does this impact your conclusions?

Figure 6 There appears to be large 30-year time scale variability in the polar cap ozone in the ensemble average is this coming from the ocean, can you explain. The panels with the time axis show dotted lines at 2000 and 2050 but if the label is correct on the other panels you are meaning to highlight 2030 instead. Same on figure 4 and fig 10.

Page 2 lines 3-5 when discussing the Antarctic ozone return dates you reference the older CCMVal-2 and WMO 2010 results and not the more recent WMO 2014 which had a significantly later recovery estimate, please add mention of the WMO 2014 result here.

Page 3 lines 13-15 For readers unfamiliar with CCMI-REFC2 can you state the GHG and ODS scenario used in this study.

Page 4 lines 13-15 for the total column ozone database please state which version used (is it the latest) and what years it covers. If it continues through 2015 can figures 2 and 3 be extended to include more recent years.

Page 8 line 19-20 4 years doesn't agree with difference 2047 and 2054 in the text. I think you meant to write 2051 instead of 2054.

Given that the largest differences were found in the periphery of the ozone hole does

the definition used 63-90 vs 60-90 make any difference in your dates. I have seen both regions used so either is fine, I would just suggest checking that it doesn't make a difference.

Page 9 line 2 change deepest to deep Page 9 line 17 change "respect to" to "with respect to" Page 10 line 5 same as above

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