Review of "Evaluating the impact of blowing snow sea salt aerosol on springtime BrO and O_3 in the Arctic"

This manuscript presents an evaluation of GEOS-CHEM's ability to reproduce observed springtime ODEs and BrO enhancements using a mechanism that produces sea salt aerosol over both first and multiyear sea ice. The evaluation is conducted via comparisons to tropospheric BrO column measurements from GOME-2 and OMI, as well as in-situ ozone measurements at a variety of Arctic locations. Crucially, rather than assuming a uniform snow salinity distribution based on Antarctic measurements, as prior studies have done, the modeled blowing snow SSA production is informed by actual Arctic snow salinity measurements in a variety of sea ice regions. The authors find that the inclusion of SSA production from blowing snow over multi-year sea ice regions produces better agreement with observations than just first year ice regions, and also postulate that remaining disagreements with observations could be resolved by incorporating snowpack production of molecular halogens into their model. This work represents a meaningful advance compared to prior literature on this topic and should be published after some revisions, which I detail below.

Major Points

- The authors discussion of improving the model's ability to reproduce ODEs suggest 4 potential sources of difficulty in line 518, but then the paper's abstract and the rest of the conclusion only focus on the inclusion of a snowpack molecular halogen production mechanism. While I agree that this important mechanism should be included in models, the authors could do a better job explaining how the other three sources mentioned might impact the modeled ODEs and why they chose to focus the bulk of the discussion on this mechanism in particular.

- One other potential explanation for the model doing a better job with BrO than O_3 is the evaluation via column measurements rather than concentrations. The ozone loss rate is dependent on the BrO concentration (among other things, [*Thompson et al.*, 2017]), but the measured BrO VCD reflects both concentration and vertical profile of BrO [*Sihler et al.*, 2012]. Thus, the same VCD could have very different implications for ozone depletion near the surface depending on the vertical profile of BrO. This issue wouldn't necessarily be resolved by adding another Br_2 source. While satellite-based measurements are a needed tool to evaluate performance over large spatial scales, it would also be good, in the future, to evaluate the model using ground-based BrO concentration measurements as the authors did with ozone.

- Section 4.1: I found this section overly qualitative, particularly when compared to the rest of the paper. This issue also pops up in line 33 of the abstract. I would encourage the authors to come up with a more quantitative description of the fraction of ODEs observed at Arctic sites captured by the model, which would strengthen this section of the paper, and allow the authors to avoid phrases like "captures a few" and "misses some" which seem a bit out of place in a scientific publication.

- Section 4.2: This section would potentially be improved by a discussion of the spatial extent of the modeled ODEs and comparison to prior studies. As an example, *Halfacre et al.* [2014] used buoy-based observations to suggest ODEs can have a spatial extent on the order of 100s of km, is this finding reflected by the model?

Minor Points

- The units for vertical column density are molecules per cm^2. To my knowledge, the omission of molecules is not an appropriate convention.

- Regarding Fig. 3a comparing the GOME and OMI measurements, is the slope calculation from a typical linear regression or an orthogonal distance regression? Since the measurements have comparable uncertainties, the residuals in both x and y should be minimized when determining the line of best fit.

- Line 331: Define what you mean by high wind speed

- Line 371: Missing reference for Cl acid displacement enhancing ODEs

- Line 477: This propagation of bromine inland has been observed [*Peterson et al.*, 2018].

- Fig. 4,8,10,12 Readibility would be improved though the use of variable line styles as well as color. Figure 8 in particular is not readable.

- Fig. 8 Perhaps move the full timeseries to a supplement and change the x axis to only show Mar 15th through April 15th to encompass the green shaded regions at all sites.

References

Halfacre, J. W., et al., Temporal and spatial characteristics of ozone depletion events from measurements in the Arctic, *Atmospheric Chemistry and Physics*, *14*(10), 4875–4894, doi:10.5194/acp-14-4875-2014, 2014.

Peterson, P. K., et al., Springtime Bromine Activation over Coastal and Inland Arctic Snowpacks, *ACS Earth and Space Chemistry*, *2*(10), 1075–1086, doi:10.1021/acsearthspacechem.8b00083, 2018.

Sihler, H., et al., Tropospheric BrO column densities in the Arctic derived from satellite: retrieval and comparison to ground-based measurements, *Atmospheric Measurement Techniques*, *5*(11), 2779–2807, doi:10.5194/amt-5-2779-2012, 2012.

Thompson, C. R., P. B. Shepson, J. Liao, L. G. Huey, C. Cantrell, F. Flocke, and J. Orlando, Bromine atom production and chain propagation during springtime Arctic ozone depletion events in Barrow, Alaska, *Atmospheric Chemistry and Physics*, *17*(5), 3401–3421, doi:10.5194/acp-17-3401-2017, 2017.