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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Analysis of satellite-derived Arctic tropospheric BrO columns in conjunction with aircraft measurements during ARCTAS and ARCPAC" *by* S. Choi et al.

Anonymous Referee #1

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This paper describes an analysis and comparison of aircraft vertical profiles of BrO (and other bromine species) with tropospheric retrievals of column BrO from two satellite instruments, GOME2 and OMI, for a number of cases in 2008. The objective is to address the question as to whether or not we understand the physical and mechanistic origin of relatively intense BrO column events, and if they are consistent with the surface level phenomenon of ozone depletion in the Arctic springtime, or if they may be more a reflection of changing tropopause heights and/or stratosphere-troposphere exchange events, involving bromine. The methods involved a model of the stratospheric component of the observed satellite column measurement, and which assumed 7 ppt of "very-short-lived" organobromine compounds in the stratosphere. The approach

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used for the stratospheric simulation seems to be the current state of the art; while the 7 ppt is near the high end of the likely range, it was reasonably well justified in the paper (and in Salawitch et al., 2010). What makes this paper unique and important is the fact that there is a good combination of aircraft-based column measurements (for the troposphere) plus a number of cases where one can argue that relatively reliable (reflective surface and few obscuring clouds) satellite-based tropospheric column BrO retrievals were obtained. This paper has some very important conclusions/findings, and I believe it is a paper that will have some significant impact. It is well-conceived and well written, and therefore I believe that it should be published. The big impact conclusion of the paper, in my judgment is stated in one sentence, the penultimate sentence of Section 4: "Our results are consistent with a surface origin of elevated BrO as well as transport of BrO enriched air parcels away from the source of origin". This should be the focus, and should be highlighted and strengthened in the paper. However, the paper is 35 pages of text, with 6 tables, and 18 figures, each of which has multiple panels, in some cases many panels. Reading this paper is a serious piece of homework, and the paper makes the reader really work and dig, going back and forth between text and figures. To me, it is worth it, but there are a very few such specialists keenly motivated to learn about the latest development in this area. For most readers then, the paper does itself a disservice; the impact of the paper could be much greater if it were rewritten with a serious attempt to focus on the supporting evidence for the main conclusions of the paper. Besides the conclusion stated above, the other important points were that satellite retrievals (making use of a good stratospheric model) for tropospheric BrO columns can be reliable if a few conditions are met, specifically that the surface albedo is large, the solar zenith angle is not too large, and that there are not optically thick clouds. The observation of some BrO events above the BL top is interesting, and perhaps they may result from convection from leads? In any case, I believe the paper should be shortened with an eye toward asking whether inclusion of material addresses the main conclusions of the paper. I have some suggestions, and there are some minor concerns and errors in the paper which should be addressed.

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These are listed below in the order they arose in the paper.

1. Lines 6-16 on page 9 are not needed, an outline of a paper just gets in the way of reading the paper!

2. Top of page 11 - the surprisingly low BrO values shown in Figure 2 should perhaps warrant more comment; while the aircraft vertical profiles show medians at the surface of perhaps ∼1-4 ppt, as an example, the median surface measurements reported recently for Barrow in April are more like 8-9 ppt, and much higher in partially depleted conditions. Was 2008, or the conditions during the flight, anomalous in some way?

3. Page 21, line 9 - or that the modeled stratospheric column BrO is too large?

4. Page 24 - line 11 - yes, indeed, this variability is important to stress, and the impact of using things like zonally fixed column BrO can be problematic.

5. Page 25, bottom paragraph - why discuss profile #13 if you are not showing the figure?

6. Page 26, line 9 - Hudson Bay is barely visible in the figure. Perhaps this discussion can be dropped?

7. Page 27, line 13 - well, GOME-2 trop is in fact shown.

8. Top page 28 and Figure 9b - this information is useful and interesting to see! I worry that the top panel of Figure 9b will be even harder to read in the published version. The same applies to Figure 6b, top. The top panels are so important, but are hard to read. Perhaps the other panels in these figures could be in supplemental?

9. Page 28, line 18 - the term “tropospheric perturbation” has no meaning, equivalent to saying “we don’t know”.

10. Page 29, for example - throughout the paper there is reference to aircraft column #s. Without reference to a specific figure in the context of these numbers, it is often cumbersome and difficult to follow.

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11. Page 29, line 6 “not significant”, but please note that they are as much as 3 times smaller!

12. Page 29, Line 18 - here and in other parts of the paper there is reference to transport (vertically in this case, on others horizontally (page 32, line 22), even using the term “long-range”, page 35, line 6) of BrO. BrO is too short-lived (perhaps ∼30s, from just photolysis alone), and does not undergo significant transport itself. I feel sure that the lifetime of BrO is very short compared to the timescale for transport across the tropopause! What is transported is an airmass/parcel that retains the ability to continue generating/recycling bromine radicals. This is indeed an important distinction. All references to transport of BrO itself must be removed, and the discussion technically improved/corrected.

13. Page 31, line 28 - on the other hand, the chain chemistry is quadratic in BrO, so, a deeper BL could slow down the chemistry as BrO (its precursors) is diluted.

14. The bottom map in Figure 6a is not necessary.

15. As an example, Figure 10b is a very important and interesting case where the agreement is not good.

16. The two little panels on the right side of Figure 13 need different colors for T and BrO. Why are there only two rows of these latter figures?

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 26173, 2011.