The authors admit that there are large uncertainties in the determination of tropospheric BrO columns from satellite measurements. To circumvent this limitation the authors calculate six different tropospheric BrO columns using two different total columns from two instruments and three different approaches to obtain the stratospheric fraction. Unfortunately, these six products cannot be validated due to a lack of sufficient in situ data.

[Response]

We believe that it is important to acknowledge the uncertainties in the satellite measurements in general. The data uncertainties will dictate what problems can be analyzed using these data. In this paper, we made the point that tropospheric BrO columns derived from satellite measurements cannot be quantitatively validated (in terms of column amounts). However, the correlations with DC-8 BrO, other bromine species onboard DC-8 and WP-3B, and surface, aircraft, and sonde ozone measurements suggest that tropospheric BrO column variations have real signals and that "judicious use of correlation analysis provides useful scientific insights into the processes of bromine-related ODEs".

As a result all six BrO columns are equally valid (or not) and the results of all correlations should be shown in the manuscript (and not only in the supplement). This concerns Figures 2a, 3, 5d, and 9 and the discussion of these figures.

[Response]

The reviewer's interpretation of the supplement correlation figures is different from what we stated in the paper. We felt that the 3 products are representative of the uncertainties of two satellites and two different methods of estimating stratospheric column BrO. Given the long discussion of the uncertainties in satellite products in the manuscript, it may indeed be better to show the results for all 6 products in the relevant figures that the reviewer mentioned. Previously the other three products were not shown because we didn't do the analysis using those products. Now we have completed the analysis and the figures are attached at the end of this response.

The 6-product results can be easily included in Figure 3. For Figures 2, 5, and 9, however, it would include a total of 18(3x6) plots and the plots in Figures 5(a,b,d) and 9 have multi panels. The main scientific contribution of this work is to understand better the characteristics of ODEs. When reading a paper, there will not be many readers who want to look at a similar figure 6 times. We believe that it is appropriate to include these figures in the Supplement, which we will do in the revision. The reviewer can verify if the main features that we discussed in the manuscript are consistent among the 6 products. There are sometimes differences in details but the main features are consistent. The problem with Alert in Figure 3 is addressed next.

The authors further claim that the uncertainty in the BrO column is unimportant because they "do not introduce in the resulting tropospheric BrO columns an unphysical correlation with tropospheric ozone." However, this clearly needs to be demonstrated by the authors.

[Response]

The statement is self-evident since SCIAMACHY stratospheric BrO data, the 20th percentile of total column BrO, and RAQMS stratospheric BrO simulation are independent of the observed tropospheric ozone, or more specifically observed ODEs in the Arctic. We see no reason that unphysical correlations can be introduced. The issue that the reviewer has may be more related to how the uncertainty affects the correlation analysis (i.e., the question below). We will address it in the next question.

At the moment a comparison of the correlations with O3 is shown in Figure 3 for only three out of the six BrO products. By the way, if the above statement is correct one correlation would be sufficient, so why does Figure 3 show 3 correlations?

[Response]

This is the question about how the data uncertainty affects the correlation analysis. In the original manuscript, we discussed it in section 2.2.1, but we should have given more details in the discussion of Figure 3, which we will do in the revision.

The uncertainty due to the estimates of stratospheric column BrO should not produce consistent "false-positive" signals. The reasoning is stated above. The uncertainty can still mask out real correlation signals. Since we don't know the nature of the uncertainties in satellite-derived tropospheric column BrO (the possibilities were given in the previous response), we did the analysis with three selected products previously. In the revision, we will show all 6 products.

Taking only the 3 presented correlations the above statement sounds correct for Barrow and Zeppelin, but not for Alert. For example, at Alert for D-3 two correlations are negative and one is positive.

[Response]

We will give more detailed discussion in the revision. We stated in the original manuscript that "The lower correlations found at Alert may reflect larger uncertainties in the tropospheric BrO columns due in part to its high latitude location (hence higher solar zenith angles)."

Another reason that we did not mention is that Alert has fewer ODE hours than Barrow and ZPL and the duration of ODEs at Alert is also shorter than the other two sites (Figure 1). The correlation R value is a function of co-variation between ozone and tropospheric column BrO. ODEs clearly drive the ozone variance at these sites. Using a dataset with noise, the (absolute) R value is higher when there is more variance. The (absolute) R value at Barrow is expected to be higher than Alert. With the new 6-product figure, we agree that the case for Alert is not very strong in Figure 3 and we will make a statement that this correlation method is not very effective at Alert in the revision.

However, overall the correlation coefficients for Alert and partly also for Zeppelin and Barrow are so small (below 0.4) that it becomes questionable if these correlation coefficients do have a scientific meaning. Probably, the small correlation coefficients only tell that there is no detectable correlation. If that is the case, Figure 3 for Alert would also support the initial statement. This would be an important finding. However, the authors need to present a serious estimate of the threshold for the correlation coefficient indicating a statistically significant correlation. The same is warranted for Figures 8 and 9 and S1 to S4.

[Response]

In general, the thresholds for R value are 0.3 for low correlation and 0.5 for good correlation. The threshold values do not necessarily apply to the time-delayed correlation analysis such as Figure 3. In time-delayed analysis, the correlation R value is calculated under the similar condition except that the time shift is different. Therefore, the change of R value as a function of time is the most important. In the new figure (attached at the end), the 6 products are grouped tightly at Barrow since the correlation signal is large. At ZPL, the correlation signal is lower. However, the change of R value is very consistent among five products, i.e., there is a large decrease of correlation from D-2 on. The exception is the OMI-RAQMS product, which has a flat small R values irrespective of time shift. It is most likely a reflection of uncertainties (random relative to ODEs) in this product. We will add this comment in the revision.

Concerning the six different BrO products, the authors state that the "reasons for product difference could be the instrument sensitivity, retrieval algorithm, cloud interference, and the estimates of the stratospheric BrO columns." From this sentence I understand that the total BrO columns from OMI and GOME2 are significantly different at least for the analyzed period. Is that correct? If yes, this should be clearly stated in the manuscript.

[Response]

The two satellites can be very different (Figures S1-S4 and Table 4 in the paper by Sunny et al. (2012)). We will state it in the revision.

New supplement figures



Fig. 2 updated using OMI-20th



Fig. 2 updated using OMI-raqms



Fig. 2 updated using GOME2-raqms







Fig. 5 updated using OMI-20th



Fig. 5 updated using OMI-raqms



Fig. 5 updated using GOME2-raqms



Fig. 9 updated using OMI-raqms



Fig. 9 updated using GOME2-raqms