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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Diurnal variations of $BrONO_2$ observed by MIPAS-B at mid-latitudes and in the Arctic" *by* Gerald Wetzel et al.

Gerald Wetzel et al.

gerald.wetzel@kit.edu

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Response to Referee #1:

First of all we thank the referee for the effort to carefully reading the manuscript and for all comments.

General comments:

1. Which is better for estimating Bry: daytime BrO or nighttime BrONO2? I would suggest to add some discussion about the estimate of Bry. If we select a condition where no heterogeneous reactions occur, is the measurement of BrONO2 in nighttime a better way? The authors state comparison with previous studies in "Conclusion" without any discussion about it in "Results and discussion". Thus, I suggest to add a

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subsection, e.g., "Comparison with other studies", then discuss about studies on BrO measurements, the estimation of Bry, and the advantage of BrONO2 in the estimation, if so.

First, we have to emphasize that MIPAS-B can only measure BrONO2 but not BrO such that we are only able to estimate Bry from BrONO2 data. However, we performed chemical model calculations with EMAC and a 1-D stacked box model to look at the diurnal variation of BrONO2 and BrO. As already mentioned in the text in section 3.2, more than 90% of Bry are in the form of BrONO2 between 21 and 29 km during the night at mid-latitudes in September. In contrast, the maximum relative daytime amount of BrO is only 80% of Bry near 36 km, the upper altitude limit of this MIPAS-B measurement. Furthermore, the BrO VMR is gradually changing during day (while BrONO2 VMR is rather constant during night). Hence, BrONO2 appears to be better suited to estimate Bry compared to BrO. This holds also for the situation during the Arctic flight in March where the nighttime BrONO2/Bry ratio is larger than the daytime BrO/Bry ratio as well. We added a new Section 3.3 where we discuss the estimation of Bry together with the comparison to DOAS results.

2. Are heterogeneous reactions on sulphate not important for the destruction of BrONO2 in nighttime under volcanically quiescent periods and temperatures observed? Under conditions where no PSCs were evident in the Arctic March and the mid-latitude September, significant enhancements of BrONO2 up to 21-22 pptv were measured by MIPAS B. This may suggest that any heterogeneous reactions (or hydrolysis) of BrONO2 on sulphate is not important, at least, under such a low aerosol surface area density and temperatures.

Aerosol surface areas are very low in the altitude regions of the BrONO2 VMR maxima (2.0E-09 cm2/cm3 at 24 km on 31 March 2011 and 2.0E-09 cm2/cm3 at 28 km on 7 September 2014 in the EMAC simulation) and are not important in these two cases.

Minor comments:

1. Page 5, line 130: What is instrumental offset? The authors mention that continuum could be separated from individual spectral lines.

Instrumental offset is an additive radiometric parameter which is not completely eliminated during the calibration process (for all instrumental issues, see Friedl-Vallon et al., 2004 as cited in the text). We included “radiometric” in the text for better clarity.

2. Page 6, Figure 6: What is a cause of difference in peak altitudes? Namely, 24 km in nighttime and 22 km in daytime. This feature is also seen from the model result, so that the authors can provide some explanation for that. In connection with this, additional figures from model computations are useful, if the authors provide figures showing difference in the partitioning of Bry species at day and night with and without PSCs. Then, add some discussion on that.

The displacement of the nighttime BrONO2 VMR maximum from 24 km down to 22 km during day can be explained by photolysis. Towards higher altitudes, the decomposition of BrONO2 according to (R2a), (R2b), and (R3) is increasingly faster than the BrONO2 build-up via (R1). We explain this in the text now and included a Figure showing BrO from the model. Further Figures showing the complete model bromine partitioning are not necessary to explain this displacement.

3. Page 7, line 209: is it right for this calculation, because the model grid (x – xa) is larger than that of MIPAS-B (xa)?*

The formula is correct. The Matrix A has not a quadratic but a rectangular form to account for the different altitude grids.

4. Page 9, line 274: The authors state "starts earlier". What is the difference in time? I suggest to write: e.g., "The BrONO2 increase starts at XXXXUT in the measurement, whereas the model BrONO2 increase starts at YYYYUT."

It is difficult, to give exact times for the beginning of the BrONO2 increases. However, we changed the corresponding text to characterize both increases more precise.

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