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Comment on acp-2021-535: Review of the manuscript "The MIPAS global climatology of BrONO2 2002–2012: a test for stratospheric bromine chemistry" by Hopfner et al., ACPD, 2021.

Rafael Pedro Fernandez (Referee)

Referee comment on "The MIPAS global climatology of $BrONO_2$ 2002–2012: a test for stratospheric bromine chemistry" by Michael Höpfner et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-535-RC2, 2021

The paper describes the first satellite-derived stratospheric BrONO2 global climatology based on MIPAS-Envisat infrared spectra. Most notably, the BrONO2 dataset has a well-resolved vertical, latitudinal and temporal resolution, that allows for a comprehensive understanding of the BrONO2 seasonality as well as the different BrONO2 abundance between day- and night-time conditions. The methodology clearly describes the uncertainties and errors associated with the satellite retrieval, as well as the dominant chemical processes that affect BrONO2 formation and destruction in the stratosphere. The satellite climatology is analyzed by means of a comprehensive comparison with the EMAC model, which presents an overall good performance in reproducing the BrONO2 seasonality as well as the day/night cycle. The major differences observed between the model and the satellite retrievals are identified and discussed in detail, highlighting the most probable causes of the model-observation disagreement. Based on this, I believe the paper should be published in ACP after the following minor issues are revised.

Main Issues:

- The total stratospheric Bry value of 21.2 ± 1.4 pptv of Bry at mid-laitudes has been estimated for the 40-60 S and 40-60N but without considering the 10° latitudinal bins used in previous sections. Wouldn't it help to evaluate if there is any Stratospheric Bry trend and/or sink by means of computing Bry at different latitudes and heights?. In particular, Section 4 (Fig. 12) would benefit of a discussion comparing the almost negligible trend in MIPAS Bry trend between 1996-2007 with the reported value in WMO of -0.16 ± 0.07 ppt for the 2004-2014 period.
- The authors suggests that the low modeled polar BrONO2 during winter is caused by a low bias in NO2 abundance due to missing mesospheric NO2 production in the model (dif_1). However, for dif_2 and dif_3, they highlight different competing processes, but they do not mention even once that an erroneous modeled NO2 abundance could also be affecting the model-observation disagreement. I think this should be explicitly mentioned for all cases. In particular, for dif_2, Barrera et al., (2020) highlighted that VSL bromine impacts in the mid-latitudes depend on the recycling efficiency of ClONO2

and HCl in the lowermost stratosphere. Could modeled ClONO2 recycling also be affecting NO2 abundance in the lower stratosphere and indirectly affecting the modeled BrONO2 sinks?

Minor comments:

P4, L109: *"the related a-priori profile for the target species BrONO2 was set to zero"*: I'm not an expert in this field, but I thought that for satellite retrievals it was necessary to include a non-zero a-priori profile.

P5, L138: *"Around that, the blue shading indicates the variability of the estimated errors between all latitude bands"*. Please rephrase. Does "that" points at the mean total error? Is it "between" of "for" all latitudes?

Fig. 1: Rapid eye-reading the figure, it is evident that below 20 km, Tot parameter errors and spectral noise are the dominant contribution to the total error, while at higher heights it is mostly dominated by spectral noise. A simple sentence on the text highlighting this would be useful.

P8, L167: *"During the MIPAS measurement periods, from the model output first all data within one hour around 10 LT and 22 LT were selected. Depending on their latitude, longitude and altitude, they were then assigned to day and night-time conditions and averaged over the observational bins of 10 latitude and three-day periods"*. Do you mean that model output was filtered for specific hours to match MIPAS observations? And also, did you consider any additional condition to filter day/night time values very close to twilight conditions where the radiation intensity is reduced (mostly at high latitudes). Please make it clear.

P9, L93: Do you mean a "seasonal" signal instead of annual? What do you mean by outstanding?. Finally, it would be useful to provide a couple of sentences summarizing the Maximum and Minimum values observed for different heights and latitudes before getting into the MIPAS-Modelling comparison.

P16,L198: What is the Averaging Kernel Matrix? A kernel including the 10 LT and 22 LT hours? If that is the case, please make it consistent to the description in Section 2.2.

P16, L220: *"Such differences are also present during day, albeit to a smaller extent (up to about 4 pptv, see Fig. 8)."* … due to the smaller BrONO2 abundance. Clearly, as BrONO2 levels are higher during the night, then the absolute differences will be higher during the night than during the day, where BrONO2 vmr are smaller. I wonder if the relative/percentage difference between model and observations are similar during the day than during the night? Independently of the answer, this could be explicitly mentioned in the text.

Fig. 9: The "diff night" and "diff day" panels show a very similar profile, though the absolute variation is considerably different. Have you estimated if the relative/percentage difference between day/night are similar?

P24, Eq.1: You have only applied the expression to night-time modelled values. Have you performed the same analysis with daytime values? If so, did you find any difference worth to be mentioned?

P25, L345-346: *"Since the model adjustment of Bry from BrONO2 is much larger in the*

tropical stratosphere (about 2.5 pptv) than at mid-latitudes (about 0.5 pptv), the second explanation would affect more strongly our estimation of Bry in the tropics." What do you mean here? That the estimated Bry will be more realistic for high BrONO2/Bry ratios? Wouldn't it be worth to compare the Bry estimation for each latitudinal bin of 10° at different seasons, and to determine if the estimated Bry stratospheric abundance for each band is consistent?

Fig. 12: I found a bit confusing that the colored symbols with measurements (other than MIPAS) at different locations are shown in all 3 panels. Wouldn't it be better to include in each panel only those observation corresponding to the latitudinal band where it was measured?

Fig. B1 and B2: It could be useful to show the modelled NO2 difference in a 3rd column on the right, as it has been shown for BrONO2 in the main text.

Would it be worth to include the estimated AOA in the published dataset?

Language editing comments:

P1,L10-11: Rephrase item (1) in the abstract.

P2, L33: ist produced à is produced

P2, L35: coupled strongly à strongly coupled

P3, L69: VSLS should be defined after it first usage in L64.

P4,5: ESA, HITRAN, ECMWF, etc. acronyms are not defined.

P16, L209: "values of less than" à "values smaller than"

P17, L259: Define SAD as it first usage in L244.

P22, L299: Tab. D1 à Table D1

P24, L327: Dependent à Depending

P24, L337: "vary from 21.0 +/- 1.4 pptv and 21.4 +/- 1.4 pptv for the northern and southern mid-latitude regions", respectively.

P25, L350: Replace Obviously by Notably or other word … as it is not obvious that measurements performed with different instrument will provide equivalent results.

References

Barrera, J. A., Fernandez, R. P., Iglesias-Suarez, F., Cuevas, C. A., Lamarque, J.-F., and Saiz-Lopez, A.: Seasonal impact of biogenic very short-lived bromocarbons on lowermost stratospheric ozone between 60° N and 60° S during the 21st century, Atmos. Chem. Phys., 20, 8083–8102, https://doi.org/10.5194/acp-20-8083-2020, 2020.