We thank referee #2 for very helpful and valuable comments, to which we hope to have responded appropriately. A list of comments including our response is given below.

Response to anonymous referee #2:

Blechschmidt et al. analyze an enhanced tropospheric BrO plume (also known as "bromine explosion", or "BrO explosion") coincided with a polar cyclone during Mar 31-Apr 3 2011 in the Arctic by utilizing a comprehensive set of meteorological data from a mesoscale model WRF and various satellite observations. They investigate the observed BrO explosion event over the course of frontal activities in the associated low pressure system, as well as examine the possible effects of first-year sea ice and blowing snow as inorganic bromine sources. The important conclusions of this study include (1) the frontal high wind speeds and BrO uplifts at the onset and mature stages of BrO explosion inferred from WRF simulations, (2) possible contributions of first-year sea ice and blowing snow as sources of inorganic bromine supported by SMOS and MODIS measurements, and (3) the suggested BrO injection heights of 0-3 km from FLEXPART simulations while ruling out the stratospheric origin from GOME-2 total ozone, MODIS cloud, and WRF tropopause height images.

This is a meaningful study for it is the first attempt to analyze a BrO explosion event in context of the frontal activities of a polar cyclone, as well as it utilizes an unprecedentedly comprehensive set of meteorological data. While it was widely reported that BrO explosion events accompanied with polar cyclones, no single study has utilized all the data sets used in this study so far; only parts of data sets used in this study have been utilized in previous studies. Moreover, interpretations of the various data sets nicely converge to its main idea, the BrO explosion of tropospheric origin contributed by frontal activities, the first-year sea ice, and blowing snow throughout the progress of a polar cyclone.

Overall, this study makes a high quality analysis and I recommend publications of this article in ACP provided that the following concerns are addressed.

1) In the manuscript, the authors use the term "bromine explosion" to indicate the observed event of the enhanced BrO plume. However, "bromine" in this context can be bromine species other than BrO, including Br, Br2, HOBr, and BrCl. Since we do not have the capability to observe these species over a wide spatial range, the extent of other bromine species is just unknown. I would like to ask the authors to justify their calling the enhanced BrO plume as "bromine explosion", or specify the term for the observed BrO plume other than "bromine explosion". Otherwise, it may give an impression that BrO would be the only species involved in "bromine explosion" to readers.

Added the following sentence to Section 1:

"Here, GOME-2 retrievals of tropospheric BrO are regarded as an indicator of activated bromine species (such as Br, Br_2, HOBr and BrCl) in general, although activated bromine species may also be present in the absence of BrO."

2) p24962 l21: please include Vasilkov et al. (2009) regarding the reduced cloud shielding over bright surfaces.

Vasilkov, A. P., Joiner, J., Haffner, D., Bhartia, P. K., and Spurr, R. J. D.: What do satellite backscatter ultraviolet and visible spectrometers see over snow and ice? A study of clouds and ozone using the A-train, Atmos. Meas. Tech., 3, 619-629, doi:10.5194/amt-3-619-2010, 2010.

Done.

3) p24969 l5: The suggested correlation between the BrO plume and the low temperature at 350 gpm

in 1-2 April 2011 is not apparent to me, in the second and third rows of Fig. 3(a) and Fig. 4(d). For example, tropospheric BrO column in April 1 looks like a comma in normal orientation while the temperature at 350 gpm looks like a comma turned 90 degree clockwisely. Can the correlation be revealed by modifying the color scale? Or does it mean correlation in terms of broad locations?

The term correlation was used here to indicate that regions of low temperatures at 350 gpm broadly coincide with the BrO plume. We agree that the usage of this term may have been misleading and have therefore changed the wording in Section 4 of the revised manuscript accordingly.

4) p24971 l16: 3 km is the suggested maximum height of vertical injection. What is the planetary boundary layer height from the WRF model for this case? I guess it would be lower than 3 km.

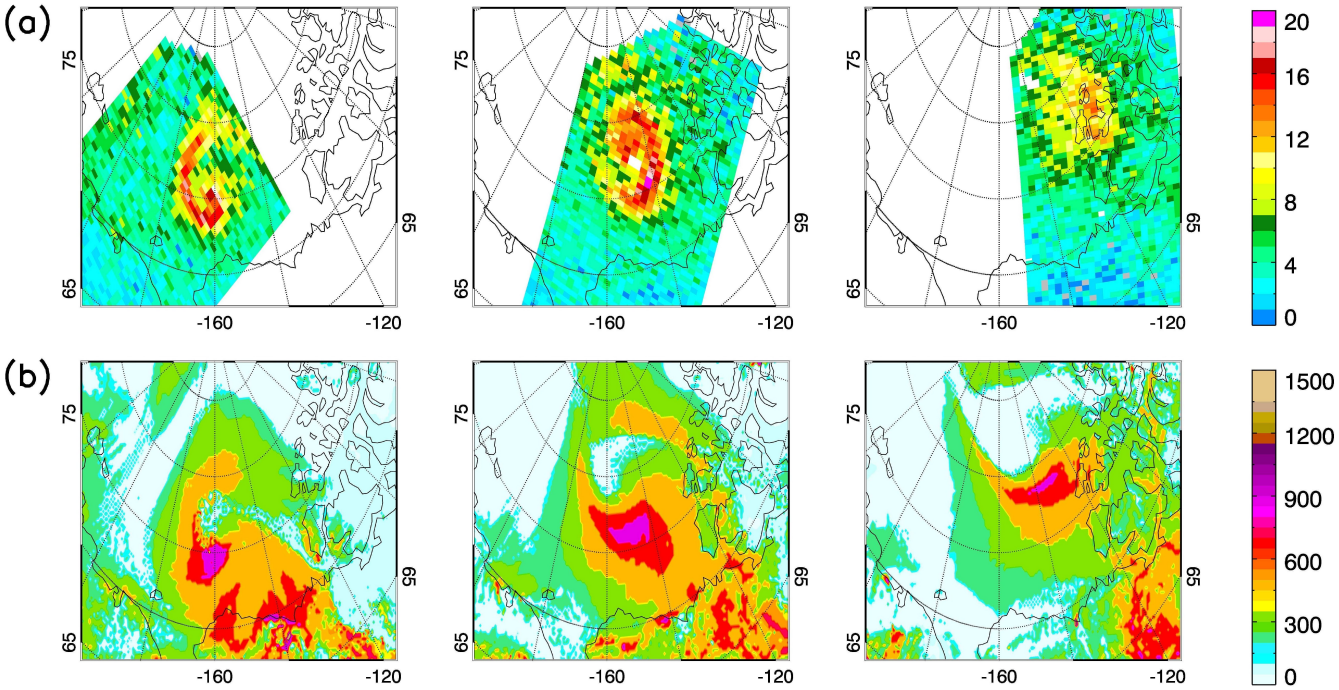

Figure R1: Satellite observations and model simulations showing (a) GOME-2 BrO tropospheric VCD [10^{13} molec cm^{-2}] and (b) WRF planetary boundary layer height [m]. Shown from left to right are different development stages of the BCTE: onset (31 March 2011 at 23:30 UTC), mature stage (01 April 2011 at 21:30 UTC) and dissolving stage (02 April 2011 at 19:30 UTC).

Figure R1 shows GOME-2 tropospheric BrO retrievals covering different development stages of the BrO plume together with corresponding planetary boundary layer heights from WRF. Simulated planetary boundary layer heights do not exceed 1 km at plume location. This means that the plume was most likely transported out of the planetary boundary layer into the free troposphere. Planetary boundary layer heights from WRF are now shown by Figure 4 (e) of the revised manuscript (Figure caption changed accordingly) and we also added the following lines after the paragraph referred to by the reviewer in Section 4 to reflect this finding:

"The WRF simulations indicate that the planetary boundary layer height (Figure 4 (e)) did not exceed 1 km in the vertical at plume location. This means that the BrO plume must have been transported out of the planetary boundary layer into the free troposphere, given that transport of BrO was most likely limited to 3 km height in the vertical."

As we think that the, compared to the surrounding areas, high planetary boundary layer at plume location agree nicely with our conclusion that the BrO plume occurred at the front of a polar cyclone

and that fronts indicate vertical lifting, we also added some lines on this matter to other parts of Section 4 (i.e. after the first and second paragraph on page 24968 of the former manuscript version).

Note that in the former manuscript version, tropopause heights from WRF were shown by Figure 4(e). The latter have been removed from the manuscript, as they showed similar WRF tropopause height data as in Figure 3 (d). Figure 4 (e) on tropopause heights was not included in the former pdf manuscript version that we submitted for quick review, but was then accidentally included during typesetting of the discussion paper. We apologize for this oversight on our part.

5) p24972 l18-20: "The higher elevation runs do not show a comma shaped plume and simulated tropospheric VCDs are on the order of observed ones." I think this is not only unnecessary, but may be also confusing since the authors already ruled out the higher elevation of BrO scenarios in the previous paragraph.

We agree that this may have been misleading and changed the text from:

"The higher elevation runs do not show a comma-shaped plume and simulated tropospheric VCDs are on the order of observed ones. Again, the simulated plume is located further northwards of where it actually occurred."

to:

"The higher elevation runs do not show a comma-shaped plume but again, the simulated plume is located further northwards of where it actually occurred."

6) p24972 l21-24: "Overall, the simulations from FS1 for the dissolving stage of the BCTE show that other emission sources as the ones included in FS1 . . . after the evening of 1 April." I think the observed BrO column shapes may reflect the continuous change of the BrO source locations (frontal areas) over the course of the polar cyclone, while the source of the FS1 simulation is fixed as the BrO plume of 00 UTC of April 1.

The reviewer is right and this is actually what we wanted to express by these lines, which may have been confusing to the reader however. This point should now be expressed more clearly in the revised version by changing the corresponding text from:

" Overall, the simulations from FS1 for the dissolving stage of the BCTE show that other emission sources as the ones included in FS1 most likely contributed to an enhanced lifetime of the BrO plume after the evening of 1 April."

to:

"This is most likely due to the fact, that emission sources are fixed to a specific point in time (01 April at 00 UTC for FS1) for FLEXPART simulations presented here. However, the shape of the BrO plume observed by GOME-2 most likely reflects the continuous change of emission sources associated with the passage of the front of the polar low pressure system."

Moreover, we added the following text to the paragraph on FLEXPART FS2 and FS3 results (starting at page 24972, line 25 of the former manuscript version) to Section 4 of the revised manuscript:

"Note that as for FS1, differences between satellite retrieved tropospheric BrO VCDs and results from FS2 and FS3 are most likely due to the fact that the continuous change of emission sources associated with the passage of the front of the polar cyclone is not reflected by the FLEXPART simulations."

7) p24975 l1-4: "Results presented in this paper . . . fronts with polar cyclones are favorable not only for development of BEEs, but also sustain high values of tropospheric BrO, thereby extending plume lifetime substantially." I personally do not think extension of BrO lifetime by fronts is the only explanation of behaviors of the observed BrO plume. It might be reflecting the continuous BrO release from frontal regions that lasted 2-3 days over the course of the low pressure system.

We agree with the reviewer and have therefore changed the corresponding text in Section 5 of the revised manuscript to:

"Results presented in this paper document that weather conditions associated with fronts within polar cyclones are favorable not only for development of BEEs, but also to sustain high values of tropospheric BrO through continuous release of bromine over the course of the low pressure system, thereby extending plume lifetime substantially."