We thank referee #1 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 #1:

Review of submission by Blechschmidt et al., " An exemplary case of a bromine explosion event linked to cyclone development in the Arctic".

The paper presents a case study of a bromine explosion event, explored using a variety of supporting datasets and models. I found the paper to be very well written, logically presented and clearly argued. As a results I have only minor corrections to suggest, many merely to improve presentation.

Line 12: "brine-covered"

Done.

Line 62: At the time that Rankin et al published their paper, it was thought that frost flowers were a primary source of bromine. Now it seems that they are not, and this should be reflected more clearly at the start of this section. At minimum, put it in the past tense: "According to Rankin et al. (2002), frost flowers were..."

Changed the corresponding paragraph to reflect this accordingly.

Line 86: similarly, "frost flowers and blowing snow in combination could be the major..."

Changed to "...frost flowers and blowing snow in combination are a source of atmospheric bromine."

Line 89: "satellied-derived"

Changed to "satellite-derived".

Line 95: Pratt et al (2013) did indeed find the most production rates of Br2 were from tundra snow, but it's important to emphasise that this snow was close to the coast, and as a result it was saline. i.e. this effect would not be widespread across the tundra with just any snow.

Added "As the snow chambers were located close to the coast, the inland tundra snow was most likely salinated by atmospheric processes." to Section 1 of the revised manuscript.

Line 107: "likelihood of" not "likeliness for"

Done.

Line 126: "temperature" spelt wrongly

Corrected.

Line 128: include the minus denotion on Br 2Cl, i.e. it should be Br2Cl-

Corrected.

Line 138: remover the "with", i.e. to read: also atmospheric mercury...

Done.

Line 154: "likelihood" not likeliness

Done.

Line 156: "two-digit" wind speeds is not the best way to describe this unless the relevant units are given. Best to give a number, e.g. "and at wind speeds greater than 10 m/s"

Changed to " ...and at wind speeds larger than 10 m/s.".

Line 239: What is the effect of assuming that all BrO is located and well mixed within the lowermost 400m? i.e. what is the sensitivity to this assumption?

The middle pannel of Figure 1 of the manuscript shows that at an albedo of 0.9 (which is assumed for GOME-2 tropospheric BrO retrievals shown in our study) and at clear-sky conditions, the air mass factor is almost constant throughout the lower atmosphere. Hence, assuming that the BrO was located at another altitude range in the lower atmosphere, would have no significant impact on GOME-2 BrO results shown in this study.

Line 251: "eliminate" is mis-spelled

Corrected.

Line 285 "cloud-free"

Changed.

Line 323: Tian-Kunze et al is not in the reference list

Added to the reference list.

Line 354: data were (not was)

Corrected.

Line 440 to 445: does the comma shape indicate the cold section of the cyclone, and could that be relevant (e.g. through the reaction kinetics you discuss earlier)?

The comma can be associated with low level clouds at the front of the polar cyclone and hence appears at a region of strong temperature gradients between the warm and cold section of the low pressure system. As described in Section 4, the BrO plume occurs at the same location as low temperatures around 350 geopotential metres, although the relation is less clear during the development of the event compared to later stages. This is in agreement with the results by Sander et al. (2006) described in Section 1, who found that recycling of BrO on aerosol surfaces is most efficient at low temperatures. The paragraph mentioned by the reviewer describes the first GOME-2 observation of the BrO plume. As this satellite observation as well as corresponding WRF weather simulations are not shown in the manuscript, we added the following sentence to the corresponding paragraph in Section 4 of the revised manuscript:

"Moreover, similar meteorological conditions were present at plume location for both satellite observations."

Line 474: and throughout, be careful how you denote longitudes, a positive number implies east, a negative number denotes west, but to say that something is -160 degrees East introduces double negatives. Why not just say it's 160W..?

Changed throughout the manuscript as suggested, e.g. -160°E changed to 160°W etc.

Line 506: spell out gpm

Done.

522 and 523: as above, care with how you denote longitude

See above.

Line 517: this section discussed figure 5, and the importance of 2 patches of thin sea ice. Within the context of the figure, they don't look very large, given their apparent effect on the atmosphere. Can you say how large they are in km 2?

As a rough estimate, these regions are 250 km in meridional direction and 200 km in zonal direction. We consider this as a sufficient size to provide substantial amounts of bromine to the atmosphere. It should also be considered here, that Figure 5 shows SMOS sea ice thicknesses smaller than 1 m only. We do not know of any study that investigated if there is an upper limit of sea ice thickness for efficient bromine release. However, as described in our paper, many studies have linked young and first-year sea ice to bromine explosion events (e.g. Simpson et al., 2007; Pratt et al., 2013). According to Kwok et al. (2015), first-yea sea ice can grow at least up to about 2 m in thickness. Hence, potential bromine release areas described in our study, may be even larger than the areas identified in Figure 5.

Moreover, the thickness retrieved with SMOS has to be interpreted as a mean thickness. The sea ice thickness and lead occurrence has a statistical distribution within the coarse SMOS footprint. For the thickness, a lognormal distribution was assumed (Tian-Kunze et al., 2014) while the lead width distribution follows a power law (Wernecke and Kaleschke, 2015). As a consequence, we can expect an enhanced occurrence of leads and thin ice (with a surface of high salinity) when the SMOS retrieval shows relatively low ice thicknesses.

Also, rather than just describe their position, it would help the reader if they were indicated explicitly on Figure 5.

Potential bromine source regions are now indicated by black arrows in Figure 5. The Figure caption has changed accordingly and arrows are referred to in the text on Figure 5 in Section 4 of the revised manuscript.

Line 585: following from above, another way to emphasise the role of the thinner sea ice might be to show an equivalent zoom-in of the SMOS data, in a panel next to the MODIS data. (e.g. Fig 6a, and 6b).

An equivalent zoom has been added to Figure 6 and the Figure caption changed accordingly. We also refer to the SMOS zoom image in Section 4 of the revised manuscript.

Also, does the SMOS data give any information on thickness of snow on the sea ice? Was the depth of snow less in the region of the MODIS zoom-in?

In prinicple, SMOS could provide information about the snow thickness (e.g. Maaß et al, 2013), but further validation is required until a reliable product can be issued.

Line 643: “origin” is mis-spelled

Corrected.

Line 657: “emission sources than...”

The corresponding sentence was removed from the manuscript as a consequence to our response to comment 6 by anonymous referee #2.

Quality (resolution) of Fig 1 needs to be improved

Done.

<u>References:</u>

Kwok, R. and Cunningham, G. F.: Variability of Arctic sea ice thickness and volume from CryoSat-2, Phil. Trans. R. Soc. A, 373(2045), doi:10.1098/rsta.2014.0157, 2015.

Maaß, N., Kaleschke, L., Tian-Kunze, X., and Drusch, M.: Snow thickness retrieval over thick Arctic sea ice using SMOS satellite data, The Cryosphere, 7, 1971-1989, doi:10.5194/tc-7-1971-2013, 2013.

Pratt, K. A., Kyle, D. C., Shepson, P. B., Douglas, T. A., P\"ohler, D., General, S., Zielcke, J., Simpson, W. R., Platt, U., Tanner, D. J., Huey, L. G., Carlsen, M., and Stirm, B. H.: Photochemical production of molecular bromine in Arctic surface snowpacks, Nat. Geosci., 6, 351-356, doi:10.1038/ngeo1779, 2013.

Simpson, W. R., Carlson, D., Hönninger, G., Douglas, T. A., Sturm, M., Perovich, D., and Platt, U.: First-year sea-ice contact predicts bromine monoxide (BrO) levels at Barrow, Alaska better than potential frost flower contact, Atmos. Chem. Phys., 7, 621-627, doi:10.5194/acp-7-621-2007, 2007.

Wernecke, A. and Kaleschke, L.: Lead detection in Arctic sea ice from CryoSat-2: quality assessment, lead area fraction and width distribution, The Cryosphere, 9, 1955-1968, doi:10.5194/tc-9-1955-2015, 2015.