**Comment to Seo et al.'s manuscript titled 'Spatial distribution of enhanced BrO and its relation to meteorological parameters in Arctic and Antarctic sea ice regions'**

General comments:

This manuscript reports a statistic analysis of polar total column BrO and its corresponding meteorological parameters (including temperature, surface pressure, wind seed, direction and tropopause height), using 10-year GOME-2 BrO and meteorological data. A further Spearman rank correlation analysis was applied to assess the dependence of total column BrO on various meteorological parameters. Some interesting results regarding the spatial distribution of enhanced BrO and its relation to the above meteorological parameters are reported which is welcome. The authors also attempted to link the relationship to relevant physical/chemical mechanism(s) being proposed previously. This study indeed adds some new knowledge to help a better understanding of the underlying processes involved. However, I found their attempt to evaluate some relevant mechanisms is dangerous and inappropriate. This is because the bromine source is a complex function of multiple (rather than one) factors and the relations between them are largely non-linear, rather than linear. For example, the SSA production from blowing snow is a complex function of wind speed, temperature and relative humidity (Yang et al., 2019), more specifically, the SSA production (and bromine flux) is actually proportional to the sublimation flux of blowing snow, rather than individual parameters (winds, temperature and *RH*). Secondly, these meteorological parameters examined are not independent, instead they are deeply correlated (also pointed by the authors). For example, they are deeply correlated during a storm system. For this reason, I suggest the authors add a table to show the cross-correlation among these meteorological parameters during enhanced BrO cases and discuss their implications to deriving your conclusions. Thirdly, it is not correct to assume that a higher correlation coefficient between two factors than others necessary means this link is stronger than other links. Unfortunately, this assumption seems being used in this manuscript to make some conclusions. For the above reasons, I suggest a major revision before recommend it to publish in ACP.

Specific comments:

P2L35-36: 'Overall, the BrOx catalytic destruction cycles are significant but not as important as those of ClOx', though this statement is correct, recent modelling-based work indicates the cross-halogen reactions (e.g. between Br and Cl) are important in terms of stratospheric ozone depletion, see recent work by Fraiser et al. (2019).

P2L43-44: 'An important tropospheric inorganic bromine source is the polar sea ice region (Kaleschke et al., 2004 and references therein)'. It would be better to cite a review paper (e.g. Abbatt et al., 2012) here, as Kaleschke et al.'s paper specifically addressed the importance of frost flowers. Or you can specify various proposed candidates of sea ice sourced bromine from frost flowers (Kaleschke et al. 2004), first-year sea-ice (Simpson et al., 2007b; Pöhler, et al., 2010), sea salt aerosol produced from blowing snow (Yang et al., 2008), stratospheric origin (Salawitch et al., 2010), snowpack photochemistry (e.g. Pratt et al., 2013) and sea spray from open leads (e.g. Peterson et al., 2015). See references shown below.

P4L119-123: 'In this study, to overcome this snapshot treatment of elevated BrO events during polar spring, and to obtain a more general understanding of the enhancements of total BrO columns, we …' I do not agree that snapshot study is less-advantaged comparing to general statistic study. They both have their individual advantage and disadvantage, they may

compensate each other at some point. I suggest a slight change to the tone used in the statement.

P15/P18: in P15L476-477 ‘Surface wind speed is not significantly correlated with total BrO vertical column density in either the Arctic or Antarctic.’ A similar statement is also in the summary (P18L557). However, they are contrary to the results shown in Table 3 and Fig. 20, where it shows ‘Note that all Spearman’s rank correlations are significant ($p<0.001$)’. Is surface wind speed significantly correlated with total BrO vertical column density or not?

P17L533-4 and L552-555, the two statements are actually duplicated, either delete one or move one to section 4.3.2.

P27 Table 3: given that the occurrence of blowing snow has a threshold wind speed, e.g. 7~8 m/s, I suggest add an extra row in the Table to show the correlation coefficients for wind speeds > 8 m/s (or >12 m/s).

Minors:

P1L26: change ‘they release bromine atoms and Br and bromine monoxide (BrO)…’ to ‘they release bromine atoms, e.g. Br and bromine monoxide (BrO) …’

P1L28: Theys et al., 2009b should be 3009a, as Theys et al., 2009a has not been cited.

P2L31: change ‘$2Br_2$’ to ‘$Br_2$’

P2L32: again you cited ‘They et al., 2009b’ before their 2009a paper.

P3L67: Theys et al., 2009a should be cited before 2009b.

P4L112: **‘**A bromine explosion event linked to cyclone development in the Arctic was investigated by Blechshmidt et al. (2016).’ The same event was also studied by Zhao et al., 2016.

Reference:

Yang, X., Frey, M. M., Rhodes, R. H., Norris, S. J., Brooks, I. M., Anderson, P. S., Nishimura, K., Jones, A. E., and Wolff, E. W.: Sea salt aerosol production via sublimating wind-blown saline snow particles over sea ice: parameterizations and relevant microphysical mechanisms, Atmos. Chem. Phys., 19, 8407–8424, https://doi.org/10.5194/acp-19-8407-2019, 2019.

Fraser, D., J., Keeble, O., Morgenstern, G., Zeng, G., A. N., Luke, X. Yang, Improvements to stratospheric chemistry scheme in the UM-UKCA (v10.7) model: solar cycle and heterogeneous reactions. *Geoscientific Model Development*, 12. 1227-1239. 10.5194/gmd-12-1227-2019, 2019.

Abbatt, J. P. D., Thomas, J. L., Abrahamsson, K., Boxe, C., Granfors, A., Jones, A. E., King, M. D., Saiz-Lopez, A., Shepson, P. B., Sodeau, J., Toohey, D. W., Toubin, C., von Glasow, R., Wren, S. N., and Yang, X.: Halogen activation via interactions with environmental ice

and snow in the polar lower troposphere and other regions, *Atmos. Chem. Phys*., 12, 6237-6271, https://doi.org/10.5194/acp-12-6237-2012, 2012.

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Simpson, WR, Carlson, D, Hönninger, G, Douglas, TA, 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**(3): 621–627, doi:10.5194/acp-7-621-2007, 2007b.

Zhao, X., et al.: A case study of a transported bromine explosion event in the Canadian high arctic, *J. Geophys. Res. Atmos*., 121, 457-477, 10.1002/2015JD023711, 2016.