Review of Luo et al "Observations and the source investigation of boundary layer BrO in Ny-Aalesund Arctic"

The paper deals with a case of elevated BrO and depleted O3 which the authors state is driven by local processes. The data are interesting, but several statements are contentious, and the conclusions do not sufficiently take into account alternative interpretations. The paper is worthy of publication in ACP, but these fundamental issues must first be dealt with.

Major/minor concerns:

1) The authors conclusion is that the event described here is a local event, and that the rate of increasing BrO and of decreasing O3 are really fast. Precisely because they are so unusual, it is extremely important to demonstrate beyond doubt that this is a locally-driven event. At the moment the paper does not do this. There are 3 possibilities that I see:

i) *That this event is a result of long-range transport.* The event starts at around 17:00 hours on 26 April 2015. This is late in the day, and Global radiation appears to be less than 200W/m2. Trajectory calculations show that the trajectory arriving at 500m agl at noon (the yellow line) travelled at ground level for roughly 2.5 days before rising rapidly to the trajectory end point. The next trajectory had a very different path, reaching the trajectory end point after travelling at roughly 1000m altitude throughout the previous 3 days. i.e. this point in time indicates a discontinuity in air mass origin, and indeed this is reflected in the observational data. The BrO map on 27/4/15 shows an area of enhanced BrO between Svalbard and Greenland, which to me looks as if it is in the path of the trajectory (yellow line) which travelled at the surface. **To help the reader**: Please make the relevant diagrams bigger. I do not see that trajectories arriving at 1000 m asl are relevant, and consider that these could be removed. Also, most of the BrO maps are not needed – the critical ones are 24th to 27th April. Please remove the others and make the ones for 24th to 27th MUCH larger. Then it will be possible to properly compare the trajectories with the BrO maps, and to make sensible assessment of the role of long range transport. If the conclusion is that it's long range transport, we would not need to worry about the low levels of radiation at this time of day.

ii) *That this event is driven by the sea ice, but that it is not local to Kings Bay.* The coincidence in timing of sea ice arriving in Kings Bay and in the drop in O3 is very interesting. However, the authors' suggestion seems to be that ozone levels are normal until the ice arrives, and then suddenly it drops. My question here is: why should ozone depletion only "switch on" when the ice arrives in King's Bay..? If the ice is active, wouldn't you expect there to be some sort of equilibrium between the air and the ice, with ozone depletion "travelling with" the sea ice..? Local depletion that has been described before has occurred because the ice has **formed** locally, or air has traversed an area with new sea ice, which is quite different to this case. If the ice is actively depleting ozone, this could have started before the ice arrived in the Bay, in which case air could already be low in ozone and thus be transported, albeit from a local area of depleted ozone. Here the maps of sea ice are critical, and here there is a bit of a problem. The authors provide the web link to the images, but in none of the files can one find the image that is presented in Fig 11. This inconsistency absolutely has to be explained, and the duration of ice in the Bay demonstrated. If a photo is used, the right and proper citation for the image must be supplied so that readers can look for themselves and assess the local conditions.

iii) *That this event is locally-driven.* However, it must be explained how depletion could occur at the very low solar radiation levels at this time. The authors state on Page 7, line 21, that the heterogenous reactions can still happen under twilight. However, the catalytic cycle shown in Fig 1 is clearly partly photolytic – please provide evidence that there is sufficient light available for the photolytic parts of the catalytic cycle to proceed at a sufficient rate to explain the observed ozone loss.

2) Another major concern is that the location of observations discussed here is not clearly provided. It seems that the MAX-DOAS measuring BrO is located at sea level, and O3 is at 474m on Zeppellin Mountain. Temperature is measured in Ny Alesund. Where is mercury measured? Please state. Also, please show, on Fig 3, the location of Zeppelin Mountain. It seems likely that MAX-DOAS view is over Kings Bay, and that O3, Hg, and temperature are measured in the opposite direction, up on Zeppelin Mountain.

The authors conclude from Fig 5 that the BrO layer 0-1km is the most possible distribution of the BrO. I do not see this so clearly. Please justify this conclusion. Better still, please do the following: Plot Fig 5b as 2 panels, one from 20:00 to 24:00, and one from 00:00 to 04:00 – this will help to clarify where the BrO is, and whether it has moved with time. Also please explain the difference between the red and orange dots? The vertical distribution of BrO is important for the argument of local depletion.

The authors also state (P5 line 27) that wind velocity during this period is more than 5m/s, but a careful look at Fig 6 shows that the wind velocity is highly variable, ranging between ~7m/s and 1 m/s – it is certainly not simply 5 m/s. This must surely affect air mass movement within the Bay… at low wind speeds, one would not expect much vertical mixing, and if a local process is at play, vertical mixing is essential if the signal of depletion (O3) is measured at 474masl…

One minor point, but actually important… If O3 depletion is observed at 474m, there must surely be a lot of sea ice to drive it… I have looked at the web-cam images referred to in the text, and I cannot see evidence of extensive sea ice. Please clarify where the image in Fig 11 came from and provide additional images across this period if possible.

One question, the authors describe that the MAX-DOAS can detect O3… It would help this discussion a lot to show the O3 measured by the MAX-DOAS, even if not very good quality, as it must surely be possible to distinguish between background levels, and none, and this would help with the timing discussion.

3) Fig 7. The authors state on Page 6, line 2, that the differences in BrO dSCD <4 degrees is very small – This is hard to assess as red and orange dots are hard to tell apart. To demonstrate this point, please plot only 2, 3, 4, 5, degrees, and use colours that are easy to distinguish.

4) Was new sea ice actually forming during this event..? And why did the sea ice dissipate.

5) Finally, is it possible to learn anything from the fine structure of Fig 8, e.g. the rise in BrO around 22:00 on 27th April..? This, however, must surely be caused by transport given the lack of solar radiation at this time?