Comments on the manuscript „Vortex-wide chlorine activation by a mesoscale PSC event in the Arctic winter of 2009/10" by T. Wegner et al.

This is an interesting study that investigates the temporal and spatial evolution of chlorine activation on PSC particels during a PSC event over Greenland in the winter 2009/10. The interpretation of observational data is completed by calculating PSC surface area density from observed backscatter with a simplified heterogeneous chemistry model. It is shown that even if only a small fraction of the vortex area is covered by PSCs, this can lead to activated air throughout the vortex. This is referred to as "processing reactor". Furthermore it is shown in this case study that chlorine activation on PSCs is faster than on binary aerosol.

The manuscript is well written and structured in a logical way, however, some points are unclear to me. Hence, I recommend this article for publication, when the following points are addressed properly.

General comment:

It is an interesting result that a small PSC area can produce vortex-wide chlorine activation. The "potential PSC area" calculated with temperature thresholds is often used as indicator for heterogeneous chemistry and hence for chlorine activation. Do you think that another quantity would be more suitable? Or is this a very special and rare event that is studied here?

Specific comments:

Abstract:

- P. 33732, L. 10/13: Please introduce HCl (hydrochloric acid) and ClONO2 (chlorine nitrate)

- P. 33732, L. 16: PSC → PSCs

- P. 33732, L. 19: PSCs → PSC particles

- P. 33732, L. 20: PSCs → PSC formation

- P. 33732, L. 21: PSC surface area **density**

1 Introduction:

- P. 33732, L. 24: the ozone hole → the Antarctic ozone hole

- P. 33733, L. 4: I think in the introductory section this should be a bit more detailed. I suggest: „... of the polar stratosphere: On the one hand heterogeneous chemistry on PSC particles impacts the partitioning of inorganic chlorine by chlorine activation, i.e. by converting inorganic chlorine reservoir species (mainly HCl and ClONO2) to photo-active species (ClOx = ClO + 2 Cl2O2). On the other hand PSC particles can grow large enough to effectively ... "

- P. 33733, L.11: Actually, two questions are asked here and not one. I suggest:

„Two of the key questions are: (1) To which extent is heterogeneous chemistry on PSC particles responsible for chlorine activation and (2) what are the time-scales for this processing."

Furthermore I suggest that the questions are picked up in the conclusion.

- P. 33733, L.14: If I understand correctly the influence of PSCs is compared to the influence of binary aerosol. I suggest:
„.. that the influence of PSCs on chlorine activation in subordinate to that **of** cold binary aerosol .."

2 Instrumentation and model description:

I recommend to re-organize parts of this section a little bit:

- P. 33734, L.10-11: „Details about the CALOP PSC classification algorithm can be found in Pitts et al. (2009, 2011, 2013)." (1)

- P. 33735, L.11-15: „The CALIOP PSC classification .." (2)

- P. 33735, L.21-25: „PSCs are identified ..." (3)
This paragraph gives additional information about the detection algorithm. Therefore, I think that it would better fit in the first paragraph of the section.

→ I suggest re-organizing it from (1)-(2)-(3) to (2)-(3)-(1).

Other comments:

- P. 33734, L.13: I suggest: „Mixtures of STS and NAT are further divided into **three groups,** MIX 1, MIX 2 and MIX 2 enhanced**,** where NAT number density ..."

- P. 33734, L.26: native → original

- P. 33735, L.6: NAT is already explained → „ ..(NAT existence temperature).."

- P. 33735, L.6ff: How large is the difference between T_NAT and T_ACl? Values?

- P. 33735, L.26: I suggest: a realistic → the

- P. 33735/6, L27-L.2: „.. a relationship" of what? I suggest: „.. to derive a relationship between CALIOP measurements of particulate backscatter at 532 nm and the liquid particle SAD."

- P. 33736, L. 18: Which season? And are the used values of the parameters representative for this season?

- P. 33736 Eq 1: I suggest writing the parentheses as in Fig. 1 b

3 The mesoscale PSC event:

- P. 33737, L. 7-9: The information about the temporal evolution can not be found in Fig. 2, right? Please make this clear in the text.

- P. 33737, L. 22: I suggest: „... processing **with** low values of HCl **indicating** air masses where ..."

- P. 33738, L. 6: „Model calculations indicate .." Does this refer to current knowledge or are the „model calculations" the simulations used in this study?

- P. 33738, L. 10: „ .. in regions**,** where our calculations indicate **that** only unprocessed air is present**,** could originate .."

- P. 33738, L. 15-25: This paragraph I find hard to follow. It would be helpful if you indicate the Figure where to look at, e.g. in line 17. Furthermore I was wondering why it is pointed to Fig 3c to show the higher HCl mixing ratios of air that was not exposed to PSCs. I think this is also shown on the other days and not exclusively on 2 January. I suggest including „e.g." .
In line 24-25: „After 3 January .." Is this related to the sentence before? This is a bit confusing.

- P. 33738, L. 26: „... for air **masses** to cirumnavigate .."

- P. 33739, L. 2: „Vortex-averaged values .." of what? HCl?

- P. 33739, L. 10: I suggest: „... indicate the formation of STS**. Figure** 4d suggests .."

- P. 33739, L. 16: Please add the Figure number to look at.

- P. 33739, L. 16-19: „As the threshold ... decreases, .." When I first read this sentence, I understood this as a temporal evolution. I suggest: „With smaller threshold backsactter values chosen for the area describing the „processing reactor" (Fig.4d to 4a), ..."

- P. 33741, L. 19 ff: Please add the Figure numbers to look at.

- P. 33742, L. 12: I suggest: „... as described in this study **chlorine activation on PSCs is faster than on** the background aerosol."

- P. 33742, L. 14/15: „... the latest.." ?

- P. 33742, L. 27: 24h → 24 hours

- P. 33742, L. 3: „... and **allow to** distinguish between .."

- P. 33743, L. 4-5: I suggest: „The average daily HCl mixing ratio shows substantially smaller HCl values in processed than in unprocessed air."

- P. 33743, L. 5-6: We've shown → We show

- P. 33743, L. 6: a uniform → an uniform

- P. 33743, L. 15: excellent → good

- P. 33743, L. 23-25: This sentence suggests that only ice PSCs can serve as „processing reactor“. Is this meant?

Figures:

Figure 1: Please add the notice to the figure caption that the x-axis for SAD is on the top.

Figure 3: Caption:
L. 1: I suggest: „The meteorological situation over a six-day period from 31st December 2009 to 5th January 2010 ..“
L. 4: „.. regions of the vortex with air which has passed through a PSC.“
L. 6: „.. values **are** indicative ..“

Figure 4: Please add y-labels. Furthermore, it would be interesting to know the used temperature thresholds.

Figure 5: Which backscatter theshold is used here for detecting processed and unprocessed air?

Figure 6: I really had problems to understand this figure. What means the date in the title of the subfigures? Is it the initialisation date of the respectice trajectory? I suggest adding „Trajectory 1“, etc. and clarifying this is the caption.
Please add a), b) .. to the figure caption.
The unit of SAD is not correct.