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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Unusual chlorine partitioning in the 2015/16 Arctic winter lowermost stratosphere: Observations and simulations" *by* Sören Johansson et al.

Anonymous Referee #1

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This work examines the heterogeneous chemistry in the 2015/2016 Arctic winter, LMS, during the POLSTRACC/GW-LCYCLEII/GWEX/SALSA campaigns. The GLORIA instrument aboard aircraft and the satellite instrument Aura MLS was used to examine activation and deactivation of inorganic chlorine, ozone depletion, and irreversible denitrification. Processes were evaluated using both the state-of-the-art lagrangian chemical transport model (CLaMS) and Eulerian (EMAC) CTM. This is an excellent study that show how observations taken on different platforms (i.e., satellite and aircraft), coupled with model analysis can explain and document the chemical processes in the atmosphere. This paper is appropriate for ACP. I have a few comments below that I would recommend the authors to consider.

Title: Is this winter that "unusual"? I.e., when the temperatures get cold enough (in the Arctic), the atmosphere will be denitrified, heterogeneous processes happen, ozone will be depleted (and if low enough), will recovery into HCl, not ClONO2. You do make some nice points about the role of O3 depletion and denitrification, e.g., you say "The (for the Arctic) unusual chlorine deactivation has been identified through CLaMS sensitivity studies to result at 380 K from low O3 abundances rather than from low NOy availability caused by PSC sedimentation. At higher potential temperatures (as shown at 490 K), denitrification played a greater role." So, my point is this, is the 2015/16 Arctic winter "unusual", or is it that this winter happened to have multiple satellite instruments flying, along with an impressive field campaign, with mature chemical models to confirm what is already known?

Introduction: Portmann et al., JGR, 1996 (ClONO2 reference) should be added. This paper was one of the first papers that gave detailed explanation on the polar chemistry of ClONO2 and how denitrification plays a role.

Page 6. Is there a reference for the STS parameterization in CLaMS? Is this based on Carslaw et al. 1994?

Page 7. Section 2.3.2, EMAC. I realize that the PSC representation is discussed in Khosrawi et al., 2017, but for the reader it would be nice to have several sentences that discuss the PSC representation in EMAC.

General Comment on comparing to Satellite observations. There are a lot of detail comments about how well CLaMS compares to MLS and ACE-FTS. Frankly, I am very impressed with the comparisons. However, in the LMS, where there are gradients and where there are differences from the observations and model – can this not be, at least partially, due to the 3-4km retrieved vertical resolution of the observations (especially when the stated vertical resolution of the model in this region is ∼800m)? I assume you have not applied the averaging kernel from the observations to the model results? If not, it would be interesting to discuss the impact of NOT including the AVK when

discussing Figure 3 and 4.

Comment on comparison of CLaMS and EMAC to observation in Figure 8. The CLaMS model representation of the GLORIA observations is excellent. The EMAC, model, even at 1-degree horizontal resolution seem to have issues representing ozone (Figure 8) and ClONO2 (Figure 9). On page 19, the authors make several good comments on the differences between CLaMS and EMAC that may contribute to EMAC not representing either CLaMS or GLORIA results. The authors suggest that EMAC has issues with representing downward transport in the lower part of the polar vortex. Besides transport, is there any reason to believe that there are chemistry differences between the two model frameworks that could be contributing to the differences. E.g., are the heterogeneous chemistry modules similar between EMAC and CLaMS? Some discussion here would be useful. In addition, it is not clear to me why the EMAC model results are in this paper?? The CLaMS model is useful since it represents the observations very well and has been used to understand chemical processes. What is the role of the EMAC model?

Figure 10. Panels (i) and (j) are unreadable if you print out the paper. One can view your symbols if you blow up the PDF on a large monitor. I would suggest move the caption (below panel "j") and expand the panels, making them larger.

Definition of ozone loss tracer. Does it make a difference if the ozone loss tracer includes gas phase chemistry? I believe you are assuming that there is no chemistry included in this tracer, correct?

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