Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2017-427-RC2, 2017

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Cyclone-Induced Surface Ozone and HDO Depletion in the Arctic" *by* Xiaoyi Zhao et al.

Anonymous Referee #2

Received and published: 1 September 2017

This is the review for the manuscript "Cyclone-induced surface ozone and hydrogen deuterium oxudy (HDO) depletion in the Arctic" submitted by Xiaoyi Zhao et al. The low ozone events have been observed in the Arctic since 1970s (i.e. NOAA Barrow ozone record, Alaska) and were linked to so-called "bromine explosion" events. There are ongoing discussions about sources and mechanisms that are behind the ozone depletion events. Authors analyzed two special ozone depletion episodes observed over Eureka, Canada, which were found to be coincident with HDO depleted-airmasses and the bromine-enriched particles transported with the blowing snow. Observations were compared with chemistry climate model (UKCA) and chemistry transport model (pTOMCAT). The new surface snow salinity scheme was used in both models, which is argued to control the level of the ozone depletion event and amount of transported

BrO. Result of UKCA simulations matched well with observed ozone and BrO levels. Analyses of meteorological conditions associated with the observed low ozone events suggest that the blowing snow creates the aerosols enriched in bromine. The models seem to have limitations with effectiveness of the boundary layer parameterization schemes and the amount of the mixing of the free tropospheric air into the boundary layer. This is well written paper that combines a wide range of measurements, modeled data and reanalyses to investigate the processes in the Arctic. There are several comments and question that should help reader to navigate the discussion of model simulations. Questions and comments: p. 8 line 30, "through", r is missing p. 8, line 37, May be it will be more clear to say "Ozone-sonde observations (Figure 4, a) indicate presence of thin ozone depleted layer at 800∼900 m during March 1 and 2 launches that is above the boundary layer". The depleted layer in March 1 profile (Figure 5) seems show either higher boundary layer than in case of two other profiles (it is hard to tell from ozone profile) or it can be showing growth of the boundary layer that is entrained the tropospheric ozone. Is it possible to discern the height of the boundary later from radiosonde readings? As you pointed out, neither model was capable reproducing the thin (500 m) ozone-depleted layer. The UKCA seems to have a more advanced boundary layer parameterization scheme, but it created a strong boundary condition that is different from ozone-sonde profile. During March 1 and 2 event, the pTOMCAT ozone mixing ratio below 2 km is lower than the UKCA results. Also, pTOMCAT produces large BrO amounts (that also show diurnal cycle) as compared to the UKCA. However, no clear diurnal gradient is observed in the pTOMCAT ozone fields. Also, in UKCA BrO panel, there seems to be a very clear thin shallow boundary layer, with almost no BrO present in the boundary. At the same time, pTOMCAT produces high BrO events that are well mixed all the way to the surface. Since there is a difference in how these two models simulate the boundary layer, there will be differences in their ability to produce ozone depletion events that can be related to the processes in the boundary layer. p.9, lines 1-21. Similarly, the lack of the representative boundary layer mixing scheme in pTOMCAT model deters it from capturing the BrO increase and ozone depletion in 2011 case, as seen in Figure 6. The issue with the boundary layer dynamics has been mentioned by Authors on p.9, line13-15. I also agree with Authors that the difference between 2007 and 2011 events should be related to the low sunlight conditions. However, it may be also related to the enhanced mixing vs well established boundary layer in 2011. It will be nice to include figure with ozone-sonde and matched model profiles for 2011 case (similar to Figure 5). Then one can understand how stable the boundary layer might have been in 2011 vs 2007. It may be nice to have the Figure that shows time development of the boundary layer over Eureka during studied ozone depletion events. p. 9, lines 32-33, Please explain the units of sensitivity. Does red color mean 100 % sensitivity? p.9 lines 35-39. Discussion of Figure 9. It appears that the boundary layer from ERA-Interim reanalyses over Eureka (circles) on February 28, 2007 stayed very shallow (lower than 200m). Can it be confirmed by comparisons with ozone-sondes? Also, could the reanalyses data for boundary layer be compared with radiosonds/ozone-sondes over Eureka? What was the boundary layer height shown in EAR-Interim data over Eureka on March 1st and March 5th? It can help to understand mixing of the free tropospheric airmasses into the boundary layer. Was the depleted ozone layer observed above the boundary layer on March 1-2 was mixed into boundary on March 3d? I believe that Figure 10, c (lidar backscatter ratio) can be used for this discussion, showing the top of the enhanced scattering levels to reduce with altitude from $\sim$ 5 km on March 1 to very shallow layer on March 3, and well mixed boundary on March 4th. It should be possible to analyze the AHSRL data for identification of the boundary layer height? p. 13, lines 8-10 and the previous discussion of the polar vortex influence. The polar vortex mixing into transported airmasses could have happened not over Eureka, but some place further North. Is it possible to do the RDF (reverse domain filling) analyses by using the MERRA 2 or modeled ozone fields to investigate the origin of the airmasses transported over Eureka and how much the ozone in the airmass might have changed during the transport?

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