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Interactive comment on "Analysis of the latitudinal variability of tropospheric ozone in the Arctic using the large number of aircraft and ozonesonde observations in early summer 2008" *by* Gerard Ancellet et al.

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We thank reviewer 1 for his careful review and the useful annotated paper. We apologize for the large number of English errors and the new manuscript has been carefully edited by one of the English speaking co-author. Find below the answers to the questions raised by the reviewer and the revised paper is provided as a supplement document

Reviewer:"The paper meets the ACP criteria and can be published after minor revision and technical corrections. An important feature of this paper is that it is not clear if only

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nighttime tropospheric O3 measurements are performed. The authors have to clarify this everywhere needed in the manuscript (i.e. in Fig. 17, it is not mentioned; and also in all Figs., this should be mentioned)".

There is no figure 17 but we specify now that the ozone lidar performances are given for daytime mesurements in section 2. It is true for both the ALTO lidar and the NASA airborne lidar. Regarding the questions about daytime versus nighttime lidar measurements. All the aircraft flights are during the day and the ozone measurement performances are given for daytime measurement. It is said more clearly in section 2.

The annotated paper is attached to this report. The main remarks in the annotated are: Reviewer "Need to rephrase line 18-20 p. 2 and line 6-7 p. 4"

The two new pieces of text are now:

" The ozone distributions over North America have been discussed for the spring period at high latitude using the Tropospheric Ozone Production about the Spring Equinox (TOPSE) and Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) data set in several publications (Browell 2003, Wang 2003, Olson 2012, Koo 2012) showing: (i) frequent occurrence of ozone depletion events (ODE) in the planetary boundary layer (PBL), (ii) a net O3 photochemical production rate equal to zero throughout most of the troposphere, (iii) a latitudinal increase of the tropospheric ozone concentrations due to transport from mid-latitudes and Stratosphere-Troposphere Exchange (STE)"

"The system is fully described in Ancellet and Ravetta (1998), and the instrument performances for different examples of daytime airborne measurements are discussed in Ancellet and Ravetta (2003) (urban pollution in the boundary layer, ozone in the UTLS, long-range transport in the free troposphere)"

Reviewer: "Need of a rephrased conclusions showing more clearly the outcome (p 21 line 20 and 26)"

The rephrased conclusion is now:

“The purpose of this work is to provide a complete picture of Arctic ozone using measurements available during the summer 2008 POLARCAT campaigns over Canada and Greenland, where 3 aircraft were deployed and 7 ozonesonde stations intensified their ozone vertical profiling. This is the first case of such complete temporal and geographical coverage. We take advantage of the large number of airborne lidar profiles (representing 67% of the O3 measurements over Canada and 26% over Greenland). The measured ozone climatology established in this paper can also be used for future model evaluation at high latitudes. For example, in our work, while a good correspondence of the measured O3 vertical and latitudinal distribution is found with model results from WRF-Chem, a negative O3 bias of -6 to -15 ppbv between the model and the observations is found in the free troposphere over 4 km, especially over Canada. This deficiency is partly related to the WRF-Chem model stratospheric ozone initialization.

The WRF-Chem model simulation is also used to discuss the relative influence of tropospheric ozone sources at high latitude in summer. Ozone average concentrations are of the order of 65 ppbv at altitudes above 4 km both over Canada and Greenland, while they are less than 50 ppbv in the lower troposphere. For Canada, the analysis of the modeled CO distribution and the weak correlation (< 30%) of O3 and PV suggest that stratosphere-troposphere exchange (STE) is not the major contribution to tropospheric ozone at latitudes less than 70° N, where transport of North American biomass burning (BB) emissions took place during the 2008 summer. Conversely, significant STE is found over Greenland according to the better O3 versus PV correlation (> 40%) and the higher value of the 75th PV percentile. This is related to the persistence of cyclonic activity during the summer over Baffin Bay.

A weak negative latitudinal summer ozone gradient of -6 to -8 ppbv is found over Canada in the mid-troposphere between 4 and 8 km because the O3 photochemical production from BB emissions mainly takes place at latitudes less than 65° N, while STE plays a larger role at latitudes higher than 70° N. A positive ozone latitudinal gra-

dient of 12 ppbv is observed in the same altitude range over Greenland not because of an increasing latitudinal influence of STE, but because of different long-range transport from multiple mid-latitude sources (North America, Europe and even Asia for latitudes higher than 77° N).

For the Arctic latitudes (> 80° N), free tropospheric O3 concentrations are related to a mixture of stratospheric O3 transport across the tropopause and Asian pollution, as already suggested by Roiger et al. (2011) using a case study of aircraft observations in the Arctic. Our study using more ozone measurements leads to the same conclusions."

The abstract has been also changed according to the changes made in the conclusions.

Reviewer "Need to quantify the differences between the backtrajectory analysis for zone 3 and 4 (p 20 line 16)"

The calculation of the fraction of air masses coming from North America (-150W/-60W, 50N/70N) has been added to quantify the role of the North American surface emissions on ozone in zone 3 and 4. The fractions of air masses coming from North America are 76% and 72% for zone 3 and 4, respectively. The fraction for zone 6 and 7 over Greenland is smaller (< 30%) and support the statement about the multiple mid-latitude sources controlling ozone in zone 7. This is now included in the text (p. 21 line 21-22 and p. 22 line 2-4)

Reviewer "Need to remove the sentence describing the WRF-Chem model charcateristics for aerosol modelling. (P. 7 line 18)"

Done

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/acp-2016-422/acp-2016-422-AC1-supplement.pdf

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