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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ozone in the Boundary Layer air over the Arctic Ocean – measurements during the TARA expedition" *by* J. W. Bottenheim et al.

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We thank the reviewer for his comments and wish to respond as follows:

Reviewer's comment: The discussion section to a large extend revisits information that has been presented extensively in previous literature. The day to day, event to event evaluation of the ozone data is lengthy, and lacks a clear direction. This section could possibly be improved by defining subsections with dedicated headlines that focus on particular conclusions derived from this study.

Response: We have completely overhauled the discussion section, separating the text into different subsections as suggested by the reviewer, to make this section better

to follow. It was (is) our purpose here to explore both the similarities and differences with previous studies of Arctic surface ozone depletion. This required us to revisit previous information. We have divided the description of the time series of the data (new section 4.1) in three parts: (1) March 20 – April 21: start of the "ozone depletion season", with frequent variation in the ozone mole fraction. (2) April 21 – May 23: a period when the ozone mole fraction is almost continually below the detectable limit. (3) May 23 – June 11: a transition period to "normal" Northern Hemispheric background conditions. Section 4.2 highlights the ambient temperature and concludes that (a) it tells us when air from above the local boundary layer brings ozone to the surface, and (b) it is mostly higher than could have been expected from previous observations Section 4.3 summarizes what can be learned from simple trajectory calculations. This section is brief in view of the well known limitations of such calculations. However we have modified Figure 5 to show the actual 3-day back trajectories when ozone was less than 5 nmol.mol-1 at TARA. Section 4.4 investigates satellite data. We shy away from a detailed interpretation of the SCIAMACHY data since we uncertain how to interpret their validity at this time with respect to surface BrO concentrations, but note that the average maximum for April does agree with the back trajectory calculations (Figure 5). We do have confidence in the QuikSCAT analysis that strongly supports the speculation that much of the Arctic surface ozone depletion would have started over the ocean off the coast of Siberia. Section 4.5 raises the question whether the chemistry is fast or not (referring to Bottenheim and Chan, 2006). We conclude that it is fast and that the TARA data support the hypothesis that most of the Arctic surface air has below detection limit ozone mole fractions, supporting the speculations of Hopper et al. (2004).

We also edited and slightly expanded the summary and conclusion section. We are more definite in our conclusion that under normal conditions the Arctic surface air contains negligible amounts of ozone, and that the presence of background ozone levels should be considered episodic, rather than the other way around. We also reformulated our speculation about the impact of this conclusion to read: "Finally, implications

should be expected from the absence of ozone in the surface boundary layer over the frozen Arctic Oceans in the spring. We have no vertical profile information at this time, but it seems possible to assume that the depth of the boundary layer was at most a few hundred meters, and probably much less. Large-scale radiative effects are therefore not likely. However, the oxidizing capacity of the surface air will not be driven by ozone chemistry, and surface exchange processes as well as the underlying ocean including the marine biology may well be impacted. Nothing is known about such effects at this time."

Reviewer's comment: It is unfortunate that there is no consideration of boundary layer height data and discussion.

Response: We agree with the reviewer but unfortunately the only information we have is from a 10-meter meteorological mast which does not permits us to be more specific about boundary layer height.

Reviewer's comment: This reviewer finds the presentation of "Origin of Observed Air", i.e. Fig. 5 and its discussion deceiving and oversimplified, as for sure sampled air does not, as shown in this figure, originate from a single/particular point and time. Most colleagues have now reverted to using dispersion models, i.e. FLEXPART, rather than back trajectory analyses, for better representation of the air mass flow path

Response: As we indicated in the text we agree with the reviewer that back trajectories oversimplify the real world, and we limited the analysis of these data. However, as mentioned previously, we have modified Figure 5 as suggested by reviewer 1 and believe that the information is now sufficiently clear about the likely origin of the air during the observed ODEs. Combined with the monthly average SCIAMACHY image showing the location of high column densities of BrO these data support our contention in the text that most of the air observed at TARA originated from the South to South-East, in particular the East Siberian Sea region. We have not undertaken a full Flexpart analysis at this time. While we agree that this may well be of considerable interest, we feel

that the TARA data deserve to stand on their own. We are considering a follow up analysis involving Flexpart, GOME-2 and QuikSCAT data to explore in more detail whether combined these datasets yield a consistent picture with the TARA observations.

Reviewer's comment: Please provide more details on the "zero trap" and inlet height

Response: The zero trap employed was an ozone removing filter (MSA type N gas mask canister). Ambient air was sampled through this canister daily for 30 minutes by electronically switching a 3 way valve. The inlet height was approx. 3 m ASL (as mentioned, the inlet filter was mounted at the back railing of the vessel). This information has been added to the text.

Reviewer's comment: Please define 'hours of daylight' (sunrise to sunset?)

Response: The reviewer is correct. The text has been modified accordingly

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