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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The potential importance of frost flowers, recycling on snow, and open leads for Ozone Depletion Events" *by* M. Piot and R. von Glasow

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Reply Part 2

Technical suggestions made by the reviewer:

Reply: Thanks for the technical suggestions, we have followed most of them.

P4532, L17: "OL provide a source region for sea salt aerosols" Is this true? I would have thought that the associated fetch associated with a small Polyna or OL would not generate large enough waves for aerosol generation."

Reply: This is an interesting question. In general, the sea salt aerosol production from an open lead depends on the size of the lead, the wind stress at the water surface, and

the morphology (presence of frazil ice, etc). Model simulations from [Gong et al.(1997)] and discussions from [Rankin et al.(2000)] suggest that open leads do contribute to the sea salt aerosol production in the Arctic. We estimate that the leads modeled in our simulations are large enough (several kilometers) to induce this production.

"General: Could the FF aerosols be replaced with blown snow with deposited bromide and still have the same impact?"

Reply: Yes. Please, see p. 4532, l. 11-13

"We don't think that leapfrogging is the best description of the process of bromine movement."

Reply: We do not see a difference between the terms "hopping" and "leapfrogging" and prefer our choice.

"if we understand correctly, all the calculations do not assume an initial presence of bromine along the trajectory"

Reply: We assume the reviewer meant "an initial presence of bromine in the snow-pack". We discuss this in detail in our first "Reply" to the first reviewer.

"What is the initial temperature profile?"

Reply: The initial temperature profiles are shown in Fig. 1:

However, we do not want to add it to the paper. We believe the change from T to θ profile in Fig. 2 (see "reply" to comment 3) is sufficient to better understand the temperature conditions in the model.

P4538, L6: "ID(Br) as defined, although accumulated deposition, this is not a local quantity as the air parcel continues to move. Rather it is the integral of deposition along the path. This should be made clearer" Reply: Done

P4542, L17: "I estimate the ozone loss due to surface deposition is about 10 ppbv in

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4 days . Or assuming a 100 m MBL would imply a VD of about 0.02 cm/s. If the MBL remains at about 100 m this seems rather rapid as it would remove the ozone is a few weeks whereas 40 ppbv can persist in transit through the Arctic for a few weeks with no perceptible depletion."

Reply: We have compared the modeled ozone deposition velocity with measured velocities over packed ice from [Strunin et al.(1997)]. In MISTRA the average deposition velocity is V_{O_3} =0.04-0.05 cm s^{-1} while it is found to be 0.07 cm s^{-1} by Strunin et al. In addition, recent observations [Peterson and Honrath(2001), Albert et al.(2002)] suggest that the ozone deposition on snow may be more important than believed in the past see [Bottenheim et al.(2002)]. Note that the polar boundary layer has an initial height of 300 m in the model, not 100 m, but it seems that the calculations made by the reviewer assume z=300 m rather than 100. Also, the PBL has often been measured at heights above 500 m [Bottenheim et al.(2002)], which significantly reduces the loss rate on snow. We have included the reference of [Strunin et al.(1997)] into the paper, p. 4541, l. 20

"In general: OL. The size of the leads used sound rather large - what sort of statistics are available? Also what are the aspect ratios of the leads? Surely the wind doesn't always blow across the leads?"

Reply: We included in the term "open lead" open leads and polynyas. Polynyas range in size from 10 to 10^5 km^2 [Morales Maqueda et al.(2004)]. Open leads are long, narrow ice openings. They are meters to kilometers wide and kilometers to tens of kilometers long; see, e.g., [Smith et al.(1990)]. As mentioned by the reviewer the wind does not always blow across a lead. Blowing in a direction different than 90° from the axis of a lead would increase the surface influence on the air parcel crossing it. Nevertheless, the extent of the modeled leads are based on a rather arbitrary choice.

"What about ubiquitous ice crystals?"

Reply: We believe the reviewer is referring to airborne ice crystals. Indeed,

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these crystals provide an adequate surface for heterogeneous reactions; see [Adams et al.(2002)]. However, our model does not include reactions on frozen surfaces. Therefore, we cannot assess the relative importance of reactions on ice in comparison with reactions in/on liquid surfaces.

P4554: "Role of acids? SO2 sources in Russia in the high Arctic appear to have been decreasing. This is likely to have affected the general acidity of aerosols over the last 20 years. Has it impacted ODEs?"

Reply: This is a very good question but it is beyond the scope of our paper and cannot be answered with certitude. The presented model results show that acidity (e.g., SO_2 or Arctic haze) impacts the strength of ODEs. Should the acidity have indeed decreased over the last 20 years, it seems very likely that reactions requiring H^+ to proceed would be reduced. The strength of the bromine explosion, e.g., is likely to be affected by less acidic transported pollutions.

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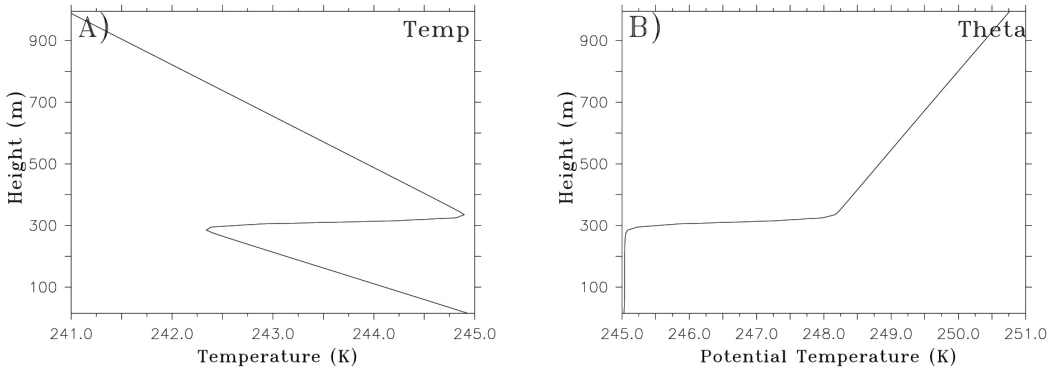

Figure 1: Initial temperature and potential temperature profiles at the start of the one-dimensional model runs in MISTRA.

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