

***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**

Anonymous Referee #2

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A Review of: “The potential importance of frost flowers, recycling on snow, and open leads for Ozone Depletion Events” by M. Piot and R. von Glasow

This paper describes a one dimensional model based study of a possible mechanism for the release of gas phase bromine from frost flowers and resulting tropospheric ozone depletion at high latitudes. The authors conclude from their model runs, that sufficient gas phase bromine to produce ozone depletion events can only be produced via heterogeneous reactions with bromine deposited on the snow pack. The authors implemented a realistic model initialized with values typical of field observations and including a large number of chemical pathways. Various simulations were performed

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to examine the sensitivity of ozone depletion to factors such as air temperature, wind speed, surface type and composition and the role of calcium carbonate in frost flower and aerosol acidification. The results of many of these simulations were compared with field observations when available. The paper is well written and thorough in its description of the problem. The modeling considerations are well explained and the results of the various simulations are analyzed in depth. The results presented in the paper are particularly relevant to the current active discussion in the community about the role of frost flowers in ozone depletion events and concur with recent field observations that suggest that direct release of gas phase bromine from frost flowers is unlikely. The paper is a valuable contribution to the body of work on polar tropospheric ozone depletion events and it is recommended that it be published with minor revisions.

In the description of the initial parameters of the model it is unclear to me as to the initial abundance, if any, of halogens in the snow pack. The case with no halogens in the snow prior to the passage of the air parcel seems unrealistic as any previous parcel with a recycling efficiency less than 100% would have a net flux of bromine to the snow. This is reflected in measurements of halogen concentrations in surface snow [e.g. Simpson et al. 2005]. Including a pre-existing amount of bromine in the snow allows for the possibility of a recycling efficiency greater than 100% via reaction (14). In the example of the base case model run (1), pre-existing halogens in the snow would reduce the tendency to accumulate gas phase HOBr as time progresses and hence increase the efficiency of ozone destruction. The fact that halogen recycling efficiency in the model is limited to 100% or less suggests no initial halogens are included in the snow pack, which is likely an unrealistic assumption. Observations of Cl-/Br- in surface snow [Simpson et al. 2005, Domine et al. 2004, Kalnajs et al. 2006] often show enhancement and occasionally depletion of Br relative to chlorine as compared to the sea water ratio of 650:1. This suggests that it is possible to have Br recycling efficiencies both greater and less than 100%, leading to Br depletion or Br enhancement respectively. While it is not necessary to re-configure the model to account for this (if it is not in the model already) this limitation should be noted in the model description.

The dependence of reaction (14), and hence the release of gas phase bromine from ionic bromine, should probably be referenced to Fickert et al. [1999]. Furthermore, observational evidence suggests that it is not necessary to precipitate calcium carbonate out of frost flowers to very rapidly achieve the required acidity for the liberation of gas phase bromine in aerosols, at least at lower latitudes [Pszenny et al. 2004]. Studies of frost flowers in the at higher temperatures in the Arctic and at very low temperatures in the Antarctic have shown that regardless of carbonate precipitation frost flowers have a pH very close to seawater. However surface snow in the vicinity of frost flowers is sufficiently acidic to support reaction (14) suggesting acidification is rapid at high latitudes as well [Kalnajs et al. 2006]. Section 3.4 would be strengthened by referencing observational evidence that supports your conclusion that bromine release and therefore ozone depletion events are not significantly affected by carbonate precipitation. It may also interesting to confirm that the modeled frost flowers are not acidified before release as aerosols, even with substantial carbonate precipitation.

On a technical note, the figures included with the paper are difficult to understand, and in some cases not of a quality suitable for publication. Figure 2 is particularly poor. In the print version the individual plots are so small as to be unreadable and in the on-line version, when enlarged sufficiently to have readable axes, they have visible image compression artifacts. Figures 1 and 5 also have clearly visible image compression artifacts and should be included as vector graphics. The lack of legends on the individual plots makes comprehension difficult, particularly with the need to turn back to reference figure 2(l) in every subsequent figure. By having the legend in the figure title, at a magnification sufficient to read the axes the title and hence the legend becomes so large as to be unreadable. Finally I question the need to have over 75 individual plots included in the paper. In several cases the the individual plots are not directly referenced in the text and could either be omitted or moved to a supplement to the paper.

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