

Interactive comment on “A mechanism for biologically-induced iodine emissions from sea-ice” by A. Saiz-Lopez and C. S. Boxe

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We would like to thank the Referee for his comments which we address as follows:

- Since the experimental data on diffusion coefficients for an aqueous medium as the one we propose in our paper is very sparse we approximate them using the Fick's laws of diffusion. In order to theoretically illustrate what an *initial upper limit* diffusion coefficient would be (e.g. $D_{aq} \sim 8 \times 10^{-3} \text{ cm}^2 \text{ s}^{-1}$) we use the first law of diffusion (Eq. (8)) considering the initial maximum concentration gradient (assumed $\sim 10^{-5} \text{ M}$) for a given flux of $J \sim 10^{12} \text{ molecules cm}^2 \text{ s}^{-1}$ estimated from initial iodine concentrations in the algae colonies.

The concentration gradient (= concentration at the phytoplankton colonies under and within sea ice – concentration at the sea ice surface) varies following accu-

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mulation of iodine in the quasi-liquid layer (QLL) at the sea ice surface. These changes in the concentration gradient with time will modulate D_{aq} and therefore the iodine diffusion timescale through the sea ice layer. Once the model is initialized we combine the Fick's first and second laws of diffusion (Eqs. (8) and (9)) to compute D_{aq} and J as the concentration within the diffusion volume changes with time.

We observe that following a decrease in the concentration gradient, as iodine accumulates in the QLL (Fig. 3b), the calculated D_{aq} decreases substantially from an initial value of $8 \times 10^{-3} \text{ cm}^2 \text{ s}^{-1}$ to $1 \times 10^{-5} \text{ cm}^2 \text{ s}^{-1}$.

We will clarify this point in the revised version.

- We thank the Referee for raising this point; the initial aqueous-phase concentration of chloride in the model is considered to be 3 times the sea-water value (0.5 M) to account for the higher salinity of the liquid brine layer at the range of low temperatures considered here. This point will be corrected in the revised version. In addition, sensitivity runs will be included to investigate of different effects of initial chloride concentration in the timescale and efficiency of the iodine release mechanism.
- We use the term quasi-liquid layer (QLL) since a QLL is a universal term that describes macroscopic layers on various surfaces. A quasi-brine layer is also a type of QLL, which of course is concentrated with salts. Additional solutes, such as salts, especially in quasi-brine layers, will enhance the thickness of this layer, compared to more dilute liquid-like layers (*i.e.*, what is more commonly referred to as the QLL) will yield a smaller thickness. In addition to Voss et al., 2005, please see Dash et al., 2006, Sadtchenko and Ewing, 2002, and Doppenschmidt and Butt, 2000, and Wettlaufer et al. 1999, which show that the range of quasi-liquid layer and quasi-brine thicknesses can vary from a few nanometers to several microns. Note that as shown on page 2958, lines 5 – 6, we do not

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assume a QLL thickness. We quantify its thickness based on the mean sea-ice thickness at coastal Antarctica, the fraction of liquid water, and a given cross-sectional area. Then, we incorporate enhanced aqueous phase reaction rates in our model simulations.

We would also like to introduce a modification in the calculation of the volumetric factor used to parameterize the aqueous-phase reaction rates in the QLL following very recent laboratory work:

To properly express aqueous phase reactions rates to QLL reaction rates, a volumetric factor (volumetric) was estimated based on laboratory derived reaction rate enhancement factors. We quantified a volumetric factor by taking the average of the upper limit reaction rate enhancement factors quantified in the lab by Grannas et al. (2007) and Takenaka et al. (1996), 40 and 2.4×10^3 , respectively, yielding:

$$\text{volumetric} = (40 + 2.4 \times 10^3)/2 = 1.22 \times 10^3 \quad (3)$$

The rate constants for the QLL reactions are then expressed as:

$$k \times \text{volumetric} \quad (4)$$

$$k \times \text{volumetric}^2 \quad (5)$$

The rate of transfer of halogen species from the QLL into the boundary layer air and the complete expression for the phase equilibration considering Henry's law constants are:

$$k_{mix} = k_t \times (0.0455 \text{cm}^3 \text{ (QLL)}/40000 \text{cm}^3 \text{ (atmosphere)}) \quad (6)$$

$$k_{(QLL \rightarrow \text{Atmosphere})} = (k_{mix} \times [\text{species concentration}])/(H') \quad (7)$$

These changes will be made in the revised version of the paper however we have already tested them in the model obtaining the same results for timescales and efficiency of inorganic iodine equilibration to the gas phase.

References:

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