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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Iodine emissions from the sea ice of the Weddell Sea" *by* H. M. Atkinson et al.

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We thank the authors of the two short contributions for the thoughtfulness they have brought to their questions, which are serious and important.

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Responses to Interactive comment by R. Saunders

This is a very interesting report containing an impressive range of measurements of iodine species off the coast of Antarctica which have potentially important consequences with regard to the role which iodine chemistry plays in such an environment. After reading the paper, I have a few questions/comments and so would be grateful if the authors could find the time to address them.

1. In section 2.1 (page 6 – line 5), it is stated that microscopy confirmed the presence of algae in the ice samples. Were any reasonably high resolution images taken of the algae? Such an image would be very interesting to see in the paper i.e. in Figure 2. Was the algal species identified as one known to participate in iodine biogeochemistry?

Response: Unfortunately, no high resolution images were taken, and the closest that we can say with confidence is that they were small pennate diatoms. The person on the cruise who might have been able to do this had hands full running the GCMS.

2. In section 3.5, it is stated that 'in general, production was observed. . .' – specifically, how many times was this the case? Also, the phrase 'in line with classical aerosol growth' is pretty vague – what was meant by this? Can the authors rule out any contribution to the particle data from sea salt nano-aerosol released as a result of ice/snow/frost flower disruption caused by the ship's passage?

Response:

(i) We said "new particle production was identified by open aerosol size spectra on nine days."

(ii) We have replaced "in line with classical aerosol growth" by "as expected from condensation and coagulation". The THAMO model exemplifies this.

(iii) We cannot rule out sea salt nano-aerosol, but some of us have shown in the lab that frost flowers do not produce aerosol, and fresh ones generally do not grow at such warm temperatures so they would by well covered by snow; and Figure 2 shows the snow to be well-bonded to the ice surface, as expected this late in the season.

3. Table 3 – data for the particle measurements are not given.

Response: Yes, we have now added this.

4. Figure 10 – there are 2 important points which I would put to the authors for consideration of more discussion in the paper:

(i) The caption for Fig. 10 states that the figure shows new particle formation as the ship breaks through the ice. I disagree with this statement and would say that it only shows particle growth (probably from condensation of vapours) from the background level starting about 20 minutes from when particle measurements were begun. The 'background' level of around 1e+4 per cc of particles at approx. 10 nm size indicated in this plot is very large for particles of this size. For newly formed particles, such a concentration would be typical of significantly smaller clusters/particles (1 – 3 nm) nucleated from background vapours (e.g. Fig. 5 in Manninen et al., ACP, 10, 7907-7927, 2010).

Response: Yes, Dr Saunders is correct to say that nucleation from background vapours occurs at smaller particle sizes that observable by our DMA, which had a minimum diameter of 9 nm. We have now said: "open aerosol size spectra, where smaller size bins contains larger counts, were observed on nine days. Open spectra are strongly suggestive of new particle formation at a diameter smaller than the 9 nm minimum observed by our DMA system, followed by growth to larger diameters. In general, the open spectra were observed as the ship moved through sea ice. Figure 10 shows an example from 13 February, where particles grow into the range >9 nm at 23:30, followed by growth over 30 minutes to size 20 to 30 nm as expected from condensation and coagulation. Before and after 23:30 the spectra had closed features, with smaller concentrations at 15 nm than 25 nm, and at 23:30 there was a 10-fold increase in particles at 9.8 nm. Hence we speculate that new particle formation occurred then at smaller diameters, and the evolution in the spectra in Figure 10 shows their growth.

(ii) The reported growth rate of 20 – 40 nm per hour is particularly high compared with typical growth rates reported in unpolluted environments. Even at the 'classic' seaweed-rich site of Mace Head, Ireland, where photolysis of iodine vapours results in rapid new particle formation events, typical reported growth rates for particles of equivalent size to this present study are only of the order of 5 – 10 nm per hour (see the bottom panel of Fig. 6 in Manninen et al., 2010).

Response: The Weddell Sea is one of the most active regions in the world for marine growth. SeaWifs images for December show parts of the Weddell Sea to have the second highest monthly average Chl-a in the world, the highest being Lake Victoria in central Africa. The Weddell Sea also has IO levels as high as Mace Head, and we have shown large amounts of other iodine compounds. Hence a higher growth rate on one occasion than generally seen at Mace Head is not necessarily surprising.

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