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Ocean Science
Discussions

Interactive comment on "Measurements of bubble size spectra within leads in the Arctic summer pack ice" *by* S. J. Norris et al.

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1) *There are many long unpunctuated sentences that are very hard to follow, and the majority of them are in the introduction. I suggest that the authors go through the whole text carefully, checking that each sentence is unambiguous and well-structured. For example, the sentence starting: "Measurements of CCN composition: : :" should be split into two separate sentences, and this is just one example of many.*

This seems a little overstated. We counted 2 sentences in the introduction that merit this criticism – they have been split.

2) *Section 1, line 20: Perhaps "previously discussed non-wave related sources" (or something similar) might be a better start to this sentence. Later in the paper the*

authors describe a mechanism not mentioned here, so this is not a complete list.

The suggested change of wording seems redundant. The existing wording "Non-wave related sources of bubbles **include**..." makes explicit that the list is not comprehensive.

3) *Section 1, line 24: Are these gels the same as the transparent exopolymer particles (TEPs) discussed by Wurl Holmes (2008) and references therein? ["The gelatinous nature of the sea-surface microlayer", Marine Chemistry] If so, it might be useful to specify this more modern term as well and to include the more recent references.*

EPS and TEP are not the same thing, TEPs are grown from the microgels, thus the difference between EPS and TEP is size. TEPs are too large to be made airborne and have a short turnover time in the surface waters. The focus of the discussion about EPS in our introduction is airborne particles so we have not included the term TEPs in the paper.

4) *Section 2, line 8: The comparison between acoustic and optical measurements shown in the Brooks et al. paper does not act as a calibration of optical against acoustical measurements. The optical and acoustical measurements were taken at different times and in different conditions, and both involve considerable temporal averaging. This comparison cannot be used to justify the phrase "close agreement", although the laboratory results listed may. I suggest removing this reference.*

The comparison with the acoustic measurements in the Brooks et al paper was not intended as a calibration, but simply to emphasise that under similar conditions (of wind and wave state) the two completely different techniques obtained very similar spectra. The statement was included since we have elsewhere received reviewer comments criticising use of an optical approach to bubble measurement as inferior to acoustic measurements. Nevertheless this statement has been removed.

5) *Section 2 describes the distribution of individual measurements in time, and it seems that it should be possible to plot the change in bubble population on timescales shorter*

than a day. This omission leaves the reader curious about why no such data is mentioned. If it is a requirement for sampling purposes (i.e. the variation between individual samples is large), then that should be stated. It would be fascinating to see the scale of the variation on the timescale of a few hours. Are there large differences between successive samples? Is there a diurnal variation? This is important information in evaluating the suggested bubble generation mechanism. There should be a comment included about whether any systematic variation was seen, and if no statistical variation was observed then this should be quantified (i.e. all samples for the day were within 10% of the mean). However, it would be very useful to the reader if some data was shown for the shorter timescales.

The sampling periods do not allow any estimate to be made of diurnal variability. Almost all the data was obtained in a 4.5-hour time window of 0930 to 1400 on each day. Only two days have data significantly later in the day – August 17 and 21 (the latter is the only day where much more than 4 hours data were obtained, 6.5 hours), both are 'ice covered' cases. Note that in the central Arctic there is little diurnal variability in meteorological properties that might influence bubble production in any case. The range of variability between individual estimates of bubble concentration is visible on figure 7 (discussion paper), and can be substantial. The nature of the variations in concentration over time display no consistent behaviour. In a few cases (Aug 18, 27) a distinct trend is evident over time, but in most cases the variations are either completely random or sufficiently so that no convincing trend over time is evident. On a sample to sample basis the variability between estimates is sufficient to disguise any functional dependence on the heat flux – this is evident on figure 11 (new manuscript), where the trend with QH for open water cases is clear for the daily averages, but the sample to sample variability is much greater than the mean trend. On a sample-to-sample basis, the mean concentrations do not display consistent convincing dependencies on any of the environmental parameters measured. A brief discussion of the short-period behaviour has been added along with a figure (figure 10) showing the time-variation on each day.

6) *Section 3, line 10 (and related to the point above). I would prefer use of the term "standard deviation", rather than "standard error". "Error" implies that there is a measurement uncertainty, which is not intended (I think). This table aims to show how much deviation there is from the daily mean over an entire day, and does not quantify measurement uncertainty. However, since there could be genuine variation in the bubble measurement data on short timescales, even the term "standard deviation" needs to be used with care.*

The table shows the standard error about the mean – a good measure of the uncertainty in the estimate of the mean. We can't simply change the wording referring to it.

7) *Table 1: This way of presenting this data is hard to read and gives little insight unless the reader copies it out and makes plots themselves. Given the online nature of this paper, the size and complexity of the table might be acceptable here even though it would certainly be unacceptable for traditional paper publication. If the authors consider that this table is essential in its current form, I suggest that they make a data file available as supplementary information. At least this would prevent someone else needing to type out the data again for themselves.*

We believe it is beneficial to provide access to the detailed spectra, not simply plots. It is difficult to compare spectra between studies without this information – picking values off published figures with log-scales is a laborious and error-prone way to achieve this (we have had to resort to this for some of the comparison spectra shown here). The table has been removed and a more extensive data file provided as supplementary material.

8) *Section 4, line 20: ": the largest only film droplets". It might be appropriate to reference Bird et al, (Nature 2010 "Daughter bubble cascades produced by folding of ruptured thin films") here, since is describes a mechanism generating jet-producing smaller bubbles as a large bubble burst at the surface. This is just a suggestion, but it*

demonstrates the complexity of setting size limits on the production of jet droplets and film droplets. Added

9) *Figure 1: It's hard to tell the red and pink lines apart. Please choose colours that are easier to distinguish. I think that the blue line refers to the ice edge, but this is not stated in the caption.*

The contrast between pink and red lines has been increased – note the drift period (red) is also clearly highlighted by a box indicating the area of the inset map. Blue line description is added.

10) *Figure 6: I think that this would be easier to read if the open ocean spectra were omitted. Presumably the point is to show the approximate variation in bubble spectra, but the grey lines make it hard to see the thinner coloured lines. If it's felt to be important to include some open ocean spectra, perhaps only the highest and lowest (circles and diamonds) could be included.*

The contrast between colours has been increased to make reading the figure easier. The ocean spectra are include in response to a previous reviewer's comments (at GRL) to illustrate the variability between individual spectral estimates contributing to a daily mean in comparison with the variability between mean spectra both within this data set and the open ocean examples.

Technical corrections – all corrected.

Line 2: spelling: Arctic

Section 2 line 15 and others: It's conventional (and would be helpful in this case) to use the word for numbers less than eleven and the numerals for numbers greater than ten. The line "126 2-min: : :" is awkward and it would be easier to read if the word "two" was used.

Interactive comment on Ocean Sci. Discuss., 7, 1739, 2010.