Reply to review by Jun Inoue

"*Mixing, heat fluxes and heat content evolution of the Arctic Ocean mixed layer*"
A. Sirevaag, S. de la Rosa, I. Fer, M. Nicolaus, M. Tjernström, and M.G. McPhee.

We thank the reviewer for constructive comments, suggestions for changes and added references which will improve the manuscript. We are especially grateful for the comments on the role of ponded ice, which we did not discuss in our analyses. Reviewer's general and specific comments are given below, followed by our response and suggested changes for a revised manuscript.

General comments

This manuscript provides an observational evidence of solar radiation through sea ice contributing to heating in ocean mixed layer. Such observation is highly valuable due to difficulty in observation. The fact that seasonal change in snow cover suppresses the ocean heating also gives the important idea for air-ice-sea coupled modelling.

However, the author needs to mention the effect of ponding over the ice, in particular, fractional coverage of melt ponds, heat transmittance and resultant effect on the heating in the mixed layer. In Figure 2, there is clearly a lot of ponds. I think it is possible to digitize the ponds from aerial photos. I expect that the authors did the visual observation of ice, pond, and open water fractions as Itoh et al. did (2011 Ann. Glaciol). In p266, the authors emphasized that the change in mixed layer heat content caused by ice part was significant during the first period (45%), however, this is too high if there is no ponding. If melt ponds are not important for heat transmission, the authors has to provide the threshold snow accumulation for suppression of heat transmission through the ice although there was 10 cm snow depth over the ice in the early period (p252).

Overall, this paper might be publishable when the additional analysis and/or comments for the effects of melt ponds are included.

Melt ponds on sea ice are certainly important for the exchange of heat between the ocean and the atmosphere, as clearly demonstrated in e.g. Itoh et al. (2011) and Inoue et al. (2008). However, there are two reasons why we have not included the specific effect of melt ponds in our analyses:

1. *The melt pond fraction was quite low during our experiment. Through analysis of the scarce number of images available, melt pond fraction was estimated to 5 % and 3 % before and after the cold period/snow fall. This differs widely from the melt pond fractions referred to in e.g. Itoh et al. (2011), where they estimate the melt pond fraction to be 27 % for the section closest to our ASCOS measurement area.*
2. *Related to eq. 7, our measurements provides us with relatively high temporal resolution estimates of the change in ocean heat content as well as the net flux balance for the ice covered areas. Hence the contribution of heat exchange in the open water areas will be estimated as the residual. If the ponded area contribution is included as well, the residual will include both the open water and ponded ice contributions. However, since we do not know the flux balance for these areas, we can not estimate the relative contribution from each of them. We could estimate the contribution through open water and melt ponds by assumptions and parameterizations of fluxes in these areas (since we do not have direct measurements). However, the uncertainty in such an estimate would be beyond the variability of our heat flux and heat content measurements.*

Specific comments

1. P250: Itoh et al. (2011 Ann. Glaciol) focused on the effect of ponds and ice thickness on the heating of mixed layer. This might be also useful to address the importance of ponds.

We will extend this part of the Introduction by giving a more proper description of the importance of ponds and include the reference to Itoh et al. (2011).

2. P252 L24: I could not find an evidence of snow fall during latter period (a figure and exact amount).

A record of precipitation from measurements at the experiment site is given in Nicolaus et al. (2010b) and we have included this reference for the precipitation record. Although no total amount is given, the precipitation was significant.

3. P260 L16: I'd like to see surface solar radiation and/or albedo in Figure 8. In the cold period, did the reflected solar radiation increase due to the snowfall?

See also above. The full data set with surface solar radiation and albedo is presented and discussed in Nicolaus et al. (2010b). We have included this reference with figure number when we refer to the shift in albedo after the snow fall. Fig 8 and 11 in Nicolaus et al. (2010b) show that this shift was significant.

4. P266 L9: Here, the authors should try to add a term for melt pond. Eq. (7) is too simple to discuss the heating in the mixed layer without the effect of melt ponds, and might mislead the conclusions. If it is difficult to calculate it, the possibility of the effect should be clearly mentioned at least.

We agree that this term should be included. In the revised manuscript we have extended eq. 7 with the contribution from the ponded ice. Since we can not estimate this contribution separately (see above), we have included a discussion where we specify that the residual of eq. 7 includes both the open water and pond contribution to the heating of the ocean boundary layer.

Technical corrections

P267 L2: Typo? trough -> through

Corrected in the revised manuscript