Ocean Sci. Discuss., 12, C1452–C1456, 2016
www.ocean-sci-discuss.net/12/C1452/2016/

Ocean Science
Discussions
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Interactive comment on "Turbulent heat transfer as a control of platelet ice growth in supercool under-ice ocean boundary-layers" *by* M. G. McPhee et al.

Anonymous Referee #1

Received and published: 12 January 2016

Summary:

This manuscript reports observations of turbulent ocean heat fluxes in supercooled waters under sea ice, in a setting that may promote platelet ice growth. Time series of ocean current, temperature, and salinity are described alongside turbulent flux measurements in the boundary layer over the course of several tidal periods. The observed turbulent fluxes are shown to be well characterised using standard bulk formulae, based on the observed supercooling and the inferred friction velocity at the ice base. The friction velocities are used to argue that the platelet ice has a greater roughness length than alternative settings for heat transfer under sea ice.

The manuscript is clearly written, subject to a few technical clarifications. In my opinion the article provides useful observational data and constraints on bulk heat transfer correlations for settings with platelet ice growth, that are worthy of publication. One concern is that whilst the supposition in the title and last sentence of the abstract that the turbulent heat transfer controls platelet ice growth seems plausible, I would argue it is not yet firmly supported by the analysis in the present version of the manuscript. The results demonstrate turbulent heat transfer consistent with interaction with a freezing boundary, but have not yet shown that this flux is as significant, or more significant than other potential sources of heat transfer as detailed below. This conclusion needs to be either better supported by some further analysis/information, or else the discussion modified accordingly. Some suggestions for how to better evaluate this hypothesis follow below, along with a few other requests for technical clarification.

Specific comments:

1. The title, last sentence of the abstract, and comment on page 2818, line 16-17 suggest that this manuscript has demonstrated that the ocean heat flux is providing a strong control on sea ice growth in this location. However, the present version of the manuscript arguably only demonstrates that the ocean turbulent flux is consistent with transfer between a boundary at the insitu freezing point, and a supercooled bulk fluid. It is less clear how significant this flux is as an overall driver of sea ice growth. Is there any evidence to demonstrate that this is indeed a strong control on the sea ice growth at this location, in comparison to other potential heat fluxes due to some combination of conduction up through the ice interior, lateral advection in the surface ocean, and relief of supercooling in the surface ocean over time by ice growth?

   If there were independent estimates of ice growth rate, these might be usefully compared to the ice growth expected if all of the downward ocean heat flux were used to remove latent heat of solidification. It may also be possible to produce scaling estimates for the heat flux conducted up through the sea ice if ice thickness and the upper and lower ice surface temperatures could be estimated.

2. The authors make several references to ice nucleation on the moorings and masts, and in particular that they have carefully discarded any of the ADV measurements that may have been contaminated by freezing. Based off your observations, is it possible to rule out any freezing onto instruments also impacting the temperature and salinity measurements, or whether such artificially induced freezing might have played a significant role in the heat budget for the region of the water column that is being measured?

3. Estimate of z_0 between equations (7) to (8). Some of the details of this calculation were not clear to me - can you provide further details? In particular, at what value of z is $U(z)$ evaluated when estimating z_0? Also, taking $\log(z_0)$ in equation (8) needs a more consistent treatment of the physical units - has there been some non-dimensionalisation here?

Minor clarifications/suggestions on presentation:

4. I didn't find definitions of the directions of u', v' and w' before first use in equation (1), or an explicit definition of the turbulent dissipation rate above equation (2).

5. It might be worth providing a background reference(s) for the justification of equations (2), (3) and (7), for readers less familiar with the relevant parts of turbulence theory.

6. The scaling estimate in equation (3) assumes that buoyancy-driven convective turbulence is not significant in modifying the boundary layer structure. It might

be useful to mention this here, but then note later (e.g. near to p.2815, lines 10-15) that the very good comparison between the two estimates of turbulent eddy lengthscales in figure 5b provides support for your hypothesis of a shear-dominated boundary layer.

7. Is there a typo in equation (4)? If I equate the production in equation (3) to the dissipation rate so that $\epsilon \sim u_*^3/(\kappa\,|z|)$ and substitute for $\kappa\,|z| \sim \lambda = c_\lambda/k_{max}$, I end up with $u_* \sim (\epsilon c_\lambda/k_{max})^{1/3}$.

8. p2816, line 8/9 “negatively increasing”. Would “decreasing” be easier to read?

9. p2816, line 11. Can you give a standard error (or other error bar) on the estimated value of c_H to allow a better estimate of it's similarity or difference to the other values? Also, I think there is a typo here as c changes from lower to upper case between lines.

10. p2817, lines 8-16; discussion of congelation vs platelet ice growth. Could this be reworded to more clearly emphasise that the key difference between congelation and platelet ice growth is that a supercooled ocean allows a significant part of the released latent heat to also be removed into the cooler ocean in the case of platelet ice growth, whereas congelation growth cannot conduct heat into the ocean when the ocean is warmer than the freezing temperature at the ice-ocean boundary.

11. p2817, lines 11 and 12 “congelation growth in water at freezing temperature requires a small upward ocean heat flux to compensate for salt release” Can you provide a reference, or more detailed justification to support this statement? It isn't immediately clear to me that such a heat flux is always required (especially if salt were segregated into the pore space within the sea-ice interior during congelation growth, rather than being rejected at the sea ice interface with the ocean,

and there is some delay in the subsequent drainage of brine out of the ice back into the ocean).

12. p2818, line 25-26. "u_* will be modulated primarily by tides". Is this universally true, rather than flows induced by ocean currents or wind-driven ice motion? Worth adding a qualifier?
13. Figure 2. The labels are small and hard to read in panel (c).
14. Figure 5(c). What is t in the label at the top left? I'm presuming it is proportional to a turbulent stress, but it should be defined before use.