Ocean Sci. Discuss., 12, C1614–C1622, 2016
www.ocean-sci-discuss.net/12/C1614/2016/


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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.

**M. G. McPhee et al.**

c.stevens@niwa.cri.nz

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Reviewer: This paper presents a nice data set of turbulence under fast ice in Antarctic waters. In contrast to "the normal" situation in polar waters the heat flux is downward into the water below the ice. The unique data set and the clear way it is presented makes this a valuable contribution. The changes suggested before publications are minor in my view.

Reviewer: I have one substantial scientific comment, regarding the conclusions, consistent with the other reviewer. Contradictory to the other reviewer I think you could make stronger conclusions based on your results though. At least we agree that a

conclusion section should be added. The conclusions given in the discussion are very modestly formulated in my view. Perhaps my view is guided by my experience and that I thus find the proposed hypothesis likely. Given the conclusive data set and that the first author is one of the most experienced researchers in this field, I would suggest that more firm conclusions should be stated. Given the very similar C_H values found here and in other studies, I think it is appropriate to fully conclude that the process has been explained, and that you can go beyond “hypothesizing” and “postulating”.

Author Response: We thank the Reviewer for their constructive and thoughtful comments, especially around the "strength" of our conclusions. With regard to this, it was not clear to us that Reviewer #1 was actually asking for a separate conclusions section to be added. However, we see the Reviewer’s point about strengthening the impact of the work and have done so. This mainly separates out the last few paragraphs of the text. Our reticence to be overly expansive in the generality of our conclusions lies in the small and focused nature of the results in a relatively unique macro-scale environment. However, saying this, the Reviewer is correct, at the boundary-layer scale it is a nice dataset and does have general applicability. We have used this as support for our strengthening of the language.

Reviewer: Minor comments: Abstract: Line 9-10: You hypothesize that platelet growth is rate limited by turbulent heat transfer. It seems to me that you should you be able to answer this question fully.

Author Response: We have made minor, but key, changes that strengthen the definitiveness of our statements. Changes include “The data show that turbulent heat exchange at the ocean-ice boundary is.... Platelet ice growth appears to increase the hydraulic roughness (drag) of fast ice compared with un-deformed fast ice without platelets. ... Platelet growth in supercool water under thick ice appears to be rate-limited by turbulent ...”

Reviewer: Introduction: On the Weddell side large ice crystals were detected quite



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deep down in the water column (Dieckmann et al 1986), but at a location where super cooled Ice Shelf Water was present. This appears to be the same type of crystals as the platelets. My point is that large crystals have been found elsewhere outside the Ross sector, and that that given presence of super cooled water such crystals have been found a few decades back. The process studied here is thus more general than what the introduction appears to describe, and this should be included somehow.

Author Response: The Reviewer makes a good point and it wasn't intentional to suggest either that this process is only seen in McMurdo and/or that our group were the only people working on the topic. The text has now been amended with "The appearance of these supercooling-induced crystals is not limited to the western margin of the Ross Ice Shelf, with observations made in most cold-cavity systems sampled to date (Dieckmann et al. 1986; Craven et al. 2014; Hoppmann et al. 2015)."

Reviewer: Methods: Page 6, line 19. "nonsensical" is new to me, I guess you mean "erroneous" or "invalid" or "wrong"?

Author Response: We have modified the text and replaced the word with "incorrect".

Reviewer: Results: Page 7, line 19. What data do you mean here? I think it would be better to say "The presented data comes from spring tide: : :." But you also present data over several days (Figure 4,5,6 three days). So I think you need to re-write this part a little.

Author Response: We use spring tide here in the sense of being a period of larger tides rather than a single tidal period. The text has been amended to state "The present data come from springs phase of the tide. . ."

Reviewer: Page 8, line 4: How do you know the water column was isothermal down to 40 m? Did you do CTD casts – if so you should state this. It would be OK to do this without showing the figure if this will be used in a different paper. Also the statement for a super-cooled water column down to 15 m depth needs to be supported by either



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data or a citation.

Author Response: Good point. Profiles made with the mobile TIC mast B indicated that the water column was isothermal to about 40 m. In addition data described in Stevens et al (2014) from the same campaign support the content that to within +/-5mK the upper 40 m was isothermal. The text has now been modified to reflect these points.

Reviewer: Page 8, line 12. Please define DOY when it is used the first time.

Author Response: done

Reviewer: Page 8, line 16 – 18. Ok here comes the part explaining why you focus on the spring tide, so this should somehow be blended with the initial text on page 7, line 21.

Author Response: I think we made this overly confusing, our point simply was by working during the larger spring tides we get a wider range of velocities. The text now says: "The present data come from springs phase of the tide (Figure 3a) in order to experience the widest range of flow speeds, although the tidal effect is only weakly manifest in the far-field thermal structure (Figure 3b)."

Reviewer: Page 8, line 23. YD should be DOY? Also the section break here seems wrong because the section above and this one cover the same.

Author Response: OK we corrected the DOY and removed the paragraph break.

Reviewer: Page 8, line 25. I have not seen "slack water" before. Perhaps my tidal vocabulary is limited, but it also sounds very American. Is there a better and more precise term to use in a European English journal?

Author Response: We discussed this among ourselves and it appears that it has an Anglo provenance. We expanded the text to make it clear that it referred to periods of near-zero bulk flow at, or around, high and low water.

Reviewer: Page 9, line 7. Delete "with". Discussion:



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Author Response: done

Reviewer: Page 11, line 11-12. “congelation : : :. release” This sentence is not meaningful to me. Ice growth leads to salt release, but in what way is an ocean heat flux required? Probably some text is missing here?

Author Response: We worked on this paragraph in conjunction with the other Reviewer’s points. It now states “There is supercooled Ice Shelf Water water below the crystals, and these large crystals could not appear from the smaller ISW plume, because such large crystals would be bouyant enough to leave the ISW plume (Jenkins and Bombusch 1995; Smedsrud and Jenkins 2004). They need further heat loss in situ to grow to the large sizes observed, but yet the heat flux through the thick fast ice must be small. The ocean turbulent heat flux was negative (downward) throughout the entire measurement period (Fig. 6a). Sea ice in this region is typically forms as congelation ice early in the growth season, then incorporated platelet ice towards the end of the growth season (e.g., Smith et al., 2001). Congelation ice grows when the latent heat released during phase change is conducted from the relatively warm ocean to the relatively cold atmosphere. In this context, relatively cold means below the freezing point temperature of seawater. Platelet ice formation occurs in supercooled seawater and when this occurs near the ice/ocean boundary, the latent heat released can either be conducted upwards through the main ice column or transported downwards by turbulent heat flux into the ocean boundary layer. The latter process of negative oceanic heat flux does not occur for congelation ice because the ocean in that case is warmer than the freezing point temperature at the ice-ocean boundary.”

Reviewer: Page 12, line 14 – 16. Again you draw conclusions extremely carefully. What else than delta T and friction velocity could contribute to the heat flux? I understand the difference in time scale between variation in u_* and the heat flux, but still think that you can pose proper conclusions based on your observations. If you can’t state that this has been explained “well enough” then who can? There is supercooled Ice Shelf Water (ISW) water below the crystals, and these large crystals could not appear from



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the smaller ISW plume, because such large crystals would be bouyant enough to leave the ISW plume (Jenkins 1995, Smedsrud 2004). So they need further heat loss in situ to grow that large, and the heat flux through the thick fast ice must be small as stated in the cited work. Some more reasoning around this issue could perhaps convince the other reviewer, that might be less familiar with the physical setting here, but probably has a better grasp of the turbulent heat transfer.

Author Response: This is a nice summary of what we were trying to get across and we have taken the liberty of paraphrasing some of it, including the suggested and relevant references. Our on-going work is looking at the deep-water supply of the crystals, exploring some of the points that follow from this and the Dieckmann observations identified elsewhere by this Reviewer.

Reviewer: Figures: Figure 1: I think it is much better to NOT use abbreviations in a figure, because people might look at it independently. There is plenty of room in the figure. Abbreviations could be given in the figure caption if needed.

Author Response: OK, we have amended the Figure as suggested.

Reviewer: Figure 2: This figure is definitely too small. It is not possible to see the names and features in the image. The middle image should be larger, and the two insets could be placed inside this one. With a larger figure the names can be spelled out properly as well. Also the square box in the upper figure seems to have no purpose.

Author Response: The figure has been restructured, largely as suggested, with the superfluous box removed. The smaller images could not reasonably be placed as insets and still be meaningful. A couple of the abbreviations had to remain but most were removed. But if this is a full width figure this will work well.

We have added the working revision as a supplementary pdf.

Please also note the supplement to this comment:



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http://www.ocean-sci-discuss.net/12/C1614/2016/osd-12-C1614-2016-supplement.pdf

Interactive comment on Ocean Sci. Discuss., 12, 2807, 2015.





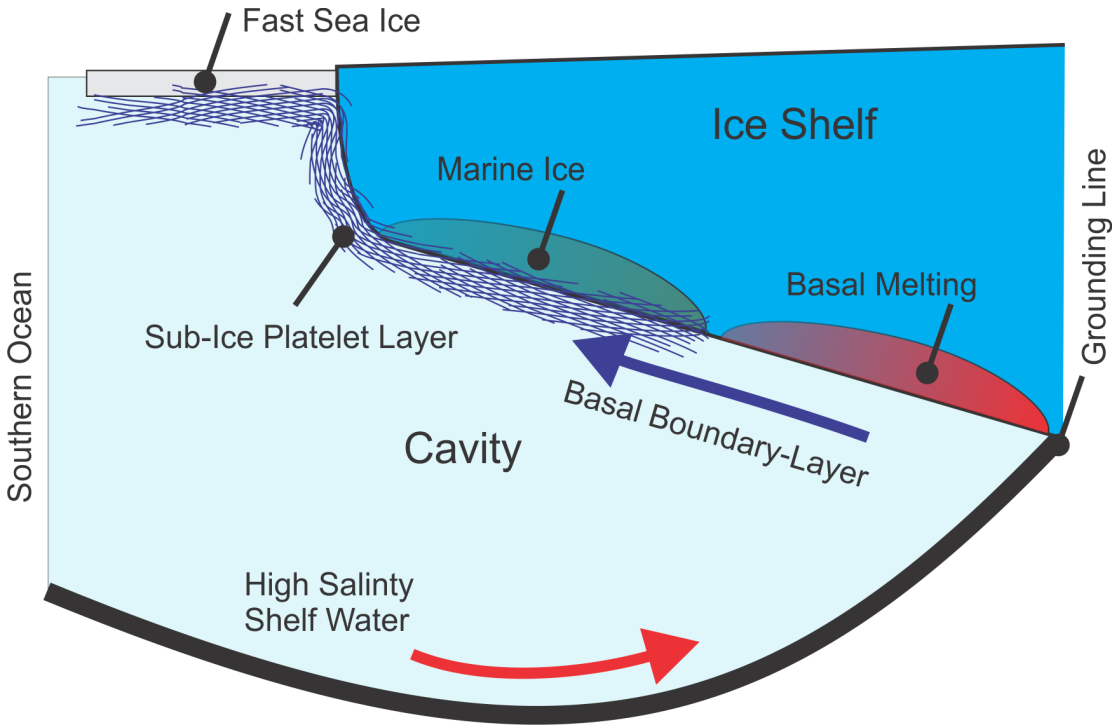


**Fig. 1.** revised Fig 1



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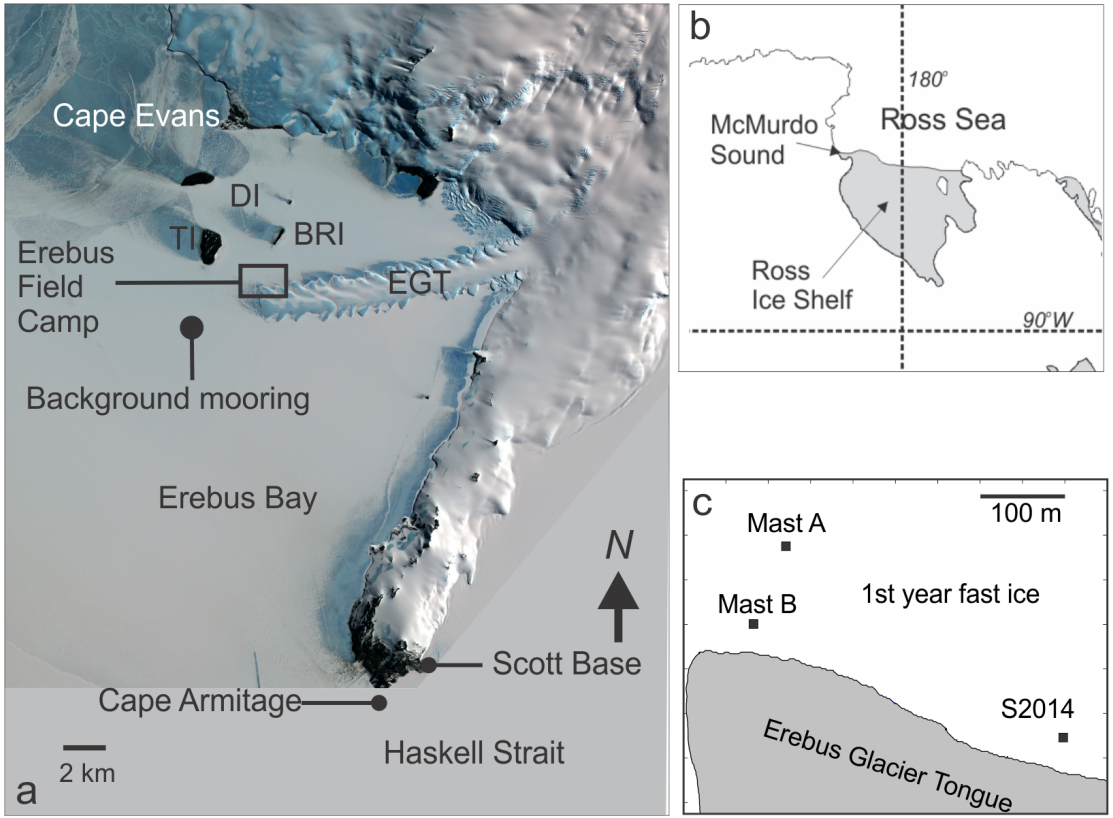


**Fig. 2.** revised Fig 2



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