Replies to Reviewer 2 (Andrew Mahoney) comments

AC: We are very grateful for the very positive evaluation by this reviewer, and by the suggestions for further improvements, which we have considered carefully. Please find our replies (AC) to the specific reviewer comments (RC) below:

RC: This is a well written paper and easy to read paper summarizing several years of work that has culiminated in a greater understanding of platelet distribution in McMurdo Sound that has implications for ISW formation and basal melt. At the same time, the technique used could applied with great value in other locations. I have only one general comment, that I think should be fairly straightforward to address. Otherwise, I look forward to seeing this paper published.

General Comments

Limited discussion on variability in consolidated in thickness

My only major comment relates to the observation that the data presented represent a very narrow range of consolidated ice thicknesses, hi. Figure 5a indicates the ratio h(a;Q)=hi increases as hi decreases, which leaves me wondering how reliable the SIPL thickness estimates would be in the presence of greater spatial or temporal variability in hi. It is unfortunate that only few measurements were made in thicker multiyear ice, but the inclusion of a brief discussion about how they compare with the AEM measurements might still be helpful. The authors might also consider how the sensitivity to SIPL thickness would be affected over thin ice, earlier in the year, which could be relevant for studying intra-annual SIPL variability.

AC: We very much appreciate this comment and indeed were going to address this much more clearly in the initial manuscript but then it got lost… Therefore we have added two paragraphs to the discussion that address this reviewer's comment as well as those from the editor:

"Our validation data are limited to drill-hole measurements from first-year fast ice that is typically 2 m thick at the end of the winter. Therefore, most of our model results were also limited to 2 m thick consolidated ice. However, Figure 5 also includes results for 4 m and 6 m thick consolidated ice (dashed curves). From the behavior of those model curves it can be inferred that with thicker consolidated ice the ratio of ha,Q/hi decreases, which suggests that, in the presence of a typical SIPL, thicker consolidated ice can be retrieved more accurately than thinner ice from the quadrature measurements. Figure 5 also shows that the scaling factor α is hardly affected by consolidated ice thickness at all, i.e. the accuracy of retrieved SIPL thicknesses is independent of ice thickness. The thickness profiles in Figure 9a include surveys of multiyear fast ice in 2013 and 2017, which are visible by large steps towards thicker ice in the west. These are indications that the measurements are indeed quite sensitive to thicker consolidated ice and SIPL as well. We only attempted very few drill-hole measurements of the thick consolidated ice and thick SIPL, as they are very challenging and their accuracy is poor. Therefore we did not include them in our analysis here.

However, thick consolidated ice and a thick SIPL pose other challenges that are related to the decreasing sensitivity of EM measurements with increasing height above the water or conductive SIPL. Despite the better behavior of ha,Q/hi discussed above with regard to Figure 5, thicker consolidated ice results in weaker inphase and quadrature signals which eventually approach the EM noise level and are then insensitive to consolidated ice thickness changes (not shown here, see Haas et al., 2009). However, these limitations only apply to ice several tens or meters thick (e.g. Rack et al., 2013). More importantly, increasing SIPL thicknesses also lead to reduced sensitivities particularly of the inphase signals as has been discussed above with regard to results shown in Figure 3. That figure shows that for typical SIPL conductivities of 900 mS/m and more the inphase signal remains approximately constant for SIPL thickness of 6 m and more. This is due to the limited EM field depth penetration into conductive layers, which make the method insensitive to changes below the level of penetration. Therefore it is likely that the good results shown in Figure 7 benefited from the fact that most drill-hole SIPL thicknesses in the study region were not larger than 6 m (total thickness of 8 m). In fact, Figure 7 shows that the uncertainties of the thickest SIPL measurements which also have the largest drill-hole errors are considerably larger than those of smaller total thicknesses."

RC: Line 175-176: I recommend introducing the concept of apparent thickness at the beginning of this paragraph and the symbol ha should be defined before it first used.

AC: agreed, we have re-arranged the sentences in that paragraph.

RC: Line 176: I don’t think the parentheses around “or Q” are necessary

AC: removed!

RC: Line 400: If the approximate values of the dimensions a,b,c, and d are really important to this discussion, then I feel the reader should be given some further explanation without need to refer to the paper by Jones 2012b. At the least, the text should provide units for the stated values.

AC: As the text stated, a, b, c are relative brine pocket dimensions and therefore have no units. However we agree that some further explanations may be useful and have therefore slightly extended the whole paragraph:

“For sea ice specifically, Jones et al. (2012a) have used a simple conductivity model (Jones et al., 2012b) to derive parameters for an ice/brine “unit cell”. Each unit cell consists of a single, isolated, cubical brine pocket with sides of relative dimension d (unitless), and three connected channels in perpendicular directions (two horizontal and one vertical direction), each with relative dimensions c ⍰ a ⍰ b (also unitless). Jones et al (2012b) found that the relative dimensions that fit the observed in situ DC horizontal and vertical resistivities depend not only on sea ice temperature but also on structure. In particular, for Antarctic incorporated platelet ice at ⍰5°C the shape of the inclusions has relative brine pocket dimensions a≈1, b≈17, c≈0.6, and d≈6 (see Jones et al. (2012a) for details). In addition, Jones et al (2012b) have shown for Arctic first-year sea ice that there is a dramatic change in these parameters with temperature, with a, c, and d becoming relatively larger, while b drops. This behavior would also be expected in incorporated platelet ice. We shall therefore assume that the shape of the inclusions in the SIPL is similar to that of incorporated platelet ice (as observed by Jones et al., 2012a), but that brine inclusion/void dimensions are very much larger because they are very close to the freezing point. Consequently, we calculate the relationship between solid fraction and conductivity from Jones et al. (2012b), by varying a and c, while keeping b and d constant and hence changing the solid/liquid content of the SIPL (see Fig. 8).”