Supporting Information for

Microwave Radiometry Improves Modelling of Surface Melt Processes of Antarctic Firn

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Figure S1: Shackleton Ice Shelf

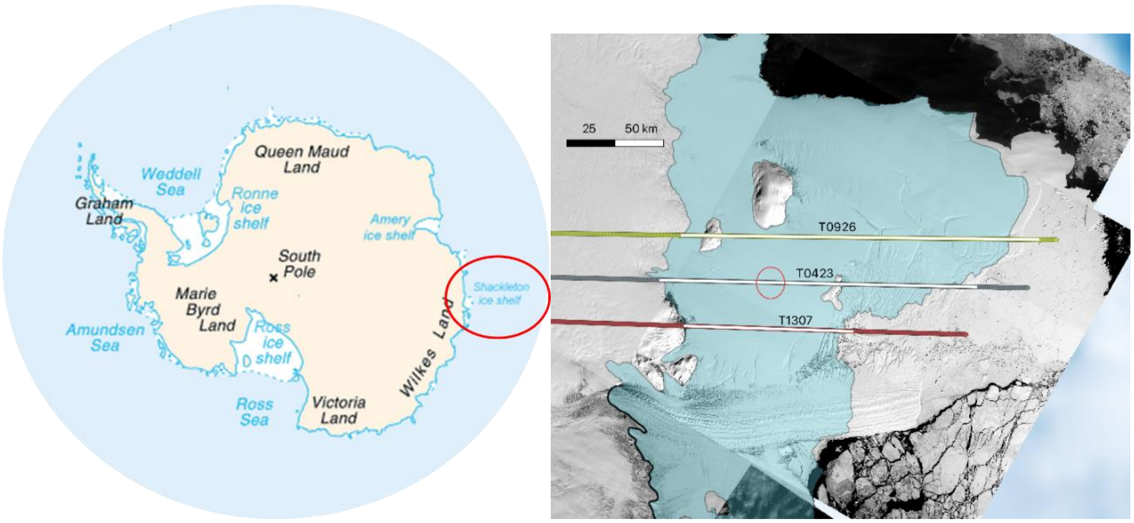


Figure S1. Shackleton Ice Shelf. The study location (red circle) and three ICESat-2 tracks crossing over it (see also Figure S2).

Figure S2: Shackleton Thickness Profiles

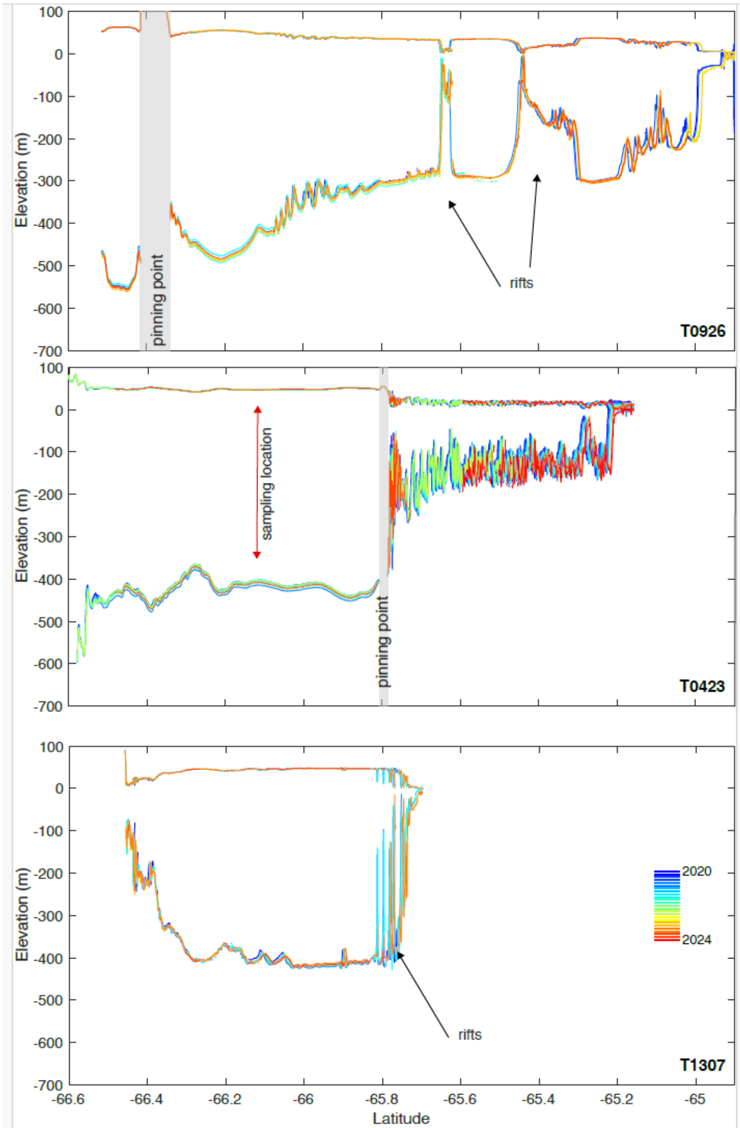


Figure S2. Thickness profiles along the ICESat-2 lines shown in Figure S1.

Figure S3: Density and Exponential Correlation Length Profiles

The pre-melt situation in Figure S3 shows the fresh snow layer on top of a density spike created by the previous refreezing of meltwater during the previous melt season. The post-melt situation shows the compaction of fresh snow (the previous seasons' spikes closer to surface, densification, and the new density spike. The exponential correlation length profile exhibits the effects of density and depth based on the model.

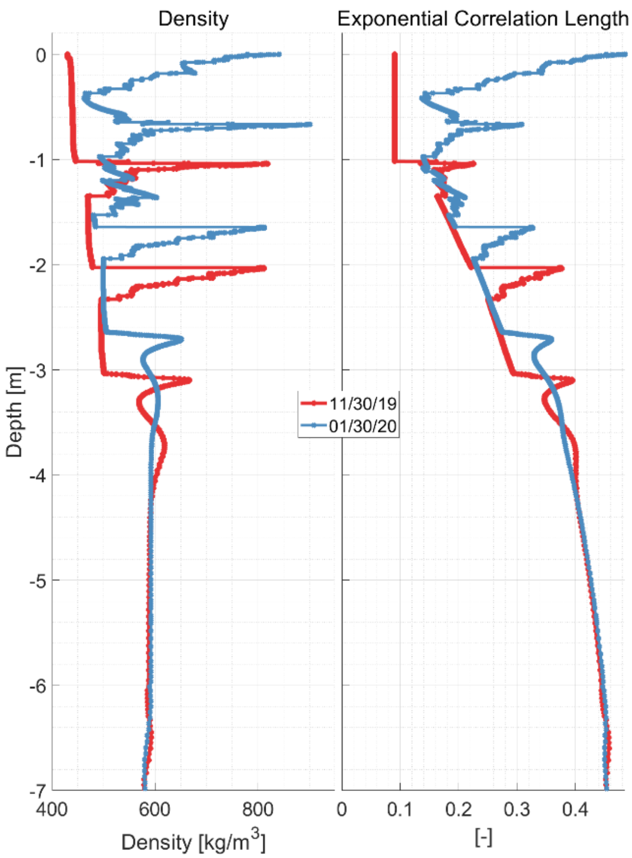
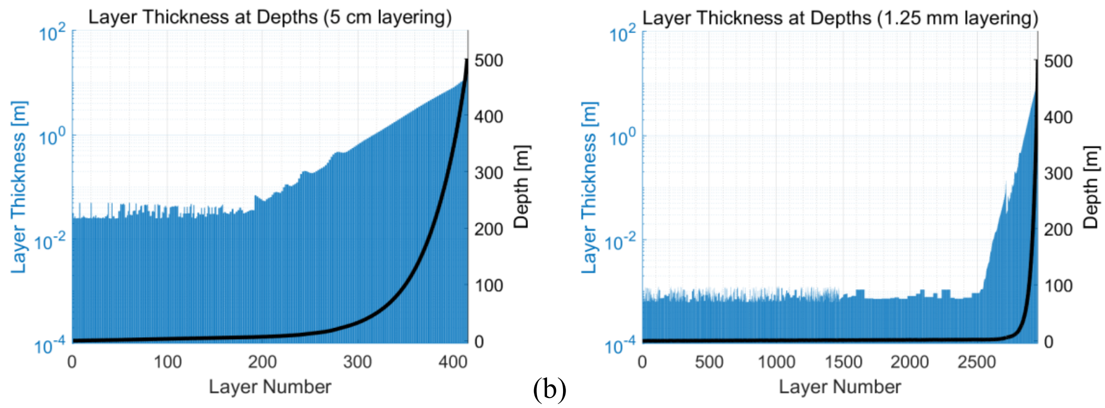


Figure S3. Density and exponential correlation length (corresponding to snow grain size) profiles for pre-melt (November 30, 2019) and post-melt (January 30, 2020) situations.

Figure S4: Layer Thicknesses



(a) (b)

Figure S4. Layer thicknesses for the (a) 5 cm and (b) 1.25 mm layering schemes.

Figure S5: Brightness Temperature Contributing Depth

The contribution of each layer was computed by perturbing the temperature at each layer and computing the effect on the simulated TB (Leduc-Leballeur et al., 2015). Figure S5 shows the relative contributing depth of 1.4 and 36.5 GHz TB simulations for frozen period conditions. The most notable differences are that 1) the 36.5 GHz TB has the maximum at the surface, whereas the 1.4 GHz TB has the maximum at about 30 m deep, and 2) the effective depth range is substantially narrower for the 36.5 GHz TB, as the relative contribution reaches zero by 30 cm depth, whereas the 1.4 GHz TB contributions come between the surface and about 200 m. In both cases, the density spikes imprint an effect on the contribution profile, although they correspondingly narrow and, therefore, do not make a significant fraction of the total contribution.

The significantly different contributing depths provide a complementary view of the LWC evolution at the study location on SIS. The 1.4 GHz contributing depth is enough to capture any surface meltwater percolation (provided the meltwater amount on top does not obscure the deeper layers). It also suggests that the ice-ocean boundary at the bottom of the ice shelf has likely only a negligible effect on the observed TB.

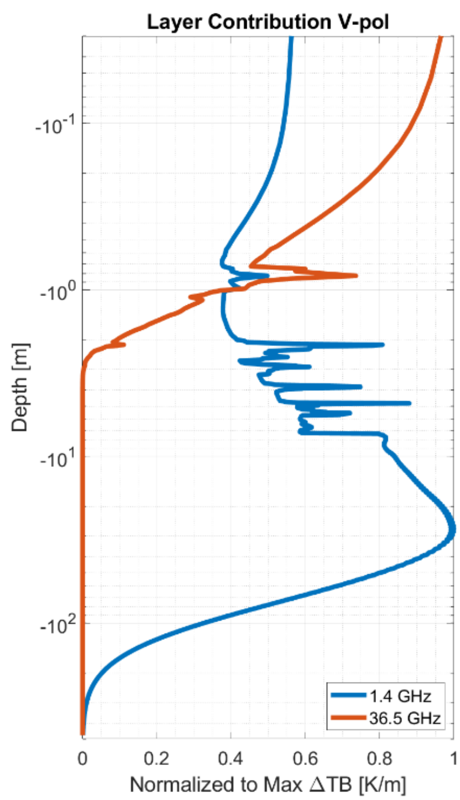
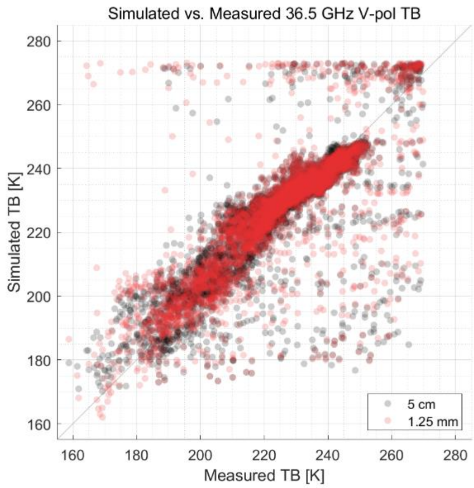
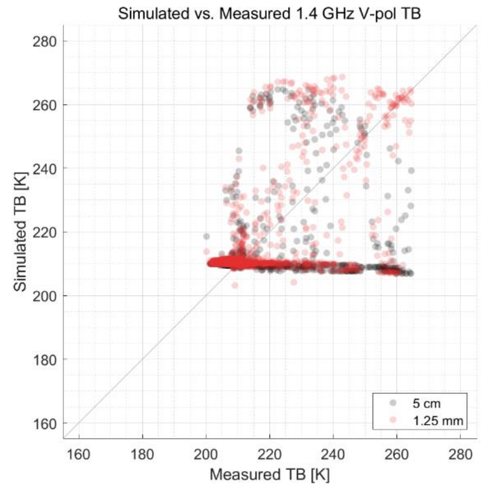


Figure S5. The relative layer contribution for the 1.4 and 36.5 GHz brightness temperature simulations during frozen period conditions.

Figure S6: Simulated vs Observed TB



(a)



(b)

Figure S6. Simulated vs observed (a) 36.5 GHz and (b) 1.4 GHz brightness temperatures (TB) for the 5 cm and 1.25 mm cases over SIS from June 2015 to July 2021.