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Predicting radar attenuation within the Antarctic ice sheet

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To better understand the ability of ice-penetrating radar to diagnose the subglacial environment from bed-returned power, we model the englacial radar attenuation of Antarctic ice. First, we use a one-dimensional thermo-mechanical model to evaluate the sensitivity of the depth-averaged attenuation rates to ice temperature as a function of surface accumulation rate, geothermal flux, and ice thickness. We find that attenuation is most sensitive to variations in geothermal flux and accumulation rate when the bed temperature is close to the pressure-melting point. But even if geothermal flux and accumulation rate remain fixed, attenuation can easily vary with ice thickness. Such high sensitivities show that one should not assume a uniform attenuation rate in the radar data analysis. Then, using ensembles of modeled ice temperatures with different boundary conditions, we generate multiple attenuation predictions for the Antarctic ice sheet and evaluate the resulting uncertainties. The largest contributor to uncertainty in these predictions is the geothermal flux. This uncertainty is localized within the deeper half of the ice sheet. By combining these temperature ensembles with ice-core chemistry data, we show that the sea salt adds little to the attenuation, but the contribution from acids accounts for ∼29% (inland) to ∼53% (coast) of the total attenuation. We conclude that improving radar diagnosis of the subglacial environment using bed-returned power requires both (1) better datainterpretation algorithms that account for attenuation variations and (2) better constraints of geothermal flux and bulk chemistry.