Modeling radar attenuation at Siple Dome using ice-core chemistry and temperature data

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The radar reflectivity of an ice-sheet bed is a primary measurement for discriminating between wet and frozen beds. Uncertainty in englacial radar attenuation and its spatial variation introduces corresponding uncertainty in estimates of basal reflectivity. Englacial radar attenuation is proportional to ice conductivity, which depends on the chemistry (acidity and salinity) and temperature profiles of the ice that is being probed. We use experimental ice-conductivity data to model attenuation and test this model using ice-core chemistry and borehole temperature data from Siple Dome. Our model has a mean uncertainty of 8 % using the acidity, salinity and temperature profiles at Siple Dome. The modeled depth-normalized attenuation rate at the Siple Dome ice-core site is several dB/km lower than the radar-derived value. We discuss possible refinements to the conductivity model to explain this discrepancy, including the effect of melting-point depression, the eutectic point of NaCl and the higher conductivity of premelting ice. This work shows how to constrain englacial radar attenuation using detailed ice-core and borehole data and establishes a basis for extrapolating basal conditions from an ice core across an ice sheet.