Histories of Accumulation and Ice Dynamics from Radar Layers and Ice-Flow Inverse Methods

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Depth-age relationships from ice cores contain a record of past accumulation and ice-sheet dynamics. Profiles of radar-detected internal layers (assumed to be isochrones) add the spatial dimension to temporally resolved records from ice cores. The deeper, older layers record conditions from further in the past, but they have also been subjected to larger horizontal gradients in strain and accumulation, making them more difficult to interpret than near-surface layers. As the depth to the layer increases to a larger fraction of the total ice thickness, accumulation rates based on depth variations alone or corrected using a 1-D flow model are no longer appropriate. We use a flow-band model to calculate ice-surface and layer evolution and to predict internal layer positions and shapes. Solving this forward calculation requires information about spatial and temporal variations of accumulation rate and ice sheet dynamics, which are not known. Inverse methods are used to find physically reasonable values for the unknown parameters that generate internal layers that fit the data within a defined tolerance. This procedure assimilates radar data to extract a spatially and temporally variable accumulation history as well as information about ice divide migration and ice thickness evolution.

We report on development and application of this tool. Future work will focus on obtaining histories of accumulation and ice dynamics for portions of the West Antarctic Ice Sheet (WAIS). Extensive airborne and ground-based radar data obtained over the inland WAIS will be used to help interpret the upcoming ice core near the Ross-Amundsen ice divide. Our modeling will provide information about divide migration, ice thickness changes, and accumulation variations during the most recent deglaciation. This information is needed to calculate ice-volume history of the WAIS, and to provide calibration for testing paleoclimate global climate models.