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Assimilation of Sonic Velocity and Thin Section Measurements from the NEEM Ice Core

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We examine the measurement of crystal orientation fabric (COF) in ice cores using thin sections and sound-wave velocities, focusing on the NEEM core in Greenland. Ice crystals have substantial plastic anisotropy, with shear orthogonal to the crystallographic c-axis occuring far more easily than deformation in other orientations. Due to strain-induced grain-rotation, COFs can become highly anisotropic, resulting in bulk anisotropic flow. Thin-section measurements taken from ice cores allow sampling of the crystal fabric distribution. Thin-section measurements, however, suffer from sampling error, as they sample a small amount of ice, usually on the order of a hundred grans. They are typically only taken at intervals of several meters, which means that meter-scale variations in crystal fabric are difficult to capture. Measuring sonic velocities in ice cores provides an alternate method of determining crystal fabric. The speed of vertical compression waves is affected by the vertical clustering of c-axes, but is insensitive to azimuthal fabric anisotropy. By measuring splitting between the fast and slow shear-wave directions, information on the azimuthal distribution of orientations can be captured. Sonic-velocity measurements cannot capture detailed information on the orientation distribution of the COF, but they complement thin-section measurements with several advantages. Sonic-logging measurements can be taken at very short intervals, eliminating spatial gaps. In addition, sonic logging samples a large volume of ice with each measurement, reducing sampling error. Our logging tool has a depth resolution of around 3m/s, and can measure velocity features on the order of 1m/s. Here, we show the results of compression-wave measurements at NEEM. We also combine sonic-velocity measurements and thin-section measurements to produce a more accurate and spatially-complete representation of ice-crystal orientations in the vicinity of the NEEM core.