Detection of in-situ ice fabric anisotropy using polarimetric radar method near WAIS Divide

K. Matsuoka[1], D. Power[1], C. F. Raymond[1], H. Conway[1], and S. Fujita[2]

1. Department of Earth and Space Sciences, University of Washington, Box 351310, Seattle, 98195 WA
2. National Institute of Polar Research, Research Organization of Information and Systems, 1-9-10, Kaga, Itabashi ku, Tokyo, 173-8515, JAPAN

Crystal-orientation fabric (fabric) has an important effect on ice deformation. As ice deforms, anisotropic fabrics are produced, which, in turn, influence further deformation. To detect spatial distribution of ice fabric pattern, polarimetric radar measurements were conducted in the WAIS Divide region during the 2005/6 and 6/7 field seasons using 60 MHz, 179 MHz, and 1.3 GHz radars. These radars allow us to examine frequency dependent effects of fabric over a wider depth range. If ice fabric is not perfectly symmetric around the radio-wave propagation axis (vertical in our case), the azimuthal variation of the echo intensity is expected to be uniaxial (180-degree periodic) or biaxial (90-degree periodic). Theory and radar evidence from Greenland and East Antarctica suggest that the former can be caused by a vertical variation of the horizontal anisotropy in the fabric (fabric-origin anisotropic reflection) and that the latter can be caused by horizontal anisotropy in the fabric integrated along the radio-wave propagation path to that depth (birefringence).

The polarimetric measurements were done at 19 sites within an area of 150 km by 60 km including the WAIS Divide coring site. Strain-grid measurements using GPS were performed over the two years at these sites. Since our measurements collected the radar signatures from the top half of the ice sheet, strain configuration responsible for the radar detected fabric is more controlled by the ice-sheet surface topography than the bed topography. Thus, we hypothesize that the radar detected fabric signatures can be a proxy for past ice-sheet surface topography.

At sites close to the current ice-flow divide, fabric-origin reflection is apparent at depths ranging between 700 m and 1500 m. It suggests that large contrasts in fabric occur over a short distance at these depths. Farther from the divide, birefringence is more apparent. It implies that contrasts in fabric are too weak to make reflections. Rather, ice fabric develops more gradually through the ice column. The principal axes of the current strain are consistent with radar derived principal axes of the fabric at most of these sites. In contrast, radar data collected at two sites about 100 km NW of the ice coring site show that principal axes of the fabric shift in terms of depth. We argue that the azimuth of the surface slope near these two sites shifted so that ice flowed from Executive Committee Range in the past but nowadays it flows from the divide. Examination of timing and spatial extent of this azimuthal shift of the slope can be related to the history of the divide area in the context of deglaciation at Executive Committee Range revealed by geological evidence. It ultimately provides regional constraints to the ice-core interpretations.