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

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The alignment of crystals in ice, called crystal-orientation-fabrics (fabrics), 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 in the WAIS divide region were conducted during the 2005-6 field season. 60-MHz and 179-MHz radar with co-polarized Yagi antennas were installed on a sled. Radar data were collected at 12 azimuths of polarization planes by alternating the azimuth of the sled in 15-degree steps. 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 difference of the horizontal anisotropy in the fabric and that the latter can be caused by birefringence.

The polarimetric measurements were done at 19 sites within an area of 150 km by 60 km including the WAIS ice coring site; nine sites are in the Amundsen side of the current ice-flow divide, 8 sites on the Ross side, and 2 sites on the divide. Radar data from 14 of the 19 sites show significant azimuthal variations of the echo. The variation was found at depths between 600 m and 2000 m depending on site. Radio echo back from depths greater than 2000 m is close to the noise level obscuring azimuthal variation. The biaxial mode was found in both 60-MHz and 179-MHz data. The uniaxial mode was more prominent at 179 MHz. These characteristics are consistent with that found in East Antarctica. Radar data collected at sites close to each other show similar azimuthal patterns. A quantitative analytical algorithm will be applied to find out principal axes of the biaxial and uniaxial modes, which can be used to map principal axes of the ice fabric. Supplemental strain-grid measurements are now underway at all polarimetric radar sites to relate the ice fabric variations detected by radar to the local strain pattern.

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