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Observation of low shear-wave velocity at the base of the polar ice sheets: evidence for enhanced anisotropy

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The subglacial structure of the arctic and antarctic continents remains widely unknown because of the presence of the thick ice caps. Geological direct investigations are almost impossible and seismological studies of the structure underneath are open to misinterpretations because of the strong reverberations of the seismic waves inside the ice layer. Knowing the thickness and the elastic parameters of the ice layer is important in order to analyze properly the seismic data in studies of the deeper crust structure.
Here we analyse seismic data from the broadband stations located on the Antarctic and Greenland ice sheets in order to determine the large-scale seismic parameters of the polar ice sheets. The P-to-S converted waves at the ice/rock interface and inside the ice sheets and their multiples (the P-receiver functions) are used to estimate the in-situ P-velocity Vp and the P-to-S velocity ratio Vp/Vs of the polar ice. The thickness of the whole ice layer is precisely known either from Radio Echo Soundings or from ice core drillings allowing thus an accurate determination of Vp and Vp/Vs. At some places in and near the Wilkes Basin, a sedimentary layer is probably squeezed between the ice and the bedrock. We find that the polar ice caps have a two-layer structure, the upper layer of variable thickness about 2/3 of the total thickness with velocities very close to the ice standard values and the lower layer preserving a standard Vp but with about 25% smaller shear-wave velocity and a more or less constant thickness. The shear-velocity drop in the lower layer may be the evidence of a strong anisotropy induced by preferred orientation of ice crystals and by fine layering of soft and hard ice layers. Enhanced water content may also play a significant role. A large variation of ice viscosity with depth is therefore expected and heterogeneous flowing of the polar ice sheet. This heterogeneous flowing may invalidate the use at great depth of the ice dating models based on monotonic layer thinning.