Seismological evidence for heterogeneous ice sheet basal conditions

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Basal conditions of the Greenland Ice Sheet (GrIS) are a key research topic in climate change studies. Recently, theoretical work provided impressive theoretical images of highly heterogeneous GrIS basal conditions, seemingly frozen in some areas, whereas it reaches pressure melting point in other areas (MacGregor et al., 2016; Rogozhina et al., 2016). An important next step in the research is to prove their theoretical work through observation.

The construction of a seismic network provides a new opportunity for direct, real-time, and continuous GrIS monitoring. Here we use ambient noise surface wave data from seismic stations all over Greenland for a 4.5-year period to detect seismic velocity changes beneath the inter-station lines. We observe clear seasonal/long-term velocity changes for many station pairs, and propose a plausible mechanism for the velocity changes. The dominant factors causing these changes might be pressurization of both the GrIS and underlying crust by seasonal/long-term snow accumulation, and depressurization by ice thinning due to GrIS flow and ice mass loss. However, heterogeneity in GrIS basal conditions might impose strong regionalities on the results.

An interesting feature is that, even at adjacent station pairs in the inland GrIS, both velocity decrease and increase can be caused by snow accumulations. The former pair might be located on a thawed bed that decreases velocity by increased meltwater due to pressure melting, whereas the latter pair might be located on a frozen bed that increases velocity by compaction of ice and bedrock. The results suggest that surface waves are very sensitive to the GrIS basal conditions.

Global warming enhances snowfall in the inland GrIS due to the moisture increase in warm air. The long-term velocity decrease at the inland areas of the GrIS may suggest that the warming climate enhances not only surface snowmelt, but also pressure melting of the GrIS basal ice. Seismological monitoring may contribute to the first real-time and continuous monitoring of the GrIS basal conditions which are indispensable to meltwater prediction in the Arctic region.

Related presentation: Progress of the GLISN field operations will be presented in this session, entitled "Seismic observations in Greenland by a joint USA and Japanese GLISN team (2011-2016)".

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