Seasonal/long-term changes in Rayleigh-wave phase velocity at the bottom of Greenland ice sheet

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The Greenland ice sheet (GrIS) is a huge storehouse of water on Earth, and has a potential to raise global sea level by ~7 m when completely melted. It is widely reported that the recent climate change has been causing a serious changes in the ice sheet status. The Greenland Ice Sheet Monitoring Network (GLISN), an international project with 11 countries initiated in 2009, now provides a broadband, continuous and realtime seismic data from 33 stations in and around Greenland. Seismic observation, therefore, is now drawing a wide attention as a direct method to monitor the ice sheet status in realtime. Mordret et al. (2016) applied the seismic interferometry to ambient seismic noise data for two years (2012-2013) from seven GLISN stations at southwest Greenland and revealed clear decrease of crustal seismic velocity in summer. However, they suggested difficulty of detecting secular variability in seismic velocity since they consider that the ambient noise has less sensitivity to the long-term changes.

In this study, we apply the seismic interferometry to the data from stations distributed all over Greenland and for longer observation period to show the possibility to detect secular changes in crustal seismic velocity. Seismic interferometry is a method taking a cross-correlation between noise data from two stations to detect Green's function of seismic waves as if one station was a source and another was a receiver. We used vertical component of seismic waveforms for 4.5 years (Sep. 1, 2011 – Feb. 29, 2015) from 16 GLISN stations, which provide clear surface wave pulses for 68 station pairs. For each pair, we defined the 4.5-year averaged CCF as a reference waveform, and detected slight phase shifts of three-month averaged CCFs from the reference to obtain relative temporal changes in crustal velocity below the two stations. We carefully selected the results with respect to computation error and the data quality, and obtained the final results for 36 station pairs.

The significant findings of this study are as follows. Firstly, clear seasonal and long-term changes in Rayleigh-wave phase velocity were found beneath a number of GLISN station pairs. Unlike the case of southwestern Greenland (Mordret et al., 2016), the velocity changes show a strong regionality that is more remarkable at inland areas. Secondly, a plausible mechanism causing the velocity changes was proposed, which consistently explains most of the observed characteristics, taking into account the air and ice mass loading/unloading, depth sensitivity of Rayleigh waves, and heterogeneities of the GrIS basal conditions. We found that, even at adjacent station pairs in the inland GrIS, the difference in the GrIS basal conditions could possibly cause completely opposite patterns of velocity changes as a response to air and snow pressure. The results demonstrate that changes in Rayleigh-wave phase velocity might be a useful tool in determining the GrIS basal conditions.

References

Mordret, A., Mikesell, T.D., Harig, C., Lipovsky, B.P. and Prieto, G.A., Monitoring southwest Greenland's ice sheet melt with ambient seismic noise. *Sci. Adv.*, **2**, e1501538, doi:10.1126/sciadv.1501538, 2016.