地震学でグリーンランド氷床の経年変動は検出可能か？

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Does seismology enable long-term monitoring of Greenland ice sheet?

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The Greenland ice sheet (GIS) 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.

Our results are summarized as follows: (1) station pairs on southwestern coastal area indicate clear velocity decrease in summer season, which are completely consistent with the previous study, (2) on the other hand, when a line between two stations passes through thick GIS, we can see both velocity increase and decrease in summer season, which may be reflecting a complex effect of snow accumulation and melting, (3) we detected secular velocity increase for 9 pairs and secular velocity decrease for 6 pairs, of which distribution is well consistent with both the long-term surface density change and the GIS basal thermal state, i.e., the secular velocity increase/decrease may be caused by a complex effect of long-term ice mass loading/unloading and continuous GIS basal freezing/thawing. Our results suggest a potential of new technology for direct and quasi-realtime monitoring of long-term ice-sheet change with a high spatiotemporal resolution. It has far-reaching implications, for example, monitoring of Antarctic ice sheet and other small glaciers.

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.