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Monitoring South-West Greenland's ice sheet melt with ambient seismic noise

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The Greenland ice sheet (GIS) accounts for $\sim$ 70% of global ice sheet mass loss and contributes to sea level rise at a rate of 0.7 mm/yr. Therefore, the GIS needs to be carefully monitored. The spaceborne techniques commonly used to monitor the GIS mass balance contain inherent uncertainties. These uncertainties can be reduced by comparing independent datasets and techniques. However, spaceborne methods remain inadequate in the sense that they offer low spatial and/or temporal resolution. This fact highlights the need for other complementary methods to monitor the GIS more accurately and with greater resolution. Here we use a seismic method: the correlation of seismic noise recorded at South-West Greenland seismic stations to show that the GIS seasonal melt produces significant variations of seismic wave speed in the Greenland crust. The amplitudes of the measured velocity variations during 2012-2013 correlate with the total ice plus atmospheric mass variations measured by the GRACE (Gravity Recovery and Climate Experiment) satellite mission. We explain the phase delay between mass maxima and velocity minima (50 days) using a non-linear poroelastic model that includes a 55 cm-thick layer of till between the ice sheet and the bedrock. We, thus, interpret the velocity variations as pore pressure variations in the bedrock resulting from the loading and unloading of the overlying glacier and atmosphere. This method provides a new and independent way to monitor in near real-time the first-order state of the GIS, giving new constraints on its evolution and its contribution to the global sea level rise. By increasing the density of seismic stations in the region it will be possible to increase the spatial and temporal resolution of the method and create detailed maps of ice-mass variations across Greenland.