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Continuously imaging sub-ice shelf geomorphology with the vibroseismic method

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Bathymetry, seabed geomorphology and water column thickness are three important quantities to investigate the current and past interaction of ice shelves with the ocean and underlying geologic strata. Water column thickness is important to understand the present water circulation and interaction of ocean water with the overlying ice, geomorphology informs us about the past activity of the ice shelf or even stream, i.e. whether it was grounded and caused megascale glacial lineations, where it was grounded and deposited grounding line wedges or whether it was floating and iceberg scaring took place. Whereas ice thickness of meteoric ice can best be derived with radar, the thickness of accreted (marine) ice, the water column and the stratigraphy of the seabed require seismic techniques. Without an ice shelf, geomorphology can best be obtained with swath sounding methods. With a floating ice shelf, things become more difficult. Although AUVs provided sub-shelf data, their deployment is restricted to regions where the AUV can safely return. In other regions, sub-shelf bathymetry was so far only estimated by sparse seismic point measurements or deduced in coarse resolution from gravimetric surveys.
Here we present results from a vibroseismic traverse on the Ekströmisen, Antarctica, which recorded 80 km of high resolution seismic data in 2014 on the ice shelf. Seabed geomorphology shows considerable variations, from undisturbed regions to troughs several tens of meters deep. Some features show a height of 300 m and could be interpreted as past grounding lines of the active ice stream. Our results demonstrate that imaging sub-ice shelf regions with vibroseismic techniques could provide 3D images of the seabed, not as highly resolved as with swath bathymetry in open water, but considerably better than presently available data sets, and should be routinely obtained to improve our understanding of past ice activity and current processes.