Monitoring and quantification of frontal ablation at Kronebreen, Svalbard, using records of seismic calving signals

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Global glaciers and ice caps lose mass through calving, however, existing models are currently not equipped to realistically predict this dynamic ice loss. This is mainly because long-term continuous calving records with high temporal resolution do not exist to calibrate calving models, and yet are necessary to better understand key climatic-dynamic feed-backs between calving, climate, terminus evolution and marine conditions. Combined passive seismic/acoustic monitoring is the only method able to capture rapid calving events continuously, independent of daylight or meteorological conditions. We have produced such a continuous calving record for Kronebreen, a tidewater glacier in Svalbard, using data from permanent seismic stations between 2001 and 2016. We use this record and independently, directly observed calving flux to quantify ice loss directly from seismic data. The direct observations are frontal ablation rates with weekly to monthly resolution derived from satellite remote sensing data between 2007 and 2013. We derive a statistical model that allows to model frontal ablation from the cumulative duration of seismic calving signals and an indicator of the completeness of the seismic record. This allows for the first time to estimate a time series of calving volumes more than one decade back in time (2001-2016) with weekly resolution.

To improve our model with more precise calibration data of ice volumes with higher temporal resolution, we carried out a field campaign combining innovative, multidisciplinary monitoring techniques. Calving ice volumes and dynamic ice-ocean interactions were simultaneously measured with terrestrial laser scanning, time-lapse camera images, and a temporary seismic/underwater-acoustic network. We present preliminary models that relate seismic and underwater-acoustic signal properties to ice volumes of individual calving events. Furthermore, we compare changes in glacier seismicity and seismic propagation properties recorded upstream the glacier with the activity at the front.