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# Tidal analysis of GNSS data from a high resolution sensor network at Helheim Glacier

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Changes in Greenland and Antarctic ice sheets due to ice flow/ice-berg calving are a major uncertainty affecting sea-level rise forecasts. Latterly GNSS (Global Navigation Satellite Systems) have been employed extensively to monitor such glacier dynamics. Until recently however, the favoured methodology has been to deploy sensors onto the glacier surface, collect data for a period of time, then retrieve and download the sensors. This approach works well in less dynamic environments where the risk of sensor loss is low. In more extreme environments e.g. approaching the glacial calving front, the risk of sensor loss and hence data loss increases dramatically. In order to provide glaciologists with new insights into flow dynamics and calving processes we have developed a novel sensor network to increase the robustness of data capture.

We present details of the technological requirements for an in-situ Zigbee wireless streaming network infrastructure supporting instantaneous data acquisition from high resolution GNSS sensors thereby increasing data capture robustness. The data obtained offers new opportunities to investigate the interdependence of mass flow, uplift, velocity and geometry and the network architecture has been specifically designed for deployment by helicopter close to the calving front to yield unprecedented detailed information. Following successful field trials of a pilot three node network during 2012, a larger 20 node network was deployed on the fast-flowing Helheim glacier, south-east Greenland over the summer months of 2013. The utilisation of dual wireless transceivers in each glacier node, multiple frequencies and four 'collector' stations located on the valley sides creates overlapping networks providing enhanced capacity, diversity and redundancy of data 'back-haul', even close to 'floor' RSSI (Received Signal Strength Indication) levels around -100 dBm. Data loss through radio packet collisions within sub-networks are avoided through the adoption of beacon based time division multiple access (tdma).

The processed GNSS data provides 1-2 cm accurate coordinate time-series at 3-5 second intervals. These time series are able to capture the glaciers response to major calving events as it receded ∼1.5 km and smaller diurnal and semi-diurnal variations in vertical and horizontal motion linked to tidal forcing. Using images from time lapse cameras to locate the calving events we are able to quantify the variation in tidal response over the 3km x 5km area at the calving front during the 53 day study period.