Multi-temporal UAV-survey of a calving glacier in Northwest Greenland

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Calving (breaking off of chunks of ice at the glacier terminus) is a major contributor to mass loss of the Greenland and Antarctica ice sheets. To better understand the calving mechanisms, a Swiss-Japanese research project monitors the calving front of Bowdoin glacier in Northwest Greenland (78 degrees latitude) since July 2014. During the summer 2015 field campaign, the camera inboard a UAV captured the initiation of a major calving event with 10 centimetres spatial resolution and a time resolution of 5 days. Two UAV flights were operated prior to and during the opening of a large crack that formed about 100 meter upstream from the calving front, propagated laterally over more than a kilometre and eventually collapsed entirely.

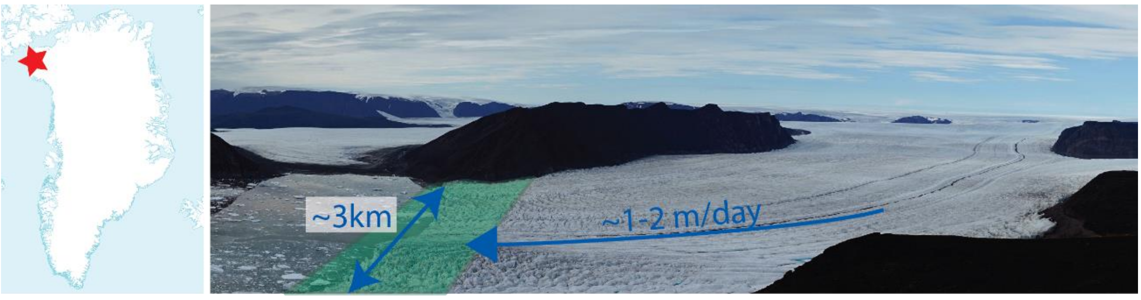

Figure 1: Overview of the calving front of the Bowdoin glacier which was monitored by using UAV (green area).

The choice of the UAV was guided by the following requirements: i) the UAV must be capable of flying autonomously more than 30 km up to 500 m above the ground while carrying a 500 grams heavy inboard camera ii) it must be fast and stable to cope with possibly windy conditions iii) the autopilot must be accessible so that problems due to North Greenland conditions can be fixed on site by fine-tuning parameter. A major issue we had to face was the weakness of the magnetic field making the compass unreliable. Hopefully, this problem could be fixed by changing the way how the orientation is computed in the Pixhawk with APM autopilot.

To achieve the mentioned requirements, the UAV was built based on the commercially available X8-Skywalker airframe and standard components including the Pixhawk autopilot. The X8 airframe provides a reliable and well known base for any kind of scientific instruments. Using a flexible layout of the cargo, the X8 was designed to be flown using 2, 3 or 4 lithium polymer 4S packages. As camera, the mirrorless system cameras of Sony was chosen. The trigger electronic and the camera holder was designed either for APS-C or Full Frame camera bodies with interchangeable lenses. This gives a high level of flexibility for different flight missions and safeness for exchange in case of failures.

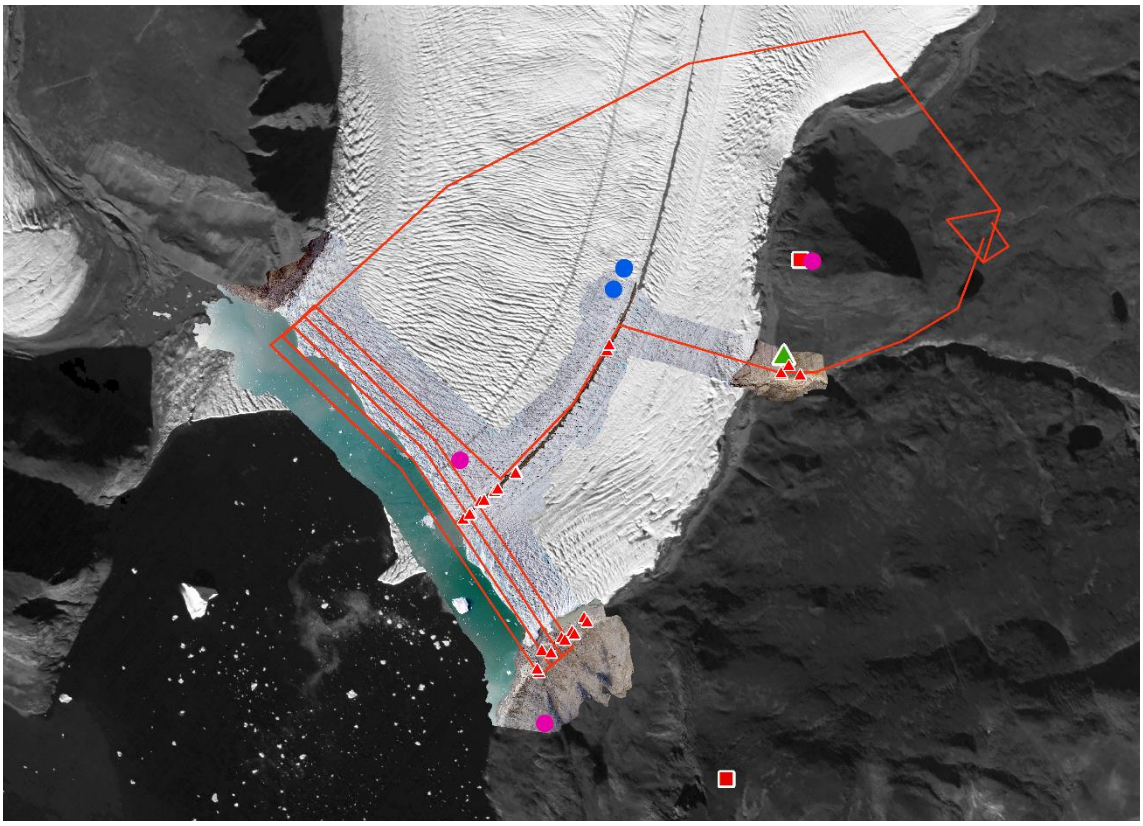

Figure 2: Flight plan (red line) of the calving front monitoring and the DGPS measured Ground Control Points (red triangles).
Additionally the locations of seismic arrays (purple dots), the boreholes (blue dots), time laps cameras (red squares) and the camp of the expedition 2015 (green triangle).

For each flight, the UAV acquired about 1000 overlapping pictures of the calving front. Ground Control Points (GCP) next and on the glacier were installed and measured with Differential GPS (DGPS) to georeference the UAV images. Due to the glacier velocity (more than 1 m/day), the GCPs located on the glacier were measured repeatedly so that their absolute positions at the time of each flight could be determined. The pictures of each flight were post-processed through the software Agisoft PhotoScan to create the digital surface models and ortho-images. High-resolution velocity and strain fields on the surface could be inferred from the ortho-images by feature-tracking techniques, allowing an in-depth fracture mechanical analysis of the calving event.