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Mapping Svalbard glaciers with USV – top technology for novel results

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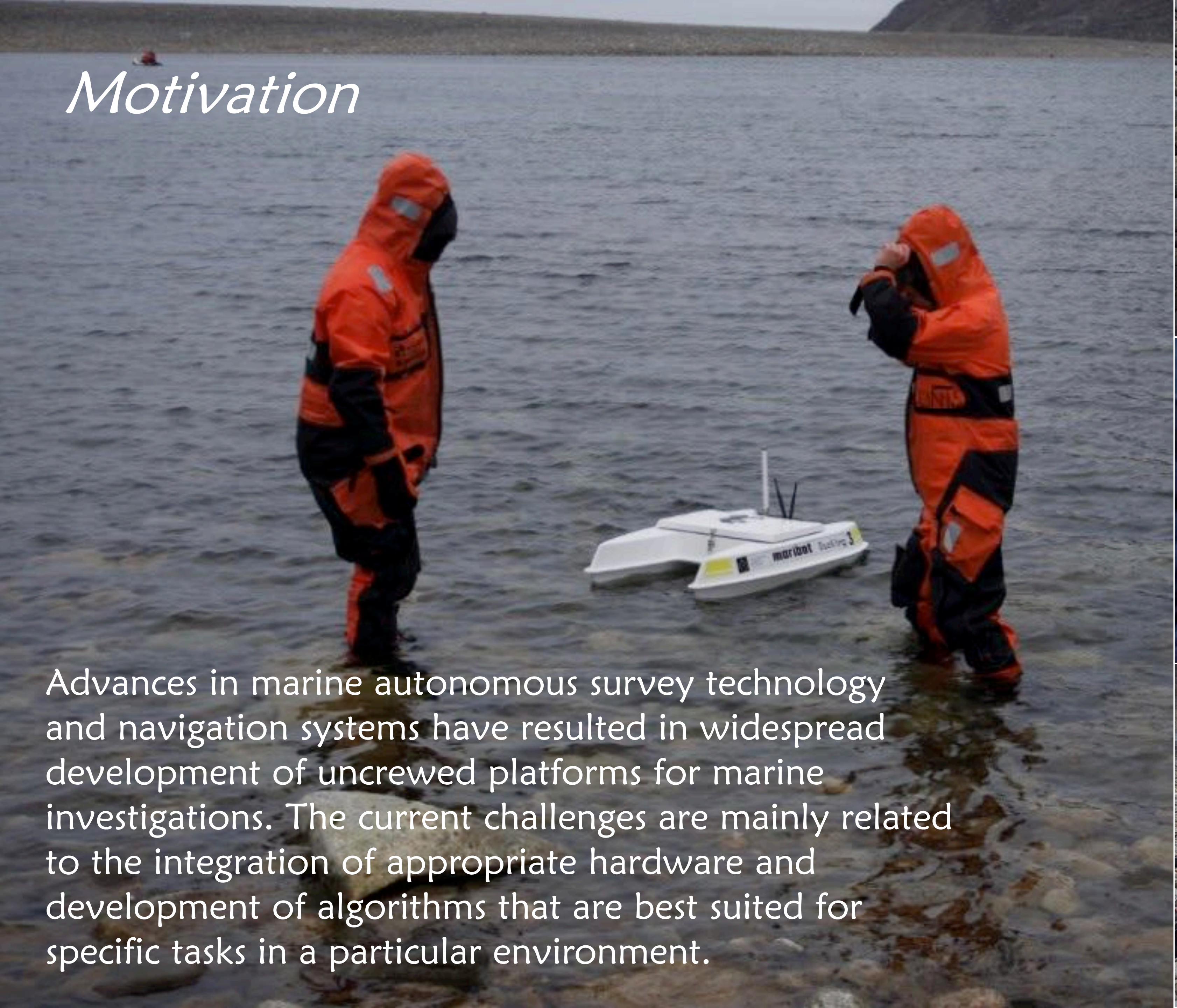
Background

- Glaciers and ice sheets are the main contributors to the rising sea level in the warming world
- Ice loss from nearly every glacier on Earth is speeding up
- Significant ice loss takes place at marine-terminating glacier margins through melting and calving
- These processes are poorly understood and are therefore improperly included in ice sheet models
- Poor understanding of the complexity and interaction of the processes shaping the marine glacier margins is largely related to the dangers of field data collection.

- Geological, glaciological as well as oceanographic data are critical for better understanding of the dynamics of marine-terminating glacier margins, and for quantifying their contribution to sea level rise.
- Acquisition of data at calving glacier margins in uncharted shallow waters and in difficult ice conditions with traditional methods, such as crewed surface vessels, is time-consuming, costly and risky.

Motivation



Advances in marine autonomous survey technology and navigation systems have resulted in widespread development of uncrewed platforms for marine investigations. The current challenges are mainly related to the integration of appropriate hardware and development of algorithms that are best suited for specific tasks in a particular environment.

USV Kuninganna

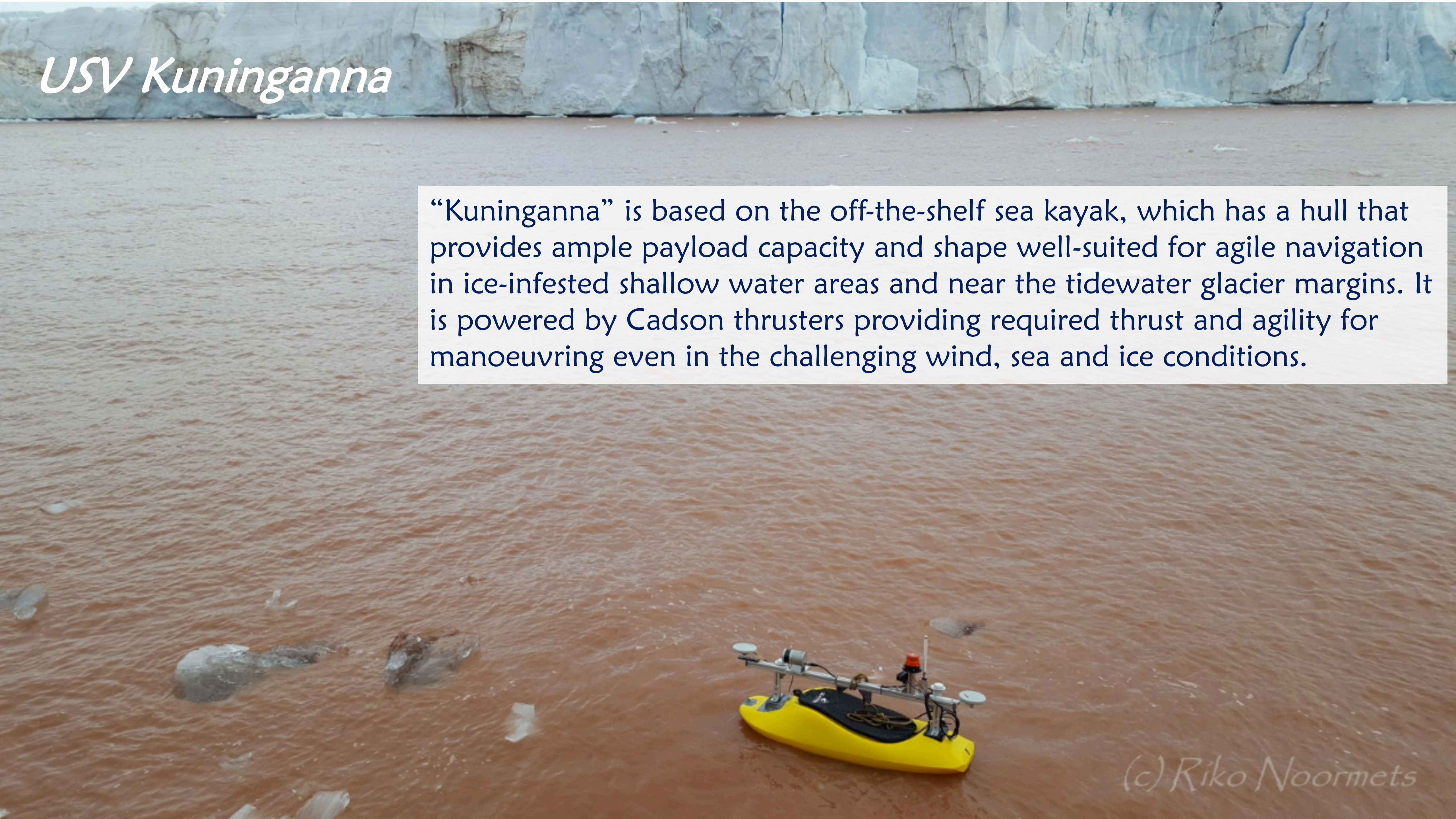
The need to map the harsh Arctic marine environments motivated the design of a portable, modular and robust ("plug and play") Uncrewed Surface Vessel (USV) "Kuninganna".

The key features are modularity in both hardware and software facilitating

- Easy transport to remote areas
- Adaptation to various instrument configurations
- Navigation and mapping algorithms adjustable to survey environment and goal.

USV Kuninganna

“Kuninganna” is based on the off-the-shelf sea kayak, which has a hull that provides ample payload capacity and shape well-suited for agile navigation in ice-infested shallow water areas and near the tidewater glacier margins. It is powered by Cadson thrusters providing required thrust and agility for manoeuvring even in the challenging wind, sea and ice conditions.



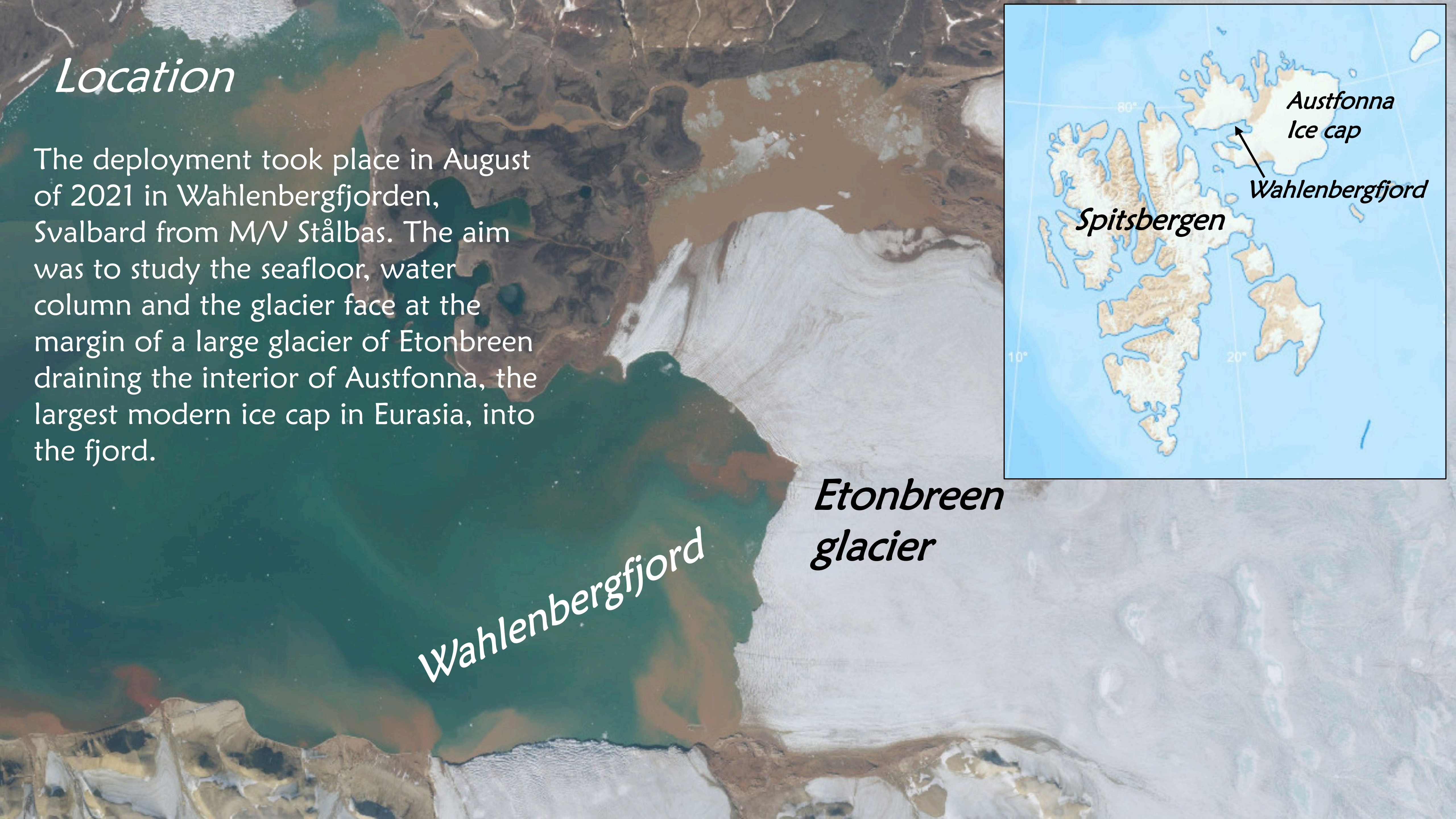
Installation of NORBIT WINGHEAD and iLidar

The USV "Kuninganna" was equipped with WINGHEAD i77h multibeam echosounder and iLidar from NORBIT.

Setup and testing were done in the workshop at UNIS and in Longyearbyen harbour. Compact build and relatively light weight enabled launching the fully operational USV from the pier by two people.

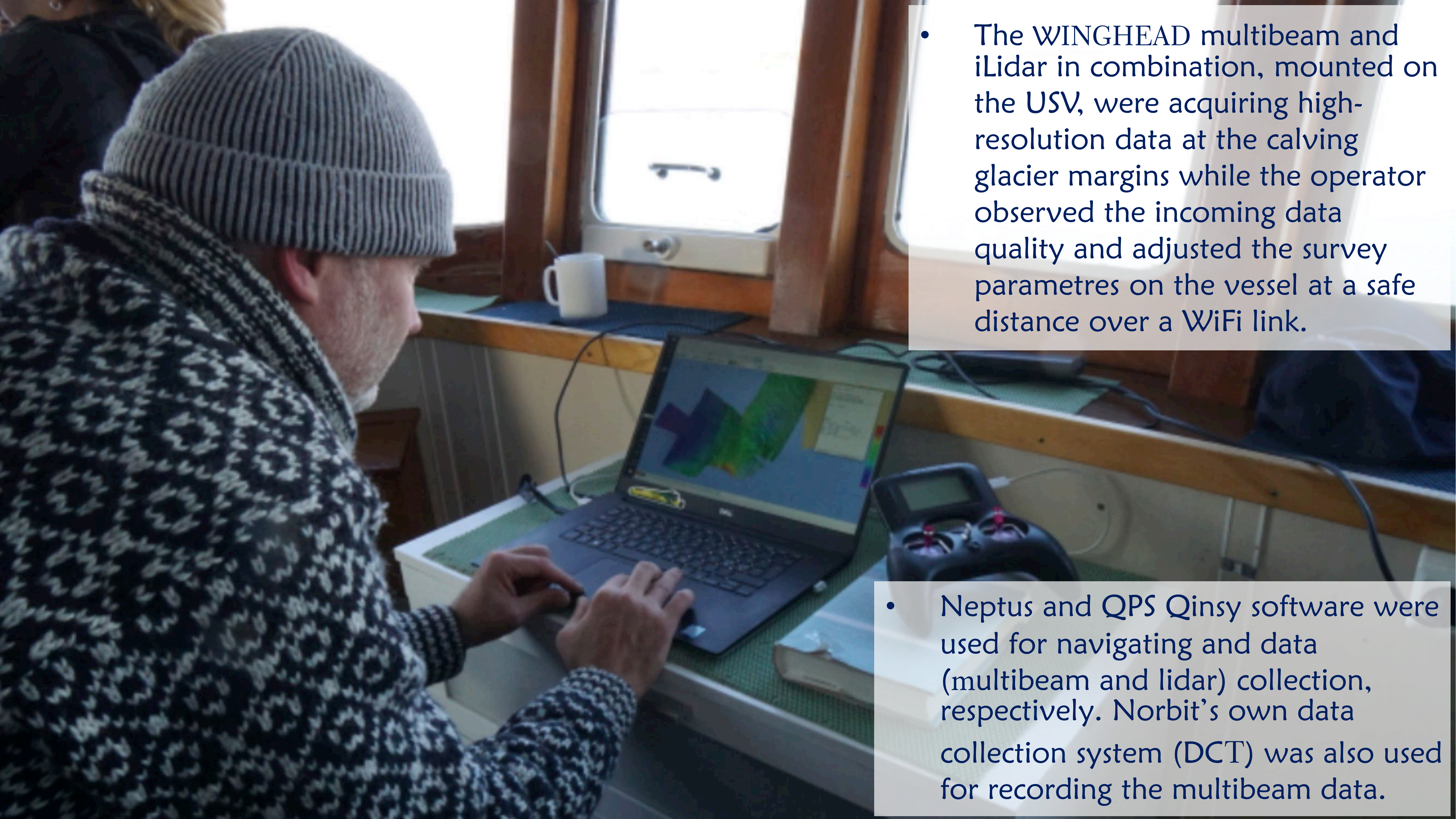
Location

The deployment took place in August of 2021 in Wahlenbergfjorden, Svalbard from M/V Stålbas. The aim was to study the seafloor, water column and the glacier face at the margin of a large glacier of Etonbreen draining the interior of Austfonna, the largest modern ice cap in Eurasia, into the fjord.



Deployment

- The USV was assembled and prepared for the missions on the M/S Stålbas. Deployment and recovery were done with the help of ship’s crane and a small boat.



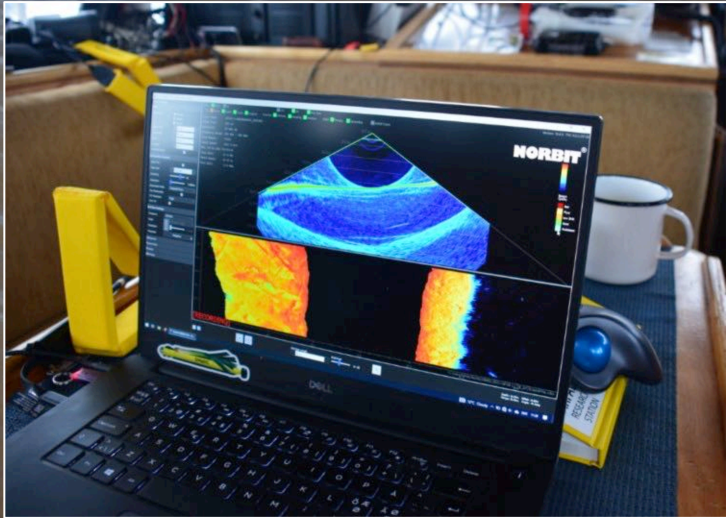
- The WINGHEAD multibeam and iLidar in combination, mounted on the USV, were acquiring high-resolution data at the calving glacier margins while the operator observed the incoming data quality and adjusted the survey parametres on the vessel at a safe distance over a WiFi link.

- Neptus and QPS Qinsy software were used for navigating and data (multibeam and lidar) collection, respectively. Norbit's own data collection system (DCT) was also used for recording the multibeam data.

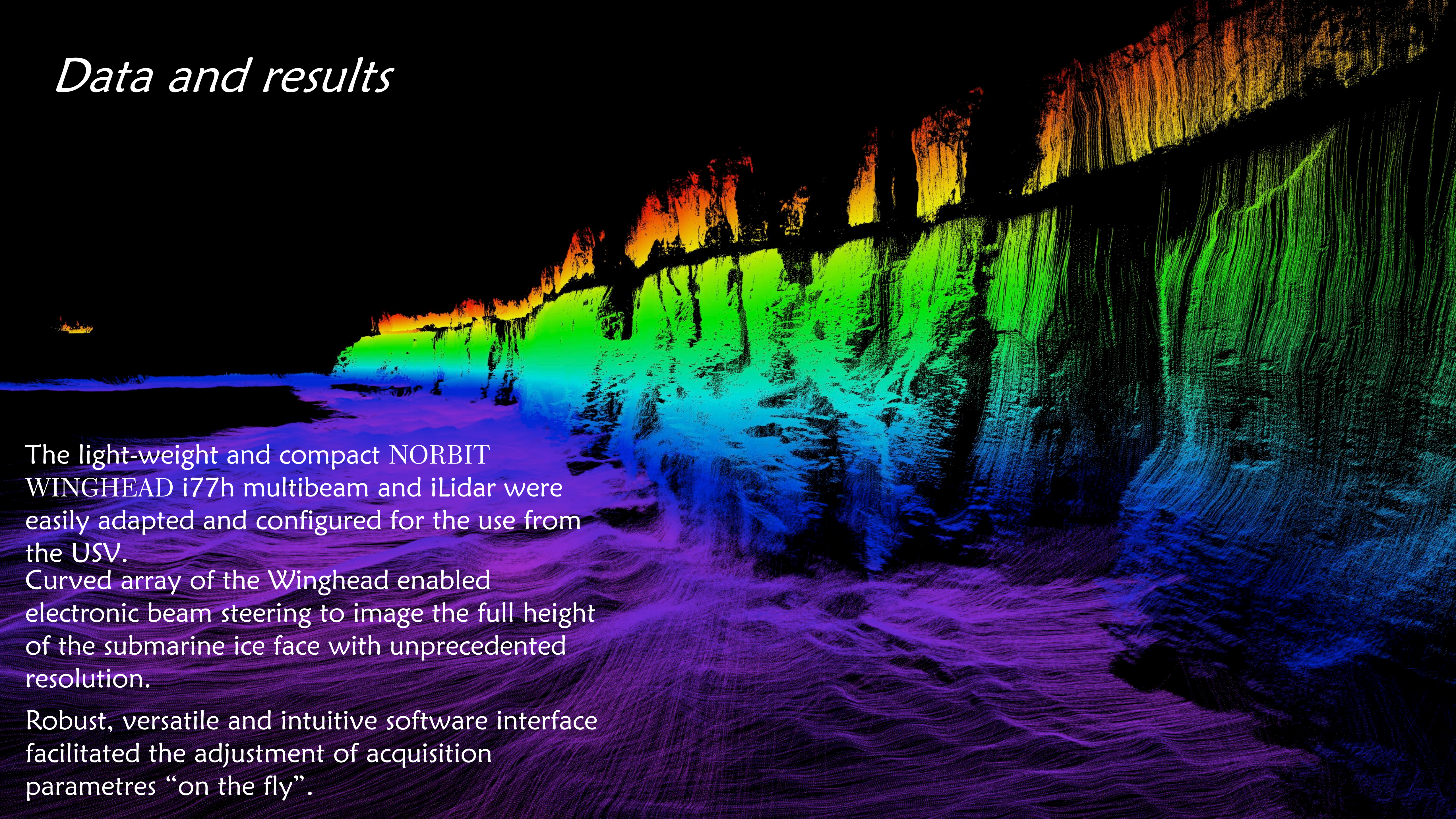
Data acquisition

The sounding density was generally uniform and the data quality great except for the areas where the USV was manoeuvring through dense patches of ice rubble from occasional calving at the ice front. In these areas, the data density varies significantly and the lidar signal was occasionally lost resulting in data gaps in subaerial part of the glacier front. The submarine part of the ice face was usually still mapped with sufficient quality. Occasional gaps in the lidar data may also result from the poor reflectivity of the glacier face.

Dense grid of sound velocity profiles through the water column was obtained throughout the survey. This is very important in the environment with sharp salinity and temperature gradients that have large spatial as well as temporal variability.



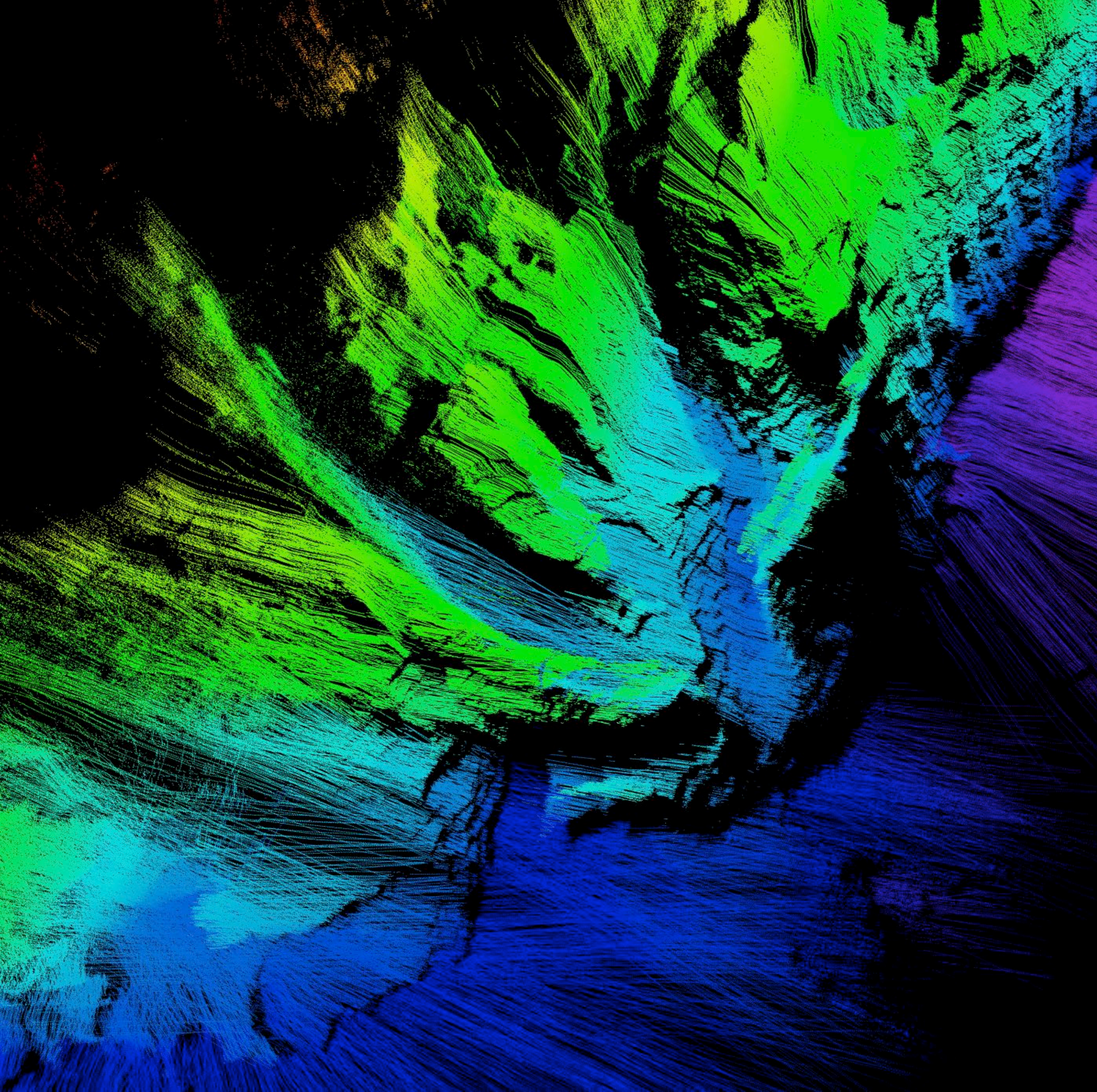
Data and results



The light-weight and compact NORBIT WINGHEAD i77h multibeam and iLidar were easily adapted and configured for the use from the USV.

Curved array of the Winghead enabled electronic beam steering to image the full height of the submarine ice face with unprecedented resolution.

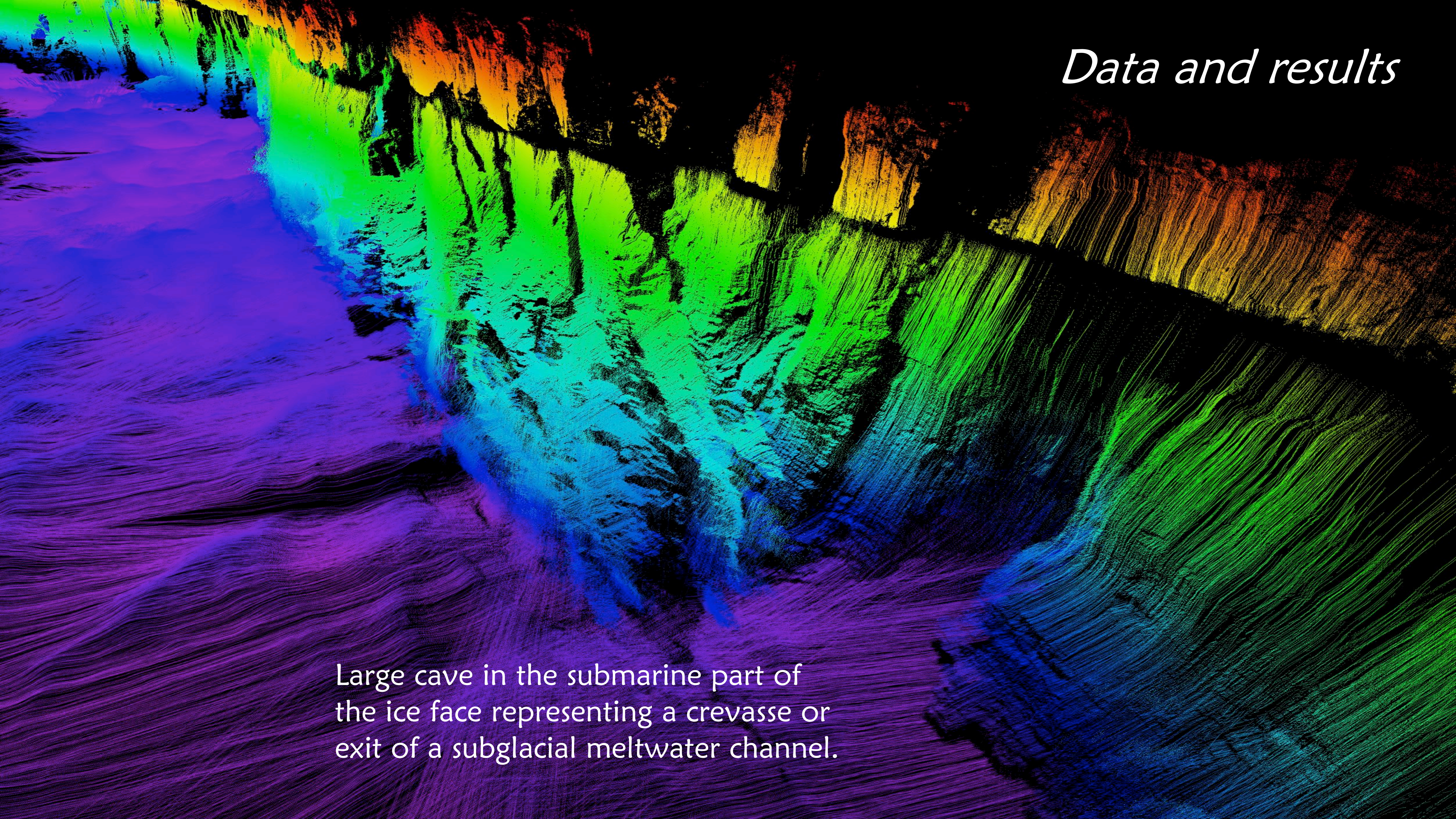
Robust, versatile and intuitive software interface facilitated the adjustment of acquisition parametres “on the fly”.



Data and results

Preliminary analysis revealed a highly variable morphology of the ice cliff with sections of flat and vertical ice walls, large notches at the sea level, severe undercuts at the base, crevasses extending deep into the ice face as well as caves and subglacial tunnel entrances at the base of the ice cliff as well as at sea level.

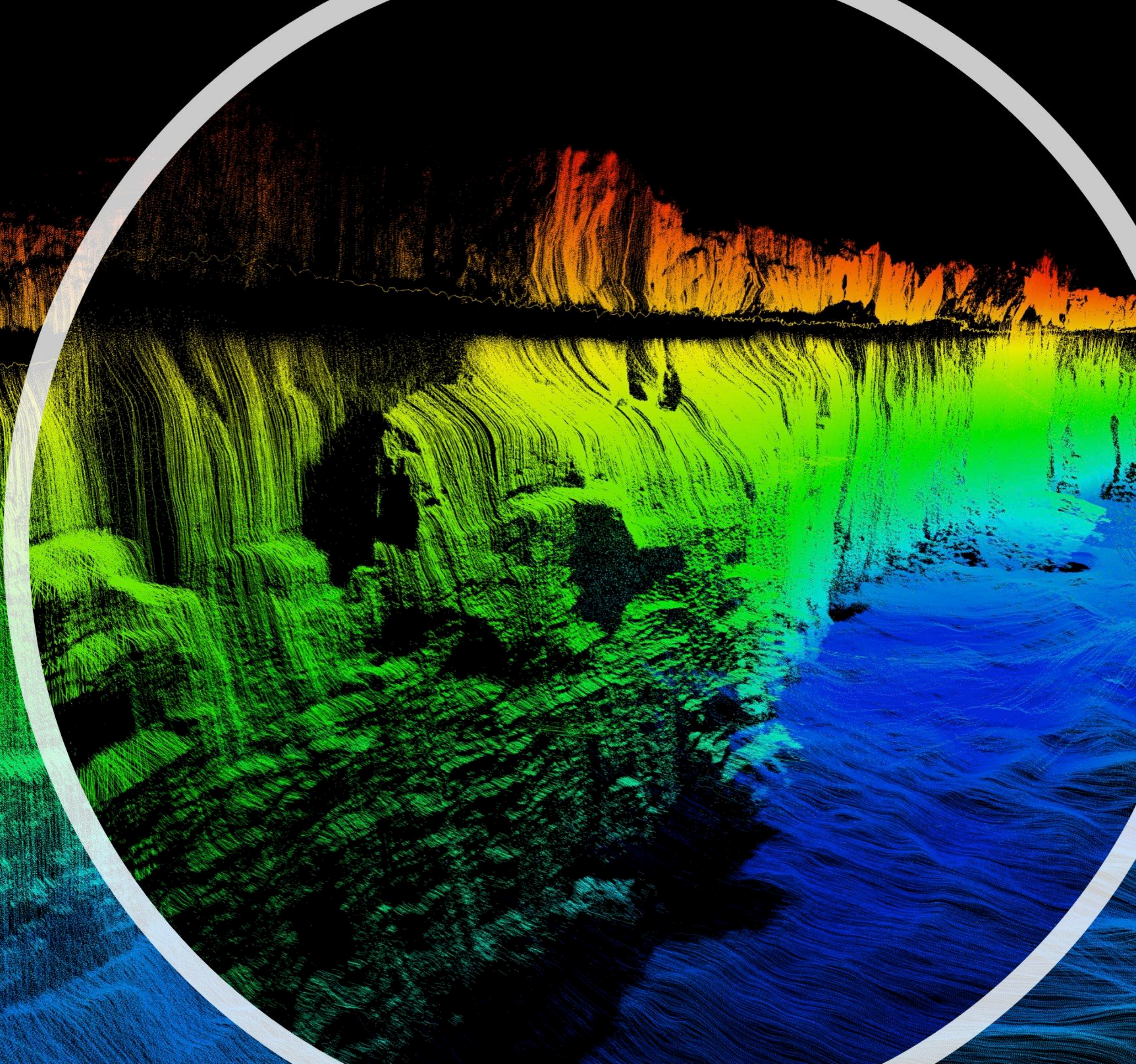
Data and results



Large cave in the submarine part of the ice face representing a crevasse or exit of a subglacial meltwater channel.

Data and results

These data, in combination with the temperature and salinity profiles through the water column will provide the basis for benchmarking the oceanographic and glaciologial conditions at the margin of Etonbreen and for assessing the ice-ocean-seabed interactions.



Acknowledgements

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None of this would have been possible without your kind help!

Thank you!

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A few bonus scans from the waterfront of the city of Longyearbyen, 78°13’N 15°35’E