IceBird Summer 2023

Polar 5 sea ice survey campaign 2023

Longyearbyen and Station Nord

Weekly Report #3 (Final Report), August 15 to 25, 2023

Christian Haas, PI, AWI

Polar 5 at Station Nord, on a bad (top) and on a good day (bottom), with EM Bird under the belly (bottom)

Link to IceBird Summer 2023 campaign video clip compiled by FO Hugh Mai:

https://www.instagram.com/reel/CwVONf8I5By/?igshid=MzRlODBiNWFlZA

About the IceBird Arctic sea ice campaigns

IceBird is a long-term airborne campaign for the observation of changes of sea ice thickness, roughness, snow cover, and melt ponds in the Arctic. It's main instrument is the EM Bird, a towed sensor that measures sea ice thickness by means of electromagnetic induction (EM) and a laser altimetry (Haas et al., 2009 & 2010).

We have carried out airborne EM surveys in the Arctic since 2001, and the IceBird program systematically observes sea ice variability and change with a summer and winter campaign with AWI's Polar 5 and 6 aircraft (Haas et al., 2010; Krumpen et al., 2016; Belter et al., 2021, von Albedyll et al., 2021, Jutila et al., 2022). While the winter campaigns typically include surveys in both Canada and Greenland, the summer campaigns usually focus on surveys over the Arctic Ocean out of Station Nord only.

The main objectives of the IceBird Summer 2023 campaign are:

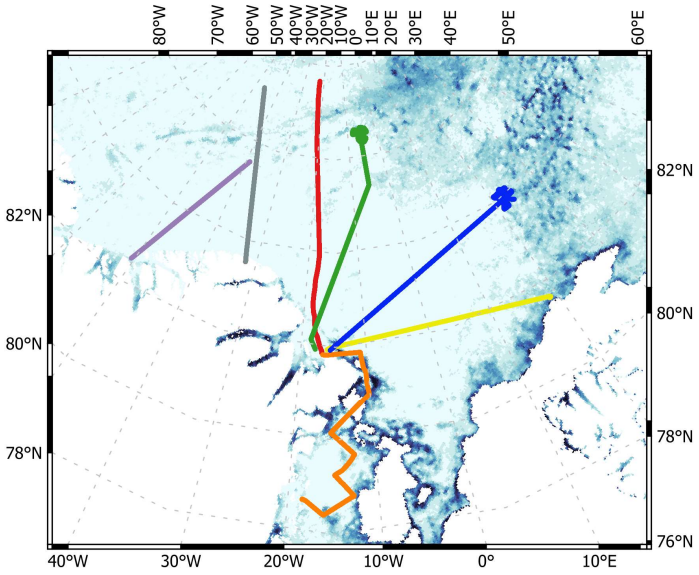
- Continue long-term observations of changes of sea ice thickness, roughness, snow cover, and melt ponds in the Arctic.
- Observe seasonal ice thickness changes in comparison to results from IceBird Winter 2023, by surveying some of the same ice during both campaigns.
- Collect ice thickness data over NPI moorings Amundsen-1 and Nansen-1 for comparison with data from ice profiling sonar (IPS).
- Coincidentally underfly tracks of the CryoSat-2 and IceSat-2 satellites at the same time to collect ground-truth data for improvement and validation of their freeboard and ice thickness retrievals.
- Observe gradients of ice thickness across the Marginal Ice Zone (MIZ) in continuation of research conducted during the ATWAICE cruise of RV Polarstern in July/August 2022.
- Survey surging glaciers on Svalbard for generation of digital elevation models (DEMs) in support of research at the University Center Svalbard (UNIS) and a MSc thesis in the Environmental Physics program at the University of Bremen.

Our main instruments are

- EM Bird for sea ice thickness (see photo above).
- Airborne laser scanner (ALS) for sea ice surface roughness and glacier surface elevation.
- MACS RGB, NIR and TIR cameras for melt pond and melt process observations and general documentation of ice conditions.

Short summary of activities between August 15 to 25

Poor weather mostly at Station Nord with rain and fog or low clouds persisted for seven days from August 11 to 17 (see top photo above), although weather conditions over the sea ice in the west were mostly good. However, conditions had much improved on August 18, and we carried out an underflight of a descending orbit on CryoSat-2 in the Lincoln Sea. We met CryoSat at 20:18 UTC on our flight from 83°30'N, 50°W to 85°36'N, 39°W, returning to Station Nord only after midnight. A middle-altitude band of clouds visible on the weather satellite images was not well visible en-route and did not cause any interruptions.



Map of all sea ice surveys: Aug 4 (red), Aug 5 (green), Aug 8 (orange), Aug 9 (yellow), Aug 10 (blue), Aug 18 (purple), and Aug 19 (grey). Map shows ice concentration of August 9 provided by Lars Kaleschke, AWI Sea Ice Section.

On the following day (August 19) we carried out a final sea ice survey from Cape Morris Jesup to 87 N, 45 W, completing excellent coverage of our survey region of old multiyear ice north of Greenland. The survey ended at a bank of thick cloud that we already expected from the weather satellite data.

After loading the aircraft on Sunday, we left for Longyearbyen on Monday August 21. Just after take off we did three runway overpasses for retrievals of squinting angles of the laser scanner and MACS camera installations, for later post-processing to obtain best possible geolocation of the measurements.

Unfortunately low-clouds prevented a repeat-survey of Vallåkrabreen on Svalbard in the following days. This glacier is of much interest because in-situ observations of glacier run-off in the previous weeks have shown little diurnal variations which points to large water reservoirs under the glacier. As these reservoirs would strongly modify glacier flow, their presence and depth could be determined by detecting changes of the glacier surface elevation.

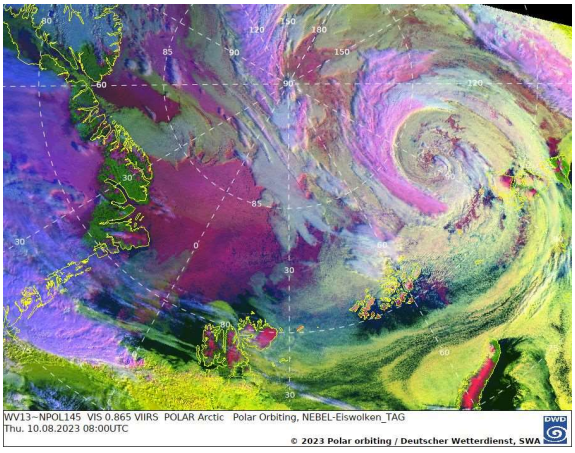
Polar 5 left Longyearbyen on August 23, taking Jack Landy to Tromsø and then on to Oslo. Customs issues in Germany allowed the aircraft to only go to Bremen on August 25. Sadly, customs procedures seem to have become as large challenges as poor weather these days. With this, IceBird Summer 2023 ended successfully and on time as planned.

Preliminary results

While most ice thickness data have already been processed and are of high quality, interpretation of results and comparison with previous years are still in progress. However, it can be said that the long transects across Fram Strait, the Transpolar Drift, and to the north nicely resolved the thickness gradients from the coast of Greenland to farther offshore which are a result of different ice age and origin, and deformation near the coast. Overall, the ice was quite thick compared to previous years, with thicknesses of up to 2 m at 87N. Summer conditions with large amounts of melt water on top of leads complicated the calibration of the ice thickness data.

There was relatively low melt pond coverage and most ponds were already frozen, in particular further north.

For flight planning, the satellite derived fog_day product by DWD was most useful (see figure below). There was remarkable agreement with the ICON cloud forecasts, although forecasts in general showed more clouds than there were in reality.



False-color cloud cover satellite image provided by DWD, showing low clouds and fog in green/yellow/grey, middle clouds in light blue/grey, and high clouds in pink. Cloud free sea ice can be seen in purple. This image from August 10 at 8 UTC suggested that a flight to the mooring Nansen-1 at 84N, 24E was just possible, and indicated that some fog may be encountered at around 0E, which we eventually did.

Acknowledgements

We would like to thank everyone who helped making IceBird Summer 2023 a big success, in particular Thomas Krumpen, Daniel Steinhage, Silke Henkel, Marcus Meierdiecks, the staff of Station Nord and at AWIPEV in NyAlesund, and many others.

Main direct collaborators:

Thomas Krumpen (Co-PI), Gerit Birnbaum, Niklas Neckel, Veit Helm, Stefan Hendricks, AWI, Germany
Andy Hodson, UNIS, Svalbard, Norway
Erik Schytt Mannerfelt, University of Oslo, Norway

On behalf of the IceBird Summer 2023 team:

Christian Haas (CH), PI, AWI, Germany
Lena Happ (LH), PhD student, AWI, Germany
Jack Landy (JL), Co-PI, University of Tromsø, Norway
Jonathan Kolar (JK), MSc student, University of Bremen & UNIS
Martin Gehrmann (MG), Aircraft science engineer, AWI, Germany
Alan Gilbertson (AG), Captain, Kenn Borek Air, Calgary AB, Canada
Hugh Mai (HM), First Officer, Kenn Borek Air, Calgary AB, Canada
Simon Gariepy (SG), AME, Kenn Borek Air, Calgary AB, Canada

From left: Jonathan, Jack, Alan, Christian, Martin, Lena, Hugh, Simon

Table 1: Overview of flights carried out until August 14

Date	Activity	Flight hours
July 28	Ferry flight Bremen-Tromsø	5.9
July 29	Ferry flight Tromsø-Longyearbyen	3.0
July 31	Survey of Scheelebreen and Slakbreen (partially)	2.9
August 2	Survey of Blankfjellbreen and Borebreen	4.5

	Runway surveys in Longyearbyen for ALS geometric calibration (Two along-runway flights at 2000 and 3000 ft and one across-runway flight at 3000 ft)	
August 3	Survey of Vallåkrabreen and Slakbreen	5.7
	Ferry Longyearbyen-Station Nord	2.6
August 4	Sea ice survey to 87.6 N, 22 W	6.3
August 5	Sea ice survey to NPI mooring Amundsen-1 at 86.5 N, 5 W	6.3
August 8	Sea ice survey of The Norske Øer Ice Barrier and other fast ice at the north-east tip of Greenland (Wandel Sea). ALS/MACS survey of glacier front of 79N Glacier and southern outflow of Flade Isblink ice cap.	5.7
August 9	Sea ice survey to ice edge north of Svalbard, appr. 81.6 N, 19 E	5.4
August 10	Sea ice survey to NPI mooring Nansen-1 at 84 N, 20 E	6.4
August 18	CryoSat underflight (overhead at 20:18 UTC), to the NE of Cape Morris Jesup	5.7
August 19	Sea ice survey from Cape Morris Jesup to 87 N, 45 W	6.1
August 21	Runway overpasses of Station Nord and ferry to Longyearbyen	2.7
August 23	Ferry Longyearbyen-Tromsø-Oslo (crew only)	6.5
August 25	Ferry Oslo-Bremen	2.7
	Total	**78.4**

References

Belter, H. J., Krumpen, T., von Albedyll, L., Alekseeva, T. A., Birnbaum, G., Frolov, S. V., Hendricks, S., Herber, A., Polyakov, I., Raphael, I., Ricker, R., Serovetnikov, S. S., Webster, M., and Haas, C. (2021). Interannual variability in Transpolar Drift summer sea ice thickness and potential impact of Atlantification, The Cryosphere, 15, 2575–2591, https://doi.org/10.5194/tc-15-2575-2021.

Haas, C., Hendricks, S., Eicken, H., Herber, A. (2010). Synoptic airborne thickness surveys reveal state of Arctic sea ice cover, Geophysical Research Letters, 37, L09501, 5 p., doi:10.1029/2010GL042652.

Haas, C., Lobach, J., Hendricks, S., Rabenstein, L., Pfaffling, A. (2009). Helicopter-borne measurements of sea ice thickness, using a small and lightweight, digital EM system, Journal of Applied Geophysics, 67(3), 234-241., doi:10.1016/j.jappgeo.2008.05.005 .

Jutila, A., Hendricks, S., Ricker, R., von Albedyll, L., Krumpen, T., and Haas, C. (2022): Retrieval and parameterisation of sea-ice bulk density from airborne multi-sensor measurements, The Cryosphere, 16, 259–275, https://doi.org/10.5194/tc-16-259-2022.

Krumpen, T., R. Gerdes, C. Haas, S. Hendricks, A. Herber, V. Selyuzhenok, L. Smedsrud, and G. Spreen (2016), Recent summer sea ice thickness surveys in Fram Strait and associated ice volume fluxes , The Cryosphere, 10 , pp. 523-534 . doi: 10.5194/tc-10-523-2016

von Albedyll, L., Haas, C., and Dierking, W. (2021). Linking sea ice deformation to ice thickness redistribution using high-resolution satellite and airborne observations, The Cryosphere, 15, 2167–2186, https://doi.org/10.5194/tc-15-2167-2021.

Appendix 1

Second weekly report August 8 to 14

After the first two sea ice surveys on August 4 and 5, and poor weather conditions afterwards, on August 8 the DWD satellite data (fog product) and cloud forecast indicated clear skies over the Greenland Sea and Belgica Bank which were still covered by fast ice, the The Norske Øer Ice Barrier. As we have occasional data from that region from previous AWI and NPI/UiT campaigns we decided to carry out an ice thickness survey there (Figure 1). Due to the long survey flight we were not able to return along the same route with the MACS camera, and therefore returned rather straight to Station Nord, with short sorties to the 79Nord Glacier and the southern outflow branch of the Flade Isblink ice cap to obtain laser scanner and MACS data for observations of surface elevation change.

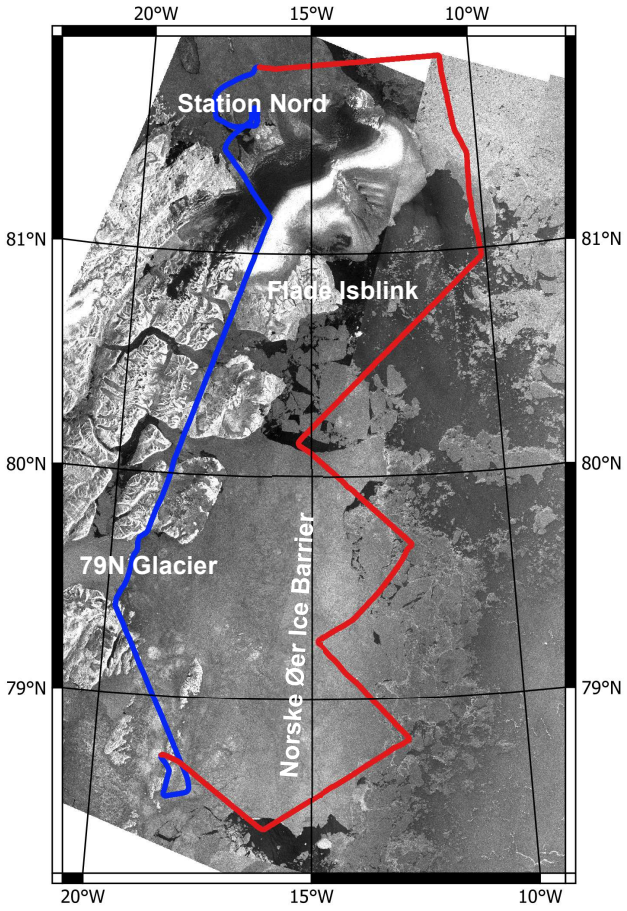


Figure 1: Map of the flight over the Norske Øer Ice Barrier on Belgica Bank on August 8. Red line shows ice thickness survey flight track, blue line shows return flight track including over the 79N Glacier calving front and the southern outflow of the Flade Isblink ice cap.

On August 9 the satellite data showed clear skies just north of Svalbard. Therefore we carried out a West-East survey from Station Nord to near the ice edge at 19°E, fully covering the ice thickness gradients across Fram Strait where ice of different origin and age is leaving the Arctic Ocean. First sightings of dirty ice just east of the Greenwich Meridian clearly indicated changes in ice regimes, and the ice near the ice edge became visibly thinner and more broken up, with frequent thaw hole, i.e. melt ponds that had completely melted through the ice. Unfortunately we could not quite reach the ice edge due to thick fog banks there. This flight passed just north of the study region of the ATWAICE/PS131 cruise of RV Polarstern in late July 2022.

Weather conditions were better farther north on August 10, and we were able to carry out a survey to NPI mooring Nansen-1 at approximately 84°N and 20°E, were we also surveyed a few extra lines to improve statistical representativeness of our ice thickness data for later comparison with the Ice Profiling Sonar (IPS) on the mooring. This flight added another cross section across the outflowing branches of the Transpolar Drift, and nicely complements our other surveys farther south and north. With this flight we successfully achieved our goal to survey both over moorings Amundsen-1 (on August 5) and Nansen-1. The Nansen-1 mooring was only approximately 50 miles away from the first ice station of the present Polarstern Arcwatch-1 cruise that took place on the same day.

Since August 11 weather conditions either at Station Nord or in our desired study regions were unfavourable for further flights.

This week brought another remarkable event with the advent of fast, public internet at Station Nord! With the Hercules arrival on Saturday came several groups with their own Starlink and One-Web systems that since are available publicly in certain locations/houses (not ours). The speed and data volume of the systems are revolutionary and we make little use of our own Iridium system any more as it is slow and very expensive. Lots of smiles all over!

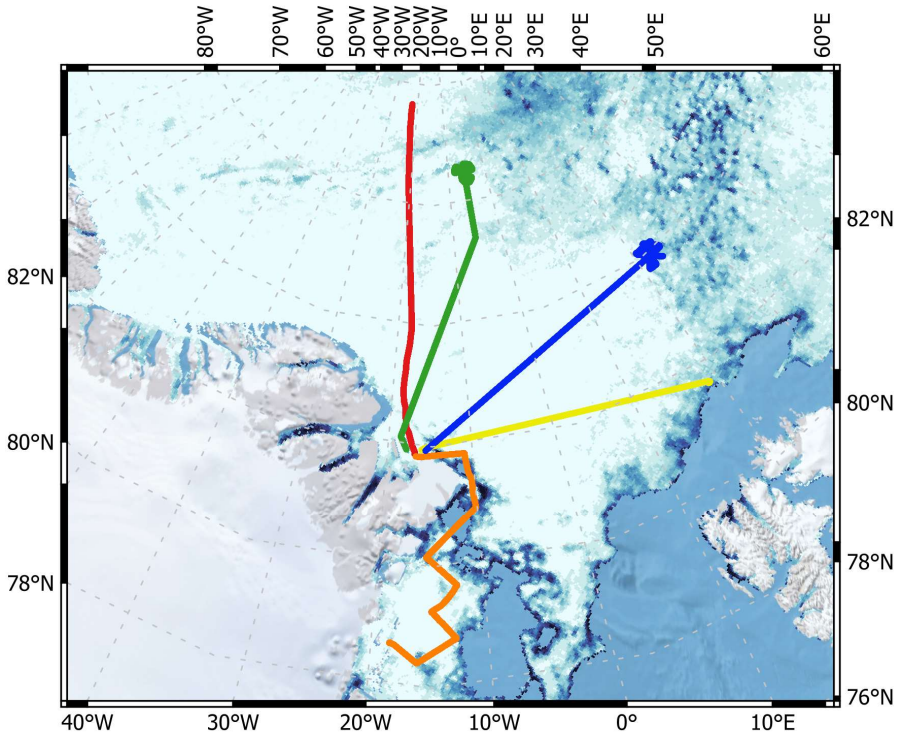


Figure 2: Map of all sea ice surveys until August 10: Aug 4 (red), Aug 5 (green), Aug 8 (orange), Aug 9 (yellow), and Aug 10 (blue). Map shows ice concentration of August 9 provided by Lars Kaleschke, AWI Sea Ice Section.

Figure 3: Typical ice conditions in the Wandel Sea north of Greenland (left, Aug 4), and in the Marginal Ice Zone north of Svalbard (right, Aug 9)

Instrument status

Most instruments continued to work very well without any anomalies.

The INS of the MACS camera showed anomalous behaviour since August 8, compromising attitude correction and georeferencing of the MACS images. However, image quality and overlap remain good.

We discovered that the wiring of the downward looking pyranometer and pyrgeometers were swapped, which led to implausible readings on the board computer. This fault was not identified during the test flight. However, raw data are fine and one just has to be aware that they are logged with the wrong instrument.

Plans for the next week

We are scheduled to leave for Longyearbyen on August 21, i.e. we have one week left for surveys. We are hopeful that we will be able to carry out further thickness surveys, in particular in combination with Cryo2Ice underflights and extending our regional coverage to 40 and 60 Degrees West.

Appendix 2

First weekly report July 28 to August 7

While the Polar 5 left Bremen in the morning of July 28 to fly to Tromsø (six-hours, non-stop), the scientific project members departed on the same day and arrived in Longyearbyen with SAS just after midnight on July 29. The Polar 5 arrived in Longyearbyen on the same day at around noon after a three-hour flight from Tromsø. The rest of the day was spent on unloading and survey preparations, with a priority of glacier surveys in the first days.

Difficult weather conditions with unpredictable and widespread low clouds made planning of glacier surveys challenging, but a real-time webcam at Svea was very helpful. With the help of the webcam and our own observations in Longyearbyen we were able to survey all target areas during three different sorties taking advantage of locally variable weather conditions. While most glaciers could be surveyed at a flying altitude of 1000 m above ground, we needed to reduce flying altitude to 300 m above ground over Blankfjellbreen to stay below the dense cloud layer, requiring closer profile line spacing to assure complete coverage of the glacier by the ALS swath measurements. Flights are summarized in Figure 1 and in Table 1.

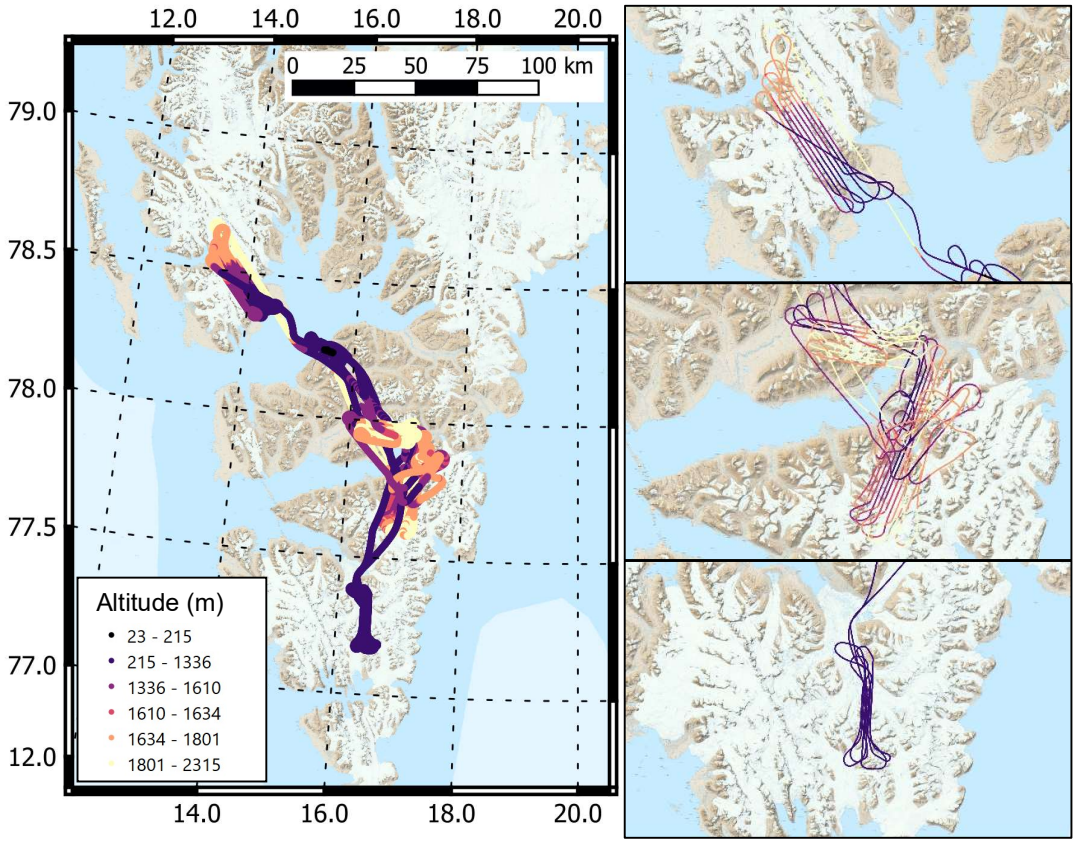


Figure 1: Map of all glacier flights carried out in Svalbard. More details on the right, showing surveys over Borebreen (top), Slakbreen, Vallåkrabreen, and Scheelebreen (center), and Blankfjellbreen (bottom). See table for dates of flights.

After the survey of Vallåkrabreen and Slakbreen in the morning of August 3 we were able to leave for Station Nord in the afternoon.

At Station Nord our only internet access is through our own Iridium Certus receiving station, which we use to access weather information from the German weather service DWD. The information showed favourable conditions to the north of Station Nord in the next two days.

Therefore we were able to carry out two successful ice thickness surveys on August 4 and 5 (Figure 2). The first survey led from the fast ice to approximately 87.6 N, 22 W, and the second to a mooring of the Norwegian Polar Institute (NPI) named Amundsen-1 with an ice profiling sonar. At the mooring we carried out some additional overflights in different directions. On both days we returned along our outward flight track at an altitude of 1600 ft to acquire ALS and MACS measurements over the same ice with a larger swath width.

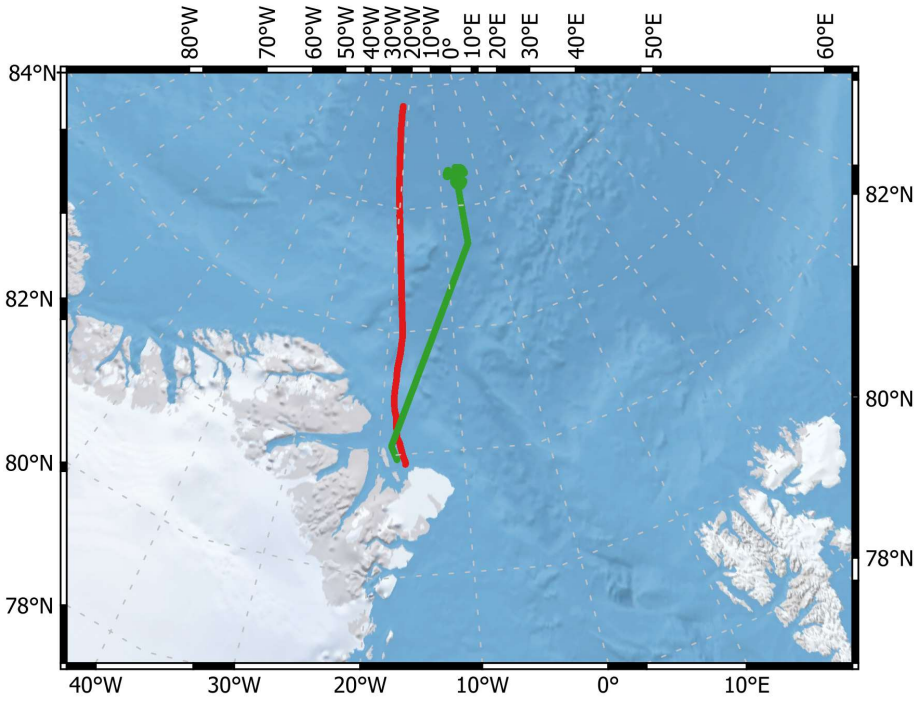


Figure 2: Map of the study region showing tracks of ice thickness surveys on August 4 (red) and August 5 (green).