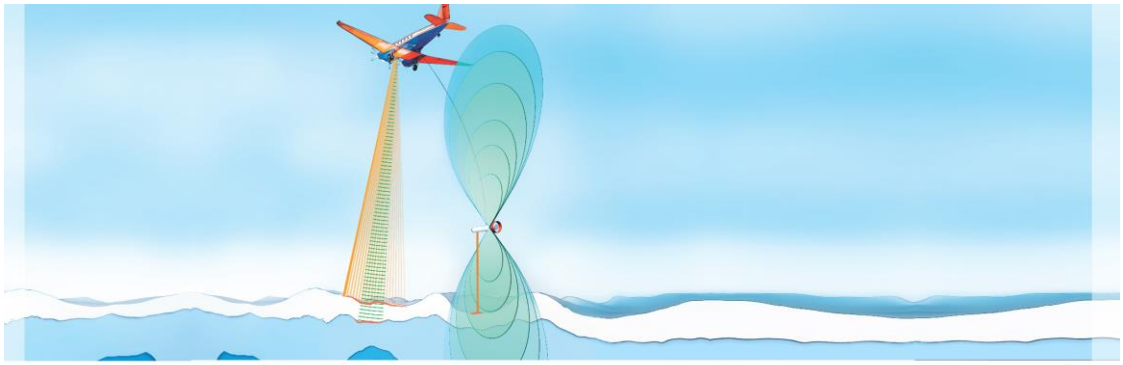
IceBird Summer 2024

Polar 5 sea ice survey campaign

Station Nord

July 20th to August 15th, 2024, Final Report

Jack Landy (PI, UiT), Gerit Birnbaum (AWI), Catherine Taelman (UiT), Eduard Gebhard (AWI), Alan Gilbertsen (KBA), Triston MacLean (KBA), Dwayne Bailey (KBA), (Thomas Krumpen supporting from home, AWI)



AWI IceBird

Leading Airborne Program for Direct Sea Ice Observations

Changing sea ice thickness and surface in the Transpolar Drift and last ice areas

The AWI IceBird program (IceBird Project Page) is a series of airborne surveys to collect measurements of sea ice thickness in the Arctic conducted by the Alfred Wegener Institute for Polar and Marine Research (AWI). Airborne surveys provide insight into composition and properties of the ice in general and how it changes over time. Additional foci are melt pond characteristics in summer and snow cover characteristics in winter. The AWI IceBird campaigns take place twice a year: In summer (August) and winter (March/April), when sea ice extent and thickness are at their minimum and maximum, respectively.

The survey program comprises and continues all airborne ice thickness measurements obtained since 2002 in the central Arctic, Fram Strait and the last ice area with the objective to ensure the long-term availability of a unique data record of direct sea ice thickness and surface state observations (deliverable of *AWI research program POFIV, Topic 2.1: Warming Climates*). IceBird's ice thickness measurements use a tethered electromagnetic sensor, the EM-Bird, towed by research aircraft 50 feet/ 15 m above the ice surface. Parallel to the ice thickness measurements, optical and laser systems are operated to derive sea ice surface models and melt pond distribution.

Long-term objectives:

The planed survey flights are intended to repeat flight tracks of previous years and as such to provide insight into long-term variability and trends in ice thickness and ice surface over the

past two decades (e.g. Krumpen et al. 2019). In addition, separate flights are made that serve specific scientific questions, such as the influence of 'Atlantification' on sea ice retreat (e.g. Belter et al. 2021) or the coupling between surface roughness and melt pond coverage. Moreover, flight hours are kept in reserve for the mapping of extreme events (deliverable *POFIV, Topic 2.2: Variability and Extremes*) as for joint surveying activities with other institutions (e.g. NPI/Kronprins Haakon in 2020 - 2022).

Scientific focus in summer 2024:

In addition to continuing the above-mentioned long-term objectives, a scientific focus of the IceBird Summer campaing in 2024 is to validate and improve novel satellite-based sea ice freeboard and thickness estimates from altimetry missions like CryoSat-2 during the melting phase. It was planned to conduct satellite underflights of CryoSat-2 and ICESat-2; however, poor weather conditions meant a lack of opportunities, and this goal was not achieved. Other goals of the 2024 campaign, to coordinate with scheduled field work (e.g. RV Kronprins Haakon servicing an oceanographic mooring in the Amundsen basin) and a separate airborne campaign, the NASA ARCSIX https://espo.nasa.gov/arcsix project, were achieved successfully. We also overflew an array of ice mass balance (CRREL) and weather buoys (UiT) www.cryosphereinnovation.com/data deployed by twin otter landings in April 2024.

Our main instruments are

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

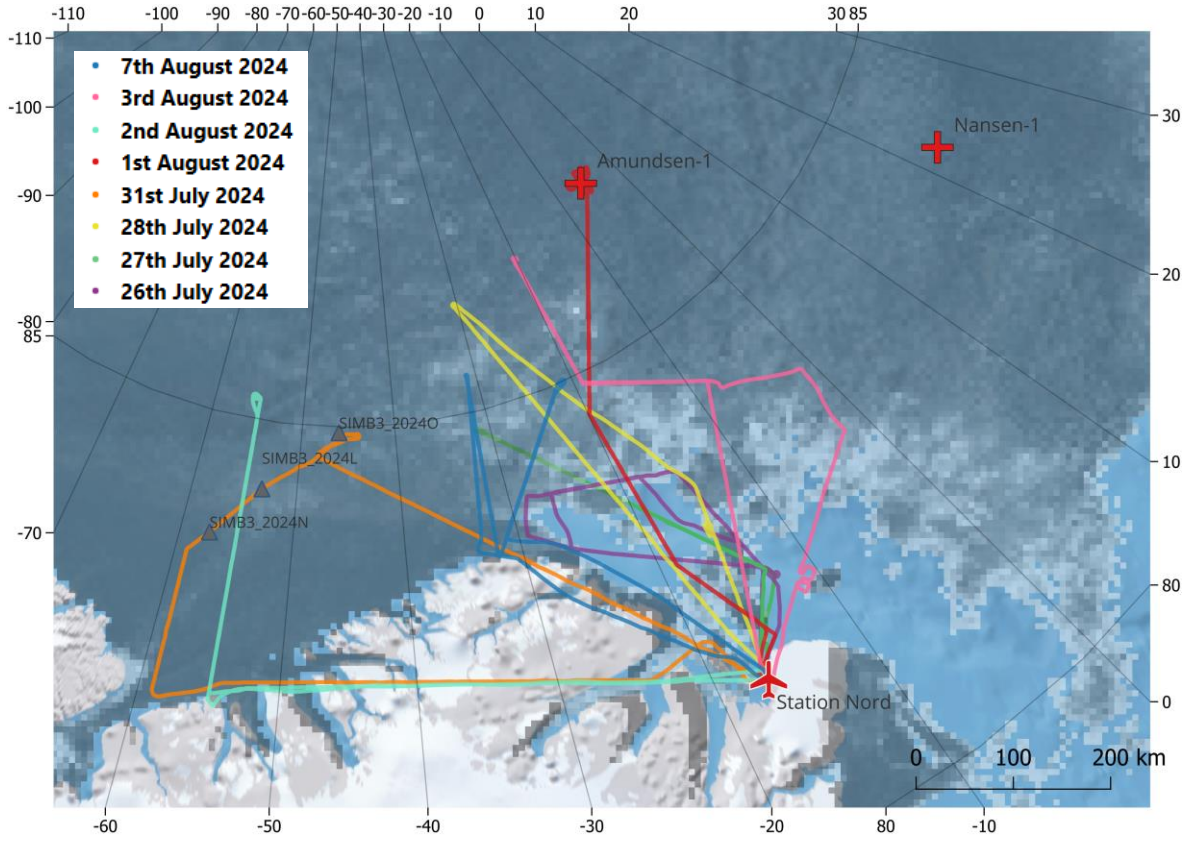


Figure 1. Map of all sea ice surveys on top of the AMSR2 ice concentration on August 2nd.

Sea ice conditions

Upon arrival at Station Nord on July 21st, the fjords around the station were all covered with fast ice. The fast ice edge was also extending eastwards into the Wandel Sea. There were no large open water areas.

Summary of activities between July 20 and 29

The IceBird team transferred from Longyearbyen to Station Nord (STN) on July 21st for the start of the campaign. Poor weather (low clouds, fog and high winds) at the station and in the survey block prevented us from flying for the first five days on site. The time was dedicated to instrument preparation, ground testing, and flight planning.

A small clear weather window opened up north of STN on July 26th and 27th, so we took the opportunity to make two flights covering the thick mostly MYI within 150 km of the northern Greenland coastline, across to about 30 W (Fig 1). A large flaw lead had opened up between the fast and pack ice north of STN and remains open. The flight on July 26th was a double loop including EM-bird on the first loop and only MACS+laser on the second, with the intention to overfly an ice mass balance buoy (SIMB3_2024J https://www.cryosphereinnovation.com/deployment/301434060407490) entering Fram Strait, but we could not get to it owing to fog. The flight on July 27th bisected the loops flown the day before and reached 85 N, 32 W along a straight profile, again with EM-bird on the outbound and MACS+laser on the inbound. Preliminary sea ice thickness data for these two flights are shown in Figure 2.

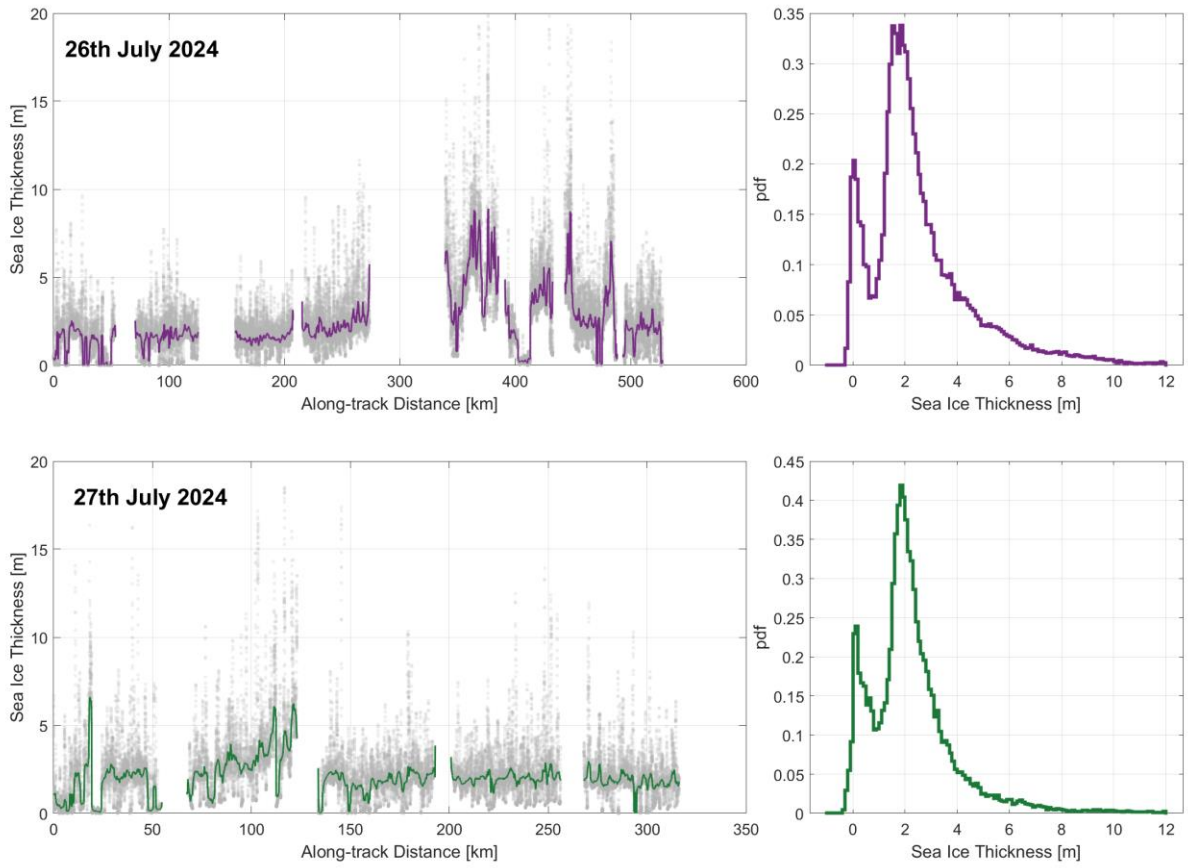


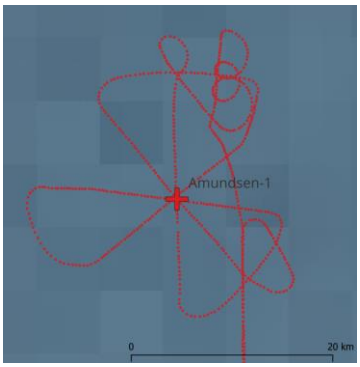
Figure 2. Preliminary sea ice thickness profiles and distributions for July 26th and 27th. An approx. 2-km running median has been applied to the profiles.

A larger clear weather window opened up on July 28th, but a forecast for afternoon fog meant that we could get out only for a restricted survey (Fig 1). However, the EM-bird experienced some technical problems right after takeoff, with the data stream delayed after startup and not appearing correctly when restarted several times. Consequently, we completed the flight to 86 N, 30 W with the laser scanner and MACS operating in both directions. On July 28th and 29th, the EM-bird was tested and a delay on the WiFi connection between plane and sensor identified as the likely problem.

Summary of activities between July 30th and August 7th

The team were lucky to get a period of improved weather between 31st July and 2nd August, with a high-pressure system pushing up from the south leaving clear skies over most of the survey block. On 31st July we completed a survey close to the Canadian border, from Nares Strait to the north. Starting at around 82N 60W we captured very thick MYI in the source region of Nares Strait, particularly in the second leg of the flight survey, then turned northeast to fly a line over three sea ice mass balance buoys and weather stations deployed in the Lincoln Sea in April (Fig. 1). The three IMBs were flown over in order: SIMB3_2024N, SIMB3_2024L, and SIMB3_2024O (although the final buoy was missed by a few km owing to fog) https://www.cryosphereinnovation.com/data.

On 1st August we flew a line to the northwest of STN, following two legs of a survey covered by the NASA ARCSIX aircraft at approximately the same time, up to 84.6N 20W. This line crossed the large flaw lead which opened up north of the station ~16th July and expanded to a width of almost 200 km by early August. Measuring sea ice and atmospheric/cloud properties in and around this flaw lead was a prime objective of ARCSIX on 1st August. Thereafter, we flew direct north to the “SUDARCO” Amundsen-1 mooring at 86.5N 6.5W and overflew it in a cloverleaf pattern matching the same survey completed in August 2023. Future work will involve comparing airborne ice freeboard and thickness observations with ice draft observations acquired by the mooring IPS https://framforum.com/2023/02/28/sustainable-development-of-the-arctic-ocean/. The R/V KPH was servicing the mooring and completing a sea ice station at the time of our flight, so we were able to overfly the vessel.



On 2nd August the weather was again fine out west, so we completed a regular IceBird survey line along the 55W meridian from the Greenland coast north to 85.2N. This included measurements of very rough and deformed MYI in the Lincoln Sea. The ARCSIX aircraft was also surveying in the Lincoln Sea on the same day.

On 3rd August the forecasts suggested a first opportunity to survey out to the northeast of STN, where the weather is traditionally much worse in summer than to the north and west. However, we encountered thick low cloud, so we were forced to reposition our survey back to the northeast of STN. Several good lines were flown up to 86.2N 20W, north of the now-large open

water flaw lead along the northeast coast of Greenland. A set of calibration squares for the radiation sensors were performed at the beginning of the flight.

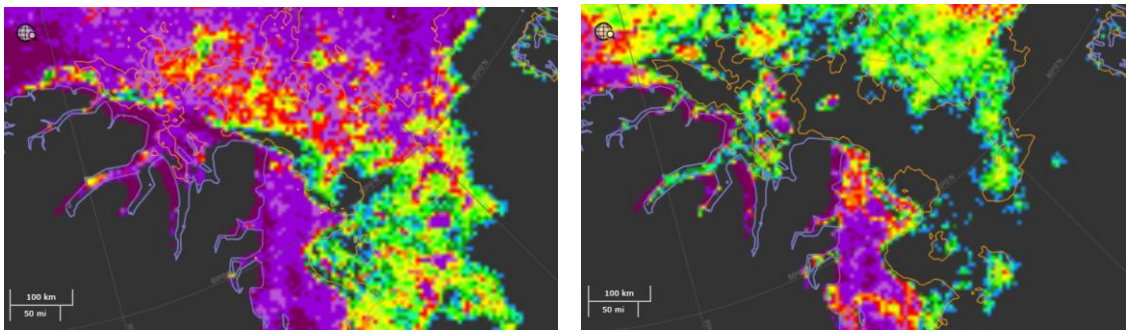
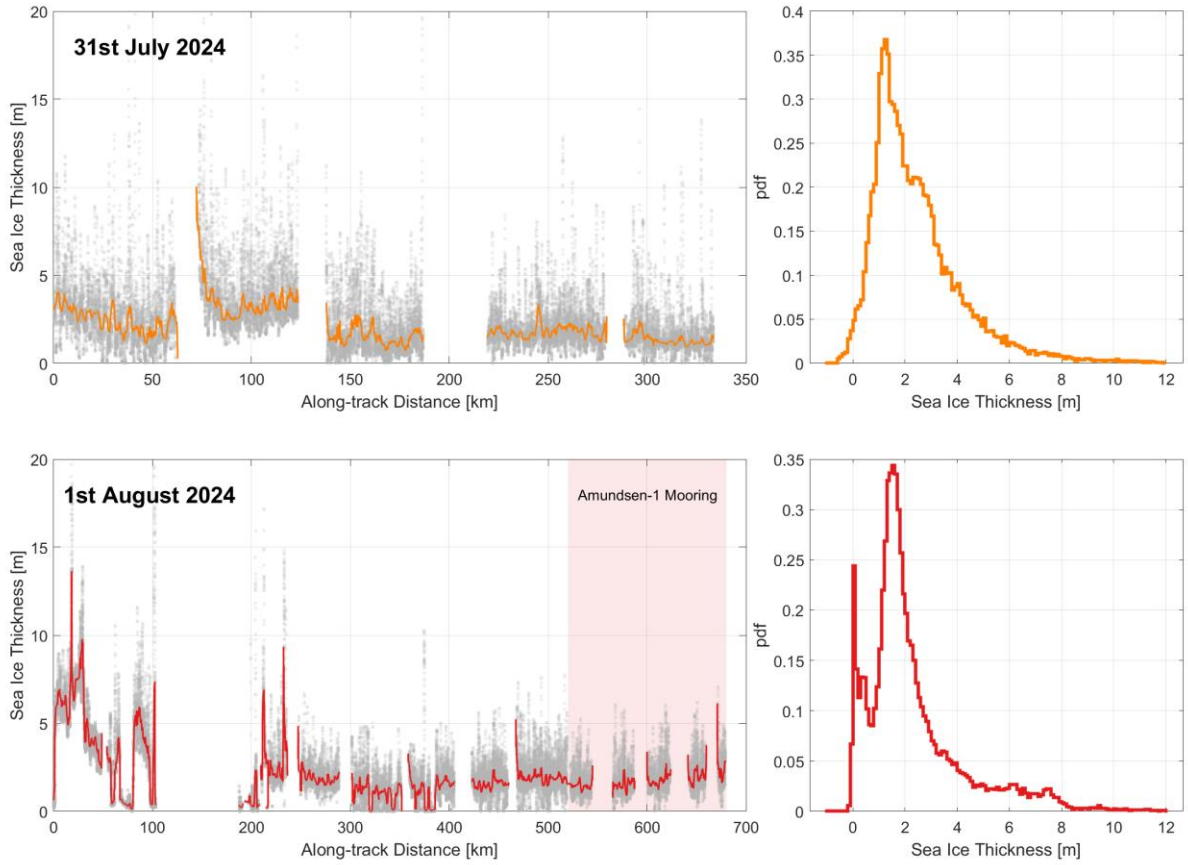


Figure 3. Opening up of the flaw lead north of Station Nord between 16th July (left) and 2nd August (right). Images from Polarview, sea ice concentration data from AMSR2.

Poor weather prevented flying until 7th August when a small window with higher clouds but uncertain low cloud/fog conditions opened up to the northeast of STN. This flight had to be more by sight than by planning, but we managed to complete several good survey lines up to 85.3N 31W.



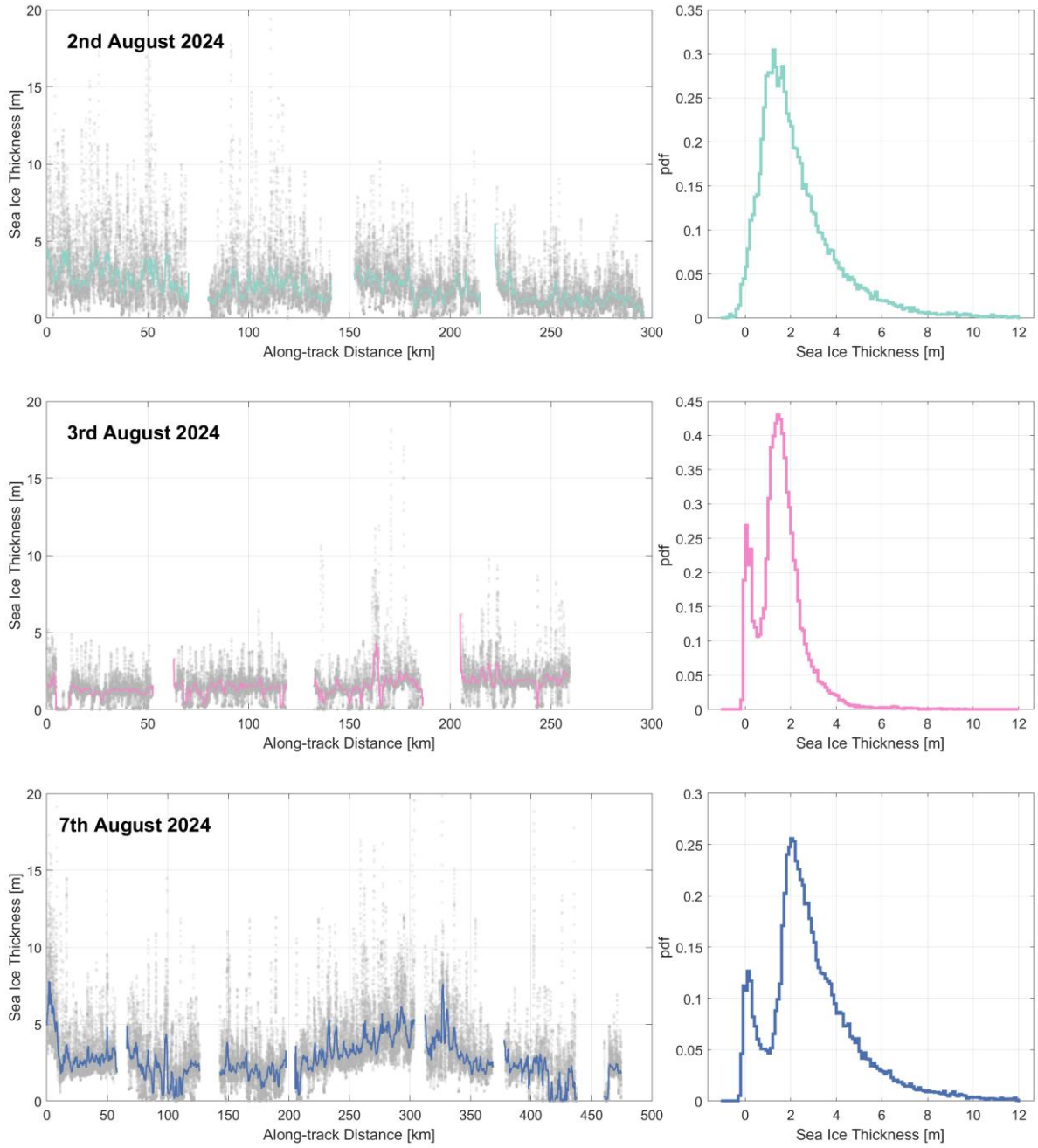


Figure 4. Preliminary sea ice thickness profiles and distributions for July 31st, August 1st, August 2nd, August 3rd, and August 7th. An approx. 2-km running median has been applied to the profiles.

Summary of activities between August 8th and 16th

Unfortunately, poor weather (low clouds and fog) in the block prevented further surveys out of STN during the final week of the campaign. Two snowfall events hit the base; the first on Aug 9-10th and the second on 15-16th, affecting the sea ice conditions in the region around STN. To avoid being caught in the second event, the IceBird team transferred from STN to Longyearbyen on Aug 14th to end the scientific campaign then onto Bremen on 16th.

Table 1. Overview of flights carried out during IceBird Summer 2024 (with a total of 80 flight hours available)

DATE	ACTIVITY	AIR HOURS	FLIGHT HOURS
JULY 13	Ferry flight Tromsø-Longyearbyen		
JULY 14-19	SPLAM campaign, Longyearbyen		
JULY 21	Ferry flight Longyearbyen-Station Nord	2.3	2.5
JULY 26	Sea ice survey along northern coast of Greenland to approx. Kapp Morris Jessup	6.1	6.7
JULY 27	Sea ice survey to 85 N, 32 W	3.8	4.5
JULY 28	Sea ice survey to 86 N, 30 W (no EM-bird)	4.1	5.0
JULY 31	Sea ice survey through Lincoln Sea and along CRREL/UiT buoy array	6.3	7.1
AUG 1	Sea ice survey along ARCSIX track in flaw lead above St Nord then grid survey over NPI/UiT Amundsen-1 mooring	5.6	6.3
AUG 2	Sea ice survey along 55W meridian from Lincoln Sea to 86N	6.3	7.0
AUG 3	Sea ice survey to 86N 22W (including radiation sensor calibration squares at start)	5.1	5.7
AUG 7	Sea ice survey to 85.4N 31W and 85N 21W	5.4	6.1
AUG 14	Ferry flight Station Nord-Longyearbyen	2.2	2.4
		47	53

Survey flights are made from the operation base (Station Nord) towards one or more pre-defined points of return. The point of return and profile length are chosen according to fuel capacity, weather condition, and ice condition.

Surveys typically comprise two parts: the observation of ice thickness and morphology are first made with the EM-Bird (including a laser altimeter), laser scanner, and MACS camera at low flight levels (bird at 50 feet, Fig. 3), while the observation of morphology and melt ponds are then made with only the laser scanner and MACS camera at higher altitudes (aircraft at 2000 feet, Fig. 3). The second part of the survey normally covers the same line(s) flown in the first part.

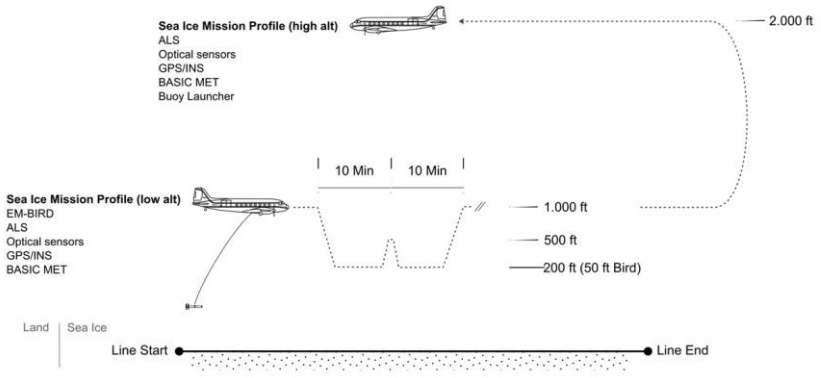


Fig 3: Flight pattern for survey flights over sea-ice.

Participants

	Name	Role
1	Jack Landy	Operator EM-Bird
2	Catherine Taelman	Operator ALS, MACS and EM-Bird
3	Gerit Birnbaum	Operator ALS, MACS and optical systems
4	Eduard Gebhard	Instrument engineer, systems operator
5	Thomas Krumpen	Support from Bremerhaven
6	Alan Gilbertsen	Chief pilot
7	Triston MacLean	First officer
8	Dwayne Bailey	Flight engineer

All photographs have been taken by Gerit Birnbaum, Catherine Taelman, Eduard Gebhard, and Jack Landy.

References

Belter, H. J., Krumpen, T., von Albedyll, L., Alekseeva, T. A., Frolov, S. V., Hendricks, S., Herber, A., Polyakov, I., Raphael, I., Ricker, R., Serovetnikov, S. S., Webster, M., and Haas, C.: Interannual variability in Transpolar Drift ice thickness and potential impact of Atlantification, The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-305, 2020.

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