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Campaign report

July-August 2021

IceBird Summer 2021 Campaign

Sea ice surveys with Polar 6 from Station Nord

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IceBird Summer 2021 campaign

Campaign overview	
Base	Station Nord
Route	Bremen - Kangerlussuaq – Station Nord – Longyearbyen - Bremen
Duration	July 20 –August 31, 2021
Aircraft	Polar 6
Crew	Kenn Borek Air
Science	H. Jakob Bünger, Gerit Birnbaum

This campaign report only documents the EM-Bird surveys and concurrent laser measurements. For details of optical measurements and surveys please contact Gerit.Birnbaum@awi.de

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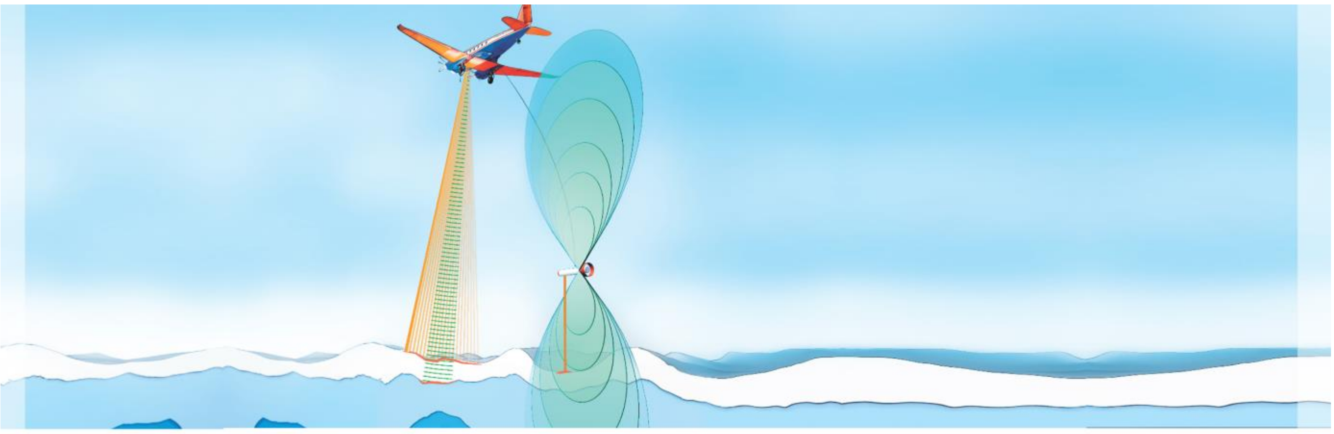

1.0 Objectives

Changes in Arctic sea ice thickness are the result of complex interactions of the dynamic and variable ice cover with atmosphere and ocean. The availability of satellite-based estimates of Arctic-wide sea ice thickness changes is limited to the winter months. However, in light of recent model predictions of a nearly ice-free Arctic in summer and to understand the role of sea ice for the causes and consequences of a warming climate, long-term and large-scale sea ice thickness and surface observations during the melt season are more important than ever.

The AWI airborne sea ice survey program 'IceBird Summer' aims to close this gap by conducting regular measurements over sea ice in summer in key regions of the Arctic Ocean. The survey program comprises and continues all airborne ice thickness measurements obtained since 2001 in the central Arctic, Fram Strait and the last ice area. The objective is 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*). Sea ice thickness measurements are obtained with a tethered electromagnetic sensor, the AEM-Bird. Jointly with the ice thickness measurements, optical and laser systems are operated to derive sea ice surface models and melt pond distribution.

Long-term objectives of IceBird and scientific focus in Summer 2021

The survey flights are intended to repeat flight tracks of previous years and thereby 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, survey flights help to answer 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.

2.0 Methods and Sensors

Survey flight organization and pattern

During IceBird 2021 the aircraft called Polar 6 was operated from Station Nord in Greenland. To extend the flight range of Polar 6, IceBird Summer is designed as a lightweight campaign. Therefore, instrumentation is limited to the AEM-Bird, laser scanners, optical cameras and radiation sensors.

Survey flights were mostly made 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. The observation of ice thickness and morphology with an AEM-Bird and scanning laser altimeter is carried out at low flight levels (50 feet, Fig. 1), The conditions of the sea ice surface are documented with a photogrammetric system on the way out and back in (at 2000 ft).

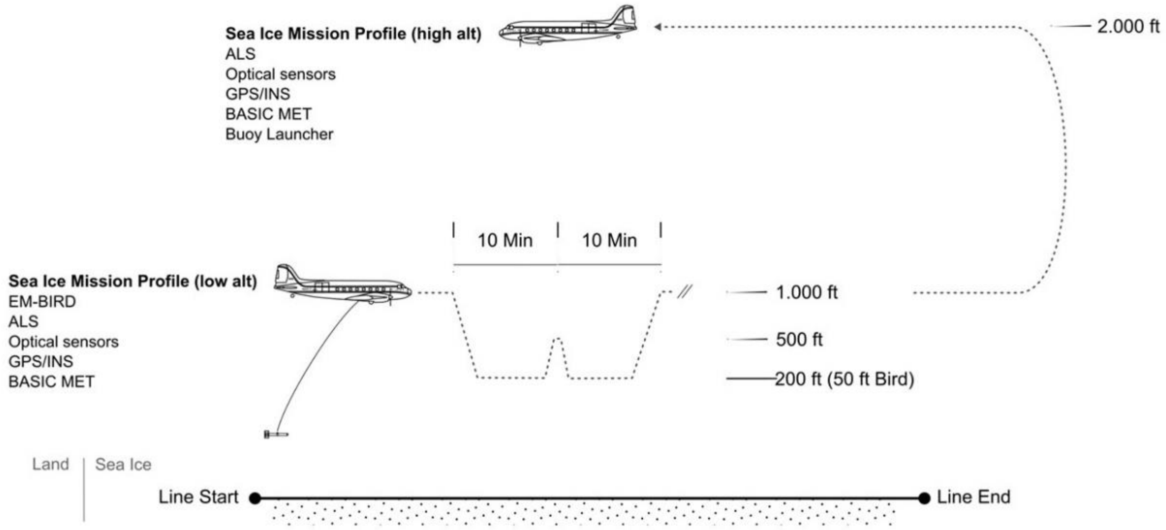

Fig. 1: Flight pattern for survey flights over sea ice.

Instrumentation

The **MACS** (Modular Aerial Camera System) is a photogrammetric camera developed by DLR's Institute of Optical Sensor Systems. It consists of a computing unit and a sensor head. The sensor head is equipped with matrix array CCD/CMOS/thermal-infrared cameras and is mounted in the fuselage providing free view down. In order to fulfill respective application requirements, sensors, their geometry and spectral ranges are modified. Thus, particular conditions are considered, e. g., flying over brightly reflecting snow, acquisition of highly structured terrain or low flight altitudes without gaps of recorded ground surface. Currently the maximum continuous image acquisition rate is 4 frames per second enabling more than 60% overlap from an altitude of 100m (AEM-Bird surveying height).

The **Airborne electromagnetic (AEM) Bird** (AEM-Bird) is a sensor system that is towed by the research aircraft Polar-5 or Polar-6 at 20m above the ice surface. The EM sensor utilizes the contrast of electrical conductivity between sea water and sea ice to determine the distance of the instrument to the ice-water interface. An additional laser altimeter mounted inside the AEM-Bird provides the distance to the snow/ice surface. The difference between AEM and laser distance measurements is the ice plus snow thickness with an accuracy in the order of ±0.1m over level sea ice. The so-retrieved thickness data enables us to determine the general thermodynamic and dynamic boundary conditions of ice formation. The most frequently occurring ice thickness, the mode of the distribution, represents level ice thickness and is the result of winter accretion and summer ablation.

3.0 EM-Bird survey overview

Below we provide an overview of sea ice surveys carried out with the EM-Bird and the laser scanner between August 18 and August 31 2021 from Station Nord in Greenland.

Tab. 1: Overview of EM-Bird and laser scanner surveys carried out between August 18 and August 31, 2021 from Station Nord in Greenland.

Airport Codes	
ENSB	Longyearbyen, Svalbard
BGNO	Station Nord, Greenland
CYLT	Alert, Canada
TOS	Tromsoe, Norway
TRD	Trondheim, Norway
EDDW	Bremen, Germany

Sensor Codes	
AEM	Airborne Electromagnetic Sensor (EM-Bird)
MACS	MACS DLR Kamera System (optical + NIR)
HC	Hyperspectral Camera, Specim AisaEAGLE
LS	Laserscanner, Rigl (VQ580)
NI	Nikon Camera
SP	Spectrometer (Ocean Optics)
CBD	Calib Buoy Deployment

Schedule **Date**	**Route**	**Type**	**Air Time**	**Flight time**	**Active sensors**
Aug 18, 2021	BGNO-BGNO	Survey flight			AEM, LS
Aug 20, 2021	BGNO-BGNO	Survey flight			AEM, LS
Aug 21, 2021	BGNO-BGNO	Survey flight			AEM, LS
Aug 24, 2021	BGNO-BGNO	Survey flight			AEM, LS
Aug 28, 2021	BGNO-BGNO	Survey flight			AEM, LS
Aug 31, 2021	BGNO-BGNO	Survey flight			AEM, LS

Survey flight August 18, 2021

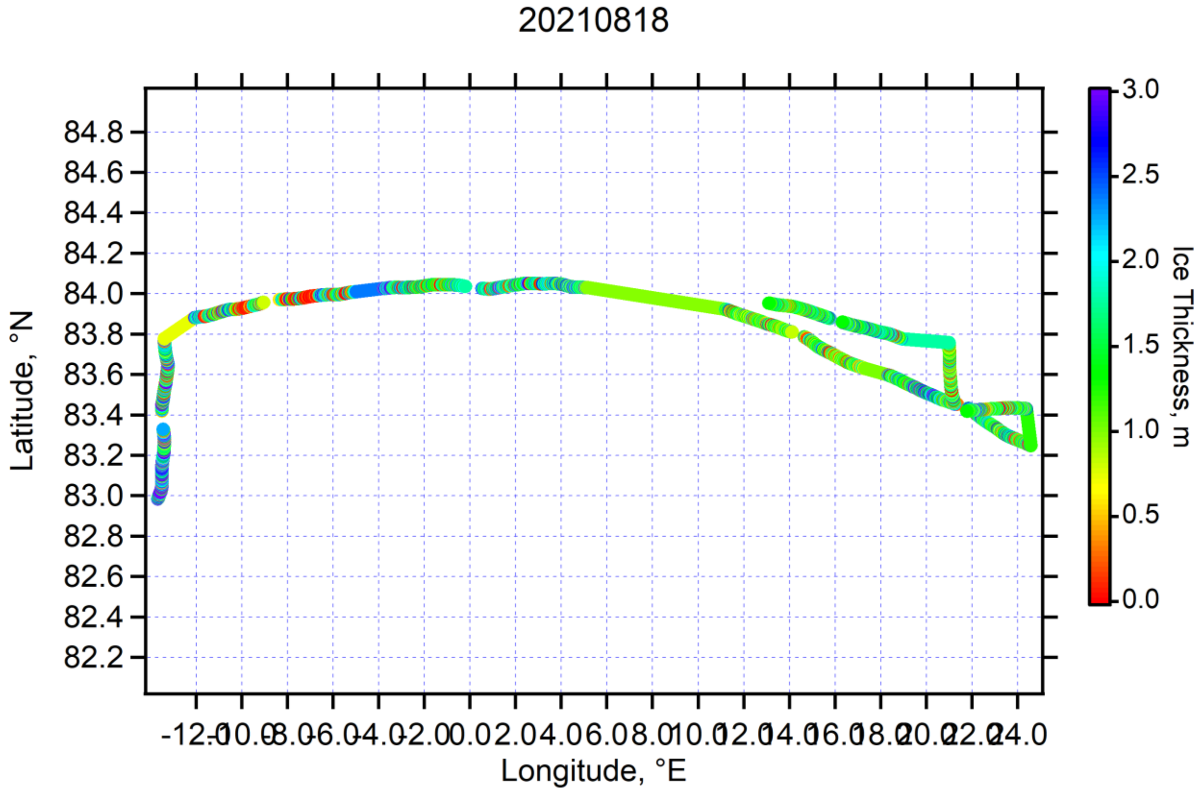

Fig. 2: EM-Bird survey from Station Nord. Color coding corresponds to measured sea ice thickness.

Survey flight August 20, 2021

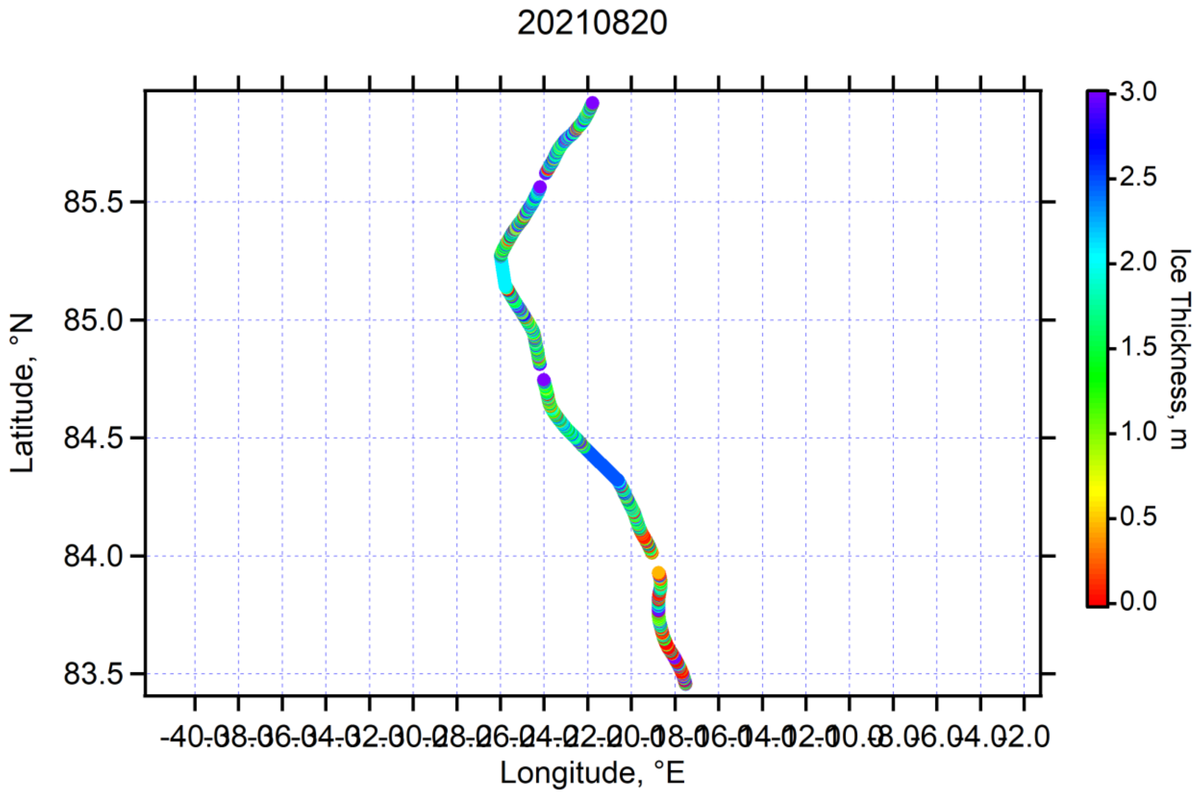

Fig. 3: EM-Bird survey from Station Nord. Color coding corresponds to measured sea ice thickness.

Survey flight August 21, 2021

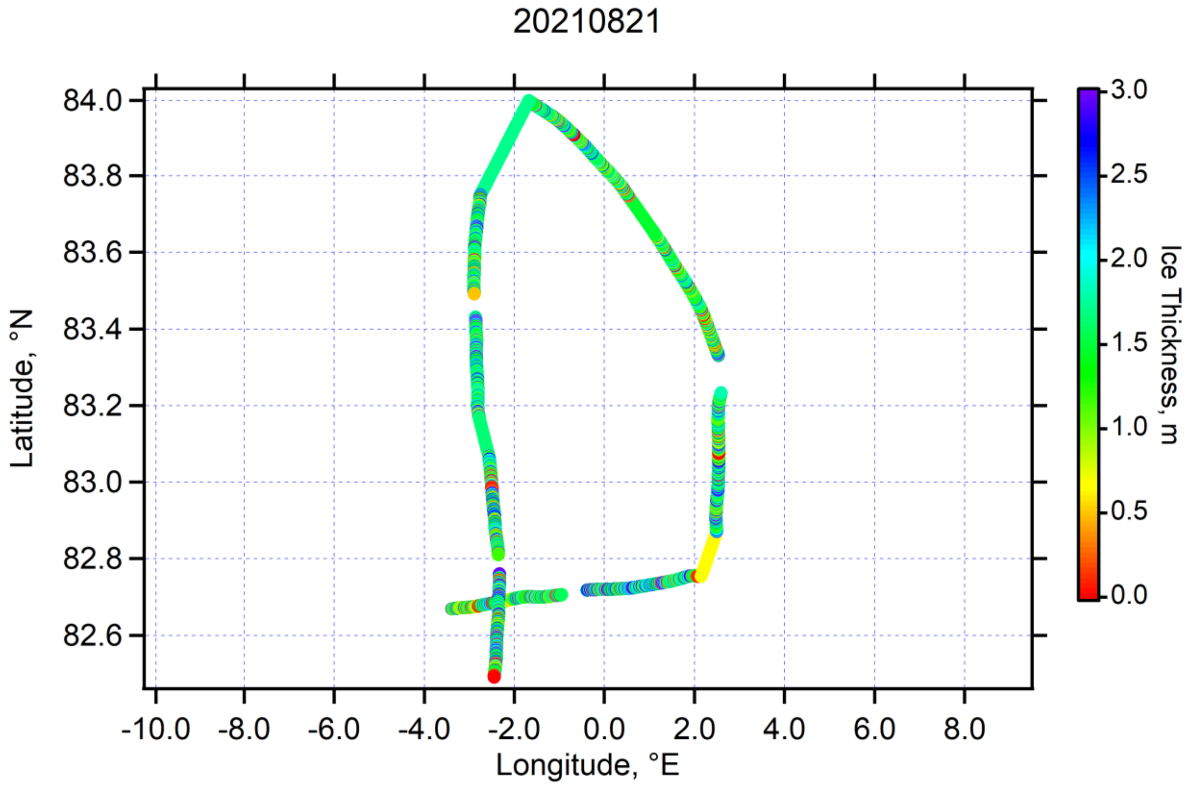

Fig. 4: EM-Bird survey from Station Nord. Color coding corresponds to measured sea ice thickness.

Survey flight August 22, 2021

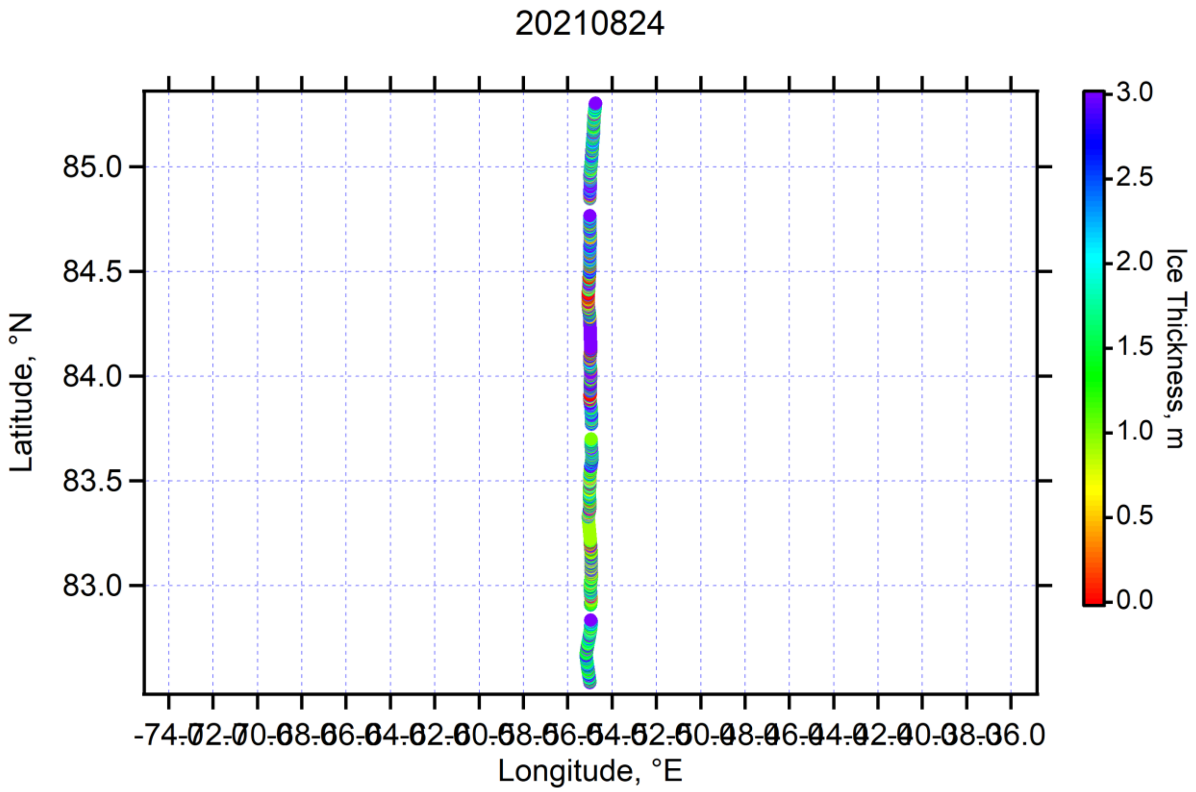

Fig. 5: EM-Bird survey from Station Nord. Color coding corresponds to measured sea ice thickness.

Survey flight August 28, 2021

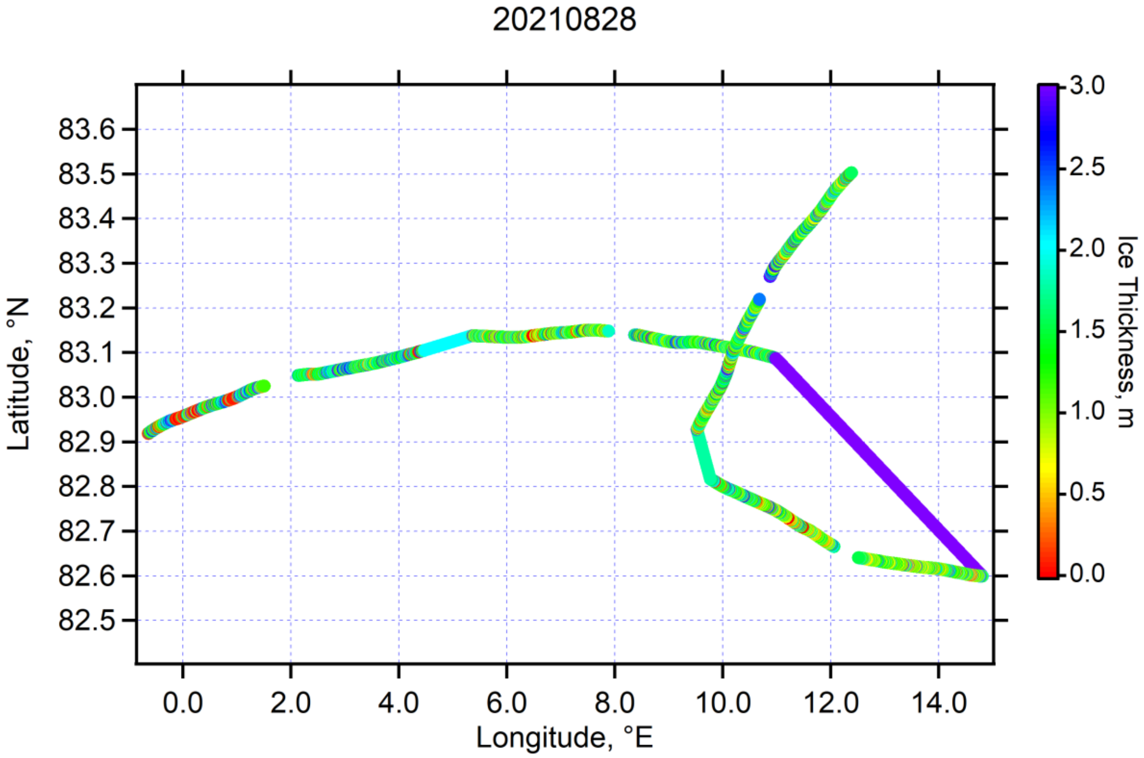

Fig. 6: EM-Bird survey from Station Nord. Color coding corresponds to measured sea ice thickness.

Survey flight August 31, 2021

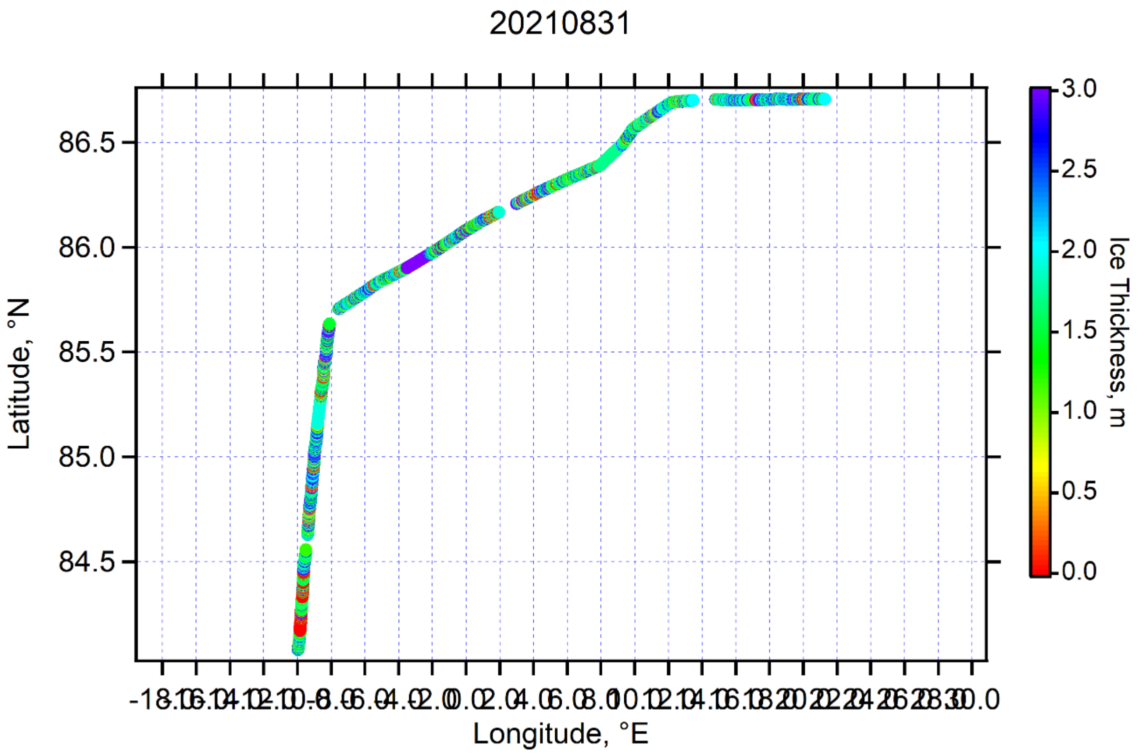

Fig. 7: EM-Bird survey from Station Nord. Color coding corresponds to measured sea ice thickness.

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