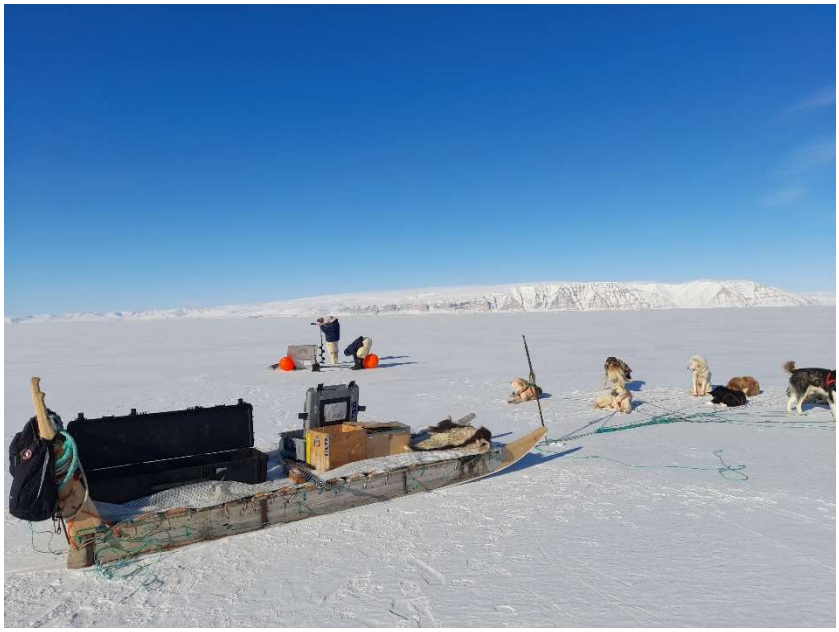
Danmarks Meteorologiske Institut

DMI Report 22-24
Climate and ocean-cryosphere interactions in NW Greenland

Final scientific report of the 2021 National Centre for Climate Research Work Package 3.1

Steffen M. Olesen, Andrea Gierisch, Ruth Mottram, Gorm Dybkjær, Jacob L. Høyer, Aksel Ascanius



Inglefield Bredning April 2021, local hunters engaged in scientific field campaign.

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1. Scientific summary

Short description

We seek to understand the interactions between climate systems components in the North West Greenland Inglefield Fjord from in-situ observations and modelling. Field campaigns are planned, coordinated and executed as part of the work package activities. Field studies carried out in 2021 target ocean climate variability in the North Water Polynya region, evidence of ocean interactions with glaciers at fjord scale, sea ice and snow properties. Data from the lower atmospheric boundary layer and radiative parameters are included. We also address the surface mass balance of the local icecaps from measurements of summer ablation as well as observations of the marine noise spectrum. Whereas ocean and sea-ice observational activities on extend monitoring started in the region in 2011, the focus on marine noise and the surface mass balance of ice-caps are pilot activities under Nationalt Center for Klimaforskning (NCKF) 2021 and part of national and international collaboration. NCKF 2021 also engaged in the ICAROS West Greenland expedition led by GEUS, with the objective to obtain a synoptic view of the properties and modification of the west Greenland current on the continental shelf, with detailed observations planned in Upernavik Fjord, Inglefield Bredning and Smith Sound.

Overall results

We have complemented and extended ongoing ocean-climate monitoring in the high arctic fjord Inglefield Bredning, Northwest Greenland. Successful scientific campaigns include winter and early summer, contributing new data on ocean-cryosphere interactions across the sea-ice covered period.

Combining new measurements of ocean heat and stratification with previous monitoring, we can document the passing of a deep, warm anomaly in the fjord system on multiannual to decadal time-scales and with origin in the west Greenland Current. First preliminary analysis of the oceanographic data from the ICAROS 2021 West Greenland expedition indicate the existence of a low salinity coastal current in the Melville Bay connecting to the region of the North Water Polynya. This current is likely seasonal and maintained in summer by runoff and melting from the Greenland Ice Sheet.

Next steps

Instruments deployed in Inglefield Bredning in December 2021 will be retrieved in 2022, this includes the pilot measurements on marine noise from the pilot deployment of the ‘sound trap’. Acoustic baseline data from the Arctic are scares and identified by working groups of the Arctic Council as a high priority.

The work package will in 2022 facilitate publication of results from process studies and monitoring in Inglefield Bredning, with emphasis on ocean and cryosphere interactions at fjord scale and, on evaluating and improving the surface properties of snow and ice in the HARMONIE and surface mass balance (SMB) models.

Publications based on the ICAROS 2021 data will be planned with collaborators in 2022 as laboratory analysis of paleo proxy records from ocean sediment cores, e-DNA samples and water chemistry becomes available.

2. Scientific reporting

Building on and extending ocean-climate monitoring since 2011 in the Inglefield Bredning, two successful scientific campaign have been planned and executed successfully in winter (March/April) and early summer conditions (June, Figure 1). These contribute additional data on ocean-cryosphere interactions across the sea-ice covered period and a perspective on inter-annual to decadal variability. In June, instruments tethered on the winter seasonal ice is recovered before breakup and data secured. A third filed activity took place in December 2021 where the aim was to reinstall instruments including oceanographic moorings and weather stations on the newly formed land fast sea-ice, expected to serve as stable monitoring platform until June 2022. All three field activities are planned and conducted with local hunters and fishermen from Qaanaaq and nearby settlements. We make use of dog-sleds for transport and integrate local knowledge in the field activities and for safety.

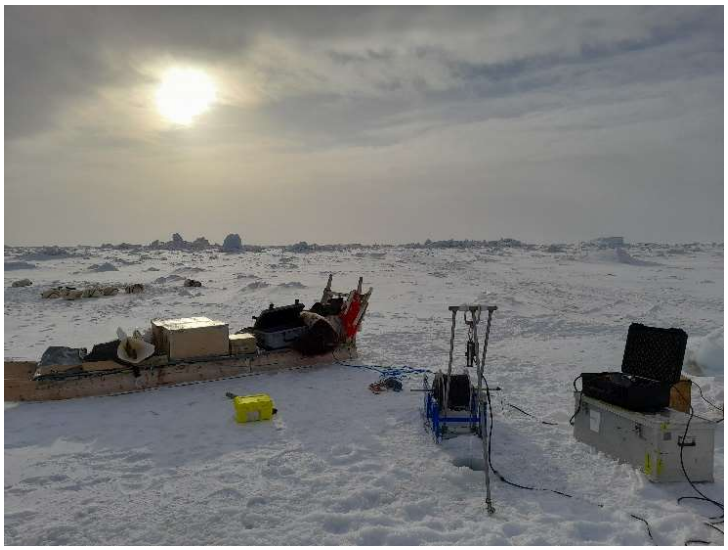

Figure 1: Top: Calibration configuration of an autonomous on-ice weather station, June 2021, Inglefield Bredning. The system has been deployed in December 2020 and to be recovered before breakup of the land fast sea ice late June. Middle: Sampling setup for CTD monitoring in the fjord system in early April 2021. We make use of a portable electric winch and a SBE19plusv2 CTD with auxiliary sensors (oxygen, turbidity, fluoresce). The system can profile to the deepest regions of the fjord which are about 930m. Bottom: Preparing for deployment of oceanographic moorings (using Seabird Microcats complemented by a larger number of temperature sensors and two sets of dissolved oxygen sensors and ADCP's) at the southern flank of Inglefield Bredning, December 2021. Similar moorings are maintained at the northern (outflow) and southern flank of the fjord.

Data from the field programs in the Inglefield Bredning and across the Smith Sound has been integrated into two scientific publications published in 2021 on the North water Polynya. These combine paleo proxy records of past climate condition and ecosystem functioning with modern oceanographic observations. Results highlight the vulnerability of the unique high arctic polynya system to climate change and shed light on past transitions:

Ribeiro, S., Limoges, A., Massé, G. *et al.* Vulnerability of the North Water ecosystem to climate change. *Nat Commun* **12,** 4475 (2021). https://doi.org/10.1038/s41467-021-24742-0

Jackson, R., Kvorning, A.B., Limoges, A. *et al.* Holocene polynya dynamics and their interaction with oceanic heat transport in northernmost Baffin Bay. *Sci Rep* **11,** 10095 (2021). https://doi.org/10.1038/s41598-021-88517-9

NCKF further engaged in the ICAROS 2021 expedition (Ice-ocean interactions and marine ecosystem dynamics in Northwest Greenland), with responsibility for the oceanographic component and with the objective to obtain a synoptic view of the water mass properties and their modification of the west Greenland current along on the west Greenland shelf. Data from the cruise extends and repeats previous cruise data from 2015 and gives a far field perspective on the local time-series of ocean properties in Inglefield Bredning. The ICAROS cruise was a multidisciplinary cruise involving a number of institutions, planned as a 3-week marine research expedition on board HDMS Lauge Koch from Aasiaat to Qaanaaq, returning from Qaanaaq to Nuuk. The expedition was however terminated before reaching Qaanaaq and Inglefield Bredning by Arctic Command due to unforeseen operational issues. Consequently, the cruise did not go north of Pituffik (Thule Air Base). A dedicated cruise report has been submitted to www.havforskning.dk, and gives an overview of the samples and data collected during the expedition, but the unexpected termination of our research activities compromises the objectives

we set out to pursue. The scientific objectives were also challenged by the lack of an integrated CTD rosette system. All oceanographic measurements and water sampling was conducted making use of a partly improvised system (Figure 3).

Oceanographic data includes sections across the continental shelf in the Melville Bay region, illustrating the key quantities investigated; the extent of the warm West Greenland Waters onto the shelf; the depth and vertical extend of the cold winter mixed layer and; the top shallow and stratified layer of summer heated waters. Data also indicates an interesting low salinity coastal currents likely maintained by meltwater from glaciers and runoff from the Greenland ice sheet. This current is seen to exit the bay region at the longitude of Cape York (Figure 2), why it likely contributes to the summer stratification of the North Water Polynya region.

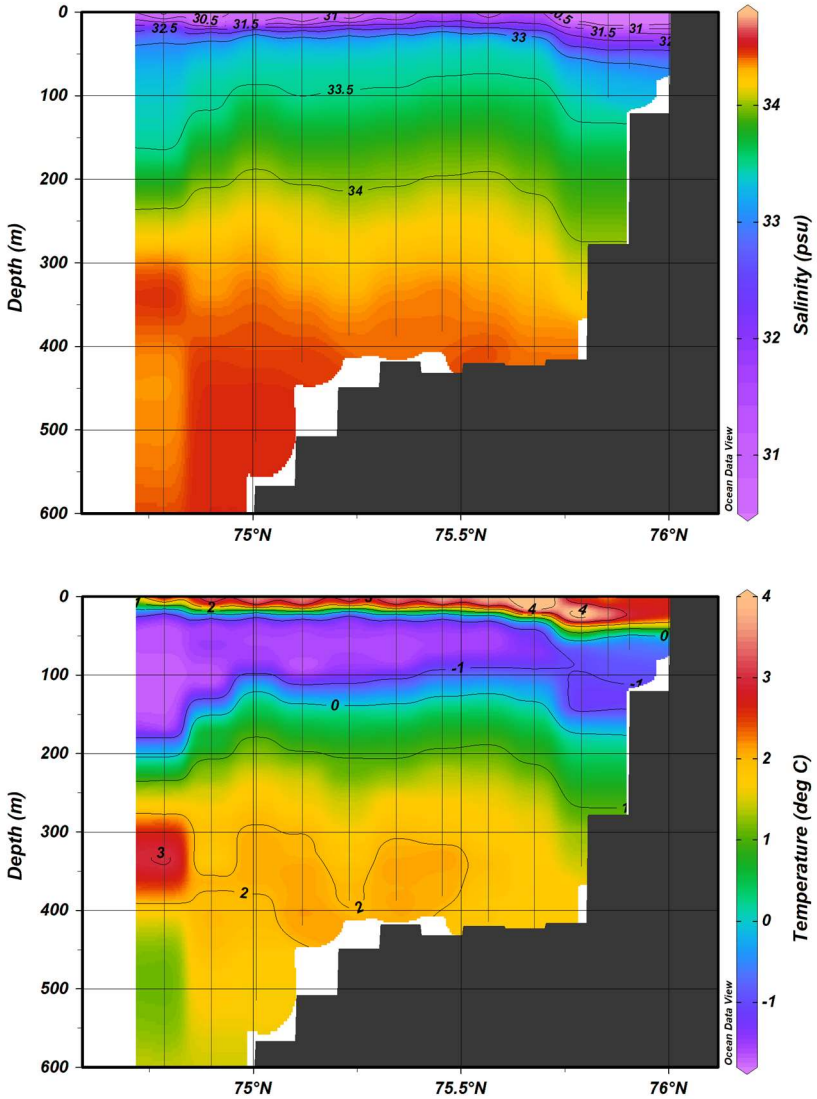

Figure 2: Salinity (top) and temperature (bottom) distribution in the upper 600m of the water column on a synoptic CTD transect off Cape York at 67°W.

Figure 3: Niskin-Rosette-CTD rack assembled for ICAROS 2021, replacing an integrated SBE911 system planned for the cruise but not mobilized.

In support of the CTD profiles obtained from the ship, a DMI Infrared Sea surface temperature Autonomous Radiometer (ISAR) was installed on the ship, looking continuously at the sea surface. The ISAR provides accurate and reliable measurements of the radiative sea surface temperature (Figure 4) and can operate autonomously for extended periods. During ICAROS, performance of the system was monitored on a daily basis including the automatic shutter system protecting the delicate infrared radiometer fore-optics.

Figure 4: ISAR installation, HDMS Lauge Koch, during ICAROS 2021

ISAR data will be combined with 'Ferry Box' data, which are measurements of water temperature, salinity and chlorophyll from a subsurface intake on the ship (see figure Figure 5 for the data coverage). Data will be used for match-up and calibration of satellite-based sea-surface temperature maps.

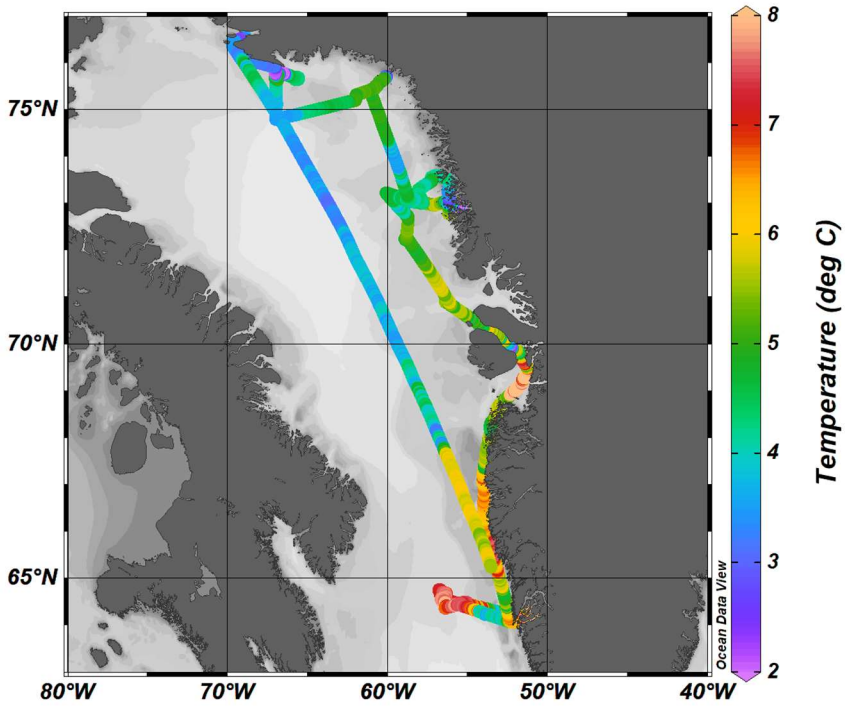

Figure 5: Continuous intake measurements ('Ferry Box') of water temperature along the ICAROS 2021 cruise track.