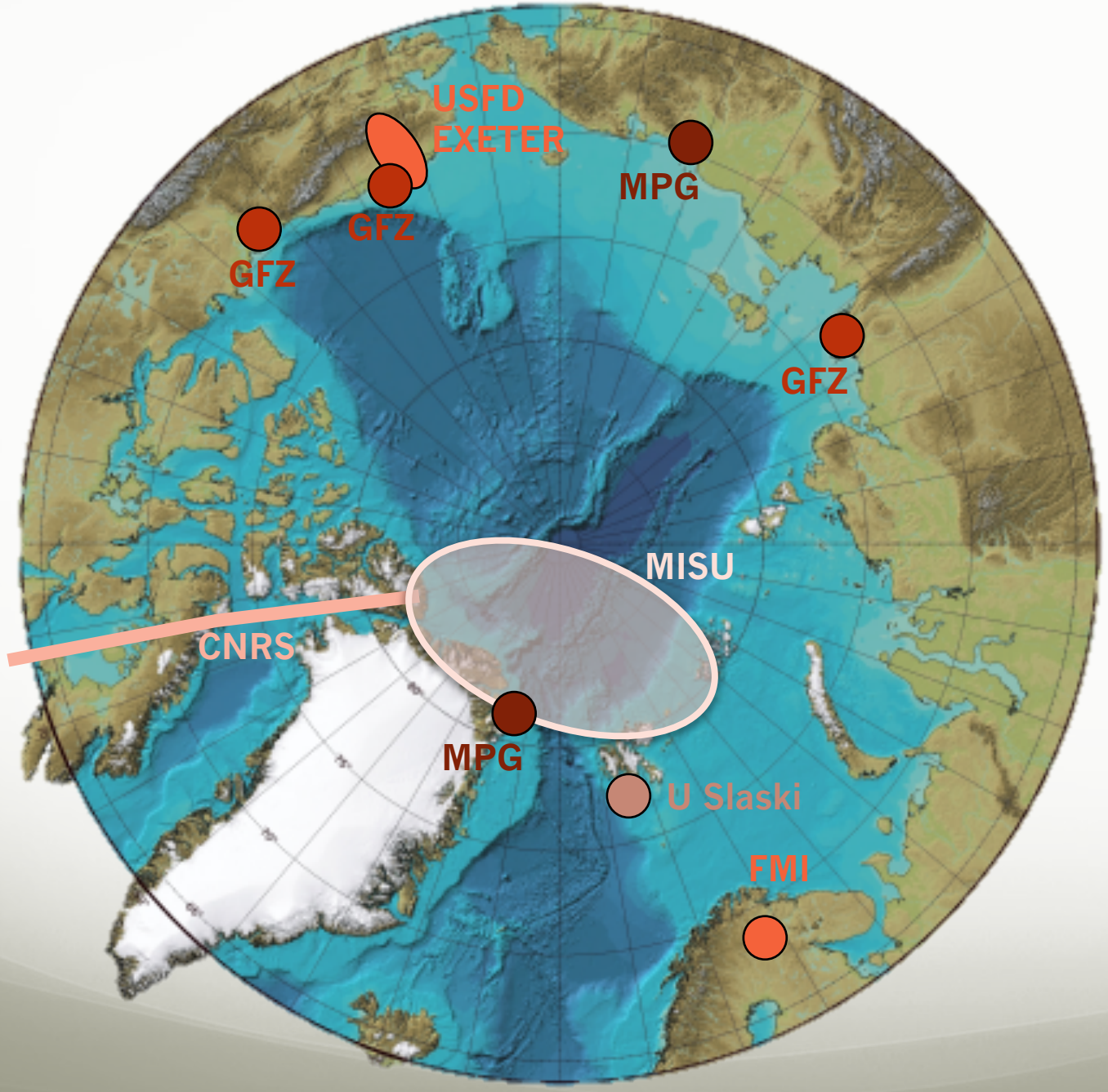
Task 3.5
Distributed systems for atmosphere and land

MPG, GFZ, EXETER, USFD, FMI,
CNRS-Takuvik, MISU, U Slaski

Project locations



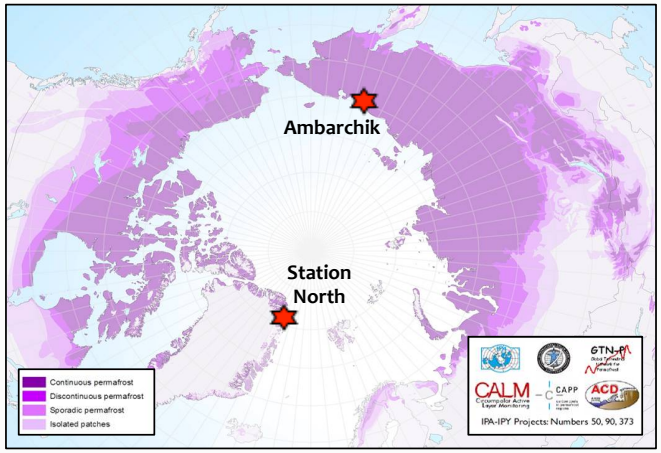
Wide range of applications

2020 activity overview

	MPG	GFZ	USFD	UNEXE	FMI	CNRS	MISU	U Slaski
Field work in 2020	❌	✅	❌	❌	✅	❌	❌	❌
COVID-related cancellations	✓		✓	✓	✓	✓	✓	✓
New data processing (2020, and earlier)	✅	✅	✅	✅	✅	✅	✅	✅
New data published	(✓)	✓	(✓)	(✓)	✓	(✓)	(✓)	(✓)
Observations planned for 2021	✅	❌	✅	✅	✅	✅	✅	✅
Long-term observations	(✓)	✓	✓	✓	✓	✓	✓	✓

MPG: flask sampler

where: Greenland



objectives

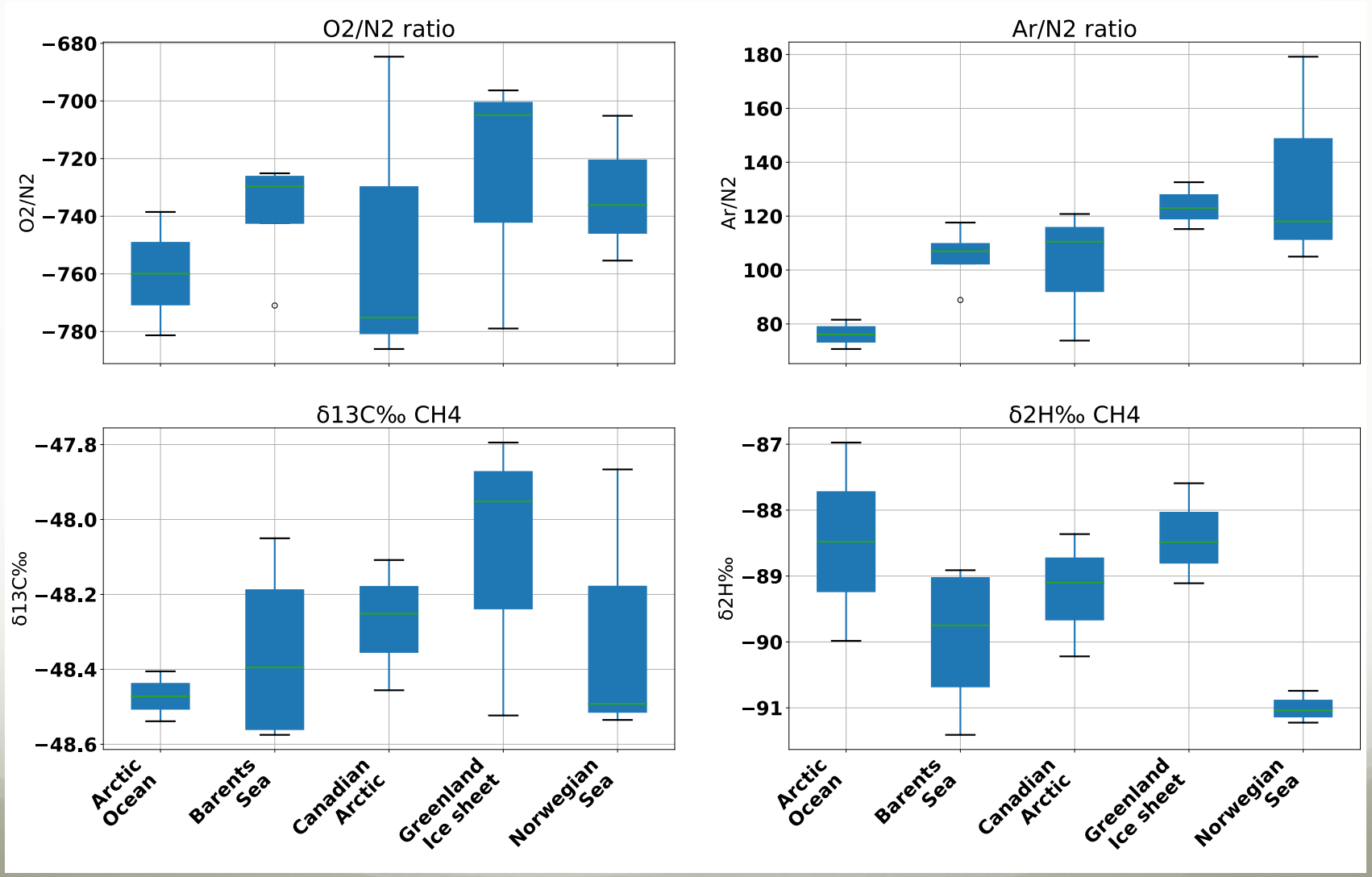
- GHG isotopes to separate emission sources (e.g. ^{13}C-CO_2, ^{13}C-CH_4, ^{2}H-CH_4, ..)
- multiple species fingerprints to improve atmospheric transport (e.g. SF_6, O_2/N_2, ..)

what: automated air sampling

Progress 2020

- Re-location of system to Siberia canceled due to travel restrictions
- First results on flask analyses available since Oct 2020

MPG: selected trace gas patterns

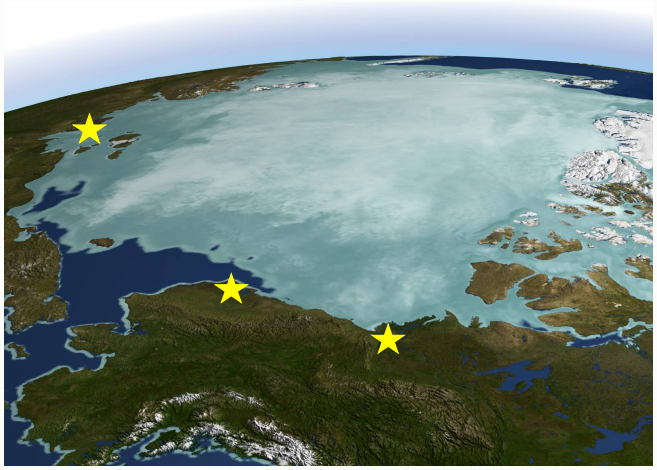


INTAROS roadmap considerations for GHGs

- Ensure long-term observation programs
  - Many Arctic observation sites rely on soft-money funding to continue operation
- Regional coverage gaps
  - High density network: Scandinavia, Alaska (fluxes)
  - Main coverage gaps: Eastern Siberia, Arctic Canada
- Strategic network upgrades, efficient investment
  - Winter-proof existing flux sites for year-round data
  - Add new sensors (e.g. CH_4, N_2O, CO) to sites
- Close collaboration with regional networks, also to ensure common metadata and data availability

GFZ: aircraft profiles

where:
AK, CAN, SIB



what: airborne
GHG sampling

objectives

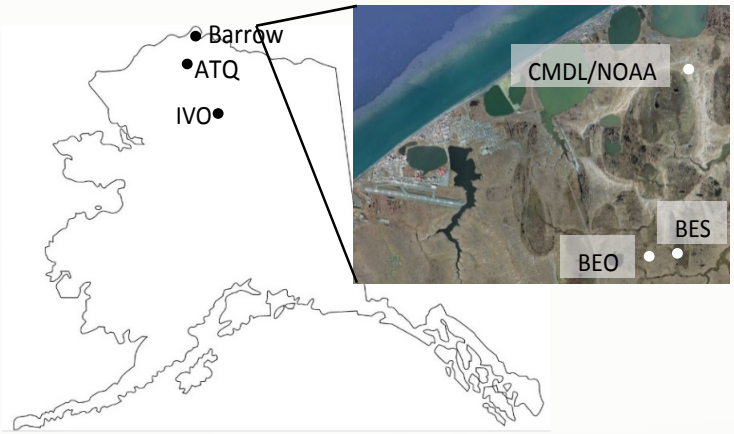
- Consolidate databases from 9 flight campaigns, 2012-2016
- in-depth insight into mixing and transport processes
- improved representation of atmospheric transport

Progress 2020

- Some HeliPod flights possible in the context of MOSAIC
- Data processing resumed with hiring of new PostDoc in spring 2020

USFD: hi-res soil profiles

where: Utqiaġvik, AK



objectives

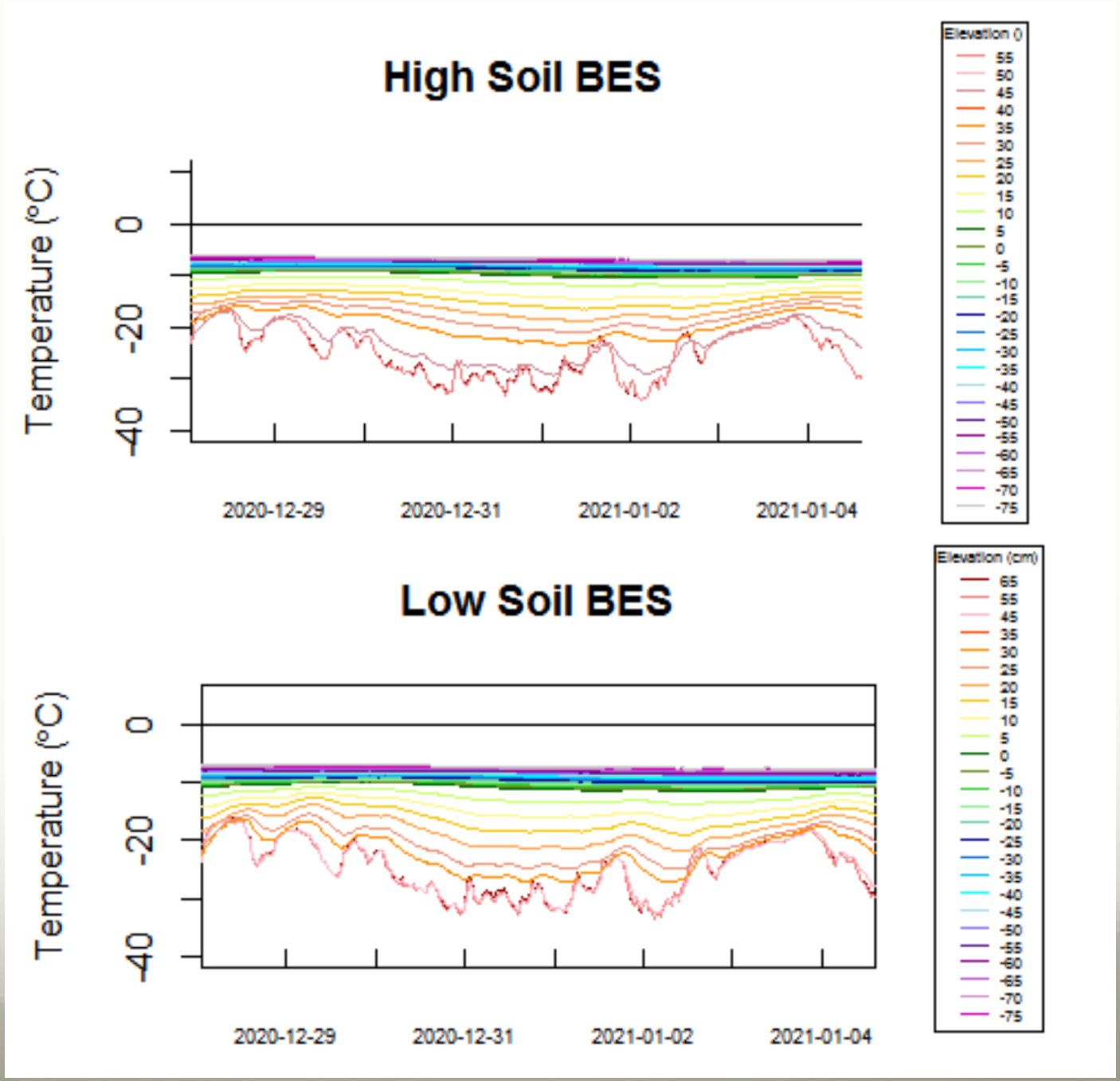
- Resolve GHG processes during freeze/thaw cycles in soil and snow cover at high level of detail
- Test new thermocouple and GHG concentration profiles

what: snow and soil profile obs.

Progress 2020

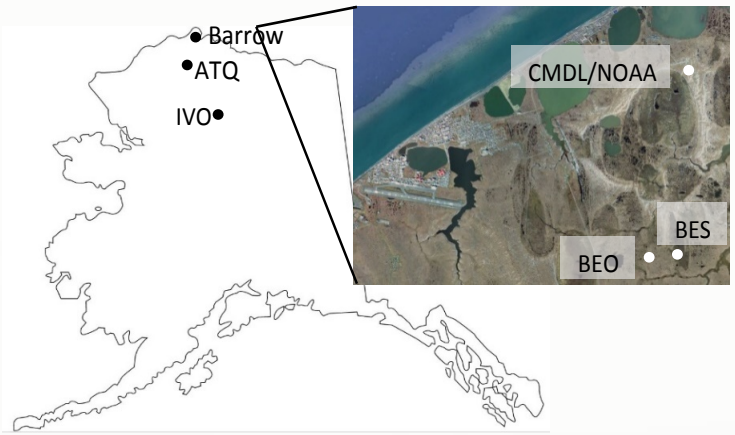
- No access to field sites in 2020
- No maintenance (data connection, damaged sensors) possible
- Some of the systems could be accessed remotely for data retrieval (large gaps)

USFD: soil profiles



UNEXE: instrument heating

where: AK north slope



objectives

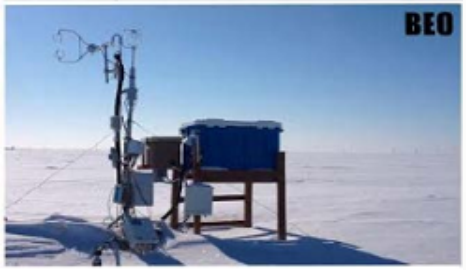
- Ice-free instruments needed, but heating may disturb instrument performance
- Customized heating devices and ‘smart’ heating algorithm under development

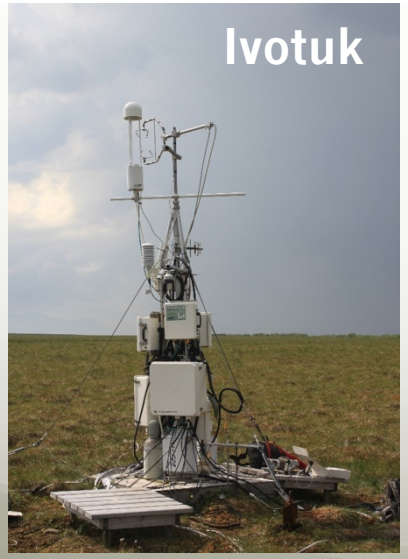
what: heating for eddy-covariance

Progress 2020

- No field work possible in 2020
- Heating strategies only partly successful in previous years
- Plans to install new METEK device in 2021 (if possible)

UNEXE: instrument heating

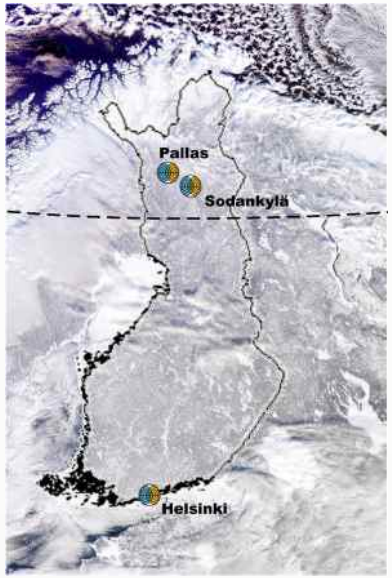


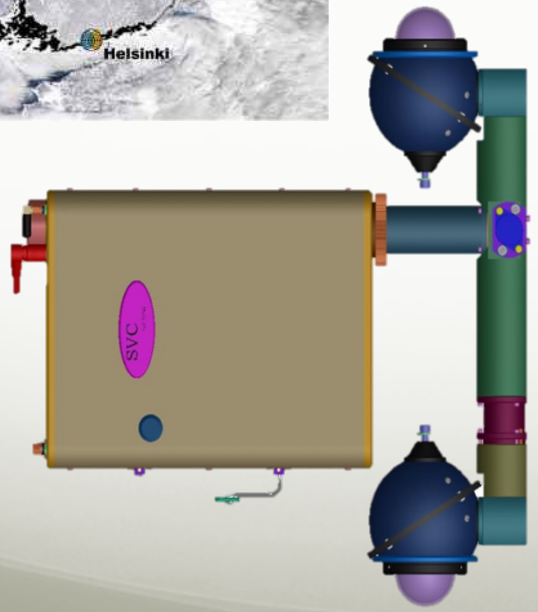


FMI: novel albedo/surface data

what: custom-built albedometer

where: North Finland





objectives

Continuous surface measurements at high temporal resolution

Test of novel albedo instrument that scans surface at high spectral resolution (3-10nm in the range 350-2500nm)

Progress 2020

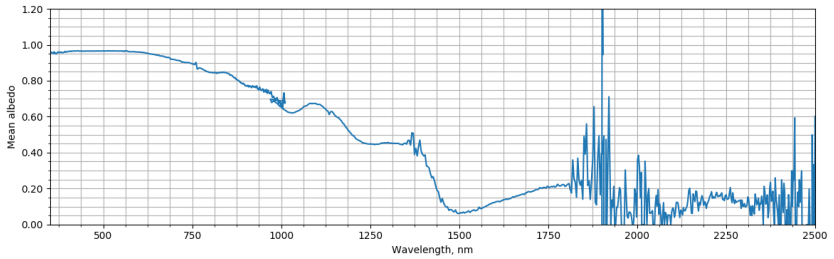
- Some installation and maintenance possible in 2020, but no supporting field campaigns possible
- Focus on data analysis
- Continue program in spring 2021, if possible

FMI: Analysis of SVC spectro-albedometer data

CLOUDY CONDITIONS

Diffuse light conditions remove the artifacts caused by instrument and setup.

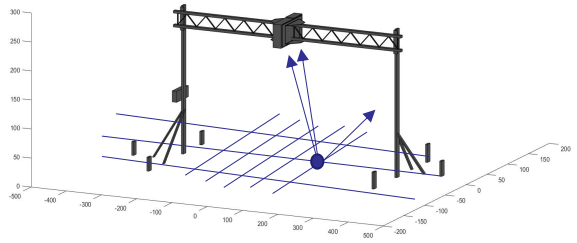
Clean data = raw data



Albedo spectrum on 27.03.2019, cloudy conditions

CLEAR SKY CONDITIONS

Under direct illumination, artefacts caused by the instrument (deviation from perfect cosine response), the setup (shadows and light obstructions), and the environment (heterogeneity of the nearby surfaces, obstacles, tilted surfaces) need to be accounted for to clean the data.



Through geometrical and radiative transfer modelling, routines are built to correct the data from these artefacts.

A paper illustrating the SVC spectro-albedometer and its data handling is under preparation for the INTAROS special issue.

FMI: Enhancement of the Sodankylä supersite measurement capacity

Due to COVID-19, the field campaign planned in Sodankylä for March-April 2020 to further test and develop the SVC-spectro-albedometer and the polarized radar was partly cancelled. The instruments were installed, but the complementary snow measurements, needed for the interpretation of the optical and microwave signals, were carried out only at low temporal resolution (once a week). As the radar stopped working soon after the beginning of the measurement period, its main components have been replaced during 2020 and we plan to have a new campaign in March-April 2021, to acquire the data that we did not get in 2020.

ONGOING WORK:
SVC and radar data collected in 2019 are analyzed, and a procedure to generate final physical parameters (spectral irradiance and albedo, snow water equivalent, snow ssa) are under development.

The processed data will be stored in netCDF format and will be openly accessible from the FMI Arctic Space Centre (https://fmiarc.fmi.fi/)

SVC spectro-albedometer, running in 2019 and 2020

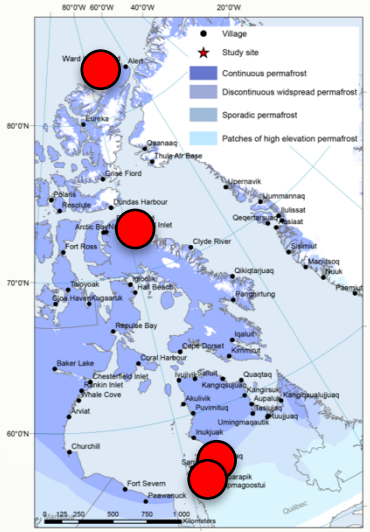
Thoughts for the roadmap

Supersites such as Sodankylä serve multiple users (public and private) and optimize the use of resources (for maintenance, upgrade, management): they certainly have a central role in the terrestrial Arctic observing system and should be maintained:

- To ensure decadal validation/calibration data records for satellite observations
- To ensure flexible and easy organization of field work that benefits from the large concurrent data collection
- To serve as reference site in the framework of networks that cannot effort the same high standards
- To provide multidisciplinary data collections needed for process studies and model validation/development

CNRS: C and heat budgets

where: NE Canada



what: multiple sensor systems

- T, rH, wind, radiation
- Snow properties
- Soil properties
- Drone surveying
- Field campaigns, e.g. for soil carbon, …

objectives

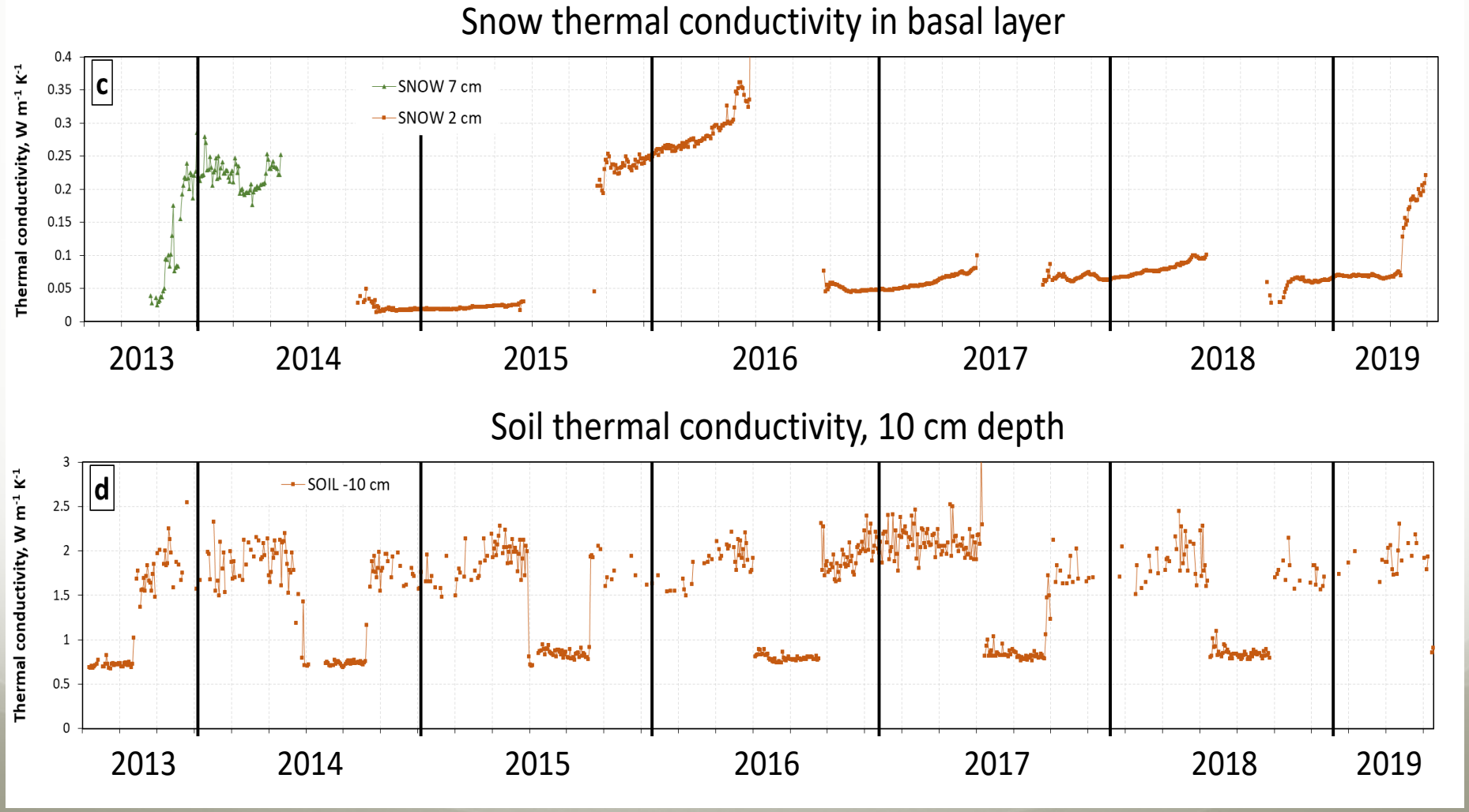
Examples:

- Identify a positive climate-snow-permafrost feedback
- impact of shrub growth on permafrost thermal regime
- Modeling of permafrost thermal regime

Progress 2020

- Canadian Arctic closed to all travel: no new field work, or data retrievals, in 2020
- Current focus on data processing, and publication
- Plan to continue field campaigns in 2021

CNRS: Long-term monitoring of thermal conductivity



Outlook, Roadmap

Future plans

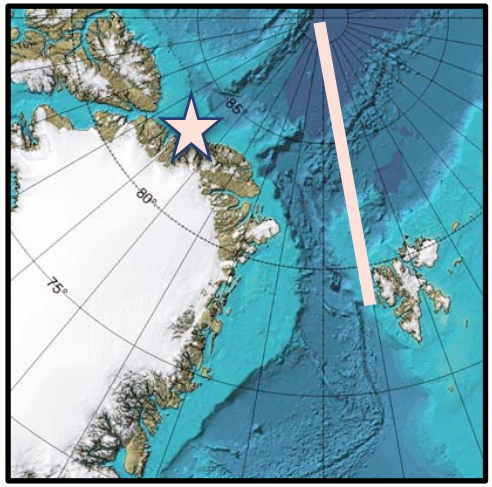
- Attempt by all means to access Arctic sites in summer 2021 for instrument maintenance and data retrieval.
- Extend measurement time series for many more years. Ideally, make this permanent.

Roadmap suggestions

- Climate change involves snow and soil feedbacks. These will be strongest in polar deserts.
- Develop snow and soil monitoring in polar deserts: vegetation cover, moisture and thermal conductivity.
- In Canada, good sites include Resolute Bay, Alert and Ward Hunt Island. Station North (Villum) on (Greenland) would also be excellent.

MISU: icebreaker sampling

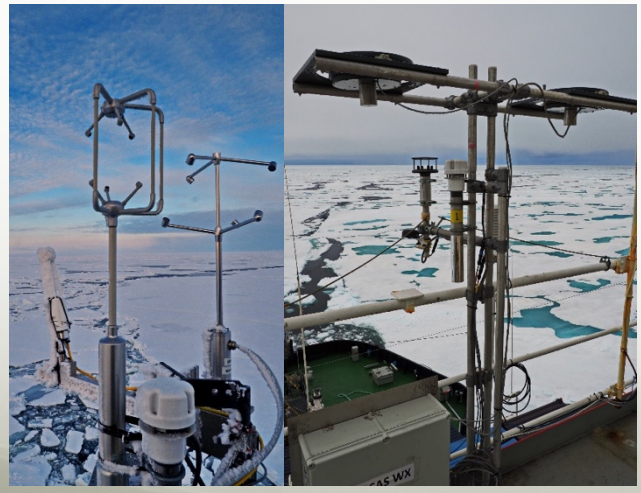
where: high Arctic ocean



objectives

- ‘Arctic Climate Across Scales’, unmanned atmospheric observatory
  - Surface fluxes
  - Radar/Lidar/Profiler
  - Radiation, visibility, …

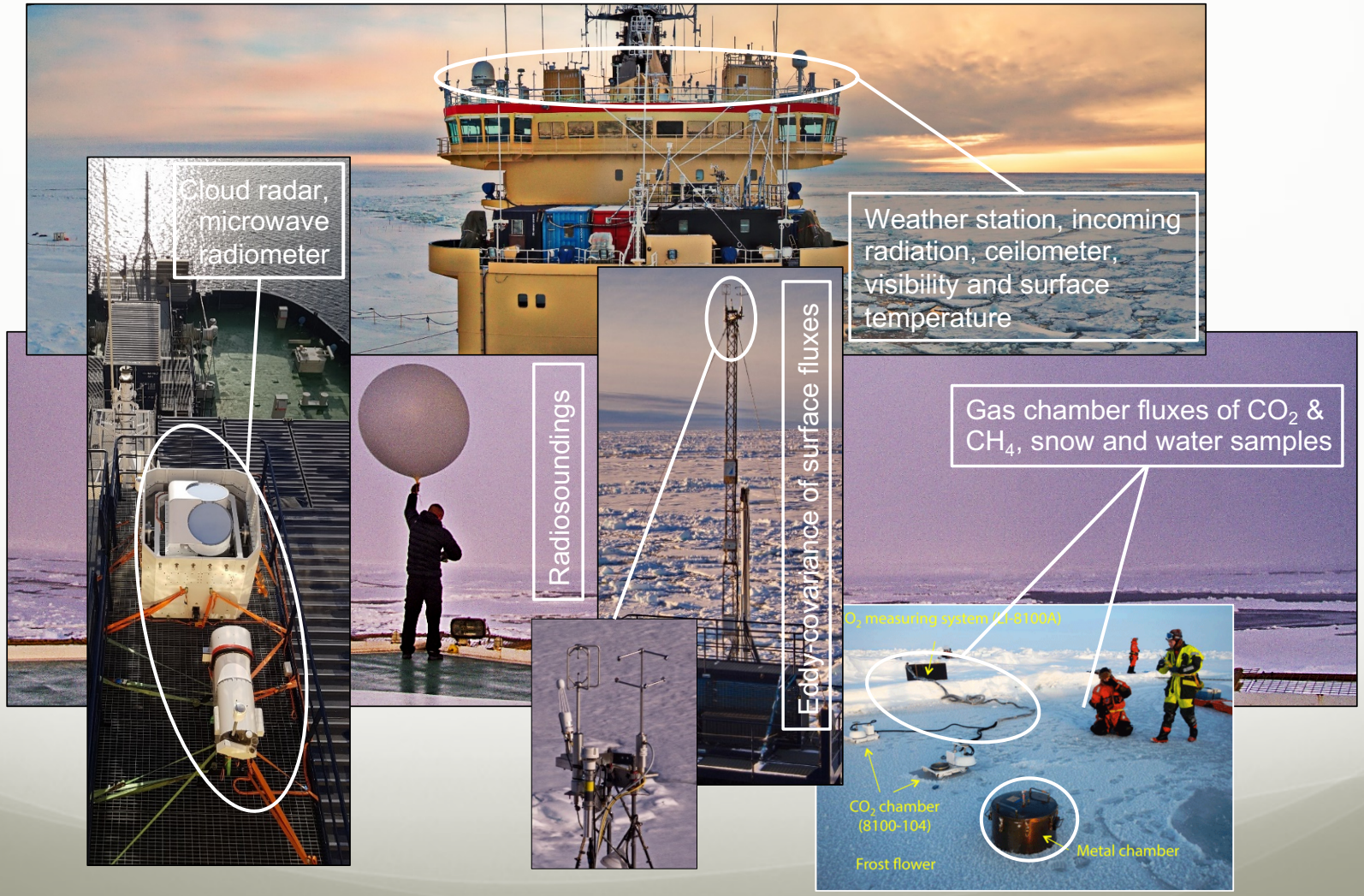
what: ‘advanced’ weather station



Progress 2020

- 3 planned cruises with Oden icebreaker cancelled due to travel restrictions
- Observation system upgrades installed
- Planning of more Oden expeditions for 2021+, longer term operation possible

MISU: icebreaker sampling: Arctic Climate Across Scales (ACAS)



INTAROS roadmap ideas

Terrestrial Arctic

enhancing existing observation stations are priority:

- complementing with new instruments
- enhancing the quality of existing observations.

Operational networks often under national weather agencies in international collaborations such as WMO and WCRP/WWRP.

Focus on existing so-called super-stations, often funded by research or infrastructure organizations

Make observations more easily accessible.

Marine Arctic

Strong focus on satellite observations and reanalysis

Complement gridded data by research expeditions.

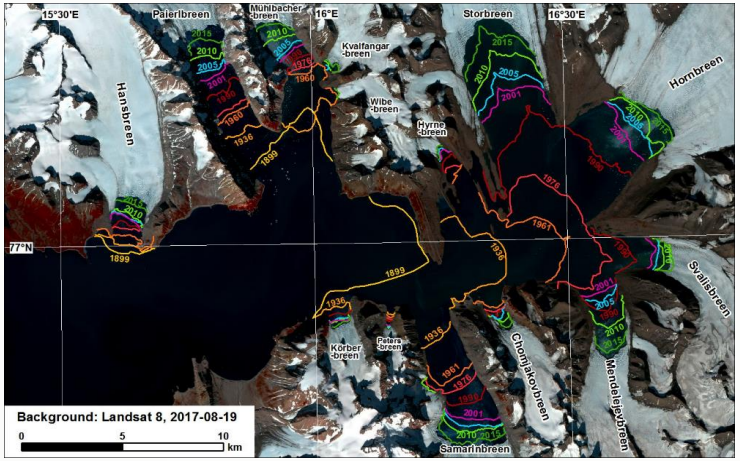
- minimum set of unmanned (or few-manned) set of observation
- especially target the vertical structure of the atmosphere and clouds
- reference data for quality control and reassurance of and improvement of reanalysis.

Overall approach:

1) Better retrieval and assimilation of satellite data in improved reanalysis systems;
2) Developing unmanned observation stations for ships navigating the Arctic Ocean, for research and otherwise;
3) Continued ship-borne "supersite"-like observation platforms on existing and new research icebreakers as reference.

U Slaski: glacier fronts & snow cover

where: South Spitsbergen

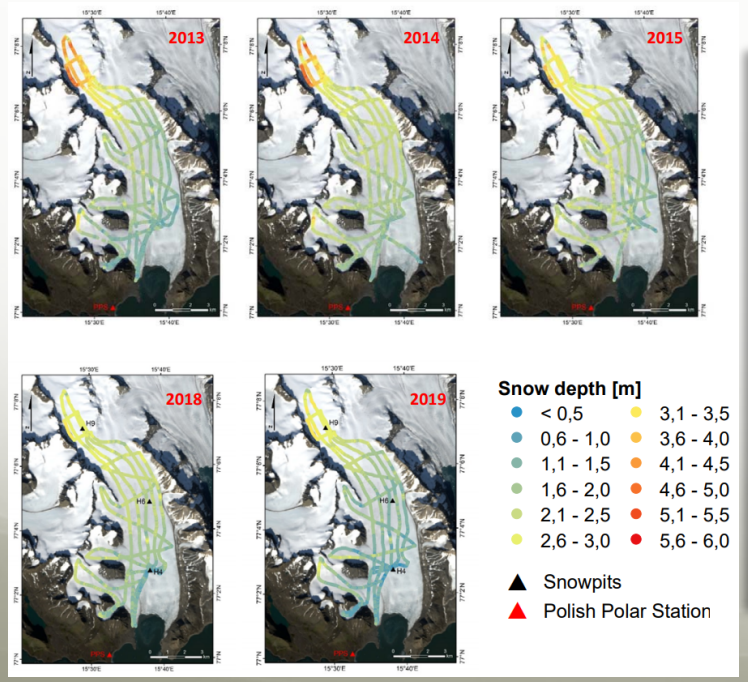


objectives

Processes on glacier fronts calving to Hornsund

Monitoring the snow cover on the Hansbreen glacier with shallow radar soundings

what: Hansbreen snow cover monitoring



Progress 2020

- Cancelation spring expedition expedition caused a gap in the monitoring of snow cover data on Hansbreen
- New data sets created to supplement the previously existing ones
- Data administration, processing and publishing
- Continue snow monitoring program in spring 2021, if possible

U Slaski: field work and data

Field work 2020

COVID-19 impacts:

- cancellation of USlaski's spring scientific expedition to Svalbard
- Limited summer expedition carried out

The lack of a spring expedition caused a gap in the monitoring of snow cover data on Hansbreen glacier, the database included in the INTAROS data catalogue.

Most of the tasks have been made up by the end of the year or will be completed by the end of May 2021

Data processing

- the Centre for Polar Studies databases assimilated with the INTAROS data catalogue were reviewed.
- In some cases, the data format was converted to machine-readable (csv, cn) and efforts were made to prepare the databases to assign them a DOI number.
- Work was carried out to create new data sets and supplement the previously existing ones included in the Centre for Polar Studies database.
- A complete collection of issues related to the front of glaciers emptying into the sea in the Svalbard area was added to the INTAROS data catalogue in January 2021.

Factors controlling terminus position of Hansbreen, a tidewater glacier in Svalbard. M. Błaszczyk, J.A. Jania, M. Ciepły, M. Grabiec, D. Ignatiuk, L. Kolondra, A.Kruss, B. Luks, M. Moskalik, T. Pastusiak, A. Strzelewicz, W. Walczowski, T. Wawrzyniak, Journal of Geophysical Research: Earth Surface, DOI: 10.1029/2020JF005763

Changes of glacier facies on Hornsund glaciers (Svalbard) during the decade 2007–2017. B Barzycka, M Grabiec, M Błaszczyk, D Ignatiuk, M Laska, JO Hagen, ..., Remote Sensing of Environment 251, 112060, doi:10.1016/j.rse.2020.112060

Main roadmap ideas

Terrestrial observations

- Close collaboration with regional networks
  - Support long-term operations
  - Collaborate to upgrade existing infrastructure
  - Develop common platforms for data sharing
- New sites, and parameters, to close gaps (high Arctic)
- Particular focus on ‘super-sites’ with special equipment

Marine observations

- Focus on assimilating satellite data for improved reanalysis products
- Autonomous shipboard systems for validation data

2020 activity overview

	MPG	GFZ	USFD	UNEXE	FMI	CNRS	MISU	U Slaski
Field work in 2020	❌	✅	❌	❌	✅	❌	❌	❌
COVID-related cancellations	✓		✓	✓	✓	✓	✓	✓
New data processing (2020, and earlier)	✅	✅	✅	✅	✅	✅	✅	✅
New data published	(✓)	✓	(✓)	(✓)	✓	(✓)	(✓)	(✓)
Observations planned for 2021	✅	❌	✅	✅	✅	✅	✅	✅
Long-term observations	(✓)	✓	✓	✓	✓	✓	✓	✓