INTAROS Review Meeting

EASME, Brussels, September 21, 2018

INTAROS

WP3: Enhancement of multidisciplinary *in situ* observing systems

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Peter Voss, GEUS, Denmark

WP3 main goals:

- To improve critical gaps in the Arctic observation system
- To build additional capacity of pan-Arctic monitoring networks

- make best use of existing reference sites and distributed observatories providing the critical data for Arctic climate and ecosystems, but still missing multidisciplinary dimension or technical advancement

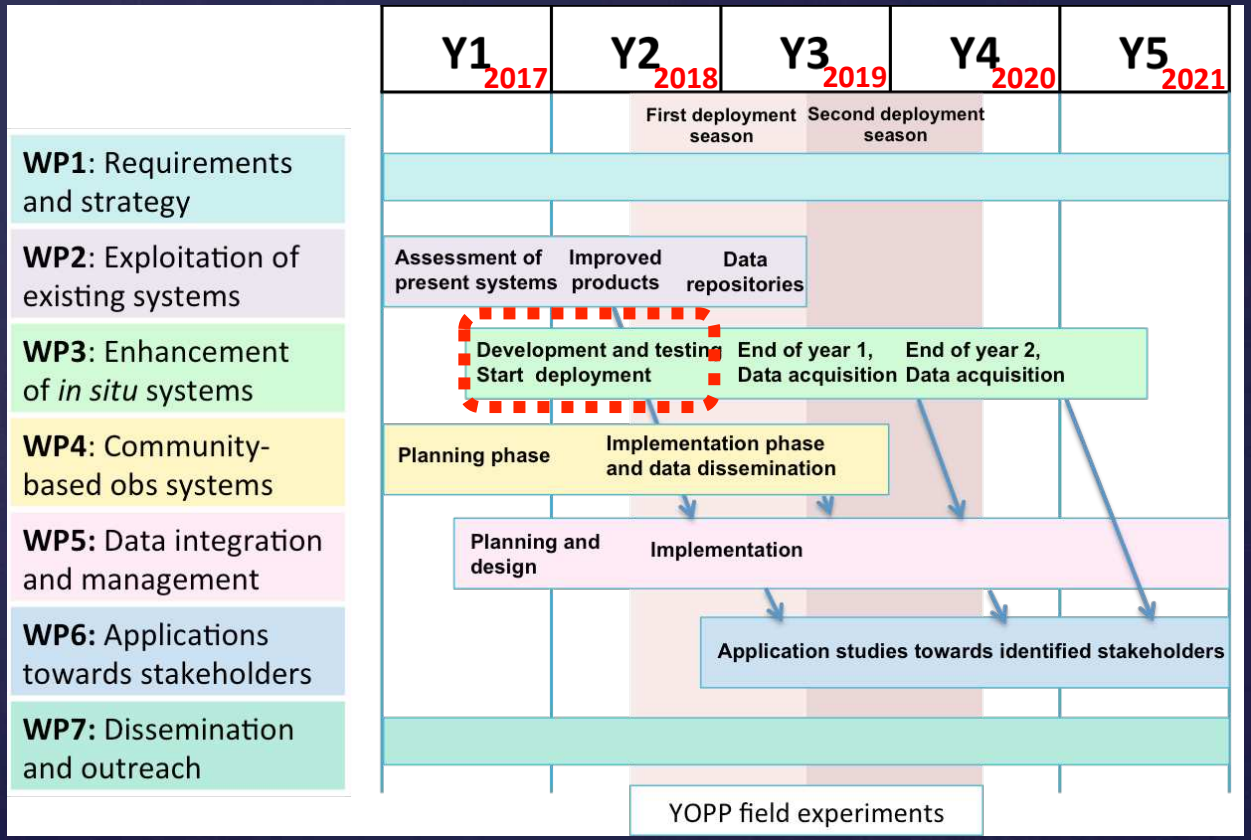
How to achieve them...

- extend temporal and geographic coverage of available infrastructures and add new key geophysical and biogeochemical variables through implementing novel technologies integrated with standard observations

Phase 1: Development of new technologies and integration of multidisciplinary sensors for autonomous in situ monitoring systems in the Arctic (M6-18)

Phase 2: Implementation of integrated multidisciplinary sensors and platforms for year-round measurements in the selected reference sites and distributed observatories (M19-48)

Phase 3: Preparation and delivery of preprocessed new data to WP5 and WP6 (M19-54, overlap with Phase 2 due to the NRT data delivery from some sensors)



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WP3 *In situ* observing systems

Task 0
Scientific and operational coordination

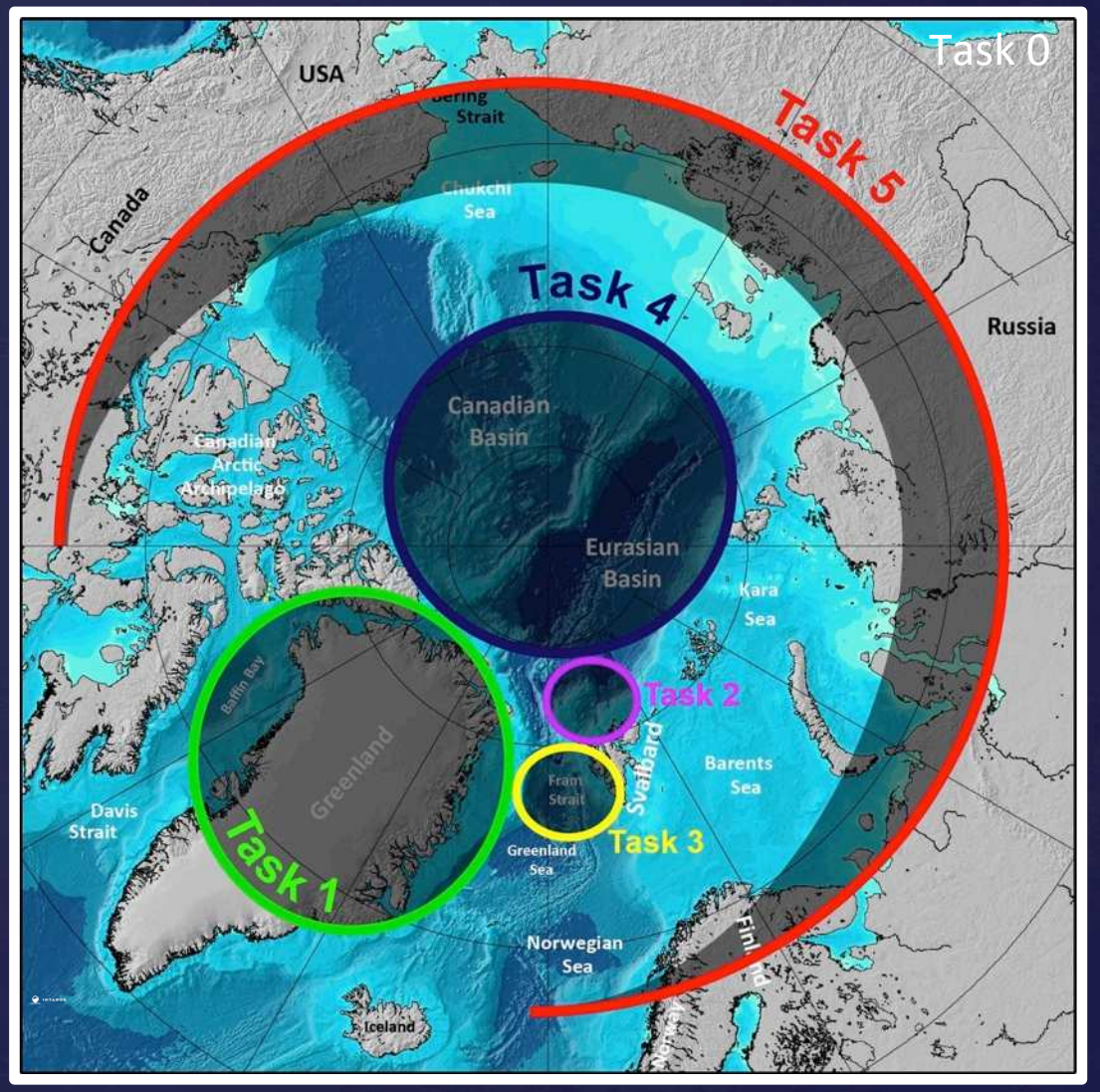
Task 1
Coastal Greenland and Baffin Bay

Task 2
North of Svalbard towards the deep Nansen Basin

Task 3
Fram Strait and Kongsfjorden

Task 4
Central Arctic: Distributed systems for ocean and sea ice

Task 5
Pan-Arctic region: Distributed systems for atmosphere and land



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WP3 *In situ* observing systems

Task 3.1
Coastal Greenland:

- ocean moorings with freshwater focus in NE Greenland (AU)
- properties of snow cover on sea ice in NE Greenland (GEUS/AU)
- surface pCO2 and ocean acidification in the Greenland coastal zone (AU)
- on-ice weather station network for snow-water equivalent (GEUS)
- precise positioning system for ice sheet dynamics (GEUS)
- novel ground penetrating radar system for ice sheet (UPM)
- multidisciplinary acoustic observatory in the Young Sound with passive acoustic (CNRS-IUEM)
- a suite of sensors for automated monitoring of bio-optical and biogeochemical properties of the coastal ocean at Baffin Bay observatory (CNRS-Takuvik)

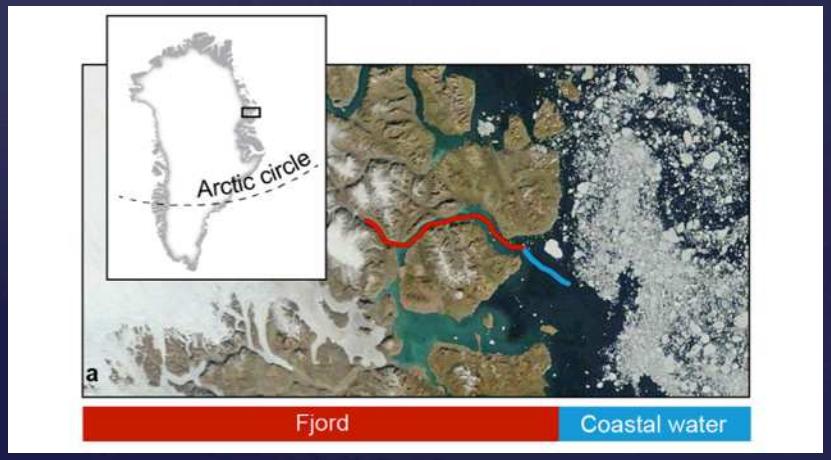
Task 3.1 Coastal Greenland:

Ocean moorings with freshwater focus in NE Greenland (AU)

- Two moorings: in the the inner fjord near the Ice Sheet and in the outer fjord (coastal)
- Measurements of key physical parameters (temperature, salinity, turbidity, fluorescence and PAR) coupled to detailed biological measurements from existing monitoring program
- New instruments (SBE18, SBE37, wave sensors, camera system system for snow and ice coverage) installed in summer 2018

Surface pCO2 and ocean acidification in the Greenland coastal zone (AU)

Under INTAROS instruments for pCO2 and pH provided, sections measured in 2017 and 2018



Task 3.1 Coastal Greenland:

Ecological monitoring using underwater passive acoustics (CNRS-IUEM)

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Young Sound (Eastern Greenland)

2017

- Passive acoustics equipment already calibrated and tested (under ASTRID) May 2017
- Deployment in autonomous mode for routine operations during summer 2017
- Test and calibration of the similar system to be deployed in Kongsfjorden in 2018

2018

- Long term cabled version deployment for year round operations

Greenland, Young Sound

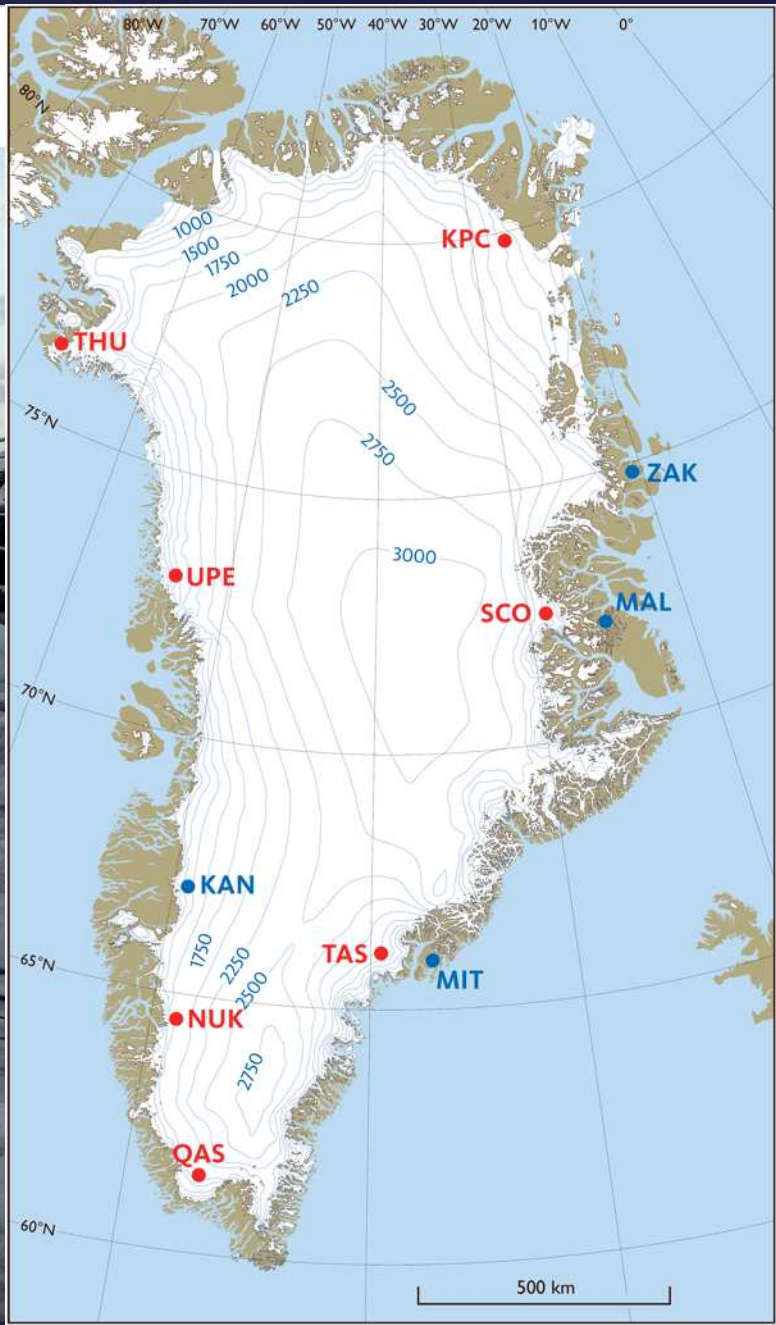
funded within French projects started in 2016

Svalbard, Kongsfjorden

funded within Task 3.3 to be implemented

Task 3.1 Coastal Greenland

PROMICE
Programme for Monitoring of the Greenland Ice Sheet



About 23 AWS operational on ice

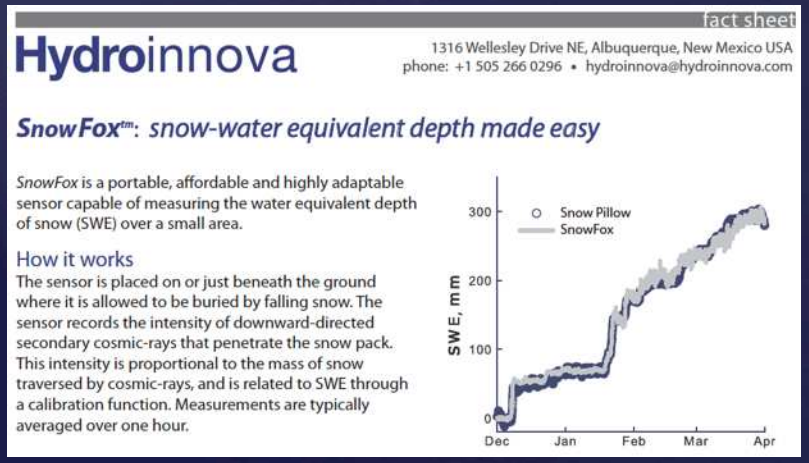
Task 3.1 Coastal Greenland:

Snow water equivalent (SWE) measurements (GEUS)

INTAROS

Work done in 2017-2018:

- Fieldwork preparation and SnowFox instrument testing
- Five SnowFoxes for snow water equivalent (SWE) measurements installed at four PROMICE locations: Tasiilaq (TAS), Qassimiut (QAS), Kangerlussuaq (KAN) and Thule (THU)


fact sheet

Hydroinnova

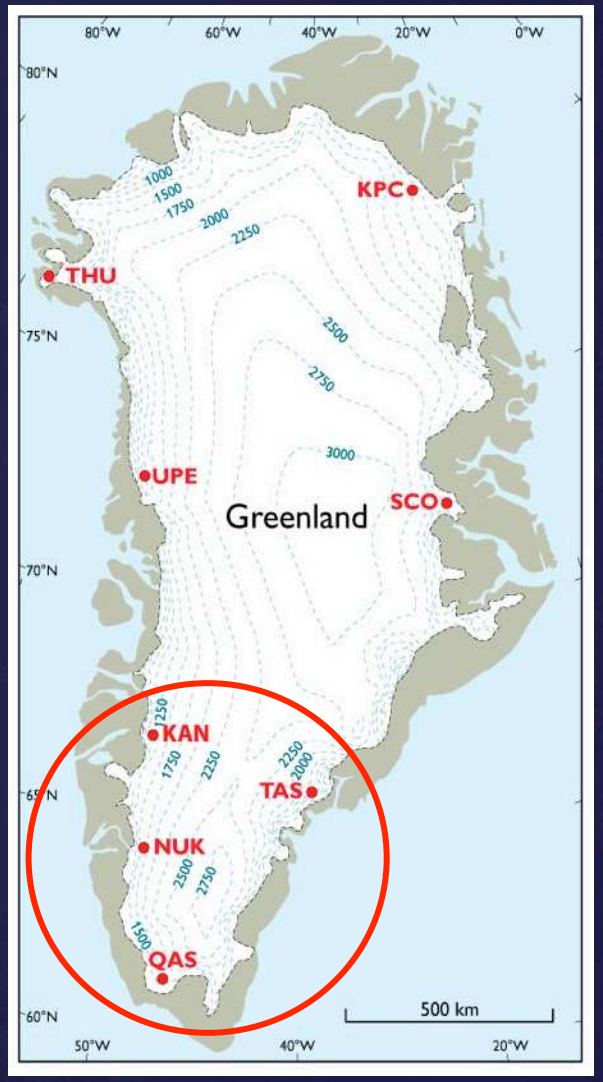
1316 Wellesley Drive NE, Albuquerque, New Mexico USA
phone: +1 505 266 0296 • hydroinnova@hydroinnova.com

SnowFox™: *snow-water equivalent depth made easy*

SnowFox is a portable, affordable and highly adaptable sensor capable of measuring the water equivalent depth of snow (SWE) over a small area.

How it works

The sensor is placed on or just beneath the ground where it is allowed to be buried by falling snow. The sensor records the intensity of downward-directed secondary cosmic-rays that penetrate the snow pack. This intensity is proportional to the mass of snow traversed by cosmic-rays, and is related to SWE through a calibration function. Measurements are typically averaged over one hour.



Task 3.1 Coastal Greenland
Multi-year melt measurements

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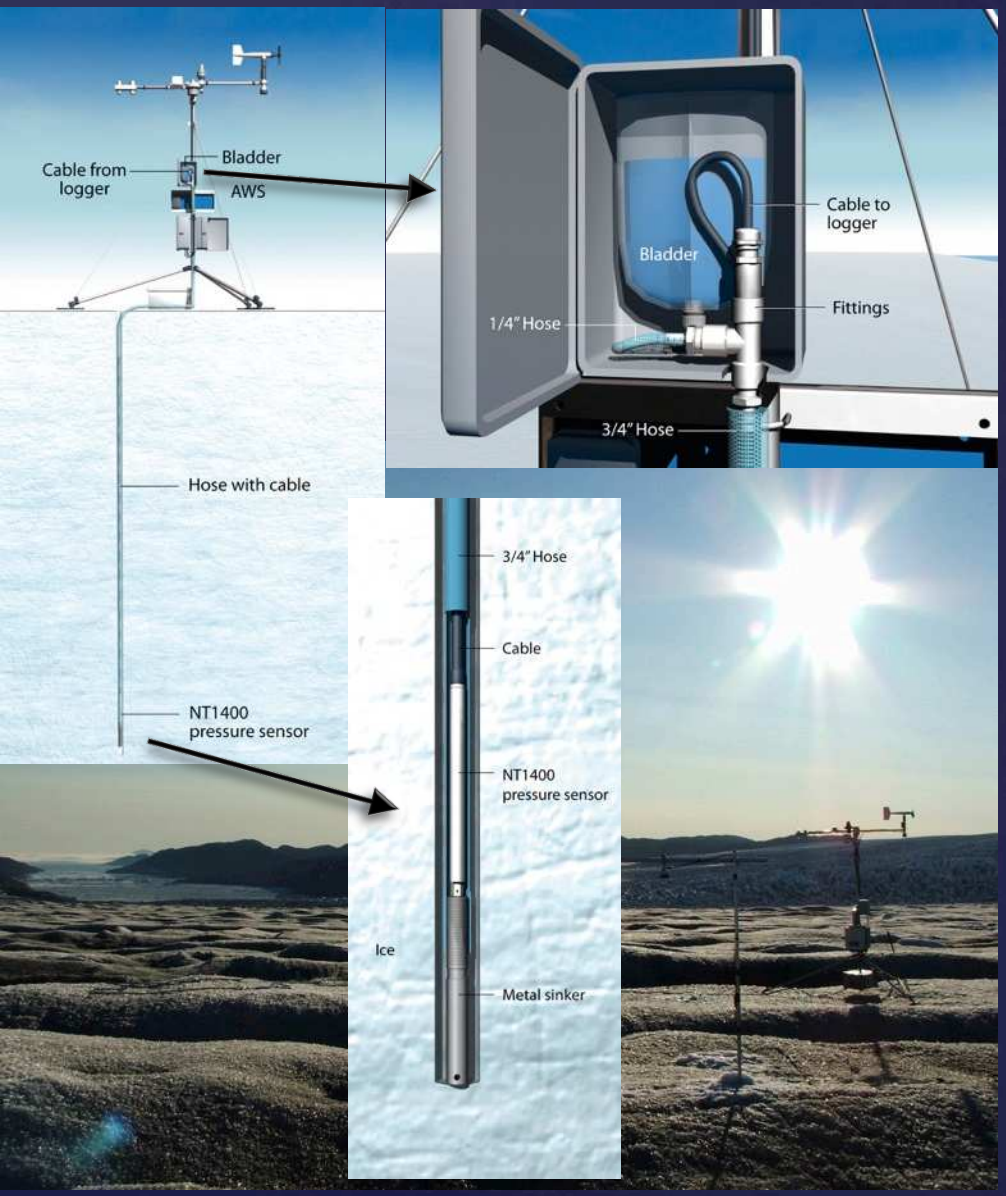

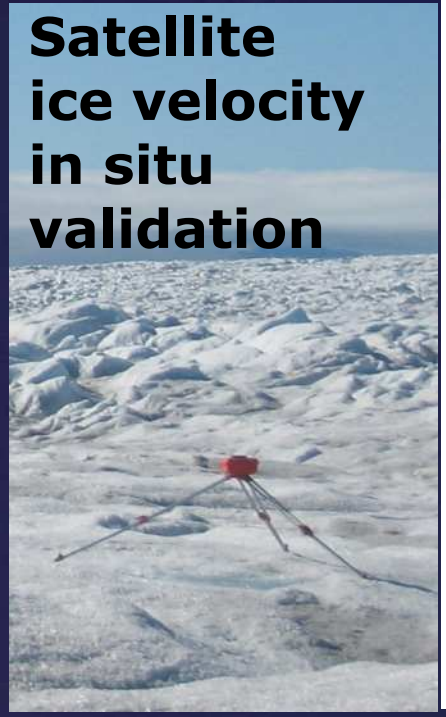

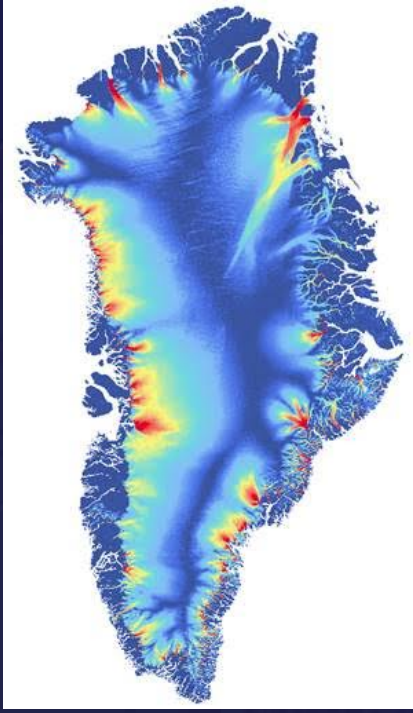

Work done in summer 2018:

- First field tests of a high accuracy GNSS device for precise positioning of the on-ice sheet network (calibration of satellite-derived ice velocity maps)
- First field tests of a combined tilt and magnetic azimuth sensor suitable for automated year-round operation and attached to a GEUS AWS on glaciers

Ground-penetrating radar for glaciological applications

Control unit and digital recording System, Patent ES 2356547 B2

Transmitter

Receiver

Task 3.1 Coastal Greenland

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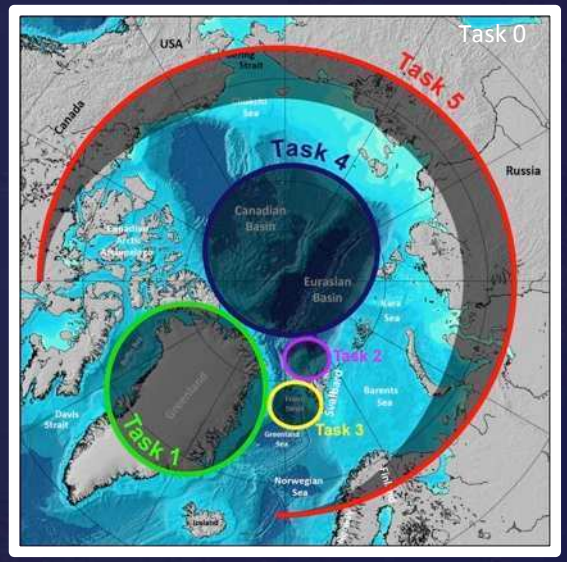
Development of new ground- penetrating radar (UPM)

INTAROS WP3 *In situ* observing systems

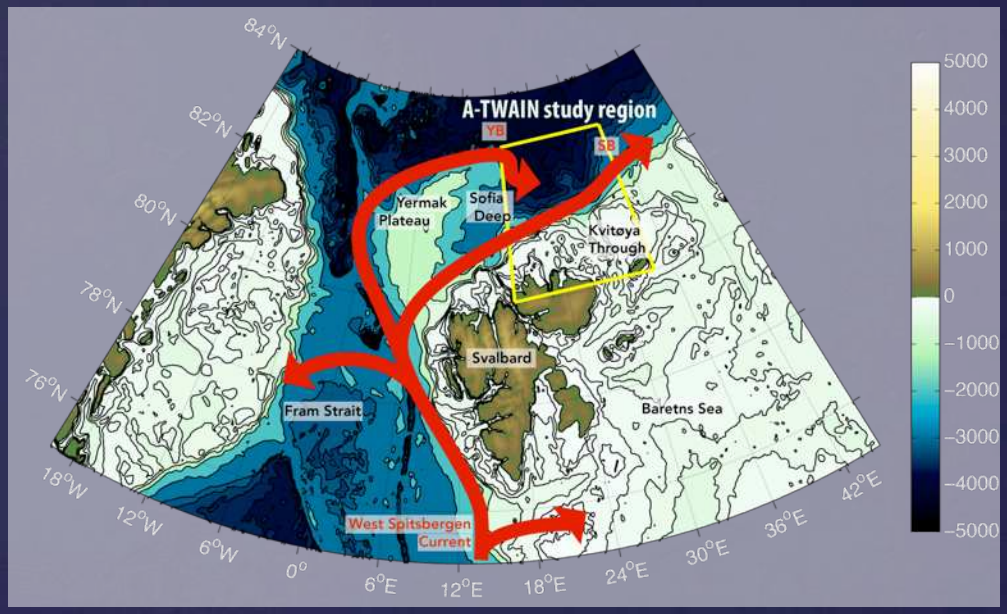
Task 3.2
North of Svalbard towards the deep Nansen Basin:

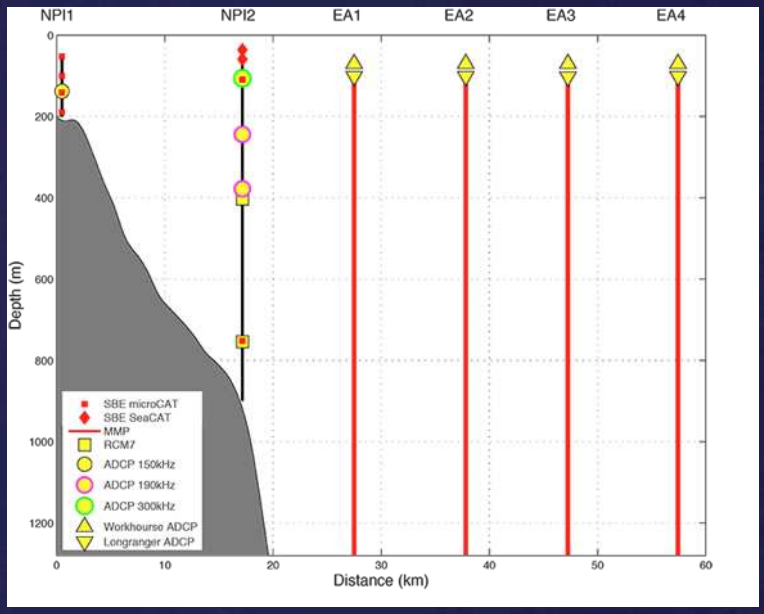
- array of multidisciplinary moorings with profiling instruments and point measurements of ocean physical variables (IOPAN, CNRS-LOCEAN, UiB-GFI)
- pCO2 sensors for carbon system variables (UiB-GFI)
- NO3 sensors for nutrients (UiB-GFI, AWI)
- autonomous passive contaminant samplers (NIVA)
- Octopus system for biological measurements with underwater vision profiler (UVP) and ECO triplet (AWI)
- upward-looking dual use ADCPs/sonars for currents and sea ice draft and drift (IOPAN, UiB-GFI)
- bottom pressure recorders (UNIS)
- combined ADCP-echosounders for currents and zooplankton (IMR)
- ocean bottom seismometers for solid Earth processes and geohazards (GEUS/UiB-GEO)



Task 3.2 North of Svalbard towards the deep Nansen Basin

Building on the A-TWAIN moored array deployed since 2012 under the project 'Long-term variability and trends in the Atlantic Water inflow region'
Main partners IMR and NPI, collaborating partners WHOI, IOPAN





Map and array scheme from http://atwain.whoi.edu/php/index.php

2012-2013: 9 moorings (8 recovered)
2013-2015: 5 moorings (4 recovered)
2015-2017: 3 moorings deployed

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Task 3.2 North of Svalbard towards the deep Nansen Basin

Multidisciplinary moored array (IOPAN, CNRS-LOCEAN)

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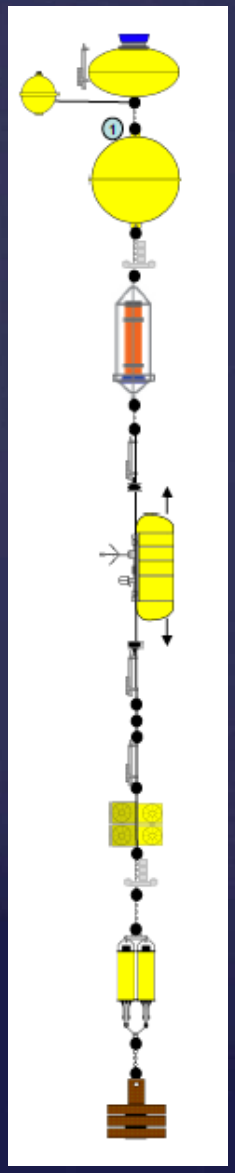
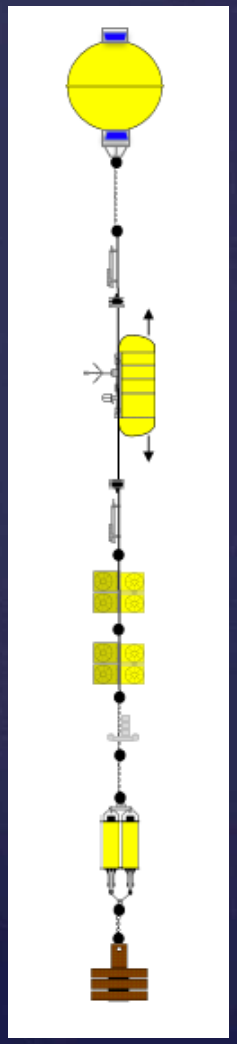
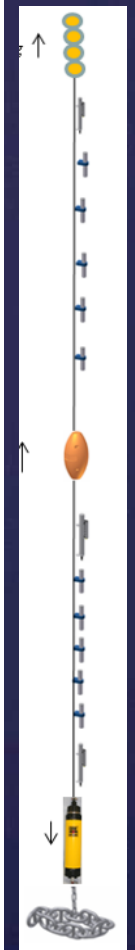
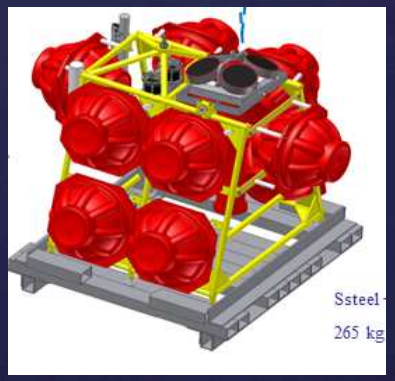
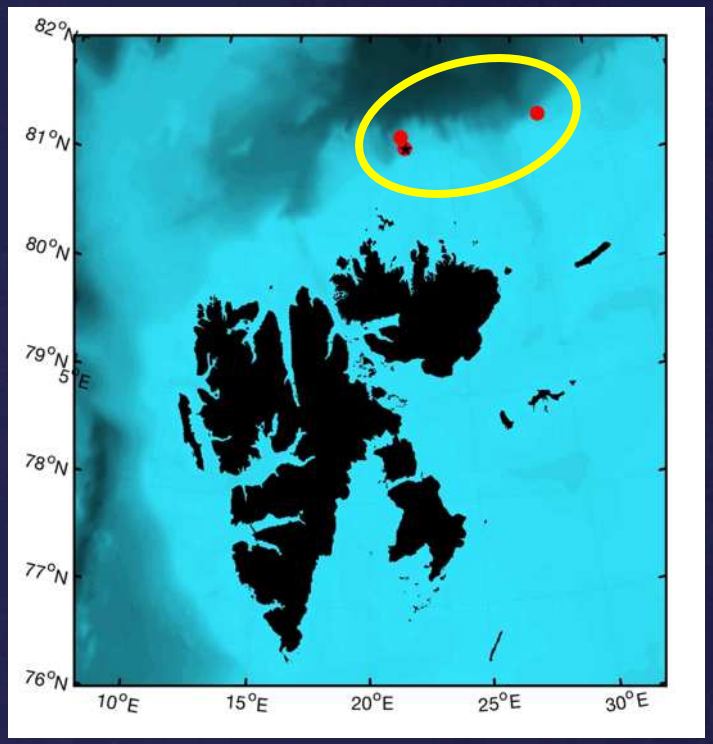










Four moorings deployed during A-TWAIN cruise of RV Lance in September 2017

were recovered and redeployed in August 2018 from KV Svalbard

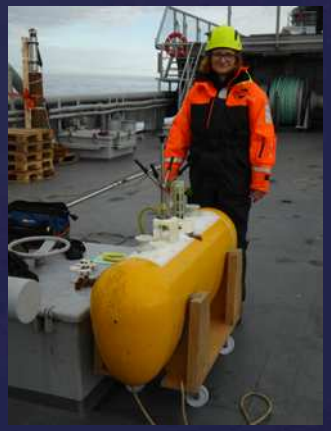
Task 3.2 North of Svalbard towards the deep Nansen Basin

Multidisciplinary moored array (IOPAN, CNRS-LOCEAN)

INTAROS

Seven moorings deployed from the Norwegian coast guard icebreaker KV Svalbard during INTAROS2018 cruise in August 2018 equipped with:

- Moored McLane Profilers (temperature, salinity, ocean currents)
- TRDI QM ADCPs (ocean currents)
- Signature 55 Dual Freq Nortek ADCP (ocean currents, different resolution/range)
- Signatures 250 (ocean currents, sea ice drift and draft)
- Microcats SBE37 CTD(O) sensors (temperature, salinity, dissolved oxygen)
- RBR temperature and pressure recorders



Task 3.2 North of Svalbard towards the deep Nansen Basin

Multidisciplinary biogeochemical mooring (UiB-GFI, IOPAN, AWI, NIVA, NERSC)

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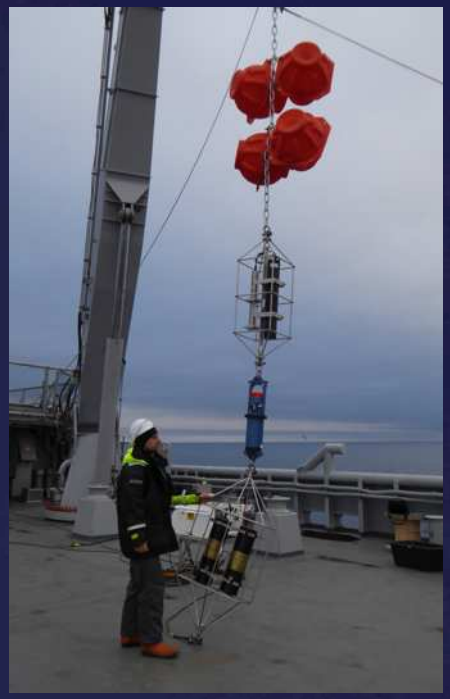

Multidisciplinary BGC mooring

Equipped with a suite of instruments for measuring carbon system, biological and standard physical parameters

Deployed at 22°E next to the IOPAS12 mooring at 850 m, measuring physical ocean and sea ice parameters

SAMI pCO2

SUNA V2 UV nitrate sensor

Underwater Vision Profiler system ‘Octopus’

Passive contaminant samplers

Task 3.2 North of Svalbard towards the deep Nansen Basin

Ocean bottom seismometers (GEUS, UiB-GEO)

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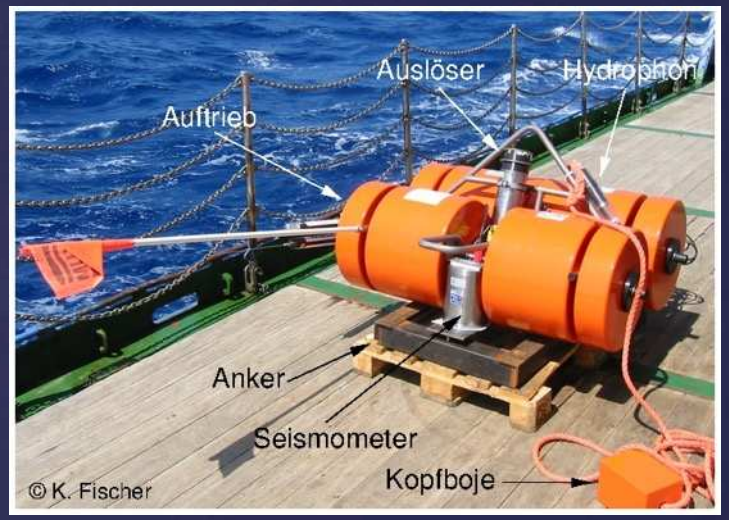
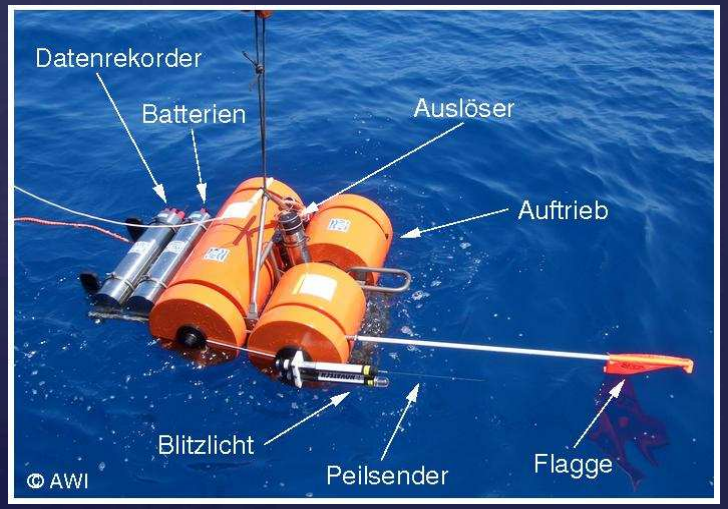
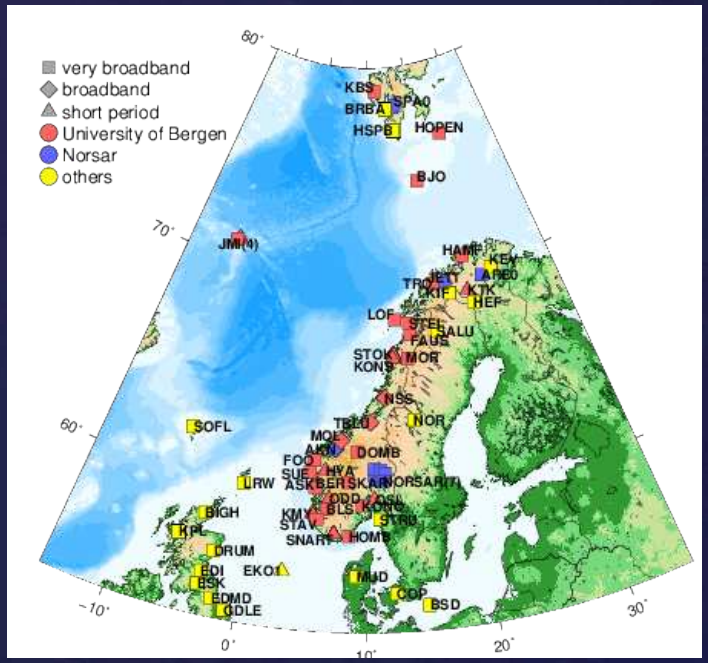




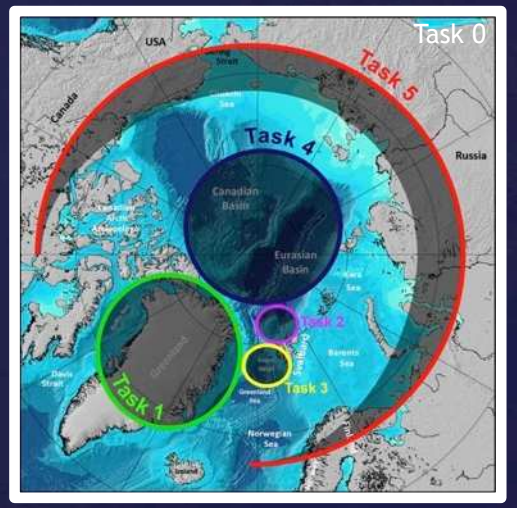
- Ocean bottom seismometers for solid Earth processes and geohazards
- Three OBS deployed in August 2018 during KV Svalbard cruise in the northern Fram Strait



INTAROS WP3 *In situ* observing systems

Task 3.3 Fram Strait:

- extending the LTER observatory Hausgarten with experimental autonomous system for impacts of ocean acidification on benthic biology arcFOCE - Arctic Free Ocean Carbon Enrichment (AWI)
- real-time measurements of pCO2 and pH, monitoring of carbon cycle parameters in Kongsfjorden (CNRS-LOV)
- directional acoustic system to monitor benthic species and dynamics of sea ice and icebergs in Kongsfjorden (CNRS-UIEM)



Task 3.3 Fram Strait

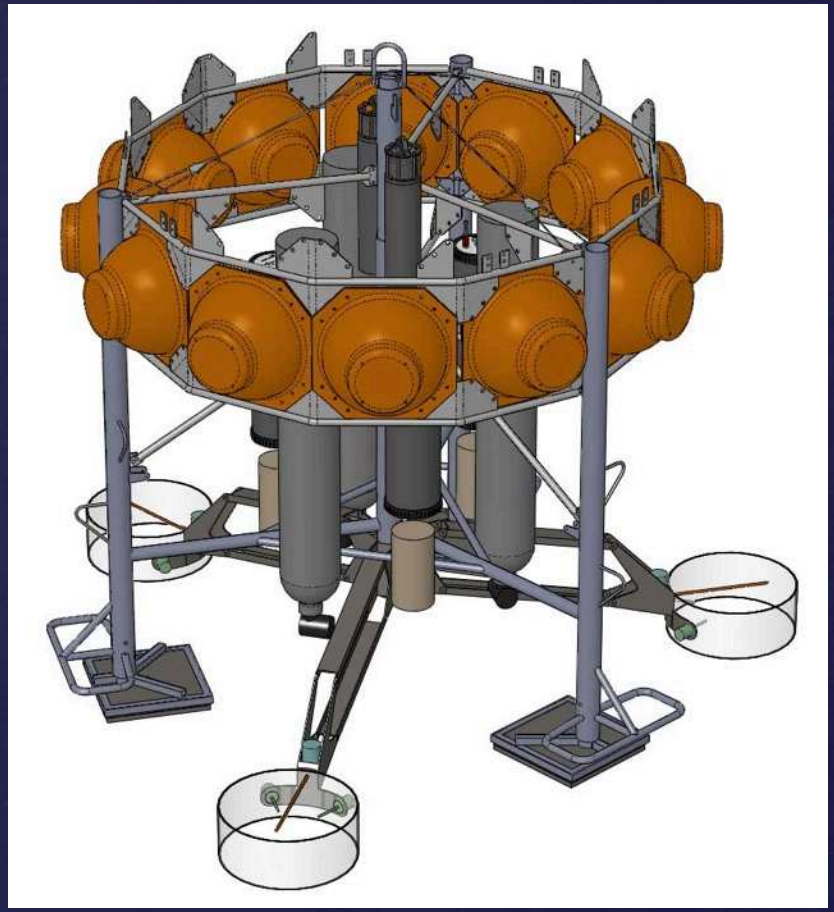
ArcFOCE - Arctic Free Ocean Carbon Enrichment (AWI)

System designed for acidification experiment (high CO_2 / low pH ocean)

to assess the effects of future changes in ocean chemistry, including ocean acidification, on the diversity and abundance of deep-sea benthic organisms and communities

Major challenges:

- Autonomy
- Energy demand
- Seawater acidification
- Sensor stability
- Installation / sampling



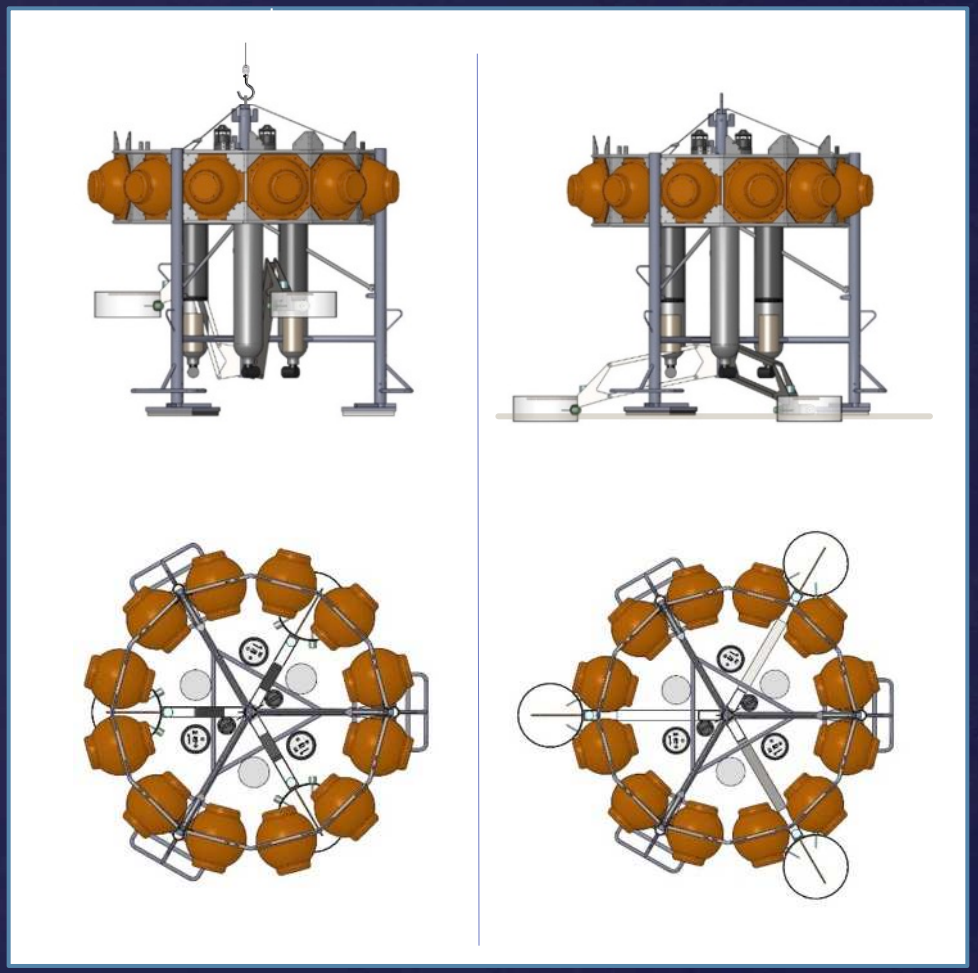
Task 3.3 Fram Strait

ArcFOCE - Arctic Free Ocean Carbon Enrichment (AWI)

Design and testing in 2017
Installation in 2018

First deployment during the RV „Maria S. Merian“ expedition MSM77 in September / October 2018

Sampling of sediments and inhabiting organisms with a Remotely Operated Vehicle in summer 2019

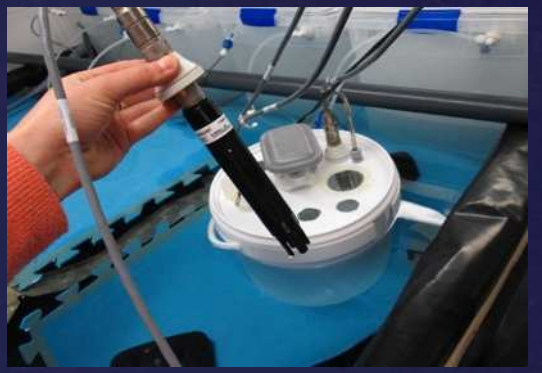


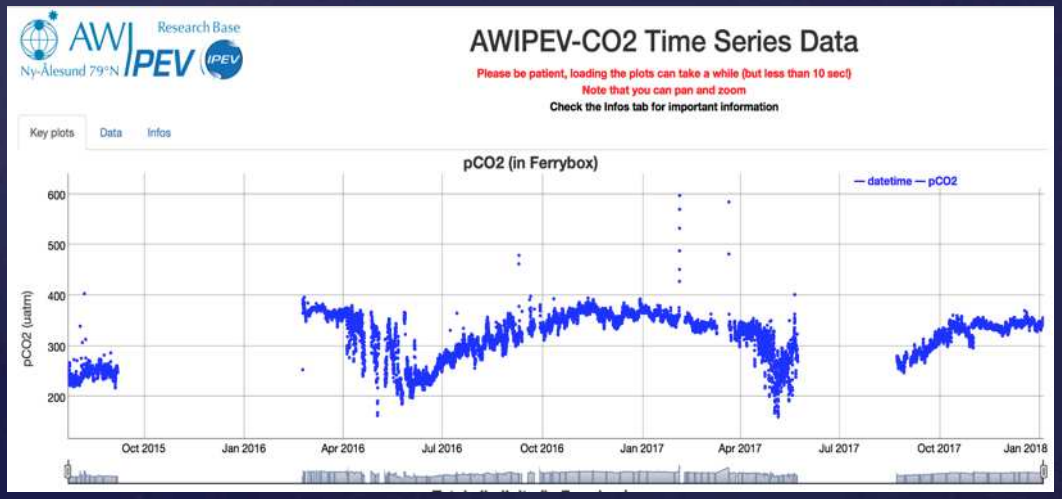
Task 3.3 Fram Strait

Time-series of carbonate chemistry in the Arctic Ocean (CNRS-LOV)

Underwater observatory (AWIPEV) Kongsfjorden

- Water pumped from 12 m water depth at Ny-Ålesund
- **Since July 2015:** Two pCO_2 sensors rotating every year (every minute)
- **Since August 2017 under INTAROS: pH measurements**
  - Continuous measurements in fjord water (seaFET)
  - Discrete pH samples once a month for calibration





Task 3.3 Fram Strait

INTAROS

Ecological monitoring using underwater passive acoustics (CNRS-IUEM)

Kongsfjorden (Svalbard)

Done in 2017

System choice: hydrophone RTSYS (HTI-92-WB 50 Hz model)
acoustics recorder RTSYS EA-SD414-320
pressure/depth sensor/recorder

Test and calibration in Brest (April 2017)

Test and calibration in Young Sound, next to the similar system deployed there (May 2017)

Algorithm adaptation (for ecological monitoring)

Done in 2018

Deployment in autonomous mode:

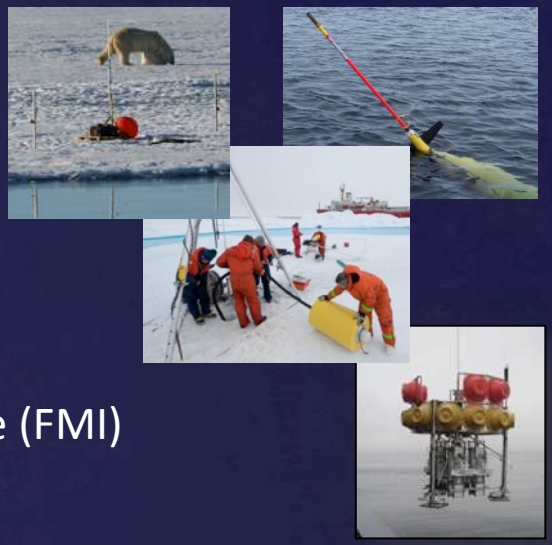
springtime and summer 2018

recovery in autumn 2018

Implementation site validation

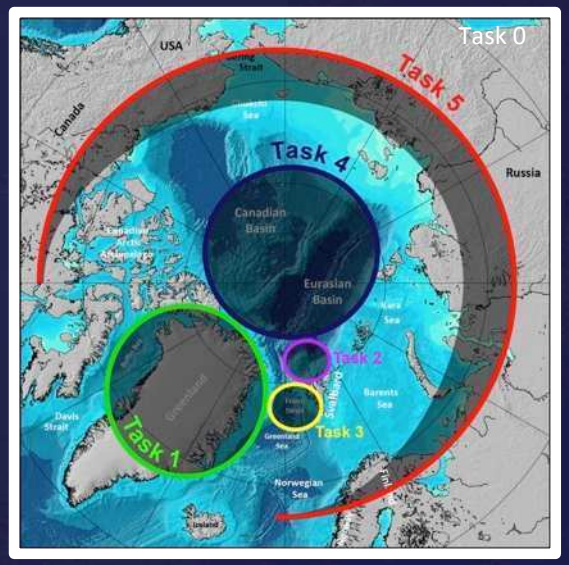
Long term cabled version planned 2019

INTAROS WP3 *In situ* observing systems



Task 3.4
Distributed systems for ocean and sea ice:

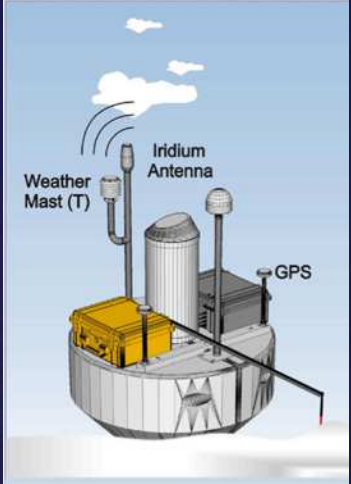
- Ice-tethered platforms for measurements of ocean physical variables with meteorological and biogeochemical sensors for multidisciplinary ITP measurements (IOPAN)
- Sea-ice mass balance buoys clustered with ITPs and standalone (FMI)
- Measurements of snow properties and ABL observations from SOOs (FMI)
- Quadrocopter measurements of broadband and surface albedo (FMI)
- Novel sensors for FerryBoxes (ocean acidification and carbonate chemistry, inherent optical properties, microplastic sampler) (NIVA)
- Endurance glider lines in the open water Arctic regions (CNRS-LOCEAN)
- BioArgo floats in Baffin Bay (CNRS-Takuvik)

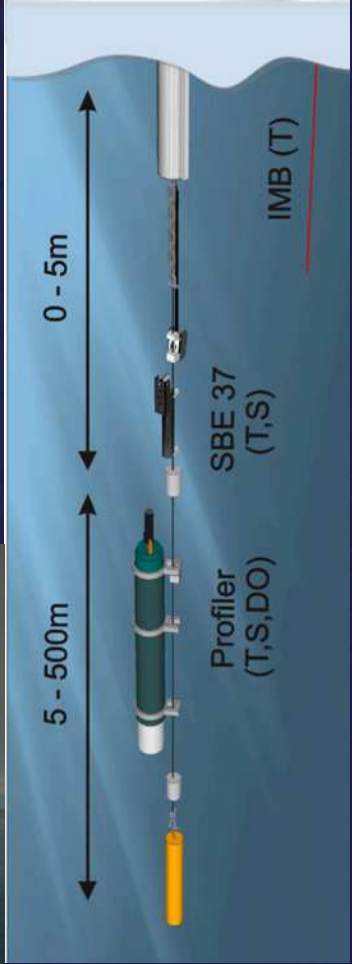


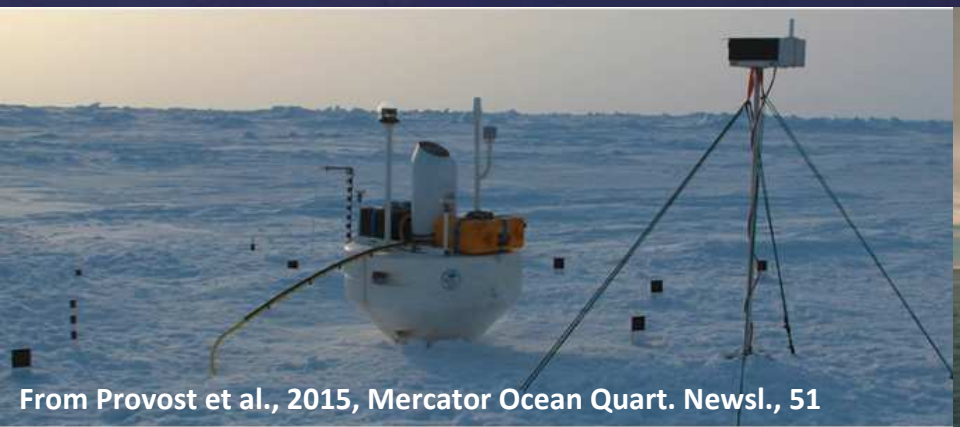
Task 3.4 Distributed systems for ocean and sea ice:

Ice-tethered platforms (IOPAN)

- One Ice-tethered IAOOS platform was acquired from the French EQUIPEX IAOOS consortium for deployment in 2018
- IAOOS platform is equipped with:
  - ⟾ CTDO profiler travelling along the 800 m wire (Koenig et al., 2016)
  - ⟾ Ice mass balance instrument (Mariage et al., 2016)
  - ⟾ Atmospheric package: microlidar, weather mast and GPS (Mariage et al, 2017)
- Deployment done during the Arctic2018 ODEN cruise in the central Arctic in the late August by the EQIPEX IAOOS team







From Provost et al., 2015, Mercator Ocean Quart. Newsl., 51

Task 3.4 Distributed systems for ocean and sea ice:

Snow and Ice Mass Balance Arrays (SIMBA) measurements (FMI)

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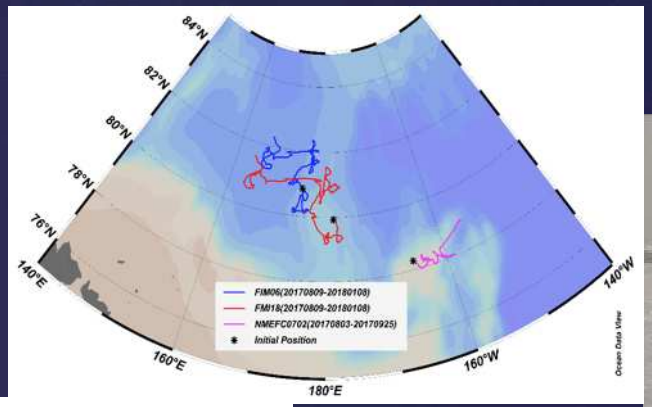
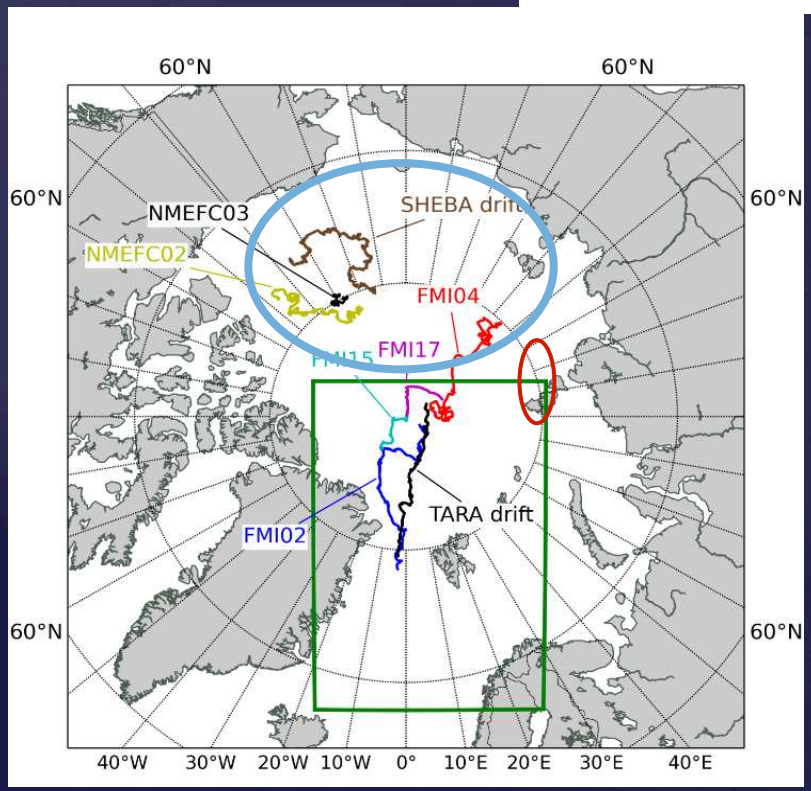
Existing and planned SIMBA deployment domains:



SIMBA deployment during CHINARE2017 and buoy drift trajectories until 8.01.2018



Buoys deployments in 2018:

- **3 SIMBAs** deployed during CHINARE2018 expedition in July-September along the Xuelong cruise trajectory
- **4 SIMBAs** will be deployed during the NABOS cruise
- **4 SIMBAs** will be deployed during the MOSAiC pre-study SPOT

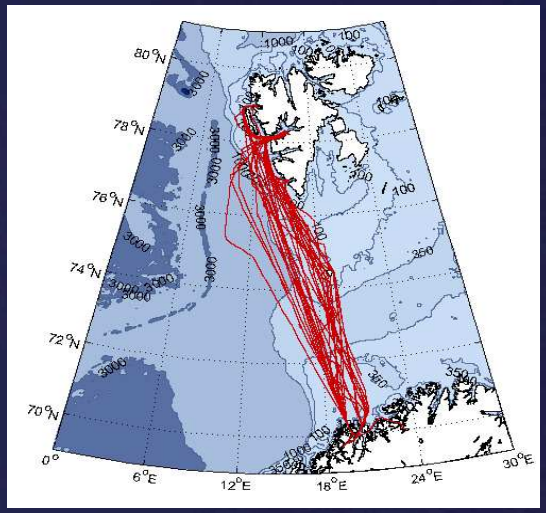
Task 3.4 Distributed systems for ocean and sea ice

Novel sensors for FerryBoxes (NIVA)

30-35 round trips/year

Barents Sea opening FerryBox biogeochemical sensors

- **pH/CO3 sensor** - fabrication and development underway, operational testing in summer 2018 on a local Ferrybox system
- **multi-wavelength spectral absorbance sensor** - lab-based calibrations are underway, operational testing in summer 2018 on a local FerryBox system



Barents Sea opening FerryBox microplastics sampler

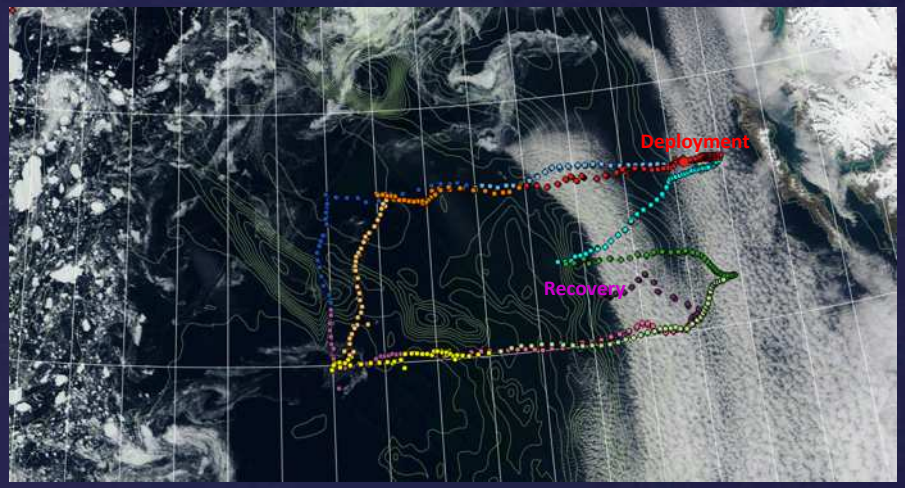
- A prototype fabricated, testing underway
- Between M18-24, preliminary tests on shore for risk management plan
- Aiming to deploy late 2018/early 2019

The core FerryBox system is operational and core observations (S, T, chl, O2, turbidity) are ongoing

Task 3.4 Distributed systems for ocean and sea ice:

Endurance glider lines along the Atlantic Water pathways in Fram Strait (CNRS-LOCEAN)

- **Teledyne Slocum glider deployed for 2 months (July 25 - September 22, 2017) in the West Spitsbergen Current, Fram Strait**
- **Glider equipped with Seabird T,C,P sensors, optode for DO, Chl-a and CDOM fluorimeters, and optical backscatter for turbidity**



- Two zonal sections (at 78°N and 78° 40'N)
- Two "meridional sections" (over the Svalbard slope and along the ice edge)
- Two repeat quadrangles separated by 1 month

Task 3.4 Distributed systems for ocean and sea ice:

BioArgo floats in Baffin Bay (CNRS-Takuvik)

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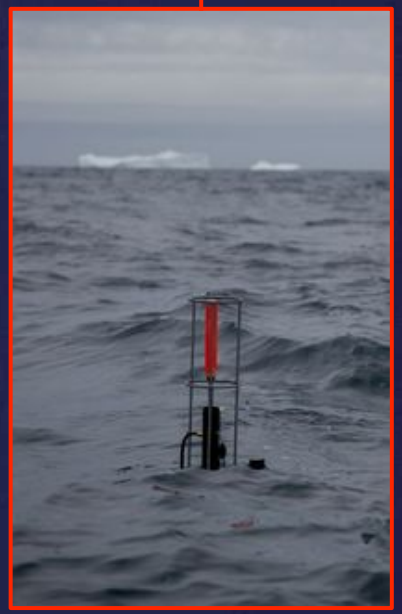
- **7 BGC-Argo floats** (PRO-ICE) deployed in Baffin Bay in July 2017
- Equipped with O2 / Ed 380, 412 and 490nm + PAR / FL-chl*a* / FL-CDOM / BB / nitrates sensors
- **4 BGC-Argo floats** deployed during the Canadian scientific icebreaker Amundsen 2018 campaign
- Validated Biogeochemical database from the GreenEdge expedition available
- Continue research efforts in ice detection for BGC-Argo floats



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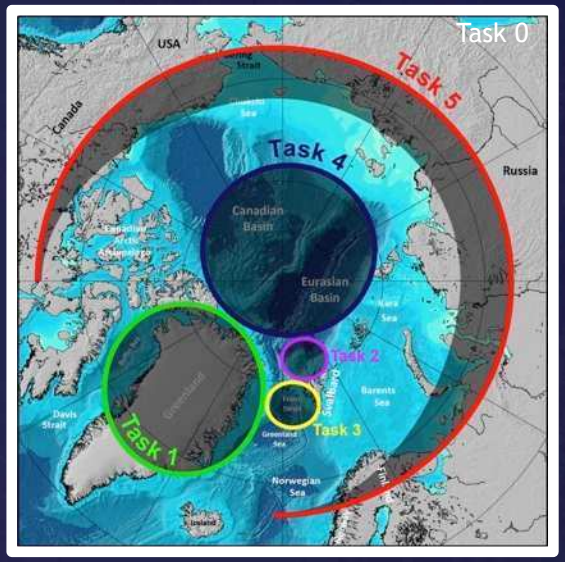
Task 3.5 Distributed systems for atmosphere and land:



- extending continuous monitoring of atmospheric GHGs with additional trace gases and isotopes measurements (automated flask sampling system) (MPG)
- vertical profiles of ABL state variables from airborne measurements along the Alaskan and Canadian Arctic (GFZ)
- de-icing system for atmospheric instruments, novel temperature sensing system, new soil diffusivity system for trace gases in the Barrow site cluster (OU, USFD)
- novel *in situ* and remote sensing of snow physical properties along a latitudinal transect in the Eastern Canadian Arctic, drone-based pulsed LIDAR observations (CNRS-Takuvik)
- improved ground-truthing of satellite remote sensing products in the Northern Finland (automatic spectro-albedometer, VNA-based radar system to monitor soil, snow and surface vegetation properties) (FMI)
- semi-autonomous system for atmospheric observations in the central Arctic for icebreaker Oden and SOOs (MISU)

Task 3.5 Distributed systems for atmosphere and land:

GHG automated flask sampling system (MPG)

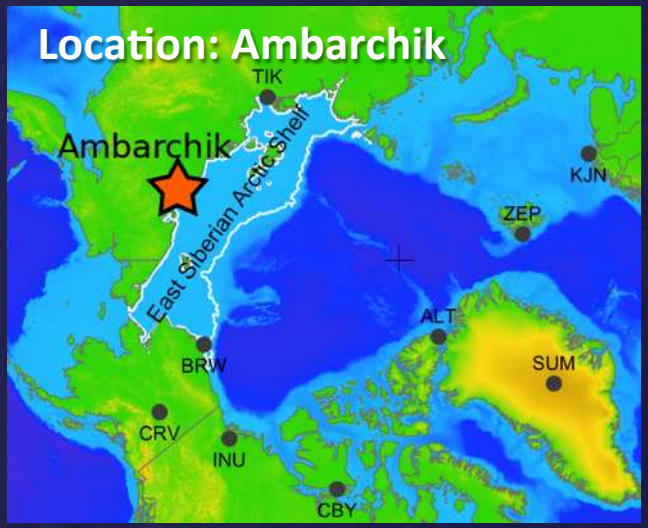
- Extend existing observation program: CH_4, CO_2 (cont.)
- Separate emission sources based on isotope data (e.g. ^{13}C-CO_2, ^{13}C-CH_4, ^{2}H-CH_4, ..)
- Evaluate and improve atmospheric transport model results using multiple species fingerprints (e.g. SF_6, N_2O, O_2/N_2, ..)

Collect gas samples (1-3L)

- At fixed intervals
- For specific boundary conditions (e.g. wind direction)
- Integrated over longer periods

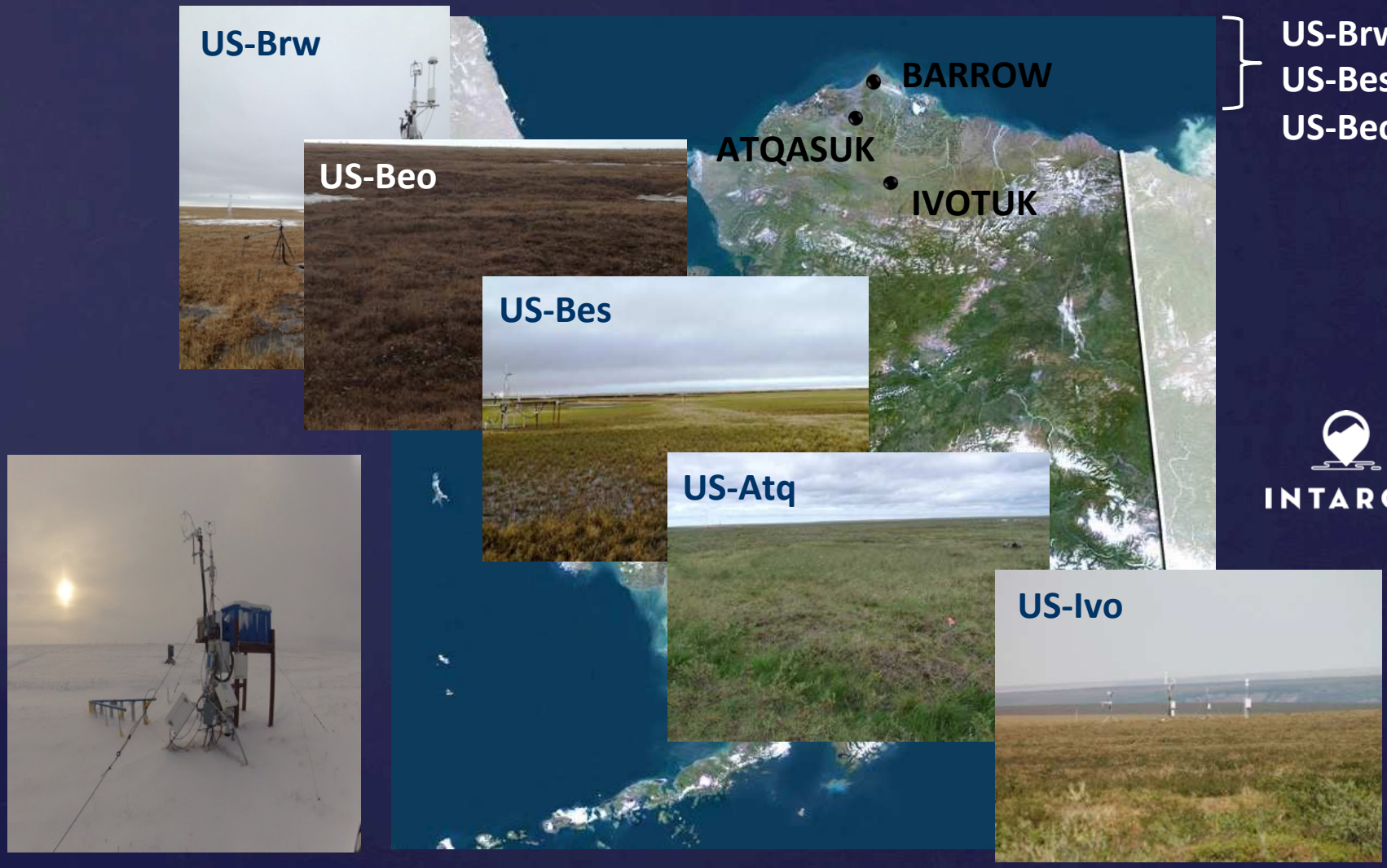
Semi-autonomous operation

- Instrument customized, ordered at ICOS lab
- Test runs with prototypes underway
- Delay in production requires re-scheduling
  - Original installation planned for late summer 2018
  - Now, instrument likely be completed in July 2018
    - Too late for test runs, shipment to Siberia
  - Extensive test runs planned in Jena for 2018/19
  - Installation in Ambarchik in early summer 2019



Task 3.5 Distributed systems for atmosphere and land

De-icing system for atmospheric instruments, novel temperature sensing system, new soil diffusivity system for trace gases in the Barrow cluster (OU, USFD)



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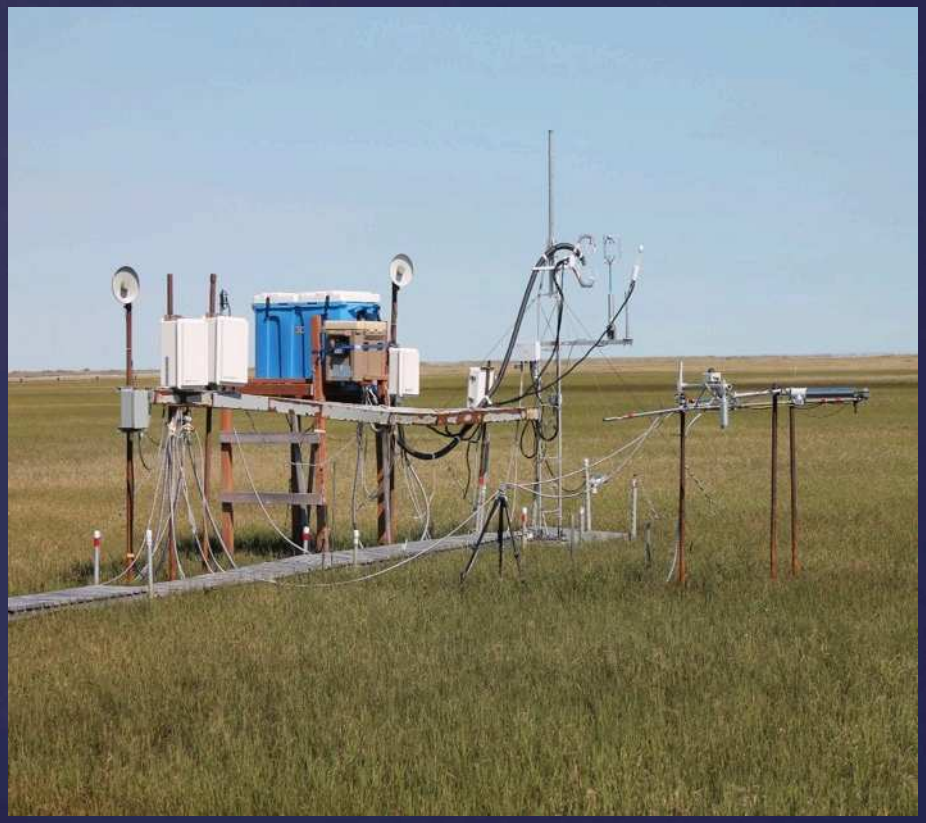
Task 3.5 Distributed systems for atmosphere and land:

Eddy-covariance towers with de-icing system (Barrow site cluster) and soil diffusivity system to estimate CO_2 and CH_4 soil concentration and define the contribution of different soil layers



- Sensor-heating device developed and implemented in 2017
- Testing conducted in the most remote of our sites, and proved successfully in maintaining ice-free the sonic anemometer during the cold period

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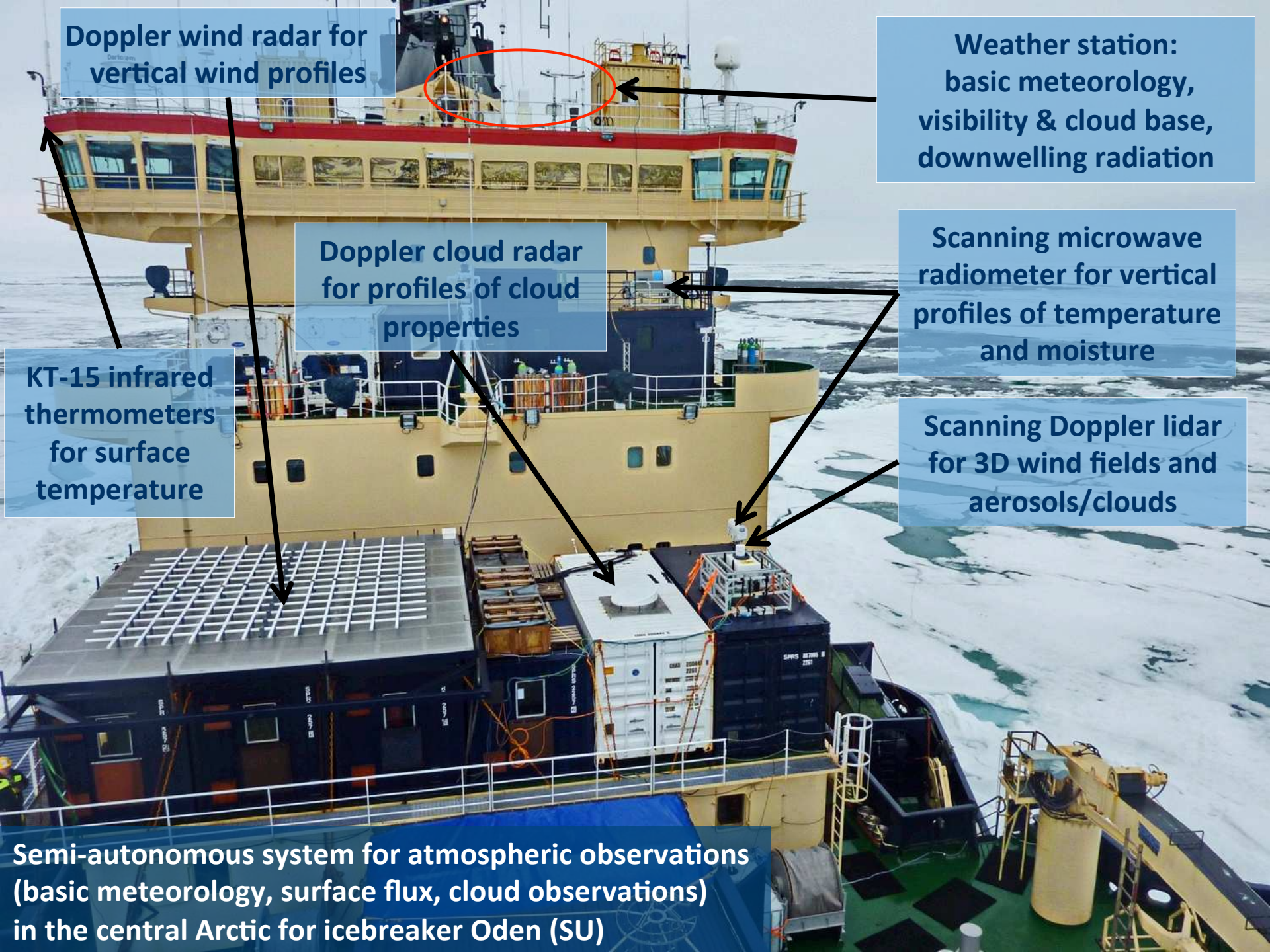
Task 3.5 Distributed systems for atmosphere and land:

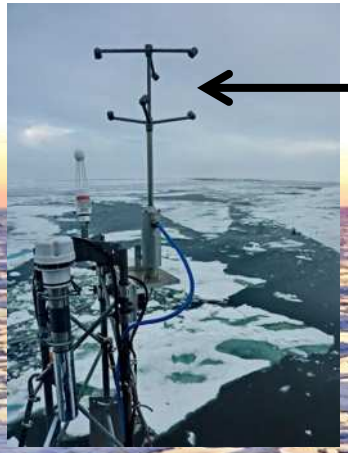
High-resolution temperature sensing systems (USFD)

for continuous measurements of water table and thaw depth

High resolution temperature profile: thermocouples located every 5 cm

- High-resolution soil temperature profilers installed at the southernmost site (Ivotuk)
- System operated continuously year-round in 2017, will continue in 2018


Doppler wind radar for vertical wind profiles
Weather station: basic meteorology, visibility & cloud base, downwelling radiation
Doppler cloud radar for profiles of cloud properties
Scanning microwave radiometer for vertical profiles of temperature and moisture
KT-15 infrared thermometers for surface temperature
Scanning Doppler lidar for 3D wind fields and aerosols/clouds
Semi-autonomous system for atmospheric observations (basic meteorology, surface flux, cloud observations) in the central Arctic for icebreaker Oden (SU)



Turbulent fluxes between atmosphere and surface

Scanning microwave radiometer for vertical profiles of temperature and moisture

Scanning Doppler lidar for 3D wind fields and aerosols/clouds

Doppler cloud radar for profiles of cloud properties

Doppler radar for vertical wind profiles

In the first pilot experiment conducted during the Arctic Ocean 2018 (AO2018) expedition on the IB Oden a system was deployed for in-situ surface flux observations using eddy-covariance and instruments for estimating the radiation flux (plus an advanced AWS)

INTAROS WP3 *In situ* observing systems

Status of deliverables due in month 18 (end of May 2018)

D3.1 Report on technical development and system design: Coastal Greenland

Delivered

D3.2 Report on technical development and system design: North of Svalbard

Delivered

D3.3 Report on technical development and system design: Fram Strait

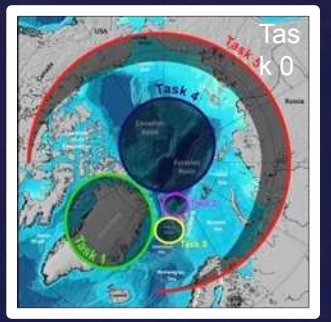
Delivered

D3.4 Report on technical development and system design: distributed systems for ocean and sea ice

Delivered

D3.5 Report on technical development and system design: distributed systems for land and atmosphere

Delivered

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