Arctic Science Summit Week 2021

Virtual Event, 19-26 March 2021

Integrating Arctic Observing Systems
Results from the H2020 INTAROS Project

INTAROS

Enhancement of *in situ* observations in the Arctic

Agnieszka Beszczynska-Möller, Peter Voss, Andreas Ahlstrøm, Truls Johannessen,
Hanne Sagen, Thomas Soltwedel, Mathias Göckede and the entire INTAROS observation team

Enhancement of *in situ* observations in the Arctic

To develop an efficient integrated Arctic Observation System by extending, improving and unifying existing and evolving systems in the different regions of the Arctic

INTAROS reference sites and distributed observatories:

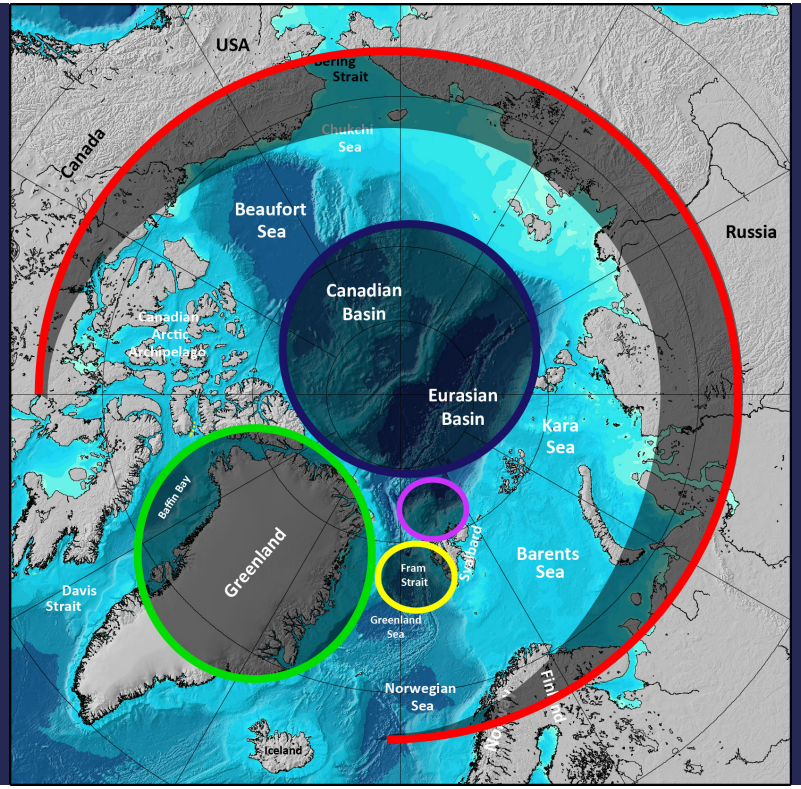
Coastal Greenland and Baffin Bay

North of Svalbard towards the deep Nansen Basin

Fram Strait and Kongsfjorden

Central Arctic distributed systems for ocean and sea ice

Pan-Arctic region distributed systems for atmosphere and land



INTAROS approach:

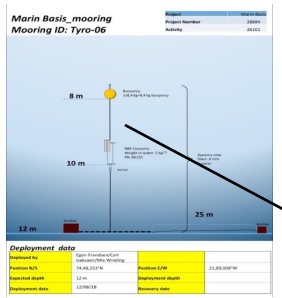
- make best use of existing reference sites and distributed observatories providing data for Arctic climate and ecosystems but missing multidisciplinary dimension or technical advancement
- extend temporal and geographic coverage of available infrastructures and add key geophysical and biogeochemical variables through implementing novel technologies integrated with standard observations

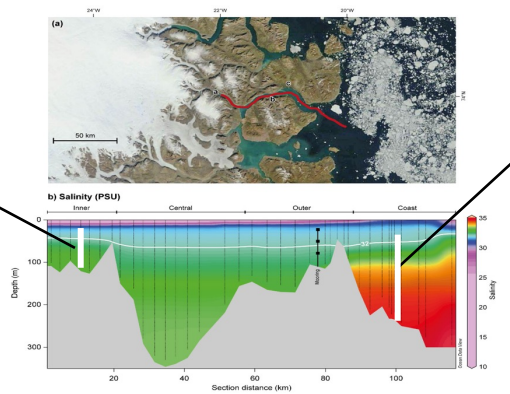
Enhancement of *in situ* observations in the Arctic

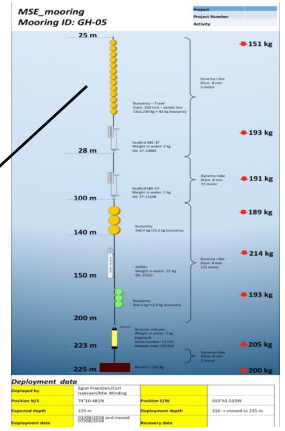
Marine and ice sheet observations in coastal Greenland

Ocean moorings with freshwater and snow on the ice focus in NE Greenland (AU)

- Two moorings in Young Sound: one in the inner fjord near the Ice Sheet and one in the outer fjord (coastal)
- Measurements of key physical parameters coupled to detailed biological measurements from existing monitoring program
- 3 years of consecutive data available at Greenland Ecosystem Monitoring Programme database



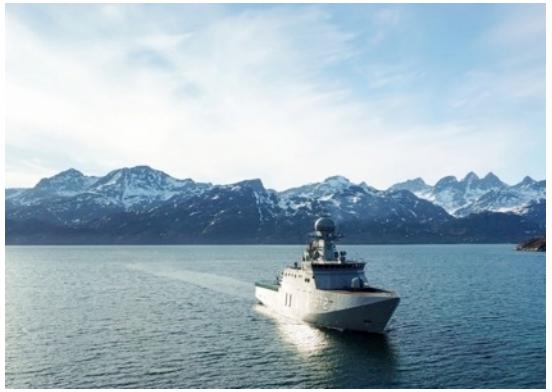


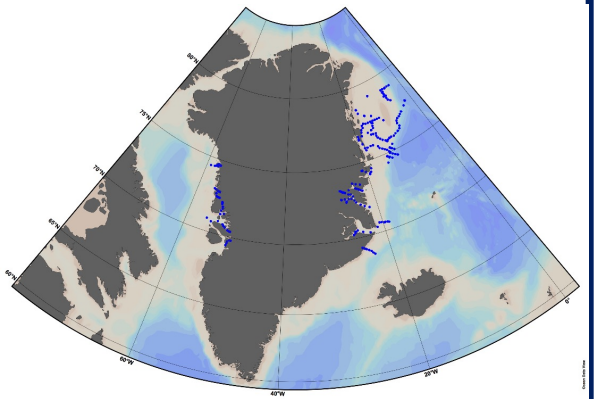


Two new moorings deployed under INTAROS

Collecting baseline dataset on surface pCO2 and OA in the entire Greenland coastal zone (AU)

- Data collected in coastal Greenland 2016-2018 (3 cruises)
- Provided 50+ CTDO profiles, pCO_2, nutrients etc.
- Joint work with stakeholder (Danish Navy) in 2018
- Data in public depository GEM data base after embargo





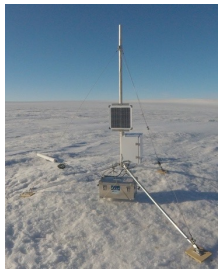
Enhancement of *in situ* observations in the Arctic

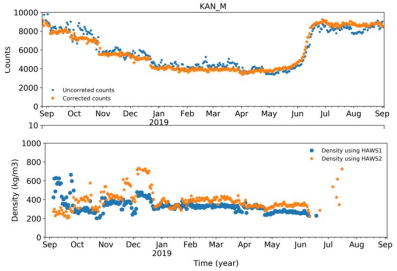
Marine and ice sheet observations in coastal Greenland

New *in situ* observations on the Greenland icesheet as contribution to PROMICE network (GEUS)

SWE measurements on ice sheet by SnowFoxes

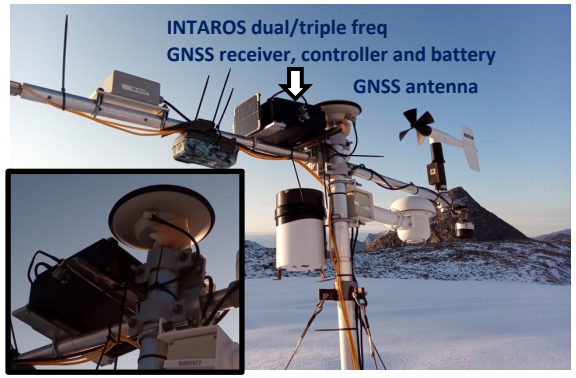
Five SnowFox instruments (water-equivalent of above-laying snow) deployed on the Greenland ice sheet in 2018-2020





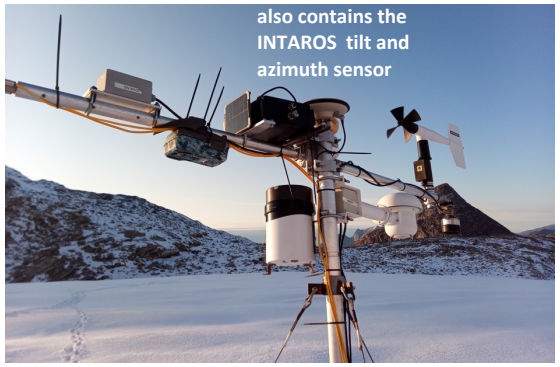
Precise AWS positioning on ice sheet with new GNSS

- In situ validation data for satellite SAR velocity & altimetry products
- Constrain elevation of barometer
- Support local strain network for ice dynamics
- Deployed since 2018, performance of new instruments significantly better than initial requirements



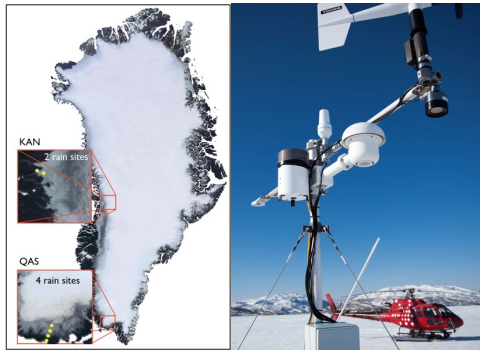
Radiometers with improved tilt and azimuth

- Improve correction for radiometer tilt for changes in azimuth and remove alignment error between radiometer and tilt sensors
- Provide accurate in situ validation data for satellite albedo products
- Deployed since 2019 with GNSS



Experimental rain gauges on ice sheet

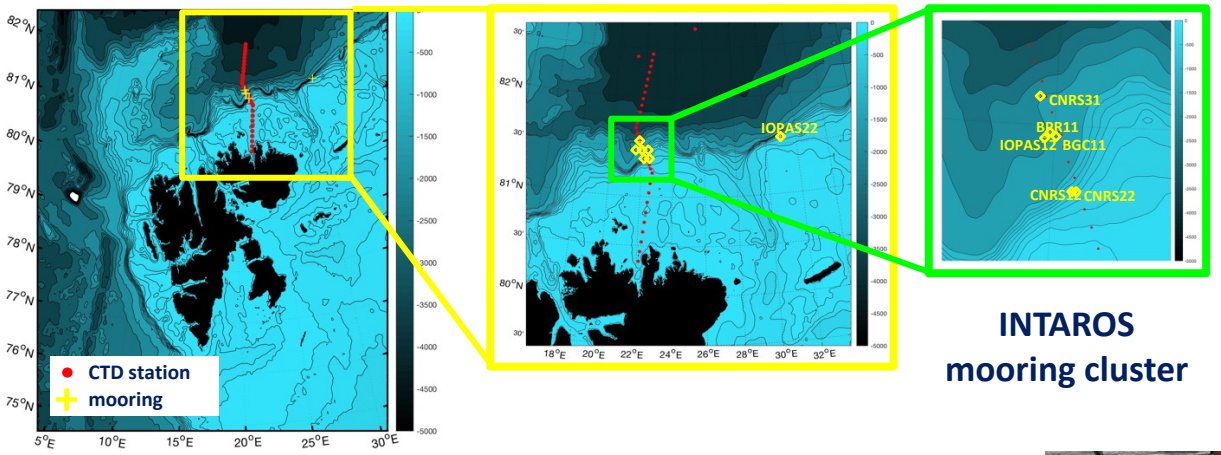
- Experimental deployment of rain gauges since 2018 (three sites with new setup)
- Implementation of a new AWS system including a rain gauge at all >20 PROMICE locations starting in 2021



Enhancement of *in situ* observations in the Arctic

Moored observatory north of Svalbard towards the deep Nansen Basin

Moorings with profiling and point measurements of physical and sea ice variables (IOPAN, LOCEAN, UiB-GFI, NERSC)



INTAROS mooring cluster

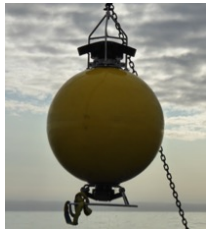
Pilot experiment in 2017-2018: 2 moorings for physical obs

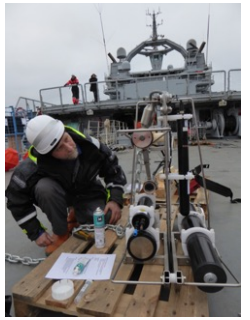
First deployment 2018-2019: 7 moorings with multidisciplinary

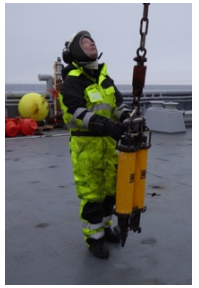
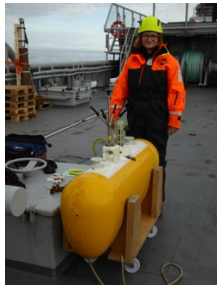
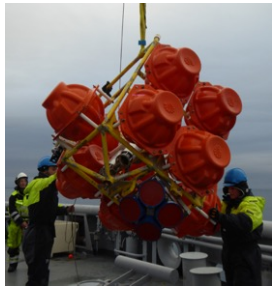
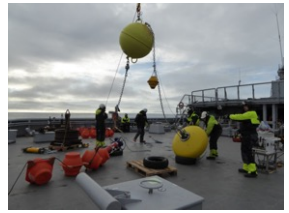
Second deployment 2019-2020: 4 moorings

- Mooring operations in collaboration with the Norwegian Coast Guard (using the icebreaker KV Svalbard)
- CTD, optical, biogeochemical and turbulence measurements on stations during mooring cruises







INTAROS moorings 2017-2021 instrumented with:

- Moored McLane Profilers (temperature, salinity, currents)
- TRDI QM and LR ADCPs (ocean currents)
- Signature 55 Dual Freq Nortek ADCPs (ocean currents, dual res./range)
- Nortek Signature 250 ADCPs (ocean currents, sea ice drift and draft)
- Microcats SBE37 CTD(O) sensors
- RBR and SBE56 temperature and pressure recorders

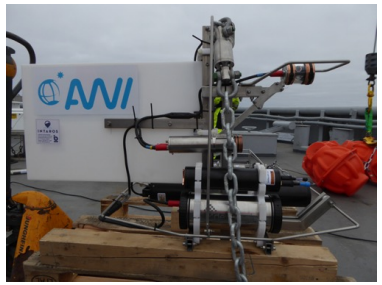
Enhancement of *in situ* observations in the Arctic

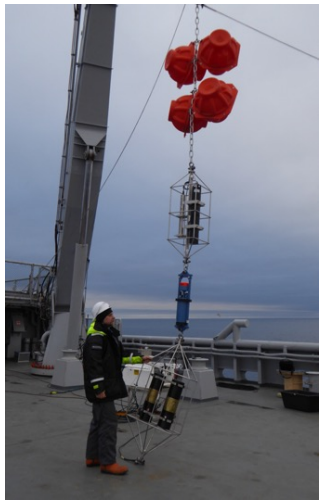
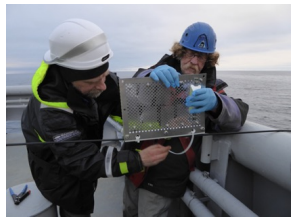
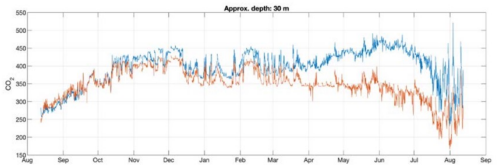
Moored observatory north of Svalbard towards the deep Nansen Basin

Multidisciplinary mooring for BGC and biological measurements (UiB-GFI, AWI, NIVA, IOPAN, NERSC)

- A suite of instruments for carbon system, biological and physical parameters: pH, pCO2, nitrate, CTDO sensors, Octopus package (UVP particle camera, nitrate sensor and ECO Triplet-w for chl a and FDOM fluorescence and backscattering), passive contaminant samplers)
- Deployed for 2018-2019 in cluster with the mooring at 850 m, measuring physical ocean and ice parameters

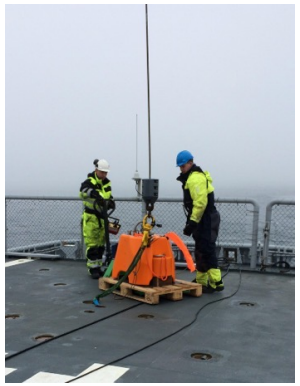


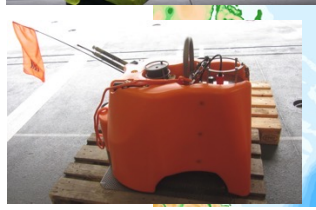
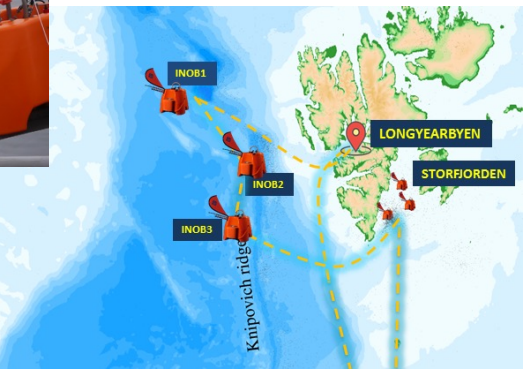


Ocean bottom seismometers in Fram Strait (GEUS, UiB-GEO) and BPR recorders (UNIS)

- Three OBS for for solid Earth processes and geohazards deployed in 2018-2019 and 2019-2020
- Deployment locations in deeper parts of Fram Strait, close to Mid Atlantic Ridge (seismically active regions) and in Storfjorden
- Data will be used to analyze earthquake sources to improve earthquake monitoring in the Arctic region



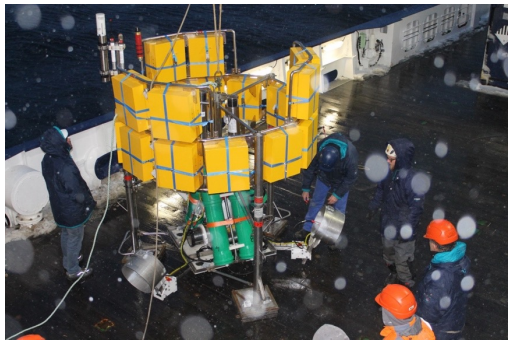
Enhancement of *in situ* observations in the Arctic

Marine observations in Fram Strait and Svalbard fjords

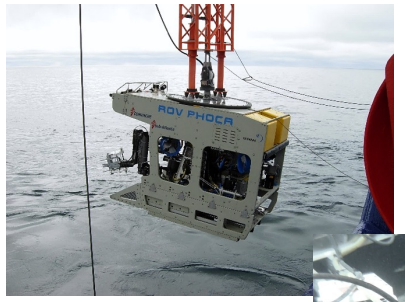
Autonomous arcFOCE (Arctic Free Ocean Carbon Enrichment) system (AWI)

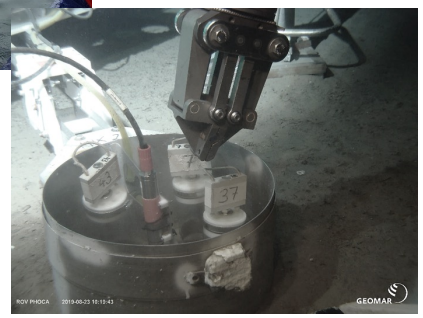
Experimental set-up (based on a free-falling system - bottom-lander)

- **CO_2 storage** (discharge of CO_2 from pressure cylinders)
- **CO_2 enrichment unit** (CO_2 mixed with seawater)
- **Experimental chamber** (mesocosms)
- **Pump system** (seawater enrichment & feed into mesocosms)
- **pH sensors** (mesocosms, CO2-seawater mixing, reference sensor)
- **Energy supply** (batteries)
- **Electronical control unit**

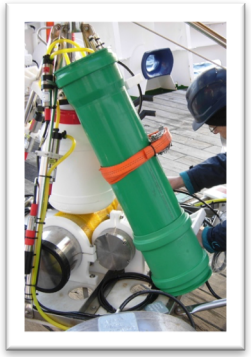


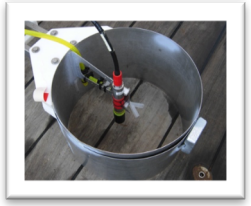
First long-term deployment from RV Polarstern for 2018-2019

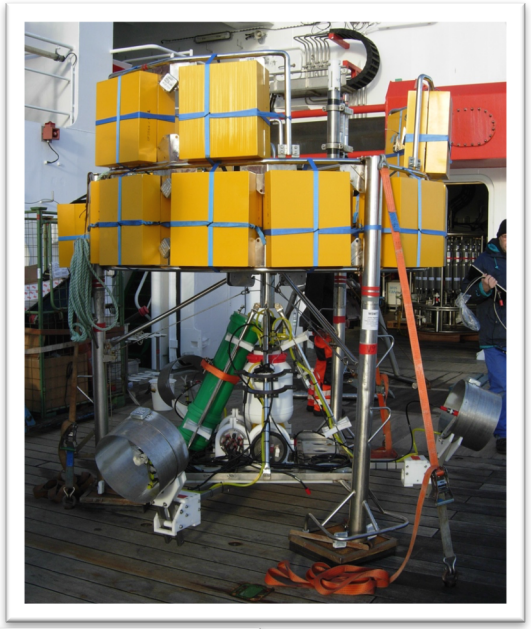




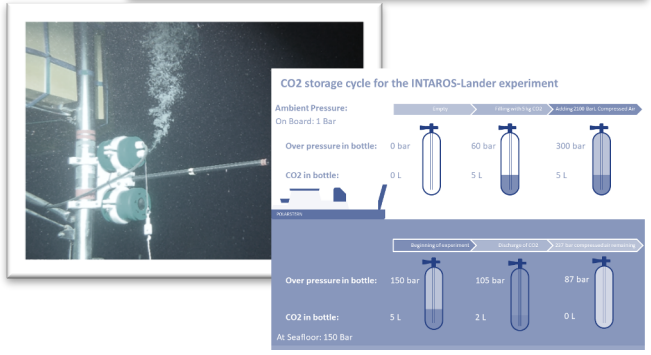
Sediment sampling before recovery in summer 2019 using ROV PHOCA







Redeployment in 2021 from RV Polarstern after reconfiguration of experimental setup

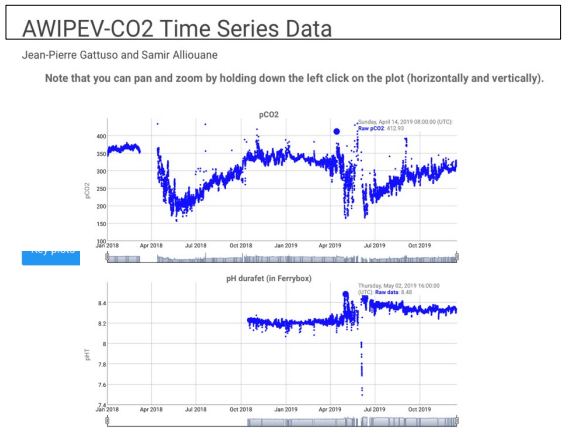


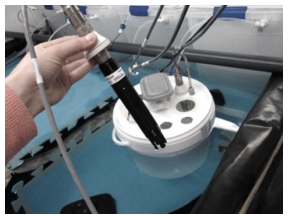
Enhancement of *in situ* observations in the Arctic

Marine observations in Fram Strait and Svalbard fjords

Real-time measurements of pCO2 and pH, monitoring of carbon cycle parameters in Kongsfjorden (CNRS-LOV)

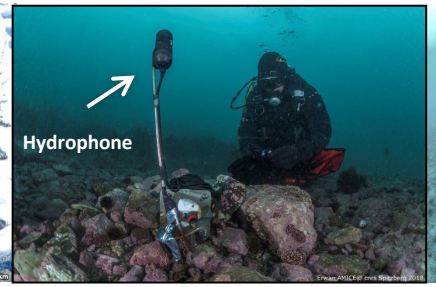
- AWIPEV observatory in Kongsfjorden, water pumped from 12 m water depth at Ny-Ålesund
- pCO2 (since 2015) and TA (since 2016) measurements
- Under INTAROS (since 2017) pH measurements:
  - Durafet pH sensor in the FerryBox
  - continuous measurements in fjord water (seaFET)
  - discrete pH samples once a month for calibration
  - regular maintenance twice a year





Ecological monitoring using underwater passive acoustics in Kongsfjorden (CNRS-IUEM)

- Monitor the soundscape diversity including benthic fauna sounds, marine mammals vocalisations, ice sounds, boat noise, wind/wave noise - antropophony (shipping noises) and biophony
- Long-term deployment at 10 m depth in the fjord entrance
- Instrument rotation by divers: up to 3 acoustic recorders, one pressure sensor
- 2020 summer acoustic dataset will allow comparing the ambient noise during the pandemic and associated reduced tourist shipping activity with previous years

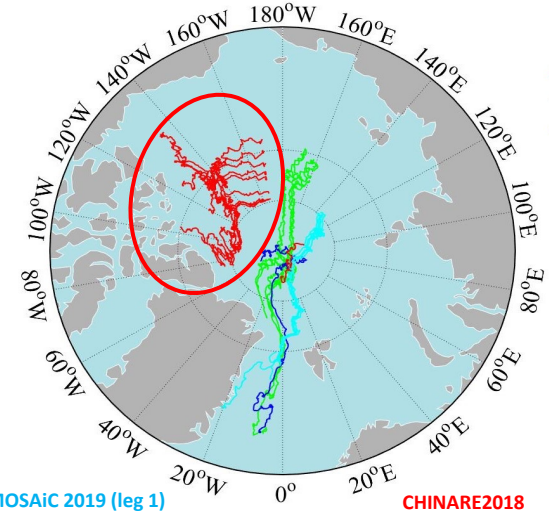


Enhancement of *in situ* observations in the Arctic

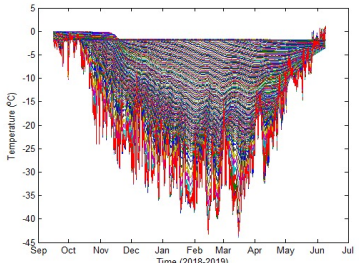
Distributed observing systems for ocean and sea ice

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

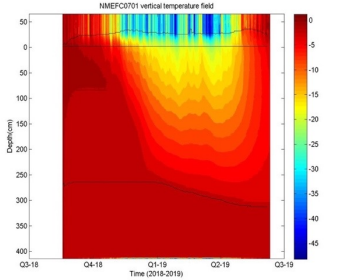
- Over 20 SIMBA ice mass balance buoys deployed by FMI during different field campaigns in 2018-2020
- Some of the buoys were in-kind contributions from collaborators (PRIC, NMEFC and AWI)
- Compared with ice camp 20 years ago, the ice drift seemed much faster



MOSAiC 2019 (leg 1)
MOSAiC 2020 (leg 5)
Young Sound 2020, landfast ice
CHINARE2018
NOBAS2018
CAATEX2019



SIMBA temperature in air-snow-ice-ocean

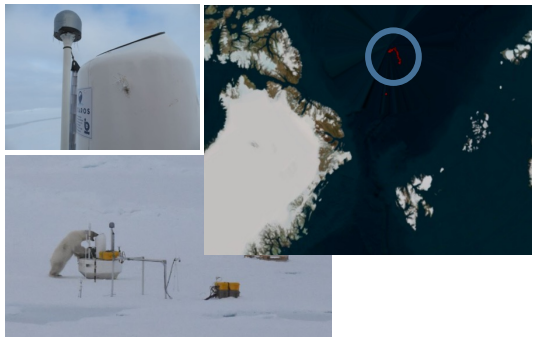


IAOOS ice-tethered platform (IAOOS Equipex for IOPAN) and deep basin mooring (IOPAN)

IAOOS platform deployed in the central Arctic in 2018 by the EQUIPEX IAOOS team

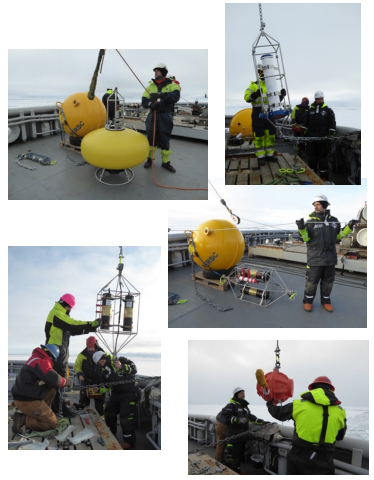
Data received for one month:

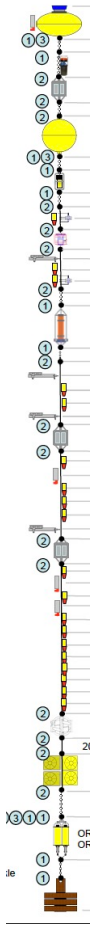
- Ocean temperature, salinity and oxygen profiles 5-600 m
- SIMBA temperature profiles (air, snow, sea ice and ocean)
- Air temperature and pressure
- Microlidar profiles



Multidisciplinary deep ocean mooring (2019-2020) in the central Nansen Basin

Deployed/recovered from KV Svalbard in collaboration with the CAATEX project





Enhancement of *in situ* observations in the Arctic

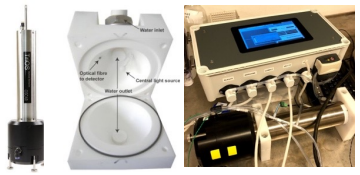
Distributed observing systems for ocean and sea ice

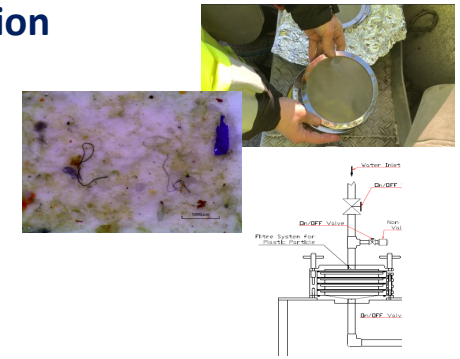
Autonomous sensors/samplers for FerryBoxes in the Arctic (NIVA)

- FerryBox on MS Norbjørn (Tromsø-Longyearbyen) with 25-30 roundtrips/year (northernmost regular shipping route in the world)

Novel sensors and samplers developed:

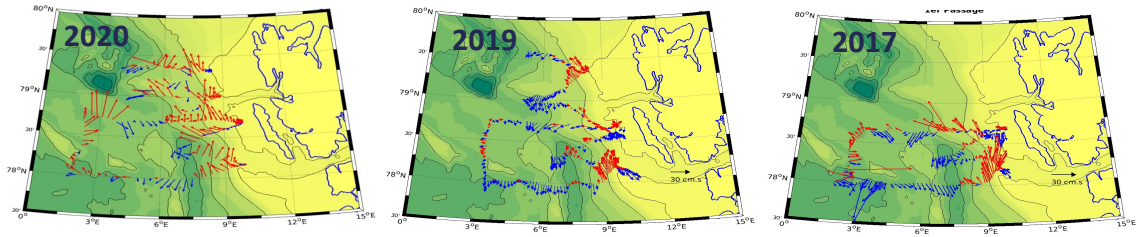
- Combined pH/CO_3^{2-} sensor: UV-Vis spectrophotometric detection
- Integrated sphere absorption sensor: cDOM, chl, and phytoplankton accessory pigments
- Microplastics sampler: 3 size fraction





Endurance glider lines for high-resolution ocean measurements around Svalbard (CNRS-LOCEAN)

- Autonomous gliders in the Atlantic Water current in ice-free waters west and north of Svalbard
- Gliders equipped with Seabird T,C,P sensors, DO optode, chl-a and CDOM fluorimeters, optical backscatter
- High resolution profiles down to max. 1000 m at the repeated sections across in eastern and northern Fram Strait with with mission duration ca. 2 months

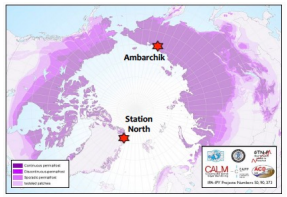


Enhancement of *in situ* observations in the Arctic

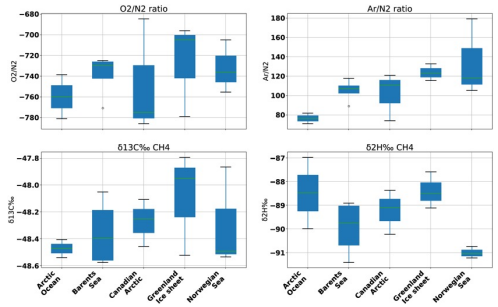
Distributed observing systems for land and atmosphere

Automated flask sampling system for greenhouse gases monitoring (MPG)

- Automated collection of air samples under standardized conditions for continuous monitoring of the atmospheric trace gases CO_2, CH_4 and H_2O
- GHG isotopes to separate emission sources
- Evaluate and improve atmospheric transport model results using multiple species fingerprints (SF_6, N_2O, O_2/N_2, ..)
- Developed and in 2019 installed in the Station North in Greenland, planned relocation to Siberia in 2021



First results of selected trace gas patterns



De-icing system for atmospheric instruments, novel soil temperature and soil diffusivity systems for trace gases in the Barrow cluster (UNEXE, USFD)

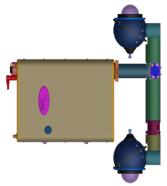
- Eddy-covariance towers with de-icing system (Barrow site cluster) and soil diffusivity system to estimate CO_2 and CH_4 soil concentration and contribution of different soil layers
- Ice-free instruments needed, but heating disturbs instrument performance so customized heating devices and 'smart' heating algorithm developed
- High-resolution temperature sensing systems for continuous measurements of water table and thaw depth with thermocouples located every 5 cm

Enhancement of *in situ* observations in the Arctic

Distributed observing systems for land and atmosphere

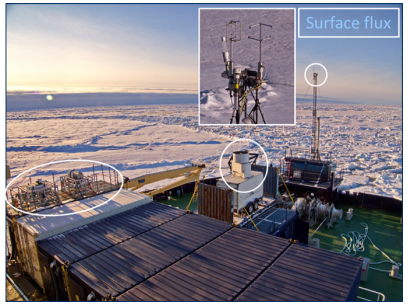
Novel albedo/surface measurements for radiation monitoring in boreal forest (FMI)

- Improved ground-truthing of satellite remote sensing products (spectro-albedometer, VNA-based radar system to monitor soil, snow and surface vegetation properties)
- Continuous observations with scatterometer together with passive microwave radiometers and an optical spectrometer since 2018 at IOA (Intensive Observation Area) at the FMI Sodankylä Arctic Space Centre
- Novel SVC-FMI automatic spectro-albedometer adapted to work in polar conditions and covering the full solar range (350-2500nm) at high temporal and spectral resolution



Semi-autonomous system for atmospheric observations in the central Arctic for icebreaker Oden (SU)

- A low-maintenance atmospheric observatory for IB Oden, first deployed during the Arctic Ocean AO2018 expedition
- Surface flux installation on the bow mast, advanced weather station on the 7th top deck (incoming broad-band radiation, surface temperature, and visibility and cloud-base lidars) and regular 6-hourly radiosoundings from helideck
- Doppler cloud radar and scanning microwave radiometer provided by other groups, planned in future
- Second deployment performed as a part of the 2019 Ryder expedition (AO2019)



Enhancement of *in situ* observations in the Arctic

Summary and further steps beyond INTAROS

- New *in situ* observations collected across all Arctic domains: ocean, sea ice, atmosphere and land
- New technologies developed or adapted to polar conditions for long-term use in a sustained Arctic observing system
- Lessons learned for challenges and requirements, related to implementing new observations and integration of new technologies with existing observatories
- Collected data currently under processing and start to flow into open repositories, most of them will be publicly available in the near future according to FAIR (see poster on INTAROS data management by Hamre et al.)
- Majority of observing platforms, networks and reference sites will be operated beyond INTAROS with the long-term perspective to become important components of a future sustained integrated Arctic observing system – INTAROS roadmap

THANK YOU FOR ATTENTION

INTAROS

www.intaros.eu

Only selected highlights of INTAROS *in situ* measurements were presented

For more information please visit the INTAROS website: www.intaros.eu
and INTAROS data catalogue: https://catalog-intaros.nersc.no