51st International Liege Colloquium on Ocean Dynamics: Polar Ocean facing changes
Session 3 : Observing changes
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# Argo floats in the Nordic Seas and the European Artic Ocean

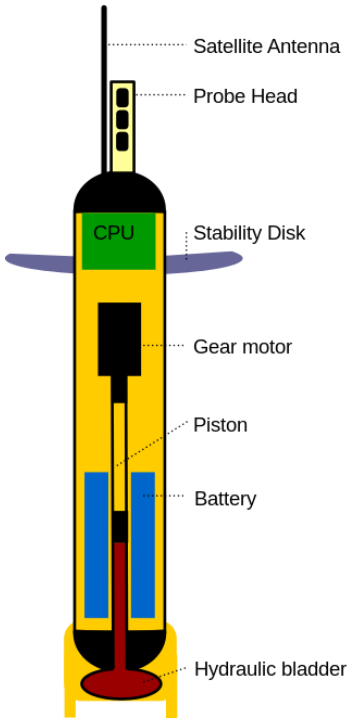
## avoiding sea ice and detecting climate change

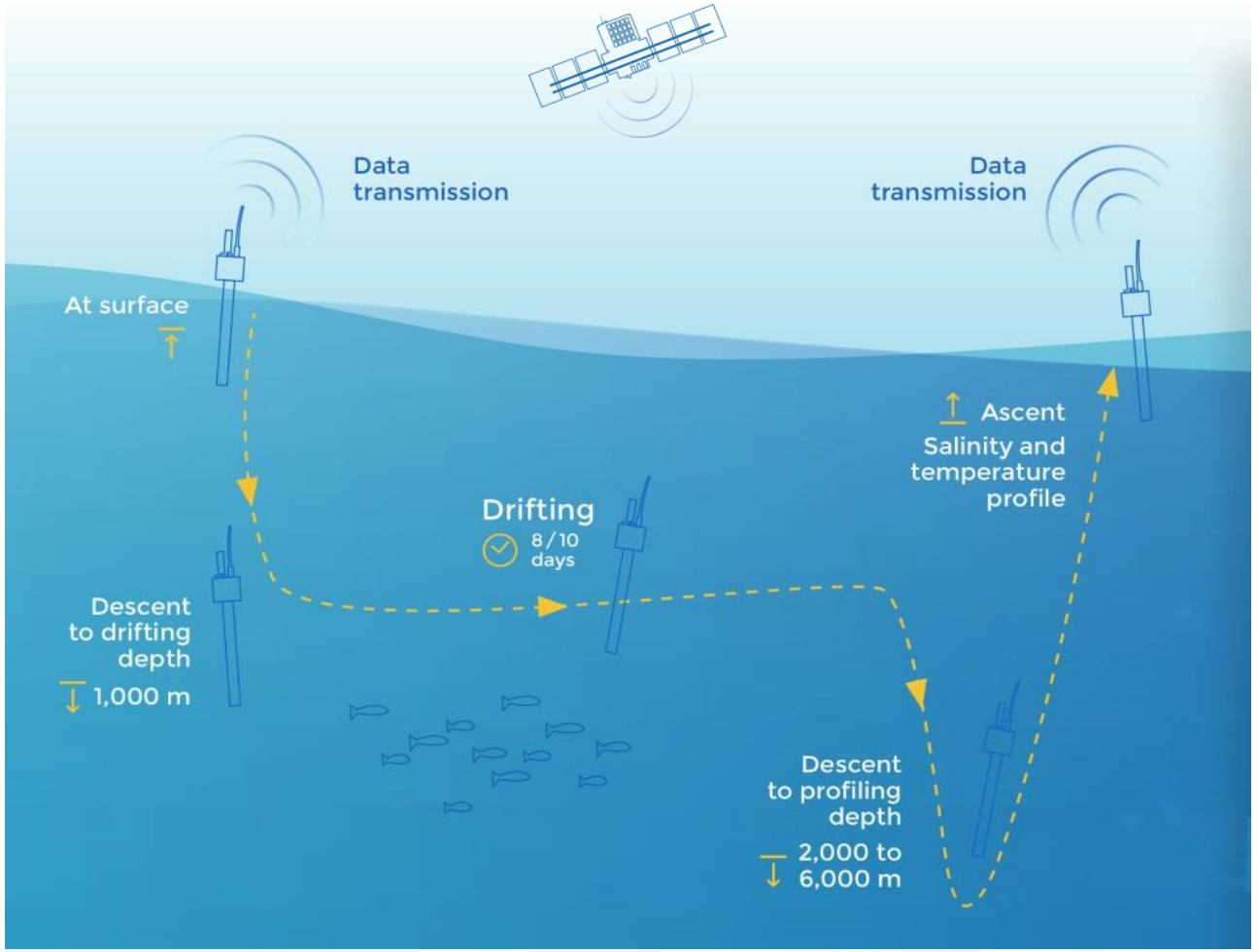
**Ingrid M. Angel-Benavides**
Based on work of
Birgit Klein (BSH), Katrin Latarius (BSH), Noé Poffa (IFREMER) and Tero Purokoski (FMI)

BSH: Federal Maritime and Hydrographic Agency (Germany)
Euro-Argo: The European contribution to the global Argo ocean observation network

# Argo: autonomous profiling floats

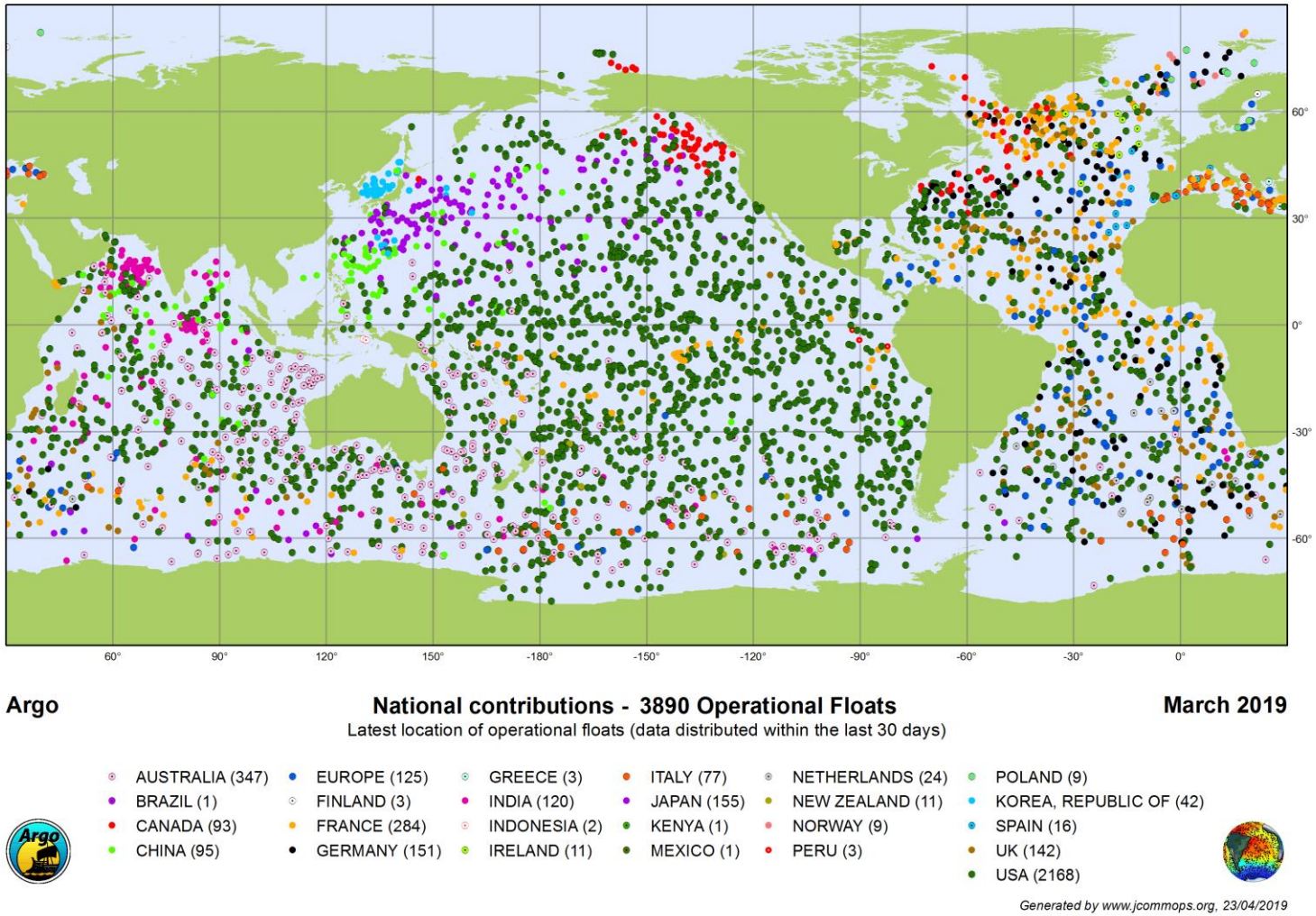
- Measure ocean temperature and salinity up to 2000 m depth




# The Argo network: a global *in situ* observing system

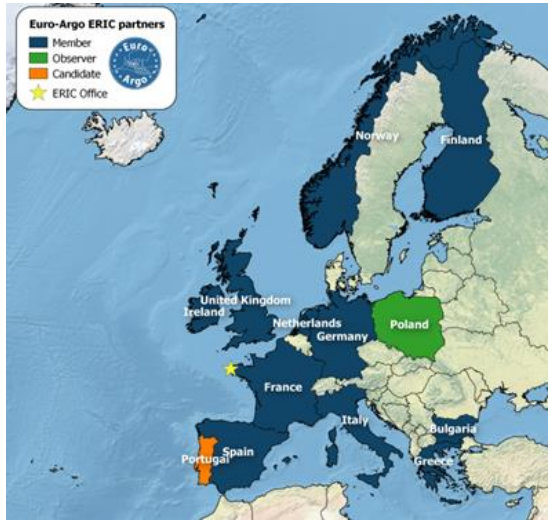
- About 4000 autonomous profiling floats all over the globe
- The network delivers essential data for
  - Ocean analysis and forecasting systems
  - Climate change research

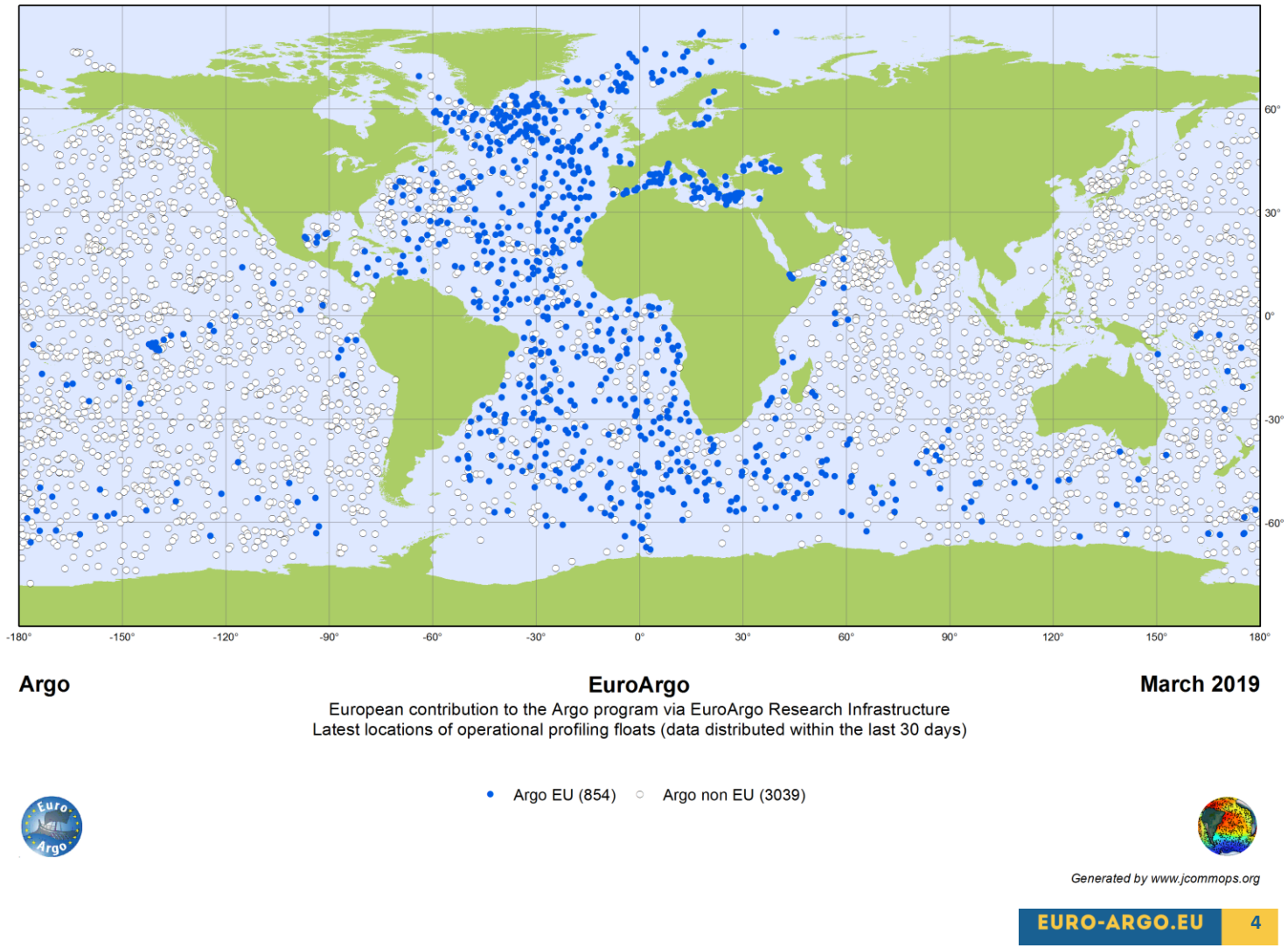


# The Euro-Argo ERIC - European Research Infrastructure Consortium

**<u>Main Objective</u> : To coordinate and sustain the European contribution to the global Argo network (1/4 of the network)**

- Euro-Argo was part of the 2006 ESFRI Roadmap
- **Was created in May 2014** and has increased from 9 funding members to 12 members in 2018.

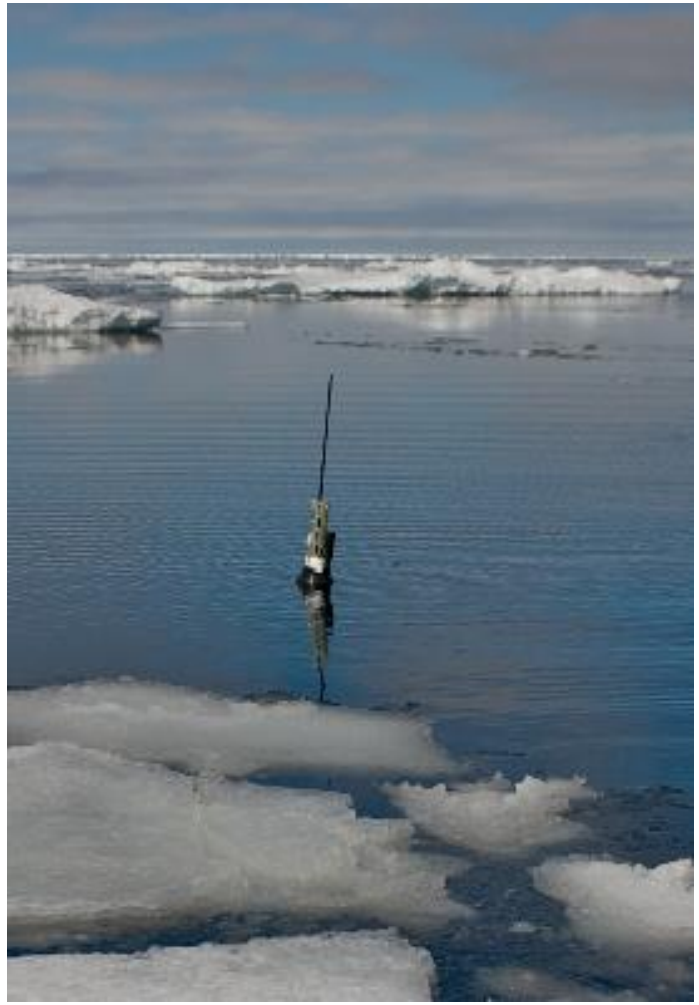


# Euro-Argo ERIC: Extending to high latitudes

**<u>Objective</u> : Extend the Argo mission to higher latitudes and partially-ice covered areas**

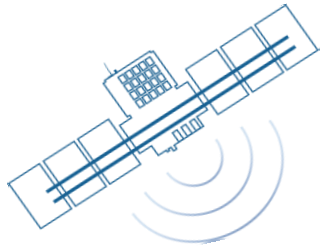
- European Artic Ocean and the Nordic Seas (Greenland, Iceland, and Norwegian seas)
  - Targets for a regional enhancement of the array
- Crucial for the understanding of the global ocean circulation
  - Hotspot for water mass formation
  - Exchange corridor for Atlantic and Polar waters.
- Two main challenges:
  - Sea-ice
  - Delayed mode data quality control.

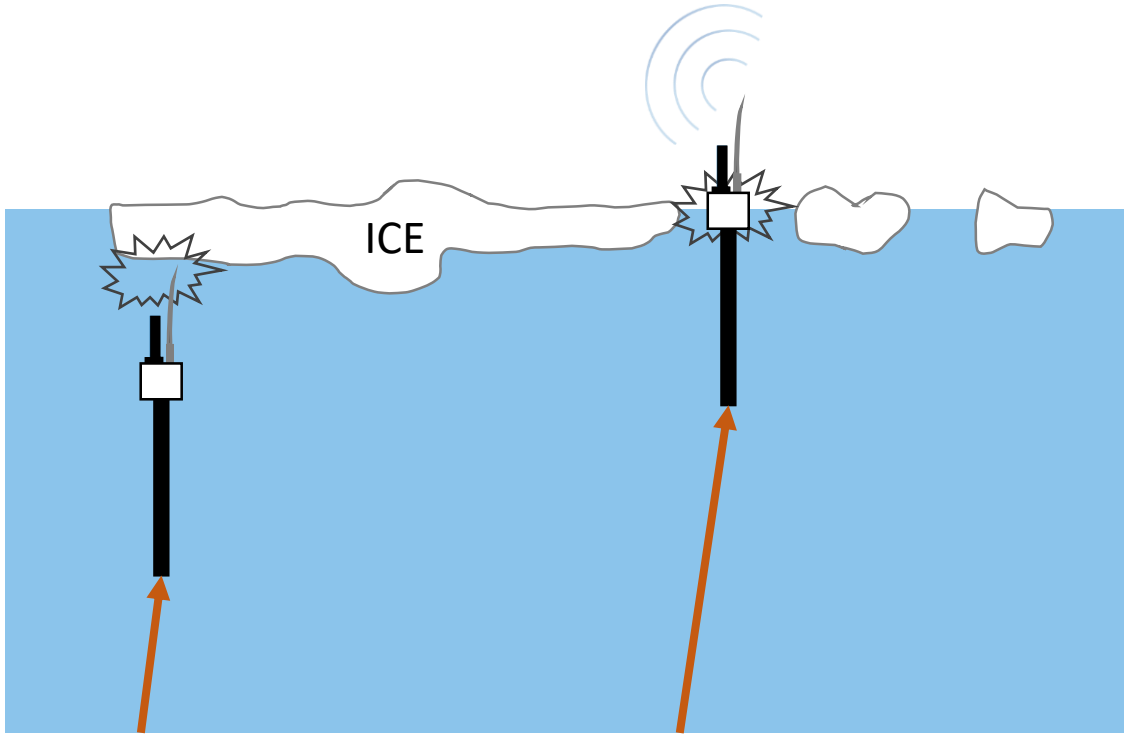


# Argo floats: Operating in partially-ice covered areas

- No access to free surface
  - No data transfer
    - ✓ Storage capabilites
  - No geolocation of the profile
- Damage during ascending or in the surface
  - Improved hardware
  - Avoid surface
    - ✓ *In situ* sea ice detection

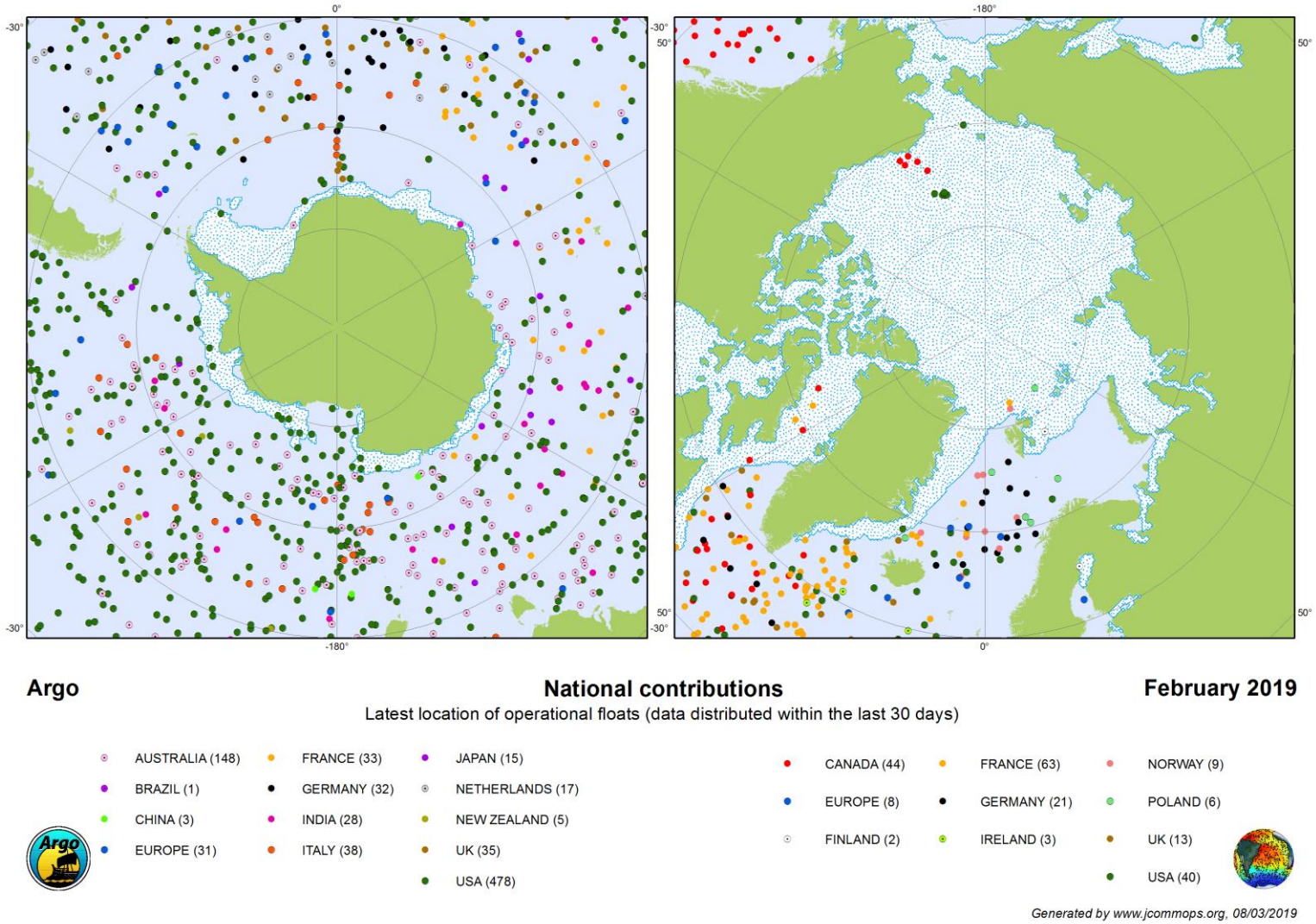
      Data collected during ascent





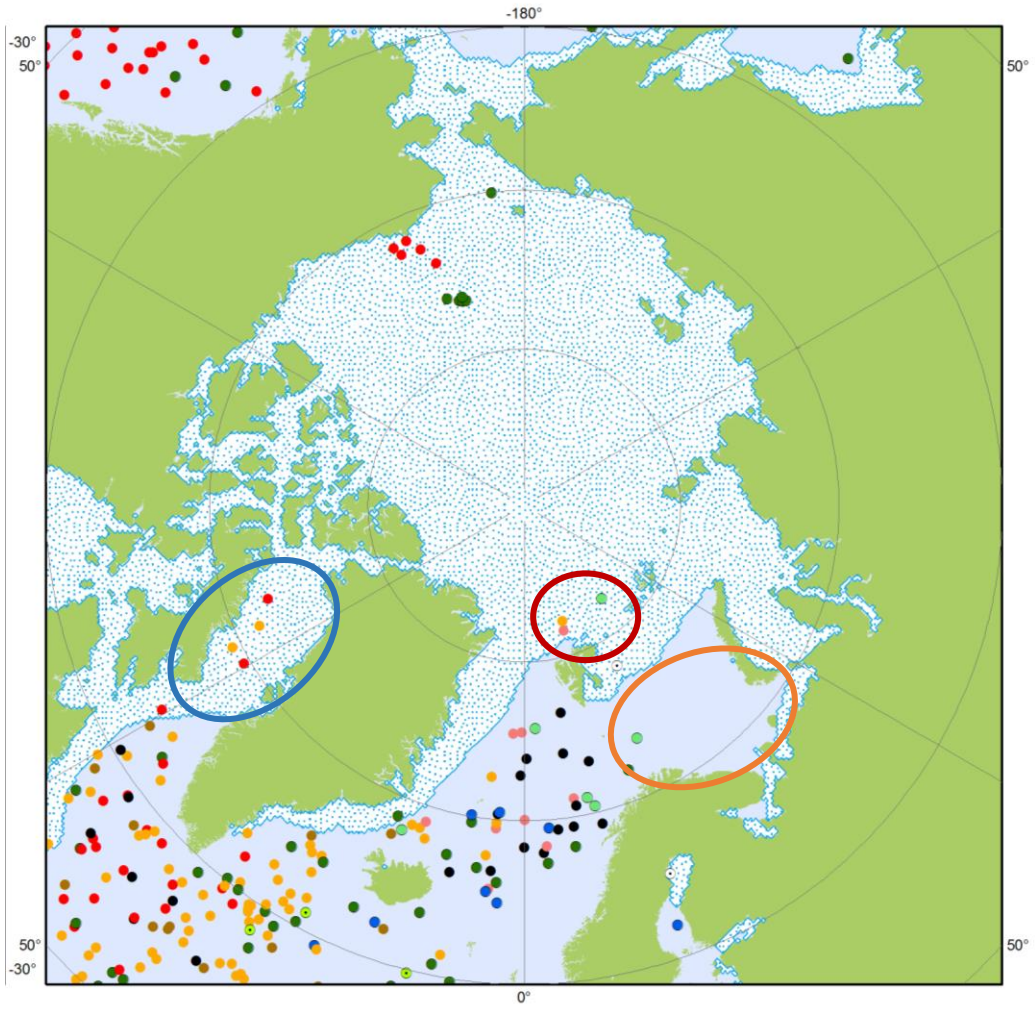
# Argo floats: Operating in partially-ice covered areas

- Southern Ocean
  - Reasonable coverage
  - Ice avoidance is established and working well
- Arctic
  - Few floats.
  - Strategies need local adaptations

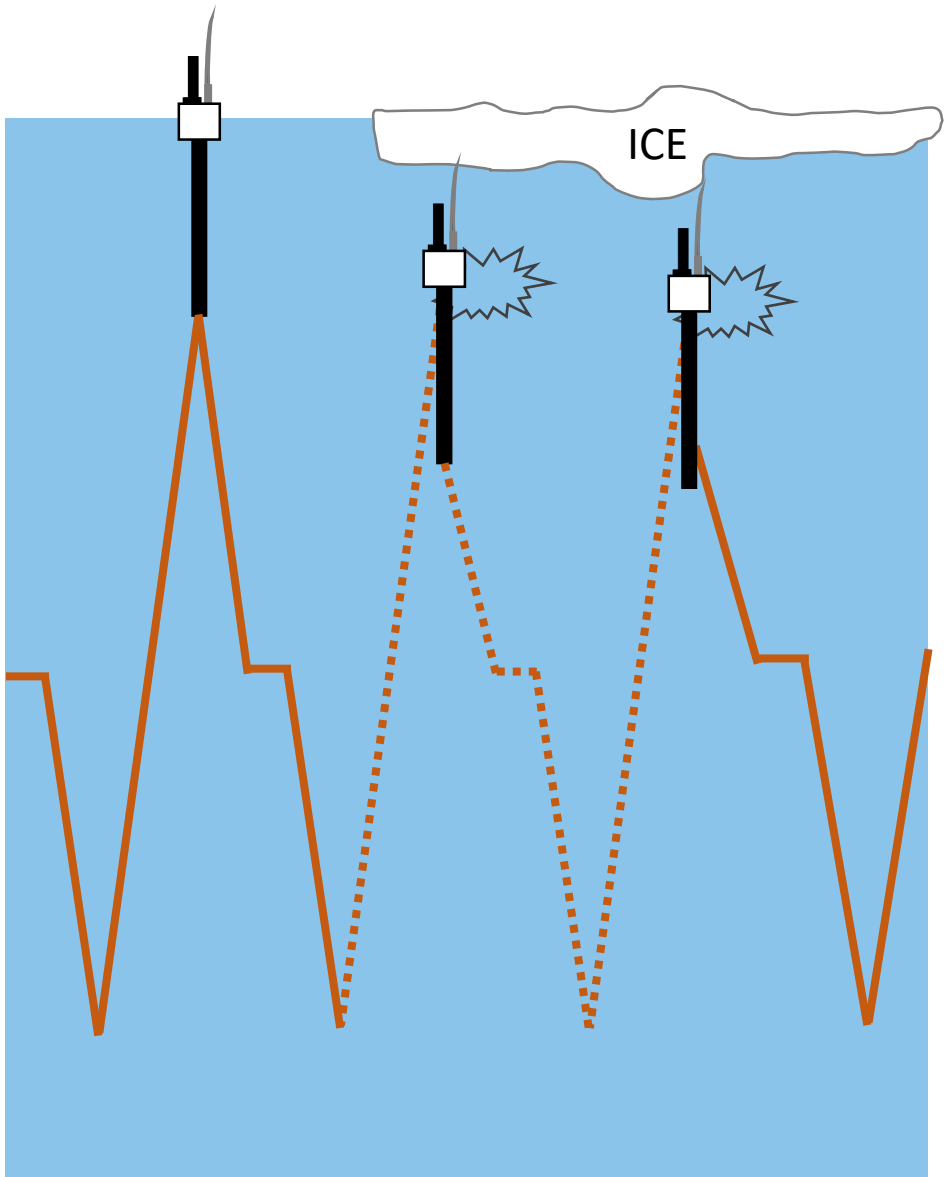


# Argo floats: Operating in partially-ice covered areas

- Pilot projects in the Arctic and Nordic Seas:
  - Tests occurring in Barents Sea, north of Svalbard, and Baffin Bay (NAOS project)
  - Collaboration opportunities within INTAROS project for underwater positioning (acoustic sources)
  - **First promising results of Ice Sensing Algorithm definition for the Barents Sea and north of Svalbard**

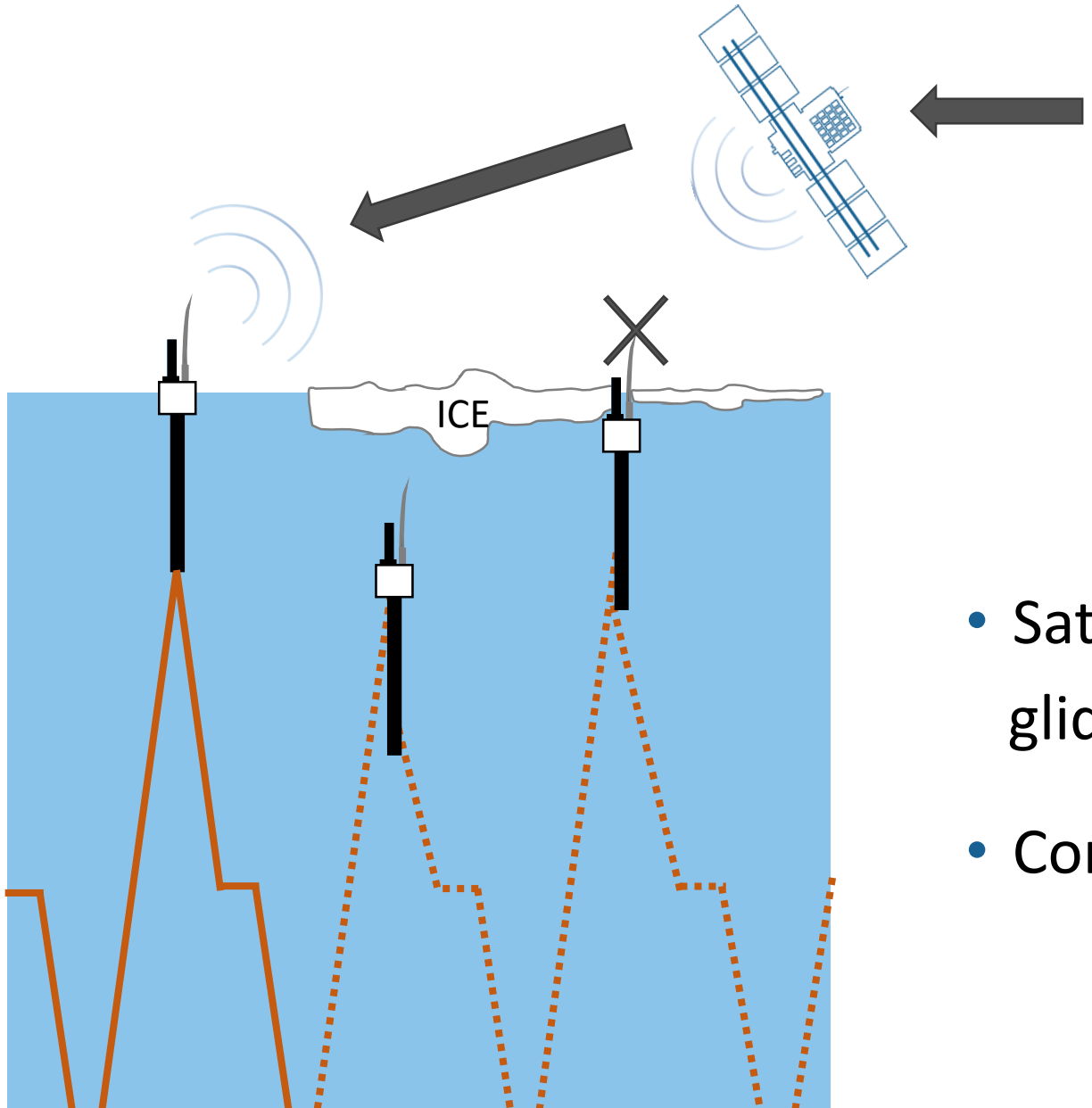


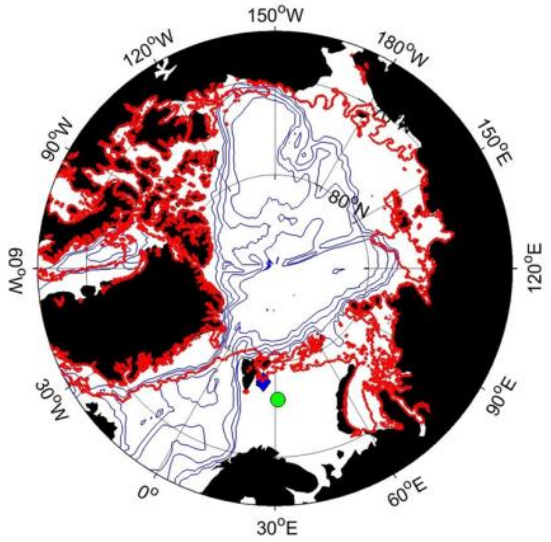
# Argo floats with ICE option: Ascent hanging




- Pump action does not result in pressure decrease (grounding)
- Erroneous detection: Melting water!!
- Adjust parameters for ascent hanging: pump efficiency in low termperatures
  - Pumping actions
  - Pumping time

# Argo floats with ICE option: Satellite mask

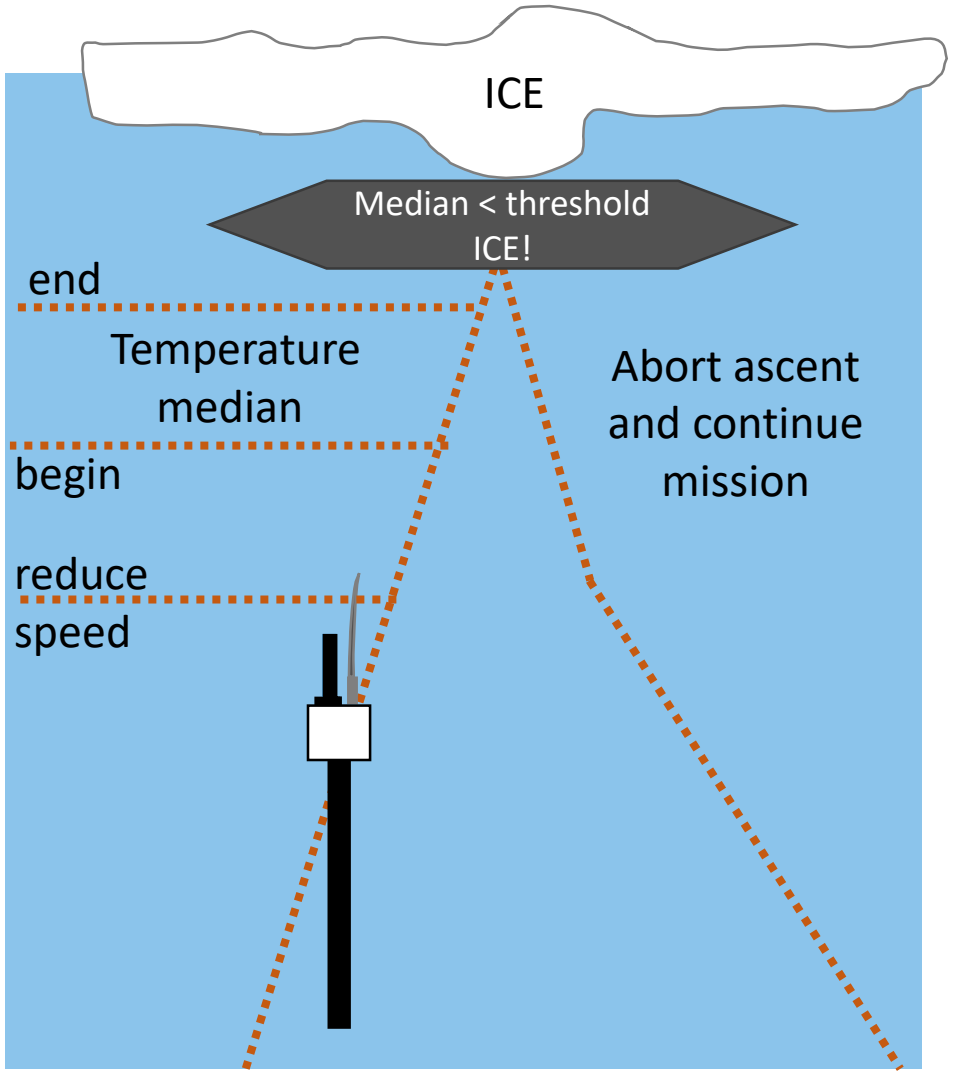



Operator:
Satellite
ice edge +
trajectory
information

- Satellite mask – Operation similar to a glider
- Communication time out: GPS & Iridium

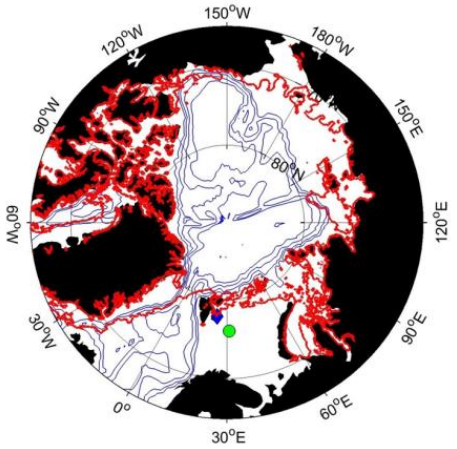
# Argo floats with ICE option: Ice Sensing algorithm

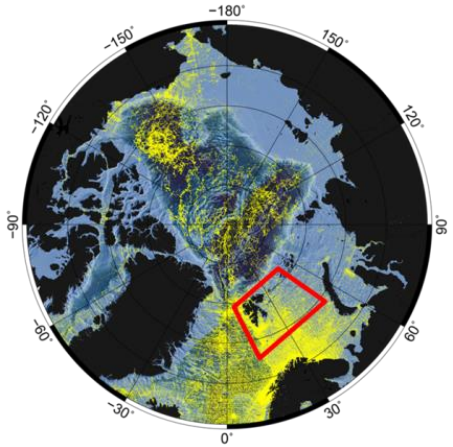



- Assumption: Temperature in the water column is related to the presence of sea ice
- Parameters
  - Initial pressure range to be evaluated
  - Median temperature threshold
    - ✓ If lower is assumed that sea ice is present = abort ascent
  - - 1.79 °C  - 50 m (Weddell Sea, Klatt et al., 2007)
- Adaptation for Artic environments (EU project MOCCA)
  - Complicated water mass structures

# Argo floats with ICE option: Ice sensing Algorithm in the Barents Sea

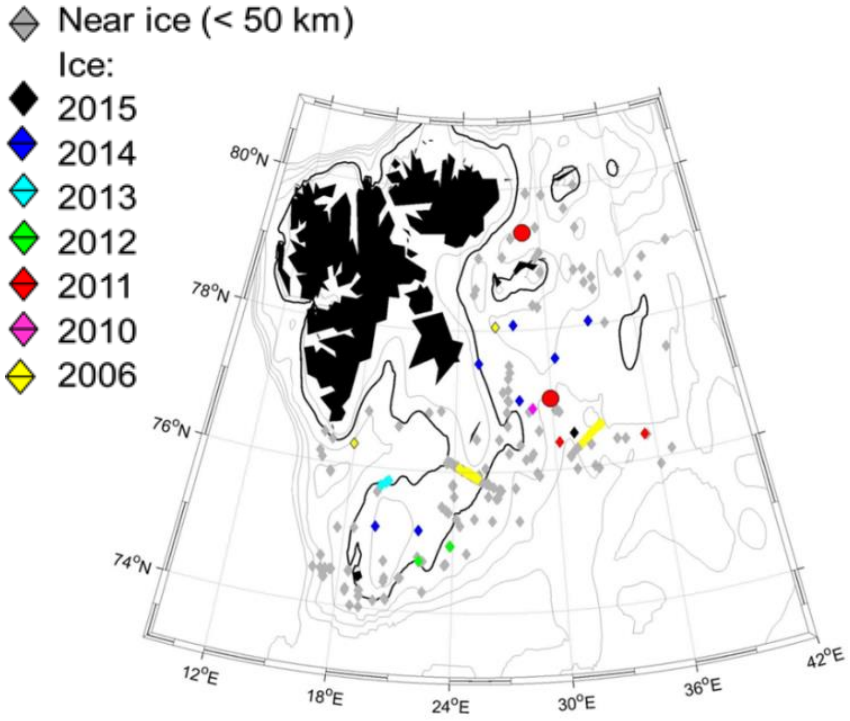
**MASIE** ice edge information



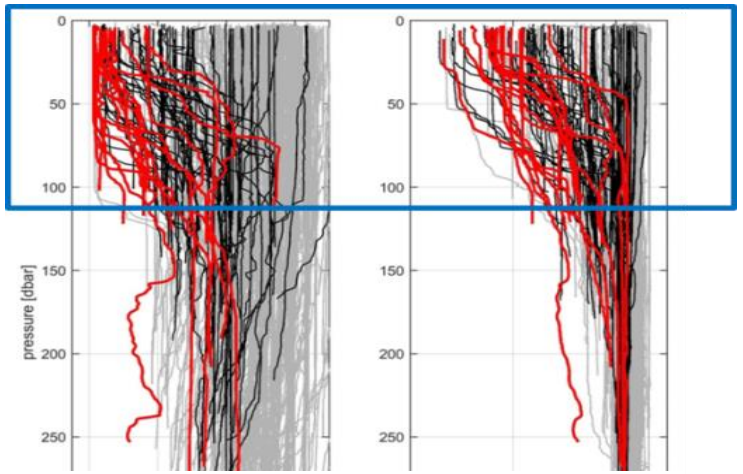




Courtesy Katrin Latarius

used to classify hydrographic profiles from **UDASH** (Behrendt et al., 2017)

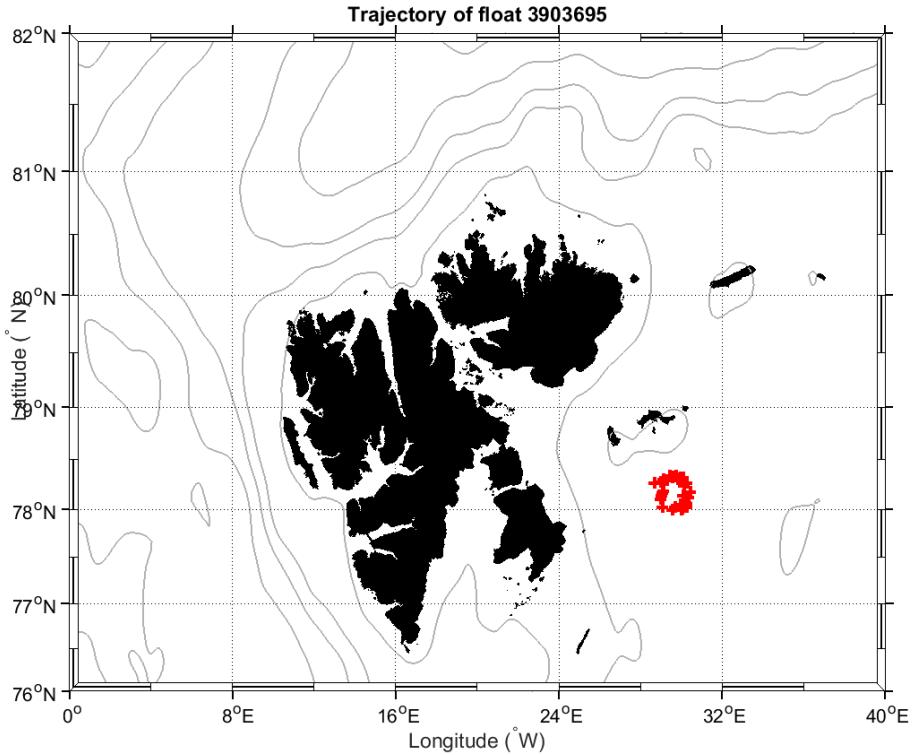


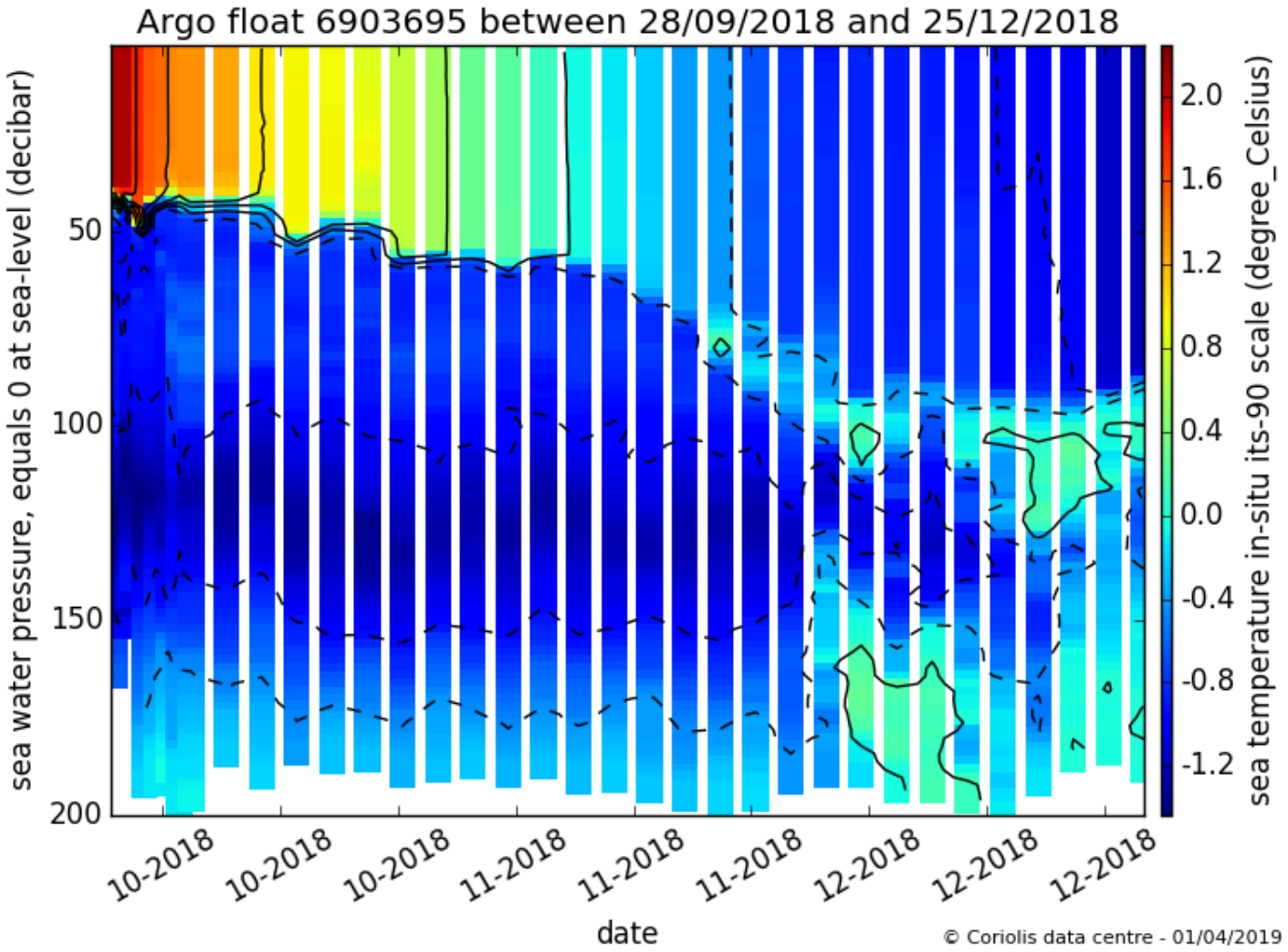

From profiles in ice and near ice (< 50 km) typical conditions for ice sensing are derived.




**Local ISA parameters**
**Temperature treshold:**
**-1.0 between 20-10 dbar**

# Pilot deployments: Argo float east of Svalbard (WMO 6903695)

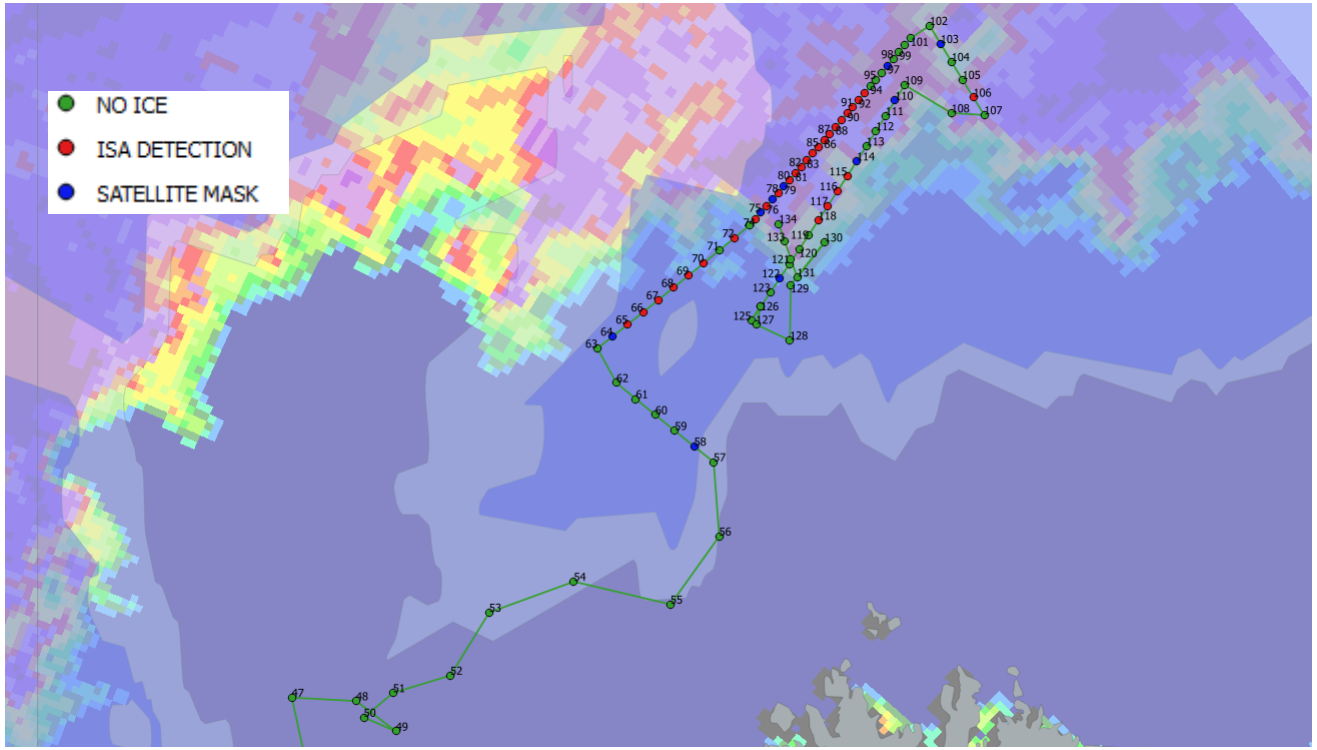



Courtesy Tero Purokoski (FMI)

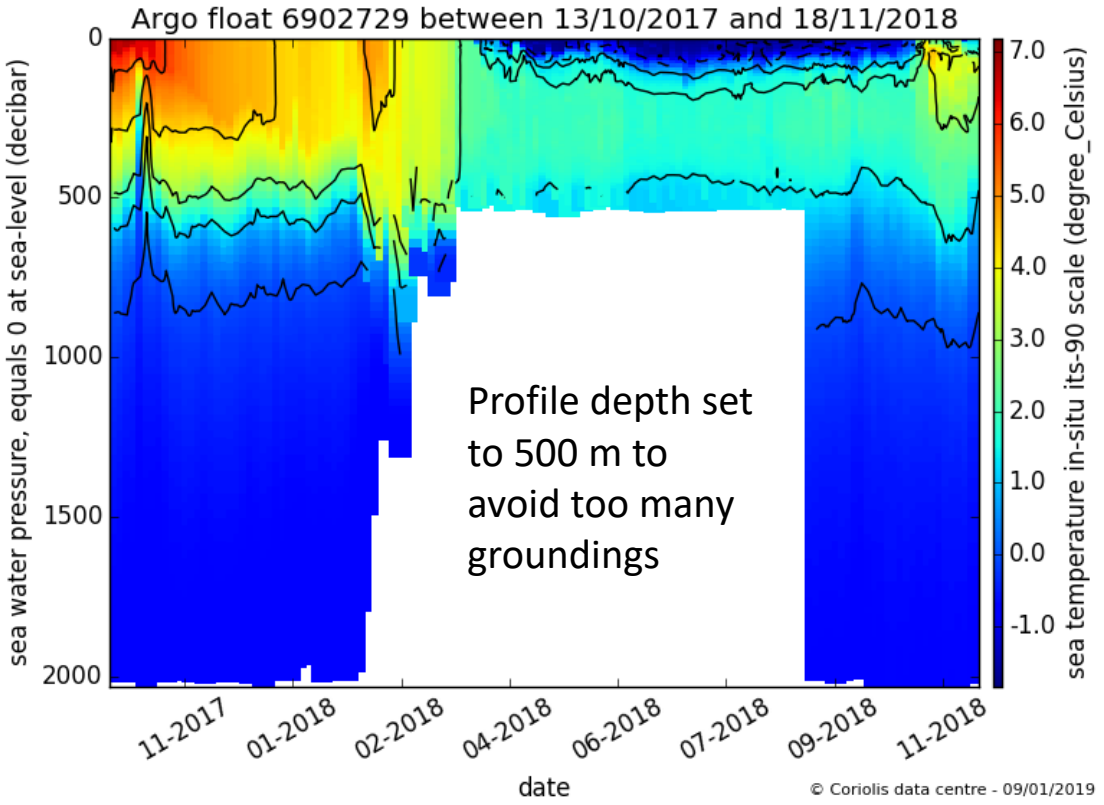
# Pilot deployments: Argo float north of Svalbard (WMO 6902729)

- ISA set to -1.6°C between 40-10 dbars
- Float under Ice (in and out) from April to October 2018




*Float trajectory and AMSR-2 image from 09/09/2018 (cycle #111)*
*Under ice positions extrapolated*

Courtesy Noé Poffa (IFREMER)

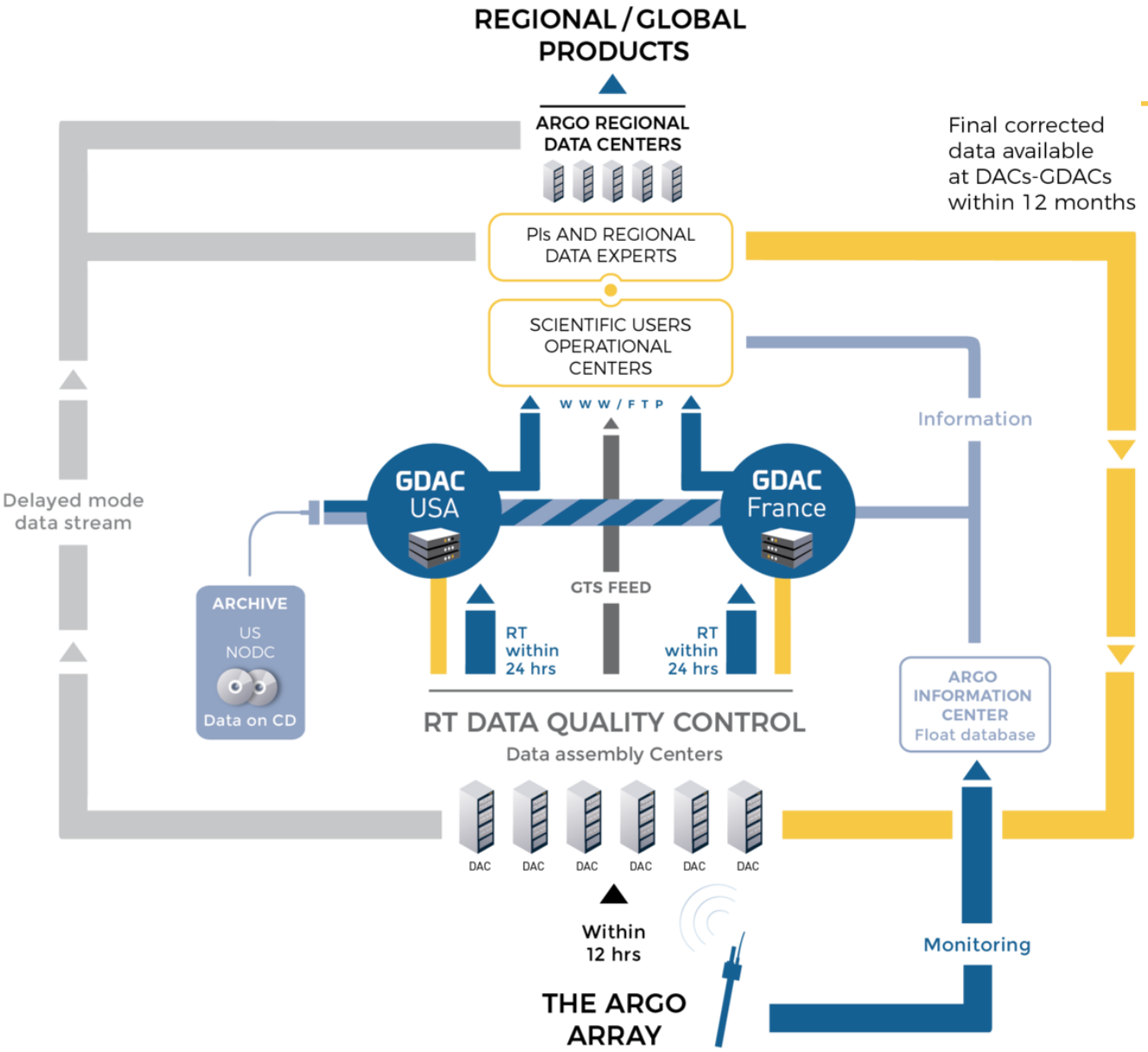


# Argo floats: Operating in partially-ice covered areas

- Feedback from deployed floats
- More ISA adaptations
  - Other regions
  - Other options
    - ✓ Salinity?
    - ✓ Other Statistics (p. ex. minimum)
- Work with the float manufacturers to incorporate alternative ISA options in the floats.

# Argo quality control

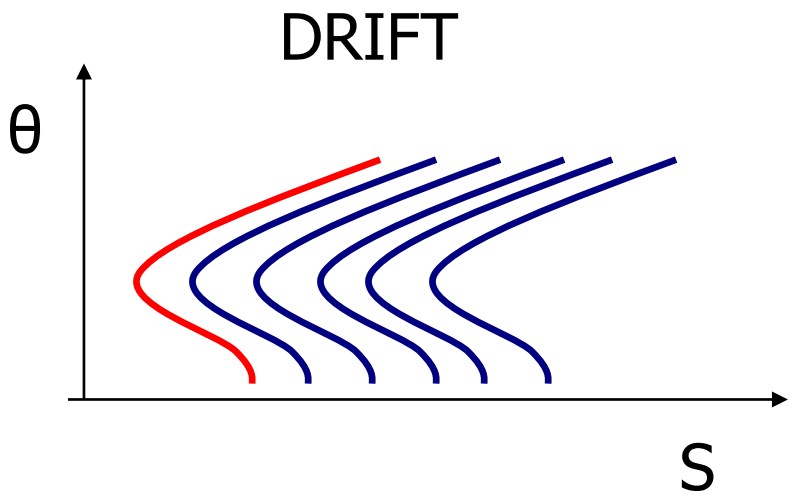
- Real-time-mode (RT) data stream
- Delayed-mode (DM) data stream
  - Timeframe: 12-18 months after transmission.
  - Who/Where: Qualified operator
  - Provide statistically justified corrections using common methods.
  - Product: Adjusted data with error estimates.




All data are available from the two Argo Global Data Assembly Centres: Coriolis at IFREMER, and USGODAE at Monterey.

# Salinity Delayed-mode quality control (DMQC)

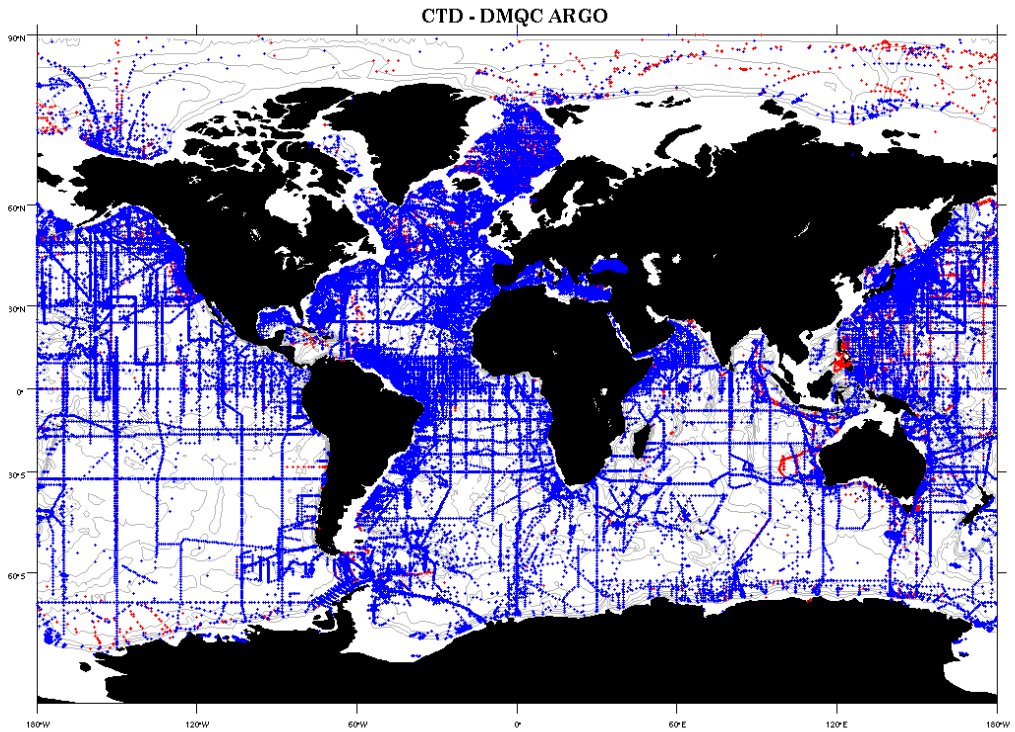
- Over time, the conductivity sensor can experience instrument drift that gives salinity measurements an artificial trend.
- The measurements are not within the required accuracy (0.01) (Argo Science Team, 2000).
- Causes
  - Leakage into the conductivity cell
  - Faulty electronic components




**Need for delayed-mode checks and corrections (when possible)**

# Salinity Delayed-mode quality control (DMQC)

- OW method (Owens & Wong, 2009)
- Historical salinity data (from reference CTD data) objectively interpolated to the float positions and observed θ surfaces
  - What **should be** the salinity at float locations?
  - 10 'best' levels: Deep water masses
- Salinity correction is suggested
- Quality of the correction
  - Appropriate scales for the objective mapping: search elipses.
  - **Reference database**

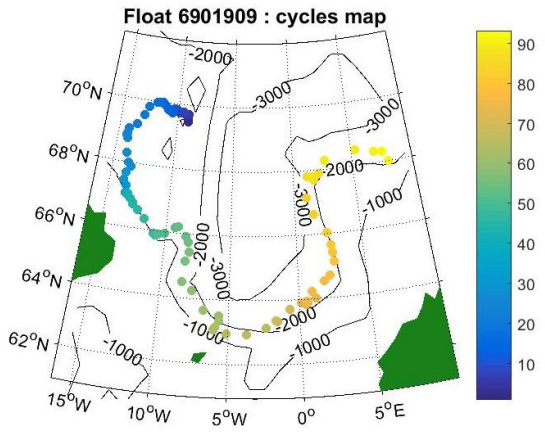


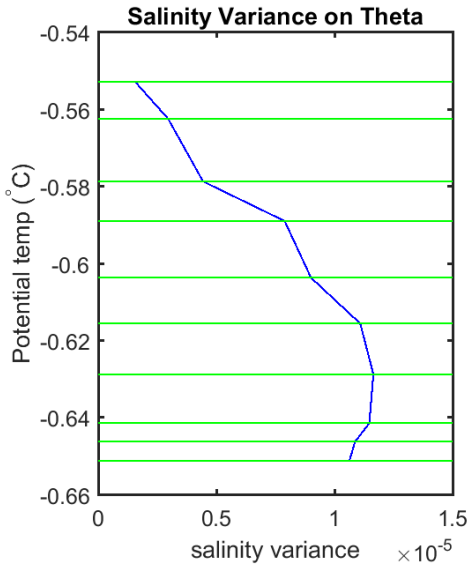

Reference CTD (IFREMER)

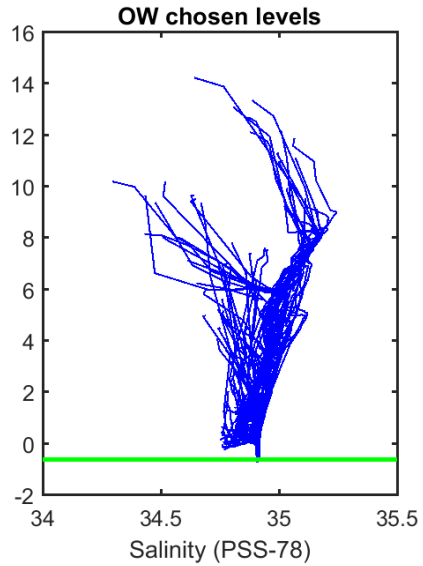
- Mostly from open databases
- Only high quality data
- > 900 dbar

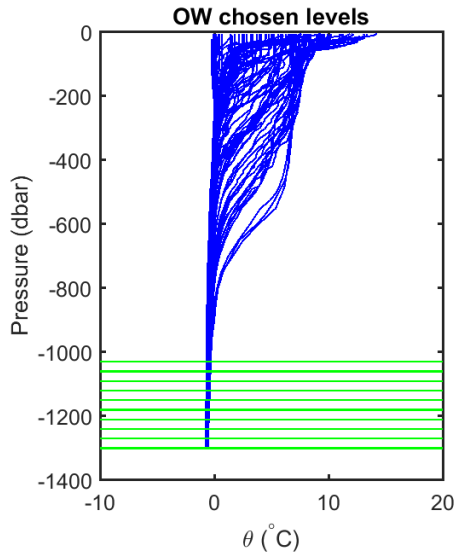
# DMQC: Reference CTD database - Nordic Seas

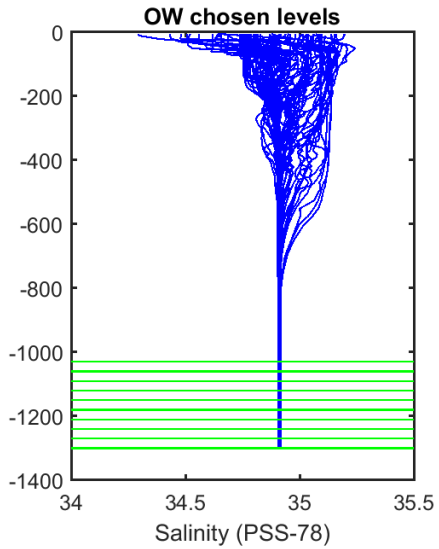
- OW setup
  - Only deep water masses can provide a stable linear reference: **theta search**
  - Region with small scales of variability: **Small spatial and temporal ranges → WARNING: Not enough data points!**



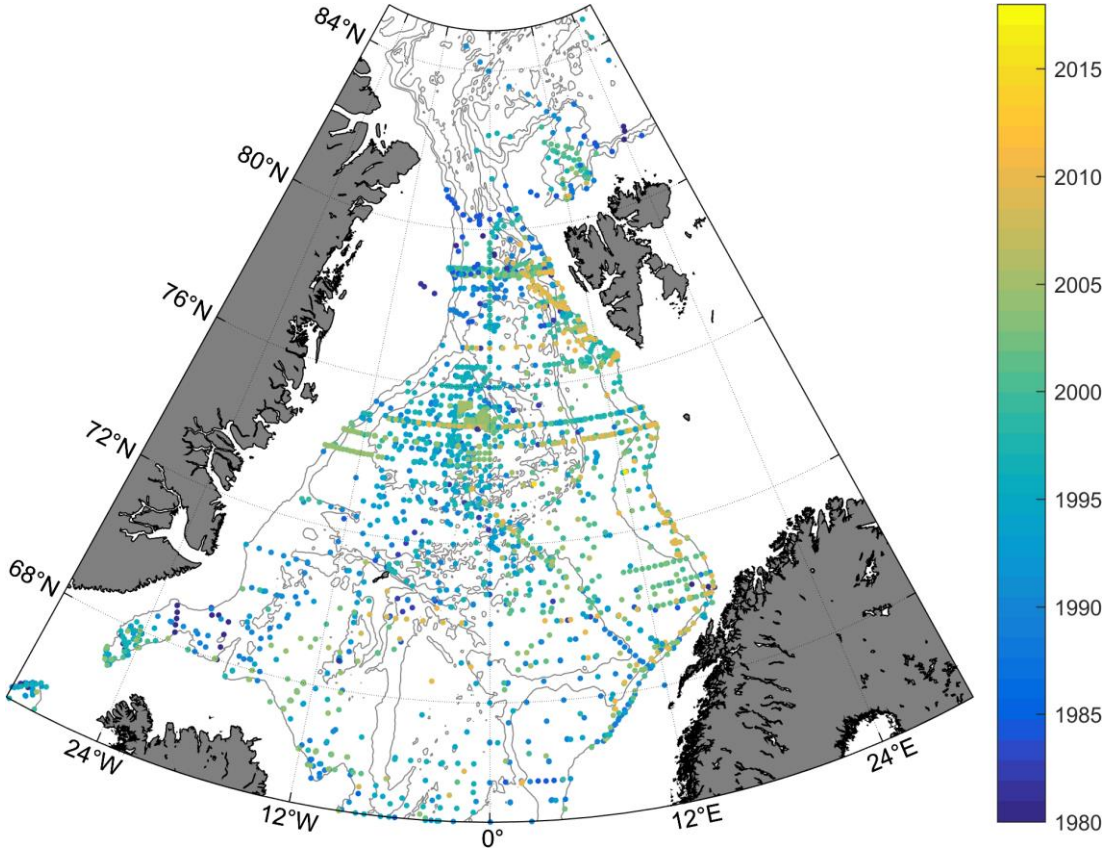




Birgit Klein (BSH)

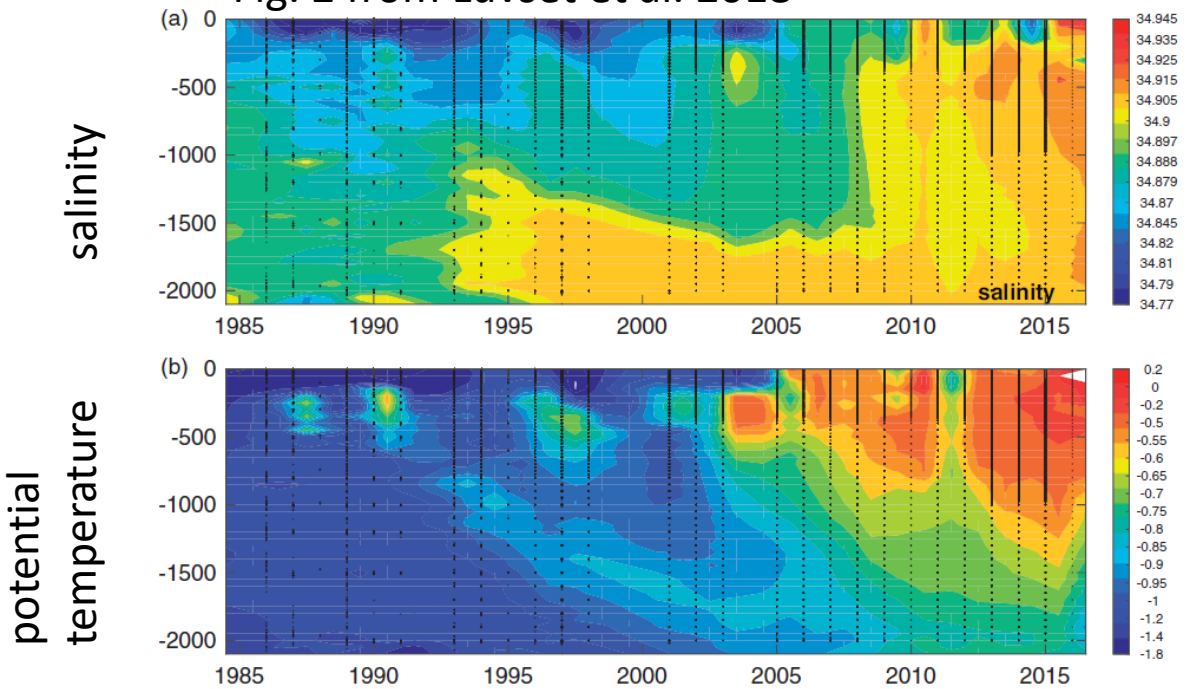
# DMQC: Reference CTD database - Nordic Seas

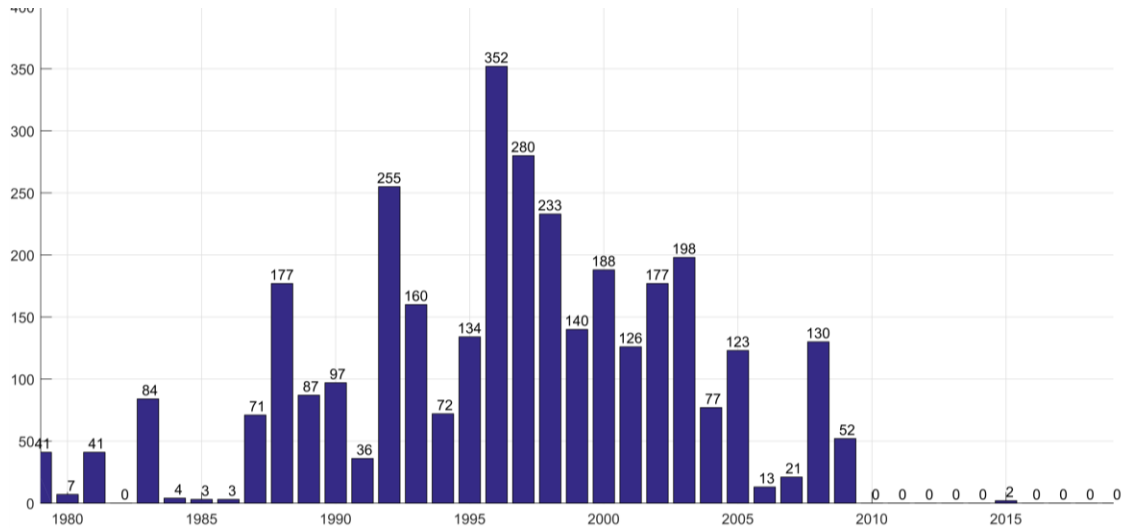
**N=3384**



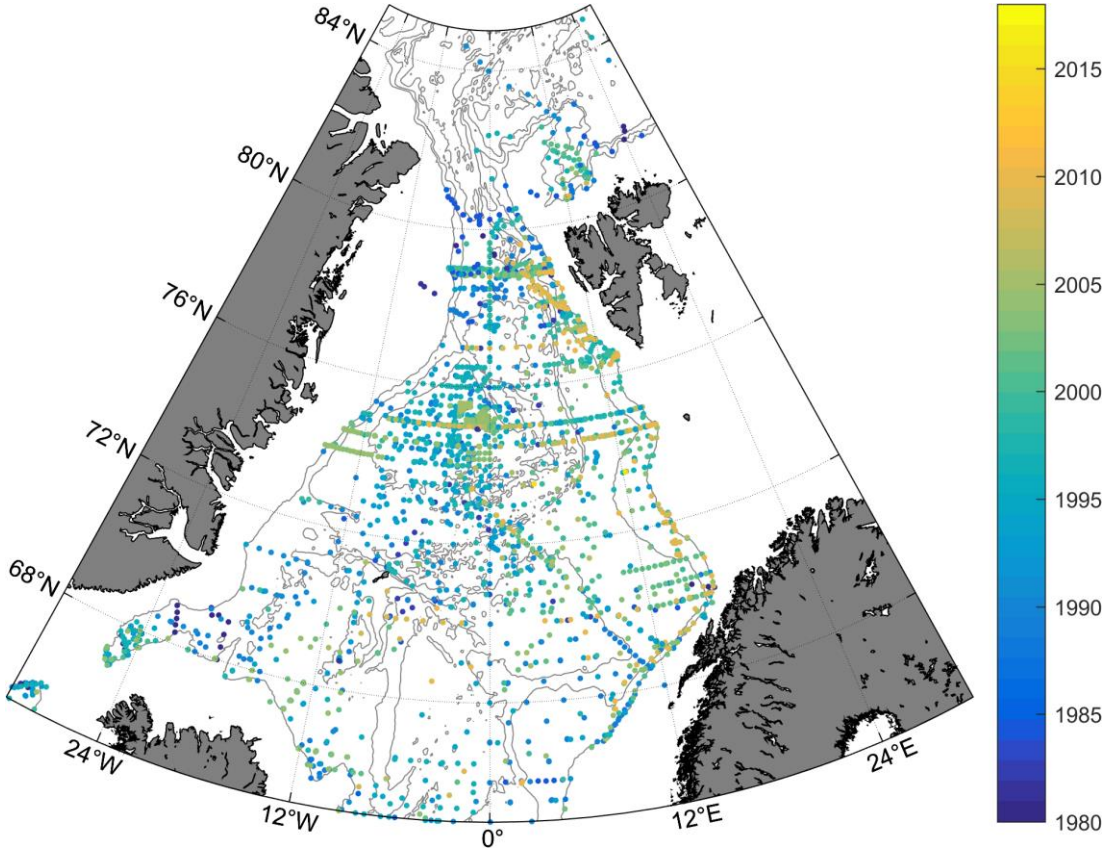

Deep waters are changing in the Greenland sea!

Fig. 2 from Luvset et al. 2018



# DMQC: Reference CTD database - Nordic Seas

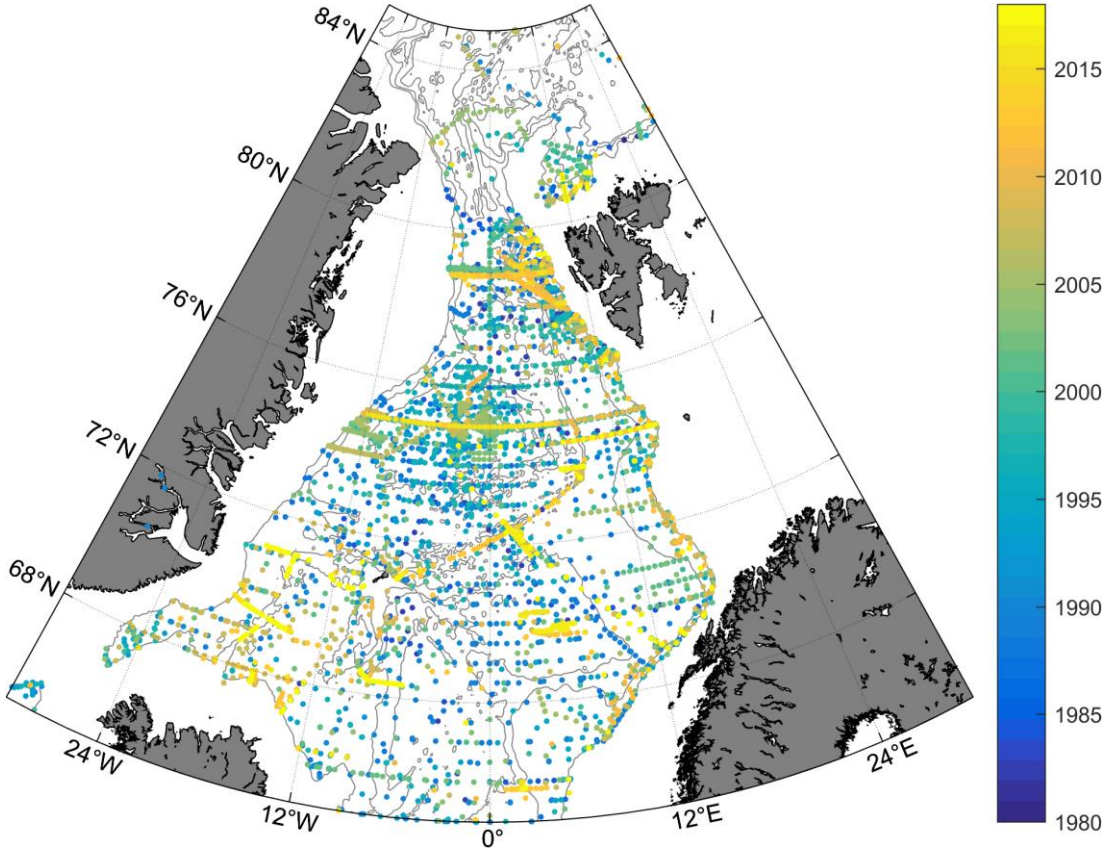



Improve the reference!

- Reference database is old = Bias in the salinity correction
- Work in progress:
  - Alternative/updated database:
    - ✓ **UDASH** (1980-2015) - Behrendt et al., (2017)
    - ✓ **ICES** (2016 on)
  - Compare OW salinity corrections
  - Feedback!!

# DMQC: Reference CTD database - Nordic Seas

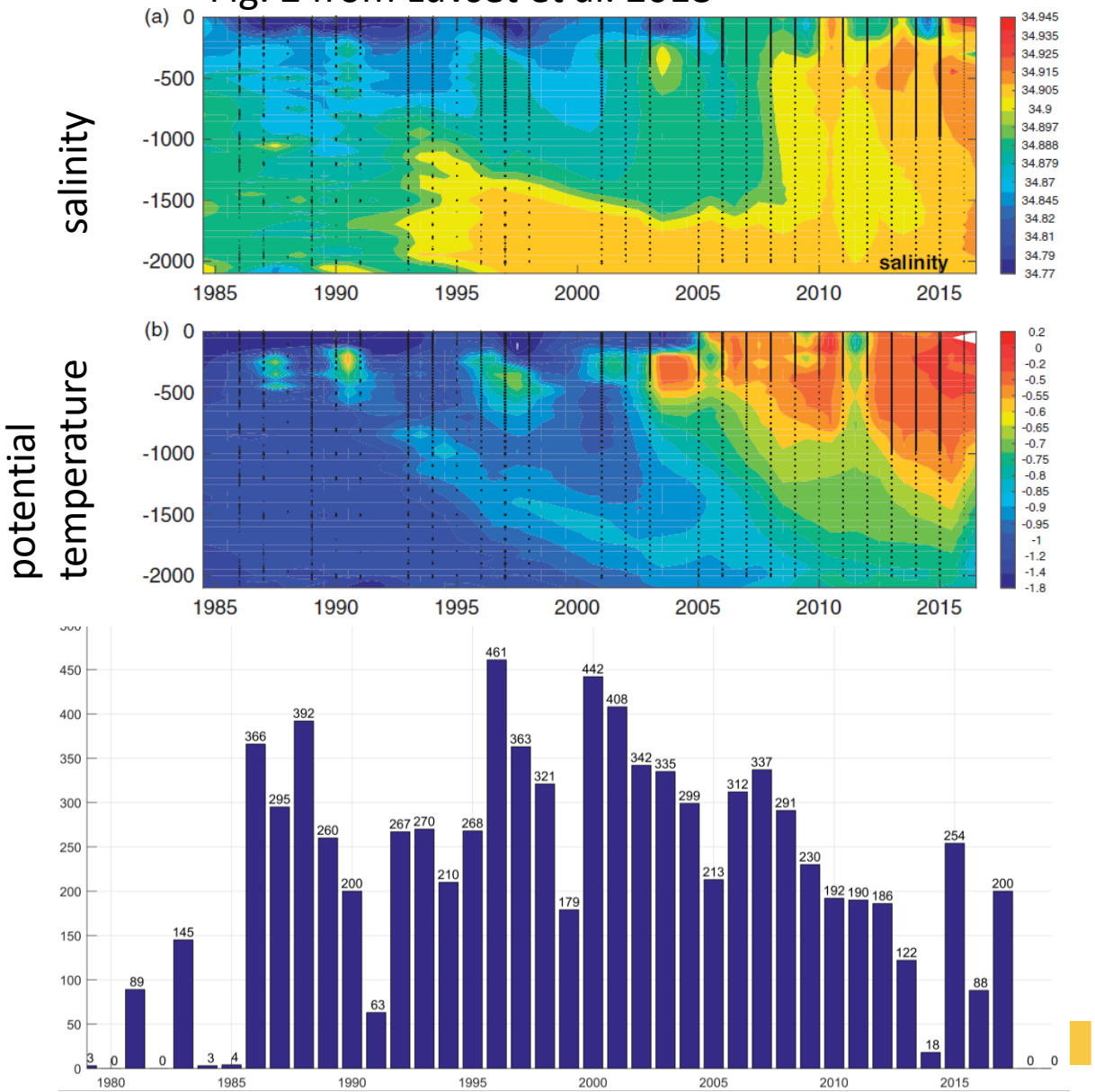
**N=8618**



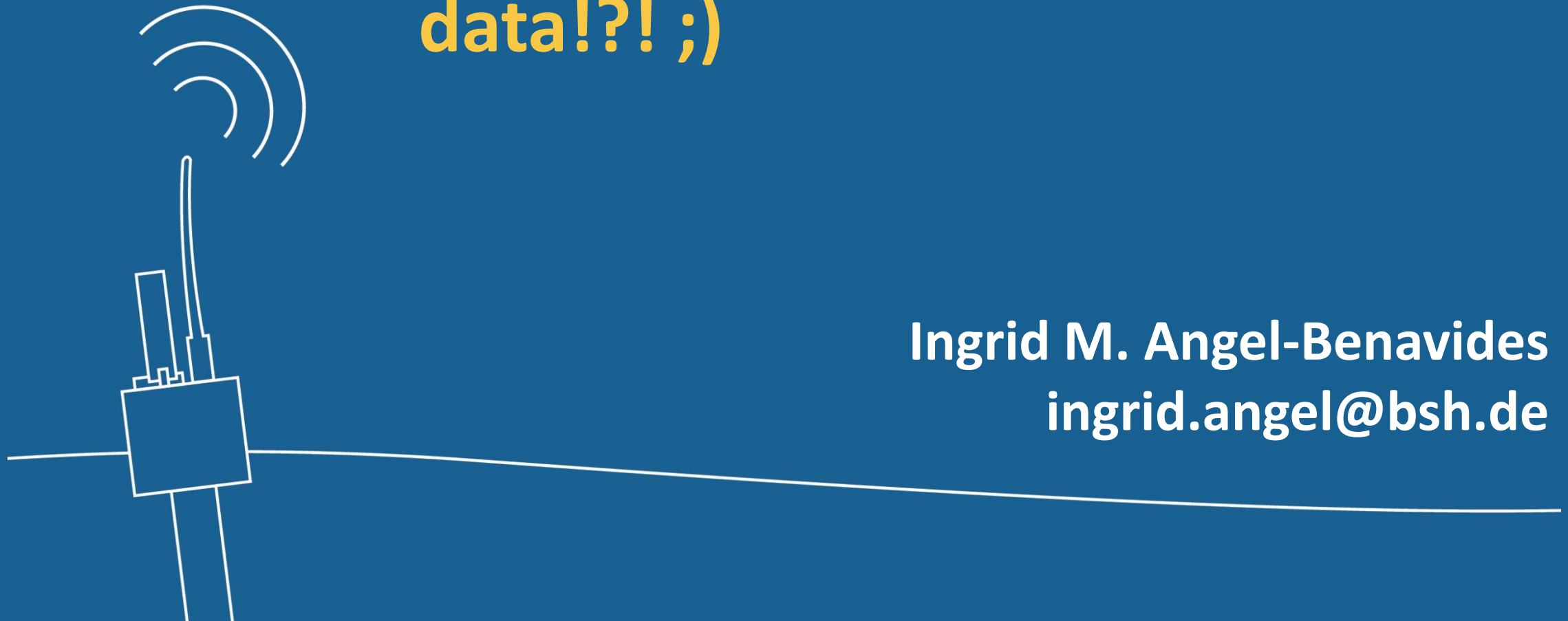

UDASH (8076) + ICES (542)

Improved temporal coverage!

Fig. 2 from Luvset et al. 2018



# Thanks for your attention, your ideas and your CTD data!?! ;)



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