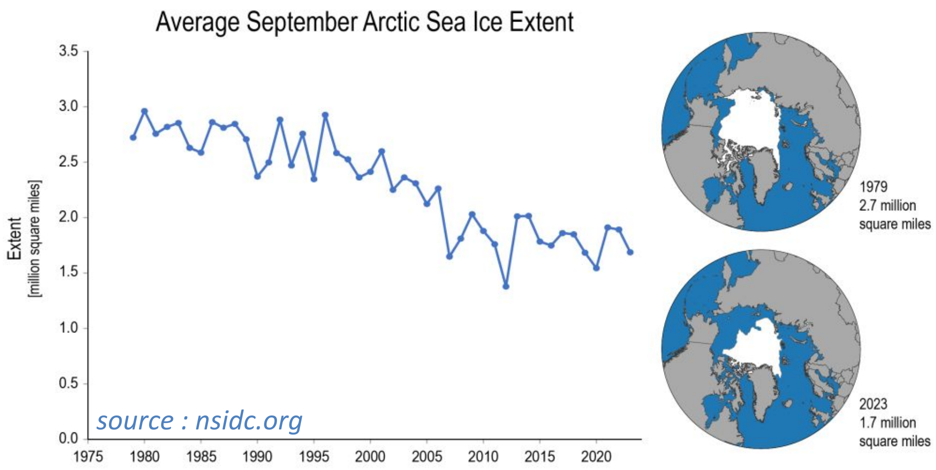
Implementing OneArgo: observing high latitudes with profiling Argo Floats

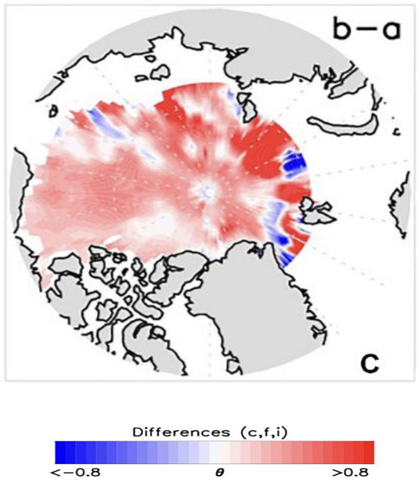
The Polar Argo Mission Team

Axe Polaire - 5 May 2025 - IUEM, Brest

Arctic Ocean is changing fast



Réchauffement de l'Océan Arctique depuis 30 ans



Polyakov et al., 2020

- Summer without sea-ice 2030 (<1 106 km (Kim et al., 2023)
- Arctic Ocean is warming and saltening (Polyakov et al., 2020)
- More seasonal sea-ice regime (Haine and Martin, 2017)

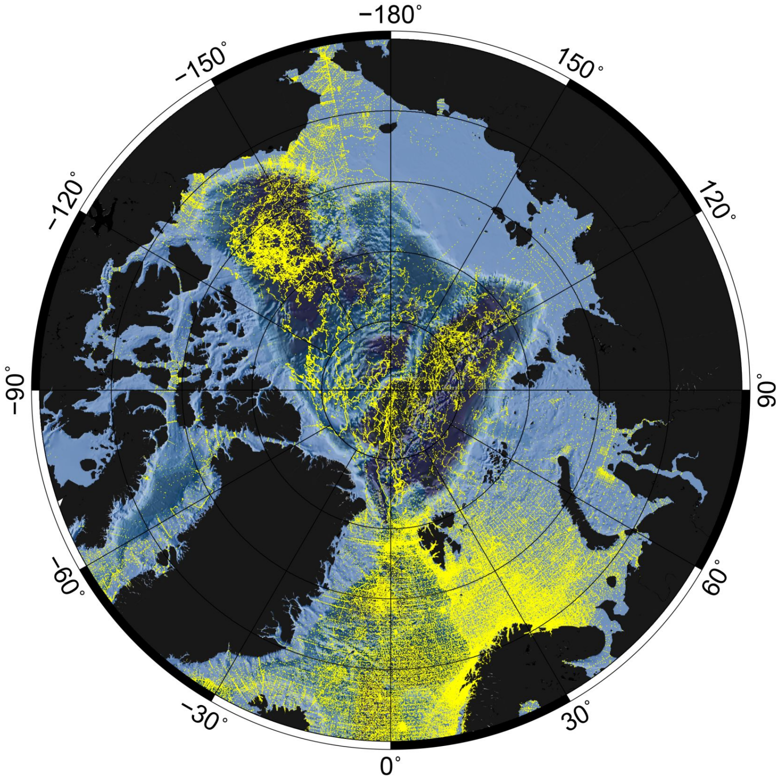
→ <u>Changes</u> : getting warmer, fresher, increase of ocean dynamics and air-sea-ice interaction,

→ <u>Impact</u> : regional and global climate, ecosystem …

Arctic Ocean is under sampled

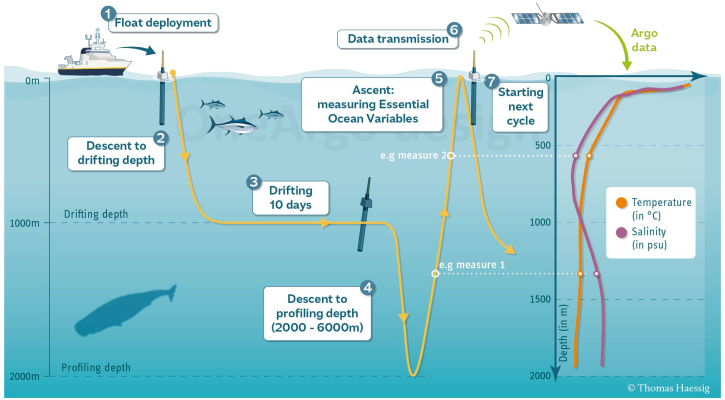
- Few in situ observations
  - Sea ice and harsh winter conditions
  - ‘Ice Tethered Profiler’ in the Ice pack
  - Cruises in the Nordics Seas and Chukchi plateau
  - Argo in the Nordic Seas and Barents Sea
- No surface satellites ocean measurements under and near the sea-ice
- Need to enhance the Arctic observing system
- New emerging technologies and complementary approach for autonomous observation *(Lee et al., 2020)*

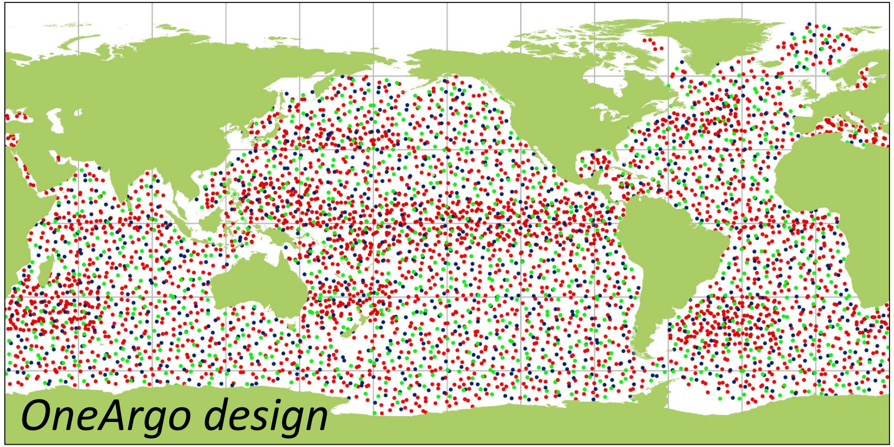
T/S profile density 1980-2015 (UDASH database)
Behrent et al., (2018)



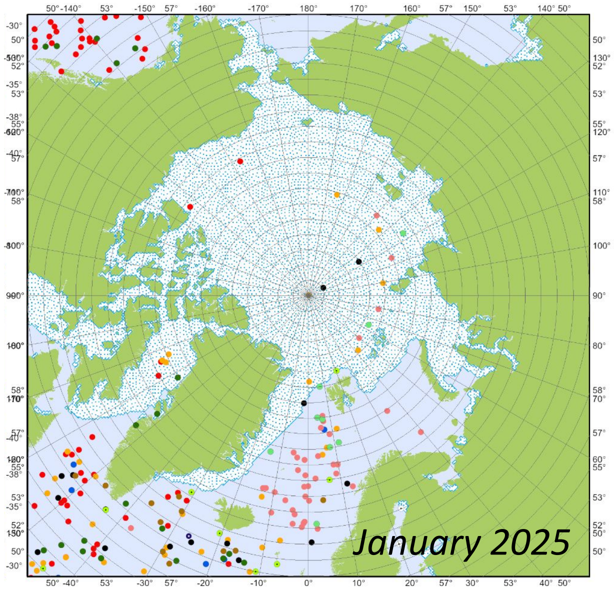
OneArgo design & Polar Argo Mission Team

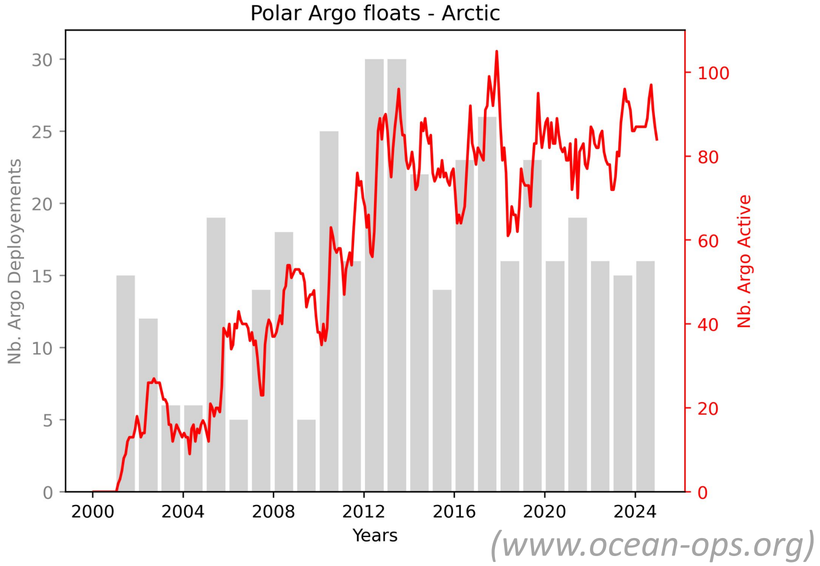
- OneArgo : Global, multidisciplinary, surface-bottom Argo network including BGC, deep and polar floats
- Polar Region are still undersampled by OneArgo
- Argo floats have proven to be an effective and cost-efficient tool to monitor Polar regions
- Polar Mission Team started in 2023, currently 33 members from 16 countries
- Mission teams provide advice on scientific design and implementation, work on technical and data problems, share knowledge and enhance collaboration
- The Terms of Reference are here: https://argo.ucsd.edu/expansion/polar-argo/





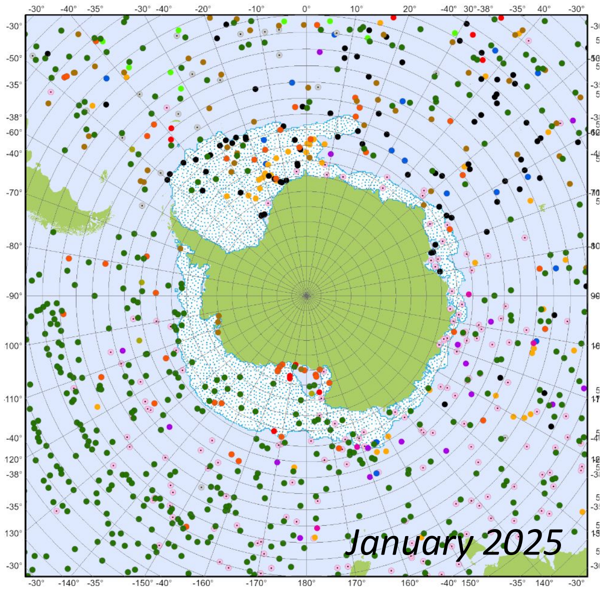
Polar Argo Status in the Arctic (>60°N)

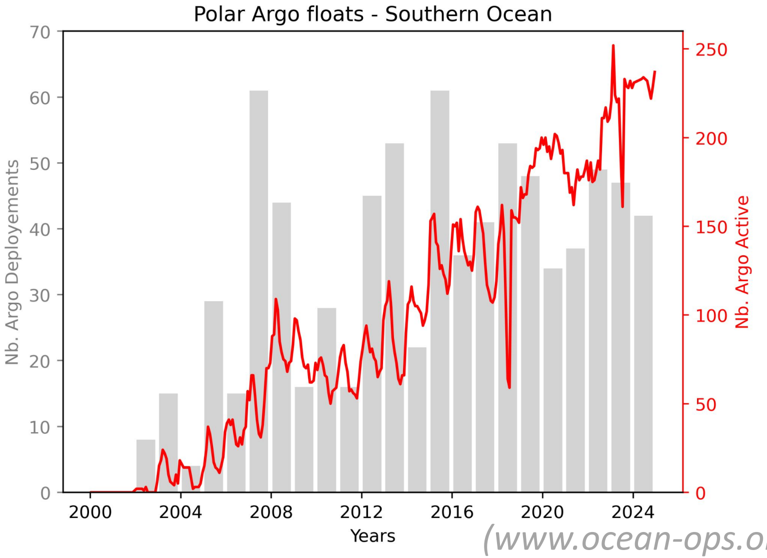




- ~80 active floats beyond 60°N since 2012
- ~20 deployments per year in Arctic
- Target 69 floats, but excluding the interior permanent ice pack
- 11 national contribution
- Mainly in the Marginal Ice Zone in Amerindian and Eurasian basin

Polar Argo Status in the Southern Ocean (<60°S)





(www.ocean-ops.org)

- ~235 active floats beyond 60°S in the recent years
- ~40 deployments per year in SO
- Target : 376 floats (~63%)
- 13 national contributors
- Interest building in a circumpolar Antarctic shelf float array

Argo floats ice avoidance strategies

1. Thermal avoidance (temp of ML)
2. Ice Cap (lack of telemetry)
3. Ascent Hanging (no change in press)

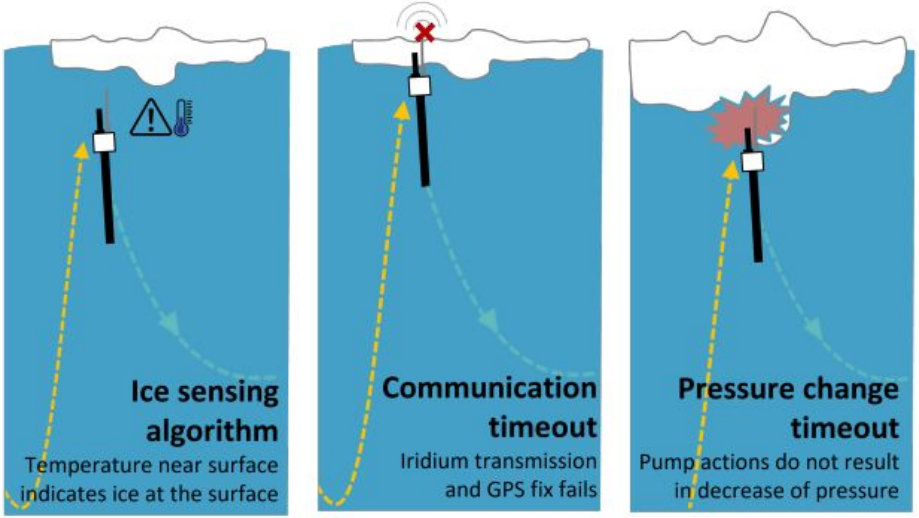


Figure from Benavides et al. (2022). Euro Argo RISE report
https://www.euro-argo.eu/content/download/159327/file/D5_1_V1.0.pdf

4. Ice Calendar (algorithm disabled/enabled)
   Specify months to use ice algorithm
5. Ice Break Up/Delayed Surfacing (time-based)
   Avoid surface for additional time at end of ice season (even if no ice detected)
6. Forced emergence (time-based)
   Float attempts to surface even if ice detected

- Polar Argo Mission Team aims to improve and share best practices to deploy and set-up polar floats in icy environments

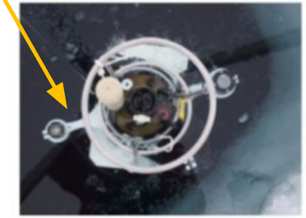
Ice Argo Hardware/Sensor Approaches

'Eggbeater' Guard 'Pole' Guard
TWR APEX

Ice Guard - UW EM-APEX, Girton et al. 2019
doi: 10.23919/OCEANS40490.2019.8962744

Other ice detection trials:

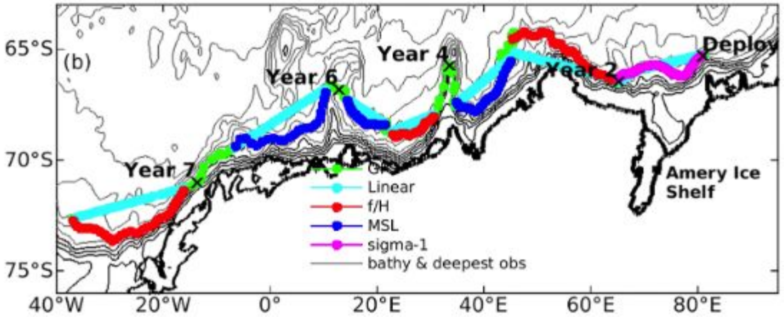
- Upward-looking acoustic altimeter (André et al. 2020)
- Optical sensor: depolarisation of laser reflection from ice (Lagunas et al., 2018)



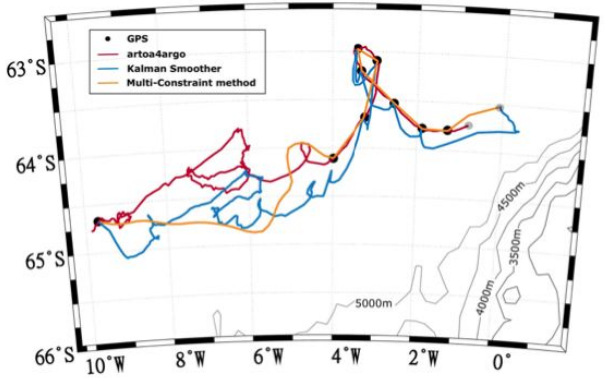
- Protect the float sensors, provide new measurements (ice draft), ice detection
- Now available from a number of manufacturers
- Relatively new technology (~ 5 yrs), but a number of groups have deployed floats with ice guards.
- In the Arctic there are trials of both an acoustic altimeter and an optical based approach to detect ice.

Geolocation of Under Ice Profiles

- Number of published methods to estimate location in post-processing :
  - Terrain-following method (Yamazaki et al. 2020)
  - Multi-constraint method (Oke et al. 2022)
  - Bathymetry-constraint method (Wallace et al. 2020)
- Geolocalisation capabilities using acoustic communication :
  - Improving RAFOS tracking algorithm for Argo (Hancock and Boebel, 2024)
  - Acoustic tracking and communication in Beaufort Gyre (Lee et al., 2020)

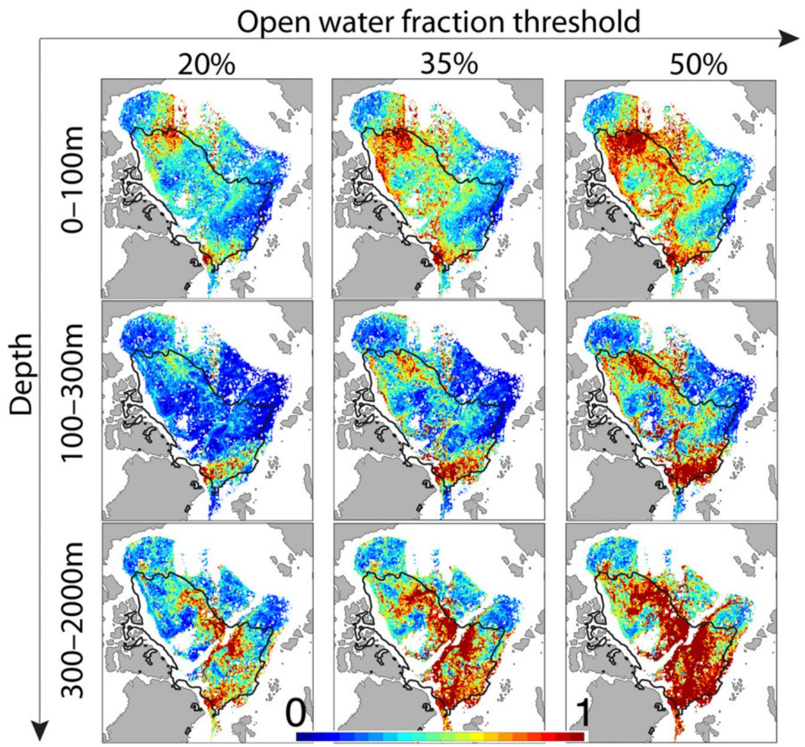


Oke et al. (2022)



Hancock and Boebel (2024)

Potential Impact of Argo floats on Coupled Ocean–Sea Ice State Estimate



- Under sea-ice Argo float cannot surface for telemetry
- OSE with synthetic Argo floats seeded in the Arctic Basin
- Temperature and Salinity estimates are suggested to be improved (reduced error) in many regions and at depth even without systematic localization

Temperature standardized error (Nguyen et al., 2020)

DOI: 10.1175/JTECH-D-19-0159.1

Summary and Challenges

- Polar Argo is now measuring regions previously out of reach, e.g., seasonal ice zone, shallow shelf, under ice shelves and measuring new properties (e.g. sea ice draft)
- Complementarity with other observing system (e.g. ITP, …)
- Arctic float lifetimes are close to core Argo (4 yrs)
- Challenge is to sustain and grow the Polar Argo array
- Handful of countries/programs sustain bulk of the polar arrays - need to diversify/increase float contributions
- Challenges :
    - Lack of sustained funding, prices are increasing…
    - Deployment opportunities can be limited
    - Polar Argo Mission team shares information and knowledge to improve float set-up, deployment practices and technical issues