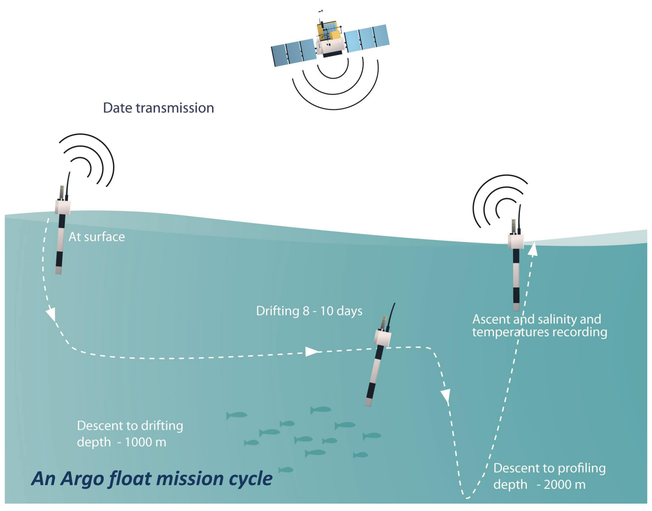
Development of ice sensing algorithms for Argo float deployments in the polar oceans

Katrin Latarius, Ingrid Angel Benavides and Birgit Klein

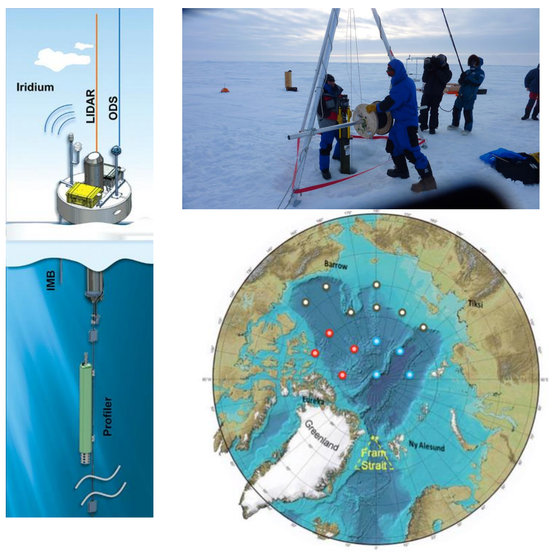
Bundesamt für Seeschifffahrt und Hydrographie, Hamburg, Deutschland

With the decline of sea-ice in the high northern latitudes the operation of Argo floats in the marginal ice zones becomes more feasible. To protect the floats from being crashed in ice they need to be equipped with an ice-sensing algorithm (ISA) that prevents their ascent to the surface. Ice-sensing algorithms have been used with success in the Southern Ocean and there basically use temperatures in the mixed layer to check if these are close to freezing point which could indicate sea ice formation. In the high northern latitudes the warm inflow of Atlantic water close to the surface make conditions more variable and the new threshold for the ISA have to be defined. This is tested for the Nordic Seas and Barent Sea based on hydrographic measurements and sea ice concentration maps.



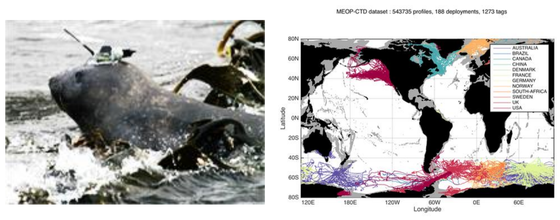
Integration of activities with existing observing strategies

Ice-thethered profiles



Source: http://www.iaoos-equipex.upmc.fr

MEOP (Marine Mammals Exploring the Oceans Pole to Pole) Network



Source: http://www.meop.net/

Protecting Argo floats for measurements in ice covered areas

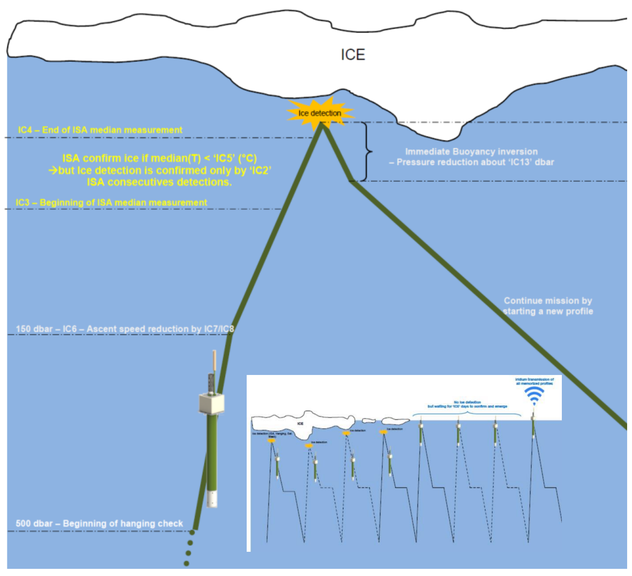


Fig. 1: Principles of an ice-sensing algorithm for a profiling float based on an Avor float.. Figure courtesy of Noe Poffa, SHOM, France

Argo floats may be damaged when encountering sea ice during ascend or while parking at the surface. Presence of sea ice above is forecasted by locally tuned Ice Sensing Algorithm (ISA). They use temperature data collected by the float during ascend to determine the presence of sea ice above. Ice detection (Fig. 1) triggers the interruption of the ascend, avoiding collision with and increasing the floats lifetime.

3 mechanisms to detect ice :

- ISA (using temperature thresholds)
- Satellite mask (using ice edge information at float position)
- Ascent hanging (pressure is no longer decreasing ascent phase)

Present status of Argo observations in high latitudes

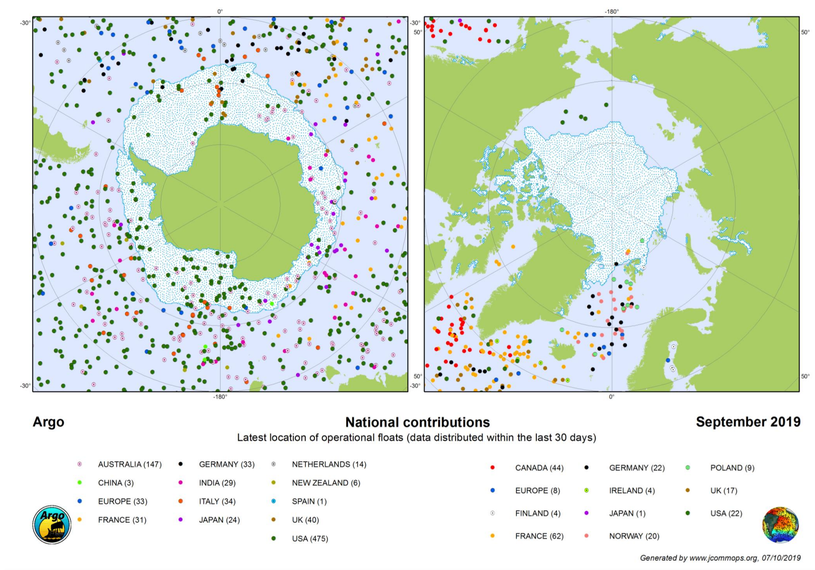


Fig. 2: Float observations in the Southern Ocean (left) and Arctic (right)

At present very few Argo float observations are reported from the Arctic, while float measurements are more abundant in the Southern Ocean. (Fig. 2). The few existing Arctic observations are from pilot experiments of US and Canadian colleagues in the Chucki and Beaufort Seas who have adapted the Ice Sensing Algorithms (ISA) locally. An ice sensing algorithm for the Southern Ocean was published by Klatt et al. in 2007, making use of the fact that mixed layer temperatures are close to freezing point during sea ice formation. Conditions in the Arctic are more complicated by a warmer subsurface tongue of Atlantic water.

Adaptation of the Ice Sensing Algorithm to the Arctic (European Sector) and first results from pilot experiments

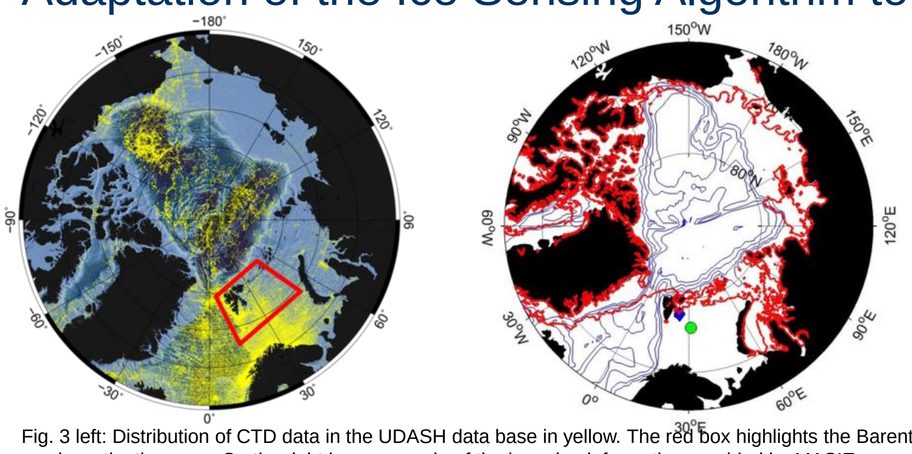


Fig. 3 left: Distribution of CTD data in the UDASH data base in yellow. The red box highlights the Barent sea investigation area. On the right is an example of the ice edge information provided by MASIE (Multisensor Analyzed Sea Ice Extent) from NSIDC (https://nsidc.org/data/masie).

BSH carried out an analysis of hydrographic conditions in the Barent Sea close to the ice edge within the EU project MOCCA. This analysis was supporting deployments from Euro-Argo members in the Barent Sea and north of Svalbard. Hydrographic profiles from **UDASH** (Behrendt et al., 2017) for the region of interest were compiled (Fig.3 left) and were combined with **MASIE** ice information (Fig. 3 right).

Through this combination profiles in ice or near ice could be identified (Fig. 4) and their hydrographic properties (red and black lines in Fig. 5) could be examined. Several temperature threshold and depth level of detection were tested and finally a temperature value of **-1 °C** at depth between **10-20 dbar** was proposed for profile abortion due to potential presence of sea ice after testing of the algorithm against other thresholds (Fig. 6).

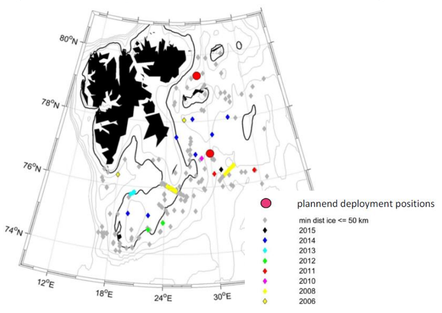


Fig. 4: *Spatial distribution of ice/near-ice hydrographic profiles in the northern Barents Sea. The color code indicates the observation year.*

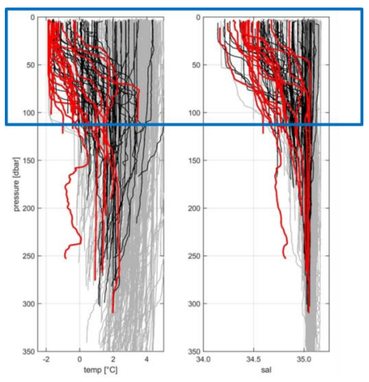


Fig. 5: *Vertical profiles of temperature (left) and salinity (right) the UDASH data set for the northern Barents Sea for month 1-4. Near ice profiles (<50 km) in black, in-ice profiles in red and all profiles in grey.*

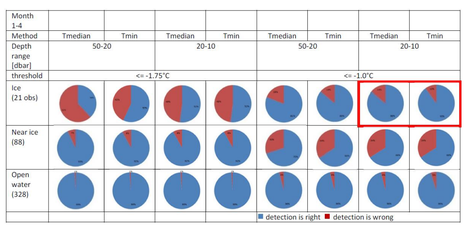


Fig. 6 *Visualization of the performance of the ISA using different thresholds. On the left hand the threshold temperature was -1.75°C, on the right hand -1.0°C.*

Results from Barent Sea deployment

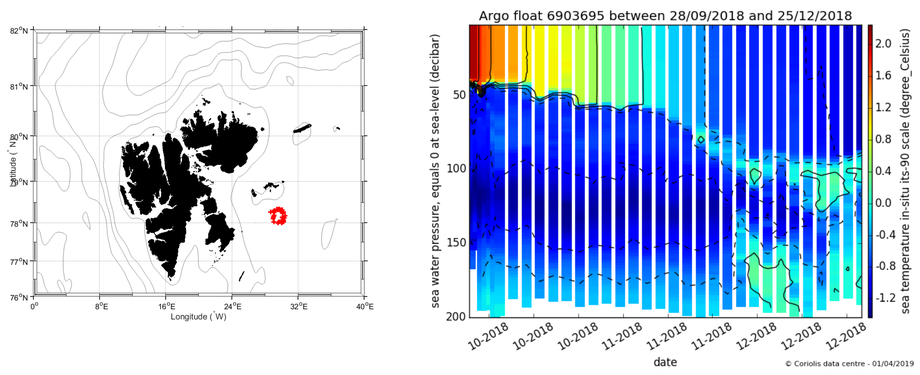


Fig. 7: Trajectory of float 6903695 deployed by Finland in Barent Sea (left) and temperature section for the upper 200 m (right). The float is under ice at the moment and will resurface later in summer. At this time the technical data reported by the float will be checked for the performance of the ISA.

Results from deployment North of Svalbard

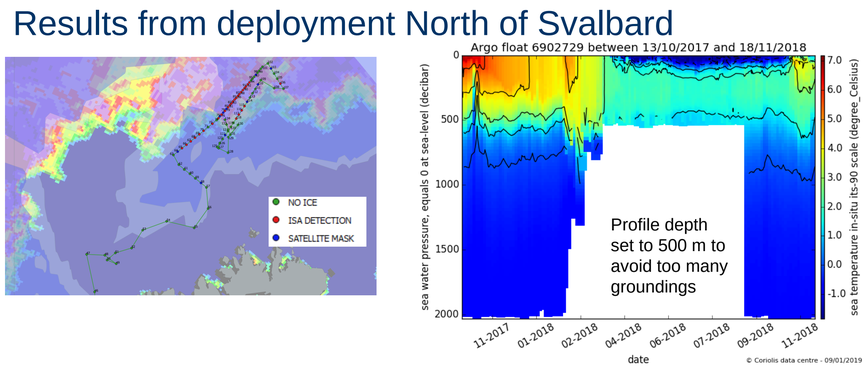


Fig. 8: Trajectory of float 6902729 deployed by France north of Svalbard (left) and temperature section for the upper 2000 m (right). The ISA temperature threshold was set to -1.6 °C at depth between 10 to 40 dbar. The float has been in out of ice from April to October 2018. Good agreement is seen between the ice sensed by the ISA and as seen from satellites. Shown on the left is the *AMSR-2 image from 09/09/2018. The analysis has been carried out by Noe Poffa, SHOM, France.*

Literature: O. Klatt, O. Boebel and E. Fahrbach: A Profiling Float's Sense of Ice, J. of Atm. and Ocean. Techn., Vol. 24, 1301-1308, 207, DOI: 10.1175/JTECH2026.1

A. Behrendt,, H. Sumata, B. Rabe and U. Schauer :UDASH – Unified Database for Arctic and Subarctic Hydrography, Earth System Science Data , https://doi.org/10.5194/essd-10-1119-2018

Acknowledgments: MOCCA project has received funding from the European Maritime and Fisheries Fund (EMFF) under grant agreement No EASME/EMFF/2015/1.2.1.1/SI2.709624. Field work in the Arctic was carried out by ERIC members from France, Finland and Poland.