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Argo Floats in the Arctic

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1. INTRODUCTION

The ocean's role in the climate system is fundamental. By accumulating and transporting heat, it shapes our climate and further mitigates the effects of anthropogenic changes occurring in the environment. The role of the Arctic, including the ocean and its ice cover, is even more critical in climate processes. These regions lie at a key location where the thermohaline circulation reverses and deep waters formation occurs. Therefore Arctic is the most sensitive to ongoing changes. Therefore, there is the need for increasingly precise and comprehensive monitoring of changes in the Arctic hydrosphere and cryosphere. This is a challenging task, as these regions are difficult to access, especially in winter. Hence the increasing role of autonomous devices capable of collecting data year-round.

2. THE ARGO NETWORK

Argo floats have revolutionized global oceanographic research. The Argo float is a relatively simple device: a metal cylinder about 2 meters tall and several centimetres in diameter, containing batteries, electronics, and a hydraulic system, with sensors and a satellite antenna on top. In the core version, it includes sensors for conductivity, temperature, and pressure. The float has no propulsion and drifts with ocean currents. Vertical movement is forced by changing the volume of an external bladder located at the bottom of the float. Pumping oil from inside the hull into the bladder increases the float's volume and causes it to ascend; retracting the oil from bladder causes it to sink slowly. Based on these devices, the ARGO network was established in the early 21st century. Today, it is the only global ocean observing system providing near-real time water column data – up to 12 hours after measurements. Around 4000 floats operate continuously, covering all oceans and marginal seas. All Argo data are free and available in CORIOLIS database.

A typical float cycle includes:

(1) descent from the surface to the parking depth;
(2) drift at the parking depth, usually 1000 m;
(3) descent to profiling depth (2000 m);

(4) slow ascent and profiling of the water column;
(5) surface measurements and satellite data transmission.

In the deep ocean, a full cycle typically lasts 10 days.

3. ARGO-POLAND IN THE ARCTIC

3.1 Oceanic floats

Poland has participated in the European Research Infrastructure Consortium Euro-Argo ERIC since 2009. In 2023, the Argo-Poland consortium was established, comprising the Institute of Oceanology PAS (IO PAS) as the leader, the Institute of Geophysics PAS (IG PAS), and the Polish Naval Academy. Since 2009, IO PAS has deployed 31 floats in the Arctic. Each year, 2–3 Argo floats are deployed from the r/v OCEANIA. The long-term experience gained during AREX expeditions, particularly the understanding of Arctic current systems, has allowed for the development of a regular deployment scheme. Floats are deployed along 75 °N latitude, one in the eastern branch of the West Spitsbergen Current, the other in its western branch. The float deployed in the eastern branch usually crosses the Fram Strait quickly, where it is carried by the Svalbard Current under the sea ice and drifts along the northern slope of Svalbard with Atlantic Water. The float in the western branch tends to operate longer: it typically recirculates westward, joins the East Greenland Current, and flows south. Such floats may operate for up to 7–8 years.

However, floats entering the Arctic Ocean are not always immediately lost. In many cases, it has been possible to recover data collected while drifting under the ice. A float entering in autumn under the ice in Fram Strait may resurface next summer near Franz Josef Land. In some cases, floats submerge again under the ice and later resurface and continue transmitting data. For example, float WMO3902114 operated for 4 years, passed Severnaya Zemlya and reached the Laptev Sea.

Due to the lack of satellite positioning, under-ice trajectories are interpolated during preliminary processing at the ARGO data centre. The RAFOS acoustic positioning system is currently not operational in the Arctic. At IO PAS, we estimate the float's position using bathymetric data (Fig. 1).

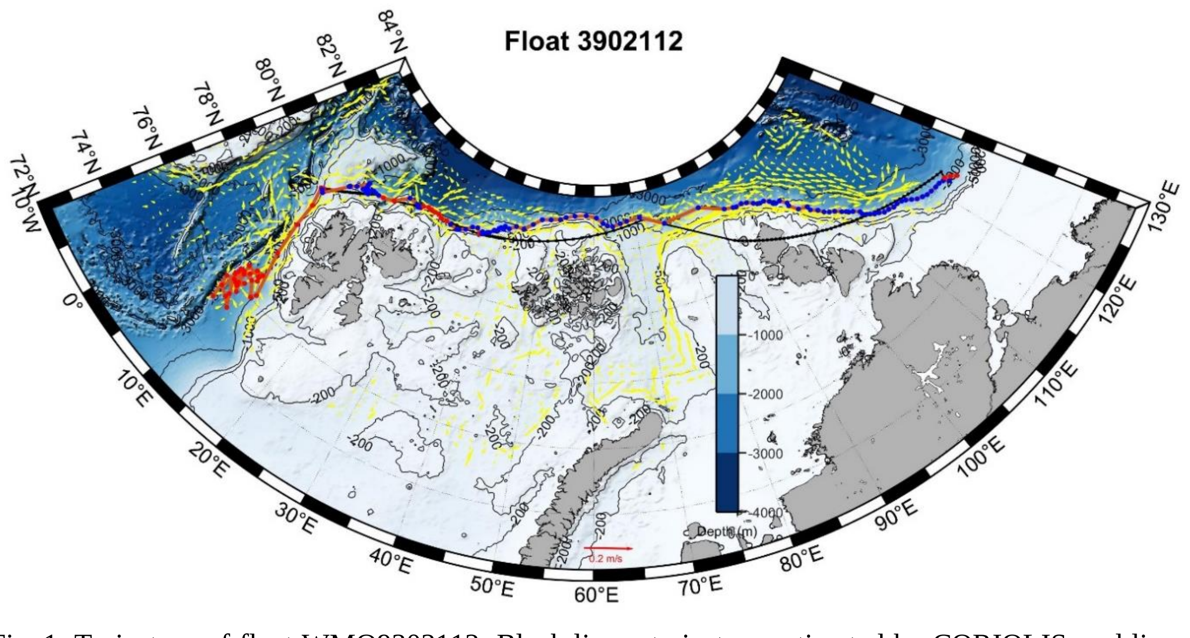

Fig. 1. Trajectory of float WMO9302112. Black line – trajectory estimated by CORIOLIS; red line – trajectory calculated using the described method; red points – known GPS positions; blue points – calculated positions. Currents at a depth of 200 m from the COPERNICUS service are indicated.

After crossing the Fram Strait, floats drift along the continental slope, and profile depths rarely exceed 2000 m, making location estimation easier. The method involves comparing the maximum depth reached during descent with regional bathymetry. In the first step, the CORIOLIS-estimated position is used to find matching depths and derive coordinates (Lat1, Lon1), considering the float's likely drift direction. In the second step, the trajectory is smoothed and the process repeated. Even when float positions are not precise, profile data allow the tracking of Atlantic Water changes during eastward advection. Of particular importance is heat content: heat exchange with surrounding waters plays a key role in Arctic Sea ice melt. These data are compared with results from moorings and research cruises, including those from r/v OCEANIA. Thus, Argo is becoming an increasingly important part of the integrated Arctic Ocean observation system.

3.2 Fjords floats

The Argo's successes in the Baltic Sea inspired us to test them in the Arctic fjords. In 2023, IO PAS and IG PAS conducted the first Argo float deployments in Hornsund. Both free-drifting and bottom-anchored floats were tested. In 2024, the focus shifted to acquiring a time series from the anchored float. It is a non-standard procedure, as Argo floats are designed to drift. However, in restricted basins, this can be beneficial. IO PAS was the first to successfully apply this technique in the Baltic Sea (Merchel et al. 2025). The experiment in Hornsund also succeeded: a 13-day time series was recorded, with 4-hourly profiles from surface to seafloor. Even this short series provided valuable insights into water column transformation near a glacier front (Fig. 2). In 2025, measurements continue in Hornsund near Hans Glacier.

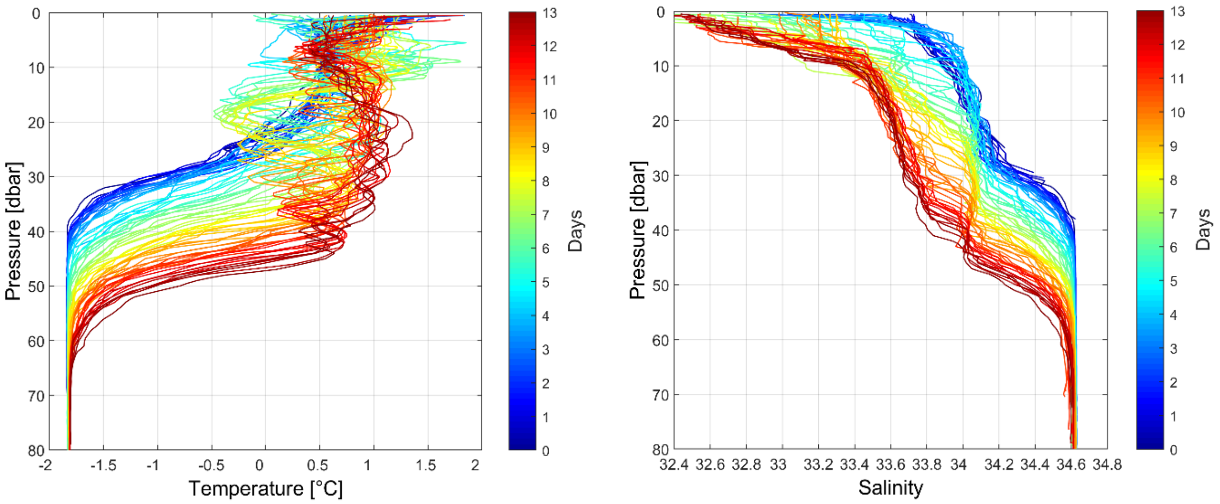

Fig. 2. Time series of temperature and salinity profiles in the region of Hans Glacier.

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