EXTENSION OF ARGO IN SHALLOW COASTAL AREAS AND EXPANSION OF THE REGIONAL COMMUNITIES (EURO-ARGO RISE PROJECT)

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Abstract

The recent technological advances of the autonomous oceanographic monitoring platforms has allowed observations of unknown regions and dynamic processes that play a key role in the physical environment and marine ecosystem functioning. Under this context Euro-Argo RISE project aims towards the investigation of Argo extension in shallow coastal areas of European marginal seas (Black Sea, the Baltic Sea and the Mediterranean Sea) as well as the seasonally ice-covered areas of the high latitudes (Arctic Ocean). Different float configurations are tested whilst the development and implementation of operational systems to control the platforms are performed. Test deployments under Euro-Argo RISE have provided indications for the best settings, the optimization of float missions and the improvement of the life expectancy and the sampling efficiency in shallow coastal areas. In addition,

guidelines and best practices for operating floats in seasonally ice-covered areas are provided. The reinforcement and expansion of the Argo infrastructure at a regional scale is performed by approaching the regional research community (also through the organization of workshops and political events) with the aim of: promoting Argo data, cooperation at sea, collaboration in technical activities, sharing best practice, knowledge and expertise.

Keywords: Argo float, Euro-Argo RISE, shallow-coastal areas, ice-covered areas

1. Introduction

In the framework of the European H2020 Euro-Argo Research Infrastructure Sustainability and Enhancement (Euro-Argo RISE) project the potential of Argo profiling floats to operate in shelf areas is investigated. The aim is to close the gap between open-ocean and shallow/coastal waters (Euro-Argo ERIC, 2017), with a focus on three European Marginal Seas (EMS) (Mediterranean, Black and Baltic Seas). The project additionally aims towards the investigation of Argo extension in the seasonally ice-covered areas of the high latitudes. These extensions will assure an improved Argo dataset that is essential for climate assessment studies and operational oceanography services to provide the most reliable ocean state analysis and forecasting. Many aspects are considered and in particular the test of the platforms, mission configurations, monitoring tools and the involvement of human resources.

Another important target planned in the framework of the Euro-Argo RISE project is the strengthening and expansion of the Euro-Argo research infrastructure at regional scale. Regional research communities, scientists of the EMS riparian countries have been approached. Collaborations and initiatives were proposed and set up, the Euro-Argo ERIC and Argo data were promoted, cooperation for activities at sea and technical aspects, sharing best practice, knowledge and expertise have been put in place.

2. Methodology

The expansion of Argo in such targeted areas is challenging since platforms are designed to perform in the open ocean whilst areas of marginal seas can be characterized by complex coastlines and bathymetry, shallow water, small archipelagos, narrow basins, shelf and shelf-break zones and ice coverage.

Argo float mission configurations in such areas can require quicker cycle time periods, shallower drift parking depths, and will to keep the floats in a targeted area. Moreover, float operators must rely on accurate monitoring systems to track their floats and change their configurations, if needed. Indeed, the aim is to prevent floats from stranding events, getting stuck at the sea bottom, and collision with ice/shore in some

areas. The eventual goal is to achieve the best float settings, and an improved life expectancy.

Altogether, eight Euro-Argo RISE floats (Figure 1) and some national platforms have been deployed in targeted areas of the Black Sea, the Baltic Sea and the Mediterranean Sea and the number of floats in the Arctic Ocean is increasing. The Euro-Argo RISE profilers used are manufactured by NKE (Arvor I model) and Teledyne Webb Research (Apex model) and are equipped with a standard Seabird Conductivity - Temperature - Depth (CTD) SBE 41CP sensor. The telemetry is performed by the Iridium bi-directional telemetry system.

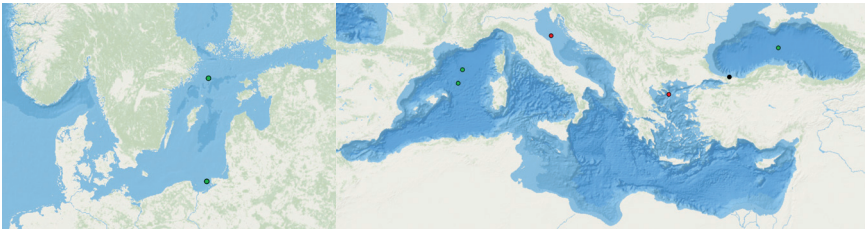

Fig. 1. Euro-Argo RISE Argo float locations (green and red/black dots for active and inactive floats, respectively) as of 23rd March 2021, in the Mediterranean and Black Sea (right panel) and in the Baltic Sea (left panel).

Different configurations were tested according to the area of deployment and the target of the missions.

Several controlling and monitoring tools were used and designed to check the floats' behavior and to send warnings and alerts. The Euro-Argo monitoring tool is a powerful tool to control the fleet and provides a set of predefined alerts and graphs. In addition to the Euro-Argo monitoring tool, the Ocean-OPS AIC tool presents a large set of statistics that permits to better assess the fleet. Home-made tools were also developed for the quick decoding of the SDB data and the provision of notifications in near real time (for platform location, bathymetry, distance from coastline, maximal depth, grounding events). These tools were utilized in conjunction with the generic tools, together with sea and atmospheric conditions systems.

Interaction with floats is much higher than the one needed for operations of Argo floats in the open ocean. Whilst the latter usually require few human activity, operations in shallow/coastal water of EMS and ice-covered areas need a more accurate monitoring and interaction with platforms on a basis mainly linked to the cycle period of the float (about 1 to 7 days). This is needed to change the configuration parameters, as the float moves to a different area (Figure 2).

The expansion and reinforcement of the regional community is planned through the organization of two workshops and one political event to engage new scientists, technicians and stakeholders. Initiative, collaborations at sea and float donations with/to new partners have been organized.

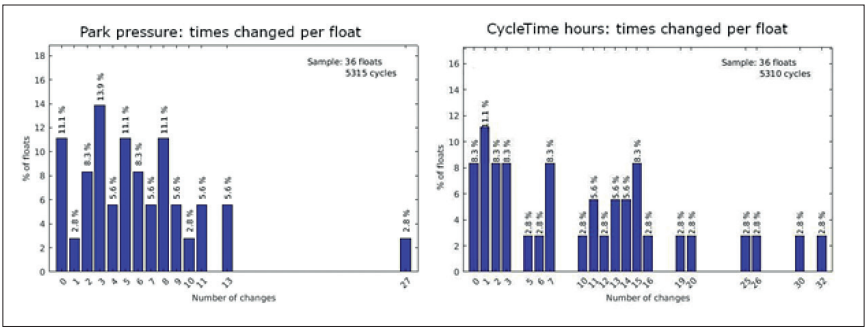

Fig. 2. The amount of changes in float configurations during missions on the park pressure (left) and cycle length (right) in the Baltic Sea. Image attribution (Euro-Argo).

3. Results

3.1 Regional extension and implementation of the Argo array

Table I. Main information of the Euro-Argo RISE fleet

TYPE	WMO	DEPLOYMENT DATE/TIME	DEPLOYMENT LOCATION	TOTAL CYCLES	DATE OF LAST CYCLE	STATUS
Arvor I	6903271	01/10/2019	44.54 N 30.97 E	253	22/03/2021	Active
Provor III	6902899	11/12/2019	43.41 N 7.86 E	157	20/03/2021	Active
Apex 11	6903288	09/02/2020	40.42 N 25.42 E	120	05/10/2020	Inactive
Arvor I	6901278	12/03/2020	39.37 N 2.52 E	126	21/03/2021	Active
Arvor I	3902109	03/06/2020	54.48 N 18.85 E	368	22/03/2020	Active
Arvor I	6903703	10/06/2020	58.88 N 20.31 E	68	22/03/2020	Active
Arvor I	6903865	24/07/2020	42.98 N 28.23 E	94	15/11/2020	Inactive
Arvor I	6903783	31/07/2020	44.05 N 13.70 E	40	06/02/2021	Inactive

The most important parameters that play a crucial role for success are cycle length and parking depth. Some floats were used as virtual moorings by setting the parking depth at the bottom or close to the seabed and one of them was used as a virtual mooring using a fishing line with neutral buoyancy. Other strategies consisted of setting a parking depth well below the surface and subsurface currents in regions characterized by high dynamic. Cycle length was set up in terms of hours or one day typically at the beginning of the mission in order to check the float behavior. Higher profiling frequency is also used in challenging areas where quick configuration adjustments based on observations are needed. Cycle length is then lengthened up to 5 or 7 days to keep the floats in the targeted area and hence to minimize their displacement from the deployment location and their drifting towards critical zones (Figure 3).

A more intense monitoring activity of the fleet and more human-platform interactivity were needed for Argo operations in shallow coastal waters of EMS. Hence, the project partners developed some home-made tools to be used in conjunction with Euro-Argo and the Ocean-OPS monitoring systems. In particular, procedures to anticipate the float decoding were developed since this might be crucial in critical times of shallow/coastal Argo operations in EMS. Implementation of notification/warning/alert systems to take into consideration crucial parameters of the floats' missions has been set up. Weather, forecasting systems, maritime traffic, detailed bathymetry tools were used to consult the most up-to-date information useful to achieve the best float mission (Notarstefano *et al.*, 2021).

3.2 Expansion of the regional Argo community

Project partners regularly attended meetings organized by regional communities to present the Euro-Argo RISE activities and the extension of Argo in shallow/coastal water of EMS and in ice-covered areas of the Arctic Ocean. Successful cooperations were established for operation at sea (floats deployments and recoveries) by many partners with countries interested in joining Argo for activities in EMS. In particular, Morocco, Russia, Sweden, Romania were contacted. Other Research Infrastructures in the marine domain (ICOS OTC, DANUBIUS, EMSO) were approached with the aim of sharing the best practice and knowledge and for joint activities.

Two workshops have been organized to pursue and foster the above targets. One workshop is focused on the Mediterranean and Black Seas whilst the other is dedicated to the Arctic Ocean and Baltic Seas. The main objectives are focused on the scientific use and the technical aspects of Argo. Moreover, the role of Argo towards addressing environmental policies and operational monitoring for the society is also highlighted. A political event for decision-makers and stakeholders is planned within the Euro-Argo RISE project. The aim of this event is to show the importance of Argo for the environment and society in the EMS. It will address the Argo program and the UN Decade of Ocean Science for Sustainable Development, present the Euro-Argo ERIC framework and its services to users, and highlight activities and benefits of the Argo program in EMS.

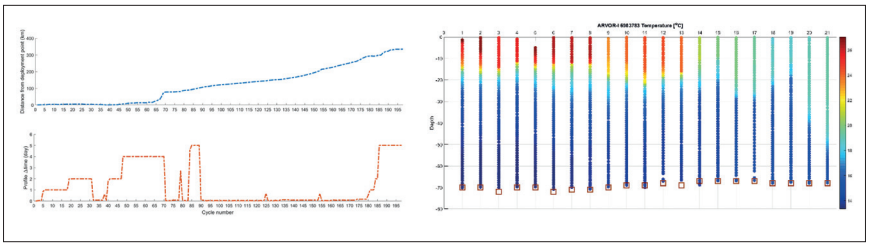

Fig. 3. Left Panel: displacement (km) of the float from the area of deployment (top) and cycle period of the platform (bottom). Right panel: Hovmöller diagram of temperature for the Euro-Argo RISE float (WMO 6903783). Grounding events are highlighted as red boxes.

4. Conclusion

The tests performed with the Euro-Argo RISE floats were promising and provided the basis for the expansion of Argo in shallow coastal areas of EMS. The mission configuration used seems adequate to explore shallow and small-sized seas and we were often able to control the float drift by limiting the displacements in a small area around the deployment location. These kinds of operations require a higher level of interactivity between the operator and the floats in order to reach a consistent life expectancy. Monitoring tools are fundamental to control the Argo platforms and a set of suggestions to try to improve the Euro-Argo and the Ocean-OPS monitoring systems were provided, together with indications on other tools and systems that might be useful to use in support of the monitoring activity.

Several new scientists and institutes were approached and introduced to Argo. Most of the riparian countries of the three EMS, regional communities, European Marine Research Infrastructures that have an interest in the regional context, were contacted and invited at the two planned scientific and technical workshops. This will help in enlarging the Argo regional community, building collaboration, sharing activities and strengthening the already existing partnerships. The Argo Regional Centers (ARCs) play a crucial role in such a context since they foster collaboration in a broad spectrum between countries working in the same region. Indeed, a good ARCs' management can help in supporting such an activity carried on in the framework of the Euro-Argo RISE project.

We would like to increase the visibility of Argo through initiatives like the political event and to make the policy makers and stakeholders aware of the role that the Argo data have in marine environment protection and services to society.

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