GREEK ARGO PROGRAMME

PRESENT STATUS AND FUTURE PLANS

G. Korres and D. Kassis
HCMR
March, 2022

1. Background and organization of GREEK ARGO activities and implementation status

Greece established national contribution to the ARGO project through national funding to the Greek Argo programme (2012-2015). The programme was co-financed by Greece and the European Union. Through the national programme Hellenic Integrated Marine Inland water Observing Forecasting and offshore Technology System (HIMIOFoTS) www.himiofots.gr (2018-2021), HCMR has established further contribution to the ARGO project. Since November 2021, when HIMIOFoTS finished, there is not any existing national funding for Greek Argo.

1.1 Floats deployed and their performance

During 2021, five (5) Argo floats were deployed in the Greek Seas under the framework of the Greek-Argo RI activities, and the Euro-Argo ERIC cooperation activities. Three (3) of the floats were Arvor-I type purchased by the Greek Argo RI whilst, two Italian floats, one (1) Arvor-DO and one (1) Arvor – Deep, were deployed by Greek Argo team on behalf of the Argo-Italy. The floats were deployed in the Aegean and Levantine basins. All floats integrate Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time. The performance of Arvor floats has been satisfactory until now (see Table 1). Regarding Greek floats, 2 were deployed in the Aegean during POSEIDON network maintenance (these cruises were funded by HIMIOFOTS national project), and 1 in the North Aegean with the help of Aegean University (funded by Euro-Argo RISE project). Two of the Greek floats (6903297-8) were deployed at deep-coastal plateaus of the North Aegean continuing the Euro-Argo RISE project task 6.1 activities within the context of the potential of Argo to contribute on the monitoring of coastal areas. The two deployments related to Italian floats (6903803-4) were undertaken by the Greek MSFD winter cruise. All missions were successful, further information on these missions are available in the Euro-Argo fleet monitoring tool
(https://fleetmonitoring.euro-argo.eu/dashboard?Status=Active).

Table 1. Active floats and new deployments performed from Greek Argo team during 2021

A/A	Float type	WMO	SERIAL NUMBER	Deployment Date	Deployment time	Deployment Latitude	Deployment Longitude	Available profiles	Status
1	ARVOR DO	6903803	AI2632-20EU010	20/09/2021	04:20	34.81	26.16	36	Active
2	ARVOR DEEP	6903804	AD2700-20EU002	20/09/2021	23:55	36.02	28.63	35	Active
3	ARVOR	6903296	AI2600-21GR001	13/09/2021	16:15	35.72	25.12	37	Active
4	ARVOR	6903297	AI2600-21GR006	17/10/2021	05:45	39.83	24.42	30	Active
5	ARVOR	6903298	AI2600-21GR004	13/11/2021	12:20	38.87	26.42	25	Active

All floats have been integrated in the MedArgo project. The 6903298 float was configured to cycle every 5 days, drift at 450 m and acquire profiles from 600 m under its special test mission whilst, for the 6903296 and 6903297 float we followed the standard MedArgo specifications. The mission parameters of the floats were set as follows: The parking depth of the floats was set to 350 m, its profiling depth to 1000 m and the cycle period to 5 days. The raw data of the Greek float are delivered at the Coriolis data Centre where the real time quality control takes place while the delayed mode quality control of the data will be processed by the MedArgo Centre at OGS.

1.2 Floats recovered

In June 2021, the Greek Argo team undertook a difficult Argo recovery mission in Kissamos Bay of North-western Cretan coast (Photo 1). The float had been seen laying on the seabed by a scuba diving centre in March 2021 (Figure 2). The Greek Argo team organized a recovery mission on the 11th of June 2021 and using scuba diving equipment recovered an APEX float with the help from a local professional scuba diver. The float was stuck on the seabed at 38 m depth and had major damages both on the upper part (antenna and CTD sensor, and at the bladder. The S/N on the float (9112) hasn't been identified yet.

Photo 1. The recovery mission of the APEX float found at the west Cretan coastline stranded at 38 m depth

1.3 Technical problems encountered and solved

Based on previous experience on platform monitoring systems, HCMR has been utilizing an automatic alerting system (http://poseidonsystem.gr/alerts/?m=2) for the monitor of basic parameters of the floats' location and data transmission. This system has been partially updated to enhance the operational monitoring needs of the Euro-Argo RISE coastal deployment needs for the 6903288 float deployed in 2020. The automatic alerting system incorporated additional features for the real-time monitoring of crucial parameters that described the float's operation. Such are the bathymetry and the maximal depth reached by the float in order to keep track of grounding events. The alerting system is based in pre-defined thresholds and an alert message is transmitted in cases the monitored parameters overcome these thresholds. Thus, similar to the alerting messages whether there are delays or major differences in the transmission time, alert messages were sent to the PI when profiling or parking pressure was recorded to be less than 155.0 dbar.

1.3 Status of contribution to Argo infrastructure, data management and delayed mode quality control process

HCMR has run an extended network of buoys within the Aegean and Ionian Seas including the multi-parametric M3A observatory of the Cretan Sea and a deep sea (2000 m) bottom platform which is part of the EMSO network and has been deployed in the Ionian Sea (POSEIDON & POSEIDON-II monitoring, forecasting and information systems). HCMR also operates the Hellenic National Oceanographic Data Centre (HNODC) established in 1986, as part of the National Centre for Marine Research (NCMR). HNODC operates as a National Agency and is responsible for processing, archiving and distributing marine data. HNODC is also developing techniques for oceanographic data processing and data base maintenance. Furthermore it promotes the International Exchange of Data in the frame of its cooperation with the "Intergovernmental Oceanographic Commission IOC) of UNESCO as it is responsible for the coordination of International Data Exchange (IODE) in Greece.

HCMR operates a large-scale integrated infrastructure that includes all marine observational systems together with ocean engineering infrastructures. Regarding the delayed mode data processing HCMR has a capability of a delayed-mode quality control for the Greek Argo data. The delayed mode quality control of the data delivered from the Greek Argo float are currently processed by the MedArgo data centre. HCMR considers the possibility of further developing a delayed-mode data processing for ARGO profiles collected within the Eastern Mediterranean region. HCMR may also contribute to the improvement of the delayed mode quality control processing conceding CTD data collected through several HCMR research cruises. HCMR operates the Med Sea data portal that was set up for the needs of Copernicus CMEMS services. Within this framework HCMR is in charge of validating biochemical data from Argo floats that are operating in the Mediterranean.

2. Present level and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo

2.1 Existing funding for Greek Argo

The procurement, deployment and operation costs of the first Greek float launched in 2010/2011 were covered by HCMR internal funds. During 2012, Greece established national funding to the Greek Argo programme through the General Secretariat of Research and Technology (GSRT), Ministry of Education, Lifelong Learning and Religious Affairs (funding agency). A major achievement is that Greece participates to the European infrastructure E-A ERIC as a full member. Until recently, the only existing national funding for the Greek Argo was through HIMIOFoTS national RI through which the purchase of 6 floats is finalized and will cover the deployment needs for this year.

2.2 On the future funding, organization and planning for Greek Argo

Efforts from the Institute of Oceanography of HCMR for further national funding for the long-term sustainability of Greek Argo are ongoing. Since HIMIOFoTS RI has ended in 2021, several actions have been undertaken by the Greek Argo team towards the General Secretariat of Research and Innovation (GSRI) in order the latter to contribute for the Greek Argo programme continuation and sustainability.

As part of the Euro-Argo, HCMR has undertaken all necessary efforts and managed to establish long term national funding for the E-A ERIC infrastructure and to meet the standards of a full

member. Regarding the Greek Argo RI annual contribution to Euro-Argo RI an indicative estimation is the following:

Personnel committed/dedicated to Euro-Argo activities (person months/year):

- National representation, member commitments: 2.5
- Float preparation, deployments, procurements: 1

Personnel committed/dedicated to Greek-Argo activities (person months/year):

- Greek Argo coordination and management: 2
- Float preparation, deployments, procurements: 2
- Monitoring of the fleet performance: 2
- Data management and analysis: 3

3. Summary of deployment plans

Greece has deployment capabilities for the Aegean, the Ionian Sea and the central Levantine basin. Float deployments in 2022 will be performed according to the plans of the Greek-Argo research infrastructure. The main goal within 2022 is to continue the development of the Greek-Argo infrastructure array in accordance with the Euro-Argo infrastructure. Future deployments are a function of the operational needs of the Greek Argo network and the current coverage of areas of interest. Although the final decisions for the areas that floats will be deployed may change, the plan for 2021 generally includes:

- 1 float deployment in the South Aegean
- 1 float deployments in the North Aegean
- 1 float deployment in the Levantine Sea

4. Summary of national research and use of Argo data

4.1. Operational and scientific use of Argo data

An important part of the Greek-Argo activities is the exploitation of Argo data for operational forecasting as well as for research applications. Along this direction, HCMR established a network of relevant Greek scientific groups mainly from Universities and Research Institutes which constitute the Greek Argo Users group/network. These different groups are already using or will be using ARGO data in ocean/atmospheric forecasting, climate studies and for educational purposes. It is expected that the Greek Argo Users Group will further grow and expand its activities concerning the scientific exploitation of Argo data and the cooperation among Greek scientists. The next step will be the expansion of the Greek Argo network in more members. The network is already in contact with many organizations / agencies / institutions and it is foreseen that the establishment of the Euro-Argo ERIC will increase the interaction of the Greek Argo Users Group with the European and international ARGO scientific community in the near future.

Additionally, Argo data are used for educational purposes in some Greek University Departments. Due to HCMR initiatives within Euro-Argo, Greek Argo, Euro-Argo RISE, and SIDERI programmes to contact potentially interested Greek and other scientists from the

eastern Mediterranean region and inform them about the benefits of Argo programme. An increasing demand for Argo data along the Aegean and Ionian Sea for both scientific and educational purposes has been registered.

4.2. Dissemination activities of the Greek Argo– links with Euro-Argo infrastructure

During 2019 the Greek Argo RI hosted the 7th Euro-Argo Science Meeting that took place in Athens on 22-23 October. The meeting has been successful and managed to bring together users of Argo data providing an opportunity for high-level science interactions. Similarly, HCMR Argo team organized the 1st Mediterranean and Black Seas Argo workshop (https://www.euro-argo.eu/News-Meetings/Meetings/Others/Mediterranean-and-Black-Seas-workshop), under Euro-Argo RISE activities, in April 2021, and is further preparing a follow-up to the workshop special session in the upcoming HCMR's Marine and Inlands Waters Symposium in September 2022 (https://symposia.gr/special-sessions/). Within 2019 several dissemination activities were carried out by the Greek Argo RI such as the participation of Greek Argo in the 2019 Researchers Night and the educational activities for high school students throughout the year. However, during 2020, similar activities were cancelled due to the Covid-19 situation. In 2021, presentations of the Greek Argo and the Euro-Argo activities have been made at high schools of Athens during 2021, and at the University of Aegean (Marine Sciences department) in November 2022 following the previous in November of 2016.

By the end of 2013 Greek Argo has launched its web page: www.greekargo.gr that demonstrates and promotes Greek-Argo and Euro-Argo activities. At the end of 2014 Greek-Argo web portal was upgraded providing information and data access from all floats operating in the Mediterranean and presenting all Greek Argo activities, news and data from Greek Argo floats. A continuous upgrade is ongoing integrating more images and videos from Greek Argo deployment activities. Furthermore, new education material has been released and a school visit programme has been established since 2015.

The Greek Argo and Euro-Argo Research Infrastructures, along with the Euro-Argo RISE project, are demonstrated on the POSEIDON updated web page, https://poseidon.hcmr.gr/components/observing-components/argo-floats. The POSEIDON system is the operational monitoring and forecasting system for the Greek Seas and many of its forecasting components use T/S Argo profiles for data assimilation purposes. The POSEIDON web page is also hosting the links to the Euro-Argo educational web site as well as to the floats from each European country. The above links along with other informative material (Euro Argo leaflet, focused questionnaire) were forwarded directly to all active and potential users of Argo data in Greece. Many research groups filled and sent back the questionnaire providing valuable feedback to HCMR team. Furthermore, the Euro-Argo poster and leaflet translated in Greek and they are hosted in the POSEIDON website.

5. Greek Argo contribution to Argo bibliography

5.1 Operational oceanography and ocean forecasting

Med-Argo data have been already used as independent data in order to assess the impact of remote sensed and Ferry-box SSS data assimilation into the Aegean Sea hydrodynamic model component of the POSEIDON system running operationally at HCMR within the framework of POSEIDON system.

Med-Argo data are routinely assimilated (using localized Singular Evolutive Extended Kalman filtering techniques) on a weekly basis in three different modelling forecasting components (Mediterranean 1/10° resolution, Aegean Sea 1/130° resolution and Ionian – Adriatic Sea at 1/50° resolution) of the POSEIDON operational system.

Some of the results of the works described above are included in the following scientific publications:

Bourma E, Perivoliotis L, Petihakis G, Korres G, Frangoulis C, Ballas D, Zervakis V, Tragou E, Katsafados P, Spyrou C, Dassenakis M, Poulos S, Megalofonou P, Sofianos S, Paramana T, Katsaounis G, Karditsa A, Petrakis S, Mavropoulou A-M, Paraskevopoulou V, Milatou N, Pagonis P, Velanas S, Ntoumas M, Mamoutos I, Pettas M, Christodoulaki S, Kassis D, Sotiropoulou M, Mavroudi A, Moira A, Denaxa D, Anastasopoulou G, Potiris E, Kolovogiannis V, Dimitrakopoulos A-A, Petalas S, Zissis N. The Hellenic Marine Observing, Forecasting and Technology System—An Integrated Infrastructure for Marine Research. *Journal of Marine Science and Engineering*. 2022; 10(3):329. https://doi.org/10.3390/jmse10030329

Petihakis, G., Perivoliotis, L., Korres, G., Ballas, D., Frangoulis, C., Pagonis, P., Ntoumas, M., Pettas, M., Chalkiopoulos, A., Sotiropoulou, M., Bekiari, M., Kalampokis, A., Ravdas, M., Bourma, E., Christodoulaki, S., Zacharioudaki, A., Kassis, D., Potiris, E., Triantafyllou, G., Tsiaras, K., 2018: An integrated open-coastal biogeochemistry, ecosystem and biodiversity observatory of the eastern Mediterranean-the Cretan Sea component of the POSEIDON system. *Ocean Science*, *14*(5), 1223-1223.

L. Perivoliotis , G. Petihakis , M. Korres , D. Ballas , C. Frangoulis , P. Pagonis , M. Ntoumas , M. Pettas , A. Chalkiopoulos , M. Sotiropoulou , M. Bekiari , A. Kalampokis , M. Ravdas , E. Bourma , S. Christodoulaki , A. Zacharioudaki , D. Kassis , M. Potiris , G. Triantafyllou , A. Papadopoulos , K. Tsiaras and S. Velanas, 2017. The POSEIDON system, an integrated observing infrastructure at the Eastern Mediterranean as a contribution to the European Ocean Observing System. Proceedings of the 8th EuroGOOS International Conference, 03-05 October 2017, Bergen, Norway

Kassis, D., Korres, G., Konstantinidou, A., Perivoliotis, L., 2017. Comparison of high-resolution hydrodynamic model outputs with in situ Argo profiles in the Ionian Sea. Mediterranean Marine Science, 0, 22-37. doi:10.12681/mms.1753

Kassis, D., Konstantinidou, A., Perivoliotis, L., Korres, G., 2015. Inter-comparing numerical model simulations in the Ionian Sea with Argo T/S profiles for the period 2008-2012. In proceedings of the 11th Panhellenic Symposium on Oceanography and Fisheries, p.945-948, ISBN 978-960-9798-08-2

Kassis D., Perivoliotis L. & G. Korres, 2014. Greek Argo: Towards monitoring the Eastern Mediterranean - First deployments preliminary results and future planning. In proceedings of the 7th International Conference on EuroGOOS, Lisbon – Portugal, 28-30 October 2014

Korres, G., M. Ntoumas, M. Potiris and G. Petihakis, 2014. Assimilating Ferry Box data into the Aegean Sea model. Journal of Marine Systems, 140 (2014) 59–72

Korres, G., K. Nittis, L. Perivoliotis, K. Tsiaras, A. Papadopoulos, I. Hoteit and G.

Triantafyllou, 2010. Forecasting the Aegean Sea hydrodynamics within the POSEIDON-II operational system. *Journal of Operational Oceanography*, Vol. 3, nu. 1, 37-49.

Korres, G., K. Nittis, I. Hoteit, and G. Triantafyllou, 2009: A high resolution data assimilation system for the Aegean Sea hydrodynamics. *Journal of Marine Systems*, 77, 325-340.

Korres, G., K. Nittis, L. Perivoliotis, G. Triantafyllou and M. Chatzinaki, 2009. The Aegean Sea –Poseidon model. Hellenic Centre For Marine Research, Greece.

5.2 Ocean science and environmental studies

Med-Argo data are currently used by a small group of researchers in Greece for studies of water mass characteristics and climatic signals of the different deep basins of the Mediterranean Sea. The continuous record of T/S characteristics provides insight in the seasonal and inter-annual variability of the Mediterranean Sea and its sub-basins. A number of publications and scientific results have been released regarding the Greek Argo acquired data during the last 4 years.

Publications in scientific journals and conferences proceedings:

Kassis, D., and G. Korres, 2021. Recent hydrological status of the Aegean Sea derived from free drifting profilers. *Mediterranean Marine Science, 22*(2), 347-361. https://doi.org/10.12681/mms.24833

Kassis, D., and G. Varlas, 2020: Hydrographic effects of an intense "medicane" over the central-eastern Mediterranean Sea in 2018. Dynamics of Atmospheres and Oceans, 2020, 101185, ISSN 0377-0265, https://doi.org/10.1016/j.dynatmoce.2020.101185

Kassis, D., and G. Korres, 2020: Hydrography of the Eastern Mediterranean basin derived from argo floats profile data. *Deep Sea Research Part II: Topical Studies in Oceanography*, *171*, 104712, https://doi.org/10.1016/j.dsr2.2019.104712

Zervakis, V., Krauzig, N., Tragou, E., Kunze, E., 2019: Estimating vertical mixing in the deep North Aegean Sea using Argo data corrected for conductivity sensor drift. Deep Sea Res Part I Oceanogr Res Papers 154. https://doi.org/10.1016/j.dsr.2019.103144

Kassis D., Korres G., 2018: Recent hydrological status of the Aegean Sea derived from free drifting profilers. In proceedings of the 12th Panhellenic Symposium on Oceanography and Fisheries, «Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean», Ionian University, Corfu, 30 May – 3 June 2018

Kassis, D., Korres, G., Perivoliotis, L., 2016. Sub-mesoscale features of the Eastern Ionian Sea as derived from Argo floats operating during 2014-2015, in: Submesoscale Processes: Mechanisms, Implications and New Frontiers. Presented at the 48th Liege Colloquium, University of Liege, Liege, Belgium.

Kassis, D., Krasakopoulou, E., Korres, G., Petihakis, G., Triantafyllou, G.S., 2016. Hydrodynamic features of the South Aegean Sea as derived from Argo T/S and dissolved oxygen profiles in the area. Ocean Dyn. 1–18. doi:10.1007/s10236-016-0987-2

Kassis, D., Korres, G., Petihakis, G., Perivoliotis, L., 2015. : Hydrodynamic variability of the Cretan Sea derived from Argo float profiles and multi-parametric buoy measurements during 2010–2012. Ocean Dynamics, 15-00058. doi: 10.1007/s10236-015-0892-0

Doctorate theses:

Kassis, D., 2017: Operational in - situ monitoring of the Greek seas as a tool to describe hydrodynamic variability and its effect on the biochemical distribution, National Technical University of Athens (NTUA),
https://www.didaktorika.gr/eadd/handle/10442/40700?locale=en

Scientific Sheets in Greek Argo web page:

"Use of Lagrangian methods in optimizing Argo float deployment locations in the Mediterranean Sea" Summary of the scientific report of the University of Aegean in the framework of the Greek Argo Project.

"The integration of Argo floats in numerical weather prediction" Summary of the scientific report of the Harokopio University in the framework of the Greek Argo Project.

"Use of Argo data in ocean numerical simulations" Summary of the scientific report of the Aristotle University of Thessaloniki in the framework of the Greek Argo Project.

"Evaluation of climate and biochemical models using Argo data" Summary of the scientific report of the University of Crete in the framework of the Greek Argo Project.

Scientific Sheets in Euro-Argo web page:

Kassis D., Konstantinidou A., Perivoliotis L. and Korres G., 2014: Comparison of Argo profiles observations against numerical model simulations in Ionian Sea. Euro Argo RI web page http://www.euro-argo.eu/Main-Achievements/European-Contributions/Science/Regional-Seas/Med-Black-Seas/

Kassis D. and Korres G., 2014: Hydrological variability derived from the first Argo mission in the Cretan Sea basin. Euro Argo RI web page http://www.euro-argo.eu/Main-Achievements/European-Contributions/Science/Regional-Seas/Med-Black-Seas/

Presentations in conferences, science meetings, and scientific workshops:

Kassis, D., Notarstefano, G., Ruiz-Parrado, I., Taillandier, V., Díaz-Barroso, L., et al.. 2021. Investigating the capability of Argo floats to monitor shallow coastal areas of the Mediterranean Sea. p. 110 – 117. In: *Proceedings of the 9th EuroGOOS International*

Conference. 3 – 5 May 2021, Online Event 2021, EuroGOOS. Brussels, Belgium. https://archimer.ifremer.fr/doc/00720/83160/

Notarstefano, G., Kassis, D., Palazov, A., Tuomi, L., Walczowski, W.,, et al., 2021. Extension of Argo in shallow coastal areas and expansion of the regional communities (EURO-ARGO RISE project). p. 375 – 381. In: *Proceedings of the 9th EuroGOOS International Conference. 3 – 5 May 2021, Online Event 2021, EuroGOOS. Brussels, Belgium. https://archimer.ifremer.fr/doc/00720/83160/*

Kassis D., Korres G., 2019: Argo missions and synergies with other platforms in marginal seas: The north Aegean and south Ionian test cases. In proceedings of the 7th Euro-Argo Science Meeting Workshop - Athens, October 22-23 2019
Kassis D., Varlas G., 2019: Investigating the impacts of a strong Medicane on the upper layers of the Eastern Mediterranean Sea. In proceedings of the 7th Euro-Argo Science Meeting Workshop - Athens, October 22-23 2019

Kassis, D., Perivoliotis, L., Korres, G., 2015: Hydrological variability of the Eastern Ionian and Adriatic Seas derived from two new Argo missions in 2014. In proceedings of the 5th Euro-Argo User Workshop - Brest, March 16-17 2015 http://www.euro-argo.eu/News-Meetings/Meetings/Users-Meetings/5th-User-Workshop-March-2015/Workshop-Programme

Kassis D., Von Schuckmann K., Korres G., 2013: Hydrographic properties of Cretan Sea derived from Argo float's profiles and buoy data measurements during 2010-2012. In proceedings of the 4th Euro-Argo Science Meeting and Workshop, June 2013, Southampton, UK http://www.euro-argo.eu/News-Meetings/Meetings/Users-Meetings/4th-Users-meeting-June-2013