German National Report 2023 for the Argo Steering Team Meeting AST25

Submitted by Birgit Klein and Meike Martins on behalf of Argo Germany

The AST requests a National Report from each country involved in implementing the Argo array prior to the yearly AST meetings. These reports help inform all Argo participants of the status of each National Program and help guide the AST meetings. Please use the questions below to help produce your report and send it to Megan Scanderbeg two weeks prior to the annual AST meeting or drop it into the National Reports folder here: https://drive.google.com/drive/folders/1VdEKiReuFglprqUXSpChB-fmpfeE-gK1?usp=drive_link .

1. **The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2023)**
   a. **floats deployed and their performance**

   On the total, 38 Floats were deployed by Argo Germany, mainly in the Atlantic Ocean. 32 were purchased from the operational budget at the BSH funded by the BMDV, 3 were deployed and funded from institutional funds by the AWI, 1 BGC Float was financed and deployed by IOW with the RV Elizabeth Mann Borgese, 2 by the ICBM with the Dagmar Aaen.

   In December 2023, Polarstern expedition PS140 deployed a series of 4 Arvor floats in Prydz Bay, East Antarctica. The floats, operated through AWI and the EU-project OCEAN:ICE, are intentionally-grounded under the sea ice of the continental shelf, in order to provide year-round profiles from one of the key Antarctic dense water formation sites. The Polarstern team also deployed 4 floats from BSH on the same cruise in the Southern Ocean. Additional 7 BSH floats were deployed on 2 other Polarstern cruises earlier in 2023, 2 in the Arctic Ocean and 5 in the Atlantic. 8 BSH floats were deployed on a Meteor cruise in the Atlantic, and other 10 floats stored at the south African hub with Tammy were deployed on a transittour of the US RV Revelle by American colleagues. 2 BGC floats were deployed during a Maria S. Merian cruise in the end of 2023 in the Labrador Sea and a 3rd one in the Northwest Atlantic on the SOOP line.

   The low number of float results from delays in cruise until 2024.

   b. **technical problems encountered and solved**

   The 3 BGC floats deployed in December in the Labrador Sea and NW corner are equipped with pH sensors shipped after June 2022, which according to the community notice issued by SBS, still showed an elevated risk of early failure. Due to project constraints the floats had

to be deployed anyway in 2023 but all floats so far behave well and the first 20 to 30 cycles of these floats show reasonable data. We will closely monitor the floats during coming months.

Three older pH sensors which have been sent back to the manufacturer are still a point of concern, because we have received no delivery date yet for the return. These floats would be needed for a cruise in summer 2024.

c.   status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

The status of the ASD floats from the German program has been documented in the joint excel spreadsheet curated by Coriolis until November 2023. No more new incidences were encountered in the past year. The European fleet which is partly handled by BSH did show however a few more cases, which will be discussed with SBS at the end of the year. There is a small delay in core float dmqc since then due to lack of personal resources. Ramping up to include BGC floats has also been hampered by the short personal resources. In the second half of 2023 the workforce for Argo Germany was reduced to half due to sickness and termination of contracts.

Certificates for 5.5 CTDs related to the ASD issue were issued by SBE for installation on future float procurement.

d.   status of delayed mode quality control process

BSH had adopted floats from all German universities and agreed to perform similar services for the AWI floats. The status of delayed mode quality process for German core floats is good, but decreased a bit compared to previous years. The national report will be updated as soon as the OceanOps webpage is online again and statistics can be calculated.

Delayed mode quality control of floats in the Baltic were discussed during a workshop in Sopot (18.04-19.04.2023) and a following workshop in Bergen (16.10-19.10.2023). During the hands-on workshops all groups with floats in the Baltic were present and a processing chain developed by IMR was provided. This close cooperation will be continued in 2024 and extended to the BGC parameters, in a first phase to the oxygen data.

Due to the lack of personal resources, BSH is behind schedule of DMQC, especially concerning BGC floats. 2 persons dealing mostly with the logistical and technical matter were ill or changed the position so that the remaining team had to take over their duties. However, close collaborations between the German institutes has been established, e.g. the deployments of the 3 BGC Floats were prepared according to the needs of the future pH data quality control.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Spatial (Polar, equator, WBCs)

The BMDV (Federal Ministry for Digital and Transport) has approved to increase the budget for the implementation of One Argo and to switch the national contribution to a mix of 36 core floats, 14 deep floats and 12 BGC floats annually and supply more funding. The budget was increased by 350.000 € in 2023 and will ramp up to an increase of 1.1 Mio. € in 2026 which amounts to a total budget of 1.9 Mio € in 2026 (excluding costs for personal). Due to the strong price increase and insufficient funds to cover the full implementation, it is expected to open negotiations with the BMDV again in 2025. For 2024 and following 4 years, BSH has established a tender with 2 manufacturers, NKE and Bornhöft (TWR), in order to ease the procurement of floats.

GEOMAR is continuing the analysis of the pH data set in the Labrador Sea and direct comparisons to surface measurements on the SOOP line Atlantic Sail in the North Atlantic. A new pH sensor from Pyroscience has been installed on the SOOP line and shows promising results. ICBM is continuing to redeploy its floats with hyperspectral radiometers, while IOW is experimenting with the pCO2 sensor. Unfortunately, one of the floats carrying a pCO2 sensor has been lost in 2023 for unknown reasons. The remaining float had been sent to NKE for checks and will be back in March 2024 for deployment in spring 2024.

Birgit Klein of the Federal Maritime and Hydrographic Agency (BSH) has continued to coordinate the national Argo Germany program and is also responsible for data management of the core floats. Meike Martins has joined the BSH Argo team in January 2023 and is presently working to establish the BGC DMQC. BSH logistics related to technical aspects, float deployments and satellite data transmission are handled by Anja Schneehorst and Simon Tewes. Ingrid Angel Benavides was involved in Argo project related matters until February of 2023. The national BGC group established in 2020 involves four research institutes: AWI, GEOMAR, ICBM and IOW. A complete list of people involved is given below.

Name and institution	Area of expertise
Birgit Klein (BSH)	National program lead, research scientist (DArgo2025, C-Scope, EuroArgo Rise), DMQC operator (core Argo)
Meike Martins (BSH)	Research scientist, DMQC operator (BGC Argo)
Ingrid Angel-Benavides (BSH)	Research scientist (EuroArgo Rise) and related DMQC obligations (only until Feb 2023)
Simon Tewes (BSH)	Technician, technical support, and performance monitoring (only until September 2023)
Anja Schneehorst (BSH)	Technician, float procurement, contracting, deployment logistics and performance monitoring (only half of the time)
Arne Körtzinger (GEOMAR)	Research scientist, BGC Argo, DMQC expert pH-sensor (BGC sensors)
Tobias Steinhoff (GEOMAR)	Research scientist, BGC group, DMQC expert pH-sensor (BGC sensors)

Cathy Wimart-Rousseau (GEOMAR)	Research scientist, BGC group, DMQC expert pH-sensor (BGC sensors)
Rainer Kiko (GEOMAR)	Research scientist, expert UVP sensor
Henry Bittig (IOW)	Research scientist (, C-Scope), BGC group, DMQC expert (BGC sensors)
Oliver Zielinski (ICBM)	Research scientist, BGC group, now at Institute of Baltic Research Warnemünde (IOW)
Hendrik Bünger (ICBM)	Research engineer, BGC group, DMQC expert radiometry (BGC sensors)
Olaf Boebel (AWI)	Research scientist, RAFOS technology
Marcus Janout (AWI)	Research scientist, project Ocean:Ice
Alexander Haumann (AWI)	Research scientist, project VERTEXO
Benjamin Rabe (AWI)	Research scientist, project ArcWatch
Krissy Reeve (AWI)	Research scientist, Weddell Gyre

Table 1: People involved in Argo in Germany and their associated institutes.

3. Summary of deployment plans: please see the separate documents explaining the longer term outlook this year as a response to G7 requests. This spreadsheet is to be **returned separately ASAP** to help prepare for the meeting. It can be sent to Megan or dropped in the folder link containing the instructions.

Deployment year:	2024					
Float Type:	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O
A. Funded	27		3	**6**	0	0
B. Business as usual/Reasonable expectation		15				
C. Proposed, with a reasonable chance of success				1		
D. Aspirational						
E. Other			3			
Totals	27	15	6	7	0	0

Further plans to deploy floats in 2025 to 2027:

Deployment year:	2025						2026						2027					
Float Type:	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O
A.	25				0	0					0	0						
B.	20	20	8	3			20	18	8	3			20	18	8	3		
C.				1													1	
D.							6											
E.																		
Totals	45	20	8	4	0	0	26	18	8	3	0	0	20	18	8	3	1	0

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

BSH is maintaining and updating the Argo Germany web site. It provides information about the international Argo Program, German contribution to Argo, Argo array status, data access and deployment plans.

https://www.bsh.de/DE/THEMEN/Beobachtungssysteme/ARGO/argo_node.html

Currently no statistics of Argo data usage are available. The German Navy uses Argo data on a regular basis for the operational support of the fleet. The SeaDataNet portal uses German Argo data operationally for the Northwest European Shelf. Argo data are routinely assimilated into the GECCO reanalysis, which is used for the initialisation the decadal prediction system MiKlip and other operational forecasting systems. At BSH, the data are used within several projects for data interpretation in the eastern North Atlantic and the Expert Network on climate change of the BMDV.

Several Phd-thesis using Argo data are conducted at the research institutes.

The annual user workshop for 2023 was held as a hybrid event on 20.06.2023. The meeting was well attended and provided a good forum for users to share their scientific work and methods.

Germany contributes to the NAARC and joined recently the SOARC. Researchers from German institutions have continued to contribute recent CTD data to the Argo climatology.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOPS, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-25 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.

   The strong increase in expenses in the order of 20% will have a negative impact on the number of floats deployed. It is unreasonable to expect increase in funding from the ministry in the order of 20%. An additional concern is the high lead time between orders and delivery. This is complicating the logistics and is challenging in terms of meeting budgets in FY.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

   During some of the deployments organized by the BSH reference CTD profiles were taken, the principal investigators are asked to provide the data as soon as they are calibrated. We will then exchange them with Coriolis.

7. Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.
   There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

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- **Ismail, M. F. A**., **Karstensen, J.** , Ribbe, J., Arifin, T., Chandra, H., Akhwady, R., Yulihastin, E., Basit, A. und Budiman, A. S. (2023) Seasonal mixed layer temperature and salt balances in the Banda Sea observed by an Argo float. Open Access Geoscience Letters, 10 (1). Art.Nr. 10. DOI 10.1186/s40562-023-00266-x.

- Purwandana, A., **Ismail, M. F. A.,** Nugroho, D., Atmadipoera, A. S. und Kampono, I. (2023) Hydrography and turbulent mixing in the Banda Sea inferred from Argo profiles. Open Access IOP Conference Series: Earth and Environmental Science, 1251 (1). Art.Nr. 012007. DOI 10.1088/1755-1315/1251/1/012007.

- **Roch, M., Brandt, P. und Schmidtko, S.** (2023) Recent large-scale mixed layer and vertical stratification maxima changes. Open Access Frontiers in Marine Science, 10 . Art.Nr. 10:1277316. DOI 10.3389/fmars.2023.1277316.

- **Roch, M. (**2023) On the Changing Upper-Ocean Stratification: Trends and Variability of the Upper-Ocean Structure during the Argo Observation Period. Open Access (PhD/Doktorarbeit), Christian-Albrechts-Universität zu Kiel, Kiel, Germany, 169 pp.

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Wimart-Rousseau, C. , Steinhoff, T., Klein, B., Bittig, H., and Körtzinger, A. (2023): Technical note: Enhancement of float-pH data quality control methods: A study case in the Subpolar Northwest Atlantic region, BG Discussions, https://doi.org/10.5194/bg-2023.

Schoderer, M**., Steinhoff, T., Bittig, H., Klein, B.**, Haegle, R., Arne, and Hornidge A.-K. (2024), It takes thousands of dots to paint a picture – Structures and practices for integrated marine carbon observations and vulnerabilities in the observation network Contribution to "Knowledge Integration in Ocean Governance" edited by Dorothea and Annegret Kuhn, in preparation.

Krissy Anne Reeve, Torsten Kanzow, **Olaf Boebel,** Myriel Vredenborg, Volker Strass, and Rüdiger Gerdes (2023), TheWeddell Gyre heat budget associated with the Warm Deep Water circulation derived from Argo floats, July 2023, Ocean Science 19(4):1083-1106,DOI: 10.5194/os-19-1083-2023

Maike Sonnewald, **Krissy Reeve,** Redouane Lguensat, (2023) A Southern Ocean supergyre as a unifying dynamical framework identified by physics-informed machine learning, Communications Earth & Environment, 4(1), DOI: 10.1038/s43247-023-00793-7.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

    No Impact.

9. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2024 and 2025 (if known) and where they might be deployed.

Yes, BSH is cooperating with RBR for deployments of the RBR CTD sensors. In 2023, several RBR sensors were deployed: 10 floats, i.e. 5 equipped with a SBE CTD and 5 with a RBR CTD were deployed as buddies, along the transittour through the South Atlantic of the Revelle by American colleagues. 3 other RBR floats were deployed in late 2023 in the South Indian Ocean, one of them has severe problems after the 7th cycle, analysis of the failure reasons are on-going. 5 floats with an RBR sensor wait in Lisbon to be deployed with the Portuguese Navy, one will be deployed south of Portugal, in March 2024. 2 floats equipped with RBR sensors will be deployed in August 2024 in the Eastern subtropical North Atlantic. Further plans to buy floats equipped with RBR CTD in 2024 and 2025 are not finalized yet, however, RBR CTD sensor are included in the tender with both manufacturers (see above) and BSH plans are to purchase 10% of the CTD sensors from RBR.