German National Report 2022 for the Argo Steering Team Meeting AST24

Submitted by Birgit Klein on behalf of Argo Germany

1. **The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)**
   a. **floats deployed and their performance**

Floats deployed by Germany in 2022 were operated by BSH and AWI. 59 floats were deployed in 2022 with a focus on the Atlantic. 37 of the floats deployed in 2022 were funded from the operational budget provided by the BMDV and 22 were funded from institutional funds at AWI. 8 more have been put on RV Meteor on transit to Namibia and have now been deployed in early 2023. Most deployments were carried out on research vessels, which comprised German and South African ships. The South African Weather Service (thanks to Tamaryn Morris) had kindly accepted to store 5 German floats delivered in late 2022 on their premises to be picked up by research ships calling into Cape Town and also to be deployed on the regular South African cruises (SANAE, SAMBA, Good Hope). These 5 floats all carry RBR CTDs. Another four floats were delivered to the Bark Europa, a sail-ship operating tourist cruises around Antarctica and the Southern Ocean. The deployment locations for 2022 are shown in Fig. 1.
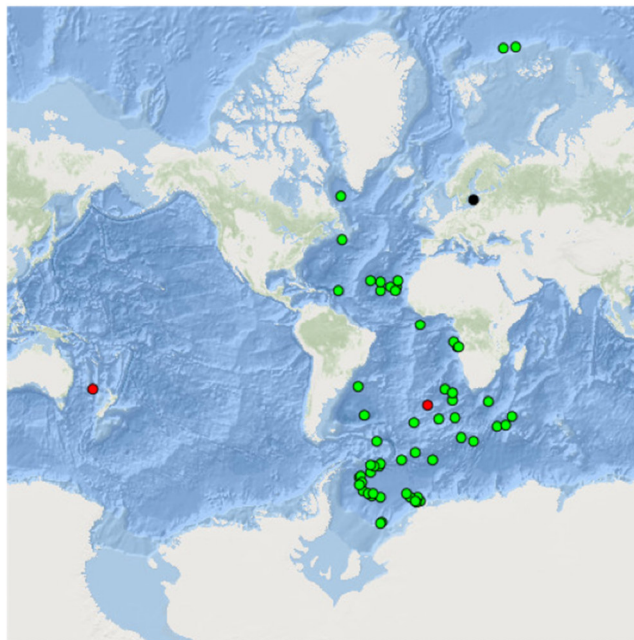

Fig. 1: Deployment positions for floats operated nationally in 2022 in the Atlantic Ocean (green: operational, red: inactive, black: closed).

Most of the floats deployed in 2022 were TS floats only, with the exception of three floats carrying BGC sensors in the Baltic, Coral Sea and Labrador Sea. The performance of the floats in general

was fine, the float in the Baltic (co-operated with IOW) has intentionally been recovered and has been redeployed in 2023. The float in the Coral Sea (cooperated with ICBM) has performed 39 cycles before communication ceased. The Apex float seemed to have problems with its buoyancy and had difficulties to ascend to the surface. Maybe it will surface again after seasonal stratification has changed. One float in the South Atlantic failed after deployment. It delivered only one shallow profile and remained then in an emergency mode at surface. It has been added to the recovery list operated by the EuroArgo ERIC.

b. technical problems encountered and solved

5 floats with pH sensors bought in the beginning of 2020 and deployed in 2021 had all been showing either low quality pH data or complete failure of the sensors shortly into their life (after ~40 cycles). We have recovered one of these floats (6904115) during 2022 and shipped it back to SBS via the manufacturer.

WMO	SBE41 Sn	pH Sensor SN	Data quality
6904114	41-12948	720-10617	drift
6904115	41-12951	720-10707	uncorrectable, recovered
6904110	41-12945	720-10722	uncorrectable
6904111	41-12949	720-10727	uncorrectable
6904112	41-13304	720-10730	drift

The pH sensor performance is still a concern since SBS warned about the reference electrode failure mode evident in floats deployed with pH serial number 10000 to 11000. Two floats bought in 2021 with pH/O2 sensor had pH sensor SN within or close to the range and were therefore shipped back to SBS via the manufacturer for warranty replacement of the sensors to minimize the remaining risks (6904232 with pH SN 11199, and 6904233 with pH SN 10764). A third float bought in 2021 (6904321) has been deployed in the Labrador Sea and has up to now performed 39 cycles without signs of pH sensor failure.

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.)

Germany has been engaged in the monitoring of high salinity drift and has continued to update the joint spreadsheet of floats affected by abrupt salinity drift shared at international level:

https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit?usp=sharing

This spreadsheet contains entries from all DMQC operators with information on floats showing ASD symptoms.

SBS had announced a manufacturing problem in the SN range 10482 – 11252 relating this to the high occurrence of abrupt salty drift behavior. In order to prepare the warranty talks a meeting was held on 15.12.2022 to define criteria for constructing lists of eligible floats in the SN range 10482 – 11252 gathering the view of Europe and Japan. The decision made during the meeting was to include all floats in the proposed serial number range, which had reached an uncorrectable

state of drift within 180 cycles (equivalent to a nominal lifetime of 5 years at a 10 day cycle). Lists for Europe and Japan were prepared and presented at a later meeting with SBS on 18.01.2023. The link to the meeting was shared with the other concerned national programs (Australia and US). SBS proposed during the meeting a rated credit for failed CTDs with a cutoff at 160 cycles or 4.4 years. How to best consider high frequency sampling in some of the floats in the cutoff-criteria still needs to be worked out. The list of European floats prepared after the meeting on 18.01.2023 contains up to six Germany floats. The lists are now under review at SBS. Updates to the list will be performed at regular intervals since some of the deployed floats in the range are still alive.

Several of the German institutes have engaged at European level to define quality control procedures for BGC variables. The knowledge gained will be transferred during 2023 to the newly filled full time-position of a DMQC operator for BGC variables at BSH. No deep floats have yet been deployed by Germany and will build into the DMQC capabilities at BSH.

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 floats is good, but decreased a bit compared to previous years. The overall percentage of D-files from all German programs is remaining at a high level (>90%). DMQC has now also been performed for all re-processed AWI floats (now in V3.1) and after discussion with the AWI PIs in January 2023 files are ready for submission to the GDACs. The remaining issue is the correction of the 'TBTO' signal in the first cycles, which will be discussed during the upcoming group meeting of the argo dm-operators. Now only 69% of the AWI files are available as D-files. The census of the delayed mode quality control was given in detail in the data management report from November 2022.

BSH has also adopted a subset of floats from Finland (10 floats), the Netherlands (121 floats), Norway (30 floats) and Poland (15 floats) for DMQC and is responsible in the framework of the MOCCA project (coordinated by the ERIC) for the delayed-mode quality control of 54 MOCCA floats in the Nordic Seas, the subpolar gyre and the Southern Ocean. The progress in these programs providing D-files is generally good. Since Argo-Norway has received funding from the national research council to increase the number of Norwegian floats deployed per year, the program has got more involved in the DMQC activities since 2020 and floats deployed after 2020 have been covered by Norwegian and Polish DMQC operators.

Delayed mode quality control of floats in the Baltic will be discussed during a workshop in Sopot (18.04-19.04.2023).

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)**

Up until last year all operational funding from the BMDV (Federal Ministry for Digital and Transport) has been for core Argo only. The ministry   had been asked to support 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 increase was principally approved by the BMDV and increased funds were included in the national budget negotiations in 2022. The budget is 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.

The Federal Ministry of Science (BMBF) had provided considerable funding in 2020 to start the transition into the new multidisciplinary strategy. The project DArgo2025 (08/2020-12/2021) had received funding in 2020 for 20 floats, 15 of which are BGC floats and 5 core floats, but equipped with RBR CTDs. Some of the BGC floats carried novel sensors such as nitrate sensors and hyperspectral sensors from the German TRIOS company and have been evaluated successfully. In the project C-Scope (01/2021-12/2023) additional funding has been received to promote pH measurements on floats, these experiments are delayed because of the quality issues with the pH sensors . In the project C-Scope a new sensor of pCO_2 has been deployed in the Baltic and analysis of the data is continuing.

In the context of the European Project EuroArgo-Rise (finished end of 2022) the BSH has worked on a contribution for the Arctic and has developed a decision tool for selecting parameters for Ice Avoidance algorithms (ISA). A cooperation has been established with the AWI and its Arctic working group to participate in upcoming Polarstern expeditions to the High Arctic with two floats per year.

For the Southern Ocean AWI has restarted its activities in float deployments including RAFOS technology. AWI has deployed 22 floats in the southern Weddell Gyre in 2022, but no long-term funding scheme is available. 3 Floats from a research project (Ocean:Ice) will be deployed on PS140 together with 4 floats from BSH in the Pacific sector. More activities are planned for the following years in support of the AWI project VERTEXO (VERTical EXchange in the Southern Ocean).

GEOMAR is continuing its 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. It is also planned to participate in experiments with new pH sensors from Pyronics. ICBM is continuing to redeploy its floats with hyperspectral radiometers, while IOW is experimenting with the pCO2 sensor.

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 just joined the BSH Argo team and will be responsible 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. 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
Simon Tewes (BSH)	Technician, technical support, and performance monitoring
Anja Schneehorst (BSH)	Technician, float procurement, contracting, deployment logistics and performance monitoring
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 (DArgo2025, C-Scope), BGC group, DMQC expert (BGC sensors)
Malin Waern (IOW)	Research scientist, BGC group
Oliver Zielinski (ICBM)	Research scientist, BGC group
Hendrik Bünger (ICBM)	Research engineer, BGC group, DMQC expert radiometry (BGC sensors)
Ahlem Jemai (ICBM(	Research scientist, BGC group, DMQC radiometry expert
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 (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.**

GER	2023					
	Total	T/S Core	T/S/O2	BGC	Bio	Deep
Nordic Seas	0					
Mediterranean Sea	0					
Black Sea	0					
Baltic Sea	4			4		
Southern Ocean	3	3				
Arctic Ocean	2	2				
Global Ocean	57	46	4	4	3	
Total	66	51	4	8	3	0

Table 2: Planned deployments for 2023 gathering deployments from all German partners. Not all deployments have already been registered at OceanOps. BSH expects to order about 11 additional floats (depending on remaining funds) for the global ocean and will add them as soon as possible.
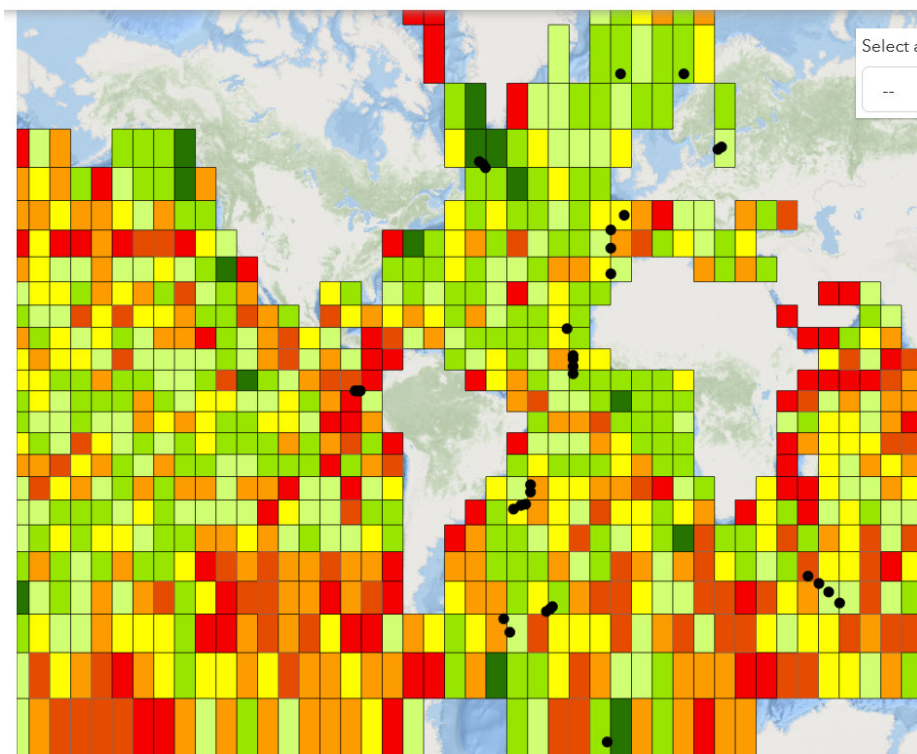

Fig.2: Planned positions of the BSH deployments confirmed so far (28.02.2023).

Focus of the deployments of the operational floats has been gap filling. Mostly areas have been targeted which lack floats including the tropical Pacific.

GER	2024					
	Total	T/S Core	T/S/O2	BGC	Bio	Deep
Nordic Seas	2			2		
Mediterranean Sea	2			2		
Black Sea	0					
Baltic Sea	2			2		
Southern Ocean	7	7				
Arctic Ocean	2	2				
Global Ocean	50	43		7		
Total	65	52	0	13	0	0

Table 3: Planned deployments for 2024 gathering deployments from all German partners

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 the Argo Germany web site. We have recently updated our webpage and have added content. 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. Their needs are communicated through a liaison officer stationed at BSH. 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. 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 2022 was held as a hybrid event on 21.06.2022. 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-24 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% is cutting into the budget and 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 increasing 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.**

   Not followed up during 2022 due to shortage of staff.

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.

   Organelli, E., E. Leymarie, O. Zielinski, J. Uitz, F. D'Ortenzio, and H. Claustre, 2021. Hyperspectral radiometry on Biogeochemical-Argo floats: A bright perspective for phytoplankton diversity. Pp. 90–91 in *Frontiers in Ocean Observing: Documenting Ecosystems, Understanding Environmental Changes, Forecasting Hazards.* E.S. Kappel, S.K. Juniper, S. Seeyave, E. Smith, and M. Visbeck, eds, A Supplement to *Oceanography* 34(4), https://doi.org/10.5670/oceanog.2021.supplement.02-33. Published online on 07.01.2022.

   Jemai Ahlem, Wollschläger Jochen, Voß Daniela, Zielinski Oliver, Radiometry on Argo floats: From the multispectral state-of-the-art on the step to hyperspectral technology, Frontiers in Marine Science, Volume 8 - 2021 | https://doi.org/10.3389/fmars.2021.676537.

   Henri Renzelmann (2022), B.Sc. Physik, Uni Bremen
   Räumliche Variabilität von Frequenzspektren interner Wellen anhand von Argo-Parkphasendaten

   Daniel, Molkenthin (2022), B.Sc. Physik Lehramt, Uni Bremen
   Stärke der Umwälzzirkulation im subpolaren Nordatlantik bei 47°N

Bastin, S., M. Claus, P. Brandt, and R. J. Greatbatch, 2022: Atlantic Equatorial Deep Jets in Argo Float Data. *J. Phys. Oceanogr.*, **52**, 1315–1332, https://doi.org/10.1175/JPO-D-21-0140.1.

Tuchen, F. P., Brandt, P., Lübbecke, J. F., & Hummels, R. (2022). Transports and pathways of the tropical AMOC return flow from argo data and shipboard velocity measurements. *Journal of Geophysical Research: Oceans*, 127, e2021JC018115. https://doi.org/10.1029/2021JC018115

Saha, A., Serra, N., & Stammer, D. (2021). Growth and decay of northwestern tropical Atlantic barrier layers. *Journal of Geophysical Research: Oceans*, 126, e2020JC016956. https://doi.org/10.1029/2020JC016956

Pohlmann, H., Brune, S., Fröhlich, K. *et al.* Impact of ocean data assimilation on climate predictions with ICON-ESM. *Clim Dyn* (2022). https://doi.org/10.1007/s00382-022-06558-w

Kiko, R., Picheral, M., Antoine, D., Babin, M., Berline, L., Biard, T., Boss, E., Brandt, P., Carlotti, F., Christiansen, S., Coppola, L., de la Cruz, L., Diamond-Riquier, E., Durrieu de Madron, X., Elineau, A., Gorsky, G., Guidi, L., Hauss, H., Irisson, J.-O., Karp-Boss, L., Karstensen, J., Kim, D., Lekanoff, R. M., Lombard, F., Lopes, R. M., Marec, C., McDonnell, A. M. P., Niemeyer, D., Noyon, M., O'Daly, S. H., Ohman, M. D., Pretty, J. L., Rogge, A., Searson, S., Shibata, M., Tanaka, Y., Tanhua, T., Taucher, J., Trudnowska, E., Turner, J. S., Waite, A., and Stemmann, L.: A global marine particle size distribution dataset obtained with the Underwater Vision Profiler 5, Earth Syst. Sci. Data, 14, 4315–4337, https://doi.org/10.5194/essd-14-4315-2022, 2022.

Drago, L., Panaïotis, T., Irisson, J.-O., Babin, M., Biard, T., Carlotti, F., Coppola, L., Guidi, L., Hauss, H., Karp-Boss, L., Lombard, F., McDonnell, A.M.P., Picheral, M., Rogge, A., Waite, A.M., Stemmann, L., Kiko, R. Global Distribution of Zooplankton Biomass Estimated by In Situ Imaging and Machine Learning, Frontiers in Marine Science, Volume 99, August 2022, Article number 894372, DOI: 10.3389/fmars.2022.89437

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.**

   Impact of COVID has faded away.

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 2023 and 2024 (if known) and where they might be deployed.**

   Germany will order >10% floats with CTDs from RBR, preferentially after the software issues of handling high frequency data on the NKE floats are finished.