# German National Report 2021 for the Argo Steering Team Meeting AST23

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 2021)**
   a. **floats deployed and their performance**

Most floats deployed by Germany in 2021 were operated by BSH. 86 floats were acquired in 2021 and altogether 77 floats were deployed including one Float from GEOMAR, 6 Floats from AWI and 20 floats from the national project DArgo2025. Nine floats were loaded on ships in 2021 and have now been deployed in early 2022. Due to cancellation of cruises in 2020 because of the COVID pandemic more floats were deployed in 2021 than in other years. The South African Weather Service (Tamaryn Morris) had kindly accepted to store German floats on their premises to be picked up by German Ships calling into Cape Town and to be deployed on the regular South African cruises (SANAE, SAMBA, Good Hope). Most deployments were carried out on research vessels, which comprised German, Polish, South African and UK ships. A contribution of five floats was made to the deployment by the sailing ship Iris that was chartered in 2021 specifically for deployments in the Atlantic Ocean. Another four floats were delivered to the Bark Europa a sailship operating tourist cruises around Antarctica and the Southern Ocean. The deployment locations for 2021 are shown in Fig. 1.The majority of the deployed floats except were Arvor floats with TS sensor only, 15 floats deployed in the DArgo2025 project were floats with BGC sensors and the remaining five floats from the project carried RBR sensors.

Argo deployments organized by Germany in 2021
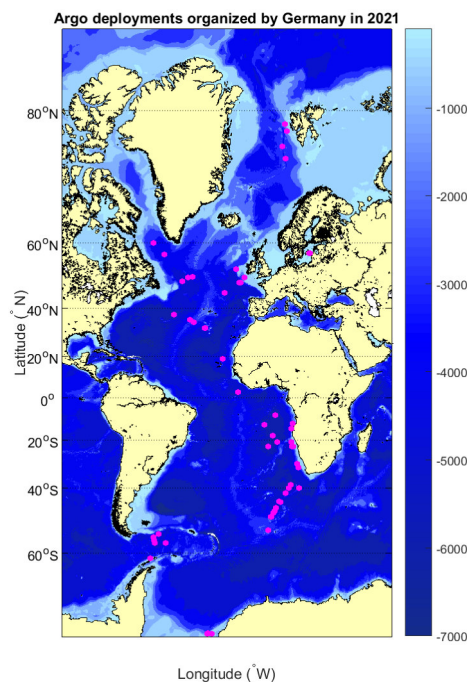
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Fig. 1: Deployment positions for floats operated nationally in 2021 in the Atlantic Ocean.

b.   technical problems encountered and solved

None of our floats deployed in 2021 has experienced serious technical problems.

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 continued its work in the European Research Infrastructure Consortium EURO-ARGO-ERIC, which was established in July 2014. In 2020, the EuroArgo ERIC has started a joint census of floats affected by fast salinity drift at European level to estimate the effects on the data stream. Initially, the list was established on GitHub and shared as a google-docx document. The working group on fast salinity drift reported at ADMT-21 and ADMT-22 on the issue. It was decided to collect the information in a joint spreadsheet with information on all premature salty drifter regardless if the develop abrupt salty drift or drift more or less continuously. The link to the spreadsheet is given below and entries can be entered either from all DMQC operators directly or be send as lists to Birgit.klein@bsh.de for inclusion in the table.

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

The national contributions to the spreadsheet will be updated for AST-23.

status of delayed mode quality control process

BSH had adopted floats from all German universities and agreed last year to perform similar services for the AWI floats. The status of delayed mode quality process for German floats is good. The overall percentage of D-files from all German programs is remaining at a high level (>90%). DMQC has now also been performed for the subset of re-processed AWI floats (now in V3.1) and is awaiting approval from AWI PIs. Now only 42% 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 2021.

BSH has also adopted floats from Finland (37 floats), the Netherlands (92 floats), Norway (58 floats) and Poland (26 floats) for DMQC and is responsible in the framework of the MOCCA project (coordinated by the ERIC) for the delayed-mode quality control of 65 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 will get more involved in the DMQC activities after we had organized a DMQC training workshop for Norway and Poland in 2019. Floats deployed from 2020 onward will be covered by Norwegian and Polish DMQC operators.

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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 core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)**

At the moment all our national funding from the BMVI is still for core Argo only. The aim is to switch our contribution to a mix of 36 core floats, 14 deep floats and 12 BGC floats annually. The budget proposal for 2022-2026 was principally supported at BMVI level. The negotiations for the national budget are presently delayed because of the elections and both budgets for 2022 and 2023 have asked for a full implementation of the One Argo strategy and a rise in annual budget to 2.5 Mio €. A decision is now expected until April/May 2022, but due to the recent political event the situation may be changed.

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. The proposal was headed by BSH with partners from the newly created BGC group (GEOMAR, ICBM and IOW). Deployments of all DArgo2025 floats have taken place in 2021 and addressed open technological questions with the data return from the floats. Some of the BGC floats carry novel sensors such as a nitrate sensors and hyperspectral sensors from the German TRIOS company. In the project C-Scope (01/2021-12/2023) additional funding has been received to promote pH measurements on floats. In 2022-2023 six floats will be upgraded with pH and O_2 sensors and a new sensor of pCO_2 will be tested.

In the context of the European Project EuroArgo-Rise the BSH has worked on a contribution for the Arctic and has developed a decision tool for selecting parameters for Ice Avoidance algorithms (ISA). Two floats from national funding were deployed in 2020 north of Svalbard, one of which was the first float to reach the Laptev Sea. Sea after nine month under the ice. Cooperation have been established with the AWI and its Arctic working group to participate in upcoming Polarstern expeditions to the High Arctic. Two more floats will be deployed in 2022 from Polarstern north of Svalbard.

For the Southern Ocean AWI has restarted its activities in float deployments including RAFOS technology. AWI will deploy 23 floats in the southern Weddell Gyre in 2022, but no long-term funding scheme is established.

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. The BSH logistics related to technical aspects, float deployments and satellite data transmission are handled by Anja Schneehorst and Simon Tewes. Ingrid Angel Benavides and Corinna Jensen are involved in Argo in project related matters. The national BGC group established in 2020 involves three research institutes: GEOMAR, ICBM and IOW. A complete list of people involved is given below.

The following people contribute to the logistics and data management for Argo Germany

Name and institution	Area of expertise
Ingrid Angel-Benavides (BSH)	Research scientist (EuroArgo Rise) and related DMQC obligations
Henry Bittig (IOW)	Research scientist (DArgo2025, C-Scope), BGC group, DMQC operator (BGC sensors)
Hendrik Bünger (ICBM)	Research engineer, BGC group, DMQC operator (BGC sensors)
Corinna Jensen (BSH)	Research scientist (DArgo2025) and related DMQC obligations
Birgit Klein (BSH)	National program lead, research scientist (DArgo2025, C-Scope, EuroArgo Rise), DMQC operator (core Argo)
Arne Körtziner (GEOMAR)	Research scientist, BGC Argo, DMQC operator (BGC sensors)
Anja Schneehorst (BSH)	Technician, float procurement, contracting, deployment logistics and performance monitoring
Tobias Steinhoff (GEOMAR)	Research scientist, BGC group, DMQC operator (BGC sensors)
Simon Tewes (BSH)	Technician, technical support, and performance monitoring
Malin Waern (IOW)	Research scientist, BGC group
Oliver Zielinski (ICBM)	Research scientist, BGC group
Olaf Boebel (AWI)	Research scientist, RAFOS technology

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.**

Due to a larger contribution of floats with RAFOS capability for the Southern Ocean from the AWI (23) about 72 deployments are expected in 2022 (see figure 2). 8 Floats will be BIO floats (4 from ICBM, 3 from BSH and 1 from IOW). Deployment opportunities come mostly from regular research cruises The commitment table at OceanOPS (link) has been edited based on the present plans and will be modified again when the national budget for 2022 is finally released and we can proceed with our procurements. The present number of 72 floats is based on the assumption that the raise in budget is postponed and we will remain to buy only TS floats with our regular national budget.

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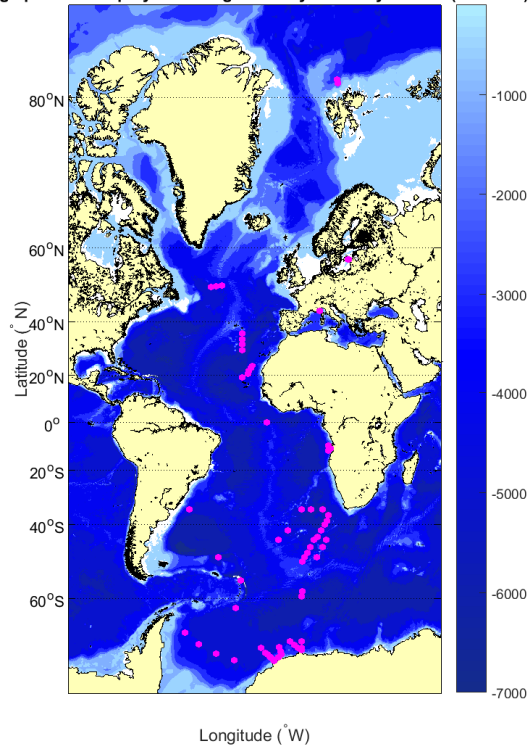
Fig. 2: Deployment positions for floats operated nationally in 2022 in the Atlantic Ocean.

GER	2021						
	Total	T/S Core	T/S/O2	BGC	Bio	Deep	
Nordic Seas	4	4					
Mediterranean Sea							
Black Sea							
Baltic Sea/North Sea	6				6		
Southern Ocean	6	6					
Arctic Ocean							
Global Ocean	61	51		1	9		
Total	77	61		1	15		

Table 2: Planned German (BSH, AWI, ICBM, GEOMAR) deployments in 2022 according to area and subprogram.

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The numbers in for 2022 depend on the national budget negotiations for 2022, at minimum there will be 50 core TS floats from the operational BSH budget, 23 floats from AWI in the Southern Ocean and 3 Bio-floats from the C-Scope project and 4 Bio-floats from ICBM deployments. Deployment positions are not yet determined, the 23 AWI Floats will all be deployed in the Southern Ocean and the remaining floats will go mostly to the Global Ocean.

GER	2022					
	Total	T/S Core	T/S/O2	BGC	Bio	Deep
Nordic Seas						
Mediterranean Sea	1				1	
Black Sea						
Baltic Sea/North Sea	2				2	
Southern Ocean	23	23				
Arctic Ocean	2	2				
Global Ocean	44	40			4	
Total	72	65			7	

Table 3: German (BSH, AWI, ICBM) deployments in 2022 according to area and subprogram.

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 moved our updated webpage to our institutional page 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 by 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 BMVI.

The annual user workshop for 2021 was held as a virtual event on 18.02.2021. The meeting was well attended and provided a good forum for users to share their scientific work and methods.

A key aspect of the use of Argo data at BSH is to develop a data base for climate analysis to provide operational products for interpretation of local changes and data for research applications for BSH related projects (e.g. Expertennetzwerk BMVI).   Argo data are being used by many researchers in Germany to improve the understanding of ocean variability (e.g. circulation, heat storage and budget, and convection), climate monitoring and application in ocean models.

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 the AIC, 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.**

We will be in contact with our colleagues at AWI about future prospects for deployments in the high Arctic after 2022. But due to the present political situation we expect delays or cancellation of Polarstern cruises and therefore also the need to the revise plans to further test technology and software in the Nansen Basin.

The strong price increase in sensors and floats might also pose a challenge to maintain the expected number of float procurements.

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.

BSH regularly ask PIs from our deployment cruises to provide us with any CTD profiles recorded after float deployments for calibration and comparison. These data are shared with Coriolis. In addition, we have collected new reference data for the Arctic and will perform quality checks on the soon to be released in the next update of the global CTD reference data base.

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.

Roemmich, D., L. Talley, N. Zilberman, E. Osborne, K. S. Johnson, L. Barbero, **H. C. Bittig**, N. Briggs, A. J. Fassbender, G. C. Johnson, B. A. King, E. McDonagh, S. Purkey, S. Riser, T. Suga, Y. Takeshita, V. Thierry and S. Wijffels (2021). The technological, scientific, and sociological revolution of global subsurface ocean observing. Oceanography 34: 2-8, doi: 10.5670/oceanog.2021.supplement.02

A. Jemai, H. Bünger, R. Henkel, D. Voß, J. Wollschläger and O. Zielinski, "Hyperspectral underwater light field sensing onboard BGC-Argo Floats", OCEANS 2021: San Diego – Porto, 2021, pp. 1-8, doi: 10.23919/OCEANS44145.2021.9705770. (https://doi.org/10.23919/OCEANS44145.2021.9705770)

Jemai A, Wollschläger J, Voß D and Zielinski O (2021) Radiometry on Argo Floats: From the Multispectral State-of-the-Art on the Step to Hyperspectral Technology. Front. Mar. Sci. 8:676537. doi: 10.3389/fmars.2021.676537 (https://doi.org/10.3389/fmars.2021.676537)

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.**

Deployments in 2021 were still affected by COVID but not as strongly in as in 2020. Fortunately, budgets were not affected since the procurements could be finished in time in 2021 and floats were stored in our warehouse or at partner's premises.

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Argo is still interested in piloting the RBR CTD. 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 2021 and 2022 (if known) and where they might be deployed.

BSH has deployed a small ensemble of 5 RBR CTDs together with 5 SBE CTDs in January 2021 in the North Atlantic (Fig. 3 and 4) in the framework of the DArgo2025 project. The 10 floats were deployed in an eddy to minimize dispersion and had been reporting at a two-day cycle for the early cycles. The analysis of the data has been carried out during 2021 and made use of the reference data collected during the cruise to calibrate the pressure dependence of the RBR conductivity cell. The coherence of the swarm appears very good (Fig.5) and until February 2022 most of the floats from the swarm still remain in its vicinity and show a fresh bias compared to climatology. It is planned to perform a similar experiment in fall of 2002 and buy at least 5 RBR CTDs.

Fig.3: Deployment of Arvor floats equipped with RBR and SBE CTDs in January 2021 on RV Sonne cruise SO280.
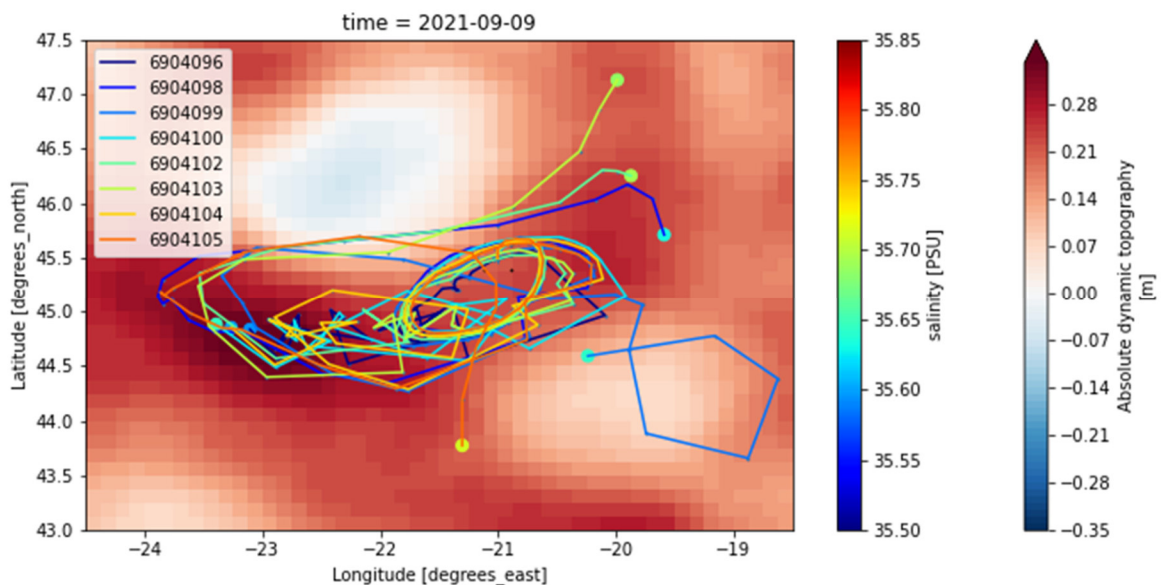
Fig. 4: Deployment positions for RBR pilot and trajectories of the swarm for the first nine month after deployment.
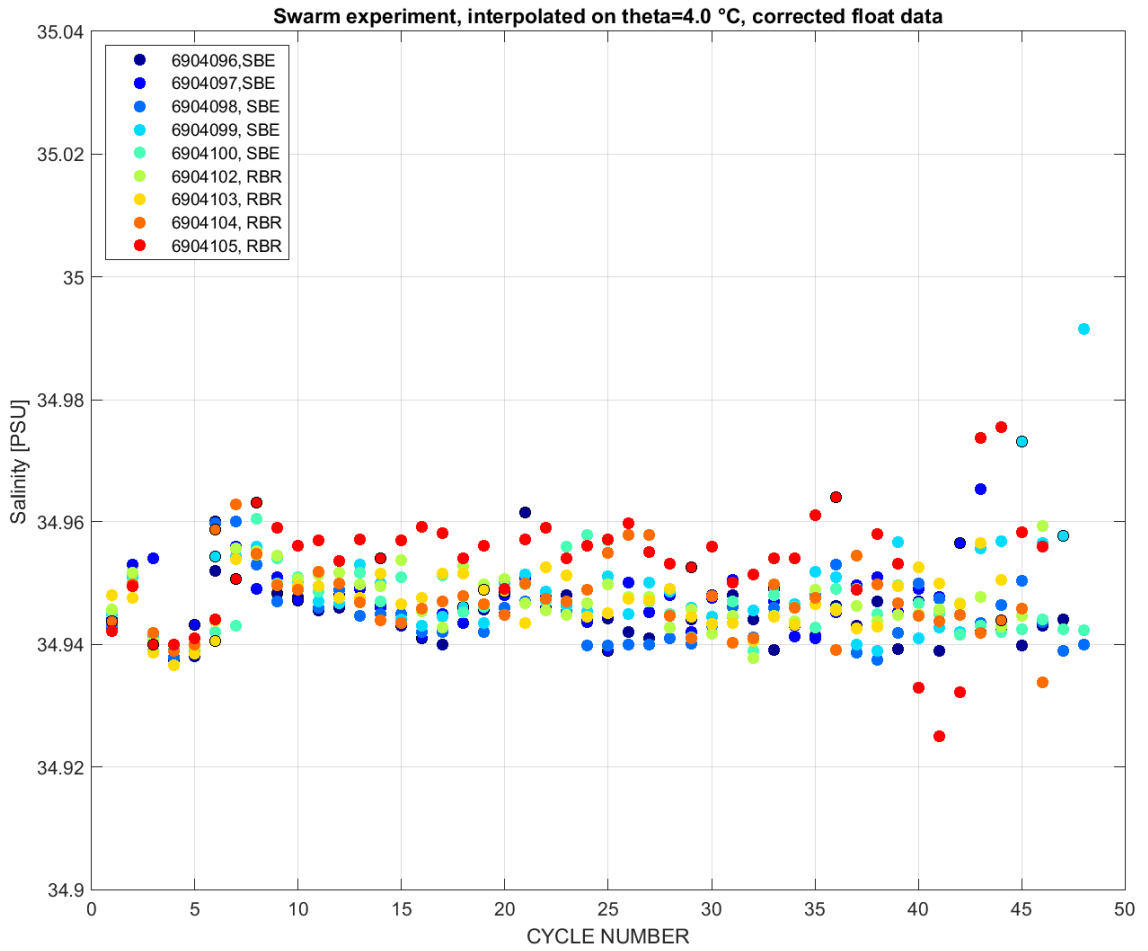

Fig. 5: Salinities at around 1600-1800 m depth on the 4.0 isotherm. The legend indicates whether the float carries an SBE or an RBR CTD.