Argo Australia National Report 2025 – AST26

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1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2024)

a. Float deployments and their performance

Between April 2024 and April 2025, Argo Australia have deployed 55 floats, including 44 core floats, 7 BGC floats, and 4 under-ice floats in the Antarctic shelf (Figure 1). That includes 42 Arvor, 6 Apex, and 7 Navis floats. We deployed floats from the RV Investigator, Antarctic Aurora, RV Kaharoa II, RV Whale Song, RV Sonne, RSV Nuyina, RV Umitaka Maru, MV L'Astrolabe, RV Tangaroa, HMNZS Aotearoa, and the Shirase (Japanese Icebreaker). All floats deployed since April 2024 are still operating, with no early failures.

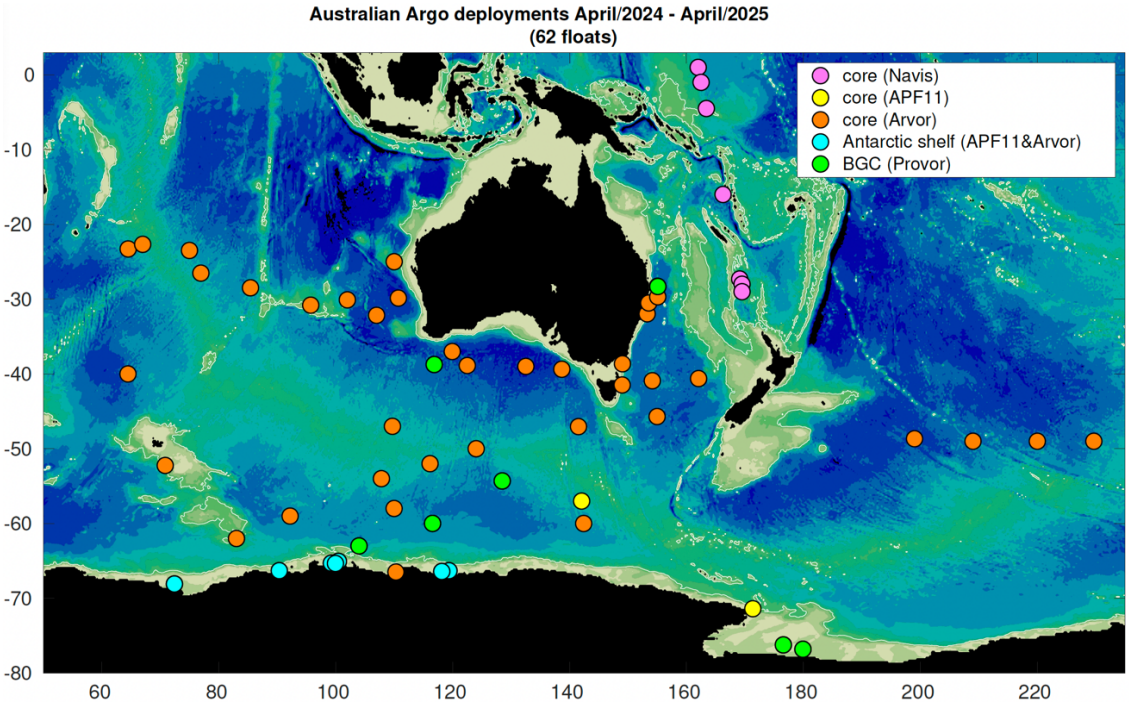


Figure 1: Map showing deployment locations between April 2024 and March 2024.

In total, the Australian DAC is managing 315 operational floats, of which 25 are BGC and 4 are Deep.

We did not deploy any Deep floats in the past year. We had planned to deploy 4 Deep floats in late 2024/early 2025 but these floats have been held back whilst the early failures of Deep floats deployed in the previous summer are investigated.

From our batch of 8 MRV Deep SOLOs deployed in Jan-Feb 2024, we have had 5 early failures. Two floats died early (one after 6 cycles with no information to help identify a cause and the other float after 18 cycles with a slight increase in relative humidity in the profile prior to failure). A third float had erratic park and profile behaviour that might be related to a pump leak (debris in the oil) that eventually stabilised after cycle 97. It then started dropping the upper few hundred metres of the continuous profile data and eventually stopped responding to the resume/reset commands. A further two floats stopped functioning after 27 and 38 good cycles respectively. The floats sent back intermittent bad pressures (abort code of 2) and eventually do not leave the surface. The floats still report position but no profile data and essentially become surface drifters.

MRV and Seabird are investigating the issues, and we hope to hear back on this issue soon so that we can reschedule our remaining 4 float deployments. The three remaining Deep floats are performing well (including under ice) and have returned 61, 68 and 70 cycles respectively. One of our very early Deep floats (7900637) is a stellar performer and still alive after 6+ years (it has returned 244 cycles).

A map of deployments is shown in Figure 1. We even selflessly deployed a float in the northern hemisphere (at 1°N) to support our northern hemisphere partners, and to repay them for deploying in our hemisphere so willingly for so long[1].

b. technical problems encountered and solved

We continued to play a leading role in the Argo Technician's Community of Practice. Together with Rick Rupan, Bill Dullea, Elizabeth Steffan and Chris Gordon, Pat McMahon organized and co-chaired a Technical Workshop at the University of Washington. The workshop was attended by 68 participants from 9 countries. The workshop was fully open with hands-on breakout sessions with floats from each mainstream manufacturer. The open collaboration fostered stronger industry relationships that will help promote the sharing of best practices across the global Argo community.

Figure 2: Group photo at recent Argo Technical Workshop at UW.

[1] You're welcome.

We reconfigured the battery layout of Teledyne APF11 Argo floats to accommodate an additional DD pack and deployed a 100% lithium powered APF11 with 5 x DDLi battery packs. This increased the total stored energy of the float by over 20%, extending the projected float life by more than 50 profiles, significantly enhancing operational efficiency.
https://fleetmonitoring.euro-argo.eu/float/5905592

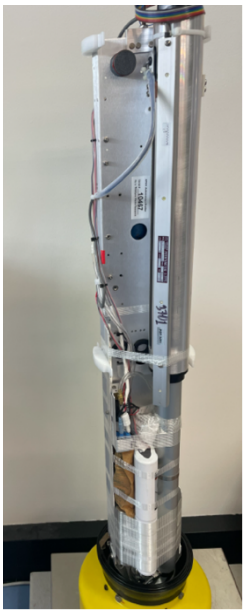
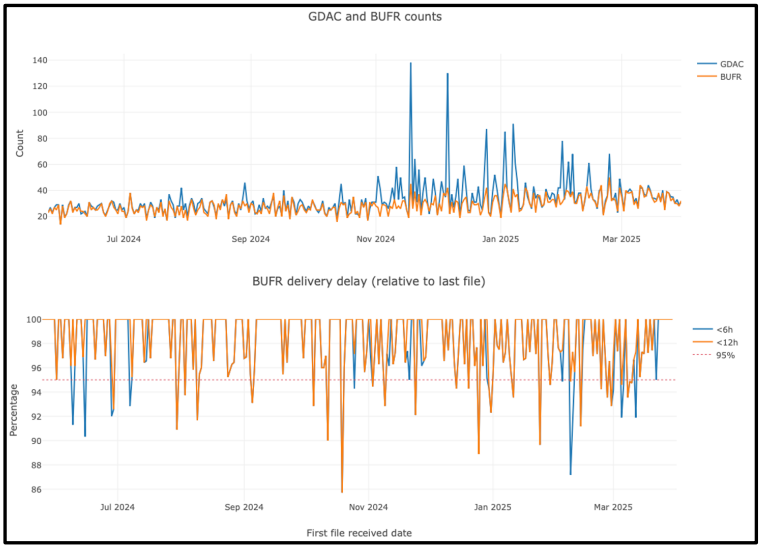


Figure 3: Photos showing how we configured additional battery packs.

We continue to experience problems in data transmission from APF11s due to buoyancy issues (presumably sticky bladder issues). We put these floats (in ice-free regions) in recovery mode about once a month so that floats stay at the surface for 2 days, or more, allowing us to retrieve data from all un-transmitted. These floats have been challenging to manage, and more expensive than normal.

c. status of contributions to Argo data management

i. the status of your DAC, if applicable



Argo Australia currently manage about 364 active floats, delivering around 35 BUFR files a day (Figure 4). We have delivered between 30 and 140 files to the GDAC per day, with higher numbers during the Southern Hemisphere summer, when Southern Ocean floats can transmit their under-ice profiles measured during winter. For most of the time, over 90% of the BUFR files are delivered within 6 hours.

Figure 4: (top) number of files delivered to WMO (BUFR files, orange) and the GDACs (nc files, blue) daily; (bottom) percentage of BUFR files created within 6 h (blue) and 12 h (orange) after profile data has been sent by the floats.

ii. status of high salinity drift floats

A summary of PSAL drift for floats processed this year:

- 16 had sudden onset uncorrectable PSAL with no adjustment required prior to the failure. Of these 4 delivered no good profiles, 4 <50 good profiles, 4 <100 good profiles, 4<150 good profiles

- 16 had PSAL drift corrected with OWC that become uncorrectable before the float died. Of these 3 became uncorrectable before cycle 50, 4 before cycle 100, 5 before cycle 150, 4 before cycle 202

- 29 had PSAL drift or offset that was corrected for some cycles and had no uncorrectable cycles. Of these 3 had fresh offset throughout

- A number of floats (~15) had fresh offset data in early cycles, some for as long as 20 cycles, possibly attributable to TBTO contamination. This represents almost 5% of the floats processed, but may be an under-estimate.

iii. decoding difficulties and highlights

In June 2024 we officially deactivated our Matlab-based RT processing code, making the new Python-based RT processing code (aka PyRT, read 'pirate') our official code. To achieve this, we migrated all the floats that were being processed in Matlab to then be processed in PyRT, with the new code sending the netcdf files to the GDACs.

Migrating our floats from Matlab to PyRT was not a simple task. We had 3 people (2 RT Operators and 1 DMQC Operator) comparing the R-, meta-, and tech-files of 160 floats created by Matlab and by PyRT to make sure the new netcdf files created by PyRT would align well with the legacy files on the GDAC. We had to do this because PyRT creates netcdf files with more information than the legacy Matlab system (e.g., two profiles within a file, one with continuous and one with spot sampling). As we compared the R-files created by Matlab and PyRT we also noticed differences in how the QC tests were applied – because of subjective interpretation of the manual at the time of coding. One example: the MEDD test was being done from the bottom to the surface in Matlab, but in the opposite direction in PyRT, leading to different results. This has been communicated to the custodians of the MEDD test available on github and has been addressed.

Our migration to PyRT was successful at CSIRO. We had no outages during the migration, and we had, and continuously have, systems in place to monitor the data processing in real-time. The migration to PyRT also meant that our Rtraj files are now all in accordance with the ADMT latest standards (with BGC data in Rtraj files to be made available on the GDACs soon). We are still to implement PyRT redundancy in the Bureau of Meteorology (BOM), our partner. However, we already have redundancy in receiving SBD data (going to both CSIRO and the BOM, in addition to the floats' manufacturers). We still have our redundant system of two servers (in two different states of Australia), and BGC data coming through the CLS server.

iv. real time BGC implementation

BR files are produced and submitted to the GDACs in real time. We have implemented BGC data into the Rtraj files and are at final stages of checking before making them available at the GDACs. In-air DOXY coefficients are now updated using the web-interface of PyRT (our python-based RT processing system).

We update the adjustments for our BGC sensors (DOXY, NITRATE, PH) every ~6 months. We have implemented BBP and CHLA RTQC and adjustments (adjustments only for CHLA; no adjustments are recommended for BBP). So far, we've mostly used SAGE for calculating the adjustments on DOXY, NITRATE and PH, but we are now transitioning to using in-air oxygen adjustments, working with Henry Bittig to calculate these off the new traj files. While this transition is in progress, and with some of our DOXY floats residing in areas where in-air calibrations are the only possible way to get a good adjustment, some floats are lagging behind getting their adjustments calculated, but they should all be up to date in a few months.

v. real time Deep implementation

Our current array of Deep floats is only sampling during the descent (due to the inability to decouple ascent and descent sampling). We intend to sample the top few hundred metres on the ascent routinely (for operational data uses) with future Deep floats. We understand there are floats in the water now that are testing firmware that allows ascent and descent sampling levels to be programmed separately, once that is made available on commercial floats, we will implement it.

d. status of delayed mode quality control process

Since April 2024, we have processed 331 floats through DMQC, including 21 with RBR_ARGO3 CTDs and one with RBRoem_v1.16. We have uploaded Dfiles for 98% of eligible profiles and have a raw percentage of 93% Dfiles on the GDACs.

It has been our experience that the US GDAC is not always reliable. We have had several outages ranging from a few hours to a few days over the last year. This affects RT and DM submission. When it happens we still submit to the French GDAC.

We're not producing BD files yet, but we expect to begin producing these in the next 6 months.

2. Present level of, and 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, Polar, Spatial (equator, WBCs)

Argo Australia has funding secured until 2028. This includes support for salary and operating costs for the Australian Argo Program, including Core, BGC, and Deep Argo.

In 2025, we expect to acquire 33 Core floats (including 4 AAPP-funded ice floats), 8 Deep floats, and deploy 3 BGC floats. Core and BGC floats are funded from a strong partnership between IMOS, CSIRO (reviewed

annually), the Australian Department of Defence (reviewed annually), BoM (reviewed annually), and AAPP (contracted until 2029). BGC floats are funded by IMOS, CSIRO, UTAS, and AAPP. Deep floats are funded by AAPP and CSIRO. The sustained funding available only allows purchase of 2-3 BGC-Argo floats annually. We therefore spend considerable time applying for other funding sources for BGC-Argo (Australian Research Council, Schmidt Foundation).

Argo Australia has one Argo technician (Pat McMahon); two scientists running real-time operations, including development and maintenance of our RT system and decoding for all floats (Roger Scott and Gabriela Pilo); two Core DMQC Operators (Jenny Lovell and Tatiana Rykova), one BGC DMQC Operator (Christina Schallenberg), and one Polar DMQC Operator (Esmee Van Wijk) – all supported by one scientific programmer (Dirk Slawinski). The Australian program is led by Peter Oke. Christina Schallenberg and Pete Strutton co-lead our BGC program and Steve Rintoul leads our Deep program. Esmee van Wijk co-chairs the Polar Argo Mission Team. In total, Australian Argo draws on ~6 FTE.

Argo Australia intends to continue providing AUD$100K funding to support operations of the RV Kaharoa II, and AUD$30K (indexed annually) funding to support OceanOps.

3. **Summary of deployment plans: as was done last year, please fill out this spreadsheet to help us understand the progress towards implementation of OneArgo. There is one new column this year for floats being deployed with experimental sensors such as UVP, C-sensor, etc. This spreadsheet is to be returned separately by 17 March to help prepare for the meeting. It can be sent to Megan or dropped in this folder link.**

Our planned deployments are summarized in Figure 5. We are encouraged by the innovation shown by NKE and have agreed to purchase and deploy 9 Arvor V2s in the coming year.

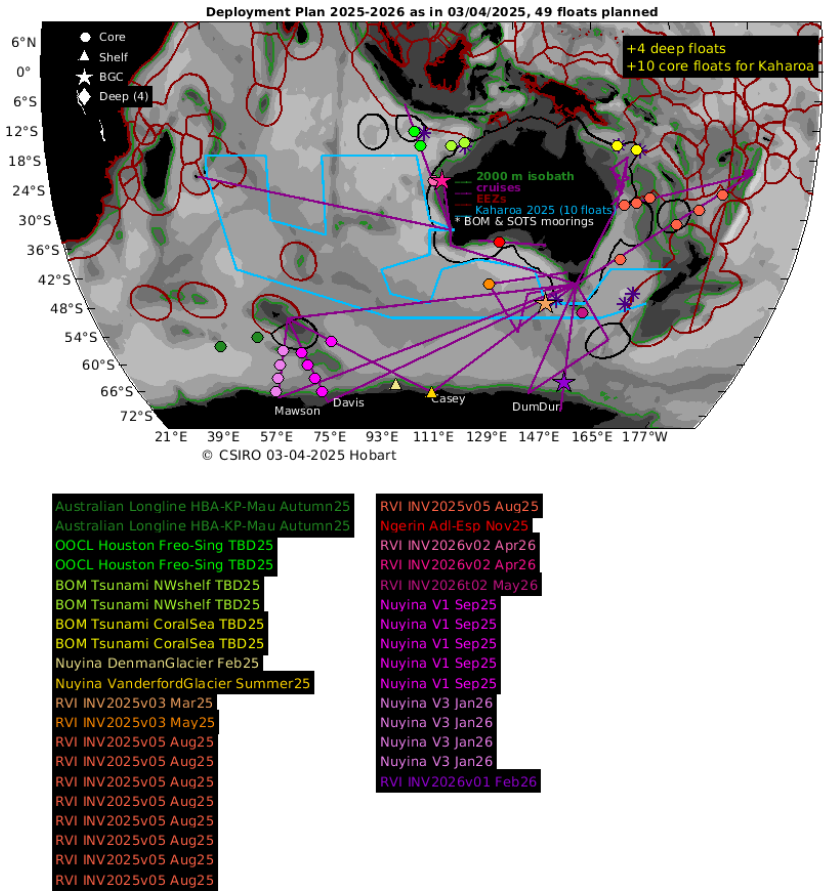
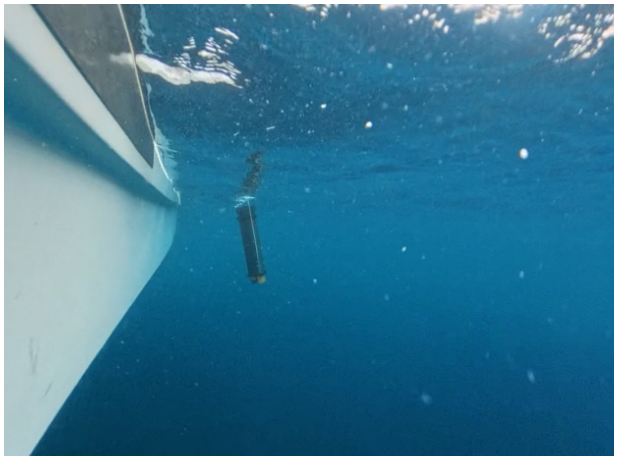


Figure 5: Deployment plan for Argo Australia, showing planned deployments by float type and by cruise.

4. Summary of any research and development efforts over the past year to try new sensors or improve float technology. This could include new collaborations with vendors or other partners.

We deployed five floats that were equipped with ice guards (both pole and eggbeater style Figure 6) and deployed in the seasonal ice zone to test if they increase survivability of floats and to gain opportunistic measurements of sea ice draft.

Figure 6: Pole type ice guard (left) and eggbeater type ice guard (right) on TWR APEX APF11 floats.



Pat McMahon has continued with the development of a shallow, low-cost float. This has included submission of one patent application Underwater Vessel, Australian Patent Application number 2024902143. We recently tested the float to a depth of 135m and aim to test to 200m later this year once we install a GPS module on the float.

Figure 7: Photo of the prototype shallow float during testing.

For BGC-Argo floats, we have settled on NKE as our preferred float for the time being, and have started adding hyperspectral irradiance sensors to our future float orders (instead of the 4-channel OCR sensor). We also recently deployed a float with UVP (in collaboration with the University of Tasmania).

Argo Australia continues to coordinate the Argo DMQC Discussion series. A record of meetings is maintained here. DMQC discussions are held every two months. The next meeting, scheduled for May, will be the 20th meeting of this community. The meeting continues to be well-attended, with 28 participants at the last meeting (meeting 19), the highest attendance at this forum to date.

Figure 8: Screenshot of participants at a recent Argo DMQC Discussion.

5. **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 Argo websites.**

Argo data are used operationally to underpin Australia's short-range ocean forecast system (OceanMAPS; www.bom.gov.au/oceanography/forecasts/), ocean, and seasonal prediction systems (POAMA; www.bom.gov.au/climate/ocean/outlooks/).

A new version of the Bluelink ReANalysis has been disseminated (BRAN2023). BRAN2023 includes incremental improvements over the previous version and includes BGC. Details are at: https://dx.doi.org/10.25914/2wxj-vt48.

6. **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-26 plenary, **each national program will be asked to mention a single highlight or issue via a very brief oral report.**

We are concerned that the Argo community may be "over-correcting" salinity, as part of the DMQC process, in the Coral Sea. We are analysing data from 289 floats in the Coral Sea (146-164°E, 25-10°S). Of these floats, the difference between PSAL_ADJUSTED and PSAL suggests that OWC has been applied to up to 116 floats – 40% of floats. We expected that OWC would only be applied to about 10% of floats (perhaps 20% after ASDs appeared). Of the corrections, the majority of disseminate PSAL_ADJUSTED fresher than PSAL. Our analysis is too preliminary to draw solid conclusions, but we are beginning to suspect that the deep salinity in the Coral Sea is slowly changing, and that our community is unintentionally "masking" this signal. This analysis is being led by Tatiana Rykova and will be raised at a future DMQC Discussion.

7. **Outreach and communication: please describe, in brief, outreach efforts within your national program over the past year. Also, if you've issued any communications, press releases, participated in articles, etc, please send the links. We are considering our social media strategy, so please let us know which social media you engage with and the corresponding handles.**

We were involved in production of a special Issue of Frontiers in Marine Science on, "Demonstrating Observation Impacts for the Ocean and Coupled Prediction". The special issue included many demonstrations of the impact of Argo on data-assimilating forecast and reanalysis systems. This was an initiative under SynObs, UN Decade Project under OceanPredict. The editorial for the special issue is accepted and will be published soon (doi: 10.3389/fmars.2025.1588067).

Peter Oke gave a presentation on "the potential of Argo data to improve coupled numerical weather prediction" at the 8th WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction and Earth System Prediction. There were three oral presentations inn plenary that demonstrated the impact of Argo on ocean or coupled prediction (by Oke, Thierry, Remy). These

presentations included strong advocacy for the Argo Program to WMO. Workshop recommendations included:

> 3.1.4. To sustain routine observations of the ocean temperature and salinity profiles (for example, Argo, gliders).
>
> 3.1.5. To further enhance capability to measure deep-ocean physical parameters and ocean biogeochemical

Other comments in the final report include:

- Argo DA has a large impact on ocean and NWP at all ranges.
- Argo is currently research-funded. It needs to be funded in the same way as atmospheric observations.
- Argo extension will help to constrain the representation of ocean heat and freshwater contents in Western Boundary Currents (WBCs) and the interannual variability in the tropics.
- Argo observations strongly constrain the large-scale vertical structure of the ocean temperature and salinity analysis up to 2000 m.

Based on a peer-reviewed paper published in May 2024, we published a piece in the Australian Conversation https://theconversation.com/floating-robots-reveal-just-how-much-airborne-dust-fertilises-the-southern-ocean-a-key-climate-shock-absorber-225793.

We've been deploying floats off voyages from the CAPSTAN Australian sea training program (~yearly voyages). These voyages offer learning and development opportunities for university students, trainers and Chief Scientists. Before the voyage, we give a talk about the Argo program, how the floats work, deployment practices, and the scientific reasons to why we're deploying a float at a specific location. It has been a rewarding experience.

We also discuss Argo data in relation to other ocean data though our partner projects (e.g., Argo profiles under a tropical cyclone, and outlook for national yacht race).

We contribute to an Instagram account that may occasionally publish stories/posts about Argo: imos_australia

Argo also has a features prominently in CSIRO's outreach initiative INVESTIGATE (a container that immerses the public into ocean science done onboard the RV Investigator) – see here (glimpse of Argo at 1:13).

8. **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.**

Table 1: Table of reference CTDs and details of buddy Argo float deployments.

Deployment date & time	Lat	Lon	Ship	Voyage	CTD#	Argo PI
2024-01-22 09:11:00	-63.8786	140.0050	RVI	2024_01	020	Rintoul
2024-01-24 13:39:00	-62.0200	132.0000	RVI	2024_01	023	Rintoul
2024-01-25 10:02:00	-63.0040	131.9682	RVI	2024_01	025	Rintoul
2024-01-30 03:11:00	-62.9990	122.9980	RVI	2024_01	031	Rintoul
2024-01-30 14:42:00	-54.4823	122.9960	RVI	2024_01	032	Rintoul
2024-02-02 11:10:00	-63.6540	113.3060	RVI	2024_01	036	Rintoul
2024-02-03 11:24:00	-62.7830	113.3160	RVI	2024_01	038	Rintoul
2024-02-05 11:47:00	-61.6577	114.1569	RVI	2024_01	043	Rintoul
2024-07-01 20:13:29	-28.3052	155.1012	RVI	2024_04	116	Shallenberg
2024-12-28 10:45:00	-38.7430	116.8650	Sonne	SO308/2	1	Shallenberg
2024-12-29 23:48:00	-38.8770	122.5130	Sonne	SO308/2	3	Oke
2025-01-01 07:13:00	-38.9970	132.5370	Sonne	SO308/2	5	Oke
2025-01-02 22:33:00	-39.3730	138.6880	Sonne	SO308/2	7	Oke
2025-01-07 22:11:00	-40.9100	154.1680	Sonne	SO308/2	13	Oke
2025-01-09 21:06:00	-40.6230	162.0730	Sonne	SO308/2	15	Oke
2025-03-10 09:03:37	-38.6400	149.0500	RVI	2025_01	006	Oke
2025-03-26 10:14:00	-65.3040	99.2665	Nuyina	Denman	45	Rintoul
2025-03-25 21:36:00	-65.3445	99.9660	Nuyina	Denman	43	Rintoul

9. **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.

Argo Australia PIs: Peter Oke, Pete Strutton, Steve Rintoul, Christina Schallenberg, Phillip Boyd, Felicity McCormack, Esmee van Wijk, Denise Fernandez (NZ)

We value the bibliography and use it often to inform reports to our funders. We do not have a c comprehensive list of papers using Core or Deep floats. But BGC Argo papers missing from the Bibliography (not all from the past year) follows:

Vives, C.R., Schallenberg, C., Strutton, P.G., Boyd, P.W. (2024). Biogeochemical-Argo floats show that chlorophyll increases before carbon in the high-latitude Southern Ocean spring bloom, Limnology & Oceanography Letters, in press, doi: 10.1002/lol2.10322

Schallenberg, C., Strzepek, R.F., Bestley, S., Wojtasiewicz, B., Trull, T.W. (2022). Iron limitation drives the globally extreme fluorescence/chlorophyll ratios of the Southern Ocean. Geophysical Research Letters 49 (12), e2021GL097616

Su, J., Schallenberg, C., Rohr, T., Strutton, P.G., Phillips, H.E. (2022). New estimates of Southern Ocean annual net community production revealed by BGC-Argo floats. Geophysical Research Letters, e2021GL097372

Tang, W., Llort, J., Weis, J., Perron, M.M.G., Basart, S., Li, Z., Sathyendranath, S., Jackson, T., Sanz Rodriguez, E., Proemse, B.C., Bowie, A.R., Schallenberg, C., Strutton, P.G., Matear, R., Cassar, N. (2021). Widespread phytoplankton blooms triggered by 2019-2020 Australian wildfires. Nature, https://doi.org/10.1038/s41586-021-03805-8

Su, J., Strutton, P., Schallenberg, C., 2021. The subsurface biological structure of Southern Ocean eddies revealed by BGC-Argo floats. Journal of Marine Systems, 220, 103569.

BGC Argo theses from the University of Tasmania missing from the list:

- https://figshare.utas.edu.au/articles/thesis/The_Southern_ocean_s_biological_response_to_atmospheric_iron_fertilisation/26123578
- https://figshare.utas.edu.au/articles/thesis/Regional_variability_of_the_Southern_Ocean_spring_bloom/25143761
- https://figshare.utas.edu.au/articles/thesis/Carbon_export_and_mesoscale_eddy_structure_in_the_Southern_Ocean_revealed_by_BGC-Argo_floats/26027068

10. 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 2025 and 2026 (if known) and where they might be deployed.

We are closely monitoring the performance of floats deployed with RBR sensors and intend to resume purchasing floats with RBR CTDs soon.