Japan National Report

(Submitted by Toshio Suga and Shigeki Hosoda)

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

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 12 Core Argo, Biogeochemical (BGC) Argo and Argo equivalent floats from January to December 2022: 10 floats for Core Argo (APEX), 2 floats for BGC Argo (BGC-NAVIS and BGC-APEX). Since 1999, JAMSTEC had deployed 1433 Core Argo, Deep Argo, BGC Argo and Argo equivalent floats mainly in the Pacific and Southern Oceans. Because COVID-19 influenced cruse plans and the price of floats was higher, the number of float deployment was decreased. The current positions of all the active Japanese Argo floats are shown in Fig.1. The float deployments were conducted through collaboration with Japanese voluntary agencies, institutes, universities, and high schools. One float was deployed in the central part of North Pacific subarctic gyre by a voluntary cargo ship owned by a Japanese merchant ship company, NYK. The arrangement of the semi-regular float deployment by cargo ships was made under the cooperative relationship between JAMSTEC and NYK. Three core floats equipped with RBRargo3 were deployed on an educational cruise of the Norwegian sailing vessel. One BGC APEX floats with RINKO ARO-FT oxygen sensor was deployed in the northwestern Pacific subtropical gyre, which is supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, Grant-in-Aid for Scientific Research on Innovative Areas (19H05700). One Deep NINJA float is planned to be deployed in the Southern Ocean in 2022/23 summer in corporation with CSIRO, Australia.

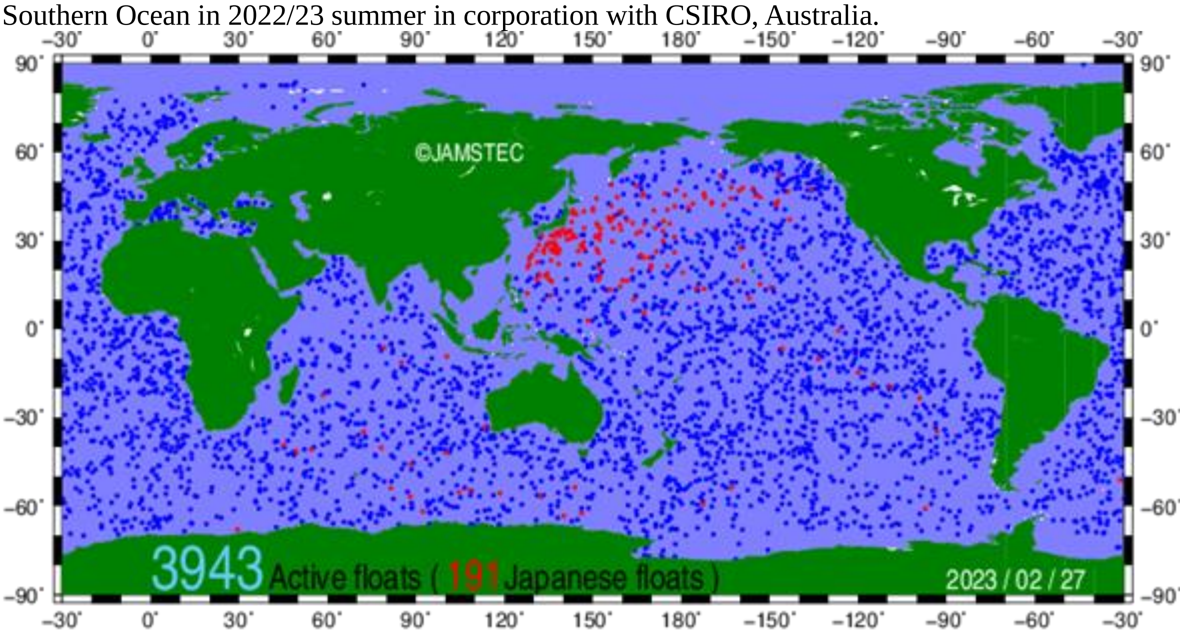

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

The Japan Meteorological Agency (JMA) deployed 22 Argo equivalent floats (22 ARVOR floats) in the seas around Japan from January to December 2022. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 387 floats (14 PROVOR, 194 APEX and 179 ARVOR floats) which JMA has deployed from 2005 to 2022, 53 floats (53 ARVOR floats) are active as of the end of December 2022, while 16 floats (16 ARVOR floats) terminated the transmission in 2022. JMA deployed 4 ARVOR floats from January to February 2023.

b. Technical problems encountered and solved

1) Sensor screening for SBE41 conductivity and pressure sensors

JAMSTEC developed a new CT sensor screening system, J-Calibration, for use with the SBE41 on the Argo float and is now in operation (Hosoda et al., 2018). Although the J-Calibration system requires careful temperature control of the artificial seawater as it is critical to maintaining a uniform water temperature, it is suitable for use in laboratory screening prior to deployment. In 2022, the J-Calibration has been conducted for 8 C sensors. Based on the screening, we did not find any doubt about C sensors. We also conduct P sensor screening using DWT. In 2022, 6 pressure sensors were checked. Two of the screened CT sensors were insufficient for the Argo criteria and were sent to SBE to conduct maintenance. In 2023, the screening performance will be investigated through a comparison using natural seawater or artificial seawater to find the appropriate solution in the J-Calibration.

2) Influence of suffering network security incident in JAMSTEC

In March 2021, JAMSTEC suffered unauthorized access to its core network system and leakage of personal information and had completely shut down the network (https://www.jamstec.go.jp/j/about/press_release/20210318_2/). Accordingly, the Argo JAMSTEC data management system and related websites were also shut down, and data submission to GDAC was suspended. The internet connection of JAMSTEC has been completely restored, so that JAMSTEC has restarted sending the raw data files of our active floats to JMA in real time since August 2022, and now back to normal. The websites of our product datasets have also been restarted at the same time. Note that their URLs have been changed from the ones before our security incident. And, JAMSTEC released the new version of PARC website in November 2022 (https://www.jamstec.go.jp/PARC/). The new URLs of products and PARC are listed on the Argo Project Office website.

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 Japan DAC, JMA has operationally processed data from all the Japanese Argo and Argo-equivalent floats including 194 active floats as of February 28, 2023. 11 Japanese PIs agree to provide data for the international Argo. All the profiles from those floats are transmitted to GDACs in the netCDF format and are also issued to GTS using the BUFR codes after real-time QC on an operational basis. Argo BUFR messages have been put on GTS since May 2007. JMA has been developing real-time QC for each BGC parameter and implemented real-time QC for DOXY with adjustments based on WOA in August 2022.

JMA has made meta-, tech-, traj-, and Rprof-files v3.1 of the floats newly deployed since March 2016 and JAMSTEC has made meta-files in v3.1 of JAMSTEC's floats newly deployed since October 2015. JAMSTEC has made meta- and Dprof-files in v3.1 since January 2016.

Abrupt salty drift floats

Japan has 85 floats, including Core, BGC, and Deep floats, suffering from Abrupt Salty Drift (ASD). 67 SBE41/41CPs have serious ASD which is unable to be adjusted. About 40% of them are equipped with SBE41/41CPs whose SNs are from 10482 to 11252. We lost about 4,500 salinity profiles because of ASD since 2015, and they are mainly in the northwestern Pacific at a rate of about 800~900 profiles every year. This is equivalent to 5~10% of the number of profiles measured by Japanese floats. Because most Japanese Core floats with serious ASD are still active, it is expected that salinity profile loss in the northwestern Pacific continues. We also have 5 Deep APEX floats with SBE61 suffering from serious ASD. We continue to monitor the salinity data of Japanese floats for detecting floats with high salinity drift and understanding features of high salinity drift found in floats. We have shared this information and joined the discussion about this issue through ADMT and the working group of this issue so that we contribute to improving salinity data quality.

As reported last year and two years ago in our national report, most of the salinity profiles in the global ocean flagged as probably bad or bad in all layers have been "Abrupt Salty Drift" in the past few years, and the number of salinity profiles flagged as probably bad or bad in all layers has been increasing every year. The percentage of global salinity profiles with all layers flagged as probably bad or bad in 2022 was about 17%, higher than that in 2020 and 2021. This is consistent with the results predicted years ago. JAMSTEC will continue to monitor the results.

New challenge to quality control for Core Argo profiles

JAMSTEC is now challenging to implement quality control methods using machine learning, developed by Sugiura and Hosoda (2020), for Core-Argo profiles. We performed supervised learning for existing Argo data with quality control flags by using the signature method, We aim to achieve efficient quality control by introducing this.

d. Status of delayed mode quality control process

JAMSTEC submitted the delayed-mode QCed Core files of 17,670 profiles in 2022, and the total number of submitted delayed-mode QCed Core data (P, T, and S) to GDACs is 188,714 profiles as of December 2022. About 77% of Japanese Core-profiles are published in GDAC as delayed-mode QCed profiles. Due to the restoration of the internet connection from a network security incident that occurred at JAMSTEC in March 2021, JAMSTEC was able to submit D files of about 18,000 profiles last year.

JAMSTEC has adjusted the salinity data of Deep floats by using optimal CPcor for each Deep float. When our Deep float is launched, shipboard-CTD observation is often performed. Therefore, the optimal CPcor for each Deep float is estimated by comparing its first profile with shipboard-CTD data at its deployment.

JAMSTEC has started performing delayed mode QC for our BGC floats. We are now preparing to process programs for DOXY-DMQC. We are also testing whether Nitrate and pH observed by our BGC floats in the North Pacific are corrected well by SAGE. We aim to start submitting D-mode DOXY_Adjusted of our BGC floats to GDAC this year.

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)

Japan Argo had been conducted in a 5-year program from FY1999 to FY2004, as a part of the

Millennium Project implemented under cooperation among the Ministry of Education, Culture, Sports, Science and Technology (operation: by JAMSTEC), the Ministry of Land, Infrastructure and Transport, JMA and Japan Coast Guard. After the Millennium Project terminated in March 2005, JAMSTEC continued the operation until FY2013 nearly on the same scale (about 80 floats to be deployed every year and associated delayed-mode data management) under its two consecutive mid-term programs for FY2004-2008 and FY2009-2013. JAMSTEC continues the float deployment and delayed mode data management but on a scale somewhat lower than before under its recent mid-term program FY2014-2018. Because of budget cuts in FY2014-2015, the number of technical staff devoted to delayed mode QC and PARC activities has decreased from 5 to 4 since FY 2015 and the number of purchased floats had been reduced to about 12-15. In FY2016, owing to ocean monitoring enhancement recommended by G7 Ise-Shima Summit, especially its Science and Technology Ministers' Meeting in Tsukuba, the additional fund for Core Argo and Argo extensions (Deep and BGC Argo) was allocated for aiming to sustain Core Argo array and to enhance Deep and BGC Argo. Furthermore, following its communique and our original research plans, JAMSTEC had got extra research funds to purchase 50 Core, 25 Deep, and 10 BGC Argo floats in FY2017, and are being deployed in the Pacific, Indian, and Southern Ocean in FY2018-19.

From FY2019, JAMSTEC has started new mid-term programs for 7 years. In FY2022, 13 Argo floats were deployed, including 10 Core, 1 Deep, and 2 BGC floats, following JAMSTEC's research purposes. In FY2022, the level of human resources for Argo deployment and QC is the same as in FY2021 (3 persons) including temporal staff. However, because of dmQC complexity, especially for BGC Argo, the number of technicians is insufficient. The deployment plan for Core, Deep, and BGC Argo floats in FY2023 is not yet fixed but will be maintained mostly at the same level as in this FY.

JAMSTEC is examining toward achievement of "next generation Argo" including ArgoMIX. The construction of the observing system is already addressed a load map of ocean science in Japan as "Global deployment of deep-sea Argo floats for more accurate prediction of climate and ecosystem change" and consensus among the Japanese ocean science community. The funding is not yet assigned. To support achieving ArgoMIX, JAMSTEC examines validations of Argo float equipped with turbulence sensor (RBR fast-response CTD and shear sensors) through the field test, in collaboration with Rockland and MRV. In 2022, we tested in situ ocean two times, and succeeded to get detailed turbulence data and to recover the two floats. In 2023, we plan to test deployment the two microALTO with ship turbulence measurements (VMP-X and L-ADCP) around the Izu-Ridge where turbulent mixing is enhanced due to rough topography. In addition, JAMSTEC purchased two Mermaid-Argo floats, called "MOBY", from OSEAN in France in 2023. One float equips with SBE61 and hydrophone sensors, and the other mounts SBE61 only. The two MOBY floats will be deployed in mid-2023 and examined to apply Argo data flow and to perform multiple observation networks.

JMA allocates operational budget to purchase 14 Core floats with Iridium communication in FY2023.

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

JAMSTEC will deploy 17 floats mainly in the North Pacific for 13 Core, 1 Deep, 3 BGC, and 2 Argo equivalent floats. The 13 Core Argo includes 3 RBR Argo floats. For the Argo equivalent floats, 2 RBR CTD Argo floats will be deployed in the western equatorial Pacific for the purpose of the air-sea interaction study. The one Deep Argo float is Deep NINJA with RINKO ARO-FT oxygen optode sensor. The 3 BGC Argo floats measure 4 parameters with a nutrient sensor (deep

SUNA) for 2, pH sensor (SeaFET) for one, oxygen sensor (SBE63) for all, and Chla and backscatter sensors (ECO-triplet) for all.

JMA plans to deploy 24 Argo equivalent floats (11 floats will be deployed in the western boundary region) around Japan in FY2023. All the JMA floats are identical with the Core Argo floats except that they are operated in a 5-day cycle, synchronized with JMA's real-time ocean data assimilation and forecast system.

JMA continues serving as the Japan DAC. JAMSTEC continues running the Pacific Argo Regional Center for the upcoming year.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers

Many groups in JAMSTEC, JMA, FRA, and Japanese universities use Argo data for climate, oceanographic and environmental research. Japanese fisheries research community is conducting their biogeochemical studies using Argo floats equipped with chlorophyll and/or oxygen sensors. Other institutes, agencies, and universities use Argo data through datasets of grided profile data or assimilation model data, although not all the activities are identified. Japan Argo supports the activities of the above institutions/agencies and promotes their further use. A national program Argo webpage works for them and has recently been updated as a site to exchange information between domestic and international programs (https://www.jamstec.go.jp/J-ARGO/?lang=en).

JMA issues operationally ocean analysis and forecast by using satellite data and in-situ data including the global Argo BUFR messages. Daily, 10 day mean and monthly products of subsurface temperatures and currents for the seas around Japan and North Pacific, based on the output of the real-time ocean data assimilation system (MOVE/MRI.COM-JPN), are distributed through the JMA web site (in Japanese). Numerical outputs of the system are available from the NEAR-GOOS Regional Real Time Data Base (https://www.data.jma.go.jp/goos/data/database.html) operated by JMA. Monthly diagnosis and outlook of El Niño-Southern Oscillation based on the outputs of the Ocean Data Assimilation System and the Seasonal Ensemble Prediction System (an ocean-atmosphere coupled model) are also operationally distributed through the JMA web site (in Japanese) and the Tokyo Climate Center (TCC) web site (https://ds.data.jma.go.jp/tcc/tcc/products/elnino/). These systems were upgraded in Feb. 2022 (for descriptions of the new systems, please refer tohttps://ds.data.jma.go.jp/tcc/tcc/products/elnino/move_mricom-g3_doc.html, andhttps://ds.data.jma.go.jp/tcc/tcc/products/model/outline/cps3_description.html). The ocean-atmosphere coupled model is also used for seasonal forecast of climate in Japan. The model products for seasonal forecast are available from the TCC web site (https://ds.data.jma.go.jp/tcc/tcc/products/model/).

JAMSTEC is providing gridded products of objectively mapped temperature and salinity field data (Grid Point Value of the Monthly Objective Analysis using Argo float data: MOAA-GPV), and gridded mixed layer depth with its related parameters (Mixed Layer data set of Argo, Grid Point Value: MILA-GPV). These products have two versions for each dataset, one is estimated by using mainly real-time QC Argo profiles and another is by using mainly delayed mode QC Argo profiles.

JAMSTEC has been providing objectively mapped velocity field data based on YoMaHa'07 (version September 2010), and Argo temperature and salinity profile data put through more advanced automatic checks than real-time quality controls (Advanced automatic QC Argo Data version 1.2a) since October 2014. JAMSTEC has also provided scientifically quality controlled data of Deep NINJA floats for convenient use on scientific or educational purposes. The QC is based on comparisons with highly accurate shipboard CTD observations conducted nearby float observations.

The Pacific Argo Regional Center (PARC) is operated by JAMSTEC, providing information about consistency check of float data related to delayed-mode QC through the website. Since 2006, PARC and its website had been operated by JAMSTEC and IPRC in collaboration with several coastal states of the Pacific region. JAMSTEC mainly operates PARC and had resumed to inform from the website as the mentor of the Pacific Ocean. Because the network incident occurred in early 2021, the plan for the new PARC website must have been modified to be more secure form. The new PARC website has been released in August 2022. It has the same functions as them before JAMSTEC's network incident. We have a plan to add functions of providing information about BGC and Deep floats as well as Core floats in the Pacific, sharing information about the deployment and technical issues, etc., in order to improve the status of the Pacific Argo array.

ESTOC (Estimated state of ocean for climate research) is a JAMSTEC product; an integrated dataset of ocean observations including Argo data by using a four-dimensional variational (4D - VAR) data assimilation approach. ESTOC is the open data that consists of not only physical but also biogeochemical parameters (See the website in JAMSTEC, http://www.godac.jamstec.go.jp/estoc/e/top/). We have been developing the system incorporating new subgrid-scale mixing schemes and it will be upgraded to reproduce more realistic ocean states in the upper layers, where Core Argos are exploring, as well as deep oceans to synthesize full-depth ocean states by 2024. In addition, we now start experiments for the evaluation of the impacts of dissolved oxygen measurements by BGC Argo for our system, which was reported in workshops (ex. SynObs). We plan to report these activities in scientific papers.

JCOPE2M (Japan Coastal Ocean Predictability Experiment 2 Modified) is the model for the prediction of the oceanic variation around Japan which is operated by Application Laboratory of JAMSTEC. JCOPE2M is the updated version of JCOPE2, developed with enhanced model and data assimilation schemes. The Argo data are used by way of GTSPP. The reanalysis data 29 years back (from 1993 to the present) and the forecast data 2 months ahead are disclosed on the following website: http://www.jamstec.go.jp/frcgc/jcope/. More information is shown at http://www.jamstec.go.jp/frcgc/jcope/htdocs/jcope_system_description.html.

JCOPE-T DA, a downscaled version of JCOPE2M, has been developed by the collaboration of JAMSTEC and JAXA. It is designed for real-time (daily-basis) assimilation of satellite and in-situ data including the Argo data and 10-day lead forecast updated every day. The latest available forecast information is available from: https://www.eorc.jaxa.jp/ptree/ocean_model/index.html.

FRA-ROMS is the nowcast and forecast system for the Western North Pacific Ocean developed by Japan Fisheries Research and Education Agency (FRA) based on the Regional Ocean Modeling System (ROMS). FRA-ROMS was operated from May 2012 to March 2022. Since March 2022, FRA began operating FRA-ROMSII, a new system based on FRA-ROMS with improved model performance in the Japan Sea. The outputs of FRA-ROMS/FRA-ROMSII are used primarily for fisheries resource surveys and are provided every week through the website: https://fra-roms.fra.go.jp/fra-roms/index.html/.

Tohoku University has released a gridded dataset of subsurface chlorophyll maximum depth, using Chl-a measurement data in the World Ocean Database 2018 (Boyer et al. 2018) and the Global Ocean Data Analysis Project version 2.2019 Release (Olsen et al., 2019). The Chl-a measurement data includes Argo profile data as well as bottle samples, CTD fluorescence, gliders, and so on. This gridded dataset can be downloaded on the websites (http://caos.sakura.ne.jp/sao/scm/).

5. Issues that our country wishes to be considered and resolved by the Argo Steering Team

regarding the international operation of Argo

As reported in 2011, the EEZ clearance procedure for Argo float deployed had been simplified following IOC Resolution XLI-4, which is performed by OceanOPS, the coordination of activities at an international level, and the performance of the Argo data system. This change reduced our time and effort for the process of EEZ clearance, while the traditional EEZ clearance is still needed for some key countries because Argo national focal points (NFPs) of those countries are not registered on the list at OceanOPS. Japan Argo hopes for more NFPs, especially of nations in and around the Pacific Ocean to provide more data measured in any EEZ and to optimize the deployment of Argo floats. This could be also helpful for the smooth implementation of any future extension of Argo and less trouble with the countries.

6. CTD cruise data being added to the reference database

After the last upload of CTD data to the CCHDO website in February 2022, which was included in the national report the year before last, we have uploaded 334 CTD cast data as "Private for Argo" in the western North Pacific.

7. Argo bibliography

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2022

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(2) Doctorate thesis

2022

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Iskandar, M.R. (2021). *Pathways, timescales and transpot of the Indonesian Throughflow, and*

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Sakamoto. T. (2019). Studies on sardine (Sardinops spp.) stocks using oxygen stable isotope ratios in otoliths, the University of Tokyo.

Yamaguchi, R. (2019). *Formation of seasonal upper-ocean stratification and its variability.* Tohoku University.

2018

Ito, D. (2018). *Oceanic submesoscale phenomena and high vertical wavenumber structures.* Tohoku University.

Li,B.F (2018). *A high-resolution mapping of oceanic carbon species in the high latitude North Pacific*. Hokkaido University.

2017

Oishi, S. (2017). *Frontogenesis and frontolysis in the Agulhas Return Current region.* The University of Tokyo.

2015

Kimiduka, M. (2015). *Mean structures and temporal variations of the North Pacific subtropical gyre as revealed from an analysis of observational data.* Tokyo University of Marin Science and Technology.

2008

Shimada, K. (2008). *The Mixing Efficiency Due To The Double Diffusive Convection In The World Ocean*. Tokyo University of Marin Science and Technology.

8. How has COVID-19 impacted our National Program's ability to implement Argo in the past year?

Due to COVID-19, some of the cruise plans were canceled or modified, mainly going to the far area from Japan. That must modify JAMSTEC's deployment plan, and we suffer difficulty to fill in the gap of the global Argo array. Recent impacts on Japanese Argo regarding COVID-19 becomes gradually smaller, however, ship cruise plan and track for deployment opportunities are still affected.

9. Deployment plans for RBR floats in the next couple years

In 2023, JAMSTEC will deploy 4 RBR APEX floats, 2 for Core Argo and 2 for Argo equivalent. The 2 RBR Core Argo floats will be deployed in the western North Pacific, at which shipboard CTD cast will be carried out. The 2 RBR Argo equivalent floats will be deployed in the western equatorial Pacific region, observing the air-sea interaction regarding MJO and ENSO. In 2024 and after, we do not have any plan yet.