Japan National Report

(Submitted by Toshio Suga)

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)

a. Floats deployed and their performance

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 25 Core Argo, Deep Argo, Biogeochemical (BGC) Argo and Argo equivalent floats from January to December 2020: 19 floats for Core Argo (APEX), 4 floats for Deep Argo (Deep APEX and Deep NINJA), 2 floats for BGC Argo (BGC-NAVIS). Since 1999, JAMSTEC had deployed 1342 Core Argo, Deep Argo, BGC Argo and Argo equivalent floats mainly in the Pacific, Indian and Southern Oceans. Because COVID-19 influenced cruse plans, the number of our float deployment was largely decreased. The current positions of all the active Japanese Argo floats are shown in Fig.1. Under the limited cruise conditions, collaboration with Japanese voluntary agencies, institutes, universities and high schools were still ongoing, enabling deployment in 12 cruises. One float was deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK, in October 2020. The arrangement of the semi-regular float deployment by cargo ships was made under the cooperative relationship between JAMSTEC and NYK, which was established in 2011 to increase float deployment opportunity.

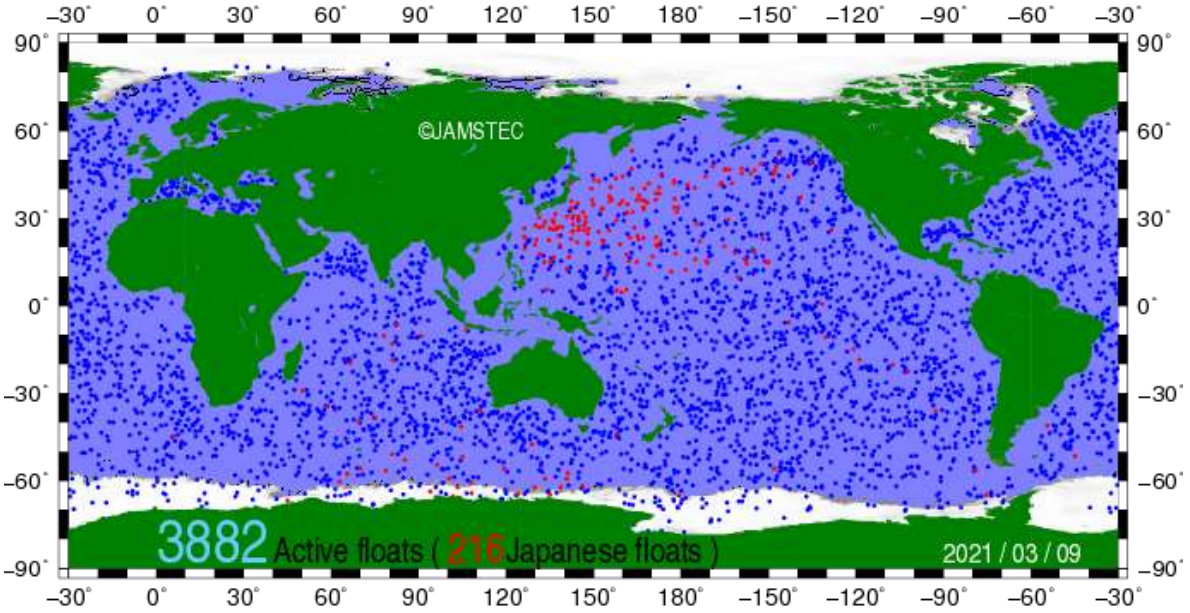

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

The Japan Meteorological Agency (JMA) deployed 28 Argo equivalent floats (4 APEX floats

and 24 ARVOR floats) in the seas around Japan from January to December 2020. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 342 floats (14 PROVOR, 194 APEX and 134 ARVOR floats) which JMA has deployed from 2005 to 2020, 51 floats (5 APEX floats and 46 ARVOR floats) are active as of the end of December 2020, while 30 floats (22 APEX and 8 ARVOR floats) terminated the transmission in 2020. JMA deployed 7 ARVOR floats from January to February 2021.

A profiling float for deep ocean observation, Deep NINJA, was developed by JAMSTEC and Tsurumi Seiki Co. Ltd. and has been available for public since April 2013. In December 2020, 4 Deep NINJA floats were operated. In January 2020, One Deep NINJA float with RINKO DO sensor was deployed in the Indian sector of the Southern Ocean. The data measured by these Deep NINJA floats were transferred to GDAC in accordance with the AST consensus on the data observed by Deep Argo floats.

b. Technical problems encountered and solved

1) Float hardware troubles and updates

Three BGC NAVIS floats (F0885, F0953, and F0955) suffered hardware troubles. Two of them were missing communication of BGCi SUNA sensors, one of them was failure ballasting of float in the manufacture. The recent version of BGC NAVIS floats is mostly stable due to hardware improvements. Although those floats were over 1 year after purchasing and some got over 100 profiles regulated by the warranty policy, SBE records on the warranty list and will back to us as alternative floats.

Some of Deep APEX floats with APF11 controller recorded buoyancy control failure in technical logging file. Teledyne Webb Research, manufacturer of Deep APEX floats, has been trying to improve their firmware of APF-11 and now they mostly become stable. As warranty of the troubled float, one Deep APEX float will be delivered in this year.

In 2018, JAMSTEC developed a new model of Deep NINJA with RINKO DO sensor in cooperation with JFE Advantech Co. Ltd. and Tsurumi Seiki Co. Ltd. One float was deployed in January 2020 from R/V Umitaka-maru in the Indian sector of the Southern Ocean after several tests of its RINKO sensor and it had survived the Antarctic winter of 2020. The RINKO DO sensor for deep float (AROD-FT) is already available at JFE Advantech.

By the comparisons with shipboard CTD measurements at deployments, salinity biases with the negative pressure dependency were identified in almost all of Deep APEX floats with SBE61. These features were different from those of Deep NINJA with SBE41 deep at several points: milder pressure dependency, almost no salinity bias expected at the sea surface, and less changeable features of the bias over time.

2) New screening method 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 now in operation, which was introduced in the previous national report. Although the J-Calibration system requires careful temperature control of the artificial seawater as it is critical to maintain a uniform water temperature, it is suitable for use in laboratory screening prior to deployment. As for now, the J-Calibration has been conducted for 122 CTD sensors, we found 2 doubt C sensors and were sent back to manufacturer.

We also conduct P sensor screening using DWT. As for now 122 pressure sensors were checked and 2 failure sensors were found. The two sensors were sent back to the manufacturer for repair.

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 218 active floats as of February 21, 2021. 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 and JAMSTEC have converted the almost all of Japanese meta-files, except a few Iridium floats, from v2 to v3.1 and submitted them to GDACs. JMA has converted almost all of Japanese tech-files and submitted them to GDACs. JMA has converted the Rprof-files of Japanese ARGOS floats, except floats with NST sampling scheme and Iridium floats. JAMSTEC has converted all v2 Dprof-files of Japanese floats to v3.1 and submitted them to GDACs. JMA has converted about 30% of Japanese traj-files from v2 to v3.1 and submitted them to GDACs.

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 Dprof-files in v3.1 since January 2016.

High salinity drift floats

Japan has 387 floats with SBE41/SBE41cp whose serial number is larger than 6000, which had been deployed since 2013. 54 floats of them had clearly high salinity drift, and 36 floats of them had differences larger than 0.05 between salinity observed by float and climatology near 2000dbar. Salinity of most of these floats started drifting from about 40-100 cycles. Four floats of them seem to have salinity drift with vertical dependency. Japanese floats with high salinity drift were all launched into the North Pacific, and about half of them were deployed in 2017. Unfortunately, the number of floats with this issue has increased by 7 in the last six months. Moreover, one Deep APEX with SBE61 has clearly high salinity drift. While about 90 active floats with SBE41/SBE41cp whose serial number is larger than 6000 and 22 active Deep APEX floats have not suffered from this issue, we continue to monitor 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 join the discussion about this issue through ADMT and working group of this issue, so that we contribute to improve salinity data quality.

We checked status of PSAL_QC flag for profiles with remarkable high salinity drift (hereafter, FSD) in the global ocean for several years. We confirmed that PSAL_QC flags of them are mostly 4 in the whole profile (Profile_PSAL_QC='F'). It means that Argo data processing of DACs and DMQC is working well. The rate of profiles whose Profile_PSAL_QCs are 'F' to all profiles measured in each year has increased by about 15% in 2020. Such profiles are globally distributed and have no regional bias. We inferred whether the profile with Profile_PSAL_QC of F will increase in the future or not, by checking the number of cycles of active floats. Once float has FSD, it cannot be restored. Therefore, when Profile_PSAL_QC of the latest cycle of a float is 'F', it is suspected that the float suffers from FSD. The number of active floats with the latest cycle between 150 and 160 is the largest in the number of active floats suspected to suffer from FSD (Fig. 1). This peak matches the average cycle of floats (Fig. 1). If the number of floats suffer from FSD do not increase, the number of profiles with Profile_PSAL_QC of 'F' may peak now and decrease in the future. However, it is possible that active floats will newly suffer from FSD, because the latest cycles of active floats with SBE41CP whose SNs are under 11250 are less than 100. The situation that the rate of profiles whose Profile_PSAL_QCs are 'F' to all profiles measured in each year has increased by about 15% is expected to continue.

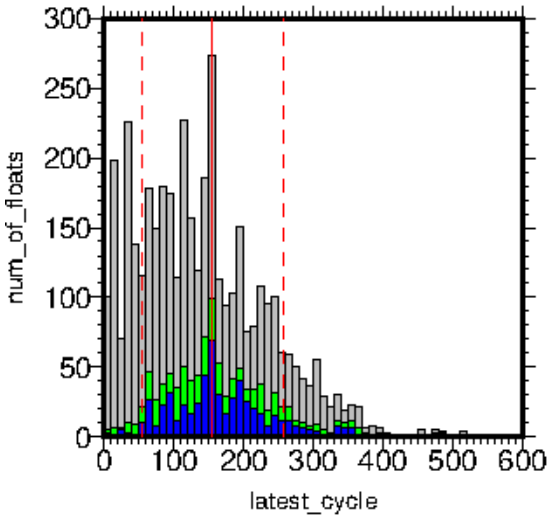

Figure 2: Histogram of number of active floats by the latest cycles. Gray denotes floats not suffering from FSD, blue denotes floats suspected to suffers from FSD, and green denotes floats whose Profile_PSAL_QC of the latest cycle is not 'F' but have past experience of Profile_PSAL_QC of 'F'. Red line and red dashed line denote mean average cycle and width of its standard deviation, respectively, calculated by using inactive floats' information.

d. Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed Core data (P, T, and S) of 202,830 profiles to GDACs as of December 2020. JAMSTEC had submitted D-Core files of 15,943 profiles in 2020.

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)

Japan Argo had been conducted in a 5-year program from FY1999 to FY2004, as a part of 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 has continued the operation until FY2013 nearly in 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 in the 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 been decreased from 5 to 4 since FY 2015 and also 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, 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 fund 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 FY2020, 25 Argo

floats were deployed, including 19 Core, 4 Deep and 2 BGC floats, following JAMSTEC's research purposes. In FY2021, the level of human resources for Argo deployment and QC is decreased from 4 to 3 including temporal staff. Deployment plan for Core, Deep and BGC Argo in FY2021 is not yet fixed but will be decided soon. JMA allocates operational budget for 27 floats in FY2021.

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

To maintain Core Argo array and to achieve its research purposes, JAMSTEC will deploy 20 floats mainly in the North Pacific, including 2 Deep and 3 BGC Argo in FY2021.

A "hot-spot" research team of special research fund "Grant- in Aid for Scientific Research in Innovative Area", being supported by JSPS KAKENHI, deploy 13 BGC APEX floats with RINKO oxygen sensor (9) and RINKO oxygen + pH sensor (4) around the subtropical region south of the Kuroshio Extension. Already 9 of them have been successfully deployed and now in healthy operation.

JMA plans to deploy 27 Argo equivalent floats (12 floats are deployed in western boundary region) around Japan in FY2021 and in the coming years. 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

*** Please also include any links to national program Argo web pages to update links on the AST and AIC websites.**

Many groups in JAMSTEC, JMA, FRA and Japanese universities are using Argo data for oceanographic researches on water mass formation and transport in the Pacific Ocean, the mid-depth circulation, the mixed layer variation, the barrier layer variation, and tropical atmosphere-ocean interaction in the Pacific and Indian Ocean and so on. Japanese fisheries research community is conducting their biogeochemical studies using Argo floats equipped with chlorophyll and/or oxygen sensors.

JMA issues operationally ocean analysis and forecast by using 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). MOVE/MRI.COM-JPN replaced the previous version (MOVE/MRI.COM-WNP) in October 2020 and numerical outputs of the new system will be available from the NEAR-GOOS Regional Real Time Data Base (https://www.data.jma.go.jp/gmd/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 El Niño 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 June 2015 (for descriptions of the new systems, please refer to https://ds.data.jma.go.jp/tcc/tcc/products/elnino/move_mricom-g2_doc.html, and https://ds.data.jma.go.jp/tcc/tcc/products/model/outline/cps2_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 a variety of products including objectively mapped temperature and salinity field data (Grid Point Value of the Monthly Objective Analysis using Argo float data: MOAA-GPV: http://www.jamstec.go.jp/ARGO/argo_web/MapQ/Mapdataset_e.html), objectively mapped velocity field data based on YoMaHa'07 (version September 2010) (http://www.jamstec.go.jp/ARGO/argo_web/G-YoMaHa/index_e.html), and gridded mixed layer depth with its related parameters (Mixed Layer data set of Argo, Grid Point Value: MILA-GPV http://www.jamstec.go.jp/ARGO/argo_web/MILAGPV/index_e.html). JAMSTEC have released 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 for convenient use on scientific or educational purposes (http://www.jamstec.go.jp/ARGO/deepninja/). The QC is based on comparisons with highly accurate shipboard CTD observations conducted nearby float observations.

JAMSTEC is also providing information about consistency check of float data related to delayed-mode QC for the Pacific Argo Regional Center (PARC) web site as a main contributor. 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 will construct a new PARC website soon as the mentor of the Pacific Ocean. Float PIs and DMQC operators can exchange various information about deployment and technical information, data quality of floats, DMQC, scientific products, etc. to improve 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. It is upgraded to version 04a in April 2020 to cover 58‐year period during 1957‐2014 (See the web site in JAMSTEC, http://www.godac.jamstec.go.jp/estoc/e/top/). Version 04a added two observational elements of ocean mixing and geothermal heating. Deep and BGC float data can be assimilated into the system after 2016. We plan to release a 60‐year state estimation (version 4b) within 2021. Some scientific papers related to the ESTOC were published (e.g., Osafune et al, 2020, Masuda and Osafune 2021).

JCOPE2M (Japan Coastal Ocean Predictability Experiment 2 Modified) is the model for 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 28 years back (from 1993 to present) and the forecast data 2 months ahead are disclosed on the following web site: http://www.jamstec.go.jp/frcgc/jcope/. More information are shown in http://www.jamstec.go.jp/frcgc/jcope/htdocs/jcope_system_description.html.

JCOPE-T DA , a downscaled version of JCOPE2M, has been recently developed by 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). Instead of FRA-JCOPE, which was the previous system of providing the hydrographic forecast information around Japan, FRA started the FRA-ROMS operation in May 2012. Argo has been one of important sources of in-situ data for the FRA-ROMS data assimilation system. The forecast oceanographic fields are provided every week on the website http://fm.dc.affrc.go.jp/fra-roms/index.html/.

5. Issues that our 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.**

As reported in 2011, EEZ clearance procedure for Argo float deployed had been simplified following IOC Resolution XLI-4. This change reduced our time and effort for the process of EEZ clearance. However, 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 AIC. Japan Argo hopes for more NFPs especially of nations in and around the Pacific Ocean to be registered to facilitate more timely and optimal deployment of Argo floats, especially about the southern islands in the Pacific Ocean. This could be also helpful for smooth implementation of any future extension of Argo.

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.

After the last upload of CTD data to the CCHDO website in January 2020, which was included in the last national report, we didn't upload any data, unfortunately.

7. Outreach activity

JAMSTEC sent an appreciation letter to schools, commercial company and institutes for contribution to Argo float deployments by voluntary ships. JAMSTEC deployed lots of Argo floats since the Argo project was started, in cooperation with voluntary ships, which is quite essential to achieve the Argo array in the North Pacific Ocean. Over 20 years after starting Argo, we presented the letter to thank and construct further collaborative relationship.

Also, JAMSTEC carried out lectures of Argo and related ocean research and investigation to high school and elementary school students , gathering in the JAMSTEC Mutsu blanch in Aomori Prefecture. At the end of the lectures, they wrote messages on the ocean environment and expectations for Argo float on float body (Fig.3). One of the floats had been deployed from Hakuho cruise in late winter, another will be deployed from Mirai cruise this summer.

Figure 3: (Upper) Writing messages on Argo float by high school students. (Lower) Deployment from Hakuho maru in Feb. 2021.

8. Argo bibliography

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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.

Due to COVID-19, many cruise plans are cancelled or modified, strongly affected for JAMSTEC's deployment plan. Because of these troubles, about a half of float deployments were cancelled, which forced the number of float deployments were decreased.

From April 2020, JAMSTEC controlled the number of researchers and technicians working at office and forced to stay at home. Due to the change of work style within short time, data processing and dmqc operations were delayed for several months. This makes us the number of dmqc data submission to be decreased.

9. 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.

JAMSTEC does not have any plan to deploy RBR Argo float at this time. However, we strongly concern to gather further RBR data and will continuously submit the data obtained from 3 active floats with RBR CTD.