The 21st Argo Steering Team Meeting, Southampton, UK, March 18-20, 2020

Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2019)

1.1 Floats deployed and their performance

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 68 Argo, deep Argo, Biogeochemical (BGC) Argo and Argo equivalent floats from January to December 2019: 7 NAVIS and 41 APEX floats for Core Argo, 15 Deep APEX and 1 RINKO-Deep NINJA floats for deep Argo, 4 BGC NAVIS floats for BGC Argo. Since 1999, JAMSTEC had deployed 1316 Argo, deep Argo, BGC Argo and Argo equivalent floats mainly in the Pacific, Indian and Southern Oceans. The current positions of all the active Japanese Argo floats are shown in Fig.1. Collaborating with Japanese voluntary agencies, institutes, university and high schools, all the floats were deployed in 23 cruises. Two floats were deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK, in August 2019. 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. In deep collaboration with CSIRO, R/V Investigator of CSIRO, having two Deep Argo floats provided by JAMSTEC on board, left Fremantle on May 13rd, 2019 for her special cruise along 110°E under IIOE-2 program. These two deep Argo floats were successfully deployed by a team lead by Prof. Linneth Beckley of Murdoch University at 39.5°S and 11.5°S on the observation section.

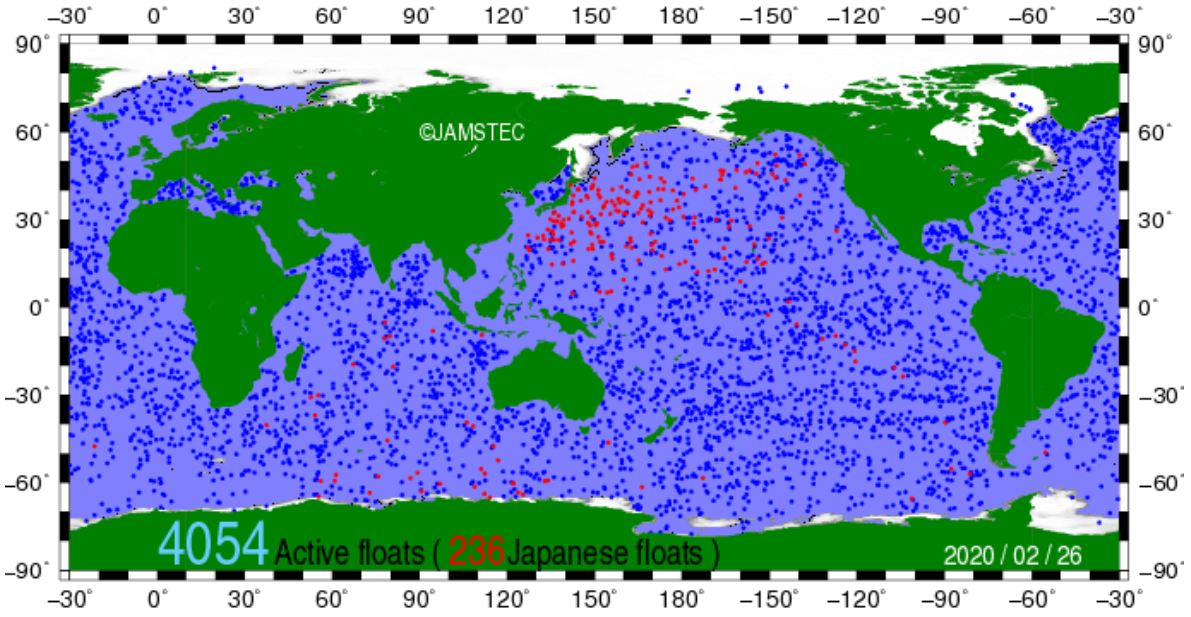

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

The Japan Meteorological Agency (JMA) deployed 35 Argo equivalent floats (23 APEX floats and 12 ARVOR floats) in the seas around Japan from January to December 2019. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 314 floats (14 PROVOR, 190 APEX and 110 ARVOR floats) which JMA has deployed from 2005 to 2019, 53 floats (23 APEX floats and 30 ARVOR floats) are active as of the end of December 2019, while 36 floats (36 ARVOR floats) terminated the transmission in 2019. JMA deployed 3 APEX floats and 2 ARVOR floats from January to February 2020.

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 2019, 4 Deep NINJA floats were operated. In January 2019, 1 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.

1.2 Technical problems encountered and solved

1.2.1 Float hardware troubles on NAVIS floats

NAVIS floats, which were purchased in 2013-2018, suffered hardware troubles. The purchased NAVIS floats are totally 71 for Core, 13 for BGC Argo; about 1/3 of them were possibly troubled on pump, bulb, bladder system, connection and/or communication error between sensors and float body. Because of efforts for improvement of hardware by SBE, recent version of NAVIS floats are mostly stable. Following the warranty policy, JAMSTEC has received 18 warranty floats for Core and 3 for BGC until 2019. However, 15 core floats are still on the watch list, and a few floats are under negotiation with SBE whether they need to be included into the watch list.

1.2.2 Deep Ninja with RINKO sensor

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. Among three floats made in October 2018, we deployed the second float in the Indian sector of the Southern Ocean in January 2019 from R/V Umitaka-maru. The float was lost probably due to damage from sea ice at surfacing. The last 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. The RINKO DO sensor for deep float (AROD-FT) is already available at JFE Advantech.

1.2.3 Deep APEX

In 2019, JAMSTEC deployed 8 Deep APEX floats in the North Pacific Ocean, Indian Ocean and Southern Ocean. Most of troubles on Deep APEX floats, which were recorded as buoyancy control failure in technical logging file, have been fixed, although sometime the same trouble occurred. Teledyne Webb Research, manufacturer of Deep APEX floats, has been trying to improve their firmware of APF-11 and now they mostly have become stable. However, because of this trouble, our deployment plan in 2019 was forced to be modified; their deployment was to be moved to the next year.

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.

1.2.4 New screening method for SBE41

JAMSTEC developed a new screening system, J-Calibration, for use with the SBE41 CTD sensor on the Argo float (Sea Bird Scientific). The system is similar to that used in UW and other institutes, but has some advantages for the use of SBE3 and 4 as reference sensors to screen SBE41 more accurately. Also, the J-Calibration does not require removal of the CTD sensor unit from the Argo float body, enabling to allow the manufacturer's warranty. The J-Calibration reduces the screening time to 1/6th of that SBE-Calibration requires and does not require a large amount of artificial seawater by conducting calibration at only 1 temperature point (22 °C). 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. Now we use the J-Calibration system as operational mode.

1.3 Status of contributions to Argo data management (including status of high salinity drift floats, decoding or production difficulties, etc.)

The Japan DAC, JMA has operationally processed data from all the Japanese Argo and Argo-equivalent floats including 235 active floats as of February 21, 2020. Ten 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.

1.4 Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed Core data (P, T, and S) of 160,302 profiles to GDACs as of December 2019. JAMSTEC had submitted D-Core files of 42,528 profiles in 2019.

1.5 Positive salinity drift of SBE41

JAMSTEC has 43 floats with SBE41cp whose serial number is larger than 6000, which had been deployed since 2015. Eight floats of them has clearly with high salinity drift, differences between salinity observed by float and climatology near 2000dbar are larger than 0.01. Salinity of these floats started drifting from about 50-60 cycles. Four floats of them seem to have salinity drift with vertical dependence. Our floats with high salinity drift were all launched into the North Pacific, and almost all of them are active. We continue to monitoring salinity data of Japanese floats as well as our floats, detecting floats with high salinity drift, and understanding features of high salinity drift found in floats. We will share 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.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo

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 FY2019, 60 Argo floats were deployed in the Pacific, Indian and Southern Oceans, including 40 Core, 16 Deep and 4 BGC floats, following JAMSTEC's research purposes. In FY2020, the level of human resources for Argo deployment and QC is the same as those in FY2018 and FY2019. Deployment plan for Core, Deep and BGC Argo in FY2020 are not yet fixed but will be decided soon. JMA allocates operational budget for 27 floats in FY2020.

3. Summary of deployment plans (level of commitment, areas of float deployment, low or high resolution profiles, Argo 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 27 floats mainly in the North Pacific, where the index of deployment intensity is not good and the age of floats tends to be higher than other areas, based on the statistics provided by Argo Information Center. Regarding Deep and BGC Argo, 1 Deep NINJA, 1 Deep APEX, 4 BGC NAVIS with Nutrient (1) and pH (3) floats will be deployed in the Pacific, Indian Oceans and the Southern Ocean.

Additionally, a team of DCOP in JAMSTEC will deploy 3 RBR-CTD APEX floats in the tropical western Pacific Ocean as Argo equivalent floats to investigate air-sea interaction process for MJO.

A "hot-spot" research team of special research fund "Grant- in Aid for Scientific Research in Innovative Area", being supported by JSPS KAKENHI, will 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 (Fig. 2). The deployment will be conducted in 4 cruises by 3 ships (JMA and JAMSTEC). The target area of this project is the Far East and western North Pacific, where the most distinct "hot-spot" in the extratropical climate system is situated. Under the "meridional contiguousness"

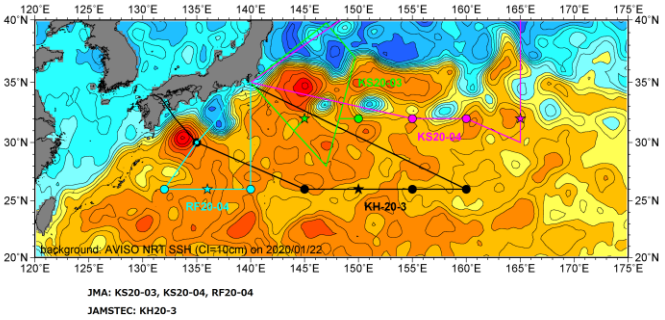

Figure 2: Deployment plan by the "hot-spot" research team. See text for details.

between the tropical heat and the polar cold caused by the Kuroshio and Oyashio and the East-Asian Monsoon, there are various interactions between the atmosphere and the ocean, accompanying a huge amount of heat release from the ocean.

Another 3 APEX floats will be deployed as Equivalent Argo floats around the Kuroshio Extension based on the Grant in Aid for Scientific Research (A) being supported by JSPS KAKENHI. The purpose of research is to investigate water mass structure and its modification into mesoscale eddies and heat content change through a process of air-sea interaction.

JMA plans to deploy 27 Argo equivalent floats (12 floats are deployed in western boundary region) around Japan in FY2020 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

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 and monthly products of subsurface temperatures and currents for the seas around Japan and western North Pacific, based on the output of the real-time ocean data assimilation system (MOVE/MRI.COM-WNP), 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 (http://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. Because IPRC found it difficult to continue maintaining the PARC website which IPRC had been in charge of in part due to limited funding and human resources, JAMSTEC and IPRC decided to maintain the website mainly by JAMSTEC, with IPRC supporting through producing useful scientific products. According to this decision, JAMSTEC is going to construct a new PARC website, through which float PIs and DMQC operators can get various information about data quality of floats, DMQC, scientific products, etc., and can exchange them interactively to improve Argo data and the status of Argo array in the Pacific Ocean.

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 3b in May 2019 to cover 58-year period during 1957-2014 (See the web site in JAMSTEC, http://www.godac.jamstec.go.jp/estoc/e/top/). The ESTOC continue being improved by introducing new observational elements (e.g., ocean mixing, a global sea level). Deep and BGC float data can be assimilated into the system after 2016. Some methodology for deep float data to be integrated was developed and published in 2018. We plan to release a 60-year state estimation (version 4) within 2020. Especially, Dr. S. Masuda provided a scientific paper entitled" Determining subsurface oceanic changes in the Indian sector of the Southern Ocean using Argo float data" published in the Polar Science in 2019. He was focusing on the relationship between Southern Annular Mode and the surface-to-2000-m oceanic state using ESTOC 4D-Var data assimilation. As a result, he showed the interannual changes in the wintertime subsurface condition in the Indian sector of the Southern Ocean are consistent with the faster response to the SAM than proposed by previous model studies.

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 27 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.

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

As reported in 2011, EEZ clearance procedure for Argo float deployed by Japanese PIs has been simplified following IOC Resolution XLI-4. This change reduced our time and effort for the process of EEZ clearance significantly. 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. This could be also helpful for smooth implementation of any future extension of Argo.

The other issue is wrong e-mail address of Focal Point (FP) listed at AIC. Some floats were drifted into Russian EEZ and JAMSTEC informed to the FP following the procedure of IOC resolution. However, because of wrong e-mail address of the FP, error e-mails were returned, thus we sent letters to the address of FP to inform drifting floats. These might be caused by a change of e-mail address due to re-construction of organization. To maintain the notification system effective, checking and updating e-mail addresses of FPs are desired.

6. Summary of the number and location of CTD cruise data to the CCHDO website

Data of 657 CTD casts conducted by JMA in the western North Pacific in 2019 were uploaded to the CCHDO website. CTD cast information (PI, location and date), which have been carried out at float launching points and used for Argo dQC, is attached as an Excel file "CTD_list_JAMSTECArgoDB_20200303."

7. Outreach activity

Deep NINJA and its scientific result were demonstrated in COP25 JAPAN Pavilion at Madrid, Spain in Dec. 2019. In the Pavilion, the deep Argo observation and future plan were introduced through a poster panel and movie, displaying a model of Deep NINJA. Two public events were led by JAMSTEC in Yokosuka and Mutsu, where Argo float series are introduced and some related contents are exposed.

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