Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2017)

1.1 Floats deployed and their performance

The current positions of all the active Japanese Argo floats are shown in Fig.1.

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 35 Argo and Argo equivalent floats from January to December 2017: 11 ARVOR, 10 NAVIS, 7 APEX, 2 Deep APEX, 1 Biogeochemical (BGC) APEX, 3 Deep NINJA, and 1 RINKO-Deep NINJA floats. All the floats except one described below were deployed with the aid of R/Vs of 8 domestic organizations.

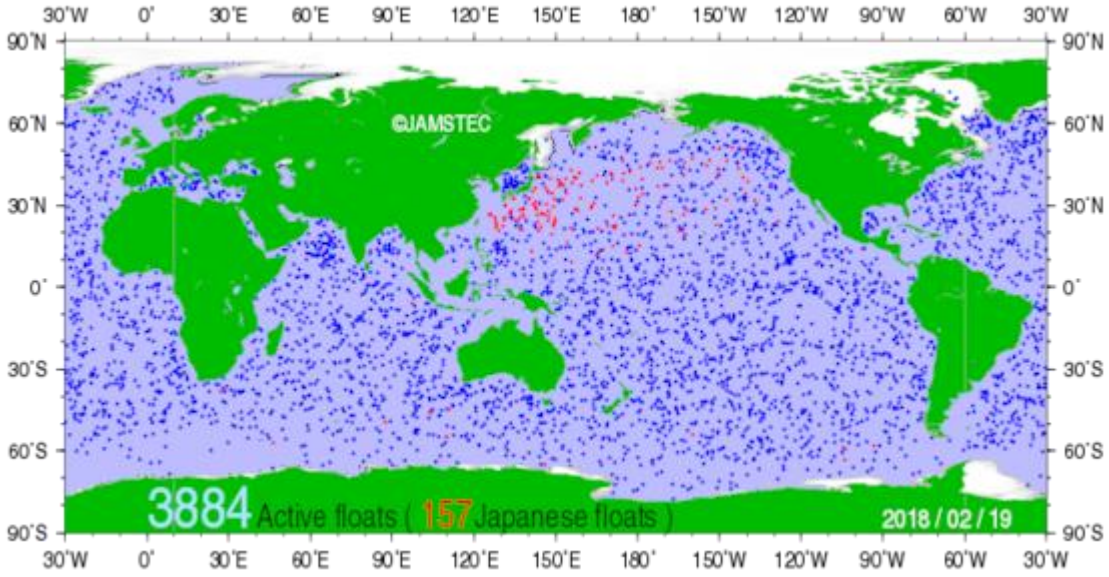

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

One Navis float of JAMSTEC was deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK Line, in July 2017. The arrangement of the semi-regular float deployment by cargo ships was made under the cooperative relationship between JAMSTEC and NYK line, which was established in 2011 to increase float deployment opportunity.

From 1999 to the end of December 2017, JAMSTEC deployed 1227 Argo and Argo equivalent floats in the Pacific (1026), Indian (107) and Southern Oceans (94; South of 50°S). As of the end of December 2017, 123 floats are active and additionally 5 floats (including Deep, BGC floats) are planned to be deployed until March 2018.

The Japan Meteorological Agency (JMA) deployed 36 Argo equivalent and WBC floats (36 ARVOR floats) in the seas around Japan from January to December 2017. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 262 floats (16 PROVOR, 167 APEX and 79 ARVOR floats) which JMA has deployed from 2005 to 2017, 50 floats (50 ARVOR floats) are active as of the end of December 2017, while 29 floats (26 APEX and 3 ARVOR floats) terminated the transmission in 2017. JMA deployed 4 ARVOR floats from January to February 2018.

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 February 2017, one Deep NINJA floats were operated in the Indian Ocean. From February 2017 to February 2018, 7 Deep NINJA floats (including two prototypes with RINKO DO sensor, to be mentioned below) were deployed; one in the South Pacific in February 2017, two in the North Pacific in July 2017, three off the Adelie Coast, Antarctica in January/February 2018 (by R/V Investigator, CSRIO), and one in the tropical Indian Ocean in December 2017. Unfortunately, three of them had lost contact. 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.

Okinawa Institute of Science and Technology Graduate University (OIST) deployed 21 Argo equivalent floats from 2011 to 2017, including 4 deployed in 2017 to investigate mid-depth ocean circulation. Four Argo equivalent floats (NEMO floats) are active as of end of December 2017.

1.1.1 Float deployment for synchronous array observation

JAMSTEC has been conducting a small synchronized float array observation since 2014 to investigate formation and dissipation process of the North Pacific central mode water (CMW) in detail, aiming for quantification of temporal variations of surface and subsurface vertical mixing process forced by wind and surface cooling. The observation array was arranged at 6 latitude grids (30-42.5N) along 170W, measuring daily temperature and salinity every 2dbar. Through a 4-year array observation, active internal waves below subsurface layer were identified, related to wind energy from atmospheric disturbances. The internal wave enhances vertical diffusivities in fall to winter, which makes the CMW diffused effectively (Inoue et al., 2017). The result of this synchronized Argo array gives us a new application for ocean observation using Argo floats.

1.1.2 Float deployment for the research project "Optimization of tropical Pacific Ocean observation system"

Three NAVIS floats were deployed as Argo equivalent floats in the western tropical Pacific to investigate interior ocean disturbances and their source region related to ENSO. The purpose of this project is to make suggestion on effective design of tropical Pacific Observation System (TPOS) for the ENSO prediction, contributing to TPOS2020. The NAVIS floats were deployed among TRITON moorings along 137E line in February; they make measurement down to 2000m every 2 days. Unfortunately the last float of the three stopped to communicate in 2017, all data are available from GDACs as well as through an objective analyses dataset.

1.2 Technical problems encountered and solved

1.2.1 Float hardware troubles on NAVIS float

NAVIS floats, which were purchased in 2013-2015, suffered hardware troubles, which were possibly caused by pump, bulb or bladder system failure, and are still operating without proper measurement. The symptom of these troubled NAVIS floats were drifting at the sea surface or not being able to control their drifting or profiling depth. Following the warranty policy, JAMSTEC has received 9 warranty floats in 2017 and 4 floats are still on the watch list.

1.2.2 Deep Ninja with RINKO sensor

In 2016, JAMSTEC began to develop a new model of Deep NINJA with RINKO DO sensor in cooperation with JFE Advantech Co. Ltd. and Tsurumi Seiki Co. Ltd. We made two prototypes in June 2017. One was deployed at K2 station in the western subarctic North Pacific in July 2017 from R/V Mirai. It had halted its operation due to a mechanical failure after the measurement of the 9-th profile. The other was deployed in the Southern Ocean in January 2018 from R/V Investigator, CSIRO. The RINKO DO sensor for deep float (AROD-FT) is already available at JFE Advantech.

1.2.3 Deep APEX

In February 2017, JAMSTEC deployed one Deep APEX float in the Southern Ocean as its first deployment of 6000m deep Argo float. Unfortunately, the float drifted at sea surface after a few cycles without acquiring proper data because of going into emergency mission due to internal hydraulic oil leaks, seawater leaks through connecting component. Based on analyses by the manufacturer (Teledyne Webb Research), it was found that the problem was caused by factory fault and they decided that warranty float will be delivered in 2018.

In November, 2017, JAMSTEC deployed one Deep APEX float with Aanderaa Optode4835 oxygen sensor (S/N:29, WMOID:2903212) in the western North Pacific region. The Deep APEX float makes measurement from sea bottom every 2 days (then changed to 15 days later), setting the parking pressure at 4000 dbar. In comparison with shipboard CTDO measurement at the deployment point, clear negative salinity bias (>0.1 psu) and unstable oxygen measurement were appeared and the situation is still continued after 15 cycles in February 2018. Further analyses and improvement by the manufacturer are required. Relevant information, data and experiences will be shared with other users.

1.3 Status of contributions to Argo data management

The Japan DAC, JMA has operationally processed data from all the Japanese Argo and Argo-equivalent floats including 157 active floats as of February 14, 2018. Ten Japanese PIs agree to provide data to 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 TESAC and 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 GDAC. JMA has converted almost all of Japanese tech-files and submitted them to GDAC. Accordingly, 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 GDAC. JMA has converted about 30% of Japanese traj-files from v2 to v3.1 and submitted them to GDAC.

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 115,054 profiles to GDACs as of December 2017. JAMSTEC had submitted D-Core files of 6,177 profiles in 2017 and will accelerate the submission of D-Core files in 2018..

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 ever before under its new 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 will be deployed in the Pacific, Indian and Southern Ocean in FY2018-19. JMA allocates operational budget for 27 floats in FY2018.

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.

Based on the additional fund, larger number of Core/Deep/BGC Argo floats will be deployed in 2018. To maintain Core Argo array, JAMSTEC will deploy 34 floats mainly in the North Pacific, where the index of deployment intensity is not good and the age of floats tend to be higher than the other area, based on the information from Argo Information Center. Those deployment will help to improve North Pacific Core Argo array. Regarding Deep Argo, 3 Deep NINJA, 4 RINKO (DO) Deep NINJA, 10 Deep APEX, 3 DO(RINKO or Optode)-Deep APEX floats will be deployed in the Pacific and Indian Oceans, especially focusing on the Southern Ocean. In Australian Antarctic Basin, freshening and warming signal of AABW had been detected from shipboard observations; however, its spatial and temporal changes are still unclear because of limited historical data. In cooperation with the Deep Argo observation campaign by Australia, France and Japan, which has been carried out in 2017-2018, JAMSTEC has a plan to deploy further Deep Argo floats (>10) in the region to investigate long-term change in AABW, enhancing Deep Argo array in the Southern Ocean. Regarding BGC Argo, one BGC float with oxygen, chlorophyll-a and BBP, and one BGC float with oxygen, chlorophyll-a, BBP and Nutrient will be deployed in the Pacific and Indian Oceans. Highlighted area is the subpolar region of the North Pacific Ocean, where oxygen minimum zone (OMZ) and ocean acidification tend to be strengthened and expanded. By deploying BGC floats with Nutrient and pH sensor, long term BGC data will be obtained to contribute to acquire more knowledge of OMZ and acidification. As a test mode, 2 APEX floats with RBR CTD sensor are deployed at the same point, evaluating RBR sensor with shipboard CTD cast. As non-Argo float, one EM APEX will be deployed in the Kuroshio Extension.

JMA plans to deploy 15 Argo equivalent floats and 12 Argo WBC floats around Japan in FY2018 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.

The global Argo TESAC and BUFR messages are used for operational ocean analysis and forecast by JMA. 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 (http://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 http://ds.data.jma.go.jp/tcc/tcc/products/elnino/move_mricom-g2_doc.html, and http://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 (http://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 1.2) since October 2014. We add our own new flag to real time profile data which tells whether it passed each check or not. 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 high 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. JAMSTEC will support the activities of the Southern Ocean ARC (SOARC) in the Pacific sector.

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 for 55 years during 1957-2011 (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), and extended for 58 years for the period of 1957-2014. A new version plan to be released in spring 2018.

JCOPE2 (Japan Coastal Ocean Predictability Experiment 2) is the model for prediction of the oceanic variation around Japan which is operated by Application Laboratory of JAMSTEC. JCOPE2 is the second version of JCOPE1, developed with enhanced model and data assimilation schemes. The Argo data are used by way of GTSPP. The reanalysis data 25 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 Fisheries Research 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 listed 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.

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

Data of 514 CTD casts conducted by JMA in the western North Pacific from October 2016 to September 2017 were uploaded to the CCHDO website.

7. Outreach activity.

In October, 2017, a domestic Argo symposium took place during annual fall meeting of the Oceanographic Society of Japan at Tohoku University. The purpose of the symposium was to inform Japanese research and operational communities about recent status of Core/Deep/BGC Argo and share experiences of those observations with scientists/technicians/manufacturers in Japan. Over 70 people participated and discussed lively about sustainability and expansion of Core/Deep/BGC Argo. All of the presentations are available on the JAMSTEC's web site and the documents of all talk will be summarized in a review paper.

8. Argo bibliography

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