Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2016)

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 31 Argo and Argo equivalent floats from January to December 2016: 11 ARVOR, 17 Navis, and 3 DeepNINJA floats. All the floats except one described below were deployed with the aid of R/Vs of 7 domestic organizations.

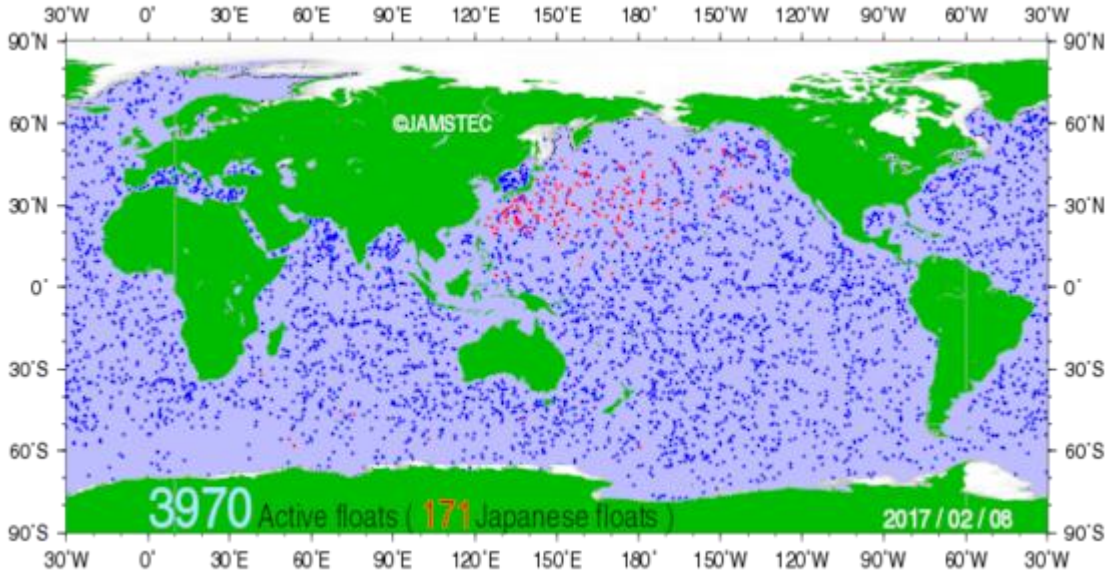

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

Two Navis floats of JAMSTEC were deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK Line, in July 2016. 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 2016, JAMSTEC deployed 1156 (1168) Argo and Argo equivalent floats (the number in parenthesis includes floats deployed as non Argo floats; most of their data are to be released as Argo data later) in the Pacific, Indian and Southern Oceans: 759 (764) APEX, 141 (143) PROVOR, 123 (123) ARVOR, 33 (39) NEMO, 66 (66) Navis, 11 (11) NINJA, 15 (15) Deep NINJA, 6 (6) POPS and 2 (2) SOLO floats. As of the end of December 2016, 128 (128) floats [6 (6) APEX, 77 (77) ARVOR, 41 (41) Navis, and 4 (4) Deep NINJA floats] are in normal operation. The other 1029 (1041) floats terminated their missions, including 1(1) floats drifting at the sea surface and 12 (13) floats recovered. JAMSTEC deployed 5 floats [2 ARVOR, 1

Navis, 1 DeepNINJA, 1 DeepAPEX equipped with Optode4835 floats) in January and February 2017.

The Japan Meteorological Agency (JMA) deployed 20 Argo equivalent floats (4 APEX and 16 ARVOR floats) in the seas around Japan from January to December 2016. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 226 floats (16 PROVOR, 167 APEX and 27 ARVOR floats) which JMA has deployed from 2005 to 2016, 53 floats (13 APEX and 40 ARVOR floats) are active as of the end of December 2016, while 19 floats (16 APEX and 3 ARVOR floats) terminated the transmission in 2016. JMA deployed 5 APEX floats from January to February 2017.

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. At the beginning of 2016 two Deep NINJA floats were operated off the Budd Coast, the Antarctica and one of them lost contact from February 2016. In 2016, two Deep NINJA floats were deployed in the Indian Ocean in January/February and one float in the subtropical North Pacific in March. Unfortunately, two 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 16 Argo equivalent floats from 2011 to 2014. Two floats (2 NEMO floats) are active as of end of December 2016.

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, for example, quantification of temporal variations of surface and subsurface vertical mixing process forced by wind and surface cooling.. In 2016, we further deployed 7 Navis floats for the array as Argo floats, to get finer vertical resolution (2 meters from the surface through 2000m) data every 10 days, synchronizing sampling interval with the other array floats. Through a 3-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. 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 "Impact of bomb cyclones on physical and biogeochemical changes in the ocean"

Two Navis floats were deployed as Argo equivalent floats in the northwestern Pacific in 2016 fall season to investigate the impact of bomb cyclones on the interior oceanic changes. The bomb cyclones break out in winter season and rapidly grow in a short time, having impacts on deeper layer ocean variability. Since 2014 8 Navis floats in total had been deployed; the mission of these floats is to be switched to 6-hour cycle when approaching bomb cyclones are predicted. From the very frequent observations, it is found that the upward vertical velocity of the Navis float itself during measurement is related to timing of passing bomb cyclones. The obtained data are opened and processed in real time, being available from GDACs and through an objective analyses dataset. The funding for this mode of deployment has been provided by JSPS (JSPS KAKENHI Grant Numbers 26707025, PI: Akira Kuwano-Yoshida, APL, JAMSTEC).

1.1.3 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. The obtained data are opened and processed in real time, being 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

Thirteen Navis floats suffered hardware troubles, which were possibly caused by pump, bulb or bladder system failure, and are still operating without proper measurement in 2016. The symptom of these troubled Navis floats were drifting at the sea surface or not being able to control their drifting or profiling depth. New version of the Navis float (Navis-EBR), which had been released from SBE since 2015, seems to be free from the problem owing to modification by the manufacturer based on diagnosis of the troubles and errors.

1.2.2 RINKO sensor on S3A

As reported last year, One S3A float equipped with RINKO sensor was operated to measure dissolved oxygen (DO) in the sea from July 2014 to January 2016. CTD and DO data were sampled at 2-dbar interval from 2000 dbar to the surface. We obtained 107 profiles of pressure, temperature, salinity and dissolved oxygen observed by it for one year and a half. The RINKO sensor mounted on S3A float is relatively stable, because the time drift of DO data in the deep water is less than 0.5 μmol/kg·year. Unfortunately, the float terminated its operation late January, 2016.

1.2.3 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 are going to make two prototypes and they will be deployed for field tests in 2017. The RINKO DO sensor for deep float is under development at JFE Advantech now, and it will be available in near future.

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 171 active floats as of February 8, 2017. 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 102,286 profiles to GDACs as of December 2016. JAMSTEC had submitted D-Core files of about 7,000 profiles in 2016 and will accelerate the submission of D-Core files in 2017. .

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 Argo extensions (mainly Deep Argo and BGC Argo) was allocated and some Deep and BGC Argo floats were purchased for feasibility study. Further increase of fund for the Argo extensions is expected in FY2017. JMA allocates operational budget for 27 floats in FY2017.

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.

In 2017, JAMSTEC will deploy about 20 floats in total in the Pacific for the Argo core mission. The main purposes of deployment is to fill the blank of 3x3 degree bins in the global Argo array. We will also deploy 9 Argo equivalent floats, the purpose of which is to investigate internal tide wave related to turbulent mixing, observing temporal and vertical high density profiles in the subtropical North Pacific Ocean. Three Deep NINJA floats will be deployed as Deep Argo floats in FY2017 in the North Pacific, Pacific part of Southern Ocean and equatorial Indian Ocean. One APEX float equipped with oxygen, chlorophyll-a, and BBP will be deployed as part of BioGeoChemical Argo in July 2017 at the mooring station K2 operated by JAMSTEC. We have a plan to deploy 3 Deep floats equipped with oxygen during 2017 as non-Argo. Two of them are Deep NINJA equipped with RINKO DO sensor. Their data are to be released as Argo data later. Since several Japanese scientists are applying for competitive research funding to purchase Argo floats, deep floats and BGC Argo floats, the number of floats to be deployed in FY2017 may be increased.

JMA plans to deploy 15 Argo equivalent floats and 12 Argo WBC floats around Japan in FY2017 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) 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/).

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 24 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 appreciates that some countries have registered their NFPs since AST-16 and 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 686 CTD casts conducted by JMA in the western North Pacific from October 2015 to September 2016 were uploaded to the CCHDO website.

7. Argo bibliography

(1) Articles

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(2) Doctorate thesis

None