Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2015)

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 27 Argo and Argo equivalent floats from January to December 2015: 8 ARVOR and 19 Navis floats. All the floats except one described below were deployed with the aid of R/Vs of 10 domestic organizations.

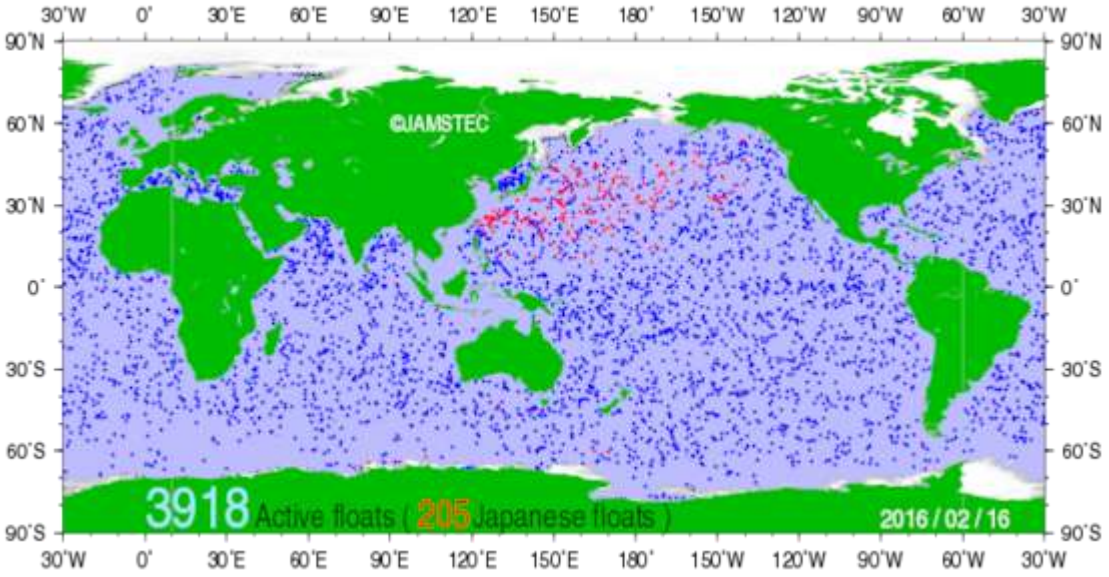

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

One of JAMSTEC Navis floats were deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK Line, in May 2015. 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. NYK Line has a lot of cargo shipping routes covering the global ocean, which is very useful to deploy Argo floats in the area of sparse float density. This is also part of environment conservation efforts of NYK Line through optimal routing owing to improvement of ocean current prediction that is benefitted from Argo.

From 1999 to the end of December 2015, JAMSTEC deployed 1105 (1130) 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: 739 (764) APEX, 141 (143) PROVOR, 112 (112) ARVOR, 33 (39) NEMO, 49 (49) Navis, 11 (11) NINJA, 12 (12) Deep NINJA, 6 (6) POPS and 2 (2) SOLO floats. As of the end of December 2015,

145 (158) floats [5 (16) APEX, 1(3) PROVOR, 92 (92) ARVOR, 42 (42) Navis, 4 (4) Deep NINJA, and 1 (1) SOLO floats] are in normal operation. The other 961 (973) floats terminated their missions, including 9 floats transmitting on the beaches after stranding or being captured by ships, 12 floats drifting at the sea surface and 10 floats recovered. JAMSTEC deployed 10 floats [5 ARVOR, 3 Navis, and 2 DeepNINJA floats) in January and February 2016.

The Japan Meteorological Agency (JMA) deployed 14 Argo equivalent floats (14 APEXs) in the seas around Japan from January to December 2015. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 206 floats (16 PROVORs, 163 APEXs and 27 ARVORs) which JMA has deployed from 2005 to 2015, 52 floats (52 APEXs) are active as of the end of December 2015, while 7 floats (7 APEXs) terminated the transmission in 2015. JMA deployed 3 APEX floats in February 2016.

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. Out of five Deep NINJA floats in operation at the beginning of 2015, three off the Budd Coast, the Antarctica lost contact from the end of June 2015, due to sea ice extension there and two survived Antarctic winter and resumed data transfer in December 2015 and January 2016. We confirmed that they have observed the Antarctic deep layer under sea ice throughout the winter. In March 2015, the data measured by these Deep NINJA floats began to be 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. 6floats (6NEMOs) are active as of end of December 2015.

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 its contribution on decadal heat content change. In 2015, we further deployed 4 Navis floats for the array as Argo floats, especially focusing on the temporal variation of surface and subsurface vertical mixing process forced by wind and surface cooling. In addition, we changed the observation frequency from normal Argo cycle (10 days) to every day for two Navis floats which were observing around the array area as normal Argo floats. The Navis floats measure temperature and salinity with fine vertical resolution (2 meters) every 1-10 days synchronizing sampling interval.

1.1.2 Float deployment for the research "Impact of bomb cyclones on physical and biogeochemical changes in the ocean"

Four Navis floats were deployed as Argo equivalent floats in the northwestern Pacific during 2015 summer to 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, enhancing air-sea interactions. Although high resolution numerical simulation suggested that they strongly work as a trigger of changes in vertical velocity and primary production associated with phytoplankton blooming in spring, there have been no observational evidences because of a lack of detailed observation with temporally and vertically frequent measurements. The four floats were deployed diffusely to capture changeable path and location of the bomb cyclone. Their mission is to be switched to 6-hour cycle when approaching bomb cyclones are predicted in the weather forecast. Thus far the floats succeeded to capture oceanic changes during bomb cyclone passing, although some of Navis floats stopped to send correct data. The obtained data are opened and processed in real time, being available from GDACs and 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).

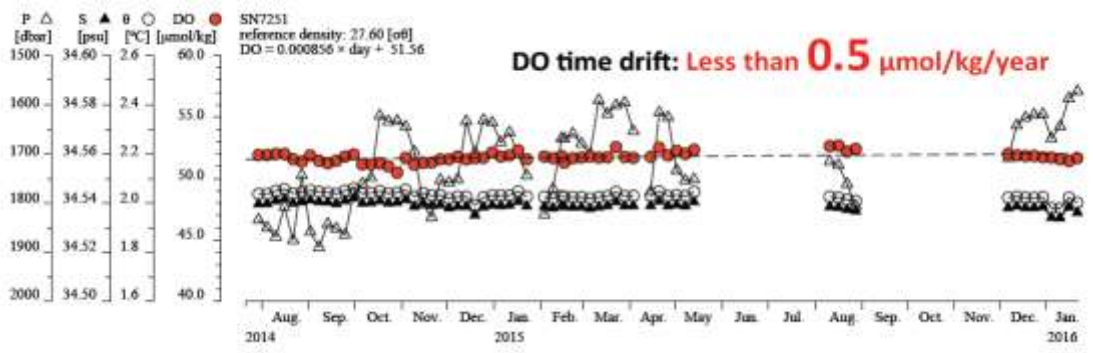

Figure 2. Time series of pressure (open triangle), salinity (filled triangle), potential temperature (open circle), and DO (red circle) recorded bu float SN7251 (WMO_ID:2902530) at a potential density of 27.6 σ_θ. The broken line represents the linear regression fitted to the DO data. Data missing period indicates that the float was drifting in shallow regions near the Hokkaido/Tohoku coast.

1.2 Technical problems encountered and solved

1.2.1 Float hardware troubles

JAMSTEC deployed 31 and 20 Navis floats as Argo floats which had been purchased in FY2013 and 2014 respectively. Eighteen of them suffered some hardware troubles, which were possible caused by pump, bulb or bladder system failure, according to the technical messages. The Navis floats with the troubles were drifting at the sea surface or not able to control their drifting or profiling depth. SBE diagnosed the troubles and judged that they were caused by manufacturer error. Following their warranty policy, SBE will deliver 7 Navis floats to JAMSTEC in 2016, and the others are now under monitoring.

1.2.2 Deep Ninja and RINKO sensor on S3A

One of two S3A floats equipped with RINKO sensor has been measuring 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 (Figure 2). We are now analyzing its DO data in detail.

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 205 active floats as of February 12, 2016. 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 been converting the meta-, prof-, tech-, and traj-files of Japanese floats, including APEX, PROVOR, ARVOR, NEMO, NOVA, Navis, NINJA, DeepNINJA and S2A, since the 15th ADMT meeting. JMA and JAMSTEC have converted almost all Japanese meta- and

tech-files from v2 to v3.1 and submitted them to GDAC. JMA has converted the Rprof-files of Japanese ARGOS floats, except floats with NST sampling scheme and Iridium floats equipped with only CTD sensor. JAMSTEC has converted all v2 Dprof-files of Japanese floats to v3.1 and submitted them to GDAC.

JMA is working on coding conversion programs for traj-files. No Japanese v3.1 traj-files were sent to GDAC.

1.4 Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed data of 95,423 profiles to GDACs as of December 2015. JAMSTEC could not submit new delayed-mode QCed profile file of Japanese floats during 2015, because JAMSTEC spent a lot of time converting meta- and Dprof-files from v2 to v3.1.

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 operation but in the scale somewhat lower than ever before (less than 50 floats to be deployed every year with delayed-mode data management) under its new mid-term program FY2014-2018. In FY2015, since their fund for research activity including Argo is cut >20% based on the fund in FY2014, the number of deployment/purchase of Argo floats should decrease. Due to this budgetary situation, the number of technical staff devoting for delayed mode QC and PARC will decrease from 5 to 4 after FY 2015. Additional research fund for enhancement of Argo, including competitive research funding, should be sought. JMA allocates operational budget for 27 floats in FY2016.

3. Summary of deployment plans (level of commitment, areas of float deployment) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

In FY 2016, JAMSTEC will deploy about 23 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. Two to four Deep Argo floats will be deployed as Argo equivalent floats in FY2015 mainly in the Pacific. To investigate response of physical/biogeochemical oceanic processes to explosive cyclones, two Navis floats with CTD sensor (SBE Inc.) will be deployed as Argo equivalent floats along winter-time storm track in the western North Pacific, based on competitive research funding. Since several Japanese scientists are applying for competitive research funding to purchase Argo floats, deep floats and bio Argo floats, the number of floats to be deployed in FY2015 may be increased.

JMA plans to deploy 27 Argo equivalent floats around Japan in FY2016 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://ds.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. Users can select profiles even if they have bad flags of our checks. The dataset is provided not only netCDF but also ascii formats for users who are unfamiliar with netCDF format. 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 23 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 532 CTD casts conducted by JMA in the western North Pacific from November 2014 to July 2015 were uploaded to the CCHDO website.

7. Argo bibliography

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