Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2013)

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 46 Argo and Argo equivalent floats from January to December 2013: 43 ARVOR and 3 NEMO floats. All the floats were deployed with the aid of R/Vs of 10 domestic organizations.

The 3 NEMO floats were deployed near the coast of Philippines in June 2013 in order to investigate oceanic mixed layer structure and tropical air-sea interaction. All the floats profile the depth range from sea surface to 500dbar every day. Two of them are now active, but one of them had already been inactive since July 2013.

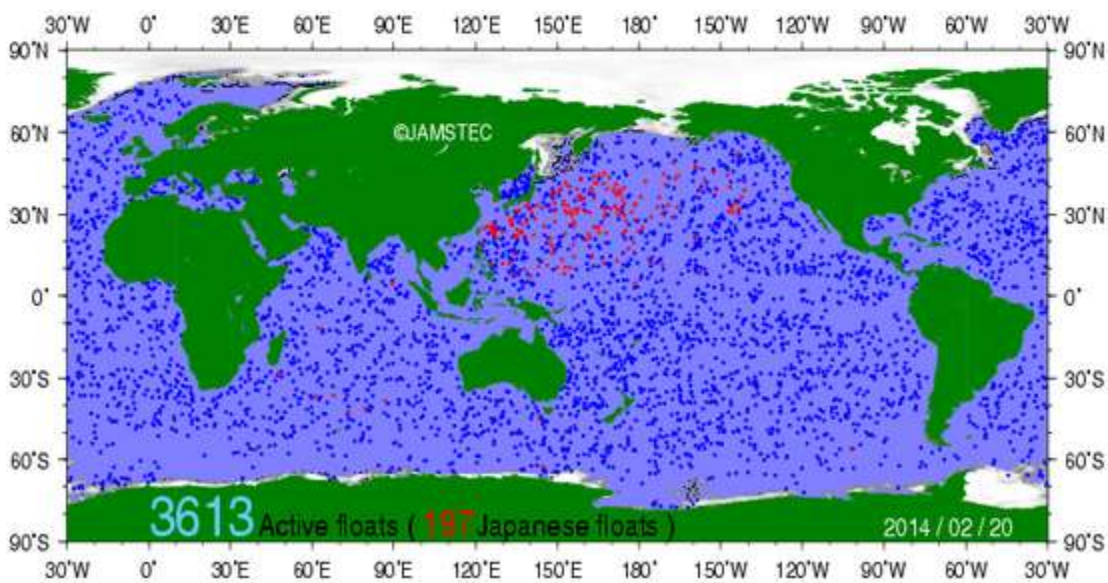

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

Four floats were deployed voluntarily from cargo ships owned by a Japanese merchant ship company (NYK Line) in 2013. This was done 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 2013, JAMSTEC deployed 995(1048) 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: 738 (764) APEX, 141 (143) PROVOR, 81 ARVOR, 14 (39) NEMO, 11 NINJA, 4 Deep NINJA and 6 POPS floats. As of the end of December 2013, 166(189) floats [48 (68) APEXs, 34(36) PROVORs, 78 ARVORs, 2(3) NEMOs, and 4 Deep NINJAs] are in normal operation. The other 828(862) 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 16 floats (10 ARVOR, 5 Deep NINJA, and 1 Navis) in January 2014.

The Japan Meteorological Agency (JMA) deployed 25 Argo equivalent floats (25APEX floats) in the seas around Japan from January to December 2013. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 166 floats (16 PROVORs, 123 APEXs and 27 ARVORs) which JMA has deployed from 2005 to 2013, 40 floats (31 APEXs and 9 ARVORs) are active as of the end of December 2013, while 32 floats (21 APEX and 11 ARVOR floats) terminated the transmission in 2013. JMA deployed 5 APEX floats in January 2014.

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 July 2013, one Deep NINJA float was deployed at a mooring station (S1, 30N, 145E) in the subtropical North Pacific by R/V Mirai. It was set to drift at 4000 dbar depth and measure PTS profiles every 10 days and has been operating well until now. Four Deep NINJA floats deployed in the Southern Ocean in 2012 has been also operating well. One of them deployed south of New Zealand has measured 33 CTD profiles (including 17 deep profiles) until now. The others off the Adelie Coast lost contact in June 2013 probably due to sea ice extension there. One of them resumed data transfer at the end of November, which means that Deep NINJA succeeded to survive Antarctic winter and observe the Antarctic deep layer under sea ice throughout the winter. In January 2014, five Deep NINJA floats were deployed off the Budd Coast by R/V Umitaka-maru and two more will be deployed off the Adelie Coast soon. The data measured by these Deep NINJA floats will be transferred to GDAC by the end of March 2014.

Okinawa Institute of Science and Technology Graduate University (OIST) has deployed 7 NEMO floats near Ishigaki Island as Argo equivalent floats during 2013. Most of those floats measure P, T, and S from 1000 dbar to surface every 6 hours.

1.1.1 Floats deployed as part of INBOX

Besides floats deployed in 2013 as described above, JAMSTEC deployed 4APEX floats equipped with dissolved-oxygen sensors (Aanderaa Optode4330) and 4 EM-APEXs. The floats were launched as part of Western North Pacific **IN**tegrated Physical-**B**iogeochemical Ocean **O**bservation E**x**periment (INBOX); the purpose is to investigate physical-biogeochemical processes associated with meso- and submeso-scale variability by integrating physical and biogeochemical ocean observations in collaboration with ship, satellites and/or mooring observations. The floats measured temperature, salinity and dissolved oxygen from surface to 2000 dbar every 2 days, telecommunicating with iridium transmitter. As reported in the Japan National Report of AST-14, two target areas are set: one is around the biogeochemical observation mooring site S1 (30N, 145E; named S1-INBOX) ; another is within an anti-cyclonic eddy in the Kuroshio-Oyashio mixed water region (42N, 146E; named ACE-INBOX).

JAMSTEC conducted pre-deployment calibration for the Optode4330 sensors in the laboratory, using the calibration formula proposed by Uchida et al. (2008). With the pre-deployment calibration along with the post-deployment adjustment based on the comparison with shipboard CTDO measurement, the accuracy of dissolved oxygen data has been greatly improved. Such quality-controlled data of the S1-INBOX floats launched in 2011-2012 will be added to Argo data by the end of 2014, if the Argo data format accommodates information of pre-deployment calibration and the post-deployment adjustment.

1.2 Technical problems encountered and solved

Fifty five APEX floats equipped with alkaline batteries, purchased by JAMSTEC in 2010 and 2011 (52 APEX floats) and by JMA in 2008 (15 APEX floatss), had terminated their missions before 100 cycles, which were clearly shorter than the specification (150 cycles). The problem was observed as rapidly decreasing battery voltage. The manufacturer, Teledyne Webb research inc., reported that the trouble was probably caused by energy flu because of troubles in some battery cells. While they recommended us to use lithium batteries for future purchasing float to avoid energy flu, JAMSTEC asked further investigation for this problem.

Among the 73 APEX floats with APF9 controllers deployed by Japan before the SBE41 and 41cp recall due to micro-leak problem, 8 floats have the negative surface pressure drift larger than -2.4 dbar. Among these floats, 4 floats have the extreme negative surface pressure drift, exceeding -10 dbar. The floats recalled or those purchased after the problem was fixed have either a Kistler pressure sensor or a Druck pressure sensor. While both pressure sensors show little drift, Kistler pressure sensors have some spikes.

It is worth to report a salinity bias found in Deep NINJA measurements. Comparisons with high-quality CTD data by R/V Mirai show that float salinity is less saline at deeper depth besides having a constant bias, which means the bias possibly depends on pressure. The bias was verified in all of the 5 floats in which the CTD measurements at float deployment are available for the comparison. Some of them showed the bias varying in time. The value set for the parameter to correct pressure effect on conductivity measurements with the SBE41CP model for deep float was the same as that with the standard SBE41CP model. Readjustment of the value possibly reduce the bias.

JAMSTEC routinely conducts CTD sensor calibration of SBE41 and 41cp using almost the same calibration system as that used at SBE inc. Since SBE conducts the CTD sensor calibration as the product check in their factory before shipping, the purpose of our calibration is to find sensor drift caused by any damage or contamination possibly during long-distance transport or any handling processes in float manufacturer/SBE/JAMSTEC. From 2001 to the present, we have checked over 400 CTD sensors, that is about 40% of the total number of the floats we deployed. We had already analyzed the result of calibration in our laboratory for 2001-2006, which was summarized on the technical paper by Yokota et al. (2007). After 2007, 214 of 423 CTD sensors (about 50%) has been calibrated on a random check basis. As a result, about 6% of the calibrated sensors showed conductivity values that did not match that of calibration result by SBE, with excluding a exceptional case that large number of sensors were contaminated for some reason. When we found CTD sensors with serious problem, we sent them back to SBE for re-check, re-calibration or repair, which successfully prevent us from deploying floats with fault CTD sensors. According to our long-term re-calibration experience, we consider that the CTD sensors of SBE 41 and 41cp are fairly reliable. Nevertheless, we think that the calibration of CTD sensors after long-distance/overseas transportation is useful to ensure the quality of CTD for the reliability of Argo float data.

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 197 active floats as of February 20, 2014. 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.

1.4 Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed data of 88,247 profiles to GDACs as of December 2013.

As of December 2013, according to the new definition of APEX Truncated Negative Pressure Drift decided at the 12th Argo Data Management Team Meeting, JAMSTEC is nearing completion to re-create D files for some APEX floats.

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 will continue the operation but in the scale somewhat lower than ever before (about 50 floats to be deployed every year with delayed-mode data management) under its new mid-term program FY2014-2018. JAMSTEC will also seek additional research fund for enhancement of Argo. JMA allocates operational budget for 27 floats every fiscal year.

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 FY2014, it has been proposed that JAMSTEC will deploy about 50 floats in total in the Pacific Ocean for the Argo core mission. One EM-APEX will be deployed near the Kuroshio Extension as part of INBOX. Some Deep Argo float will be deployed in 2014. Two S3A floats, manufactured by MRV Systems inc., equipped with RINKO (ARO-FT) sensor will be deployed in the central North Pacific. The RINKO sensor is an optically-based sensor and measures dissolved oxygen. Its response time is 1 sec. As the first trial experiment of float-based RINKO, JAMSTEC will calibrate the sensor in advance in the lab and monitor drift/error of its DO data after launching, to contribute to develop a QC method. JMA plans to deploy 27 Argo equivalent floats around Japan in FY2014 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 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://goos.kishou.go.jp/) operated by JMA. Monthly diagnosis and outlook of El Nino-Southern Oscillation based on the outputs of the Ocean Data Assimilation System and the El Nino 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/). JMA has introduced the ocean-atmosphere coupled model, which is the same as that for El Nino prediction, into seasonal forecast of climate in Japan since February 2010. 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 has plan to release two new products. One is the ascii files of temperature and salinity profile data of Argo which are converted from the netcdf profile files. The other is Argo temperature and salinity profile data put through more advanced automatic checks than real-time QC.

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.

JCOPE2 (Japan Coastal Ocean Predictability Experiment 2) is the model for prediction of the oceanic variation around Japan which is operated by Research Institute for Global Change of JAMSTEC. JCOPE2 is the second version of JCOPE1, developed with enhanced model and data assimilation schemes. The Argo data is used by way of GTSPP. The reanalysis data 20 years back 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. Since the procedure following IOC Resolution XLI-4 is applied only to the coastal nations whose Argo NFP is registered. Japan Argo has a strong desire for 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.

As mentioned in Section 1.1.1, JAMSTEC is almost ready to release dissolved oxygen data obtained with the Optode4330 sensors after pre-deployment calibration using the calibration formula proposed by Uchida et al. (2008) and post-deployment adjustment. But it is not clear whether the Argo oxygen data format being considered will accommodate data calibrated and adjusted in that way. The pre-deployment calibration and post-deployment adjustment using Uchida's formula or similar ones were recommended by several participants in Argo-oxygen meeting in 2011. While such calibration may not be always available, Argo oxygen data format should be capable of keeping data processed in that way and the information on the calibration/adjustment.

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

Data of 1160 CTD casts conducted by JMA in the western North Pacific from January 2013 to January 2014 were uploaded to the CCHDO website.

7. Argo bibliography

Doi, T., S. K. Behera and T. Yamagata (2013): Predictability of the Ningaloo Nino/Nina, *Scientific Reports*, 3, 10.1038/srep02892.

Ebuchi, N. and H.Abe (2012): Evaluation of sea surface salinity observed by Aquarius, *Proceedings of IGARSS 2012*, pp. 5767-5769, doi:10.1109/IGARSS.2012.6352300.

Horii, T., I.Ueki, K.Ando, and K.Mizuno (2013): Eastern Indian Ocean warming associated with the negative Indian Ocean dipole: A case study of the 2010 event, *Journal of Geophysical Research – Oceans,* 118, doi:10.1002/jgrc.20071.

Kashino, Y. (2013): Observational discovery of an eastward undercurrent below the North Equatorial Current, North Equatorial Undercurrent, OHM, 100 (6), 96. (in Japanese)

Katsura S., E. Oka, B. Qiu, and N. Schneider (2013): Formation and subduction of North Pacific Tropical Water and their interannual variability, *Journal of Physical Oceanography*, 43, 2400-2415, doi:10.1175/JPO-D-13-031.1.

Kobayashi, T. (2013): A realization of a profiling float for deep ocean observation, Engineering Materials, 61(7), 67-70. (in Japanese)

Kobayashi, T.and M. Tachikawa(2013): An introduction of a domestic deep float, Deep NINJA, and its deep/bottom layer observation in the Southern Ocean, JOS News Letter, 3(1), 7-8. (in Japanese)

Kobayashi, T., K.Watanabe, and M.Tachikawa (2013): Deep NINJA collects profiles down to 4000 meters, *Sea Technology*, 54(2), 41-44.

Qui, B., D.L.Rudnick, S.Chen, and Y.Kashino (2013): Quasi-stationary North Quatorial Undercurrent jets across the tropical North Pacific Ocean, *Geophysical Research Letters*, 40, 1-5, doi:10.1002/grl.50394.

Sekiguchi, H. and N.Inoue (2010): Larval recruitment and fisheries of the spiny lobster Panulirus japonicas coupling with the Kuroshio subgyre circulation in the western North Pacific: a review, *Journal of the marine biology association of India*, 52(2), 195-207.

Shiozaki, T. and Y.-l. L. Chen (2013): Different mechanisms controlling interannual phytoplankton variation in the South China Sea and the western North Pacific subtropical gyre: A satellite study, *Advances in Space Research*, 52, 668-676.

Sugimoto, S., N. Takahashi and K. Hanawa (2013): Marked freshening of North Pacific subtropical mode water in 2009 and 2010: Influence of freshwater supply in the 2008 warm season, *Geophysical Research Letters*, 40 (12), 3102-3105.

Ueno, H. (2003): Decadal variation of temperature inversions along Line P, *Journal of Oceanography*, 69, 277-283, doi:10.1007/s10872-013-0172-x.
Watanabe, M. and T. Hibiya (2013): Assessment of mixed layer models embedded in an ocean general circulation model, *Journal of Oceanography*, 69(3), 329-338, 10.1007/s10872-013-0176-6.