WORLD METEOROLOGICAL ORGANIZATION

DATA BUOY COOPERATION PANEL

THIRTY-SECOND SESSION

LA JOLLA, USA
17-21 OCTOBER 2016

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

DBCP-32 / Doc. 6
(15-Oct-16)

ITEM: 6

ENGLISH ONLY

REPORTS BY ACTION GROUPS

(Submitted by Action Groups)

SUMMARY AND PURPOSE OF DOCUMENT

The document includes in its appendices the reports from the DBCP Action Groups on their respective activities during the last intersessional period.

ACTION PROPOSED

The Meeting is invited to note the information contained in this document when discussing how it organises its work and formulates its recommendations.

Appendix:
A. Report by the International South Atlantic Buoy Programme (ISABP)
B. Report by the Network of European Meteorological Services (E-SURFMAR)
C. Report by the International Buoy Programme for the Indian Ocean (IBPIO)
D. Report by the International Tsunameter Partnership (ITP)
E. Report by the DBCP-PICES North Pacific Data Buoy Advisory Panel (NPDBAP)
F. Report by the Tropical Moored Buoy Implementation Panel (TIP)
G. Report by the International Arctic Buoy Programme (IABP)
H. Report by the WCRP-SCAR International Programme for Antarctic Buoys (IPAB)
I. Report by the Global Drifter Programme (GDP)

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DISCUSSION

-A- DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

6.1 Under this agenda item, the Panel was presented with reports by the DBCP Action Groups. Each group maintains an observational buoy program that supplies data for operational and research purposes. The implementation of buoy deployments is also coordinated through global, regional, or specialized Action Groups.

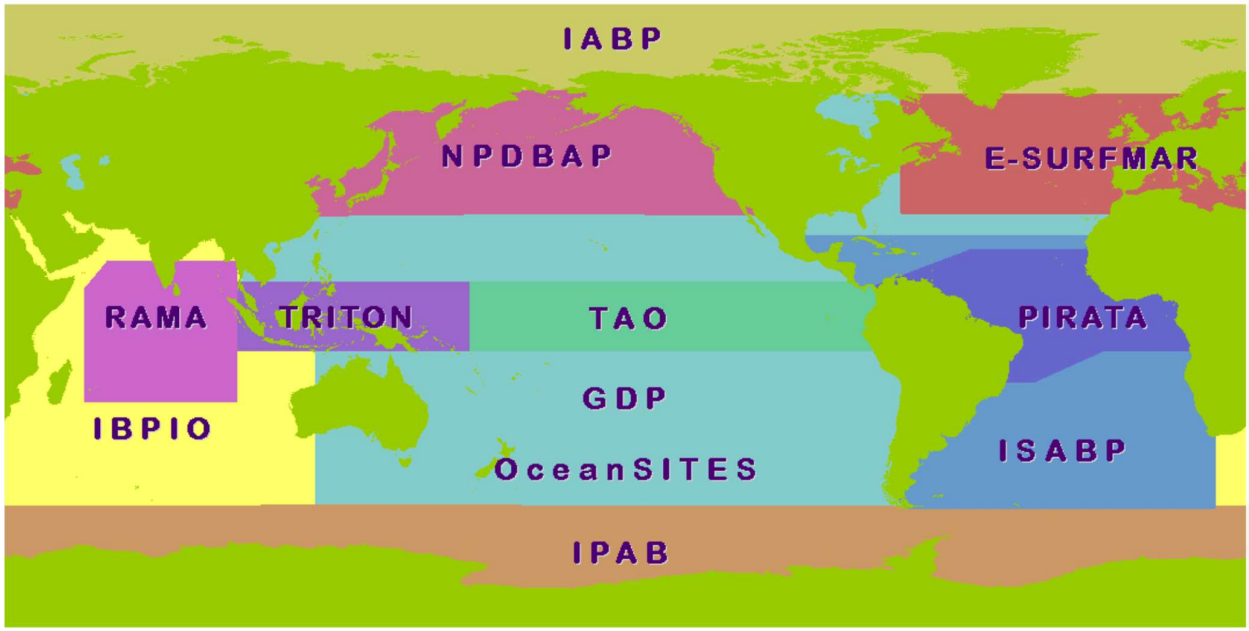

Figure 1: The regional extent of several of the DBCP Action Groups.

6.2 The reports included:

(i.) **GDP**: Global Drifter Programme (verbal presentation by Rick Lumpkin (USA) on behalf of the GDP);
(ii.) **E-SURFMAR**: Surface Marine programme of the Network of European Meteorological Services, EUMETNET (verbal presentation by Paul Poli (France), representing the E-SURFMAR officers);
(iii.) **IABP**: International Arctic Buoy Programme (verbal presentation by Dr. Ignatius Rigor (USA), representing IABP);
(iv.) **IBPIO**: International Buoy Programme for the Indian Ocean (verbal presentation by Ms Mayra (Australia), Chairperson of the IBPIO);
(v.) **IPAB**: WCRP-SCAR International Programme for Antarctic Buoys (verbal presentation by Ignatius Rigor (USA) on behalf of the IPAB);
(vi.) **ISABP**: International South Atlantic Buoy Programme (verbal presentation by Mayra Pazos (USA), representing the ISABP);
(vii.) **NPDBAP**: DBCP-PICES North Pacific Data Buoy Advisory Panel (verbal presentation by Mr Shaun Dolk (USA), technical coordinator of the NPDBAP);
(viii.) **OceanSITES**: OCEAN Sustained Interdisciplinary Timeseries Environment observation System (verbal presentation by the Technical Coordinator, Champika Gallage, representing OceanSITES project office);
(ix.) **TIP**: Tropical Moored Buoys Implementation Panel (verbal presentation by Dr Iwao Ueki (Japan) on behalf of the TIP);
(x.) **ITP**: International Tsunameter Partnership (verbal presentation by Dr Venkatesan (India) on behalf of the ITP).

6.3 The full reports of the action groups are provided in Appendices A to J, and will be reproduced in the Panel's Annual Report.

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Appendices: 10

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6.4 Xxxxx

6.5 Xxxxx

6.6 **The meeting made the following recommendations**:

(i.) Rec1;

(ii.) Rec2;

(iii.) Rec3;

(iv.) Rec4;

(v.) Rec5.

6.7 **The meeting decided on the following action items**:

(i.) Action1 (**action; by; deadline**);

(ii.) Action2 (**action; by; deadline**);

(iii.) Action3 (**action; by; deadline**);

(iv.) Action4 (**action; by; deadline**);

(v.) Action5 (**action; by; deadline**).

-B- BACKGROUND INFORMATION *(if necessary, provide additional material to further explain the information in part A but that will not be included in the report of the meeting)*

APPENDIX A

ISABP
International South Atlantic Buoy Programme

1) Summary

Name of Action Group	ISABP
Date of report	17 August 2016, submitted by Mayra Pazos, NOAA/AOML/GDP
Overview and main requirements addressed	The main objective of ISABP is to establish and maintain a network of platforms in the Tropical and South Atlantic Ocean in order to provide meteorological and oceanographic data for both real-time and research purposes. The task includes support to the World Weather Watch Programme (WWW), the Global Climate Observing System (GCOS), the World Climate Research Programme (WCRP), and the Global Ocean Observing System (GOOS), as well as to the research activities of participating institutions.
Area of interest	South Atlantic Ocean north of 55S plus Tropical Atlantic Ocean up to 20N (90° W to 30° E)
Type of platform and variables measured	Lagrangian drifters with Argos and Iridium transmitters, measuring sea level pressure, SST, salinity and sea-surface velocity
Targeted horizontal resolution	5 degrees x 5 degrees
Chairperson/Managers	Felipe Santos, DHN, Brazil
Coordinator	Mayra Pazos, NOAA/AOML, USA
Participants	Countries interested in the region (Brazil, US, Argentina, South Africa, Tristan Is.)
Data centre(s)	Historical drifter data are assembled, quality controlled at AOML, Miami, USA then sent to MEDS (Canada, GDAC for drifters) for archival and further distribution. Real time data is also archived at MEDS. GTS quality control is handled by AOML GDP for both Argos and Iridium and disseminated to the GTS by SIO GDP for Iridium drifters and by CLS-America for Argos drifters
Website	http://www.jcommops.org/dbcp/isabp/index.html http://www.oceatlan.org/isabp/en/
Meetings *(meetings held in 2015/2016; and planned in 2016/2017)*	Starting in 2014, ISABP meetings are held during DBCP. Last Meeting took place on October 20, 2015 during DBCP-31 in Geneva, Switzerland. A similar meeting is planned this year during DBCP-32 in San Diego, Ca., USA
Current status summary *(mid-2016)*	As of August 8, 2016, there were a total of 222 drifters in the S.A. Region, 32 more than last year at this same time, (64 SVP of which 4 are Iridium, 156 SVPB of which 45 are Iridium, and 2 salinity. Of the total, 22% are Iridium, compared to 12% iridium last year. (Figure 1)
Summary of plans for 2017	Continue to address observational gap areas, increase the number of SVPB drifters in the region and transition from all Argos to Iridium drifters.

2 Deployment plans for 2016

Details on deployment plans, and opportunities for next year.

Deployments during the last year (July 2015 through June 2016) are shown in Figure 1.
There were a total of 105 drifters deployed in the region, 19 less than last year, 45% are iridium, compared to15% that were Iridium last year. The breakdown is as follows:
24 SVP (0 Iridium), 81 SVPB (47 are Iridium), four failed on deployment.

Efforts to populate hard to reach areas (i.e. Gulf of Guinea and Angola Basin) continued during the intersessional period. Deployments were carried out by US vessels, the Brazilian Navy, South Africa Weather Service (SAWS), the Falkland Islands Fisheries Department, Tristan da Cunha fishermen, South Thule fishing vessels and several others. SAWS will deploy again about 25 drifters during the SANAP cruise annual voyage to Gough Island, potential scientific cruises planned for late 2016 as well as other cruises in the South Atlantic area. All drifters were donated by NOAA and the custom duties were paid by South African government. One stationary weather buoy will be kept in Tristan da Cunha Island for consistent pressure data.

There were 81 drifters deployed in the region between 55° S and 65° S region. Many of these deployments are funded by special projects in this area, and are likely to continue in the next year. Most of these drifters made it to the ISABP region soon after deployment. Figure 2 shows these deployments.

The GDP plans to deploy in 2016-2017 the same number of drifters that were deployed during 2015-2016 period in the region.

The GDP deployment plan from July 1, 2016 – June 30, 2017 is as follows:

Tropical Atlantic (20S – 30N):	SVP=170	SVPB=80
Extra Tropical Atlantic (400S – 200S):	SVP=25	SVPB=25
Southern Atlantic (600S – 400S):	SVP=0	SVPB=100

3 Data management

3.1 Distribution of the data

Data are assembled and quality controlled at the AOML GDP Drifter Data Assembly Centre, (DAC). The historical data are available through the DAC web page http://www.aoml.noaa.gov/phod/dac/dacdata.php), and from the MEDS web page http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/drib-bder/index-eng.htm.
Brazilian Buoy Program has its data available at http://www.goosbrasil.org/produtos/pnboia.php, for moored and drifting buoys.

3.1.1 Data policy

Details on data exchange policy.

Following current standards, ISABP promotes timely, free and open data exchange

3.1.2 Real-time data exchange

All data from drifters are disseminated via GTS as soon as drifters are deployed. These data are monitored and taken off GTS when sensors stop giving good quality data. As of August 8, 2016,

there were a total of 222 surface drifters in the South Atlantic region, 32 more than this time last year, all transmitting good quality data on the GTS, 22% are Iridium.

3.1.3 Delayed mode data exchange

Updates of the raw, quality controlled and interpolated data sets are sent to MEDS, the RNODC for drifter data, once a year, for further archival and distribution.

Metadata from GDP drifters are collected at the DAC directly from the manufacturers, archived and made available at the DAC web page www.aoml.noaa.gov/phod/dac/deployed.html and also www.aoml.noaa.gov/phod/dac/dirall.html, Metadata for drifter specifications, drogue specifications, and barometer metadata can be downloaded from this link: http://www.aoml.noaa.gov/phod/dac/gdp_doc.php

3.2 Data quality

All data are quality controlled by removing bad locations from the raw data, based on speeds between consecutive locations. Deviant SST values are removed by applying a temperature change criterion relative to the recent temperature measured by the instrument. Then data values are interpolated in space and time to 6 hour intervals, using an optimal interpolation method called Kriging. (Quality Control and Interpolations of WOCE-TOGA Drifter Data, peer reviewed open literature by Hansen, D. V and P.-Marie Poulain, 1996.)

4) Instrument practices

5) Other issues as needed

Figure 3 shows the status of the drifter array in the region. As of August 8, 2016 there were a total of 222 drifters actively reporting, 64 SVP (Iridium:4), 156 SVPBs (Iridium:45) and 2 salinity.

Annex (optional)

Status maps and graphics

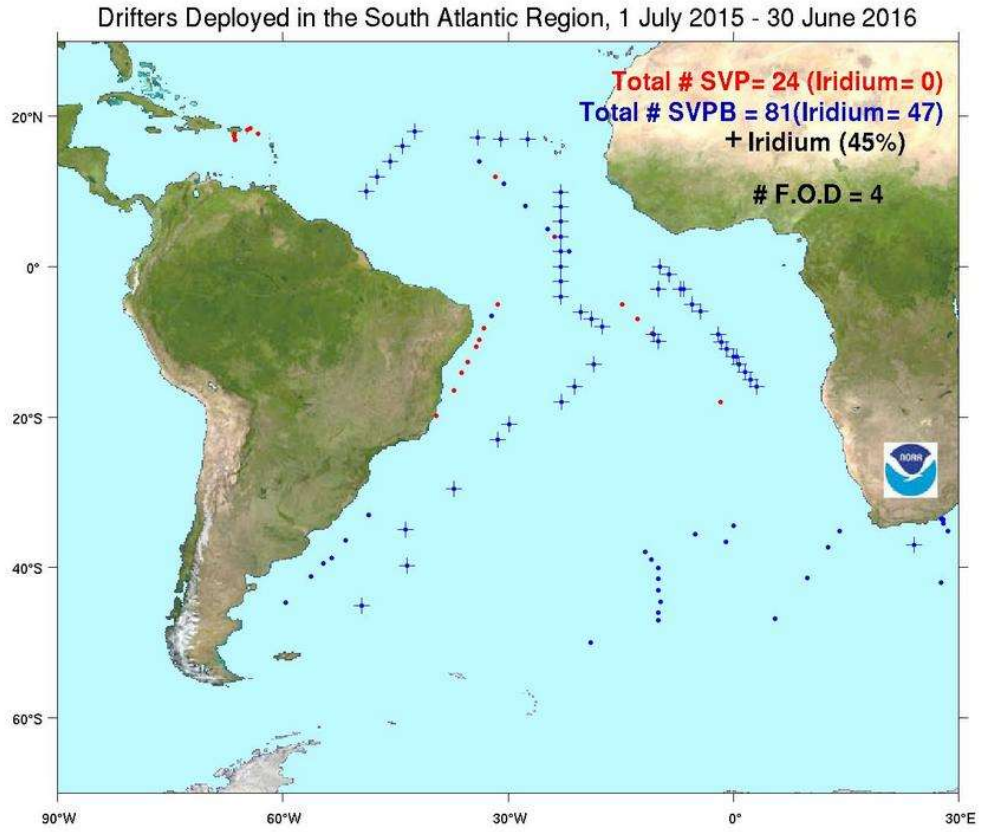

Figure 1. Deployment locations. A total of 105 drifters were deployed in the area. 45% of the deployed drifters are iridium. One fixed weather buoy was deployed on the Tristan da Cunha Island for consistent pressure data.

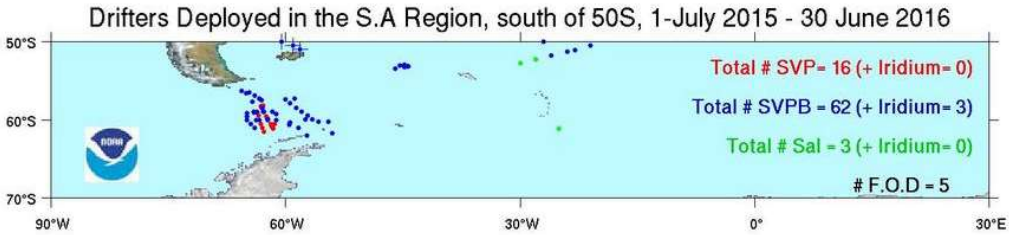

Figure 2. Deployment locations between 55S and 65S. A total of 81 drifters were deployed, 3 were Iridium. All SVPBs

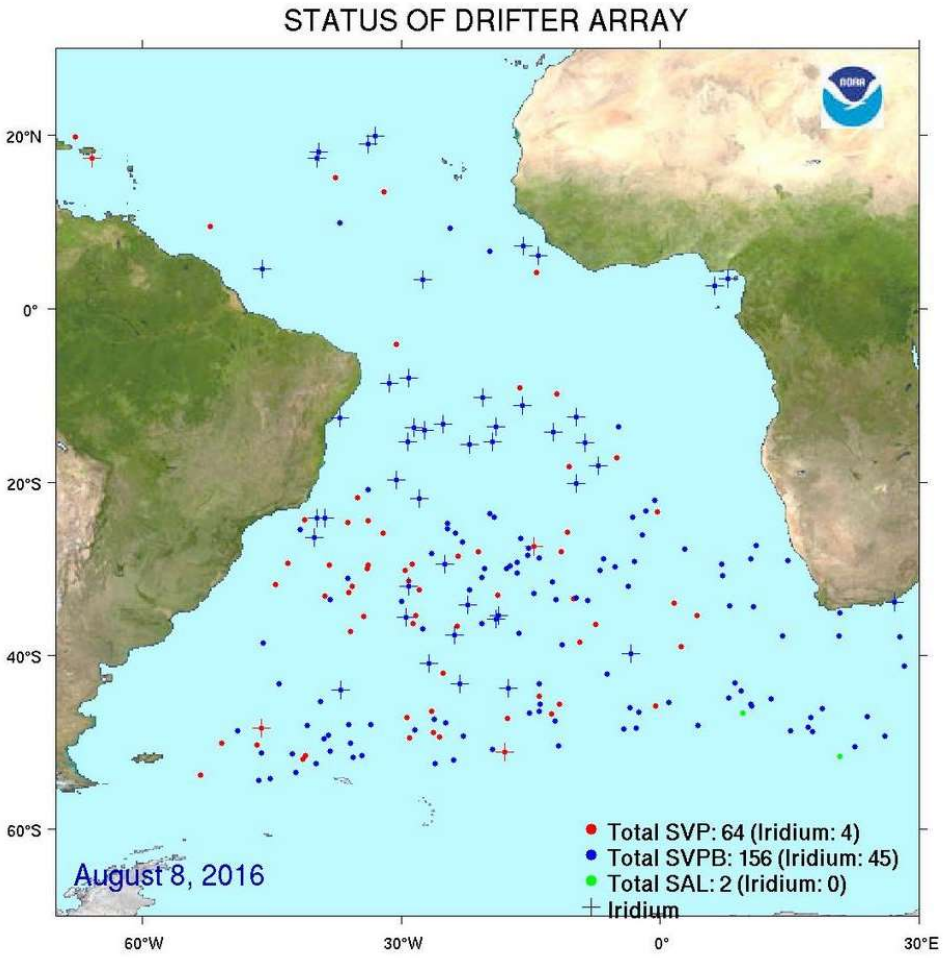

Figure 3. Status of the South Atlantic Array as of August 8, 2016.
A total of 222 drifters were present in the region, of which 22 % are Iridium, compared to188 (12% only were iridium) at the same time last year.

APPENDIX B

E-SURFMAR
Operational Service of the Network of European Meteorological Services, EUMETNET

1) Summary

Name of Action Group	Operational Service of the Network of European Meteorological Services, EUMETNET (E-SURFMAR)
Date of report	31 August 2016
Overview and main requirements addressed	The EUMETNET operational service E-SURFMAR is an optional programme involving 19 out of the 31 EUMETNET members, who fund the activity on a GNI basis. Its main objectives are to coordinate, optimise and progressively integrate the European meteorological services activities for surface observations over the sea – including drifting and moored buoys, and voluntary observing ships. E-SURFMAR is responsible for coordination of buoy activities carried out by the European meteorological services, and the programme supports a Data Buoy Manager (DBM) to manage these activities. The DBM is supported and advised by the E-SURFMAR Expert Team-Data Buoy (ET-DB). E-SURFMAR ET-DB is an action group of the DBCP.
Area of interest	Ocean areas potentially affecting NWP over European countries. This covers the North Atlantic Ocean (north of 10°N), the Mediterranean Sea and a part of the Arctic. In 2015, E-SURFMAR started to extend its activities in the North of the South Atlantic (from 20S to 10N) in the frame of AtlantOS project (April 2015- March 2019).
Type of platform and variables measured	Drifting buoys: air pressure, SST Moored buoys: air pressure, wind, air temperature, SST, waves (directional spectra), relative humidity.
Targeted horizontal resolution	E-SURFMAR: 250 km x 250 km, >100 drifting buoys, 4 moored buoys for satellite calibration/validation. AtlantOS: a network of 13 drifting buoys.
Chairperson/Managers	E-SURFMAR Operational Service Manager: Mr Pierre Blouch, Météo-France Expert Team-Data Buoy (ET-DB), Outgoing Chairperson: Mr Jon Turton, UK Met Office
Coordinator	E-SURFMAR Data buoy Manager: Mr Gilbert Emzivat, Météo-France
Participants	Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, The Netherlands, Norway, Portugal, Serbia, Spain, Sweden, Switzerland, and the United Kingdom.
Data centre(s)	CORIOLIS as French trial GDAC for drifting buoys DFO/OS as Canadian trial GDAC for drifting buoys NOAA/AOML for DBCP/GDP
Website	http://www.eumetnet.eu/, http://esurfmar.meteo.fr (restricted working area web site for E-SURFMAR participants)
Meetings	ET-DB meets once a year. ET-DB13 in Hambourg, 12-15 April 2016

Current status (mid-2016)	148 E-SURFMAR drifting buoys in operation (all Iridium including 14 AtlantOS, 17 MF and 51 SVP-B upgrades) + 23 others reporting AP. 4 E-SURFMAR supported moored buoys in operation, plus a further 30 others operated by members.
Summary of plans for 2017	Maintain : - a network of 100 drifting buoys in North Atlantic, - a network of 13 drifting buoys in South Atlantic, - and the 4 reference moored buoys in operation.

2 Deployment plans for 2017

The drifting buoys will be deployed from various locations (Canada, Iceland, France, Norway, UK, USA...) in the Atlantic Ocean. Drifters from GDP are regularly upgraded with barometers and deployed in the North Atlantic Ocean by vessels plying from North America to Iceland, from North America to Europe and from Europe to North America. Within the allocated budget, more than 100 buoys (including 30 upgrades) will be deployed in the E-SURFMAR area of interest in the coming twelve months.
E-SURFMAR will maintain a permanent network of 13 SVP-B in the Tropical South Atlantic in the framework of the AtlantOS project. Drifters are deployed in the South Atlantic by vessels plying from France to South Africa and research campaigns.

E-SURFMAR will continue to deploy buoys in the Arctic Ocean in collaboration with IABP.

The 4 E-SURFMAR moored buoys K5 (6400045)(59.1N – 11.5 W), M6 (6200095)(53.1N – 15.9W), Cabo Silleiro (6200084)(42.1N – 9.4W) and Lion (6100002)(42.1N – 4.7E) are operated by United Kingdom, Ireland, Spain and France, respectively. At present, Cabo Silleiro and K5 are equipped to report directional wave spectra. Spectra data from K5 are disseminated on GTS by the Met Office

3 Data management

3.1 Distribution of the data

3.1.1 Data policy

ESURFMAR encourages free and open access to data, in the spirit of WMO data exchange policy defined in WMO Congress Resolution 40 (Cg-XII). All basic meteorological and oceanographic data are coded in the appropriate WMO code forms and disseminated on the WMO Global Telecommunication System (GTS)

3.1.2 Real-time data exchange

All the data are put on the GTS as quickly as possible.

The processing chain at Météo-France producing GTS reports from Iridium SBD data was consolidated. This chain is able to produce FM13-SHIP, FM18-BUOY or FM94-BUFR messages. The distribution of BUFR messages allows to transmit the data of the drifters having a resolution of 0.01K for SST. New OMM template for drifting buoys (TM315009) is used by “Centre de Meteorologie Marine” (CMM) at Meteo-France since th 1st of June 2015.

Since March 2016 CMM is using non-convertible 7 digit WMOId.

CMM is processing about 750 BUFR messages per day, that is to say about 6600 observations reports per day.

All the operating drifters are now using Iridium. This improves the data timeliness (see Annex). In June 2016, the number of daily observations transmitted onto the GTS was more than 3,000. The target (90%) for the percentage of data received within 50 minutes continue to be met. This results from efforts made during recent years to have all buoys reporting through Iridium.

The mean lifetime (for Air Pressure) of the SVP-B drifters increased to 408 days (368 days last year). 122 buoys failed to report air pressure measurements (73 last year), including 12 buoys failed at deployment.

The availability of moored buoy data depends on the number of buoys operating. More than 80 hourly observations for all the intersessional period except in March 2016 due to Cabo Silleiro (February and March) and M6 (February to May) failure.

3.1.3 Delayed mode data exchange

The raw data from drifters are archived at CMM. CMM processing about 750 BUFR messages per day, that is to say about 6600 observations reports per day.

Data inserted onto the GTS are routinely archived by various centres (for drifting buoys DFO/OS, AOML/GDP, Coriolis, Meteorological Services for drifting and moored buoys).
Archived data from drifters are also used to produce surface currents deduced from the buoys movement on a weekly basis
The metadata collection system at JCOMMOPS is used for drifting buoys.
E-SURFMAR members are invited to compile Moored Buoy Metadata in line with the metadata variables defined on the DBCP website (http://www.jcommops.org/dbcp/data/metadata.html).

3.2 Data quality

The web page giving access to the Quality Control (QC) tools was maintained. The transmission delays onto the GTS are monitored (see http://www.meteo.shom.fr/qctools). Monthly statistics and 16-day graphs are available for all surface marine observations through the same interface. Buoys reporting in BUFR are monitored as those reporting through BUOY or SHIP alphanumeric messages. The blacklists, automatically issued for air pressure every day, are used to identify and correct potential problems.

For drifters the Air Pressure (AP) differences from the French model outputs, the target of 1% of Gross Errors was achieved. The RMS of AP differences (about 0.5 hPa) still has a seasonal variation, being higher in winter than in summer.

For moored buoys the Air Pressure (AP) differences with the French the target of 0.5% of Gross Errors was achieved, except in February. The RMS of AP differences was lower than 0.6 hPa, except from October to February where the RMSAP reached 1.6 hPa, due to possible seasonal variations.

4) Instrument practices

ESURFMAR drifting buoys use recommended DBCP formats.

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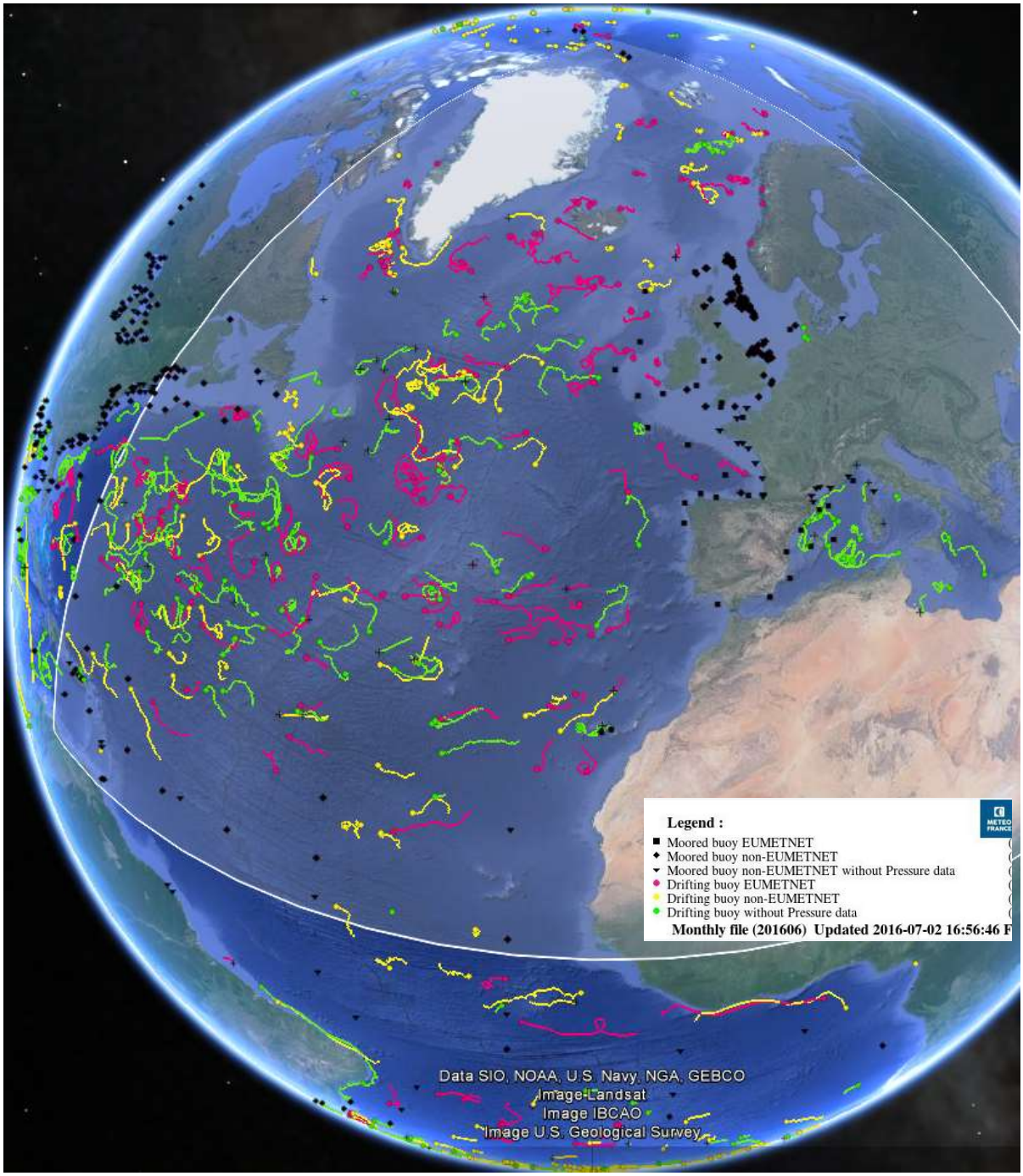
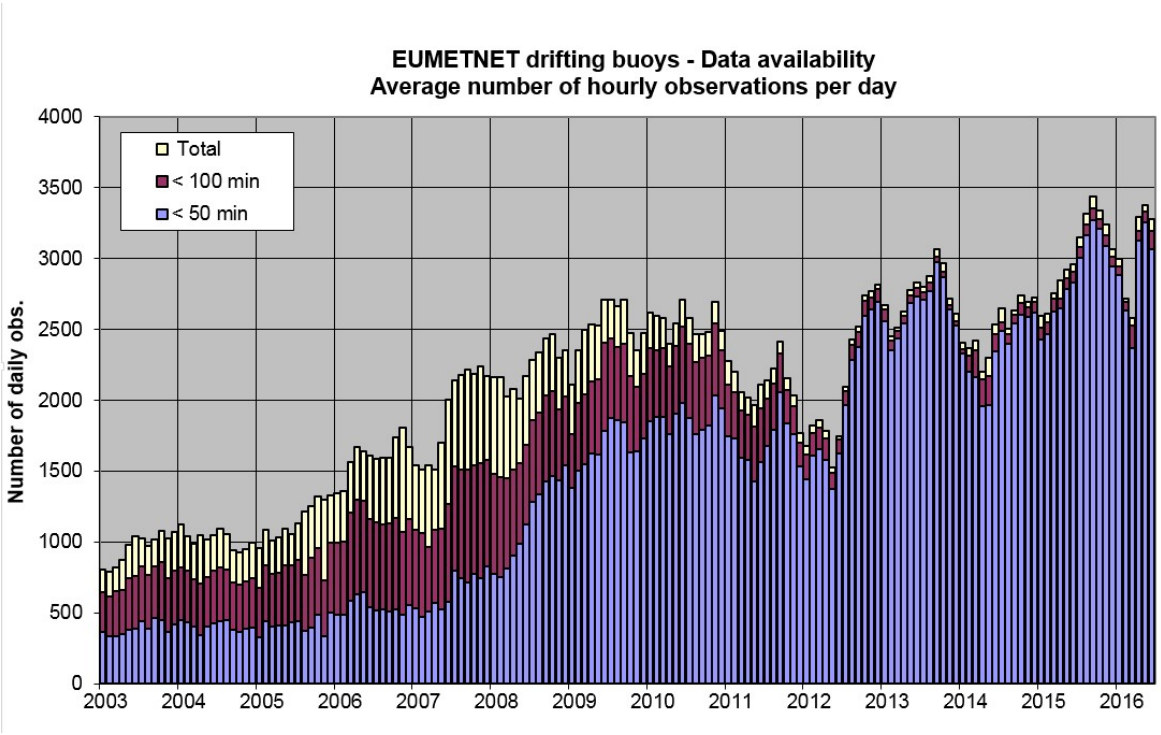
Annex



Drifting buoy trajectories and moored buoy positions
(June 2016)



Drifting buoys data availabilty

APPENDIX C

IBPIO
International Buoy Programme for the Indian Ocean

1) Summary

Name of Action Group	International Buoy Programme for the Indian Ocean (IBPIO)
Date of report	31 August 2016
Overview and main requirements addressed	The International Buoy Programme for the Indian Ocean (IBPIO) was formally established at a meeting in La Reunion in 1996. The primary objective of the IBPIO is to establish and maintain a network of platforms in the Indian Ocean to provide meteorological and oceanographic data for both real time and research purposes. More specifically, the IBPIO supports the World Weather Watch Programme (WWW); the Global Climate Observing System (GCOS); the World Climate Research Programme (WCRP); the Global Ocean Observing System (GOOS); tropical cyclone forecast and monitoring; as well as the research activities of the participating institutions. The programme is self-sustaining, supported by voluntary contributions from the participants in the form of equipment and services (such as communications, deployment, storage, archiving, co-ordination...).
Area of interest	Indian Ocean North of 55°S and between 25°E and 120°E (130°E in the North of Australia)
Type of platform and variables measured	Drifting buoys: Air pressure, SST, (wind) Moorings: air pressure, wind, air temperature, SST, waves, relative humidity, radiation, rainfall, SSS, subsurface temperature and salinity, current…
Targeted horizontal resolution	500 km x 500 km
Chairperson/Managers	Mr Shaun Dolk, NOAA/AOML, USA – Chair Mr Johan Stander, SAWS, South Africa – Vice Chair
Coordinator	Mr Gilbert Emzivat, Météo-France
Participants	Australia (ABOM), France (Météo-France), India (NIO, NIOT, INCOIS), Kenya (KMD), Mozambique (EMU), South Africa (SAWS), TIP (Tropical Moored Buoy Implementation Panel), USA (GDP, Navoceano).
Data centre(s)	CORIOLIS as French trial GDAC for drifting buoys DFO/OS as Canadian trial GDAC for drifting buoys NOAA/AOML for DBCP/GDP
Website	http://www.shom.fr/meteo/ibpio
Meetings	Annual meetings in conjunction with DBCP meetings. IBPIO 19 in La Jolla (USA) in October 2016
Current status (mid-2016)	212 drifters (120 with Air Pressure)

	53 moored buoys (35 for RAMA, 76% of the planned 46 site array)
Summary of plans for 2017	Maintain a network of 150 drifters at least. Maintain or expand the moored buoy arrays.

2 Deployment plans for 2016-2017

IBPIO participants are regularly encouraged to maintain their contributions of buoys, or to fund barometers to equip SVP drifters provided by GDP. Météo-France, ABOM and SAWS, regularly, fund barometer upgrades in the Indian Ocean. About 205 drifters are planned to be deployed during the next intersessional period, of which 1/3 at least will be equipped to transmit through Iridium (Action by ABOM, GDP, Météo-France).

Efforts are aimed at filling data gaps in the tropical regions, primarily during the Tropical Cyclone season. In the southern tropical area the buoys are provided by NOAA/GDP and will include about 10 Iridium barometer upgrades funded by Météo-France. Météo-France will also deploy about 10 Iridium SVP-B drifters (self funded, for scientific purposes, before the winter monsoon period) in the Arabian Sea where piracy is conducting to a large data gap. The ABOM is likely to deploy 20 drifting buoys between the central Indian Ocean and the Australian coast. NIO plans to continue to provide and deploy drifters in the Arabian Sea and in the Bay of Bengal (about 10 in 2016-2017).

Support for the basin-scale moored buoy array referred to as the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) will continue to provide important Indian Ocean observations leading to improved understanding and prediction of monsoons, the Indian Ocean Dipole, and long-term climate variability. RAMA maintenance will continue in the coming year with a potential for participation by up to 6 countries in support of up to 32 moorings. A limited number of research vessels in the Indian Ocean are capable of RAMA mooring maintenance. The number of moorings actually serviced will be dependent on the availability of ship time. RAMA cruises will continue to provide deployment opportunities for surface drifters and Argo floats.

NIOT is maintaining a network of 12 deep sea buoys with subsurface measurements radiation and precipitation sensors (Ocean Observation Systems, OOS): there are 7 sites in the Bay of Bengal, 5 in Arabian Sea. These OMNI buoys are similar to RAMA moorings but also include current measurements. Another Indian made OMNI buoy, designed to collect and transmit 104 parameters, is installed and working in Arabian Sea. These OMNI buoys systems have given new scientific in-sight into oceanic processes during cyclones in the Bay of Bengal. NIOT also operates 5 tsunami buoys and has installed 4 coastal buoys. A newly designed buoy with video cameras off Goa, on the west coast of India, provides live video streaming through 3G telemetry.

In the southern part of the Indian Ocean (South of 40S), the deployment of SVP-B drifters provided by GDC and upgraded by Météo-France (about 9 Iridium units) should continue. The ABOM expects to deploy 10 SVP-B drifters in this area over the next 12 months including 8 upgrades. These deployments will be supported by opportunity ships leaving La Réunion during their rotations between La Reunion, Crozet, Kerguelen and Amsterdam Islands.

In addition to the drifters upgraded by Météo-France and ABOM, GDC plans to provide SVP-B drifters for deployment in the Southern Indian Ocean.

In the sub-tropics (between the Tropic of Capricorn and 35 S) the ABOM will most likely deploy about 10 SVP-B.

The SAWS plans to obtain buoys on behalf of South Africa. 5 drifters to be kept for scientific cruises as part of the IIOE-II. The deployment of these will be conducted in consultation with DEA: OC. 5 drifters to be used for deployment on the SAMBA line during Marion Island logistical cruise in April/May 2017 and or any other SAMBA line voyage.

As in previous years, the GDP remains the biggest contributor to the IBPIO, with about 120 planned drifters deployments (upgrades included).

3 Data management

3.1 Distribution of the data

3.1.1 Data policy

IBPIO encourages free and open access to data, in the spirit of WMO data exchange policy defined in WMO Congress Resolution (Cg-XII). All basic meteorological and oceanographic data are coded in the appropriate WMO code form and inserted to the Global Telecommunication System (GTS)

3.1.2 Real-time data exchange

All the data are placed on the GTS as quickly as possible.

The processing chain at Météo-France producing GTS reports from Iridium SBD data is maintained. The chain is able to produce FM13-SHIP, FM18-BUOY or FM94-BUFR messages.

The use of the Iridium communication system continued. Ninety seven drifters using Iridium were deployed (39 last year). This improves the data timeliness. Two hundred and twelve drifting buoys (134 last year) were deployed of which about 46% measured air pressure (SVP-B). The number of daily observations on the GTS decreased to 2900 by June 2015 (see Annex) due to the decline in number of operating drifters. It's nowadays more than 4100. At the end of June 2016, the percentage of data received within 50 minutes is about 52%. This may be attributed to a higher number of Argos drifters deployed this year, despite the increased use of Iridium.

In July 2016, 18 of 28 RAMA surface moorings were reporting on the GTS (WMO ID's 1400040, 1400041, 1400043, 1400047, 2300003, 2300006, 2300007, 2300008, 2300009. 2300010, 2300015, 2300016, 2300017, 5300005, 5300006, 5300009, 5300040, 5600053). Replacement of older ATLAS mooring systems with newer T-Flex mooring systems begun in August 2015 will continue in the coming year. T-Flex data use Bulletin Header IOBX08 KPML.

In June 2016, 18 deep sea NIOT moored buoys (9 in Bay of Bengal and 9 in Arabian Sea) were reporting.

3.1.3 Delayed mode data exchange

Data are routinely archived by various centres (for drifting buoys ISDM, GDP, Coriolis,…, Meteorological Services for drifting and moored buoys).

Archived data from drifters are also used to produce surface currents deduced from the buoys movement on a weekly basis

The metadata collection system at JCOMMOPS is used for drifting buoys.

PMEL's Tropical Moored Buoy website displays and distributes the RAMA data (http://www.pmel.noaa.gov/tao/rama/).
INCOIS's website displays Indian moored buoys availability and data (http://www.incois.gov.in/portal/datainfo/mb.jsp).

3.2 Data quality

The transmission delays onto the GTS are monitored through the Météo-France QC tools webpage: http://www.meteo.shom.fr/qctools. Monthly statistics and 14-day graphs are available for all surface marine observations through the same interface. Buoys reporting in BUFR are monitored in the same manner as those reporting through the BUOY or SHIP character-based codes. The blacklists, automatically issued for air pressure every day, are used to identify and correct potential problems.

The number of daily messages sent onto the GTS increased from 3000 to more than 4000 during the intersessional period. More than 50% of the drifting buoys data arrived on the GTS within 50 minutes.

For drifters the Air Pressure (AP) differences from the French model outputs were lower than 0.5% of Gross Errors (except during october). The RMS of AP stand about 0.6 hPa.

4) Instrument practices

IBPIO drifting buoys use recommended DBCP formats (DBCP-M2 for Argos, formats published on Iridium PP website for Iridium).

NIOT is following best of practise method vetted by NOAA MPEL and NDBC.

Results of a land-based comparison of ATLAS, T-Flex and China's BaiLong meteorological data have been published :

Freitag, H.P., C. Ning, P. Berk, D. Dougherty, R. Marshall, J.M. Strick, and D. Zimmerman (2016): ATLAS, T-Flex, BaiLong meteorological sensor comparison test report. NOAA Tech. Memo. OAR PMEL-148, NOAA/Pacific Marine Environmental Laboratory, Seattle WA, 40 pp, doi: 10.7289/V57942PP, Published online.

A NOAA Technical Memorandum comparing ocean deployed, side-by-side ATLAS and T-Flex mooring deployments in RAMA and PIRATA is in preparation.

5) Issues: maintenance of moored buoys

Between July 2015 and June 2016 22 RAMA surface moorings and 5 ADCP moorings were serviced. During this time 126 sea days were provided in support of these RAMA sites. Sea days were provided by India, Indonesia and the US. One new RAMA mooring site was implemented near 4°S, 57°E. Twenty (20) surface drifters (provided by the Global Drifter Program) and 2 Argo floats (provided by PMEL's Argo project) were deployed on RAMA cruises in the past year.

A PMEL ATLAS mooring in the Bay of Bengal was enhanced to include CO_2 measurements for the third year in a row. This effort was a collaborative effort of PMEL, BOBLME and NIOT. In support of the Ocean Tracking Network 12 RAMA moorings were instrumented with acoustic recorders provided by Dalhousie University.

Damage to buoys and theft of instrumentation continues to be a problem, especially at sites near areas of intense fishing activity. In addition to vandalism, well-publicized piracy events have resulted in the suspension of RAMA implementation off Africa and in the Arabian Sea. The occurrence of piracy has decreased in recent years and events have largely been limited to areas near the Somalia coast and the Gulf of Aden. Despite the decline, Lloyds of London has not reduced the size of their Exclusion Zone. Based on the reduction in risk, RAMA cruises aboard Indian research vessels in the central equatorial Indian Ocean since 2014 have been conducted without embarking sea marshals for security and will continue so as long as threat levels remain low.

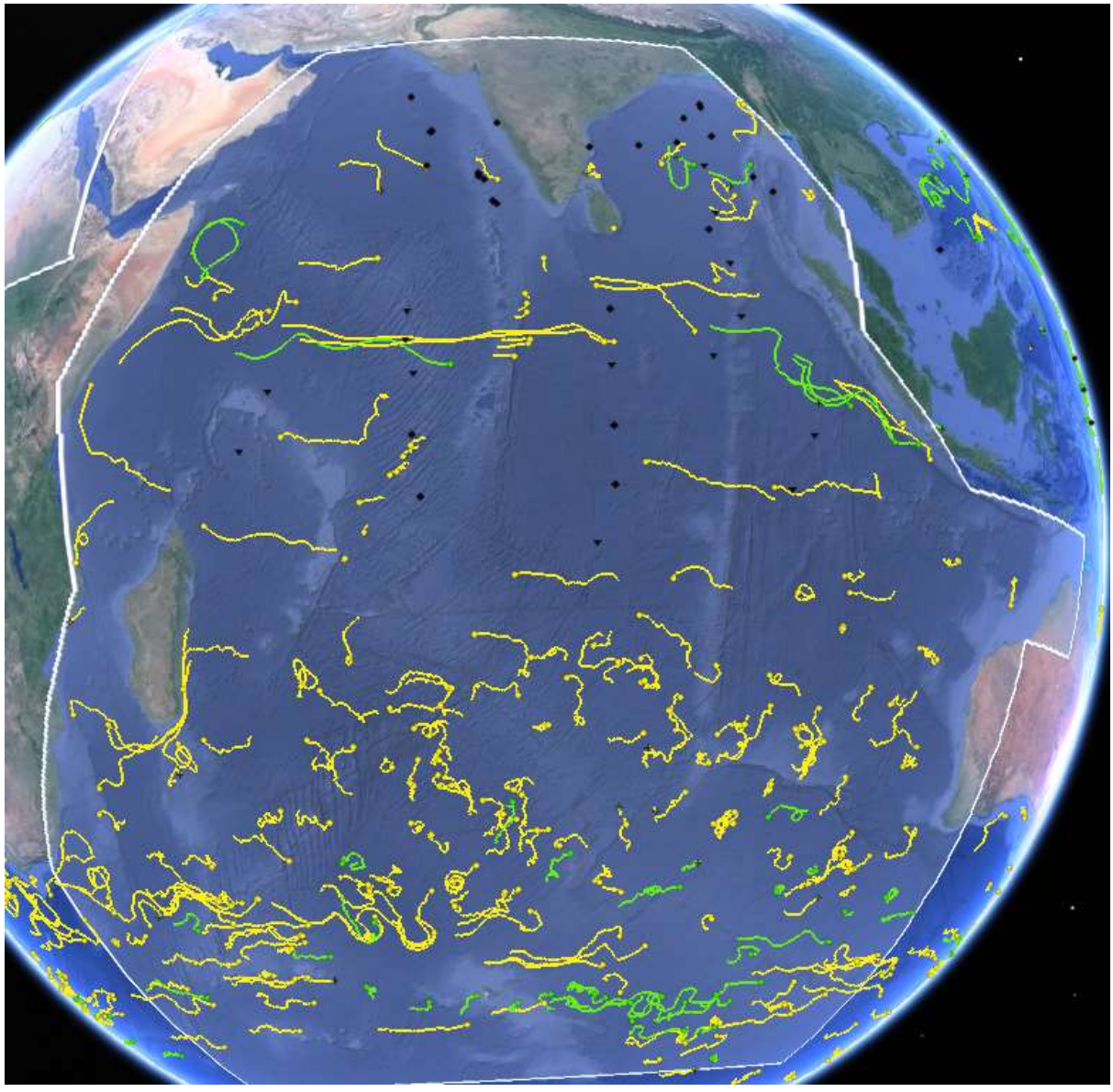
_____

ANNEX

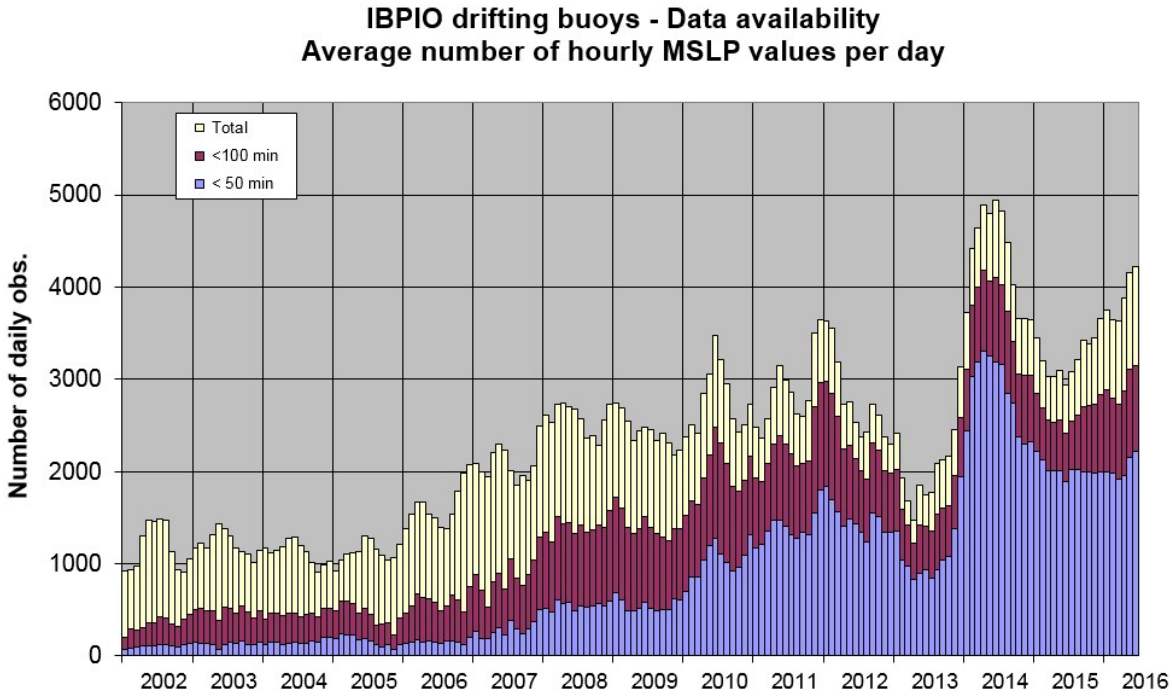
IBPIO Recommendation to the DBCP

……

Drifting Buoy Trajectories and Moored Buoys position (June 2016)



Drifting Buoy Data Availability


IBPIO drifting buoys - Data availability
Average number of hourly MSLP values per day
Number of daily obs.
Total
<100 min
< 50 min
6000
5000
4000
3000
2000
1000
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

APPENDIX D

ITP
International Tsunami Partnership

1) Summary

Name of Action Group	International Tsunami Partnership (ITP)
Date of report	3 September 2016
Overview and main requirements addressed	Activity since last report (DBCP-31): status of Tsunameters; (appendix A); issues/enhancements to data sharing, technological developments, challenges, other
Area of interest	Discussion Topic 1: Develop a forum for a coordinated dialogue between IOC TOWS and JCOMM DBCP to promote a global sensing strategy for tsunamis, which identifies gaps and promotes collaboration to meet these gaps. DBCP ITP can serve as a technical collaborator in the dialog and provide a link between TOWs and DBCP Discussion Topic 2: the year's progress in partnerships -- e.g. US/Chilean discussions to enhance sensing in the Southern Chilean Trench.
Type of platform and variables measured	Surface expressions (buoys and autonomous vehicles) and deep ocean water level recording devices
Targeted horizontal resolution	IOC Tsunami Programme: http://www.ioc-tsunami.org/index.php?option=com_content&view=featured&Itemid=93&lang=en Promotes a coordinated but regionalized approach to awareness, risk assessment, observation networks and early warning systems
Chairperson / Managers	Venkatesan; Stephen G. Cucullu
Coordinator	Champika Gallage
Participants	DBCP Representatives
Data centre(s)	Various
Website	http://www.jcomm.info/index.php?option=com_oe&task=viewEventRecord&eventID=1792
Meetings (meetings held in 2015/2016; and planned in 2016/2017)	31st session of the DBCP, Geneva 2015 25 - 26 Feb 16, 9th session of Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Paris cedex 07, France. **Annexure – 3** http://www.ioc-unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=17045 Regional Marine Instrumentation Center; Region IV Meeting; March 3, 2016 Bay St. Louis Mississippi. US National Tsunami Hazard Mitigation Program (NTHMP) Annual Meeting February 1 – 5, 2016. US NTHMP Annual Meeting; Portland Oregon; January 30 – February 3, 2017
Current status	Refer to section 2.1.
Summary of plans for 2017	Refer to Section 2.2.

2. Deployments Accomplished 2015 / 2016 & plans for 2016

2.1. Accomplished 2015 / 2016

2.1.1. *BOM – Australia*:

Three service voyages were conducted in the last 12 months.

Indian Ocean
This voyage was undertaken in October 2015 using the MV Guru out of Darwin, NT, Australia. The following activities were undertaken:

- Deploy complete DART II system at 56001 Indian Ocean 1
- Changeover surface buoy to STB at 56003 Indian Ocean 2

Coral Sea
This voyage was undertaken in April 2016 using the Pacific Conquest out of Gladstone, QLD, and Australia. It was conducted earlier than originally planned to address an outage at 55012. The following activities were undertaken:

- Deploy complete replacement ETD system (separately moored buoy, recoverable BPR) at 55012 Coral Sea 1
- Changeover ETD buoy at 55023 Coral Sea 2

Tasman Sea
This was a remedial voyage was undertaken in April 2016 using RV Kaharoa out of Bluff, NZ. The following activities were undertaken:

- Replace BPR at 55015 Tasman Sea 1

2.1.2. *INDIA*:

Four service voyages were conducted in the last 12 months.

Bay of Bengal
This voyage was undertaken in June 2015 on-board ORV Sagar Nidhi and March 2016 and in June 2016 on-board ORV Sagar Kanya. The following activities were undertaken:

- Deploy complete new DART II systems at STB05, STB04, STB03 in the Bay of Bengal
- Replace new surface buoy and Bottom Pressure Recorder (BPR) at 23223, 23220, 23219, 23217 in the Bay of Bengal

Arabian Sea

One voyage was undertaken in November 2015 on-board ORV Sagar Kanya.

- Complete replacement of new ITB system (Surface buoy system & recoverable BPR) at 23226

Presently 7 Tsunami buoys are reporting data to Indian Tsunami warning centre at Hyderabad and same being shared to NOAA –NDBC.

2.1.3. *UNITED STATES:*

***NOAA*:**

NOAA-PMEL deploys next generation DART-4G tsunami detection systems off Oregon and Chile

As part of next generation Deep-ocean Assessment and Reporting of Tsunami (DART) technology development, the Pacific Marine Environmental Laboratory (PMEL) of NOAA has

deployed two DART-4G systems off central Oregon atop a portion of the Cascadia subduction zone and two systems off Chile in partnership with the U.S. National Weather Service and Chilean Servicio Hidrográfico y Oceanográfico de la Armada (SHOA).

NOAA-NDBC deployed an SAIC STB-MF system, in the Gulf of Mexico, in October 2015 reinstituting a WMO station formerly identified as – 42429; re-identified as station 42409. The station has operated very well and continues to provide reliable observation data. The real test for location was the month of August where, historically, eddies shed and produce areas of high impulsive currents that have been detrimental to moorings. We have seen some instances of missed data during August, but the system continues to function (at the time of reporting) at the moored location. The brief periods of intermittent data are believed to be either due to localized eddy currents or a strong thermocline. It is worth noting that this is the longest uninterrupted deployment of a tsunameter in the Gulf of Mexico since NDBC has operated the network.

Similarly, the NDBC has deployed a test buoy and Bottom Pressure Recorder (BPR) adjacent to its station at 46410 (Cordova, AK) to validate design changes in acoustic transducer models. Once validated, this will move NDBC moorings to slack systems and further improve mooring reliability. The station is returning expecting data, since its deployment in June 2016.

2.1.4. *CHINA*:

● National Marine Environmental Forecasting Center (NMEFC) of State Oceanic Administration (SOA) of China is responsible for operating the tsunami warning and mitigation system in China. It is the host center of South China Sea Tsunami Advisory Center (SCSTAC) under the framework of Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS).

Two tsunami buoy and coastal seismic stations have been installed by SOA to detect earthquakes that may trigger local tsunamis. Efforts have been made to re-deploy the tsunami buoy and keep it in stable service since June 2014. South China Sea Branch of SOA successfully recovered the top structure and the drogue of HX2 in Mach 2016 to calibrate its location drift. The HX2 was deployed again at the beginning of June 2016. However, the transmission stopped at 26 July 2016. Effort on identifying the technical problems is on-going.

A project on “Tsunami hazard, vulnerability and risk assessment”, particularly for some seriously vulnerable areas was initiated in China in 2012. This on-going project has completed tsunami risk assessment with evacuation maps of 9 coastal counties in Zhejiang Province.

2.1.5. *Manufacturers/Observation Providers*

***Science Applications International Corporation*:**

SAIC has produced and delivered 37 Tsunami Buoy systems (STB-MF, STB, and ETD DART) for its customers in Australia, Chile, China, India, Japan, Russia, Thailand and NOAA NDBC. Two additional buoy systems are available in SAIC’s inventory for rapid delivery. In addition to buoy production, SAIC provided a wide range of reconditioning and repair services for previously deployed tsunami buoy systems, as well as replacement parts and components.

***Fugro Oceanor*:**

Fugro has delivered one deep sea tsunami system to Malaysia and China. In China SOA has tested out different systems; however, the tsunami system delivered by FOAS is the only one system in operation so far.

Both in Malaysia and China the Seawatch tsunami systems are performing well.

***Sonardyne*:**

Sonardyne have nothing to report to the ITP this year.

2.2. Plans for 2017:

2.2.1. ***Australian -- Bureau of Meteorology*** - Two service voyages are planned for the next 12 months.

Coral Sea
Restoration of 55012 Coral Sea 1 by re-deployment of ETD buoy/mooring over existing BPR.

Tasman Sea
Routine maintenance: Changeover of surface buoys at 55015 Tasman Sea 1 & 55042 Tasman Sea 2.

2.2.2. ***The INDIA Tsunami program*:**

Arabian Sea:

- One service voyage is planned in the next 12 months during November-December for restoration of Surface buoy and BPR at 23228 referred as STB-02
- Complete replacement of new ITB system (Surface buoy system & recoverable BPR) at 23226

Bay of Bengal:

- One Service Voyage is planned in the next 12 months during January 2017 - June 2017 period for recovery of old Surface buoy and BPR from 23227 referred as STB-01 buoy
- Changeover new surface buoy and BPR at 23223, 23220, 23219, 23217 in the Bay of Bengal

2.2.3. ***Science Applications International Corporation*:**

- Deploy one STB-MF system in the Arabian Sea in November 2016
- SAIC engineers are planning to deploy one ETD DART in the central Andaman Sea for Thailand in early October 2016 and one STB in the eastern Bay of Bengal in late October 2016

2.2.4. United States:

- NOAA – Maintain current network, test sites, partnerships at current levels, servicing with various voyages at or about existing levels

3. Data management

3.1. Distribution of the data (USA):

The NOAA National Data Buoy Center receives data from its buoys via Iridium constellation. The data are delivered to the National Weather Service Telecommunications Gateway (NWSTG) which then distributes the data in real-time to two Tsunami Warning Centres (TWCs) via NWS communications and nationally and internationally via the Global Telecommunications System. The bottom pressure recorders of US owned buoys may be placed in high resolution event mode via two way communications initiated by the TWCs or NDBC mission control centre personnel.

Indian tsunami buoy data sets are delivered to Indian Ocean Tsunami Warning Centre INCOIS and National Data Buoy centre.

Data from Australian tsunameters is transmitted on the GTS. There are no other data sharing arrangements currently in place, e.g. for 15-sec data from recovered bottom-pressure recorders. Data is also available through NOAA's National Data Buoy Centre (e.g. http://www.ndbc.noaa.gov/station_page.php?station=55012&type=2&seriestime=20140412201900&startyear=0000&startmonth=00&startday=00&endyear=0000&endmonth=00&endday=00&submit=Submit)

3.2. Data policy

Distribution of data has been largely centralized in the west with other partners relying on localized distribution and more of a regionalized approach. Through agreement with NOAA, Russia, Thailand, and Chile have provided the data feed to NOAA-NDBC and the US TWCs. The data for those partners' stations are displayed on the NOAA-NDBC Website. The control of high resolution

data or “event mode triggering” for those stations remains with the host countries. Several additional countries make their data available to the GTS (refer to the annex).

3.2.1. ***Australian -- Bureau of Meteorology***: Make their data available through GTS.

3.2.1.1. Real-time data exchange

The Iridium RUDICS service is used for data communications

Data timeliness

The BoM systems are located to ensure at least 30 min travel time from the source to the buoy (in order to separate the seismic signal from water perturbations). It is usual for the systems to be triggered by the seismic signal before any true water height perturbations arrive

Event Mode

One-minute averaged data reaches the BoM every 8 min of the first 90 min of an event and then every 16 min until approximately 180 min have elapsed since the event.

Non-event mode

Data is delivered every six hours in 15 min resolution.

3.2.1.2. Delayed mode data exchange

Data is archived at BoM and at NOAA NDBC and National Geophysical Data Centre.

3.2.2. ***Indian Tsunami buoy***

3.2.3. ***Distribution of the data***

Data from Indian tsunameters are transmitted through FTP to NDBC and also on the GTS. There are no other data sharing arrangements currently in place in real time; e.g. for 15-sec data from recovered bottom-pressure recorders.
Data is also available through NOAA’s National Data Buoy Center
(http://www.ndbc.noaa.gov/station_page.php?station=23219)

3.2.4. ***Data policy***

Pushing through FTP to NDBC server and freely distributed onto the GTS

3.2.5. ***Real-time data exchange***

The Iridium RUDICS service is used for data communications

3.2.6. ***Data timeliness***

The ITEWS systems are located to ensure at least 30 min travel time from the source to the buoy (in order to separate the seismic signal from water perturbations). It is usual for the systems to be triggered by the seismic signal before any true water height perturbations arrive

Event Mode

STB system - One-minute averaged data reaches the ITEWS every 8 min of the first 90 min of an event and then every 16 min until approximately 180 min have elapsed since the event.

ITB system – thirty second averaged water level data reaches the ITEWS every 5 min of the event until approximately 180 min since the event.

Non-event mode

STB - Data is delivered every six hours in 15 min resolution.

ITB – Data is delivered every one hour in 15 min resolution.

3.2.7. *Delayed mode data exchange*

Data is archived at Sea Level Data Server of ITEWS at INCOIS and at NOAA NDBC.

India has also developed a Bottom Pressure Recorder for technology indigenization and it worked satisfactorily.

3.2.8. ***SAIC*** currently supports tsunami buoy programs in 8 countries: Australia, Chile, China, India, Japan, Russia, Thailand, and the United States. For those countries that send their buoy data initially to NOAA, NDBC immediately makes the data available over the GTS and also transfers the files directly to the host country servers through the internet using the File Transfer Protocol (ftp).

3.3. Real-time data exchange

As shown in the Annex, a significant portion of the users are making their real time data available through the GTS. There continues to be a positive trend and is a notable event in international collaboration. Approximately, 77 percent of the deployed tsunameters are providing data through the GTS.

India is making data available through GTS to NDBC website

3.4. Delayed mode data exchange

The US recovers and analyzes the data recovered from BPR flash storage. Short durations of high resolution data can be recovered via two way iridium communications if requested by TWCs.

India is sharing the data through GTS and CREX format data being exchanged to NDBC.

3.5. Data quality

The NDBC publishes its *Handbook of Automated Data Quality Control Checks and Procedures* on its website; specifically, at the following URL:
http://www.ndbc.noaa.gov/NDBCHandbookofAutomatedDataQualityControl2009.pdf

The mode of exchange of the above data shall be through Global Telecommunication System (GTS) on through any other appropriate is to be implemented jointly by the India Meteorological Department (IMD) and the Indian National Center for Ocean Information Services (INCOIS). The real time access to the data to various international agencies is extended on request to the NTWC and RTWP operated by India at the INCOIS, Hyderabad

3.5.1. *Australian -- Bureau of Meteorology*:

Quality control is restricted to visual inspection of the data.

SAIC: SAIC continues to modularize and enhance cross-compatibility of STB-MF and SAIC Easy-to-Deploy (ETD) DART systems, including improvements to electronics and buoy design. The results of this effort are continuing high levels of data quality and reliability, with data availability of SAIC systems greater than 92% in 2016.

3.5.2. ***INDIA:***
Quality control is restricted to visual inspection of the data.

4. Instrument practices

The tsunameter standard which was approved by ITP, and then by DBCP, was presented in the TOWS working Group (TOWS-WG). As agreed upon, the Chair or Co-Chair of ITP could not attend due to funding constraints. However, the presentation was sent to working group. The report of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems during the Ninth Meeting held in Paris, France from 25 to 26 February 2016 discussed and decision and recommendation was presented to IOC 28 session

The group appreciated the efforts of the International Tsunameter Partnership Group (ITP) under the Data Buoy Cooperation Panel (DBCP) in preparing the "Tsunameter Equipment Performance Standards and Guidelines", and further requested DBCP-ITP to (i) recommend a standard data format and encourage its use by tsunameter manufacturers, station operators and data centres to enable real-time data access to the tsunami service providers, (ii) find ways to keep the equipment and operations costs low to ensure sustainability of the tsunameter networks, (iii) enhance redundancy of satellite communication channels by using some different satellite communication services to ensure high availability of data and (iv) ensure mechanisms to trigger tsunameters based on seismic waves and also the capability for the operator to trigger tsunameters based on requests from authorized TSPs and NTWCs. IOC-28 - 28th Session of the IOC Assembly from 18 to 25 June 2015, Paris, France

The NDBC shared details on best practices and processes used to ensure traceability and accuracy with users at the March 2016 Regional Marine Instrumentation Center (RMIC) at the University of Southern Mississippi campus near the Stennis Space Center, Mississippi site.

NIOT India follows best of practices and methods to ensure accuracy in provided data to users.

These two regional centres have collaborated closely and shared information over the last several years.

Several partners have conveyed recent experience with Mid-Frequency acoustic technology (e.g. Japan) used in areas where high ocean currents were hindering mooring survivability when used in conjunction with typical low frequency acoustic systems. This item warrants future updates as this has been one of the significant challenges to maintaining tsunameter moorings. As mentioned in the preceding paragraphs, the NOAA-NDBC has recently had success with the Mid-Frequency system.

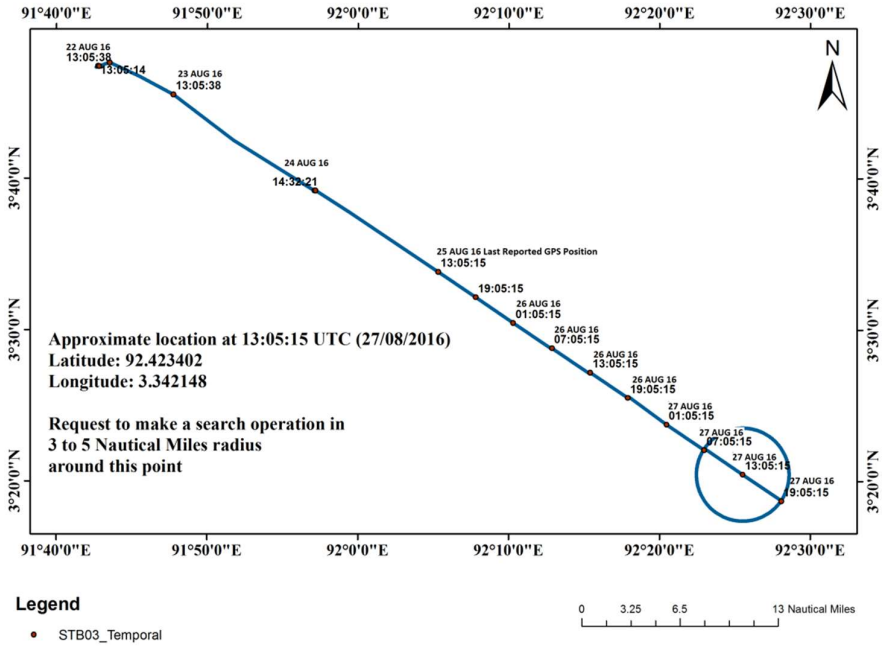
5. Challenges:

5.1. INDIA:

Vandalism
There were cases of Vandalism in both Arabian Sea and Bay of Bengal. The Buoy at STB 01 at 23227 has been anchored and dragged by a fishing boat to a distance around 2 NM which causes some data gaps in the communication between the BPR and Surface buoy. Also, there was an instance in the Arabian Sea where the Surface buoy was dragged on 13 March 2016 from its actual position to a distance of 3 NM away by a fishing boat. This interference stopped the communications between the Surface Buoy and BPR; the system has been non-functional since that time.

The menace of Vandalism of buoys at Sea is costing us and the whole community heavily. We call your attention to the loss of a tsunami buoy (SAIC) by India, which was installed by INCOIS India.

STB03 (IN3) Surface buoy was not reporting data from August 23, 2016 and it was drifting in a south easterly direction from its original position (3.81N, 91.70E). Vandalism is suspected as a boat likely encroached on the buoy and stressed or cut the mooring. We observed the buoy drifting on 24th August and immediately requested Indian Navy and Coast Guard teams to send their vessels for buoy recovery. The Navy responded quickly and their team reached the buoy deployment/mooring position on the evening of August 26, 2016. They searched all probable locations for several days. No progress has been made in finding the buoy at the time of this report, and the Navy team informed us that they are going to call-off the search operation. The buoy's last GPS position was 3.5639N, 92.0885E on 25 August 2016 at 18:35 hrs IST and it was drifting SE direction with around 0.5 knots speed. The illustration below depicts the last GPS position location.



Probable location of STB03 as of 27 August 2016.

Ship Time

Delay in servicing of buoys in Arabian Sea due to ship time unavailability in fair weather

Weather

Tried servicing TB12 buoy once during July 2015 and in June 2016 but due to rough weather the servicing was called off both times.

6. Technological developments

6.1. **Australian -- Bureau of Meteorology** There have been no technological developments made this year. Alternative technologies for deep-ocean tsunameter operation are being watched, but none seem mature enough for operational use at this time, e.g. telecommunications cable-based sensors; wave glider technology for temporary or permanent replacement of surface buoys and GPS

6.2. ***The INDIA Tsunami program Sagar Bhoomi:***

Indigenously developed Indian Tsunami Buoy System (ITBS) comprises of an indigenous Bottom Pressure Recorder (BPR) anchored to the sea floor and Indigenous Surface Buoy System (Buoyancy module with mooring & Buoy electronics) with increased lifetime and bi-directional communication links with reliable acoustic communication.

The system worked satisfactorily for 135 days at 3300 m depth and was recovered during February 2016. The Sagar Bhoomi system has new generation surface buoy system and indigenously developed Paroscientific pressure sensor based bottom pressure recorder for monitoring the hydrostatic pressure using NOAA tsunami detection algorithm.

Fig1.Buoy system and BPR during deployment

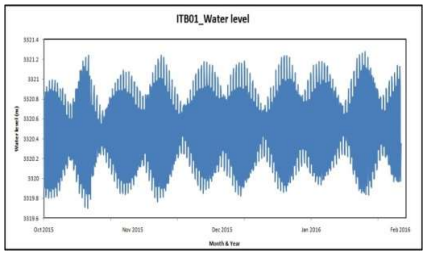


Fig2.Transmitted water level

There were few design changes that were made for the Bottom Pressure Recorder system with same specification as the DART II system, which was used during the Bay of Bengal cruise other than that there been no technological developments made this year. Alternative technologies for deep-ocean tsunameter operation are being watched, but none seem mature enough for operational use at this time, e.g. telecommunications cable-based sensors; wave glider technology for temporary or permanent replacement of surface buoys and GPS.

6.3. ***The NOAA/NWS Tsunami Program :***

DART-4G is designed to take advantage of new sensing and processing technologies to detect a tsunami while the earth is still shaking. This design allows the system to be located closer to a potential earthquake source and so might provide faster detection of tsunami waves. The DART-4G can also work outside the near-field zone and perform as a traditional DART system. In order to verify the design and anticipated rapid sensing capabilities, we need in-situ testing. The data will be routed through the National Data Buoy Center (NDBC) who is now positioned to ingest these data, and put onto the GTS for global real-time distribution to the tsunami warning centers and to PMEL for analysis. All DART-4Gs will be deployed for two years during which time detection schemes will be evaluated and updated as we learn about near-field tsunamis, what the technology can detect, and how best the information can be used for earlier tsunami warning. A November 11 6.9MW earthquake near Illapel, Chile activated the DART-4G's and the functionality was tested. Although no tsunami was measured at the buoys it was an important test of the filtering algorithm. The testing report, comparison with models and tide gauges can be viewed here (http://nctr.pmel.noaa.gov/chile20151111/).

7. **Other issues as needed**

Action Item 1: Call for approximate locations of tsunameters (specifically those not currently shared on GTS). Request information by DBCP 33.

Action item 2 ITP Tsunameter Equipment Performance Standards and Guideline is recommended by IOC Forty-ninth Session of the Executive Council Paris, 7-10 June 2016 way forward to encourage member countries /manufactiurers to follow this guidelines

Action item 3: IOC EC and TOWS WG requested DBCP-ITP to

(i) recommend a standard data format and encourage its use by tsunameter manufacturers, station operators and data centres to enable real-time data access to the tsunami service providers,

(ii) find ways to keep the equipment and operations costs low to ensure sustainability of the tsunameter networks,

(iii) enhance redundancy of satellite communication channels by using some different satellite communication services to ensure high availability of data and

(iv) ensure mechanisms to trigger tsunameters based on seismic waves and also the capability for the operator to trigger tsunameters based on requests from authorised TSPs and NTWCs. IOC-28 - 28th Session of the IOC Assembly from 18 to 25 June 2015, Paris, France

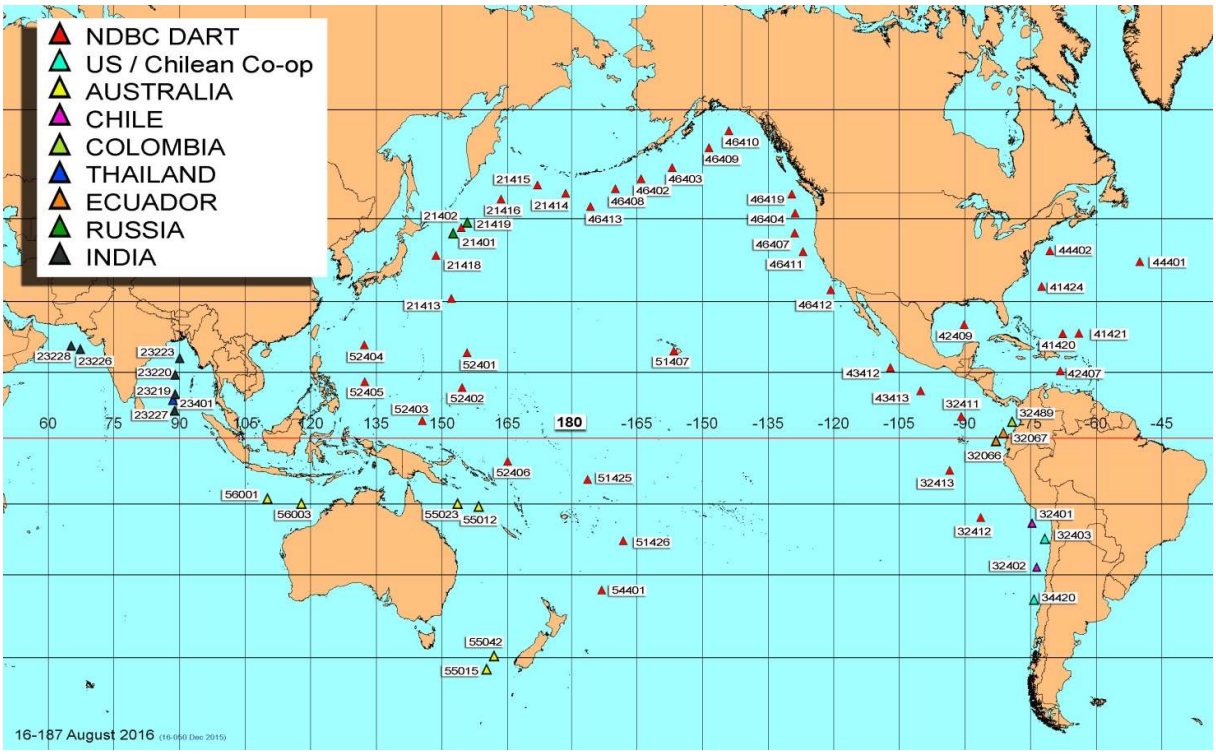
Action item 4 Vandalism of Tsunameters : IOC Executive Council (and the WMO Executive Council) a decision was adopted
IOC Decision EC-XLIX/3.4) that :
Requests the IOC and WMO, working through the Data Buoy Cooperation Panel and TOWS, to develop a regionally relevant,education and outreach strategy, for discussion at the IOC Assembly at its 29th session in 2017, that could be jointly implemented by IOC, WMO, FAO, regional fisheries management organizations, Member States, the fisheries sector and other relevant organizations in order to substantially reduce damage through vandalism or interference with ocean data buoys;

Contributions: Technical input for this report provided by partnering nations as well as from key vendors -- SAIC Fugro Oceanor and Sonardyne International Ltd.

ITP Annexure - 1

Status maps and graphics

Global Tsunameter Network								
Country	Planned Network	Currently Operational	Tsunameter Types	Local Reception	Data to GPS	Data to FTP	Data Formats	Vandalized Stations
Australia	6	5	SAIC - STB SAIC – ETD DART II MF	Yes	Yes	No	NOAA-DART BUFR/CREX	Yes; 1 event
Chile	3	2	SAIC - DART - II SAIC - STB	Yes	Yes	Yes	NOAA-DART	-
China	2	2	DART - STB	Yes	No	No	NOAA-DART BUFR	Yes; 3 - 5 events
Ecuador	2	2	EBM22TS Mediterráneo Señales Marítimas (MSM)	Yes	Yes	Yes	NOAA-DART	-
India	7	7 2 NIOT 5 SAIC	SAIC-STB Indian Buoy Sagar Bhoomi - Sonardyne	Yes	Yes INCOIS	No	BUFR/CREX	Yes; 2 – 1 Event
Indonesia	14	-	InaBuoy SAIC-ETD	Yes	No	No	Local Format NOAA-DART	-
Japan	6	3	SAIC-STB-MF	Yes	Yes	No	CREX	-
Malaysia	3	-	-	Yes	No	No	-	-
Republic of Korea	2	-	-	-	-	-	-	-
Russia	3	2	SAIC-STB SAIC-ETD	No	Yes	Yes	NOAA-DART	-
Thailand	3	1	SAIC-STB Environtec	No Yes	Yes Yes	Yes No	NOAADART -	No No
USA	39 4	29 2	DART – II SAIC-MF	Yes	Yes	Yes	NOAA-DART	Yes



Source: http://www.ndbc.noaa.gov/dart.shtml dated: 01.Sep 2016

APPENDIX E

NPDBAP
DBCP-PICES North Pacific Data Buoy Advisory Panel

1) Summary

Name of Action Group	DBCP-PICES North Pacific Data Buoy Advisory Panel (NPDBAP)
Date of report	16 September 2016
Overview and main requirements addressed	The goals of the NPDBAP are to deploy 60 SVPB drifters a year, and maintain 75 active buoys in the region.
Area of interest	North Pacific Ocean and marginal seas generally north of 30°N
Type of platform and variables measured	Lagrangian drifters measuring sea level pressure, SST, and sea-surface velocity
Targeted horizontal resolution	5° x 5°
Chairperson/Managers	Co-Chairperson for the NE Pacific: Dr. Rick Lumpkin, NOAA, United States Co-Chairperson for the NW Pacific: Dr. BG Lee, Jeju National University, South Korea
Coordinator	Mr Shaun Dolk, NOAA / AOML
Participants	Rick Lumpkin, BG Lee, Shaun Dolk, Ignatius Rigor, Champika Gallage, Mayra Pazos, Erik Valdes, Jooyoung Lee, Etienne Charpentier, Mathieu Ouellet, Serge Hagan-Deschamps, Myungwon Park, Sang Kill Park,
Data centre(s)	Drifter Data Assembly Centre (DAC) Integrated Science Data Management (ISDM), Canada
Website	http://dbcp.jcommops.org/npdbap/
Meetings	Yearly meetings usually held in conjunction with DBCP meetings. Next meeting planned 18 October, 2016 in La Jolla, California.
Current status summary	From 01 September 2015 to 31 August 2016, 62 drifters were deployed in the North Pacific Ocean. Of the 62 drifter deployments, 53 units were equipped with barometer sensors and the remaining 9 drifters were standard SVP type drifters.
Summary of plans for 2017	The goal for 2017 is to deploy 75 drifters, of which, 50 drifters will be equipped with barometer sensors.

2 Deployment plans for 2017

Both the GDP and Environment Canada will continue to utilize ships of opportunity for drifter deployments, while also looking for new possibilities within the Canadian and United States Coast Guards.

3 Data management

3.1 Distribution of the data

The drifter Data Assembly Center (DAC) assembles, quality controls and interpolates data from approximately 1300 drifters per month from all GDP national and international partners, from all oceans of the world. These data are made available through the web with a delayed time of 3—4 months. As of the time of writing this report (September 2016), data are available through June 2016. These data can be accessed at http://www.aoml.noaa.gov/phod/dac/dacdata.php.

3.1.1 Data policy

The DAC, located at NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) has access to drifters from GDP partners that have given Service Argos permission to make these data available to the DAC. In return the partners have access to all quality controlled and interpolated data available in the database via the World Wide Web. Non-interpolated quality controlled data and raw data are made available via ftp transfer upon request.

3.1.2 Real-time data exchange

All data from drifters in the GDP's programs are disseminated via GTS as soon as drifters are deployed. The GDP monitors data going out on the GTS, and transmissions of sensors producing bad data or transmissions from grounded drifters are removed from the GTS data stream.

The GDP does not monitor GTS data timeliness and relies on operational centres to report on these issues.

3.1.3 Delayed mode data exchange

Drifter data (raw Argos data, edited non-interpolated and interpolated data) are archived at AOML. These datasets are also sent once or twice a year with a 6-month delay to Integrated Science Data Management (ISDM), the RNODC for drifter data, for permanent archival and further distribution. The DAC is currently preparing to send data through June 2015 to ISDM.

Metadata for GDP drifters are received at the DAC directly from drifter manufacturers who send standardized specification sheets for batches of identical drifters prior of delivery of the instruments. Portions of this metadata are extracted and are made available on the deployment log at the DAC web page www.aoml.noaa.gov/phod/dacdeployed.html. Specification sheets are archived at the DAC. Deployment date, date of last transmission, drogue off and cause of death metadata are determined during quality control of the dataset and are made available through the web at www.aoml.noaa.gov/phod/dac/dirall.html. These web pages are interrogated by JCOMMOPS to gather information for their metadata systems.

3.2 Data quality

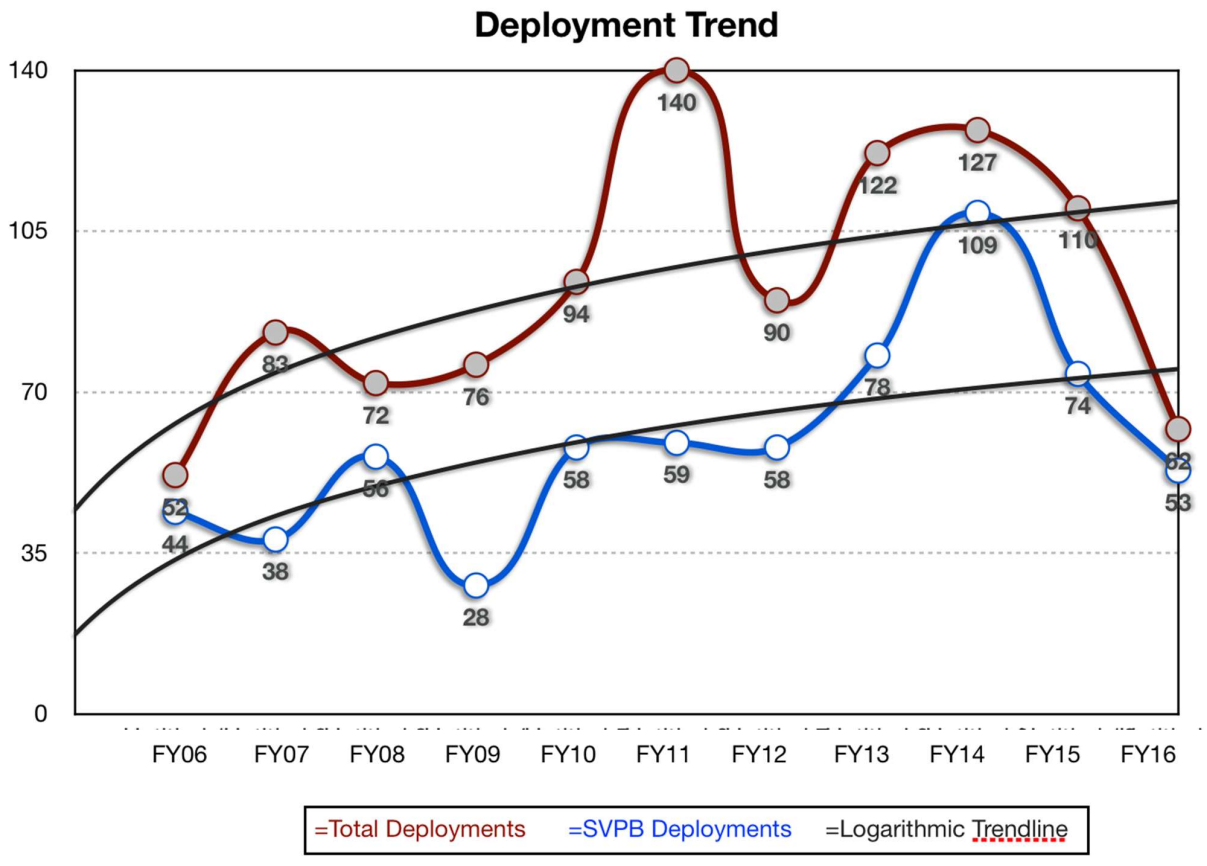
4) Instrument practices

5) Other issues as needed

Annex (optional)

Status maps and graphics

	Total	SVPB	SVP	SVPW	SVPBW	SVPG
FY2006	52	44	6	0	2	0
FY2007	83	38	44	1	0	0
FY2008	72	56	16	0	0	0
FY2009	76	28	35	0	0	13
FY2010	94	58	13	1	0	22
FY2011	140	59	81	0	0	0
FY2012	90	58	32	0	0	0
FY2013	122	78	44	0	0	0
FY2014	127	109	18	0	0	0
FY2015	110	74	28	0	0	8
FY2016	62	53	0	0	0	9



APPENDIX F

TIP
The Tropical Moored Buoy Implementation Panel

1) Summary

Name of Action Group	The Tropical Moored Buoy Implementation Panel (TIP)
Date of report	15 September 2016
Overview and main requirements addressed	The Tropical Moored Buoy Implementation Panel (TIP) oversees the design and implementation of the following components: • The Tropical Atmosphere Ocean / Triangle Trans-Ocean Buoy Network (TAO / TRITON), a central component of the ENSO Observing System, deployed specifically for research and forecasting of El Niño and La Niña; • The Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) • The Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA)
Area of interest	The tropical ocean regions as part of an integrated approach to observing the climate system to address the research needs of CLIVAR and the operational strategies of GOOS and GCOS. Pacific Ocean: 8°N to 8°S; Atlantic Ocean: 20°N to 10°S; Indian Ocean: 15°N to 25°S.
Type of platform and variables measured	Tropical moorings with surface meteorological and sub-surface oceanographic sensors measuring: Surface wind, air temperature, relative humidity, SST and SSS on all surface moorings. Air pressure, precipitation, short wave radiation, long wave radiation on some surface moorings. Sub-surface temperature profiles down to 500m-750m on all surface moorings. Salinity profiles as deep as 750m on some surface moorings. Current velocity on some moorings. Also, biogeochemical measurements, including CO_2 and O_2 on select moorings. Some moorings also have specialized instruments to measure turbulence dissipation and listening devices for tracking marine animals. Subsurface ADCP moorings measuring velocity profiles in the upper few hundred meters. Some have additional single point current meters at deeper levels.
Targeted horizontal resolution	Tropical Pacific Ocean: 68 moorings; Tropical Atlantic Ocean: 19 moorings ; Tropical Indian Ocean: 45 moorings
Chairperson/Managers	Dr. Mike McPhaden, PMEL, USA, Chairman Dr. Kentaro Ando, JAMSTEC, Japan, Vice-Chairman
Coordinator	Mr. Kenneth Connell, PMEL, USA
Participants	TAO/TRITON: NOAA National Data Buoy Center (NDBC),NOAA Pacific Marine Environmental Laboratory (PMEL), Japan Agency for Marine-Earth Science and Technology (*JAMSTEC)* PIRATA: NOAA PMEL, NOAA Atlantic Marine Oceanographic Laboratory (AOML), L'Institut de recherche pour le développement (IRD), Meteo-France, Instituto Nacional de Pesquisas Espaciais (INPE), Diretoria de Hidrografia e Navegacao (DHN**)**

	RAMA: NOAA PMEL, JAMSTEC, Indian National Center for Ocean Information Services (INCOIS), Indian National Institute of Oceanography (NIO), the Indonesian Agency for the Assessment and Application of Technology (BPPT), the Indonesian Meteorological, Climate, and Geophysical Agency (BMKG), the Chinese First Institute of Oceanography (FIO), Bay of Bengal Large Marine Ecosystem (BOBLME) program, and University of Tasmania.
Data centre(s)	PMEL, NDBC, JAMSTEC, NIO
Website	http://www.pmel.noaa.gov/tao/global/global.html http://tao.ndbc.noaa.gov/
Meetings *(meetings held in 2015/2016; and planned in 2016/2017)*	• PREFACE-PIRATA-CLIVAR Tropical Atlantic Conference, Cape Town, South Africa, 25-27 August, 2015 • CLIVAR Pacific Ocean Panel 10th session, Santiago, Chile, 10-11 October, 2015 • TPOS2020 Steering Committee 2nd meeting, Hobart, Australia, 14-17 October, 2015 • International Symposium on the Indian Ocean, Goa India, 30 November – 4 December 2015 • CLIVAR GOOS Indian Ocean Panel 12th session, IndOOS Resource Forum, Goa, India, 5-9 December, 2015 • AMS 96th Annual Meeting, New Orleans, LA, 9-14 January 2016 • Ocean Sciences, New Orleans, LA, 21-26 February, 2016 • OceanSITES 8th Data Management Team Meeting, Southampton, UK, 25-29 April, 2016 • GCOS-COOS-WCRP Ocean Observations Panel for Climate, 19th Session, Esporles, Spain, 6-8 April 2016 • Asia Oceania Geosciences Society 13th Annual Meeting, Beijing, China, 31 July – 5 August, 2016 • CLIVAR Pacific Ocean Panel 11th session, Qingdao, China, 17-18 September 2016 • CLIVAR Open Science Conference, Qingdao, China, 19-23 September 2016 • PREFACE-PIRATA-CLIVAR Tropical Atlantic Conference, Paris, France, 28 Nov-2 Dec 2016 • Fall AGU Meeting, San Francisco, CA 12-16 December 2016 • AMS 97th Annual Meeting, Seattle, WA, 23-26 January 2017 • CLIVAR GOOS Indian Ocean Panel 13th session and 7th session of the IndOOS Resource Forum, Perth, Australia, 30 Jan-3 Feb 2017 • GCOS-COOS-WCRP Ocean Observations Panel for Climate, 20th Session, Woods Hole, MA, 14-17 March 2017 • EGU General Assembly, Vienna, Austria, 23-28 April 2017

Current status summary *(August 2016)*	TAO/TRITON: 51 of 55 TAO, 8 of 8 TRITON surface moorings reporting data. PIRATA: 15 of 18 surface moorings reporting data. RAMA: 16 of 28 surface moorings reporting data.
Summary of plans for 2017	TAO/TRITON: Maintain 63 mooring array. (11 of 13 original TRITON/ADCP moorings retired.) PIRATA: Maintain 19 mooring array RAMA: Maintain 30 sites, including 1 new site.

2 Deployment plans for 2017

TAO/TRITON: NDBC 4 cruises, JAMSTEC 1 cruise
PIRATA: AOML/PMEL 1 cruise, IRD 1 cruise, INPE 1 cruise
RAMA: PMEL/INCOIS 3 cruises, PMEL/Seychelles 1 cruise, JAMSTEC/BPPT 1 cruise, PMEL/BPPT/BKMG 1 cruise, FIO 1 cruise

3 Data management

3.1 Distribution of the data

Most tropical surface mooring data are telemetered in real time and are placed on the GTS. High resolution TAO Refresh data are telemetered via Iridium and placed on the GTS by NDBC. TRITON data and data from ATLAS moorings (the majority of systems in PIRATA, and RAMA) are telemetered via the Argos system and are placed on the GTS by the French Space Agency (CLS). Data from recently deployed T-Flex moorings in PIRATA and RAMA are telemetered via Iridium and placed on the GTS by PMEL. Real-time data, delayed-mode data (e.g., data of higher temporal resolution than are available in real time) and data from subsurface moorings are available via several web based distribution sites:

PMEL (www.pmel.noaa.gov/tao/disdel/disdel.html),
NDBC (http://tao.ndbc.noaa.gov/tao/data_download/search_map.shtml),
(http://dods.ndbc.noaa.gov/thredds/catalog/data/oceansites/DATA/catalog.html), and
(ftp://data.ndbc.noaa.gov/data/)
JAMSTEC (www.jamstec.go.jp/jamstec/TRITON/real_time/delivery/
www.jamstec.go.jp/iorgc/iomics/datadisplay/buoysummary.php?LANG=0
NIO (www.nio.org/index/option/com_nomenu/task/show/tid/2/sid/18/id/5).

During the period September 2015 through August 2016 the PMEL web pages had more than 12M hits and delivered more than 398K data files in response to more than 126K user requests. In addition to web page deliveries, more than 3.2M files were delivered via FTP. During the same period the NDBC web pages had more than 4M hits and delivered 3.4M files totaling 413 Gb of data.

3.1.1 Data policy

Data are freely available on the web and distributed via the GTS in real-time. The protocol for TAO-Refresh data delivery is based on an Open Source Project for a Network Data Access Protocol (OPeNDAP).

3.1.2 Real-time data exchange

TAO Refresh systems, designed to make observations comparable to legacy ATLAS systems, transmit 10-min data via Iridium, with hourly observations placed on the GTS by NDBC. ATLAS moorings place daily mean meteorological and oceanographic observations and some (about 10 per day on average) hourly meteorological observations on the GTS using Argos2 PTTs. TRITON and mini-TRITON (m-TRITON) buoys submit hourly mean meteorological and oceanographic data to the GTS: TRITON via Argos2 PTTs and m-TRITON via Argos3 PMTs. Hourly T-Flex data transmitted via Iridium are placed on the GTS by PMEL. Compared to the volume of ATLAS data received at PMEL, more than 90% is typically reported on the GTS by CLS. Most operational centers receive nearly all ATLAS data placed on the GTS, with the exception of the European Centre for Medium Range Weather Forecasts (ECMWF) which typically reports volumes of about 75%, presumably due to stricter latency criteria.

NDBC submits TAO Refresh data onto the GTS under the SSVX08 KWNB header in World Meteorological Organization (WMO) FM18 – BUOY alphanumeric format and also in BUFR format under header ISSF/G08. The WMO numbers for the TAO Refresh buoys are those used for the previous ATLAS moorings at the same sites.
PMEL submits T-Flex data onto the GTS in BUFR format with Bulletin Header IOBX08 KPML. WMO numbers for T-Flex moorings take the 7-digit analog of the 5-digit code for the previous ATLAS

system at the same site. For example, the WMO number for the first T-Flex mooring implemented (4°S 81°E in RAMA) is 2300010 (vs 23010 for the previous ATLAS moorings at that site).

Daily average primary sensor real-time data return for the period 1 September 2015 through 31 August 2016 was 75% for TAO, 65% for TRITON, 87% for PIRATA and 55% for RAMA. Primary reasons for data loss in RAMA were a high incidence of vandalism coupled with long mooring deployment periods at some sites. Details are discussed in section 5.1.

3.1.3 Delayed mode data exchange

Delayed mode data (*i.e.,* data retrieved after mooring recovery) are available at the web sites listed in 3.1 above. System metadata are available at the web sites listed in 3.2 and 4 below.

The TAO web sites (http://www.pmel.noaa.gov/tao/ and http://tao.ndbc.noaa.gov/), PIRATA web site (http://www.pmel.noaa.gov/pirata/), and RAMA web site (http://www.pmel.noaa.gov/tao/rama/) provide additional information including scientific background, technical information, present status of the arrays, a bibliographies of refereed publications, history of cruises, and additional information.

TAO delayed mode data are archived by NDBC following the definitions and principles of the *Open Archival Information System (OAIS) Model (ISO 14721:2003);* these data are available at NOAA National Center for Environmental Information https://data.noaa.gov/dataset/physical-and-meteorological-data-from-the-tropical-atmosphere-ocean-tao-array-in-the-tropical-p0a3d0

3.2 Data quality

Data quality control procedures are described at www.pmel.noaa.gov/tao/proj_over/qc.html for ATLAS moorings, at http://tao.ndbc.noaa.gov/proj_overview/qc_ndbc.shtml for TAO refresh moorings and at www.jamstec.go.jp/jamstec/TRITON/real_time/overview.php/po.php for TRITON moorings.

4) Instrument practices

Sensor specifications and calibration procedures are described on a number of web sites:

- www.pmel.noaa.gov/tao/proj_over/sensors.shtml (ATLAS)
- http://tao.ndbc.noaa.gov/proj_overview/sampling_ndbc.shtml (TAO Refresh)
- http://www.jamstec.go.jp/jamstec/TRITON/real_time/overview/ (TRITON)
- http://www.jamstec.go.jp/iorgc/iomics/projectoverview/1_b3_eng.html (m-TRITON)

Real-time (daily averaged) and delayed mode (10-minute) data from NDBC's TAO Refresh moorings and PMEL's T-Flex moorings were independently compared during testing alongside ATLAS moorings for several years. TAO Refresh moorings have now replaced all ATLAS Legacy moorings in TAO. Side-by-side T-Flex/ATLAS comparison deployments were also conducted for several years. T-Flex moorings have now replaced ATLAS moorings at 4 RAMA and 3 PIRATA sites. Additional RAMA and PIRATA replacements are planned for the coming year. A NOAA Technical Memorandum comparing the ocean-deployed, side-by-side ATLAS and T-Flex mooring deployments in RAMA and PIRATA is in preparation.

RAMA mooring specifications from PMEL, JAMSTEC and NIO are also listed in the Supplement to RAMA: The Research Moored Array for African—Asian—Australian Monsoon Analysis and Prediction (McPhaden, et al., 2009)

China's First Institute of Oceanography (FIO) mooring, named BaiLong (White Dragon), was designed to make meteorological and ocean measurements comparable to ATLAS moorings. FIO first deployed a BaiLong at the 8°S 100°E RAMA site in February 2010 and maintained the site on an annual basis until 2015. FIO plans to re-establish the mooring in fall of 2016. PMEL and FIO have

incorporated data from the BaiLong mooring into PMEL's Tropical Moored Buoy web pages which display and distribute RAMA data from ATLAS and TRITON moorings.

Results of a land-based comparison of ATLAS, T-Flex and China's BaiLong meteorological data have been published.

Freitag, H.P., C. Ning, P. Berk, D. Dougherty, R. Marshall, J.M. Strick, and D. Zimmerman (2016): ATLAS, T-Flex, BaiLong meteorological sensor comparison test report. NOAA Tech. Memo. OAR PMEL-148, NOAA/Pacific Marine Environmental Laboratory, Seattle WA, 40 pp, doi: 10.7289/V57942PP, Published online.

5) Other issues

5.1 RAMA Implementation and Maintenance

The number of RAMA sites implemented stands at 36 (78% complete). One new ATLAS mooring site near 16°S, 95°E is planned for the coming year.

Between August 2015 and July 2016, 138 sea days were provided by India, Indonesia, the US and China in support of RAMA. During this period 24 RAMA moorings were deployed (22 surface and 2 subsurface). As of 30 August 2016, 16 of 28 RAMA surface moorings were reporting data.

Due to lack of cruise opportunities 7 of 28 surface mooring sites were not maintained in the past year, including 3 which have not been visited for more than 3 years. Data return for the 21 sites which have been maintained on a nearly annual basis was 68%, 13% higher than when all surface moorings are considered. Vandalism (Sec. 5.6) combined with long deployments lower RAMA mooring survival rates. The survival rate for PMEL surface moorings in RAMA since initial deployments in 2004 is 77%, compared to 90% for TAO (1980 to 2010) and 94% for PIRATA (September 1997 to August 2016). The RAMA site at 1.5°N, 81.5°E has been especially vulnerable to vandalism, with an average mooring survival rate of 50% since the site was first implemented in 2004.

A November 2015 PMEL cruise used a small ship in the Seychelles during which 2 RAMA ATLAS moorings were deployed. One deployment implemented a new RAMA site (4°S, 57°E) and the other resumed maintenance of a site last visited in 2012 (8°S, 55°E). The ship will be used again in November 2016 to maintain these 2 sites.

NIO has ceased maintenance of their Deep Ocean RAMA mooring at 0°, 93°E and do not have plans to maintain their moorings at 0°, 77°E and 0°, 83°E beyond 2017.

The CLIVAR/GOOS Indian Ocean Panel (IOP) will convene a review of the Indian Ocean Observing System (IndOOS), including RAMA, in 2017. The review will consider possible array re-configuration and opportunities to introduce new technologies into IndOOS that can meet sampling requirements not met by RAMA or other observing system components.

5.2 Array enhancements

Meteo-France provides barometers to maintain surface pressure measurements at 4 RAMA sites and 1 PIRATA site.

CO_2 and additional biochemical (e.g., pH, O_2, chlorophyll, turbidity) measurements are made on some TAO moorings (http://www.pmel.noaa.gov/co2/moorings/) and on some PIRATA buoys by LOCEAN (http://www.lodyc.jussieu.fr/CO2tropiques/) and the Leibniz Institute of Marine Sciences at the University of Kiel (IFM-GEOMAR). A PMEL CO2 system supported by the Bay of Bengal Large Marine Ecosystem Project (BOBLME) was been maintained on a RAMA mooring since November 2013. The University of Tasmania provided fluorometers for two RAMA moorings in the past. These measurements are made by independent electronic systems (i.e., not integrated with ATLAS, T-Flex

or TAO Refresh electronic systems.) PMEL and GEOMAR are developing integrated real-time telemetry of O_2 from T-Flex moorings in PIRATA. China's BaiLong systems deployed in RAMA included CO_2 measurements in 2011 and 2012, and are scheduled to resume in 2016.

Dalhousie University's Ocean Tracking Network (OTN) program has deployed acoustic telemetry receivers on all PIRATA surface moorings and 20 RAMA moorings, adding additional biological monitoring capabilities to the array by tracking marine animals. Additional deployments on RAMA and TAO moorings are planned.

Oregon State University deploys microstructure measuring instruments (known as ChiPods) on tropical moorings in TAO, PIRATA and RAMA. At present a total of 24 instruments are deployed on 6 moorings.

Enhancements to PIRATA moorings, to include adding current meters to some moorings and increased vertical resolution of salinity profiles, are planned for 2017.

5.3 International cooperation and capacity building

A number of formal bilateral agreements have been created between agencies of the United States, India, Indonesia, Australia and ASCMLE to help complete and sustain RAMA. A 5-year Implementing Arrangement between NOAA and the Indonesian Ministry of Marine Affairs and Fisheries (KKP) expired in 2013. A new Implementing Arrangement between NOAA and Indonesia's Meteorological, Climate, and Geophysical Agency (BMKG) has since been developed. The ASCLME Project ended in March 2014. Korea plans to launch a new research vessel in 2016 with interest being expressed by the Korea Institute of Ocean Science & Technology (KIOST) towards support of RAMA. A collaborative KIOST/NOAA pilot cruise in 2017 has been funded.

To facilitate and coordinate resources that may be applied to the Indian Ocean Observing System, an IndOOS Resource Forum (IRF) was established in 2009. The Forum held its 6th meeting in Goa, India, in December 2015.

KIOST maintains 3 subsurface ADCP moorings near TAO moorings along 165ºE. This work is being conducted under the context of a Joint Project Agreement between NOAA and the Ministry of Oceans and Fisheries, Republic of Korea.

As mentioned above T-Flex moorings replaced ATLAS moorings in PIRATA this past year. Six PIRATA mooring sites are maintained by French scientists and technicians aboard French research vessels. In preparation for a March/April 2016 French cruise, PMEL hosted a T-Flex training workshop for 2 IRD technicians in November 2015. Similar training for Brazilian technicians will be provided in anticipation of the replacement in 2017 of additional PIRATA sites maintained by DHN and INPE.

5.4 TPOS2020

The Tropical Pacific Observing System 2020 (TPOS 2020) is an international project under GOOS for review of the observing system. TPOS was originally designed in the 1980s based on 1980s science issues and largely on techniques from that era. The objectives of the TPOS 2020 are to redesign and refine the TPOS to observe ENSO and advance scientific understanding of its causes, to determine the most efficient and effective observational solutions to support prediction systems for ocean, weather and climate services, and to advance understanding of tropical Pacific physical and biogeochemical/ecosystem variability and predictability. A draft First Report on the TPOS 2020 was posted to the TPOS 2020 website: http://www.tpos2020.org in August 2016 and is available for download, review, and comment. The report summarizes the TPOS 2020 requirements and basis, design principles, integration, future evolution, and implementation.

5.5 Retirement of Pacific TRITON Sites

In 2000 JAMSTEC assumed responsibility for 12 surface and 1 subsurface TAO sites between 137°E and 156°E, which established the TAO/TRITON array. At the same time, JAMSTEC established 4

additional TRITON moorings along 130° and 138°E. In 2012 JAMSTEC began to retire some TRITON sites in the Pacific. At present 8 of the original TAO surface sites are active. Plans for later in 2016 are to retire 6 of these. In addition to the remaining 2 sites, JAMSTEC will continue to maintain an ADCP mooring at 0°, 156°E (not a formal TAO/TRITON site) and will deploy a new TRITON mooring at 13°N, 138°E (north of TAO/TRITON).

5.6 Research experiments

Four TPOS 2020 experiments to be conducted over a 4 year period have been funded by NOAA. These include:

- Enhanced ocean boundary layer observations on the TAO moorings
- Profiling Rainfall, Wind Speed, and Biogeochemical Sensors for Use in the Tropical Pacific Observing System
- Autonomous Surface Vessels as Low-Cost TPOS Platforms for Observing the Planetary Boundary Layer and Surface Biogeochemistry
- Development and Testing of Direct (Eddy Covariance) Turbulent Flux Measurements for NDBC TAO Buoys

PMEL conducted a multi-year (2008-2014) process study within RAMA with the addition of 9 subsurface ADCP moorings in the region spanning 2.5°N to 4°S and 78°E to 83°E. After removal of some sites in 2014 to 2016, the array will continue with 3 ADCP sites in addition to those formally in RAMA.

The Second International Indian Ocean Expedition (IIOE-2, 2015-2020) is in progress. IndOOS, of which RAMA is a major component, will provide basin-scale, multi-year observations for IIOE-2. IIOE-2 in turn presents an opportunity to complete and enhance RAMA. The Eastern Indian Ocean Upwelling Research Initiative (EIOURI) is a core contribution to IIOE-2. EIOURI related experiments will be conducted in 2017/2018 in conjunction with a Years of Maritime Continent cruises aboard Japan's R/V Mirai and China's R/V Xiang-Yang-Hong-01.

JAMSTEC is developing instrumentation for use on Wave Gliders to make air-sea flux measurements. Test deployments near Palau and Micronesia are planned for later in 2016.

5.6 Vandalism

Damage to buoys and theft of instrumentation continues to be a concern, especially at sites near areas of intense fishing activity such as the far eastern and western equatorial Pacific and equatorial Indian Ocean. JAMSTEC has experienced increased vandalism to their TRITON moorings in the eastern equatorial Indian Ocean. They suspect that a change in fishing method from long line to purse seine may be the cause, as moorings can be more susceptible to damage from nets compared to monofilament long line. Analysis of data return confirms that data losses have increased in the area over the past 5 years.

Details and metrics of vandalism experienced in TAO/TRITON, PIRATA and RAMA are given in the DBCP Working Group on Vandalism Report. Surprisingly, vandalism has abated significantly in the Gulf of Guinea in recent years relative to the late 1990s and early 2000s.

5.7 Piracy

In addition to vandalism, well-publicized piracy events delayed RAMA implementation off Africa and in the Arabian Sea. Prior to December 2015, Lloyds of London defined an Exclusion Zone (EZ) north of 12°S and west of 78°E in which additional premiums apply to insure commercial vessels. In response, Sea Marshalls were stationed aboard some RAMA cruises in 2012 and 2013. South Africa would not permit the RV Algoa to enter the EZ in 2013. Pirate attacks have diminished dramatically in the past several years, both in number and distance from Somalia. Lloyds reduced the area of the EZ by moving its eastern border from 78°E to 65°E in December 2015. Reported pirate attacks in the Gulf of Guinea have increased in number, exceeding those in the Indian Ocean. While primarily

occurring in nearshore waters and far from PIRATA moorings, these reports are of concern for future cruises that use ports in the region.

	2010	2011	2012	2013	2014	2015	2016
Indian Ocean							
Vessels Hijacked	51	27	7	0	0	0	0
Vessels Boarded	16	17	1	0	0	0	0
Vessels Fired Upon/ Attempted Boarding	119	122	24	9	2	0	0
Gulf of Guinea							
Vessels Hijacked	1	19	14	11	9	2	2
Vessels Boarded	26	41	31	26	33	29	24
Vessels Fired Upon/ Attempted Boarding	12	26	30	43	31	40	73
Kidnapping	17	18	14	32	26	27	26

Table of reported acts of piracy in the Indian Ocean and Gulf of Guinea from 2010 to 2016 (though August 24, 2016). Source: U.S. Office of Naval Intelligence. http://www.oni.navy.mil/Intelligence-Community/Piracy/

5.7 Publications

TIP data are used by many researchers worldwide. The following are recent publications by TIP Principle Investigators and other research which draws upon TIP observations:

Amaya, D. J., S.-P. Xie, A. J. Miller, and M. J. McPhaden, 2015: Seasonality of tropical Pacific decadal trends during the 21st century global warming hiatus. *J. Geophys. Res.*, 120, 6782-6798, doi:10.1002/2015JC010906.

Ascani, François, Eric Firing, Julian P. McCreary, Peter Brandt, and Richard J. Greatbatch, 2015: The Deep Equatorial Ocean Circulation in Wind-Forced Numerical Solutions. *J. Phys. Oceanogr.*, 45, 1709–1734, http://dx.doi.org/10.1175/JPO-D-14-0171.1

Ayako, S., N. Motoki, H. Takuya, Y. Kunio, 2015: Seasonal onset of the Madden-Julian Oscillation and its relation to the southeastern Indian Ocean cooling, Journal of the Meteorological Society of Japan, 93A, 139 – 156.

Boilley, A. and L. Wald, 2015: Comparison between meteorological re-analyses from ERAInterim and MERRA and measurements of daily solar irradiation at surface. *Renewable Energy*, 75, 135-143.

Boutin, J., Y. Chao, W. Asher, T. Delcroix, R. Drucker, K. Drushka, N. Kolodziejczyk, T. Lee, N. Reul, G. Reverdin, J. Schanze, A. Soloviev, L. Yu, J. Anderson, L. Brucker, E. Dinnat, A. Santos-Garcia, W. Jones, C. Maes, T. Meissner, W. Tang, N. Vinogradova, and B. Ward, 2016: Satellite and In Situ Salinity : Understanding Near-Surface Stratification and Sub-footprint Variability. *Bull. Amer. Meteor. Soc.*, in press, http://dx.doi.org:/10.1175/BAMS-D-15-00032.1.

Brandt, P., M. Claus, R. J. Greatbatch, R. Kopte, J. M. Toole, W. E. Johns, and C. W. Böning, 2016: Annual and semi-annual cycle of equatorial Atlantic circulation associated with basin mode resonance. *J. Phys. Oceanogr.*, in press, http://dx.doi.org/10.1175/JPO-D-15-0248.1.

Burmeister, K., P. Brandt, and J. F. Lübbecke, 2016: Revisiting the cause of the eastern equatorial Atlantic cold event in 2009. *J. Geophys. Res. Oceans*, 121, 4777–4789, http://dx.doi.org/10.1002/2016JC011719.

Cai, W. A. Santoso, G. Wang, S.-W. Yeh, S.-I. An, K. Cobb, M. Collins, E. Guilyardi, F.-F.Jin, J.-S. Kug, M. Lengaigne, M. J. McPhaden, K. Takahashi, A. Timmermann, G. Vecchi, M. Watanabe, L. Wu, 2015: ENSO Extremes and global warming, *Nature Climate Change*, 5, 849-859.

Cai, W., G. Wang, A. Santoso, M.J. McPhaden, L. Wu, F.-F. Jin, A. Timmermann, M. Collins, G. Vecchi, M. Lengaigne, M.H. England, D. Dommenget, K. Takahashi, and E. Guilyardi, 2015:

Increasing frequency of extreme La Niña events induced by greenhouse warming. *Nature Geosci.*, 5, 132-137, doi: 10.1038/nclimate2492.

Camara, I., N. Kolodziejczyk, J. Mignot, A. Lazar, and A. T. Gaye, 2015: On the seasonal variations of salinity of the tropical Atlantic mixed layer. *J. Geophys. Res. Oceans*, 120, 4441–4462, http://dx.doi.org/10.1002/2015JC010865.

Castellanos, P., E. J. D. Campos, I. Giddy, and W. Santis, 2016: Inter-comparison studies between high-resolution HYCOM simulation and observational data: The South Atlantic and the Agulhas leakage system. *J. Marine Sys.*, 159, 76—88, http://dx.doi.org/10.1016/j.jmarsys.2016.02.010.

Chen, G., W. Han, Y. Li, Dongxiao Wang, M. J. McPhaden, 2015: Seasonal-to-Interannual Time Scale Dynamics of the Equatorial Undercurrent in the Indian Ocean. *J. Phys. Oceanogr.*, 45, 1532-1553.

Chen, D., T. Lian, C. Fu, M. A. Cane, Y. Tang, R. Murtugudde, X. Song, Q. Wu, and L. Zhou, 2015: Strong influence of westerly wind bursts on El Niño diversity. *Nature Geosci.*, doi: 10.1038/NGEO2399.

Chiodi, A.M. and D.E. Harrison, 2015: Equatorial Pacific easterly wind surges and the onset of La Niña events. *J. Climate*, 28, 776-792.

Cintra, M. M., C. A.D. Lentini, J. Servain, M. Araujo, and E. Marone, 2015: Physical processes that drive the seasonal evolution of the Southwestern Tropical Atlantic Warm Pool. *Dyn. Atmos. and Oceans*, 72, 1-11.

Cuypers, Y., P. Bouruet-Aubertot, J. Vialard, M.J. McPhaden, 2016: Focusing of internal tides by near inertial waves. *Geophys, Res. Lett.*, submitted.

D'Mello, J. R. and P. Kumar, 2015: Why is the Bay of Bengal experiencing a reduced rate of sea surface warming? *Int. J. Climatol.*, DOI: 10.1002/joc.4414.

de Szoeke, S.P., J.B. Edson, J.R. Marion, C.W. Fairall and L. Bariteau, 2015: The MJO and air-sea interaction in TOGA COARE and DYNAMO. *J. Climate*, 28, 598-622. DOI: http://dx.doi.org/10.1175/JCLI-D-14-00477.1.

Drushka, K. H. Bellenger, E. Guilyardi, M. Lengaigne, J. Vialard, G. Madec, 2015: Processes driving intraseasonal displacements of the eastern edge of the warm pool: the contribution of westerly wind events. *Clim. Dyn.*, 44, 735-755, doi10.1007/s00382-014-2297-z

Duan, Y., L. Liu, G. Han, H. Liu, W. Yu, G. Yang, H. Wang, H. Wang, Y. Liu, Zahid, and H. Waheed, 2016: Anomalous behaviors of Wyrtki Jets in the equatorial Indian Ocean during 2013. *Sci. Rep.* 6, 29688; doi: 10.1038/srep29688.

Fedorov, A. V., S. Hu, M. Lengaigne, and E. Guilyardi, 2015: The impact of westerly wind bursts and ocean initial state on the development and diversity of El Niño events. *Clim. Dyn.* 44, 1381-1401.

Foltz, G., C. Schmid and R. Lumpkin, 2015: Transport of surface freshwater from the equatorial to the subtropical North Atlantic Ocean. *J. Phys. Oceanogr.*, 45 (4), 1086—1102, http://dx.doi.org/10.1175/JPO-D-14-0189.1.

Freeman, E., S. D. Woodruff, S. J. Worley, S. J. Lubker, E. C. Kent, W. E. Angel, D. I. Berry, P. Brohan, R. Eastman, L. Gates W. Gloeden, Z. Ji, J. Lawrimore, N. A. Rayner, G. Rosenhagen, and S. R. Smith, 2016: ICOADS Release 3.0: a major update to the historical marine climate record. *Int. J. Climatol.*, in press, http://dx.doi.org/10.1002/joc.4775.

Giarolla, E., L. S. P. Siqueira, M. J. Bottino, M. Malagutti, V. B. Capistrano, and P. Nobre, 2015: Equatorial Atlantic Ocean dynamics in a coupled ocean–atmosphere model simulation. *Ocean Dynamics*, 65 (6), 831-843.

Grodsky, S. A., B. K. Johnson, J. A. Carton, and F. O. Bryan, 2015: Interannual Caribbean salinity in satellite data and model simulations. *J. Geophys. Res. Oceans*, 120, 1375– 1387, http://dx.doi.org/10.1002/2014JC010625.

Horii, T., I. Ueki, K. Ando, T. Hasegawa, K. Mizuno, and A. Seiki, 2016: Impact of intraseasonal salinity variations on sea surface temperature in the eastern equatorial Indian Ocean. *J. Oceanogr.*, 72, 313-326.

Horii, T., F. Syamsudin, S. Ibnu, I. Ueki, and K. Ando, 2016: Intraseasonal coastal upwelling signal along the southern coast of Java observed using Indonesian tidal station data. *J. Geophys. Res. Oceans*, 121, 2690–2708, doi:10.1002/2015JC010886.

Hounsou-Gbo, G. A., J. Servain, M. Araujo, E. S. Martins, B. Bourlès, and G. Caniaux, 2016: Oceanic Indices for Forecasting Seasonal Rainfall over the Northern Part of Brazilian Northeast. *American Journal of Climate Change*, 5 (2), 261-274.

Hounsou-Gbo, G. A., M. Araujo, B. Bourlès, D. Veleda, and J. Servain, 2015: Tropical Atlantic contributions to strong rainfall variability along the Northeast Brazilian coast. *Advances in Meteorology*, 2015, Article ID 902084, http://dx.doi.org/10.1155/2015/902084.

Hu, Z.-Z. and A. Kumar, 2015: Influence of availability of TAO data on NCEP ocean data assimilation systems along the equatorial Pacific. *J. Geophys. Res. Oceans*, 120, 5534-5544. doi: 10.1002/2015JC010913.

Izumo, T., J. Vialard, H. Dayan, M. Lengaigne, and I. Suresh, 2015: A simple estimation of equatorial Pacific response from windstress to untangle Indian Ocean Dipole and Basin influences on El Niño . *Clim. Dyn.*, doi:10.1007/s00382-015-2700-4.

Jadhav, J., S. Panickal, S. Marathe, and K. Ashok, 2015: On the possible cause of distinct El Niño types in the recent decades. *Nature Sci. Rep.*, 5, doi:10.1038/srep17009.

Jensen, T.G., T. Shinoda, S. Chen, and M.Flatau, 2015: Ocean response to CINDY/DYNAMO MJOs in air-sea coupled COAMPS. *J. Meteor. Soc. Japan*, 93A, 157-178. http://doi.org/10.2151/jmsj.2015-049.

Klepp, C., 2015: The Oceanic Shipboard Precipitation Measurement Network for Surface Validation: OceanRAIN. *Atmospheric Res.*, 163, http://dx.doi.org/10.1016/j.atmosres.2014.12.014.

Kolodziejczyk, N., G. Reverdin, and A. Lazar, 2015: Interannual Variability of the Mixed Layer Winter Convection and Spice Injection in the Eastern Subtropical North Atlantic. *J. Phys. Oceanogr.*, 45, 504–525, http://dx.doi.org/10.1175/JPO-D-14-0042.1.

Kumar, A., M. Chen, Y. Xue, and D. Behringer, 2015: An Analysis of the Temporal Evolution of ENSO Prediction Skill in the Context of the Equatorial Pacific Ocean Observing System. *J. Climate*, in press.

Legler, D.M., H.J. Freeland, R. Lumpkin, G. Ball, M.J. McPhaden, S. North, R. Crowley, G.J. Goni, U. Send, and M.A. Merrifield, 2015: The current status of the real-time in situ Global Ocean Observing System for operational oceanography. *J. Operational Oceanogr.*, 8, Suppl. 2, s189-s200, http://dx.doi.org/10.1080/1755876X.2015.1049883.

Levine, A. F. Z., F. F. Jin, M. J. McPhaden, 2016: Extreme Noise-Extreme El Niño: How State-Dependent Noise Forcing Creates El Niño-La Niña Asymmetry. *J. Climate*, 29, 5483-5499. DOI: http://dx.doi.org/10.1175/JCLI-D-16-0091.1.

Levine, A. F. Z., and M. J. McPhaden, 2016: How the July 2014 Easterly Wind Burst Gave the 2015-6 El Niño a Head Start. *Geophys. Res. Lett.*, 43, 6503-6510. DOI:10.1002/2016GL069204.

Li, K., Y. Liu, Y. Yang, Z. Li, B. Liu, L. Xue and W. Yu, 2015: Possible role of pre-monsoon sea surface warming in driving the summer monsoon onset over the Bay of Bengal. *Climate Dyn.*, DOI: 10.1007/s00382-015-2867-8.

Li, K., Z. Li, Y. Yang, B. Xiang, Y. Liu and W. Yu, 2015: Strong modulations on the Bay of Bengal monsoon onset vortex by the first northward propagating intra-seasonal oscillation. Climate Dyn., DOI: 10.1007/s00382-015-2826-4.

Li, Y., W. Han, and T. Lee, 2015: Intraseasonal sea surface salinity variability in the equatorial Indo-Pacific Ocean induced by Madden-Julian oscillations, *J. Geophys. Res.*, 120, 2233-2258, doi:10.1002/2014JC010647.

Liu, C., A. Kohl, Z. Liu, F. Wang, and D. Stammer, 2016: Deep-reaching thermocline mixing in the equatorial pacific cold tongue. *Nat Commun.* 7, doi:10.1038/ncomms11576.

Lübbecke, J. F., J. V. Durgadoo, and A. Biastoch, 2015: Contribution of Increased Agulhas Leakage to Tropical Atlantic Warming. *J. Climate*, 28, 9697–9706, http://dx.doi.org/10.1175/JCLI-D-15-0258.1.

Lumpkin, R., L. Centurioni, and R. C. Perez, 2016: Fulfilling observing system implementation requirements with the Global Drifter Array. *J. Atmos. Ocean. Tech.*, 33, 685-695.

Martins, S., M., N. Serra, and D. Stammer, 2015: Spatial and temporal scales of sea surface salinity variability in the Atlantic Ocean. *J. Geophys. Res. Oceans*, 120, 4306–4323, http://dx.doi.org/10.1002/2014JC010649.

Masumoto Y., M. Nagura, T. Miyama, Shang-Ping Xie, Zuojun Yu, J. P. McCreary Jr., P. N. Vinayachandran, Raleigh R. Hood, Hezi Gildor, 2016: Ocean Processes Relevant to Climate Variations in the Indian Ocean Sector Indo-Pacific Climate Variability and Predictability, T. Yamagata and S. K. Behera, eds.,7, 8, 25 – 61

McGregor, S., A. Timmermann, F.-F. Jin, W. S. Kessler, 2015: Charging El Niño with off-equatorial westerly wind events. *Clim Dyn.* 45, 1-15, DOI 10.1007/s00382-015-2891-8.

McPhaden, M. J., 2015: Playing hide and seek with El Niño. *Nature Climate Change*, 5, 791-795.

McPhaden, M. J., A. Timmermann, M. J. Widlansky, M. A. Balmaseda and T. N. Stockdale, 2015: The Curious Case of the El Niño that Never Happened: A Perspective from 40 Years of Progress in Climate Research and Forecasting. *Bull. Am. Meteorol. Soc.*, 96, 1647-1665, doi: http://dx.doi.org/10.1175/BAMS-D-14-00089.1.

McPhaden, M. J., Y. Wang, and M. Ravichandran, 2015: Volume transports of the Wyrtki Jets and their Relationship to the Indian Ocean Dipole. *J. Geophys. Res.*, 120, 5302–5317, doi:10.1002/2015JC010901.

Nagura M., T. Terao, M. Hashizume, 2015: The role of temperature inversions in the generation of seasonal and interannual SST variability in the far northern Bay of Bengal, Journal of Climate, 28 / 9 / 3671 – 3693.

Nagura M. and Y. Masumoto, 2015: A wake due to the Maldives in the eastward Wyrtki jet, Journal of Physical Oceanography, 45, 1858 – 1876.

Nagura, M. and M.J. McPhaden, 2016: Zonal propagation of near surface zonal currents in relation to surface wind forcing in the equatorial Indian Ocean. *J. Geophys. Res.*, submitted.

Nubi, O. A., B. Bourlès B., C. A. Edokpayi and M. N. Hounkonnou, 2016: On the Nutrient distribution and phytoplankton biomass in the Gulf of Guinea equatorial band as inferred from In-situ measurements. *J. Oceanogr. and Marine Sci.*, 7 (1), 1-11, http://dx.doi.org/10.5897/JOMS2016.0124.

Penny, S. G., D. W. Behringer, J. A. Carton, and E. Kalnay, 2015: A Hybrid Global Ocean Data Assimilation System at NCEP. *Mon. Wea. Rev.*, 143, 4660–4677, http://dx.doi.org/10.1175/MWR-D-14-00376.1.

Pujiana, K., J.N. Moum, W.D. Smyth, and S.J. Warner, 2015: Distinguishing ichthyogenic turbulence from geophysical turbulence, *J. Geophys. Res. Oceans*, 120, 3792-3804. doi:10.1002/2014JC010659.

Puy, M., J. Vialard, M. Lengaigne, and E. Guilyardi, 2015: Modulation of equatorial Pacific westerly/easterly wind events by the Madden-Julian oscillation and convectively-coupled Rossby waves. *Clim. Dyn.*, DOI 10.1007/s00382-015-2695-x.

Puy, M., J. Vialard, M. Lengaigne, E. Guilyardi, A. Voldoire, M. Balmaseda, G. Madec, C. Menkes, and M.J. McPhaden, 2016 : 2015 vs. 2014: The El Niño lottery? *Nature Comm.*, submitted.

Rao, R.R., T. Horii, Y. Masumoto, K. Mizuno, 2016: Observed variability in the upper layers at the Equator, 90°E in the Indian Ocean during 2001-2008, 1: zonal currents. *Clim. Dyn.*, DOI 10.1007/s00382-016-3234-0.

Rao, R.R., T. Horii, Y. Masumoto, K. Mizuno, 2016: Observed variability in the upper layers at the Equator, 90°E in the Indian Ocean during 2001-2008, 2: meridional currents. *Clim. Dyn.*, DOI 10.1007/s00382-016-2979-9.

Richter, I., P. Chang, Z. Xu, T. Doi, T. Kataoka, M. Nagura, Pascal Oettli, S. de Szoeke, and T. Tozuka, 2016: An overview of coupled GCM performance in the tropics. Indo-Pacific Climate Variability and Predictability, World Scientific Series on Asia-Pacific Weather and Climate, T. Yamagata and S. K. Behera, eds.,7, 8, 213 – 263.

Rodríguez-Fonseca, B., E. Mohino, C. R. Mechoso, C. Caminade, M. Biasutti, M. Gaetani, J. Garcia-Serrano, E. K. Vizy, K. Cook, Y. Xue, I. Polo, T. Losada, L. Druyan, B. Fontaine, J. Bader, F. J. Doblas-Reyes, L. Goddard, S. Janicot, A. Arribas, W. Lau, A. Colman, M. Vellinga, D. P. Rowell, F. Kucharski, and A. Voldoire, 2015: Variability and Predictability of West African Droughts: A Review on the Role of Sea Surface Temperature Anomalies. *J. Climate*, 28, 4034–4060, http://dx.doi.org/10.1175/JCLI-D-14-00130.1.

Rugg, A., G. R. Foltz, and R. C. Perez, 2016: Role of mixed layer dynamics in tropical North Atlantic interannual sea surface temperature variability. *J. Climate*, in press, http://dx.doi.org/10.1175/JCLI-D-15-0867.1.

Santoso, A., W. Cai, M, Collins, M. McPhaden, F.-F. Jin, E. Guilyardi, G. Vecchi, D. Dommenget, and G. Wang, 2015: ENSO Extremes and Diversity: Dynamics, Teleconnections, and Impacts. *Bull. Am. Meteor. Soc.*, 96, 1969-1972.

Sena Martins, M., N. Serra, and D. Stammer, 2015: Spatial and temporal scales of sea surface salinity variability in the Atlantic Ocean. *J. Geophys. Res. Oceans*, 120, 4306–4323, http://dx.doi.org/10.1002/2014JC010649.

Smyth, W. D., T. S. Durland, and J. N. Moum, 2015: Energy and heat fluxes due to vertically propagating Yanai waves observed in the equatorial Indian Ocean, *J. Geophys. Res. Oceans*, 120, 1–15, doi:10.1002/2014JC010152.

Strutton, P. G., V. J. Coles, R. R. Hood, R. J. Matear, M. J. McPhaden and H. E. Phillips, 2014: Biogeochemical variability in the equatorial Indian Ocean during the monsoon transition. *Biogeochem.*, 12,2367-2382, doi:10.5194/bg-12-1-2015.

Sutton, A.J., C.L. Sabine, R.A. Feely, W.-J. Cai, M.F. Cronin, M.J. McPhaden, J.M. Morell, J.A. Newton, J.-H. Noh, S.R. Ólafsdóttir, J.E. Salisbury, U. Send, D.C. Vandemark, 2016: Using present-day observations to detect when anthropogenic change forces surface ocean carbonate chemistry outside pre-industrial bounds. *Biogeosci.*, in press.

Takahashi, K. and B. Dewitte, 2015: Strong and moderate nonlinear El Niño regimes. *Clim. Dyn.*, doi:10.1007/s00382-015-2665-3.

Tchilibou, M., T. Delcroix, G. Alory, S. Arnault, and G. Reverdin, 2015: Variations of the tropical Atlantic and Pacific SSS minimum zones and their relations to the ITCZ and SPCZ rain bands (1979–2009). *J. Geophys. Res. Oceans*, 120, 5090–5100, http://dx.doi.org/10.1002/2015JC010836.

Valdivieso, M., Haines, K., Balmaseda, M. et al., 2015: An assessment of air–sea heat fluxes from ocean and coupled reanalyses. *Clim. Dyn.*, http://dx.doi.org/10.1007/s00382-015-2843-3.

Wenegrat, J. O. and M. J. McPhaden, 2016: A simple analytical model of the diurnal Ekman layer. *J. Phys. Oceanogr.*, in press, http://dx.doi.org/10.1175/JPO-D-16-0031.1.

Wenegrat, J.O., and M.J. McPhaden, 2015: Dynamics of the surface layer diurnal cycle in the equatorial Atlantic Ocean (0°, 23°W). *J. Geophys. Res. Oceans*, 120, 563-581, http://dx.doi.org/10.1002/2014JC010504.

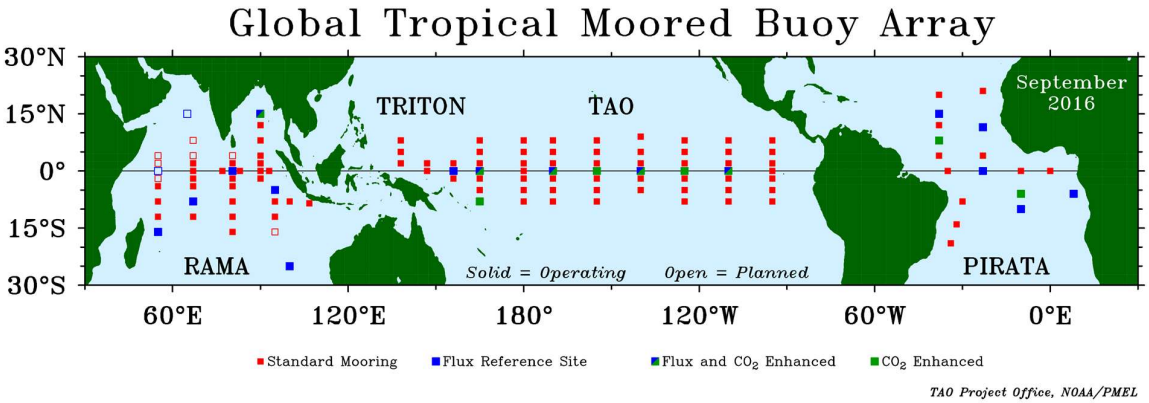
Xiangze, J. L. Yu, D. L. Jackson, and G. A. Wick, 2015: An Improved Near-Surface Specific Humidity and Air Temperature Climatology for the SSM/I Satellite Period. *J. Atmos. Oceanic Technol.*, 32, 412–433, http://dx.doi.org/10.1175/JTECH-D-14-00080.1.

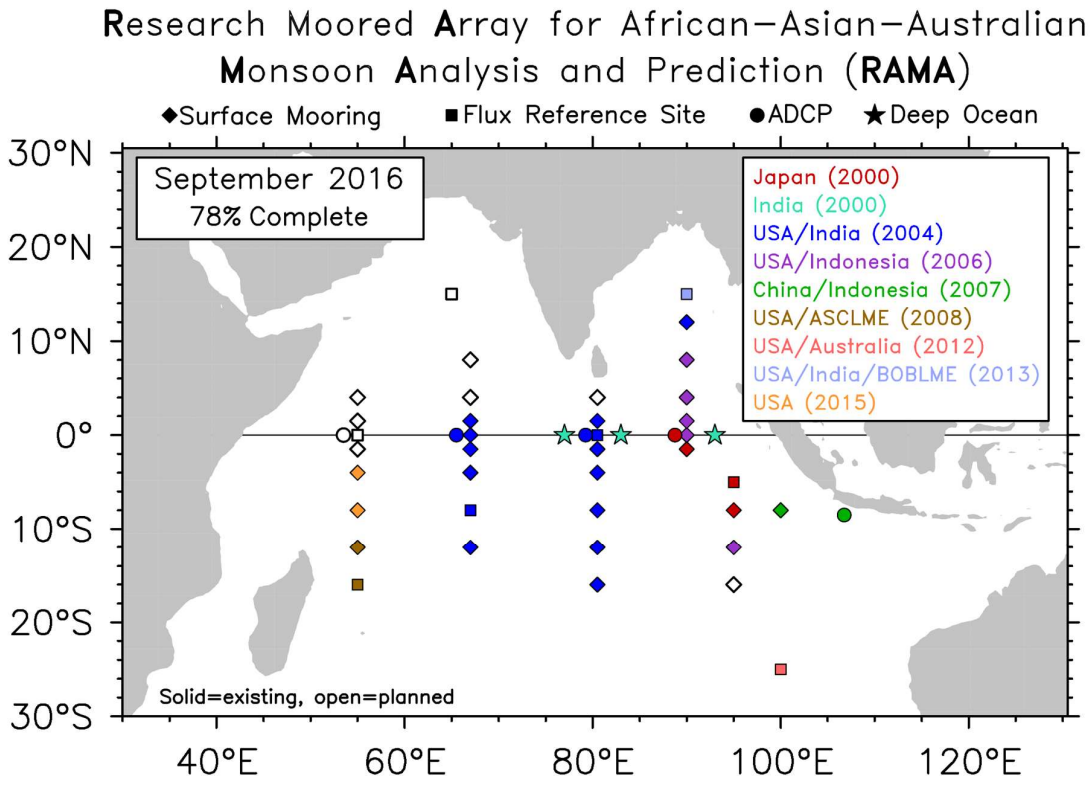
Yang Y., T. Li, K. Li and W. Yu, 2015: What Controls Seasonal Variations of the Diurnal Cycle of Sea Surface Temperature in the Eastern Tropical Indian Ocean? *J. Climate*, 28, 8466-8485. DOI: 10.1175/JCLI-D-14-00826.1.

Yang, G., W. Yu, Y. Yuan, X. Zhao, F. Wang, G. Chen, L. Liu, Y. Duan, 2015: Characteristics, vertical structures and heat/salt transports of mesoscale eddies in the Southeastern Tropical Indian Ocean, J. Geophys. Res.-Oceans, DOI: 10.1002/2015JC011130.

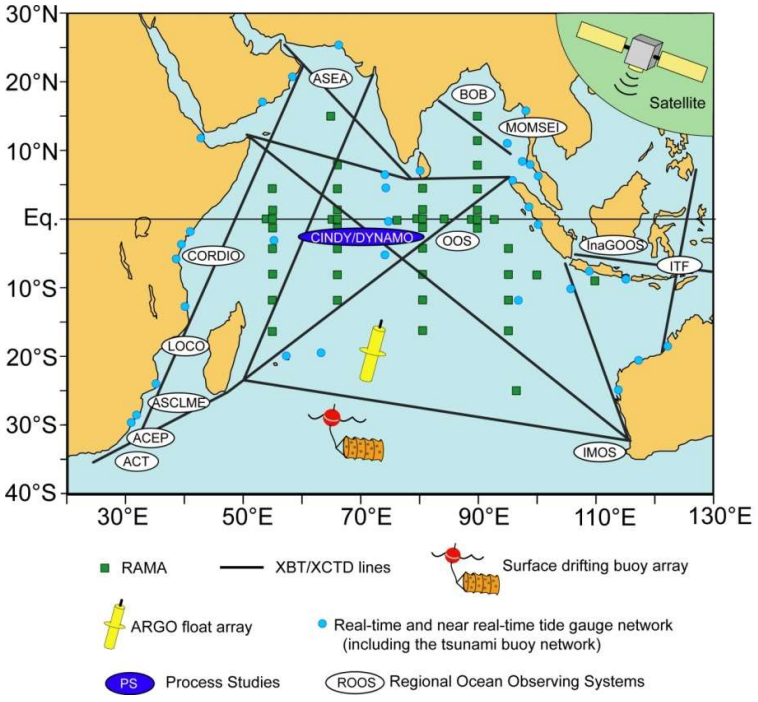
Annex

Status maps and graphics





Indian Ocean Observing System (IndOOS)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Satellite
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BOB
MOMSEI
CINDY/DYNAMO
OOS
CORDIO
InaGOOS
ITF
LOCO
ASCLME
ACEP
ACT
IMOS
RAMA
XBT/XCTD lines
Surface drifting buoy array
ARGO float array
Real-time and near real-time tide gauge network
(including the tsunami buoy network)
PS
Process Studies
ROOS
Regional Ocean Observing Systems

APPENDIX G

IABP
International Antarctic Buoys Programme

Name of Action Group	International Arctic Buoy Programme (IABP)
Date of report	17 Sep 2016
Overview and main requirements addressed	Participants of the IABP continue to work together to maintain a network of drifting buoys on the ice of the Arctic Basin to provide meteorological and oceanographic data for real-time operational requirements and research purposes including support to the World Climate Research Programme (WCRP) and the World Weather Watch (WWW) Programme.
Area of interest	Central Arctic Ocean and its marginal seas, excepting Exclusive Economic Zones, where agreements of the Coastal States have not been obtained.
Type of platform and variables measured	Buoys on ice and/or in water measuring: Basic meteorological variables such as atmospheric air pressure and air temperature. Other variables such as: atmospheric pressure tendency, air chemistry (e.g. ozone), snow and sea-ice properties, as well as sub-surface oceanographic characteristics (e.g. temperature and salinity)
Targeted horizontal resolution	250 km x 250 km
Chairperson/Managers	Chairperson: Christine Best, Meteorological Service Canada
Coordinator	Ignatius Rigor, Polar Science Center, University of Washington, USA
Participants	Participants range from Science Institutions to Universities to Government Agencies. http://iabp.apl.washington.edu/overview_participants.html Participant contributions are shown on this site http://iabp.apl.washington.edu/overview_contributions.html
Data centre(s)	
Website	http://iabp.apl.washington.edu/
Meetings *(meetings held in 2015/2016; and planned in 2016/2017)*	Annual meetings spring or early summer in the Northern Hemisphere. 25th Annual Meeting of the International Arctic Buoy Programme [IABP], hosted by the Korean Polar Research Institute (KOPRI) to coincide with KOPRI's International Polar Science Symposium in May, 2016. IPAB participants also reported. We are considering to hold the next IABP participants meeting in coordination with IPAB during the IGS/IACS/CliC 2017 Cryo Symposium in Wellington, NZ, during the week 12–17 February 2017.
Current status summary *(mid-2016)*	142 buoys were reporting in May 2016 (Figs. 1 and 2).

Summary of plans for 2016/17	Summer is the primary deployment season in the Arctic. Participants will deploy 70+ buoys ranging from: SVP's providing surface air pressure, buoys providing air pressure and air temperature, Ice Mass Balance buoys, Oceanographic Profiling buoys measuring temperature and salinity to great depths and buoys that measure atmospheric air components such as ozone. A broad overview map of our deployments plans is shown in Fig. 3. Details may be viewed at http://iabp.apl.washington.edu/overview_deploymentplans.html. Plans for future years will be similar.

2 Deployment plans for 2016/17

Deployment plans for 2016 will be posted on the IABP web page http://iabp.apl.washington.edu/overview_deploymentplans.html. As plans and opportunities for deployments become known, Participants are encouraged to contact the IABP Coordinator Ignatius Rigor Ignatius@uw.edu.

3 Data management

3.1 Distribution of the data

Most of the meteorological and oceanographic data is posted on the GTS. Much of the ice data and atmospheric chemistry data are available from Participants' web pages. Efforts continue to have those using Iridium communication to find means to post data to the GTS.

3.1.1 Data policy

Data exchange policies of the Participants for that data not getting onto the GTS has not been catalogued. However, most Participants have web sites that display data and/or graphs of the data.

3.1.2 Real-time data exchange

Participants are encouraged to transmit their data to the GTS. Most of the buoys deployed by the USIABP transmit to the GTS. Other participants are overwhelmed by new requirements due to increased usage of Iridium transmission.

3.1.3 Delayed mode data exchange

We work closely with the Integrated Science Data Management Service (ISDM) of the Department of Fisheries and Ocean (DFO), Canada on the reception, archiving, and posting of IABP GTS data.

3.2 Data quality

Feedback is ad hoc. Data is suppressed when noted to be questionable. The IABP Coordinator participates in the buoy QC forums of the DBCP and JCOMM, and performs day-to-day QC of the data. More thorough QC of the data is performed during the analysis and production of the research data bases.

4) Instrument practices

We are currently in the midst of a sensor intercomparison for the various buoys/instruments that we use to observe polar meteorology and oceanography at the Arctic Observing Experiment (AOX) test site in Barrow, Alaska.

Data analyses procedures for the Arctic are documented in journal papers. As part of our efforts to collect and provide the metadata, details on instruments and other procedures will be provided through our web pages.

5) Other issues as needed

- Our challenges remain the same, i.e. maintaining the network of buoys in an ocean of increasingly dynamic sea ice, and deploying buoys in the Eurasian Arctic.
- Need boost for YOPP

_____

Annex (optional)

Status maps and graphics

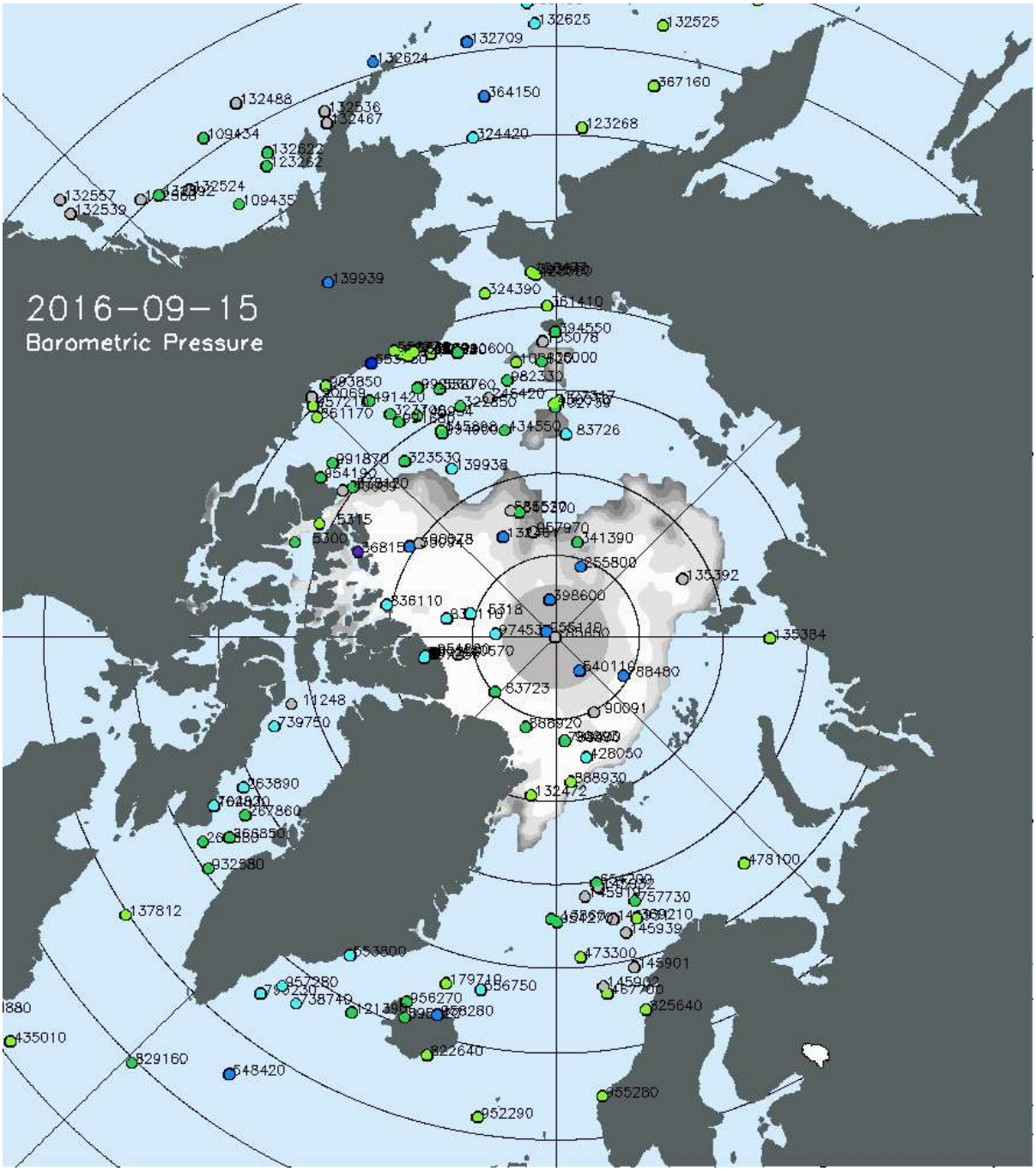

Figure 1. Map of buoy positions on 15 September 2016 from IABP.apl.uw.edu. 160 buoys were reporting.

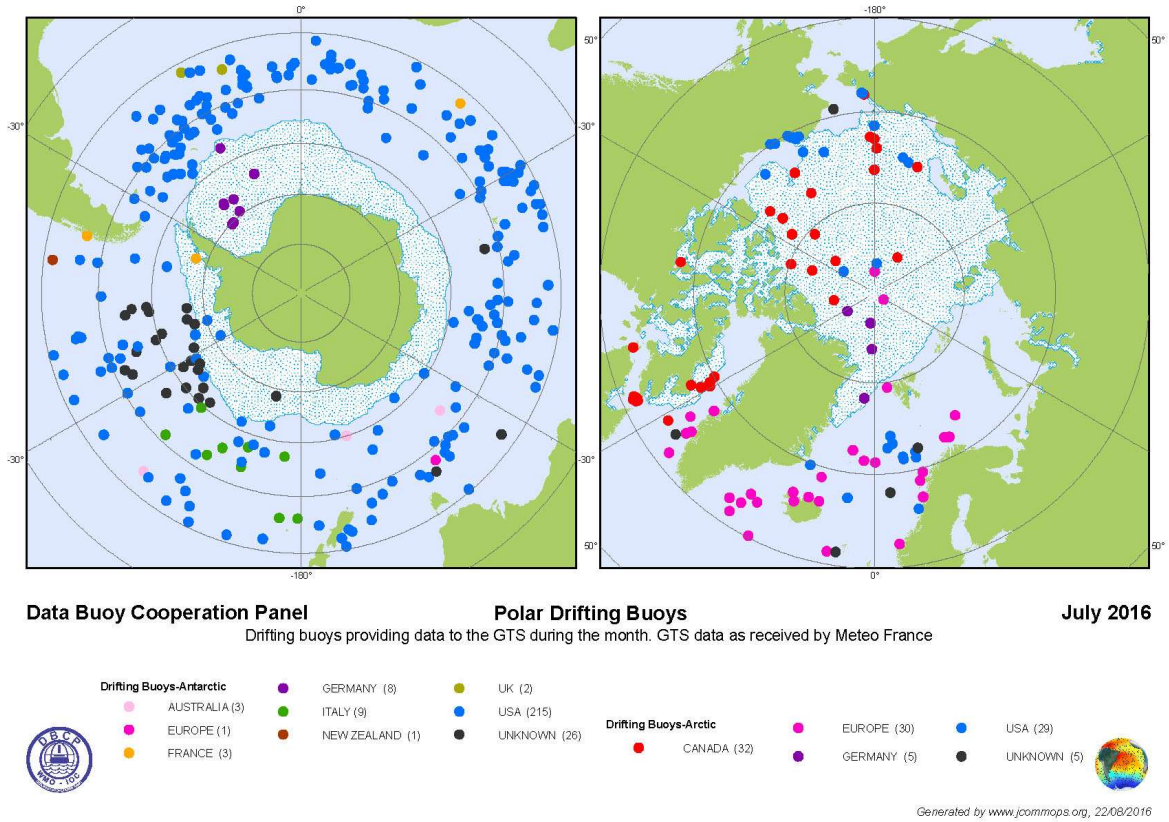

Figure 2. Map of buoys reporting on GTS on July 2016 from JCOMMOPS.

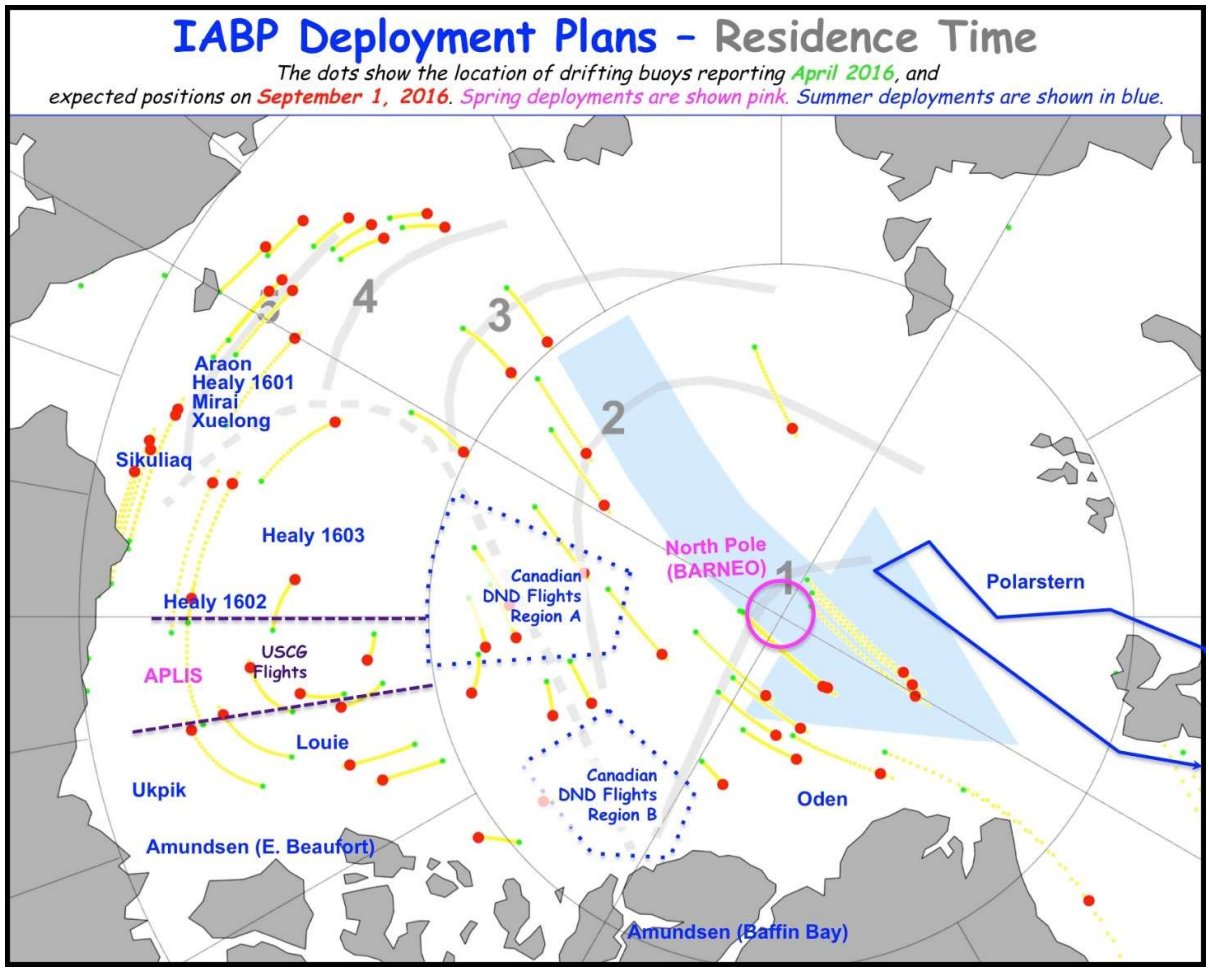

Figure 3. Broad overview of IABP deployment plans during the Spring (pink), and Summer (blue) of 2016. The IABP and Collaborators plan to deploy over 200 buoys at over 80 different locations. The cyan arrow shows the typical drift of buoys n the Arctic Ocean from Eurasia to Fram Strait and the North Atlantic. The grey lines show the average number of years it takes to drift to Fram Strait. The green dots show buoys that were reporting in April 2016, the yellow lines show the expected drift of these buoys through Summer, and the red dots show the expected position of these buoy in September 2016. We plan to deploy buoys using the logistics shown in blue to fill the holes in the IABP network. **This year the IABP will not be able to deploy buoys in the Eurasian Arctic (top of map).**

Details may be found at http://iabp.apl.washington.edu/overview_deploymentplans.html.

APPENDIX H

IPAB
WCRP/SCAR International Programme for Antarctic Buoys

1) Summary

Name of Action Group	WCRP/SCAR International Programme for Antarctic Buoys (IPAB)
Date of report	11 Sep 2016
Overview and main requirements addressed	The Participants of the WCRP/SCAR International Programme for Antarctic Buoys (IPAB) work together to maintain a network of drifting buoys in the Southern Ocean, in particular over sea ice, to provide meteorological and oceanographic data for real-time operational requirements and research purposes. The IPAB was established in 1994 and became an Action Group of the Panel in October 1994.
Area of interest	South of 55°S and that region of the Southern Ocean and Antarctic marginal seas within the maximum seasonal sea-ice extent.
Type of platform and variables measured	Ice buoys measuring the following: Minimum variables: Buoy position Basic variables: Buoy position, atmospheric pressure and SST Other variables: Air temperature, ice and/or snow temperature, atmospheric pressure tendency, wind speed and direction, snow accumulation, other sea-ice properties and oceanographic variables
Targeted horizontal resolution	500 km x 500 km
Chairperson/Managers	Dr Petra Heil, AAD and ACE CRC, Hobart, Australia
Coordinator	Dr Christian Haas, York University, Toronto, Canada; and: Alfred Wegener Institure for Polar and Marine Research, Bremerhaven, Germany Dr. Ignatius Rigor, University of Washington, Seattle, USA
Participants	- Alfred Wegener Institut, Germany - Australian Antarctic Division, Australia - Bureau of Meteorology, Australia - British Antarctic Survey, UK - Finnish Institute for Marine Research, Finland - GI, University of Alaska Fairbanks, USA - IARC, University of Alaska Fairbanks, USA - National Ice Center, USA - National Snow and Ice Data Center NSIDC, USA - ISDM/MEDS, Dept. of Fisheries and Ocean, Canada - Meteorological Service NZ LTD, New Zealand - Norwegian Polar Institute, Norway - Polar Science Center, Univ. of Washington, USA - National Institute of Polar Research, Japan - JAMSTEC, Japan - Programma Nazionale di Ricerche in Antartide, Italy - DAMTP, UK - SAMS, UK - York University, Toronto, Canada - CLS/Service Argos, France

	- South African Weather Service, South Africa- Meteorological Office, UK - CRREL, USA
Data centre(s)	Alfred Wegener Institute for Polar and Marine Research, Germany: http://www.pangaea.de/search?q=ipab National Snow and Ice Data Center NSIDC, USA: http://nsidc.org/data/docs/daac/nsidc0084_ipab_antarctic_buoys.gd.html
Website	http://www.ipab.aq/
Meetings *(meetings held in 2015/2016; and planned in 2016/2017)*	IPAB participants reported during the annual meeting of the International Arctic Buoy Programme IABP in Incheon, Korea, on May 12 and 13, 2016. It is considered to hold the next IPAB participants meeting during the IGS/IACS/CliC 2017 Cryo Symposium in Wellington, NZ, during the week 12–17 February 2017
Current status summary *(mid-2016)*	7 snow depth buoys, 9 IMBs, 7 SVPs and 3 AWSs were deployed on sea ice floes during AWI Polarstern cruise PS96/01 in the Eastern and Southern Weddell Sea, contributed by AWI. 11 SVP-B buoys with drogues were deployed in open water by USIPAB from the Polar Star in January 2016 on its trek from McMurdo to Punta Arenas. The South African National Drifting Weather Buoy Programme deployed 12 NOAA weather buoys during the 2015/16 period, north of the ice edge. The Meteorological Services Australia and New Zealand continue to operationally deploy numerous SVP's in the Southern Ocean, primarily north of the sea ice edge.
Summary of plans for 2016/17	USIPAB will deploy several SVPs in the Ross & Amundsen Sea. AWI will deploy few buoys in the Weddell Sea. South African Weather service plans to deploy 15 X drifters for 2016/17

2 Deployment plans for 2016/17

- USIPAB will deploy several SVPs in the Ross & Amundsen Sea. AWI will deploy few buoys in the Weddell Sea. Buoy contributions from other participants are welcome during these cruises.
- The Meteorological Services of South Africa, Australia, and New Zealand will continue to operationally deploy numerous SVP's in the Southern Ocean, primarily north of the sea ice edge.

3 Data management

3.1 Distribution of the data

3.1.1 Data policy

Data are generally freely distributed among IPAB participants as part of general scientific collaboration. Participants are encouraged to submit their data to the IPAB coordinator upon completion of their own scientific analyses.

3.1.2 Real-time data exchange

Participants are encouraged to transmit their data to the GTS. Most of the buoys deployed by the USIPAB program transmitted to the GTS. Other participants are overwhelmed by new requirements due to increased usage of Iridium transmission.

3.1.3 Delayed mode data exchange

We work closely with the Integrated Science Data Management Service (ISDM) of the Department of Fisheries and Ocean (DFO), Canada on the reception, archiving, and posting of IPAB GTS data.

3.2 Data quality

Data quality is an ongoing issue. QC is performed by the individual science groups, or by some national data centres and the DBCP when data are transmitted to the GTS.

4) Instrument practices

N/A

5) Other issues as needed

- GTS transmission of data remains a challenge; need to raise awareness of buoy operators
- Small number of buoys and short survival times remain important challenges, as does GTS transmission.
- Need boost for YOPP

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Annex (optional)

Status maps and graphics

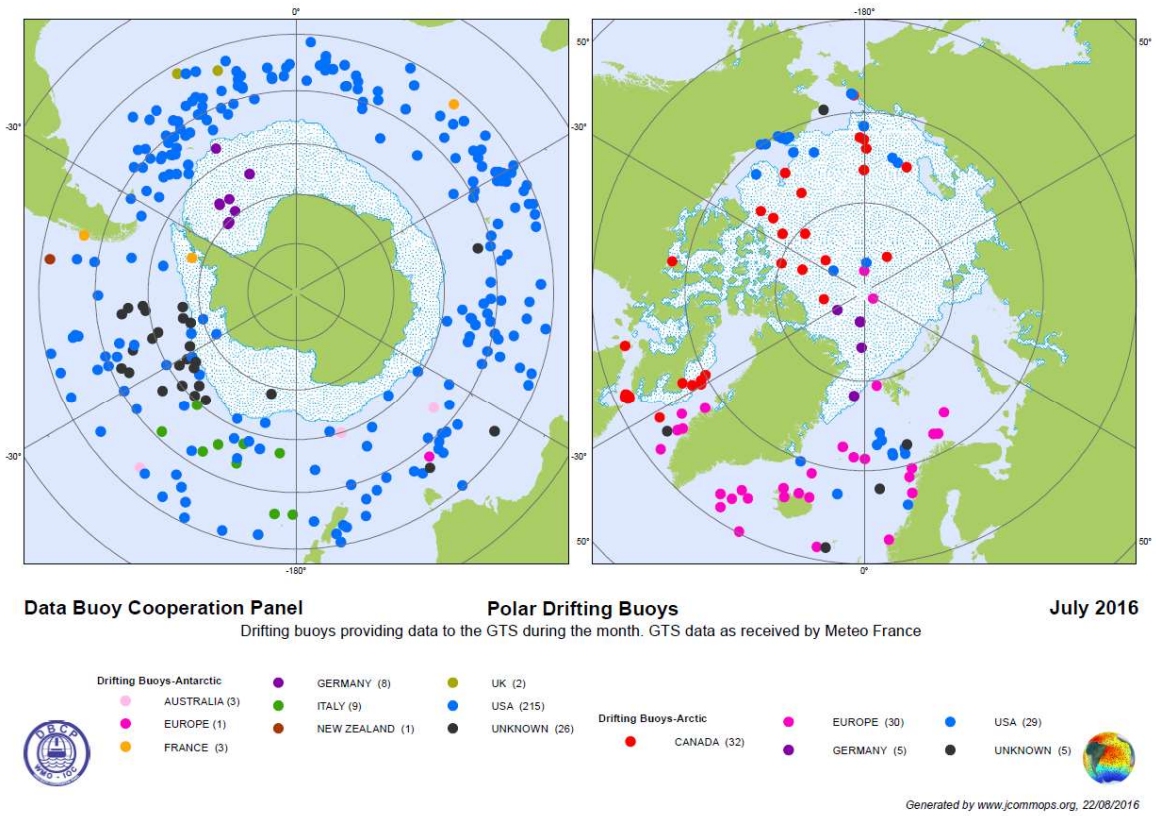

Figure 1: Status of Southern Ocean (left; and Arctic, right) GTS buoy network, July 2016. Downloaded from the DBCP @ http://www.jcommops.org/dbcp/network/maps.html .

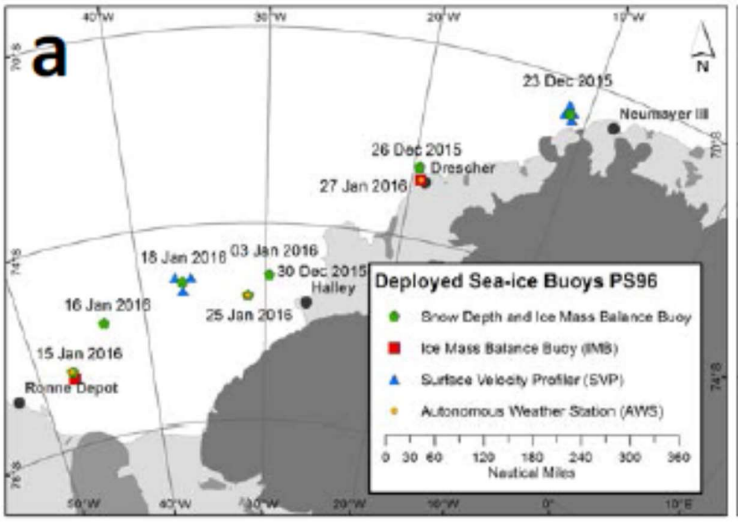

Figure 2: Map of all deployment locations of AWI buoys in January 2016. Map courtsey Stefanie Arndt, AWI, from PS96 cruise report.

INTERNATIONAL PROGRAMME FOR ANTARCTIC BUOYS

Report on the South African 2015/2016 National Drifting Weather Buoy Programme

The following report details progress of the South African National Drifting Weather Buoy Programme for the International Programme for Antarctic Buoys for the intersessional period 2015/2016, up to 30 June 2016. A total of 12 weather buoys were deployed during the 2015/16 period.

Drifting Weather Buoy Deployments

Deployments 2015/2016

Argos ID	Date of deployment	Latitude	Longitude
101810	13/11/2015	53° 11.30' S	044° 19.20' W
40433	17/12/2015	**53° 12.0'S**	**044° 11.5'W**
132636	27/12/2015	61° 09.80' S	025 0.20' W
132638	31/12/2015	52° 43.90' S	030° 0.00' W
132637	31/12/2015	52° 15.70' S	028° 0.00' W
132635	31/12/2015	50° 01.40' S	027° 0.20' W
132730	31/12/2015	51° 48.00' S	026° 03.80' W
139593	01/01/2016	51° 18.20' S	024° 0.00' W
132669	01/01/2016	51° 03.60' S	023° 0.00' W
132727	01/01/2016	51° 03.30' S	022° 58.50' W
132668	01/01/2016	51° 02.90' S	022° 56.80' W
J04VCY	01/01/2016	50° 49.00' S	21° 59.80' W
132728	01/01/2016	50° 31.00' S	020° 59.70' W
132729	01/01/2016	50° 30.60' S	020° 58.40' W
139595	01/01/2016	49° 58.60' S	018° 59.90' W
139587	12/03/2016	53° 09.30' S	044° 27.40' W

- One stationary buoy was deployed at South Thule Island (with the previously-stationary buoy being subsequently deployed as a drifter).
- Six drifters were handed over to South Georgia.
- This brings the total deployed number to **22**.

Partnerships

All drifters deployed as part of the IPAB were supplied by NOAA. The South African Weather Service (SAWS) remains grateful to NOAA in this regard. Most of these drifters were deployed during the annual voyage to Antarctica on board the national research vessel, *SA Agulhas II.* Three of the drifters reported on here were deployed by the vessel *Pharos SG*. The National Department of Environmental Affairs: Oceans & Coasts (DEA: OC) paid for ship time and deployments. The SAWS paid for the customs clearance of the buoys. The Government of South Georgia and the South Sandwich Islands allows SAWS to place a buoy on South Thule Island to provide consistent pressure readings for this area.

Challenges

Consistent reporting of drifter deployment by Falkland Islands.

Future Plans:

15 X drifters for 2016/17.

APPENDIX I

GDP
GLOBAL DRIFTER PROGRAMME

1 Summary

Name of Action Group	Global Drifter Program
Date of report	15 September 2016
Overview and main requirements addressed	Global Drifter Program (GPD). Goals: 1. Maintain a global 5x5° array of ~1300 satellite-tracked surface drifting buoys to meet the need for an accurate and globally dense set of in-situ observations of mixed layer currents, sea surface temperature, atmospheric pressure, winds and salinity; and 2. Provide a data processing system for scientific use of these data. These data support short-term (seasonal to interannual) climate predictions as well as climate research and monitoring.
Area of interest	Global ocean
Type of platform and variables measured	Lagrangian drifters measuring surface velocity, SST; some drifters also measure sea level pressure, wind, salinity, and/or sub-surface temperature profiles
Targeted horizontal resolution	5 degree x 5 degree (~1300 units)
Chairperson/Managers	Dr Rick Lumpkin, NOAA/AOML, USA Dr Luca Centurioni, SIO/CIMEC, USA
Coordinator	Operations Manager: Mr Shaun Dolk, NOAA/AOML, USA
Participants	Numerous national and international institutions
Data centre(s)	GDP Data Assembly Center (DAC) – Manager: Ms Mayra Pazos, NOAA/AOML, USA
Website	http://www.aoml.noaa.gov/phod/dac/
Meetings *(meetings held in 2015/2016; and planned in 2016/2017)*	DBCP; Climate Observations Division review of Global Drifter Program (22 October 2016, La Jolla, CA)
Current status summary	Annual size of array was 1411 drifters. Current size as of 12 September 2016 is 1398 drifters.
Summary of plans for 2016-2017	Maintain array at ~1300 drifters

2 Deployment plans for 2016-2017

Deployments in the period 1 September 2015 through 30 August 2016 are shown in Fig. 1. A total of 878 drifters were deployed during this period, compared to 1117 drifters last year and 1660 drifters the year before (when the array had fallen below 1250 drifters and needed to be replenished). The array began this period at 1478 drifters.

In the coming year, the GDP Deployment Plan is:

Operational Buoy Deployments	800
Consortium Research Buoy Deployments	200
Total Deployments in 2016-2017	1000

More deployments may be needed to fill gaps in the global array as they develop, and will be conducted if more drifters are available for deployment.

In addition to the regular deployment opportunities provided by vessels of opportunity and regularly occurring research cruises, notable deployments planned for August 2016-July 2017 include:

- ~ 80 SVP drifter deployments in the equatorial Pacific, during TAO mooring cruises (~ 10 deployments per line)
- 30 SVP drifter deployments in the equatorial Pacific Ocean from KIOST
- ~40 SVPB drifter deployments in the Indian Ocean, during RAMA mooring cruises
- 10-15 SVP drifter deployments in the Atlantic Ocean, during the PIRATA mooring cruise
- 10 SVPB drifter deployments in the Indian and Pacific Oceans from the R/V *Kaharoa*
- 10 SVPB drifter deployments in the southern Indian Ocean from NZ Navy
- ~15 SVP drifter deployments in the equatorial Pacific Ocean, during P18
- ~15 SVPB drifter deployments in the south Pacific Ocean, during P18
- ~50 SVP drifter deployments in the Pacific Ocean by the US Coast Guard
- 40 SVPB drifter deployments in the Drake Passage
- 20 SVPB drifter deployments in the SE Pacific Ocean by the University of Valparaiso
- 20 SVPB drifter deployments in the south Pacific Ocean, during STRATUS

3 Data management

3.1 Distribution of the data

The drifter Data Assembly Center (DAC) assembles quality controls and interpolates data from approximately 1300 drifters per month from all GDP national and international partners, from all oceans of the world. These data are made available through the web with a delayed time of 3—4 months. As of the time of writing this report (mid-September 2016), quality-controlled data are available through June 2016. These data can be accessed at http://www.aoml.noaa.gov/phod/dac/dacdata.php.

3.1.1 Data policy

The DAC, located at NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) has access to drifters from GDP partners that have given Service Argos permission to make these data available to the DAC, and to Iridium drifters deployed under several VARs. In return the partners have access to all quality controlled and interpolated data available in the database via the World Wide Web. Non-interpolated quality controlled data and raw data are made available via ftp transfer upon request.

3.1.2 Real-time data exchange

All data from drifters in the GDP's programs are disseminated via GTS as soon as drifters are deployed. The GDP monitors data going out on the GTS, and transmissions of sensors producing bad data or transmissions from grounded drifters are removed from the GTS data stream.

As of 12 September 2016, there were 1398 GDP drifters transmitting good quality data on the GTS. Other GDP partners are expected to distribute their drifter data on the GTS as soon as deployments have occurred. The GDP does not monitor GTS data timeliness and relies on operational centres to report on these issues.

3.1.3 Delayed mode data exchange

Drifter data (raw data, edited non-interpolated and interpolated data) are archived at AOML. The quality controlled data bases are currently available through June 2016. These datasets are also sent to Integrated Science Data Management (ISDM), the RNODC for drifter data, for permanent archival and further distribution. Last year, the DAC identified some issues with the ISDM archive and is actively working with the manager of that archive to rectify these issues. The entire AOML data set has been resent from its beginning in 1979 through the March 31, 2016 update. ISDM is working to reload this new data set.

Metadata for GDP drifters are received at the DAC directly from drifter manufacturers who send standardized specification sheets for batches of identical drifters prior of delivery of the instruments. Portions of this metadata are extracted and are made available on the deployment log at the DAC web page www.aoml.noaa.gov/phod/dacdeployed.html. Specification sheets are archived at the DAC. Deployment date, date of last transmission, drogue off and cause of death metadata are determined during quality control of the dataset and are made available through the web at www.aoml.noaa.gov/phod/dac/dirall.html. These web pages are interrogated by JCOMMOPS to gather information for their metadata systems.

3.2 Data quality

The DAC has implemented drogue detection procedures for drifters with GPS using Time To First Fix, as recommended in DBCP-30.

4) Instrument practices

Technical supervision and developments related to the design of the SVP drifter are led by the Scripps component of the GDP. These developments aim to standardize and improve the drifter design. In previous years, this has included:

- Ruggedized tether attachment for strength and water infiltration implemented across the drifter fleet;
- Recommendation for high quality batteries issued to manufacturers and implemented;
- Design of ruggedized battery packs;
- Recommendation for more accurate SST (0.05°C) issued to manufacturers and implemented by SIO;
- Recommendation for ruggedized drogue design issued to manufacturers and implemented;
- New tether material (synthetic rope) is currently under evaluation.

The following tables summarize deployments, deaths, etc. for drifters by year and by manufacturer, calculated through the end of December 2015. Lifetime values are reported as a function of the deployment year of a drifter (e.g. the half-life for 2014 is for drifters deployed in the period 1 January –31 December 2014). The appearance of "*" indicates that there were not enough values to make the calculation. A half-life of ">X" is a minimum estimate, indicating that more than half are still alive or still have drogues attached; the final value will be larger. The Percent Quit statistics for a year represents the number of drifters that quit in that year (regardless of the year of their deployment) divided the number of drifters deployed in that year, which can yield values >100%. Note that "quit"

drifters are drifters which are believed not to have been picked up or ran aground, and also excludes all drifters that died poleward of 55 degrees latitude. In other words, “quit” drifters are those likely to have died from internal reasons such as battery failure. However, this value can be contaminated if there is a region where drifters are frequently picked up but not detected as such, potentially biasing the statistics in vandalism like the South China Sea and the Bay of Bengal. For details of this calculation, see Lumpkin, Maximenko and Pazos (2012; *J. Atmos. Oceanic Technol*., **29**, 300—308).

NUMBER OF DEPLOYMENTS

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015
Clearwater	390	355	441	259	408	166	76	17
DBi	0	0	0	4	157	278	273	257
Marlin-Yug	17	24	10	0	7	0	7	0
Metocean	143	215	199	220	159	104	175	71
Pacific Gyre	269	262	231	357	199	279	384	312
SIO	0	0	0	0	102	255	210	242
Technocean	175	279	393	251	27	20	34	23

NUMBER OF DEATHS

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015
Total:								
Clearwater	487	391	454	361	336	264	115	69
DBi	0	0	0	1	51	170	147	216
Marlin-Yug	14	24	7	7	4	4	7	3
Metocean	185	149	233	259	201	84	149	116
Pacific Gyre	192	204	225	271	385	224	264	211
SIO	0	0	0	0	48	172	176	217
Technocean	269	259	344	433	224	103	47	32
"Quit":								
Clearwater	303	237	314	246	240	204	96	51
DBi	0	0	0	1	23	84	59	90
Marlin-Yug	3	2	3	1	3	1	6	3
Metocean	125	79	134	153	122	54	84	65
Pacific Gyre	98	112	141	182	266	157	120	70
SIO	0	0	0	0	20	74	45	85
Technocean	120	121	177	288	178	85	24	14
Ran aground:								
Clearwater	131	120	113	89	47	38	14	10
DBi	0	0	0	0	19	46	60	87
Marlin-Yug	10	22	4	6	1	2	1	0
Metocean	33	35	56	81	48	17	37	33
Pacific Gyre	50	84	62	59	77	43	94	107
SIO	0	0	0	0	22	66	87	84
Technocean	123	106	123	91	34	11	17	17
Picked up:								
Clearwater	15	22	21	14	11	12	2	1
DBi	0	0	0	0	8	37	22	27
Marlin-Yug	1	0	0	0	0	1	0	0
Metocean	9	13	25	23	26	4	13	6
Pacific Gyre	8	10	8	25	23	8	35	23
SIO	0	0	0	0	8	35	43	50
Technocean	14	12	26	16	6	3	4	0

PERCENT QUIT

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015
Clearwater	78%	67%	71%	95%	59%	123%	126%	300%
DBi	*	*	*	25%	15%	30%	22%	35%
Marlin-Yug	18%	8%	30%	*	43%	*	86%	*
Metocean	87%	37%	67%	70%	77%	52%	48%	92%
Pacific Gyre	36%	43%	61%	51%	134%	56%	31%	22%
SIO	*	*	*	*	20%	29%	21%	35%
Technocean	69%	43%	45%	115%	659%	425%	71%	61%

HALF-LIFE (DAYS)

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015
"Quit" drifters:								
Clearwater	217	213	162	155	199	388	459	421
DBi	*	*	*	364	298	715	>760	>422
Marlin-Yug	856	634	963	*	962	*	>389	*
Metocean	456	448	274	221	180	316	262	>238
Pacific Gyre	598	346	345	235	227	498	>754	>539
SIO	*	*	*	*	201	482	579	>422
Technocean	959	642	280	190	54	0	32	4
All drifters (including picked up/ran aground):								
Clearwater	253	217	165	140	192	363	457	379
DBi	*	*	*	364	260	426	555	>279
Marlin-Yug	78	162	485	*	483	*	435	*
Metocean	396	388	211	189	174	292	208	>218
Pacific Gyre	236	286	284	208	190	360	413	>435
SIO	*	*	*	*	138	158	202	156
Technocean	497	476	262	148	54	0	19	4

PERCENT LIVED <90 DAYS ("Quit" only)

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015
Clearwater	11%	11%	25%	27%	12%	12%	14%	12%
DBi	*	*	*	25%	9%	6%	4%	5%
Marlin-Yug	6%	0%	10%	*	14%	*	29%	*
Metocean	5%	6%	5%	11%	17%	11%	14%	24%
Pacific Gyre	12%	16%	4%	5%	7%	3%	5%	2%
SIO	*	*	*	*	4%	7%	8%	14%
Technocean	8%	4%	11%	31%	52%	90%	32%	26%

DROGUE HALF-LIFE (DAYS) (all drifters)

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015
Clearwater	101	104	95	84	>293	>438	434	>431
DBi	*	*	*	279	227	243	228	>263
Marlin-Yug	72	57	167	*	0	*	20	*
Metocean	269	224	77	89	115	207	217	>232
Pacific Gyre	206	241	248	207	>228	241	229	206
SIO	*	*	*	*	66	>140	130	>149
Technocean	33	63	74	154	>62	0	>14	0

PERCENT THAT HAD DROGUE OFF <90 DAYS (all)

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015
Clearwater	36%	30%	36%	39%	14%	5%	16%	0%
DBi	*	*	*	25%	11%	12%	7%	6%
Marlin-Yug	41%	46%	40%	*	43%	*	71%	*
Metocean	17%	26%	40%	45%	33%	14%	21%	6%
Pacific Gyre	22%	17%	10%	16%	21%	9%	16%	15%
SIO	*	*	*	*	40%	23%	14%	20%
Technocean	78%	53%	46%	27%	33%	30%	44%	57%

PERCENT THAT HAD DROGUE OFF <10 DAYS (all)

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015
Clearwater	4%	7%	7%	5%	3%	2%	4%	0%
DBi	*	*	*	0%	4%	3%	0%	0%
Marlin-Yug	24%	33%	10%	*	43%	*	43%	*
Metocean	13%	6%	12%	6%	8%	5%	3%	0%
Pacific Gyre	11%	8%	2%	4%	7%	0%	1%	2%
SIO	*	*	*	*	25%	1%	0%	0%
Technocean	11%	10%	9%	3%	15%	15%	29%	57%

5) Evolution of the Global Drifter array

The growth of the array through 12 September 2016 is shown in Fig. 2. During the last year, the array had an average size of 1411 drifters. This period began with the array at 1478 drifters and concluded with the array at 1398 drifters.

Annex (optional)

Status maps and graphics

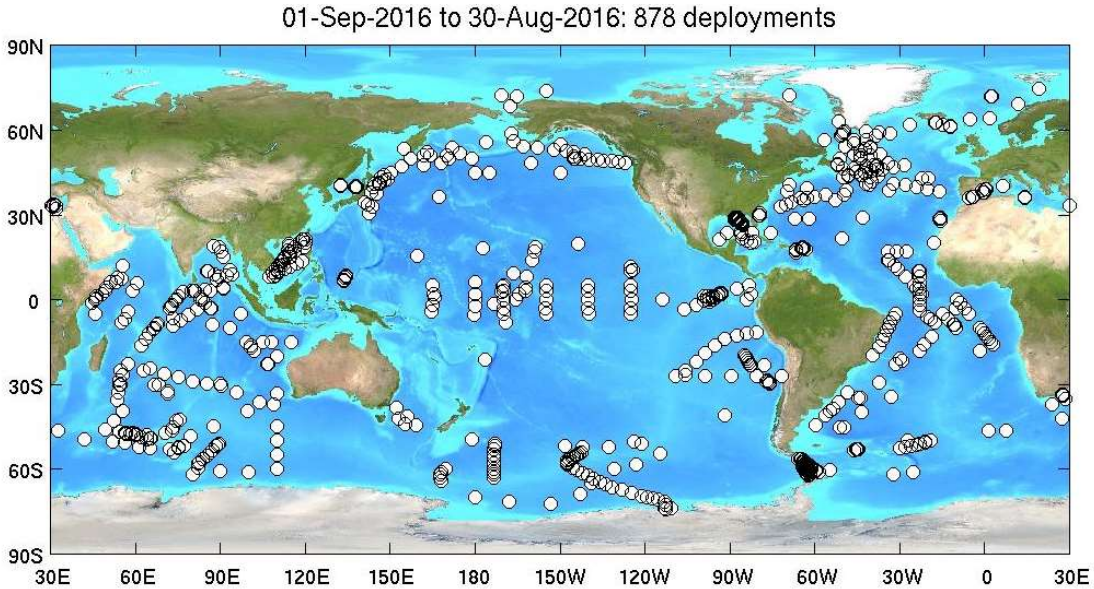

Fig. 1: Global Drifter Program deployment locations during the year.

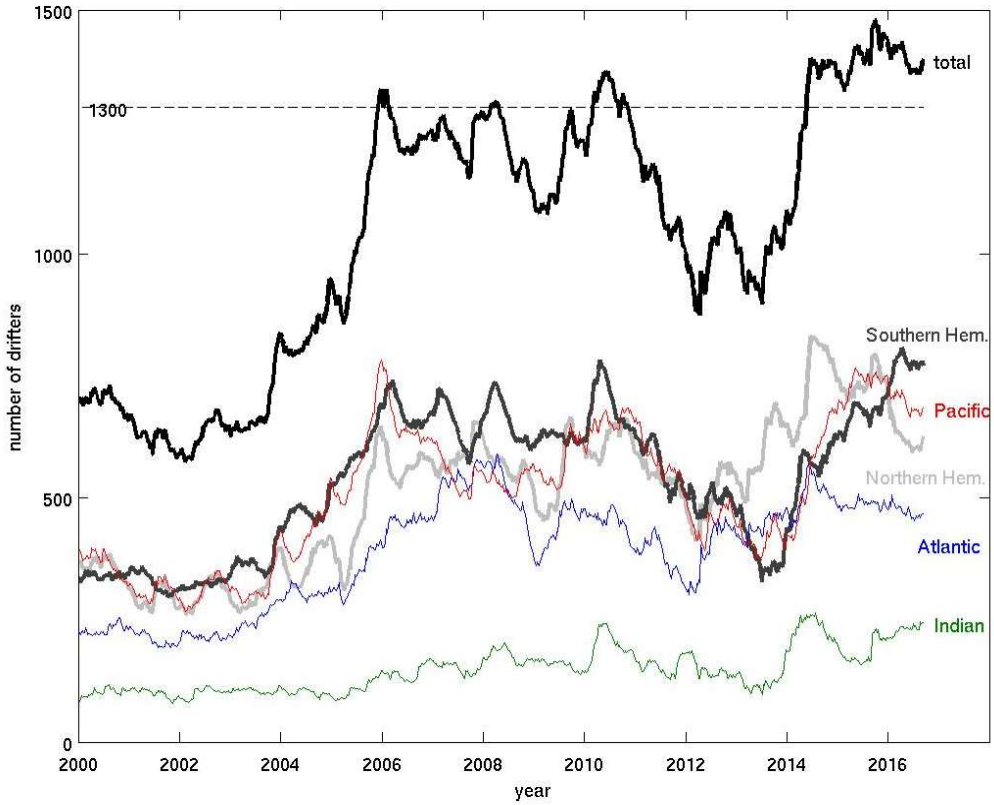

Fig. 2: Size of global drifter array, total (black) and in various subregions (color). Atlantic/Indian divided at 25°E in the Southern Ocean, Atlantic/Pacific at 70°W in the Southern Ocean, Indian/Pacific at 125°E south of Timor.