

DATA BUOY COOPERATION PANEL

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TWENTY-SIXTH SESSION

ITEM: 7

OBAN, UNITED KINGDOM
27 – 30 SEPTEMBER 2010

ENGLISH ONLY

REPORT BY THE ACTION GROUPS

(Submitted by the Action Groups)

Summary and purpose of the document

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

ACTION PROPOSED

The Panel will review the information contained in this report and comment and make decisions or recommendations as appropriate. See part A for the details of recommended actions.

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- Appendices:**
- A. Report by the Global Drifter Programme (GDP);
 - B. Report by the Tropical Moored Buoy Implementation Panel (TIP);
 - C. Report by the EUCOS Surface Marine Programme (E-SURFMAR);
 - D. Report by the International Buoy Programme for the Indian Ocean (IBPIO);
 - E. Report by the DBCP-PICES North Pacific Data Buoy Advisory Panel (NPDBAP) – not included;
 - F. Report by the International Arctic Buoy Programme (IABP);
 - G. Report by the WCRP-SCAR International Programme for Antarctic Buoys (IPAB) – not included;
 - H. Report by the International South Atlantic Buoy Programme (ISABP);
 - I. Report by the Ocean Sustained Interdisciplinary Timeseries Environment observation System (OceanSITES);
 - J. Report by the International Tsunameter Partnership (ITP) – *not available* –

-A- DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

7.1 Under this agenda item, the Panel was presented with reports by its action groups, including:

- (i) Surface Marine programme of the Network of European Meteorological Services, EUMETNET (E-SURFMAR) (verbal presentation by Jon Turton – United Kingdom –, representing the E-SURFMAR officers);
- (ii) Global Drifter Programme (GDP) (verbal presentation by Rick Lumpkin – USA – on behalf of the GDP);
- (iii) International Arctic Buoy Programme (IABP) (verbal presentation by Mr Ed Hudson – Canada –, representing IABP);
- (iv) International Buoy Programme for the Indian Ocean (IBPIO) (verbal presentation by Mr Graeme Ball – Australia –, Chairperson of the IBPIO);
- (v) WCRP-SCAR International Programme for Antarctic Buoys (IPAB) (written report only);
- (vi) International South Atlantic Buoy Programme (ISABP) (verbal presentation by Ms Mayra Pazos – USA –, representing the ISABP);
- (vii) DBCP-PICES North Pacific Data Buoy Advisory Panel (verbal presentation by Mr Shaun Dolk – USA –, technical coordinator of the NPDBAP);
- (viii) OCEAN Sustained Interdisciplinary Timeseries Environment observation System (OceanSITES) (verbal presentation by Dr Robert Weller – USA –, representing OceanSITES project office);
- (ix) Tropical Moored Buoys Implementation Panel (TIP) (verbal presentation by Dr Mike McPhaden – USA –, representing the TIP)
- (x) International Tsunameter Partnership (ITP) (verbal presentation by Mr Ken Jarrott – Australia – representing the ITP).

7.2 Summaries of the presentations are reproduced in Appendices A to J. The full reports of the action groups will be reproduced in the Panel's Annual Report.

Appendices: 10

APPENDIX A

REPORT BY THE GLOBAL DRIFTER PROGRAMME (GDP)

1) Summary

Name of Action Group	The Global Drifter Programme (GDP)
Date of report	31 July 2010
Overview and main requirements addressed	The goals of the GDP are to: 1. Maintain a global 5x5° array of 1250 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	The global ocean
Type of platform and variables measured	Lagrangian drifters measuring the following variables: Basic: surface velocity, SST; Other: surface pressure, wind, salinity, sub-surface temperature profiles
Targeted horizontal resolution	5 degree x 5 degree (1250 units)
Chairperson/Managers	Dr Rick Lumpkin, NOAA/AOML, USA Dr Peter Niiler, SIO, USA
Coordinator	Operations Manager: Mr Shaun Dolk, NOAA/AOML, USA
Participants	
Data centre(s)	GDP Data Assembly Center (DAC) – Manager: Ms Mayra Pazos, NOAA/AOML, USA
Website	http://www.aoml.noaa.gov/phod/dac/gdp.html
Meetings	
Current status (mid-2010)	Annual size of array maintained close to 1250 drifters. Current size as of July 5, 2010 is 1388 drifters.
Summary of plans for 2011	Maintain array at ~1250 drifters; reevaluate drogue presence for historical data; begin incorporating salinity data into data stream; continue participation in Iridium and Argos 3 pilot projects; conduct ADB study of SVPB drifters.

2 Deployments in 2010 and plans for 2011

Deployments in the period 6 July 2009 through 7 July 2010 are shown in Fig. 1. Some unusual or outstanding deployments during this period:

- 35 across the Pacific Ocean during DART servicing cruise.
- 17 in the central Gulf of Guinea from the R/V *Ronald H. Brown*, CLIVAR line A13.
- ~40 drifters in the western Indian Ocean and 15 in the Gulf of Guinea from various US Navy vessels, as part of the “African Partnership Station II” program.
- 10 from the Argo-chartered *Kaharoa* along 45°S, from 86—141°E.
- 36 from the R/Vs *Walton Smith* and *Nancy Foster* to monitor ocean currents in the Gulf of Mexico, in support of NOAA’s response to the Deepwater Horizon oil spill.

In the coming year, the GDP Deployment Plan is:

Operational Buoy Deployments	800
Consortium Research Buoy Deployments	<u>200</u>
Total Deployments in 2011	1000

Regional deployment opportunities in 2011 include the US Navy-led “African Partnership Station” program in the western Indian and eastern Atlantic, the possible NSF-funded “Dynamo” project in the tropical Indian Ocean, and the 2011 Argo charter of the *Kaharoa* in the South Pacific. As in previous years, cruises to service the global tropical moored array will be used opportunistically to seed drifters.

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 (July 2010), data are available through March 2010. 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.

As of July 5, 2010, there were 1,296 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 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 Dec 2009 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

As reported in earlier years' DBCP reports, drogue detection was hampered for many years by extremely noisy submergence values, especially problematic for many Technocean drifters (Technocean is the largest single contributor to the array). Since the implementation of tether strain, complemented by adjustments to Technocean's submergence sensors that improved their behaviour, the GDP has been able to assess drogue presence more reliably. These improved drifters were deployed and represented a significant fraction of the global array by late 2008. During this same period of transition, the fraction of drifters identified as "drogue on" fell from around 70% to approximately 50% (Fig. 2). This suggests that a significant fraction of drifters in the pre-2008 period were misdiagnosed as "drogue on", when in fact they had lost their drogues. Because drifters without drogues are more strongly affected by direct wind forcing, misdiagnosis has the potential to bias ocean currents derived from drifters. This problem is the subject of a three-year NOAA Climate Change Data and Detection-funded project starting in 2010 (Principal Investigators Rick Lumpkin, NOAA/AOML, and Jim Carton and Semyon Grodsky, Univ. Maryland). The fraction of drogue-on drifters by manufacturer is shown in Fig. 3. For reference, if a manufacturer is meeting the goal lifetime of 450 days for a drifter and 300 days for drogue attachment, approximately 67% of the drifters should have a drogue attached. Clearwater drifters, which have used the reliable tether strain method for many years, show a steady decline from 60—80% in 2000—2005 to 30—50% in 2008—2010. Technocean drifters appeared to be at 70—80% until 2008, but were particularly subject to misinterpretation. The fraction of Technocean drifters with drogues dropped precipitously to <40% with the implementation of more reliable drogue detection sensors. Around 60—80% of Pacific Gyre and Metocean drifters have drogues attached, although Pacific Gyre had delayed introduction of tether strain compared to the other manufacturers so interpretation of their drogue presence may be questionable.

This year, the GDP also identified a large series of Clearwater SVP drifters (ID values 90305—90544) that had an anomalously high "failed on deploy" rate and in many cases short lifetimes after deployment. A large fraction of these also quickly reported bad SST values (in many cases after only a few months in the water). This problem has been reported to the manufacturer.

A large number of "failed on deployment" or significant lags (many days to months) between deployment and first data transmission was observed for Technocean drifters. This was reported to the manufacturer, as it suggested a possible problem with magnet separation after deployment.

4) Instrument practices

For the sixth consecutive year, AOML deployed drifters in clusters of four, at the same time and location and from four different manufacturers (Clearwater, Metocean, Technocean, Pacific Gyre), for comparison. In January and March 2010, four clusters of SVP drifters were deployed. We expect to deploy five more clusters of SVPB drifters from 5 different manufacturers during August/September. These clusters will include drifters manufactured by Marlin Yug Inc, purchased by the DBCP.

At the end of June 2010, eleven drifters out of the sixteen deployed were still alive; only six have drogues still attached. Two Technocean drifters failed on deployment and one started to transmit 31 days after deployment, while all others in that cluster transmitted right away. Clearwater had one drifter that transmitted only for 6 days, and one had a delay of 17 hours with respect to all others in the cluster before starting to transmit. Only one has its drogue still attached at the end of June. All Metocean drifters were still active at the end of June, two with drogues still attached. Pacific Gyre had three drifters transmitting and with drogues attached, while one lasted only 90 days. However, Pacific Gyre had not implemented tether strain in time for the 2010 ADB study (they have now implemented tether strain), and thus we must rely on less reliable submergence to determine drogue presence. As of the end of June, all “alive” drifters were transmitting good SST measurements and were reporting on the GTS.

5) Evolution of the Global Drifter array, 6 July 2009—5 July 2010

The growth of the array through 5 July 2010 is shown in Fig. 4. For the most recent 365 days, the array had an average size of 1284 drifters. This period began with the array at its minimum of 1148 drifters, caused in part by a larger than normal death rate (see last year’s DBCP report for more details). In response, the GDP increased the rate of deployments: 1181 drifters were deployed during 6 July 2009—5 July 2010 (Fig. 1). The array reached its maximum size of 1403 on June 21. Its current size as of 5 July 2010 is 1388 drifters.

Annex

Status maps and graphics

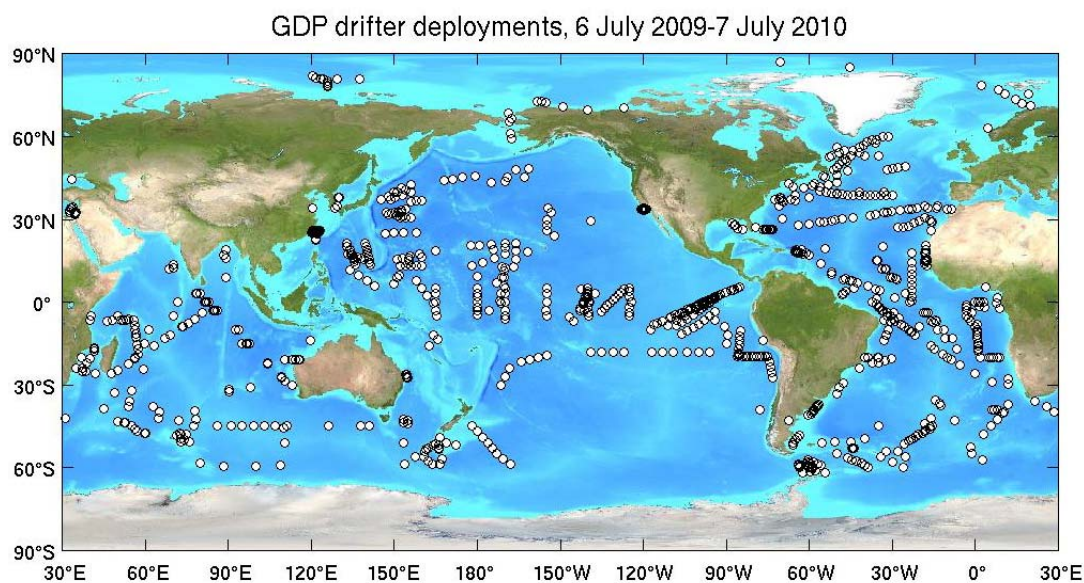


Fig. 1: Deployment locations during the year. A total of 1181 drifters were deployed.

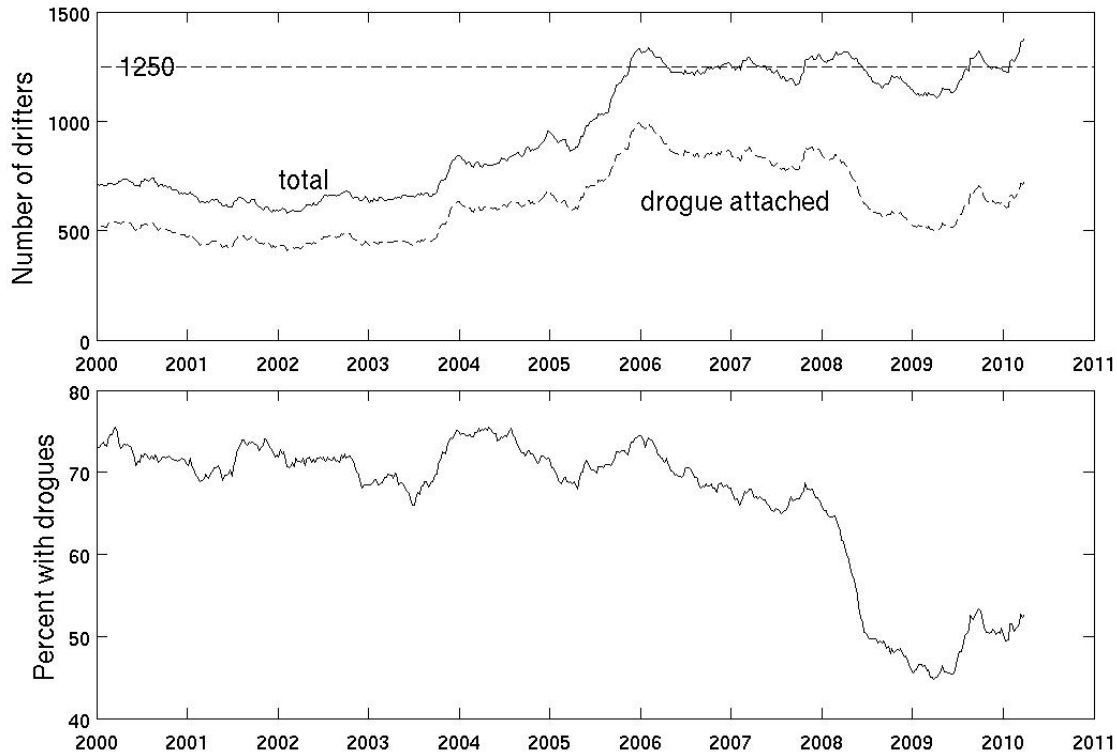


Fig. 2: Top: total number of drifters in array and number with drogues attached (from delayed mode quality-controlled data set), identified from submergence or tether strain values. Bottom: fraction of drifters with drogues attached.

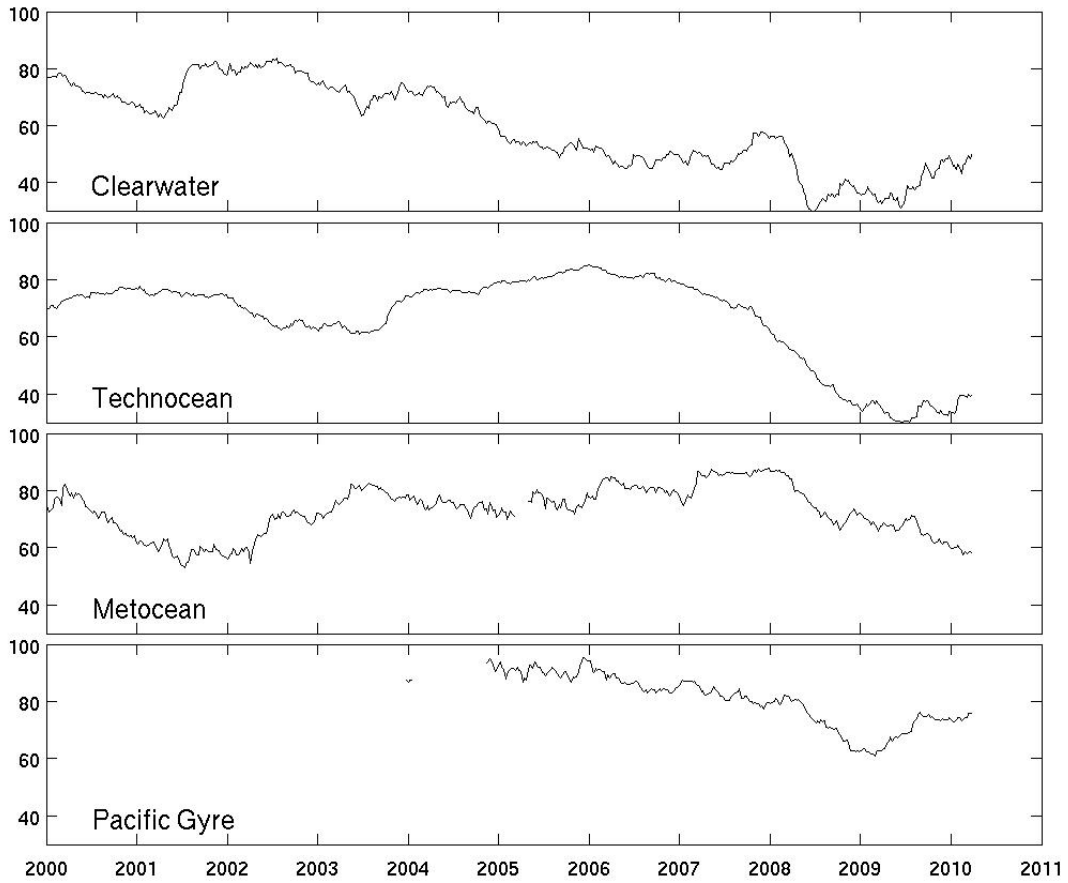


Fig. 3: Fraction of drifters with drogues attached, by manufacturer, for the four largest contributors to the global array.

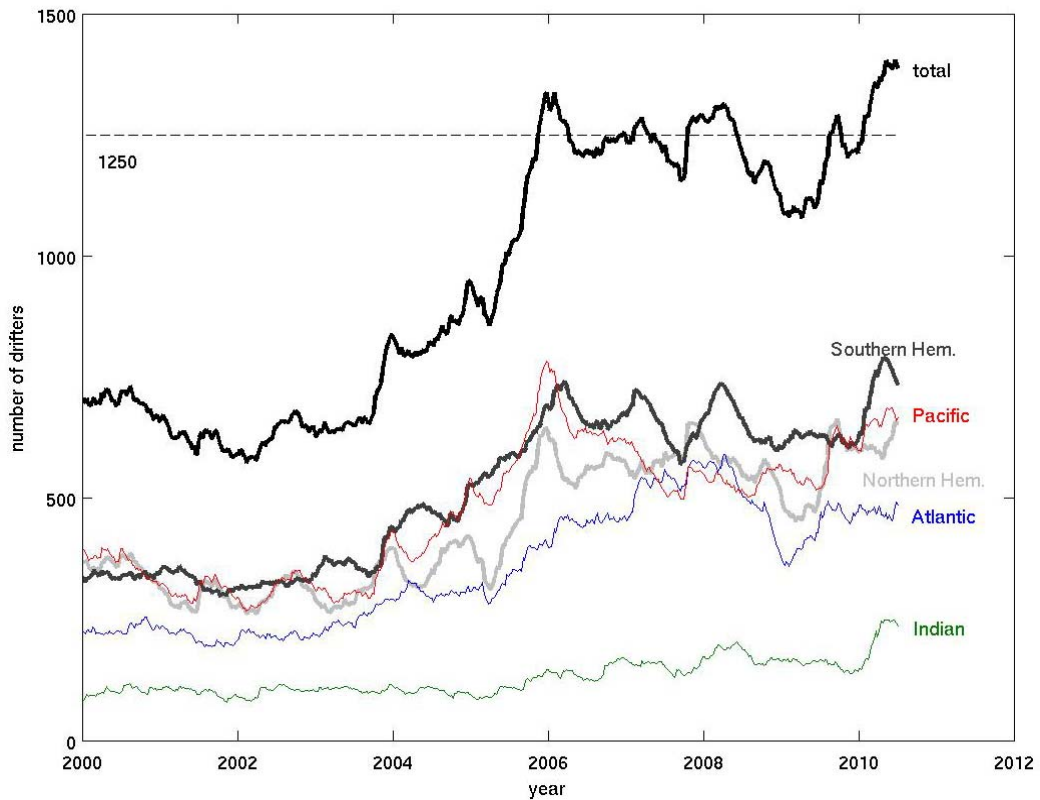


Fig. 4: Size of global drifter array in regions. Atlantic/Indian divided at 25°E in the Southern Ocean, Atlantic/Pacific at 70°W in the Southern Ocean, Indian/Pacific at 125°E south of Timor.



APPENDIX B

REPORT BY THE TROPICAL MOORED BUOY IMPLEMENTATION PANEL (TIP)

1) Summary

Name of Action Group	The Tropical Moored Buoy Implementation Panel (TIP)
Date of report	31 July 2010
Overview and main requirements addressed	<p>The Tropical Moored Buoys Implementation Panel (TIP) oversees the design and implementation of the following components:</p> <ul style="list-style-type: none"> • 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	<p>Tropical moorings with surface meteorological and sub-surface oceanographic sensors measuring:</p> <p>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.</p> <p>Sub-surface; temperature profiles down to 500m on all surface moorings. Salinity profiles down to 120m on some surface moorings. Current velocity on some moorings.</p> <p>Subsurface ADCP moorings.</p>
Targeted horizontal resolution	Tropical Pacific Ocean: 72 moorings ; Tropical Atlantic Ocean: 18 moorings ; Tropical Indian Ocean: 46 moorings
Chairperson/Managers	Dr. Mike McPhaden, PMEL, USA
Coordinator	Mr H. Paul Freitag, PMEL, USA
Participants	<p>TAO/TRITON: NOAA National Data Buoy Center (NDBC), NOAA Pacific Marine Environmental Laboratory (PMEL), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)</p> <p>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)</p>

	RAMA: NOAA PMEL, JAMSTEC, Indian National Center for Ocean Information Services (INCOIS), National Institute of Oceanography (NOI), Agency for the Assessment and Application of Technology (BPPT), Ministry of Marine Affairs and Fisheries (DKP), First Institute of Oceanography (FIO), Agulhas and Somali Current Large Marine Ecosystems (ASCLME).
Data centre(s)	PMEL, NDBC, JAMSTEC, NIO
Website	http://www.pmel.noaa.gov/tao/global/global.html
Meetings	PIRATA-15, 2-5 March 2010, Miami, Florida CLIVAR/GOOS Indian Ocean Panel 7th Session, 12-16 July 2010, Perth, Australia TIP Workshop, 26 September 2010, Oban UK.
Current status (mid-2010)	TAO/TRITON: 60 of 67 surface moorings reporting. PIRATA: 15 of 17 surface moorings reporting. RAMA: 21 surface and 6 subsurface moorings deployed. 19 surface moorings reporting.
Summary of plans for 2011	TAO/TRITON: Maintain 72 mooring array. PIRATA: Maintain 18 mooring array RAMA: Increase number of sites deployed up to 34.

2 Deployment plans for 2011

TAO: NDBC 7 cruises, JAMSTEC 1 cruise

PIRATA: AOML/PMEL 1 cruise, IRD 1 cruise, INPE 1 cruise

RAMA: PMEL/INCOIS 3 cruises, JAMSTEC 1 cruise, NIO 1 cruise, PMEL/BPPT 2 cruises, FIO/BPPT 1 cruise, PMEL/ASCLME 1 cruise

3 Data management

3.1 Distribution of the data

Most surface data are telemetered in real time via the Argos system and are placed on the GTS by the French Space Agency (CLS). These real time data plus delayed-mode data (data of higher temporal resolution than are available in real time and data from subsurface moorings) are available via web based distribution from PMEL (www.pmel.noaa.gov/tao/disdeld/disdeld.html), NDBC (tao.noaa.gov), JAMSTEC (www.jamstec.go.jp/jamstec/TRITON/real_time/php/top.php, <http://www.jamstec.go.jp/iorgc/iomics/datadisply/buoysummary.php?LANG=0>), and NIO (www.nio.org/index/option/com_nomenu/task/show/tid/2/sid/18/id/5). One surface mooring (FIO) telemeters data via Iridium which are available via the web only. During the period July 2009 through June 2010 the PMEL web pages had more than 19.6M hits and delivered more than 214K data files in response to nearly 25K user requests.

3.1.1 Data policy

Data are freely available on the web.

3.1.2 Real-time data exchange

Most surface moorings are Autonomous Temperature Line Acquisition System (ATLAS) moorings which place daily mean meteorological and oceanographic observations and some hourly meteorological observations on the GTS. TRITON buoys submit hourly mean meteorological and oceanographic data to the GTS every 3 hours. Compared to the volume of data received at PMEL, more than 90% is typically reported on the GTS by CLS. Most operational centers receive nearly all data placed on the GTS, with the exception of the ECMWF which typically reports volumes of about 75%, presumably due to stricter latency criteria.

Daily average data return for the present fiscal year to date (1 October 2009 to 15 July 2010) was 85% for TAO/TRITON, 84% for PIRATA and 65% for RAMA. The primary reasons for lower data return in RAMA are a higher incident of vandalism coupled with longer mooring deployment periods. Intense fishing activity in some regions has led to high vandalism rates. The survival rate for ATLAS moorings since the first deployments (2004) is 79%, compared to 90% for TAO (since 1980) and 93% for PIRATA (since 1997). Cancelled and delayed cruises have resulted in deployments much longer than the 12-month design lifetime of the moorings. Deployments of 16 to 20 months are not uncommon, and one mooring was recently recovered after 33 months.

3.1.3 Delayed mode data exchange

Delayed mode data are archived at the web sites listed in 3.1 above. System metadata are available at the web sites listed in 3.2 and 4 below.

3.2 Data quality

Data quality control procedures are described at www.pmel.noaa.gov/tao/proj_over/qc.html for ATLAS 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 at www.pmel.noaa.gov/tao/proj_over/sensors.shtml for ATLAS moorings and at www.jamstec.go.jp/jamstec/TRITON/real_time/overview.php/po-t3.php for TRITON moorings. RAMA mooring specifications from PMEL, JAMSTEC and NIOT are listed in the [Supplement to RAMA: The Research Moored Array for African—Asian—Australian Monsoon Analysis and Prediction](#) (McPhaden, et al., 2009)

Several new mooring instrument systems are emerging or under development. JAMSTEC has replaced its TRITON moorings in RAMA with m-TRITON systems, which are based on TRITON technology, but use smaller mooring hardware. Two m-TRITON moorings telemeter data using the Argo3 PMT. NDBC has developed a refreshed ATLAS mooring which uses more commercially available electronic components with Iridium telemetry of high temporal resolution data for use in TAO. Several NDBC refresh systems are deployed next to ATLAS moorings. Comparison of data is underway and it is expected that refresh systems will begin to replace TAO ATLAS moorings in the coming year. China's FIO has developed a new mooring which was deployed in RAMA in February 2010. PMEL is developing a tropical mooring named TFlex which incorporates electronics first used on Ocean Climate Stations in higher latitudes. The system is being designed for use both in RAMA and the Indonesian Global Ocean Observing System (InaGOOS). TFlex will telemeter hourly surface and subsurface data via Iridium. First deployments, scheduled for the coming year, will be next to ATLAS moorings in RAMA.

5) Other issues

5.1 RAMA Implementation:

As of July 2010 the number of RAMA sites implemented stands at 27 (59% complete). Five sites which were first occupied in the past year include: US ATLAS moorings at 12S 67E (September 2009), 4°S 67°E (September 2009), and 12°S 81°E (May 2010); a Japanese m-TRITON mooring at 8°S 95°E (November 2009); and a Chinese surface mooring at 8°S 100°E (February 2010). With sufficient ship time and security arrangements (see 5.6 below) the number of RAMA moorings may reach 34, or 74% completion of the IOP planned array, by June 2011.

Between July 2009 and June 2010, 106 sea days (74 by India and 32 by Indonesia) were provided in support of ATLAS RAMA sites. Additional ship time was provided by India in support of their Deep Ocean moorings (~37 days), Japan in support of their m-TRITON moorings (14 days) and Indonesia in support of China's moorings (28 days).

The University of Tasmania has proposed an investigation of transports in the subtropical Southeast Indian Ocean in 2012, during which a RAMA mooring would be deployed near 25°S 97°E.

5.2 Array enhancements:

Meteo-France provided barometers in 2009 to initiate and maintain surface pressure measurements at 4 existing ATLAS sites in RAMA and 1 PIRATA site. Installation of the instruments has been established at 4 of 5 sites, with the 5th scheduled for fall 2010.

Biogeochemical measurements are made from several TAO moorings by PMEL (<http://www.pmel.noaa.gov/co2/moorings/>) and the [Monterey Bay Aquarium Research Institute \(MBARI\)](http://www.mbari.edu/) and on several PIRATA buoys by LOCEAN (<http://www.lodyc.jussieu.fr/CO2tropiques/>) and the Leibniz Institute of Marine Sciences at the University of Kiel (IFM-GEOMAR). The first biogeochemical instrumentation in RAMA (provided by the University of Tasmania) was placed on a mooring in May 2010. Plans for additional measurements on other RAMA moorings are being proposed within the context of the Sustained Indian Ocean Biogeochemical and Ecosystem Research Program (SIBER).

5.3 International cooperation and capacity building:

The number of sea days necessary to fully maintain the RAMA array when complete is estimated to be at least 200 days per year. Formal bilateral agreements have either been approved or are under development between NOAA and agencies of the various partner countries to help complete and sustain the array. To facilitate and coordinate resources that may be applied to the Indian Ocean Observing System, an IndoOOS Resource Forum was established in 2009. The Forum held its first meeting on July 14, 2010, in Perth, Australia.

JAMSTEC conducted a capacity building workshop for the transfer of surface buoy technology in Jakarta and Serpong, Indonesia, June 8-11, 2010. A goal of this collaboration is for Indonesia to assume responsibility for a TRITON site in 2012. PMEL will host a technical training session on mooring systems for 2 Indonesian scientists August 16-20, 2010.

The Korean Ocean Research & Development Institute (KORDI) deployed a surface mooring near 10°N 150°E in May 2010. How this site may be included within TAO/TRITON Array will be discussed at the TIP Workshop in Oban, UK, September 2010.

5.4 Research experiments:

The US is conducting a 3-year (2008-2011) 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.

IFM-GEOMAR will conduct a process study in the Gulf of Guinea in May through July, 2011, including a glider swarm experiment making microstructure and tracer observations at the onset and peak of equatorial upwelling.

The Cooperative Indian Ocean experiment on intraseasonal variability (CINDY) is a multi-national field and modeling study of the oceanic and atmospheric processes responsible for the initiation of the Madden-Julian Oscillation (MJO). Field work will be conducted from late 2011 to early 2012. As part of the US contribution to CINDY, Dynamics of the MJO (DYNAMO), Oregon State University will enhance several ATLAS moorings in RAMA with ocean turbulence and other sensors

5.5 Vandalism:

Damage to buoys and theft of instrumentation continues to be a problem, especially at sites near areas of intense fishing activity such as the eastern equatorial Pacific, the Gulf of Guinea and equatorial Indian Ocean. Some ATLAS moorings in RAMA have been modified to inhibit vandals from boarding the buoy. While proving successful at keeping moorings in place (3 of 4 moorings were recovered and 2 are presently operating) and producing sustained subsurface measurements, an adequate method of inhibiting vandalism upon surface met sensors has not yet been found.

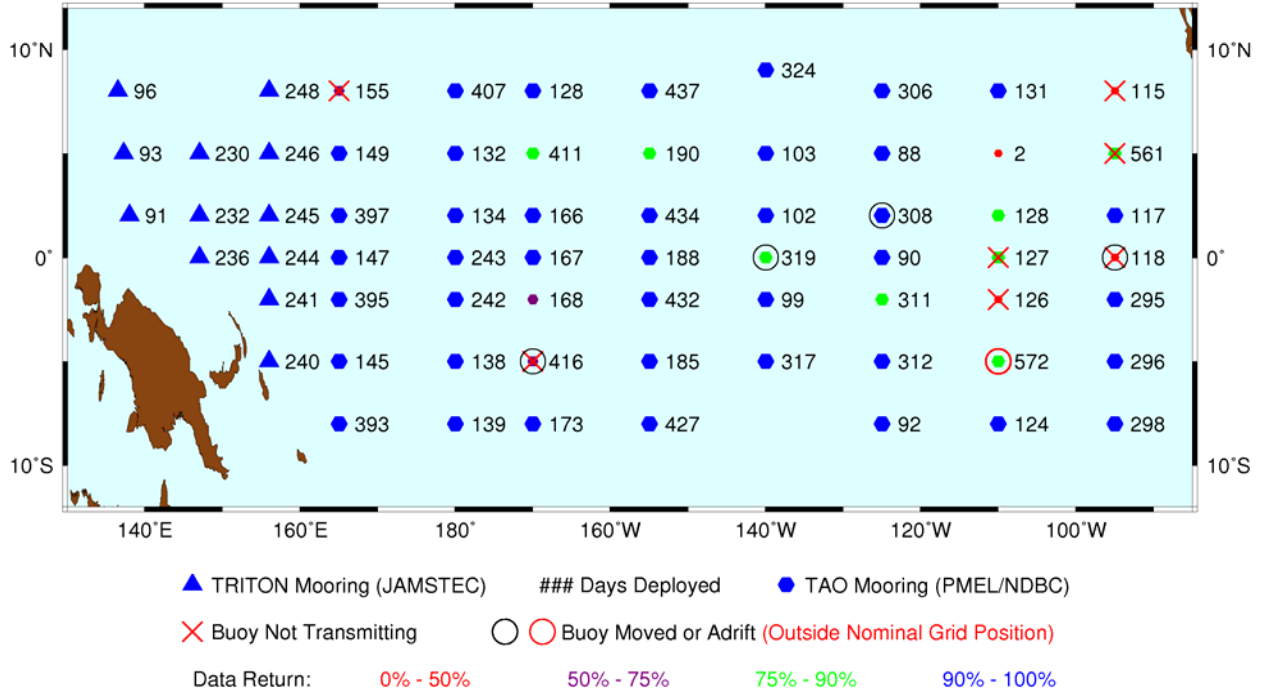
5.6 Piracy:

Acts of piracy in the Indian basin, while primarily occurring off the Somali coast, have become more common farther offshore. Security concerns have resulted in the cancelation of 2 RAMA cruises in the past year. To address these concerns, ASCLME has arranged for a Seychelles Coast Guard escort on an October 2010 cruise while in the Seychelles EEZ. A security zone defined by Lloyds of London extends to other sites in the western portion of RAMA. Adequate solutions, such as that provided by ASCLME, will have to be provided before implementation can proceed in these areas.

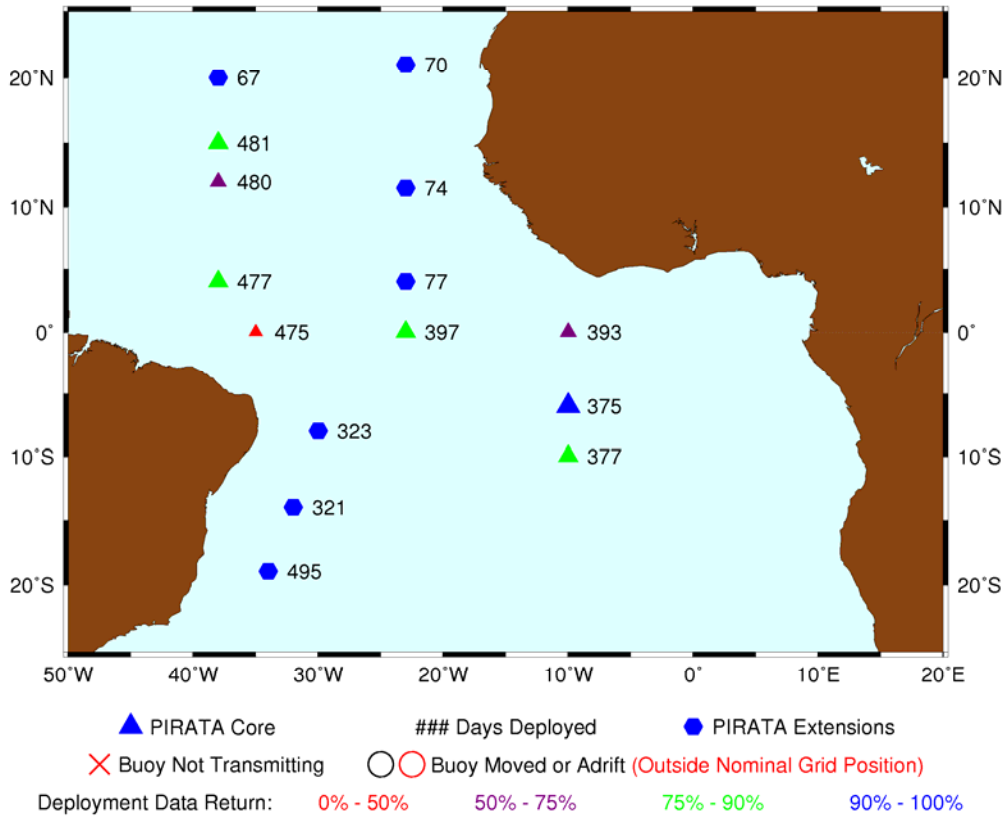
Annex

Status maps and graphics

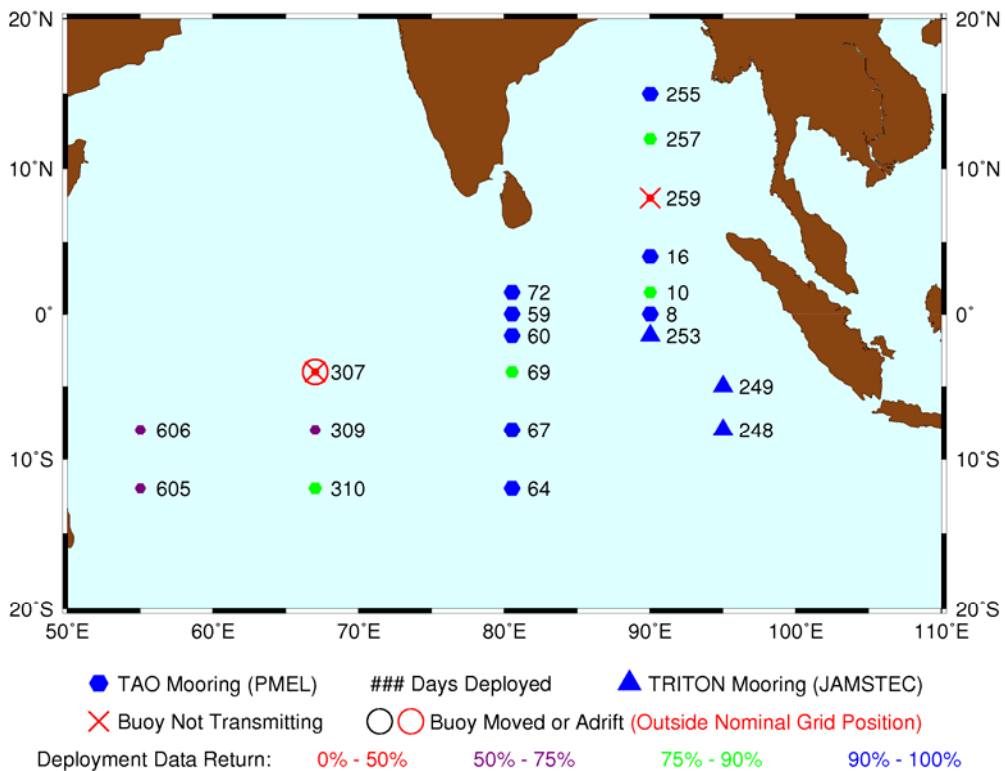
TAO/TRITON Mooring Status Update: Jul 20, 2010

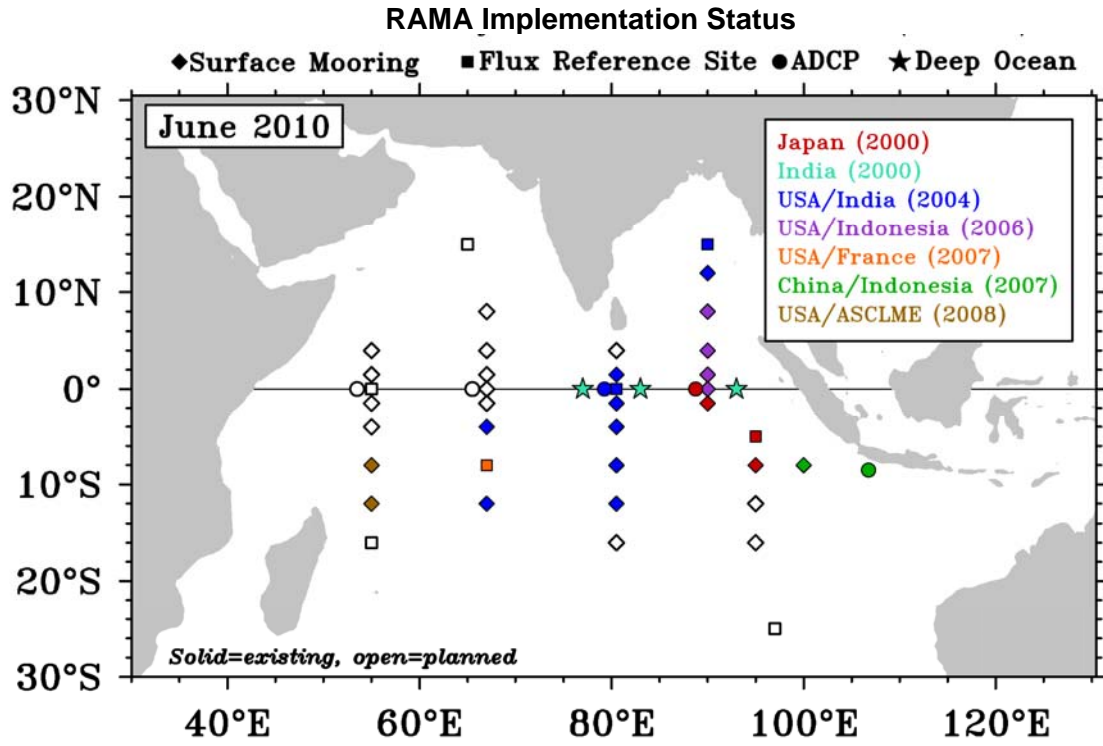


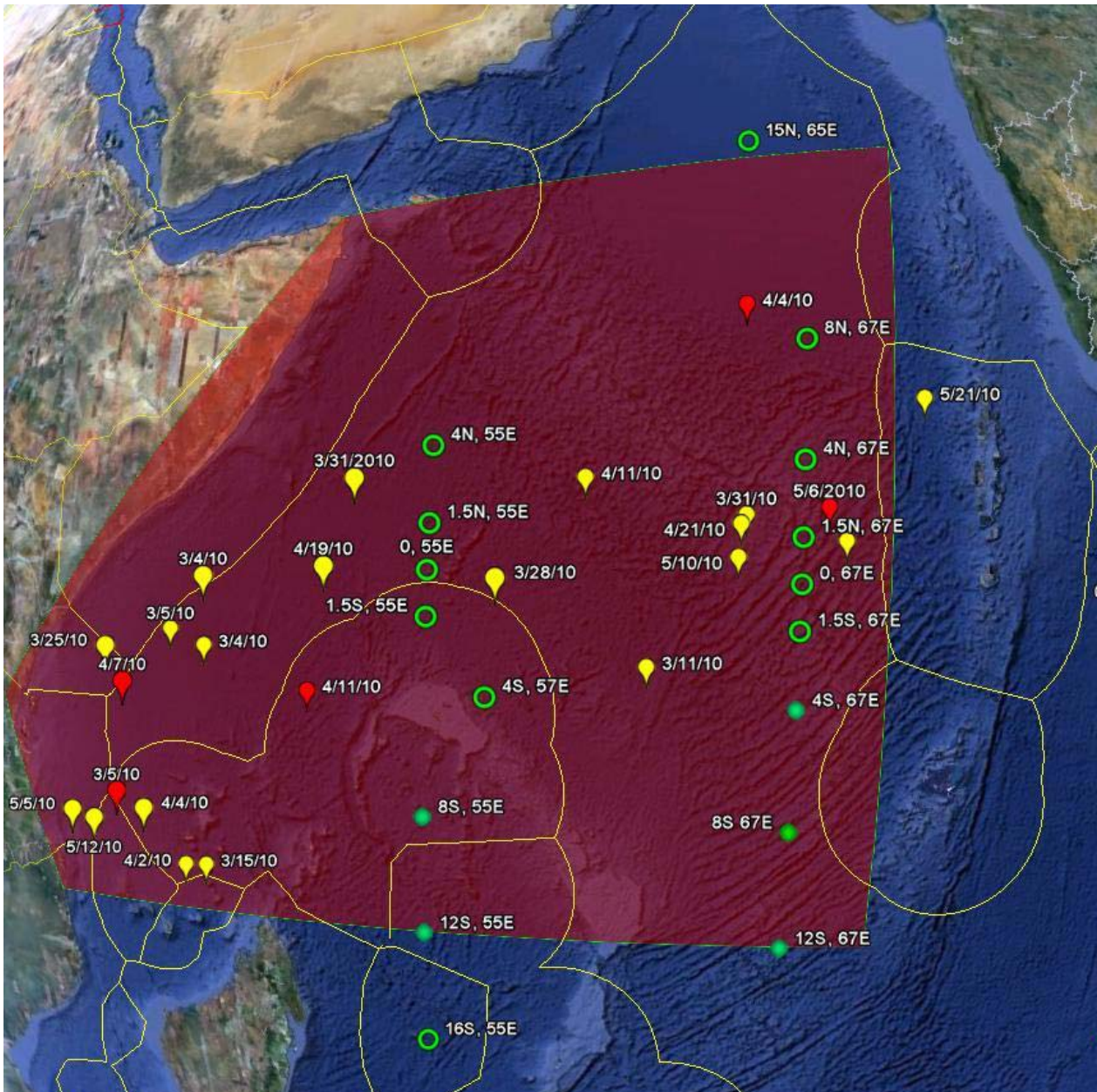
PIRATA Mooring Status Update: Jul 20, 2010



Indian Ocean Mooring Status Update: Jul 20, 2010







Exclusion Zone as declared by Lloyds of London. Solid green dots show deployed RAMA moorings; open circles are RAMA sites not yet occupied. Red pointed symbols show hijacking; yellow pointed symbols are ships fired upon. Dates of attacks for March-May 2010 are next to symbols.

APPENDIX C

REPORT BY THE EUCOS SURFACE MARINE PROGRAMME (E-SURFMAR)

1) Summary

Name of Action Group	Surface Marine programme of the Network of European Meteorological Services, EUMETNET (E-SURFMAR)
Date of report	31 July 2010
Overview and main requirements addressed	The EUMETNET Composite Observing System (EUCOS) surface marine (E-SURFMAR) programme is an optional programme involving 17 out of the 26 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 Data Buoy Technical Advisory Group (DB-TAG) which 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 and the Mediterranean Sea (90°N-10°N; 70°W - 40°E).
Type of platform and variables measured	<u>Drifting buoys</u> : air pressure, SST, (wind) <u>Moored buoys</u> : air pressure, wind, air temperature, SST, waves (directional spectra), relative humidity.
Targeted horizontal resolution	250 km x 250 km, >150 drifting buoys, 4 moored buoys for satellite calibration/validation.
Chairperson/Managers	Manager E-SURFMAR: Mr Pierre Blouch, Météo-France Chairperson, Data Buoy Technical Advisory Group (DB-TAG): Mr Jon Turton, UK Met Office
Coordinator	Data buoy Manager: Mr Jean Rolland, Météo-France
Participants	Belgium, Croatia, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom
Data centre(s)	Météo-France as SOC ISDM (Canada) as RNODC/DB
Website	http://www.eucos.net , under the heading “EUCOS Public” in “EUCOS networks” http://esurfmar.meteo.fr (restricted working area web site for E-SURFMAR participants)
Meetings	DB-TAG meets once a year. DB-TAG7 Madrid 18-19 May 2010
Current status (mid-2010)	109 drifting buoys in operation (48 Iridium, 61 Argos). 4 E-SURFMAR supported moored buoys in operation, plus a further 17 K-series buoys and 16 Oceanor buoys operated by members.
Summary of plans for 2011	Maintain a network of 100 drifting buoys, and the 4 reference moored buoys in operation.

2 Deployment plans for 2011

The drifting buoys will be deployed from various locations (Canada, Iceland, France, Norway, UK, USA, ...) in the Atlantic Ocean. The drifters from GDP upgraded with barometers will be deployed by vessels plying from USA to Iceland and from USA to Europe. 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. New deployment routes will be investigated.

E-SURFMAR will continue to deploy buoys in the Arctic Ocean through IABP. The main challenge with the ice buoys is their ability to survive after being released from frozen ice.

At present, Cabo Silleiro (transmission through Inmarsat) is the only EUCOS moored buoy which reports directional wave spectra onto the GTS. Spectral data from K5 (transmission through Iridium) are still experimental. Lion moored buoy (transmission through Meteosat) reports omnidirectional spectra and M6 (transmission through Meteosat) is only reporting mean wave height and period. It is expected that a modified version of the system developed by the Met Office for K5 will be also installed on the Lion buoy with similar capability on M6 in due course.

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 form 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 developments on a processing chain at Météo-France producing GTS reports from Iridium SBD data were consolidated. The chain is able to produce FM13-SHIP, FM18-BUOY or FM94-BUFR messages. The distribution of BUFR messages should start during summer 2010 after the first drifters having a resolution of 0.01K for SST are deployed.

The evaluation of the Iridium communication system was done as a contribution to the DBCP drifter Iridium Pilot Project. Half of the number of drifters operating are now using Iridium. This improves the data timeliness (see Annex). About 2,500 daily observations are carried out on to the GTS. The short term target (70%) of the percentage of data received within 50 minutes was reached. The long term target (90%) will be only reached if all the buoys move to Iridium SBD. NOAA buoys upgraded with barometers by ESURFMAR are still reporting through Argos.

The mean lifetime (for Air Pressure) of the SVP-B drifters was approximately 12 months (351 days). Ninety eight buoys failed to report air pressure measurements.

The availability of moored buoy data depends on the number of buoys operating. An average of 80 hourly observations per day have been reported from E-SURFMAR buoys to the GTS.

Since buoy Cabo Silleiro was taken into account in the performance computations, the percentage of EUCOS moored buoys data available within 50 minutes dropped from 100% to 80% i.e. below

the target of 90%.

3.1.3 Delayed mode data exchange

The raw data from drifters (Argos and Iridium) are archived at "Centre de Meteorologie Marine" (CMM) at Meteo-France.

Data inserted onto the GTS 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.

E-SURFMAR will generate Moored Buoy Metadata, once a standard template is provided - this is still to be agreed by the DBCP Task Team on Moored Buoys in its metadata initiative.

3.2 Data quality

The web page giving access to the Quality Control (QC) tools was enhanced in 2009 (see <http://www.meteo.shom.fr/qctools>). Monthly statistics and 14-day graphs are now available for all surface marine observations through the same interface. More parameters are considered in the statistics: humidity, wave height and direction, salinity have been added. 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 showed that the target of 1% of Gross Errors was easily being achieved. The RMS of AP differences still has a seasonal variation, being higher in winter (0.8 hPa) than in summer (0.6 hPa).

For moored buoys the Air Pressure (AP) differences with the French the target of 0.5% of Gross Errors was achieved. The RMS of AP differences are between 0.5 to 0.8 hPa.

4) Instrument practices

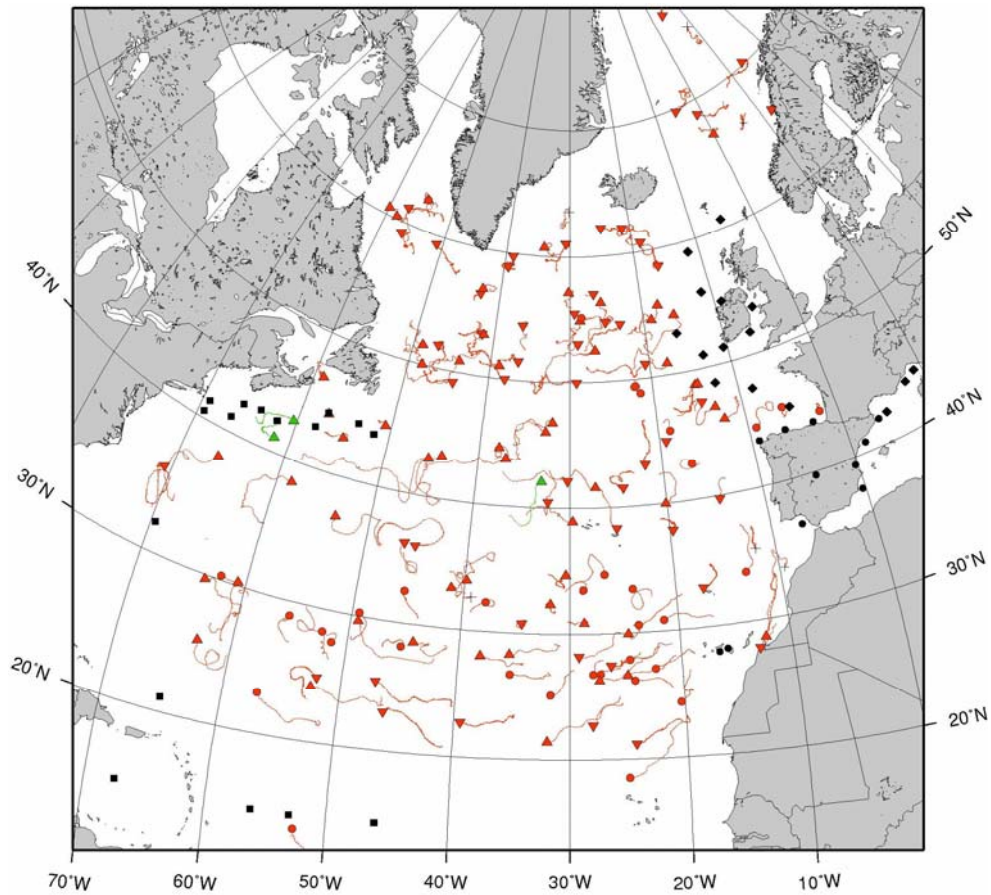
ESURFMAR drifting buoys uses recommended DBCP formats (DBCP-M2 for Argos, formats published on Iridium PP website for Iridium).

A draft technical document on E-SURFMAR moored buoys is under review. It is hoped to have a completed document for the next DBTAG meeting in May 2011.

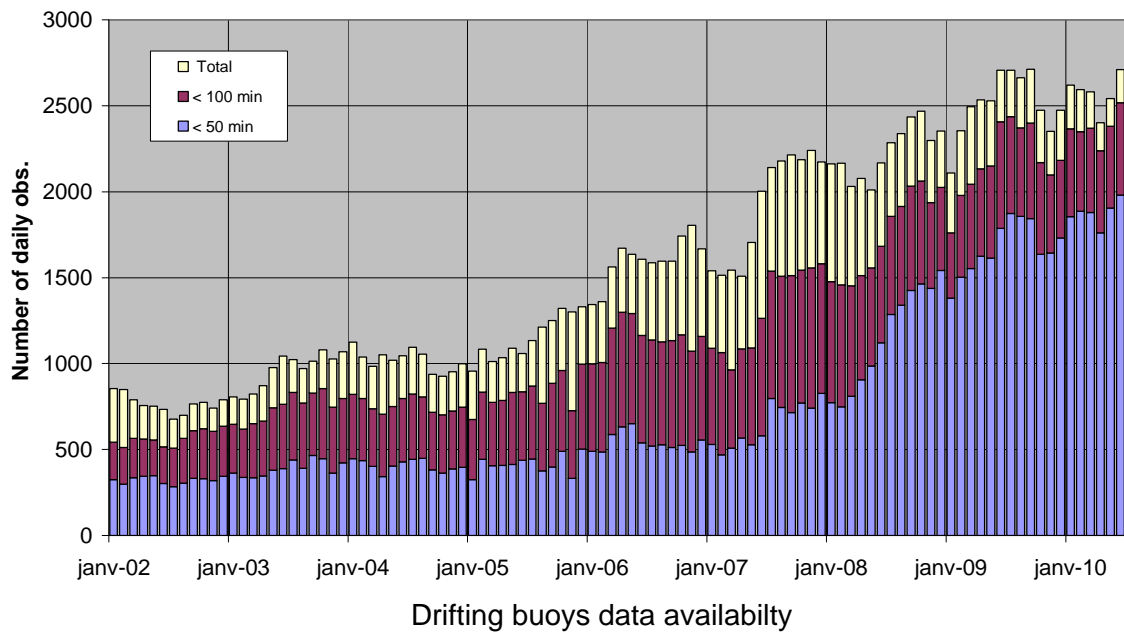
5) OSE experiment

An OSE experiment has been carried out by ECMWF on surface marine data. The study showed a clear positive impact of buoy data, strongest at 1000hPa but lasting up to 500hPa. The impact is stronger and lasts longer when GPS Radio Occultation (GPSRO) data are used. The present density of additional buoys –compared to the situation before ESURFMAR started- has a visible but moderate impact in terms of forecasts scores. The impact on storms Klaus and Xynthia was slightly positive for 24 h forecasts but remarkable for 48 h and 96 h.

Annex



Operating Buoys in E-SURFMAR area
Drifting buoy trajectories and moored buoy positions
(June 2010)



APPENDIX D

REPORT BY THE INTERNATIONAL BUOY PROGRAMME FOR THE INDIAN OCEAN (IBPIO)

1) Summary

Name of Action Group	International Buoy Programme for the Indian Ocean (IBPIO)
Date of report	31 July 2010
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
Type of platform and variables measured	Drifting buoys: Air pressure, SST, (wind) Moorings: air pressure, wind, air temperature, SST, waves, relative humidity, SSS, current...
Targeted horizontal resolution	500 km x 500 km
Chairperson/Managers	Mr Graeme Ball, BoM, Australia
Coordinator	Mr Jean Rolland, Météo-France
Participants	Australia (ABOM), France (Météo-France), India (NIO, NIOT, INCOIS), Kenya (KMD), South Africa (SAWS), Mozambique (EMU); USA (GDP, Navocean), TIP (Tropical Moored Buoy Implementation Panel).
Data centre(s)	ISDM (Canada) as RNODC/DB, Météo-France as SOC AOML, NOAA/PMEL
Website	http://www.shom.fr/meteo/ibpio
Meetings	Annual meetings in conjunction with DBCP meetings. IBPIO 13 in OBAN in September 2010
Current status (mid-2010)	221 drifters (148 with Air Pressure) 39 moored buoys (27 for RAMA 59% of the planned 46 site array)
Summary of plans for 2011	Maintain a network of more than 150 drifters. Maintain the moored buoy arrays, reach 34 buoys deployed for RAMA

2 Deployment plans for 2011

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, SAWS, regularly, fund barometer upgrades in the Indian Ocean. More than 200 drifters are planned to be deployed during the next intersessional period, of which forty five will be equipped to transmit through Iridium (Action by BOM, GDP, Météo-France and DBCP)

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 and the DBCP. The ABOM plans to deploy 9 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 20 in 2010-2011).

RAMA implementation and maintenance will continue in the coming year. MOUs between the US and Indian or Indonesia will provide 90 or more sea days annually to support US sites. JAMSTEC will maintain 4 RAMA sites on a RV Mirai cruise in January 2011. China intends to maintain their surface and subsurface mooring with annual cruises of about 15 days from Indonesian research vessels. An Implementing Arrangement (IA) being developed between the US and the United Nations Developing Programme (UNDP) will formalize efforts to maintain and expand moorings along 55°E. To address security concerns in the area, ASCLME (Agulhas and Somali Current Large Marine Ecosystems, a consortium of 9 African countries) has arranged for a Seychelles Coast Guard escort while in areas of piracy during a cruise in October 2010. The 4th Météo-France supported barometer site will be deployed on this cruise. As security issues are addressed in other areas, further implementation may proceed. By June 2011 the number of RAMA moorings may reach 34, or 74% completion of the IOP planned array.

PMEL is developing a replacement for the ATLAS system which will comprise more commercially available components, provide higher temporal resolution data in real time, and inhibit the theft of surface electronics. Under the terms of an IA between the US and Indonesia, this system will support both RAMA and the Indonesian Global Ocean Observing System (InaGOOS). First prototype deployments will be in the coming year.

NIOT will maintain a network of 12 deep sea buoys, 5 in the Arabian Sea and 7 in the Bay of Bengal.

In the Southern part of the Indian Ocean (South of 35S), the deployment of SVP-B drifters provided by GDC and upgraded by Météo-France (about 30 units, of which 20 will be Iridium buoys) should continue. The ABOM plans to deploy 13 SVP-B drifters in this area over the next 12 months including 8 upgrades. These deployments will be supported by the RV Marion Dufresne during her 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 35S) the ABOM will deploy 6 SVP-B, including 2 near the Indian Ocean Gyre.

The SAWS, through the PMO in Cape Town, will continue to coordinate the deployment of drifters on behalf of GDP, ABOM and Météo-France from voyages to Marion Island (4 voyages every year, March, April, August and November). The ABOM plans to provide 2 SVP-B buoys for deployment from the scheduled voyages in 2011.

As in previous years, the GDP remains the biggest contributor to the IBPIO, with more than 150 planned drifters deployments. Many of the drifters are standard SVP (60 planned deployments) that only measure SST in addition to the surface current deduced from their movement.

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

The evaluation of the Iridium communication system was done as a contribution to the DBCP drifter Iridium Pilot Project. Only a few of the drifters are using Iridium. This improves the data timeliness. One hundred and forty drifting buoys were deployed of which about 73% measured air pressure (SVP-B). The number of daily observations (about 3500 in June 2010) carried out on to the GTS is increasing (see Annex). The percentage of data received within 50 minutes increased from 20% to more than 35%.

By mid-2010, 13 of 17 ATLAS moorings were reporting on the GTS (WMO ID's 14040, 14043, 23001, 23002, 23003, 23004, 23005, 23006, 23008, 23009, 23010, 53005, 53006).

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.

3.2 Data quality

The Météo-France Quality Control (QC) website was enhanced in 2009 (see <http://www.meteo.shom.fr/qctools>). Monthly statistics and 14-day graphs are now available for all surface marine observations through the same interface. Additional parameters are now available, including humidity, wave height and direction, and salinity. Buoys reporting in BUFR are monitored along with those reporting in BUOY or SHIP 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 were generally lower than 1% of Gross Errors. The RMS of AP differences still has a seasonal variation, being higher in winter (1.1 hPa) than in summer (0.8 hPa).

4) Instrument practices

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

5) Issues: maintenance of RAMA moored buoys

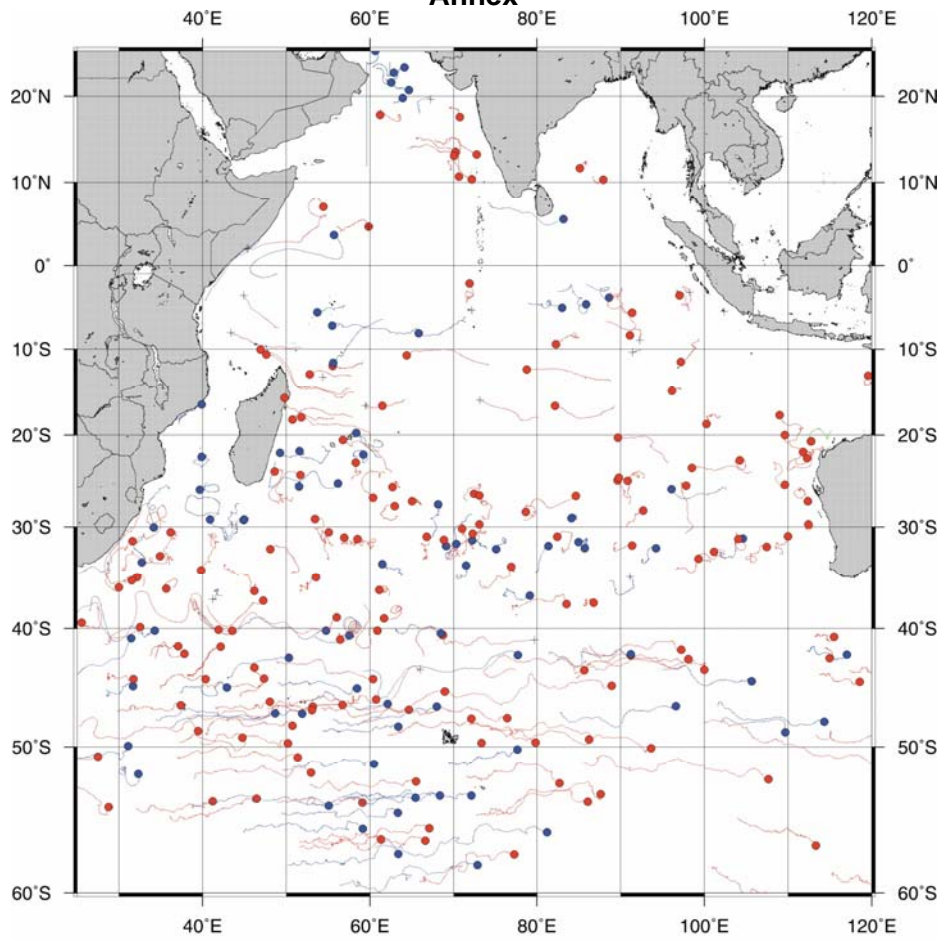
The combination of heavy vandalism and moorings being deployed for unusually long periods has resulted in data return rates significantly lower than those for the tropical moored buoy arrays in the Pacific and Atlantic Oceans. Bad weather and difficulty in obtaining timely and sufficient sea days has led to many RAMA moorings being deployed longer than their intended 12 months. For example, a mooring deployed at 4°N 90°E in October 2007 and vandalized in January 2008 was not replaced until July 4, 2010 (33 months), resulting in a prolonged data gap. The loss of data emphasizes the need for sustained and regular ship support and for measures to combat vandalism.

Damage to buoys and theft of instrumentation continues to be a problem, especially at sites near areas of intense fishing activity. Some ATLAS moorings have been modified to inhibit vandals from boarding the buoy. While proving successful at keeping moorings in place (3 of 4 moorings were recovered and 2 are presently operating) and producing sustained subsurface measurements, an adequate method of inhibiting vandalism upon surface met sensors has not yet been found.

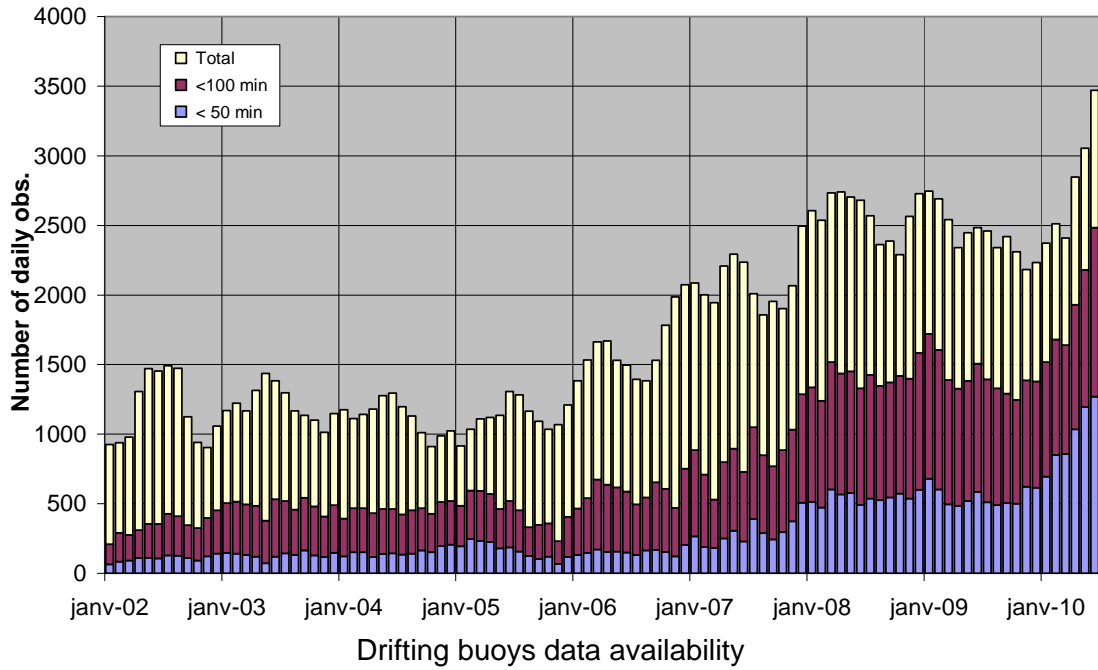
Between July 2009 and June 2010, 106 sea days (74 by India and 32 by Indonesia) were provided in support of ATLAS RAMA sites. Additional ship time was provided by India in support of their Deep Ocean moorings (~37 days), Japan in support of their m-TRITON moorings (14 days) and Indonesia in support of China's moorings (28 days). The number of sea days necessary to fully maintain the completed array is estimated to be at least 200 days per year. Formal bilateral agreements have either been approved or are under development between NOAA and agencies of the various partner countries to help complete and sustain the array. To facilitate and coordinate resources that may be applied to the Indian Ocean Observing System, an IndOOS Resource Forum was established in 2009.

In addition to vandalism, recent well-publicized piracy events have resulted in the suspension of RAMA implementation off Africa and in the Arabian Sea

Annex



Drifting buoy trajectories (June 2010)



APPENDIX E

REPORT BY THE DBCP-PICES NORTH PACIFIC DATA BUOY ADVISORY PANEL (NPDBAP)

1) Summary

Name of Action Group	DBCP-PICES North Pacific Data Buoy Advisory Panel (NPDBAP)
Date of report	31 July 2010
Overview and main requirements addressed	The goals of the NPDBAP are to deploy 50 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: Al Wallace, MSC, Canada Co-Chairperson for the NW Pacific: Position vacant and to be proposed by PICES
Coordinator	Mr Shaun Dolk, NOAA / AOML
Participants	Al Wallace, Chris Marshall, Joe Linguanti, Ignatius Rigor, and Shaun Dolk
Data centre(s)	Global Drifter Assembly Centre (DAC) Integrated Science Data Management (ISDM), Canada
Website	http://npdbap.noaa.gov/
Meetings	Yearly meetings usually held in conjunction with DBCP meetings. Next meeting planned 26 September 2010 in Oban, UK
Current status (mid-2010)	From 01 September, 2009 to 27 July, 2010, 94 drifters have been deployed. 58 of these drifters were equipped with barometers, 22 were equipped with GPS, and one was equipped with a wind sensor (the remaining 13 drifters were basic SVP type units).
Summary of plans for 2011	The goal for 2011 is to reach 100 drifter deployments, of which, at least 60 drifters shall be barometer equipped.

2 Deployment plans for 2011

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

Through the tremendous help of Ignatius Rigor, a collaboration with JAMSTEC has been established, which allows for drifter deployments on Japanese vessels.

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 (July 2010), data are available through March 2010. 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 Dec 2009 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

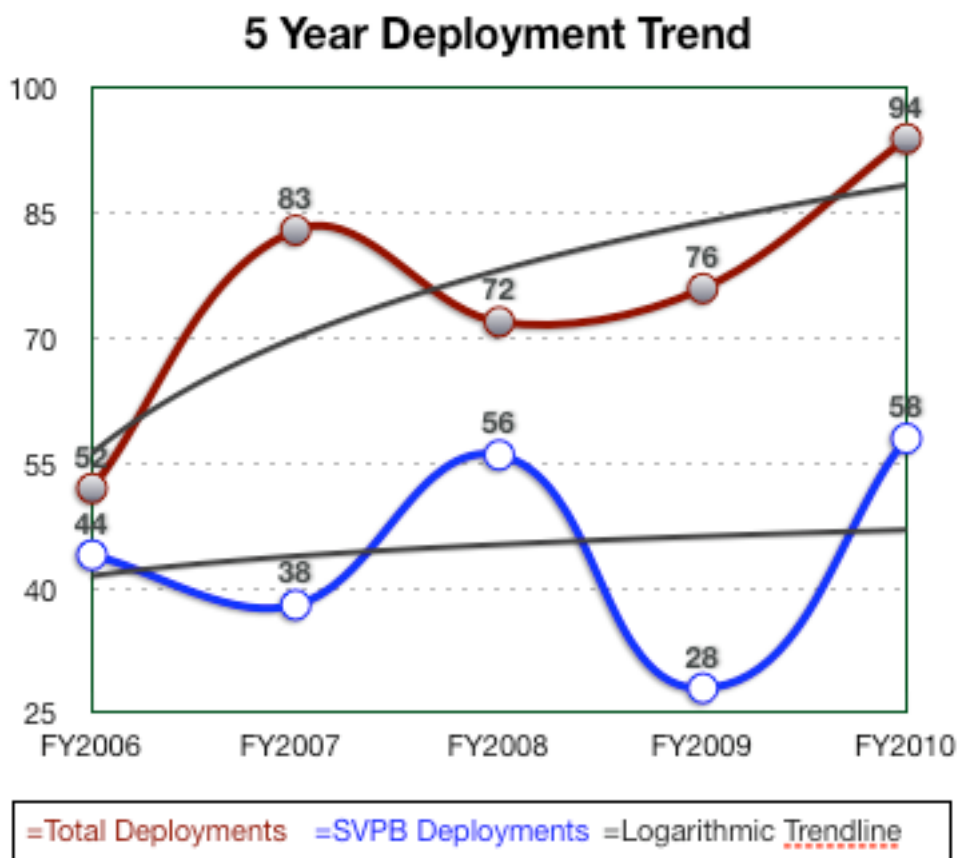
5) Other issues as needed

Annex

Status maps and graphics

5 Year Deployment Trend

	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



APPENDIX F

REPORT BY THE INTERNATIONAL ARCTIC BUOY PROGRAMME (IABP)

1) Summary

Name of Action Group	International Arctic Buoy Programme (IABP)
Date of report	25 August 2010
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 platforms 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	Christine Best, Meteorological Service Canada (MSC)
Coordinator	Ignatius Rigor, Polar Science Center, University of Washington, USA
Participants	Participants range from Science Institutions to Universities to Government Agencies. A listing of Participants and contact information is given on http://iabp.apl.washington.edu/overview_participants.html
Data centre(s)	n/a
Website	http://iabp.apl.washington.edu/
Meetings	Annual meetings in spring/early summer in the Northern Hemisphere
Current status (mid-2010)	Total of 72 buoys in the IABP array 23 August 2010
Summary of plans for 2011	Participants will deploy buoys ranging from SVP's providing surface air pressure to buoys providing air pressure and air temperature to Ice mass Balance buoys, Oceanographic profiling buoys measuring temperature and salinity to great depths and buoys that measure atmospheric air components such as ozone

2 Deployment plans for 2011

Specific details on deployment plans, and opportunities for next year are not known. As plans and opportunities for deployments become known Participants are encouraged to make them known to the IABP Coordinator Ignatius Rigor Ignatius@apl.washington.edu.

Participants are also encouraged to share their plans and opportunities with Jenny Hutchings, IARC, jenny@iarc.uaf.edu for posting on the web page www.iceplan.org

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 is 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 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

The percentage of data from the buoys being distributed on GTS has not been calculated. Details on data timeliness (i.e. reception time at operational meteorological services minus observation time), including known problems, possible solutions, statistics, etc is not available.

3.1.3 Delayed mode data exchange

Data are available from <http://iabp.apl.washington.edu> as well as ISDM. Data are also archived at the World Data Center for Glaciology (<http://www.nsidc.org>), and the U.S. National Science Foundation's Cooperative Arctic Data and Information Service (<http://www.AONCADIS.org>)

Collection of - and distribution of - metadata is an ongoing task of the Coordinator. We plan to provide these through our web server (<http://iabp.apl.washington.edu>) and produce netCDF data files containing this information

Details on the provision of discovery metadata about available data-sets using ISO 19115 standard are to be determined.

3.2 Data quality

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

4) Instrument practices

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

5.1 Challenges to sustain IABP network

- Increasing areas of First-Year Ice and Open Water during summer
- Deploying buoys in the Eurasian Arctic

5.2 Buoy data not getting onto GTS

5.2.1 Argos Buoys - Yann Bernard, Service Argos, provided the IABP Coordinator a list of active Argos platforms in the IABP area north of 66N not yet being processed by Service Argos for the GTS. The IABP Coordinator will contact those on the list to see if they are willing to share via having data posted to the GTS.

5.2.2 Iridium Buoys - Many researchers are using Iridium rather than Argos to get their data and that data is being posted to ftp sites and no further. Efforts are being made to have data flipped to the GTS. For example, Joubeh, Scotia Weather, and Environment Canada are collaboration for posting Iridium data on the GTS.

5.3 Obtaining data that did not get onto the GTS

During the IPY in particular, there were buoys on ice whose data has yet to make it to GTS or IABP archives. Efforts are ongoing to get that data in GTS and IABP archives.

Annex

Status maps and graphics

IABP Program Buoy Status 23 August 2010 with comparisons back to 2006

	2006 7 August	2007 17 August	2008 15 August	2009 9 August	2010 23 August ¹
Ocean Profiling POPS or ITP	2	9	7	11	13
Ocean Profiling UpTempo					2
Arctic Ocean Flux Buoy			1 ²	1 ²	2
Ice Mass Balance	6	8	9	5	4
Near Surface Air Chemistry O buoy					1
Only Surface air temperature and surface air pressure	27	33	30	25	11 ⁴
Only Surface air temperature	2	1	1	1	1
Only Surface air pressure	2	8	20	40	22
Position only ³	4	30	23	6	15
Russian manned station			NP 35	NP 36	Nil NP37 established September 2009 and removed May 2010
Total Numbers of buoys	43	89	91	89	72

¹ The annual White Trident aerial deployment historically occurs early August and accounts for 7 to 12 buoys once it has occurred. The 2010 mid August buoy count is low as the annual WT exercise has not yet occurred. WT 2010 is scheduled for September and is expected to add up to 10 buoys to the array.

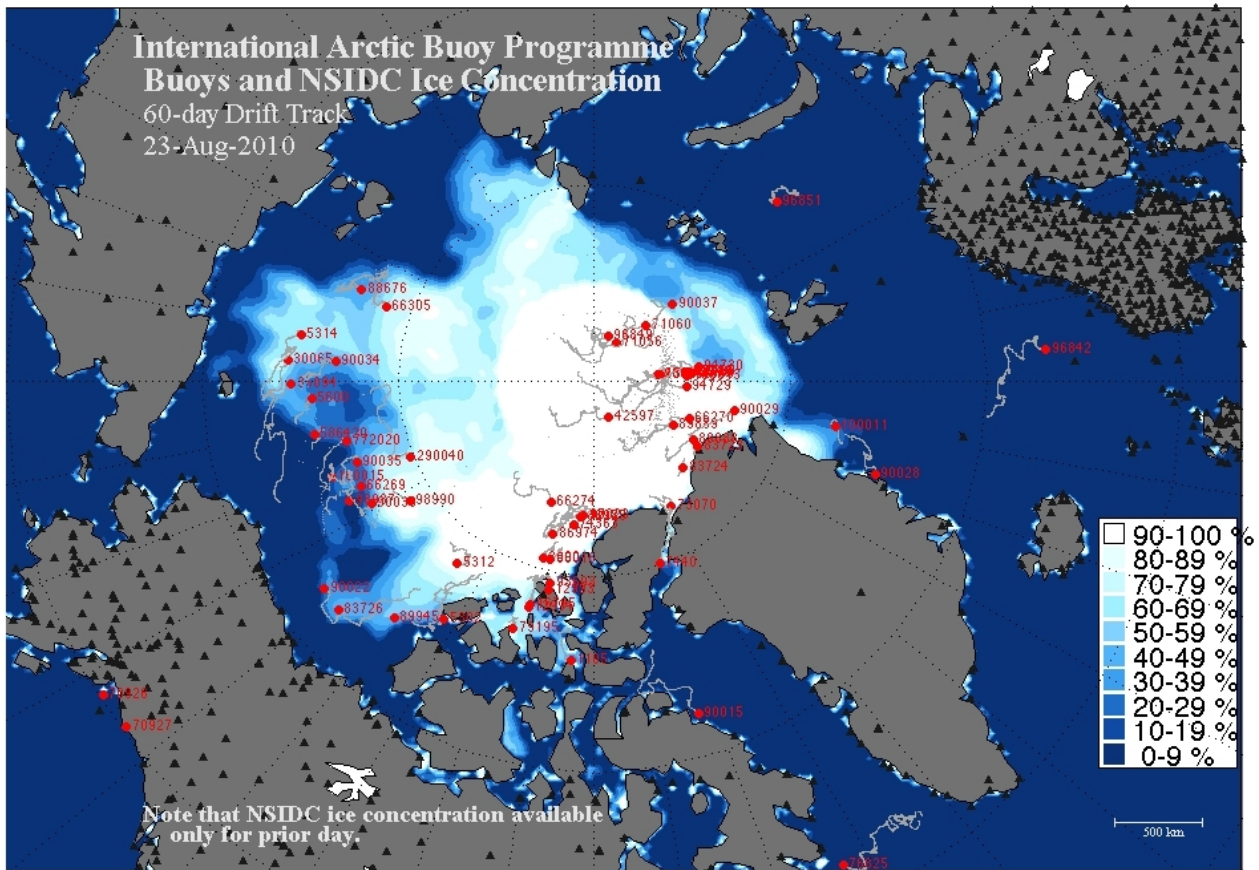
² Not reflected in 2008 or 2009 editions of table

³ By design or because the surface air temperature and surface air temperature data has failed or become unreliable

⁴ Six buoys shown elsewhere in the table also provide both surface air temperature and surface air pressure.

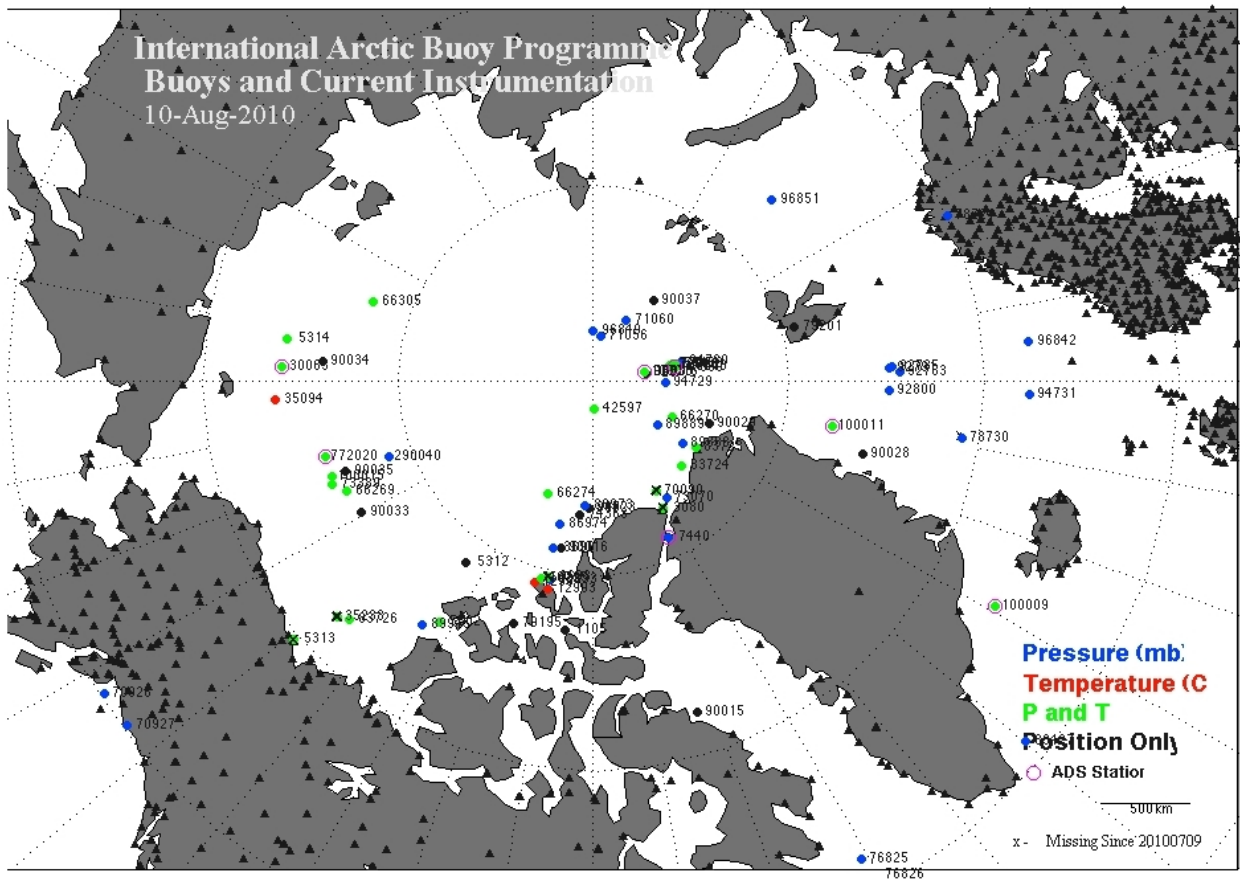
Buoy map with 60-day buoy track and ice concentration 23 August 2010

From International Arctic Buoy Programme web page <http://iabp.apl.washington.edu> daily map series



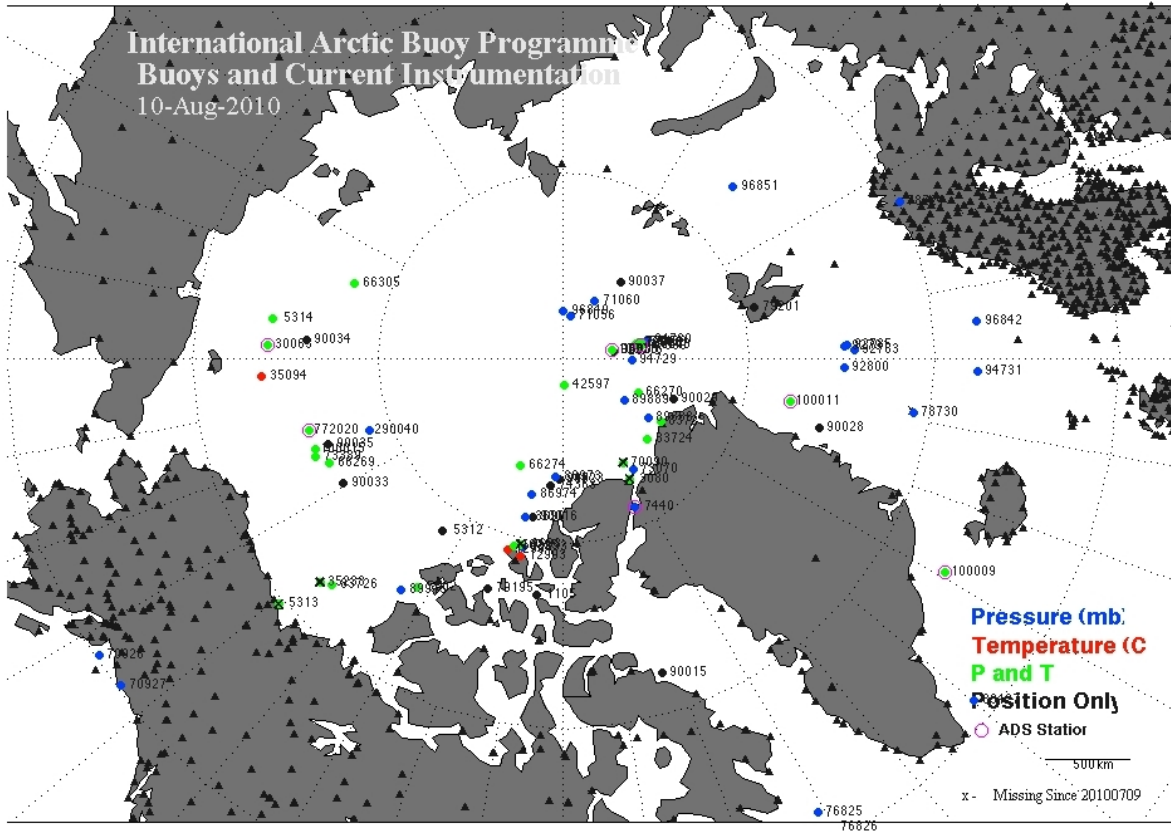
Buoy map with respect to instrumentation 10 August 2010

From International Arctic Buoy Programme web page <http://iabp.apl.washington.edu> monthly map series

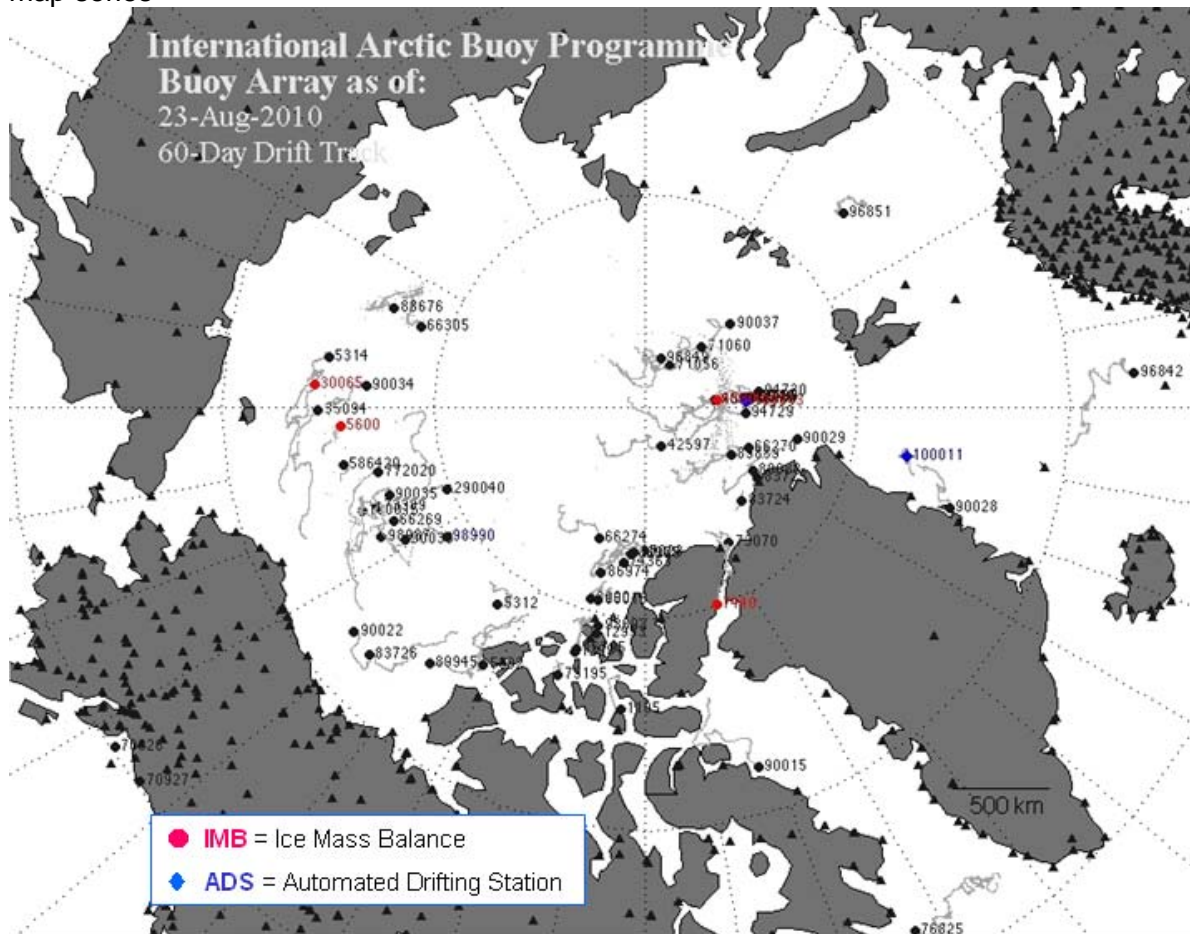


Buoy map with respect to meteorological data provided 10 August 2010

From International Arctic Buoy Programme web page <http://iabp.apl.washington.edu> monthly map series

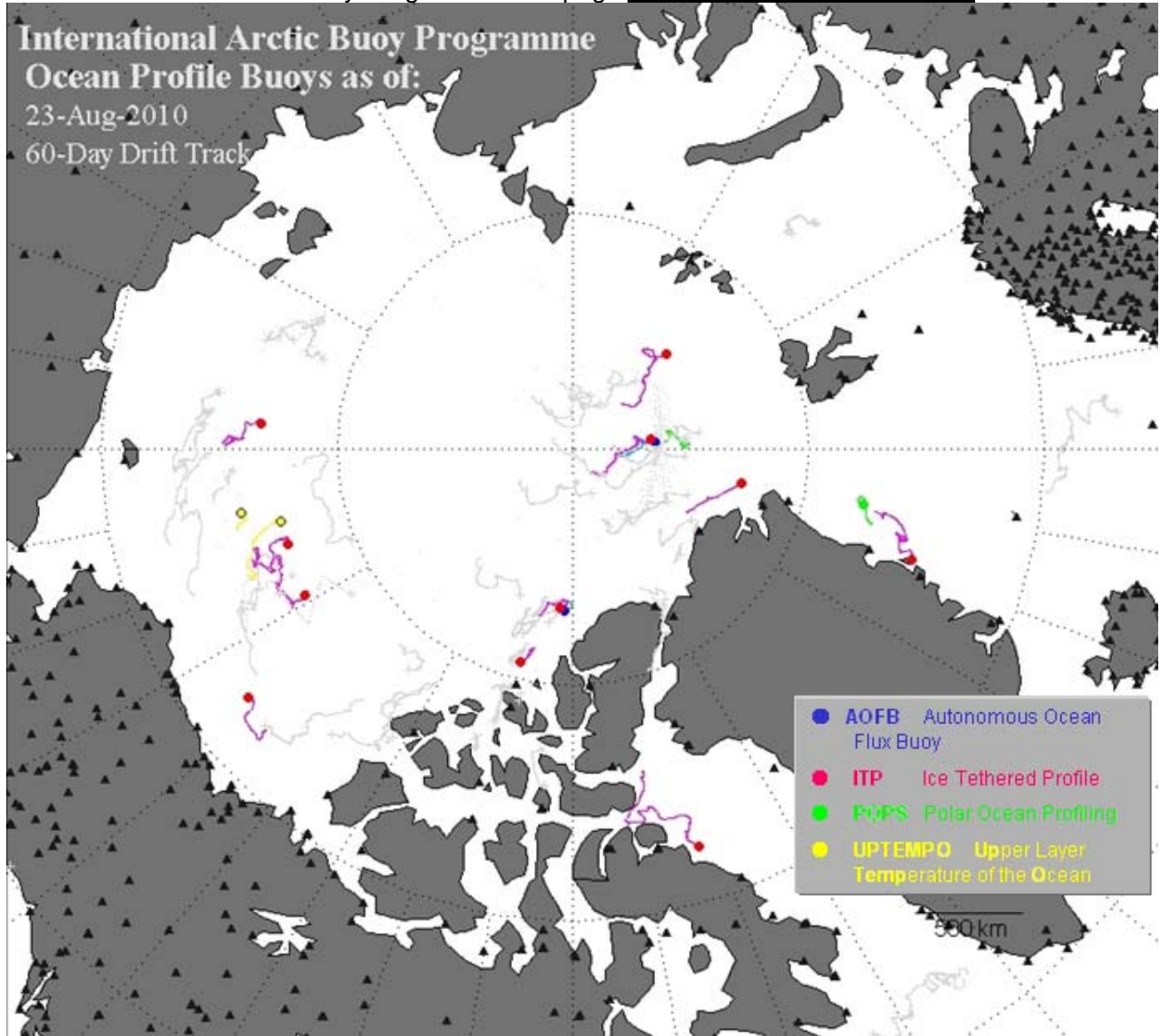


Buoy map highlighting ice mass balance buoys and automated drifting stations 23 August 2010 From International Arctic Buoy Programme web page <http://iabp.apl.washington.edu> daily map series



Buoy mapping showing ocean profiling buoys 23 August 2010

From International Arctic Buoy Programme web page <http://iabp.apl.washington.edu>



APPENDIX G

REPORT BY THE WCRP-SCAR INTERNATIONAL PROGRAMME FOR ANTARCTIC BUOYS (IPAB)

1) Summary

Name of Action Group	WCRP-SCAR International Programme for Antarctic Buoys (IPAB)
Date of report	31 July 2010
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.
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: Basic variables: Buoy position, atmospheric pressure and SST Other variables: air temperature, ice and / or snow temperature, atmospheric pressure tendency, wind, snow and sea-ice properties and oceanographic variables
Targeted horizontal resolution	500 km x 500 km
Chairperson/Managers	Mr Shuki Ushio, NIPR, Japan
Coordinator	Dr Christian Haas, University of Alberta, Canada
Participants	<ul style="list-style-type: none"> - Alfred Wegener Institut, Germany - Australian Antarctic Division, Australia - Australian Bureau of Meteorology - British Antarctic Survey, UK - Finnish Institute for Marine Research, Finland - GI, University of Alaska Fairbanks, USA - IARC, University of Alaska Fairbanks, USA - Institut für Meteorologie und Klimaforschung, Universität Karlsruhe, Germany - National Ice Center, USA - National Snow and Ice Data Center, USA - Met. Service NZ LTD, New Zealand - Norwegian Polar Institute, Norway - NSF, USA - National Institute of Polar Research, Japan - JAMSTEC, Japan - Programma Nazionale di Ricerche in Antartide, Italy - DAMTP, UK - SAMS, UK - University of Alberta, Edmonton, Canada

	<ul style="list-style-type: none"> - CLS/Service Argos, France - South African Weather Service, South Africa - United Kingdom Meteorological Office, UK - CRREL, USA
Data centre(s)	
Website	http://www.ipab.aq/
Meetings	Biennial meetings
Current status (mid-2010)	An informal IPAB meeting was held at the International Antarctic Sea Ice Workshop on May 30, 2010, in Tromsø, Norway, where all of the most active IPAB participants were present. There were no deployments performed on sea ice in the 2009/2010 season, although numerous SVPs were deployed in open water by the Meteorological Services of South Africa, Australia, and New Zealand.
Summary of plans for 2011	The Meteorological Services of South Africa, Australia, and New Zealand will continue to deploy SVPs in the open water zone during December 2010 to March 2011. In addition, 22 buoys will be deployed on ice during two research cruises in the Southern Pacific. Participants are encouraged to transmit their data to the GTS, and support by the coordinator has been offered.

2 Deployment plans for 2011

Buoys will be deployed during two research cruises to the Southern Pacific.

20 prototype ice mass balance buoys will be deployed by SAMS and BAS in the Bellingshausen Sea during a research cruise of RV James Clark Ross in November 2010. These buoys include GPS and thermistor chains through the snow and ice.

2 standard CRREL ice mass balance buoys will be deployed by the University of Texas San Antonio in the Bellingshausen and Amundsen Seas during a research cruise of IB Oden in November/December 2010. These buoys include GPS and thermistor chains through the snow and ice, as well as sonic rangefinders to measure changes of snow and ice thickness.

Other nation's research cruises are generally available for opportunistic buoy deployments, however, cruise tracks are generally not favourable of sustained deployments on ice floes with a good chance of survival through the summer.

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. However, unfortunately only few

data are actually being transmitted. Many participants are overwhelmed by new requirements due to increased usage of Iridium transmission.

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 is data are transmitted on GTS.

APPENDIX I

REPORT BY THE INTERNATIONAL SOUTH ATLANTIC BUOY PROGRAMME (ISABP)

1) Summary

Name of Action Group	International South Atlantic Buoy Programme (ISABP)
Date of report	31 July 2010
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 upto 20N
Type of platform and variables measured	Lagrangian drifters measuring sea level pressure, SST, and sea-surface velocity
Targeted horizontal resolution	5 degrees x 5 degrees
Chairperson/Managers	Mr Ariel Troisi, SHN, Argentina
Coordinator	Mayra Pazos, AOML-NOAA, USA Lithakazi Mkatshwa, SAWS, South Africa
Participants	
Data centre(s)	Historical drifter data are assembled, quality controlled at AOML, Miami, then sent to ISDM for archival and further distribution. Real time data is also archived at ISDM
Website	http://www.jcommops.org/dbcp/isabp/index.html http://www.oceanlan.org/isabp/en/index.html
Meetings	Meetings are held every other year, normally in May-July. ISABP-13 took place in Buenos Aires, Argentina, on April 19, 2010
Current status (mid-2010)	As of July 19, 2010, there were a total of 296 drifters in the SA (160 SVP, 136 SVPB) surpassing the goal of 100 SVPB in the area.
Summary of plans for 2011	Continue to address observational gap areas specially in the Gulf of Guinea and Angola Basin; pursue recommendation of conducting studies and evaluate the impact of drifter pressure data and SST on the skills of numerical weather forecasting models for the region; increase number of SVPB in the region.

2 Deployments in 2010 and plans for 2011

Deployments during the last year (19-July 2009 through 19 July 2010) are shown in Figure 1. Efforts to populate hard to reach areas (i.e. Gulf of Guinea and Angola Basin) continued during the intersessional period, mainly with the help of the US Navy vessels(12). Other deployments were carried out by the Brazilian Navy (53), SA Agulhas(31) LM Gould(8), Argentinian Navy(7), and several other research vessels. Brazil will deploy a total of 95 drifters in 2010 (75 SVP provided by GDP and 20 SVPB upgraded by Brazil). Tristan da Cunha and the Falklands/Malvinas, participated actively in the deployment of drifters from their fisheries vessels, throughout the year. South Africa Weather Service acquired 5 Iridium drifters to be deployed as part of the Iridium Pilot Project, of which 2 have been deployed in the region (and one in the Indian Ocean sector). The remaining two will be deployed, again in the South Atlantic in September. Brazil expects to finish repairs to one moored buoy and have it deployed between Jul-Dec 2010.

In 2011, the US Navy will continue its African Partnership Station program and will carry out more deployments in the area.

SAWS is now actively finding deployment opportunities as well as increasing the VOS fleet, therefore they expect to be able to arrange for more deployments. It is expected that the Polarstern will be returning to the Atlantic sector in the 2010/2011 austral summer season.

Argentina can now receive donations of instruments without paying any taxes, and will continue to deploy drifters in the area. There is also a center in Puerto Madryn that is very interested in participating in the program by deploying instruments.

The GDP deployment plans from June 1, 2010 – May 31, 2012 are as follows:

Tropical Atlantic (20 ⁰ S – 30 ⁰ N):	SVP=335	SVPB=25 (upgraded by Brazilian Navy)
Extra Tropical Atlantic (40 ⁰ S – 20 ⁰ S):	SVP=25	SVPB=75
Southern Atlantic (60 ⁰ S – 40 ⁰ S):	SVP=0	SVPB=225

Servicio de Oceanografia, Hidrografia & Meteorologia de la Armada, Uruguay, who recently joined ISABP agreed to provide deployment opportunities in 2011.

3 Data management

3.1 Distribution of the data

These data are assembled and quality controlled at the GDP Drifter Data Assembly Center, and available through the DAC web page (<http://www.aoml.noaa.gov/phod/dac/dacdata.php>) and from ISDM web (<http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/drib-bder/index-eng.htm>)

3.1.1 Data 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 July 19 there were 296 surface drifters in the South Atlantic region transmitting good quality data on the GTS.

Details on data timeliness (i.e. reception time at operational meteorological services minus observation time), including known problems, possible solutions, statistics, etc.

Because of the less-than-ideal satellite coverage of the parts of the region, the South African

Weather Service wanted to re-install the Local User Terminals at its Island bases (Marion Island and Gough Island) in order to support the timely delivery of buoy data in the vast contiguous ocean areas. Unfortunately, recent global economic downturn put paid to the SAWS' plans to reinstall and upgrade LUT's. Since then, CLS has revealed their plan to upgrade their IS antenna network to achieve greater coverage over the oceans. This network will extend to the Southern Hemisphere to ensure the timely delivery of buoy messages for inclusion in the synoptic analyses. This will be expanded on by CLS/Argos.

3.1.3 Delayed mode data exchange

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

Metadata from GDP drifters are collected at the DAC directly from the manufacturers, archived and made available on the deployment log at the DAC web page www.aoml.noaa.gov/phod/dac/deployed.html

3.2 Data quality

A large number of drifters deployed by the Brazilian Navy this year failed on deployment. The manufacturer was contacted and it was determined that particular batch or drifters was manufactured more than 2 years prior to deployment and kept in storage for a long period of time and that may have been the cause of the early failures.

4) Instrument practices

Details on instrument practices, followed standards and procedures, traceability to SI units, instrument inter-comparisons, etc.

5) Evolution of the South Atlantic Drifter array

Status of the South Atlantic drifter array as of July 19, 2010 is shown in Figure 4. A total of 296 drifters (SVP: 160 and SVPB: 136) were transmitting at the time. The goal of 100 SVPB in the regions was surpassed, most of them found south of 20°S, and some north of 20°N.

Figure 3 shows the number of deployments in the region by year since 2000. A moderate increase in the total number of drifters deployed per year is noticeable, except in 2007-2008, when deployment opportunities were scarce due to some ships breaking down, but were well averaged out by the large deployment increase in 2009. Also the number of SVPB has slowly increased throughout the years. A sharp increase in the number of SVPB can be seen in 2007, due to 40 Iridium SVPB drifters from Brazil, deployed in the area and data processed at the DAC.

Annex

Status maps and graphics

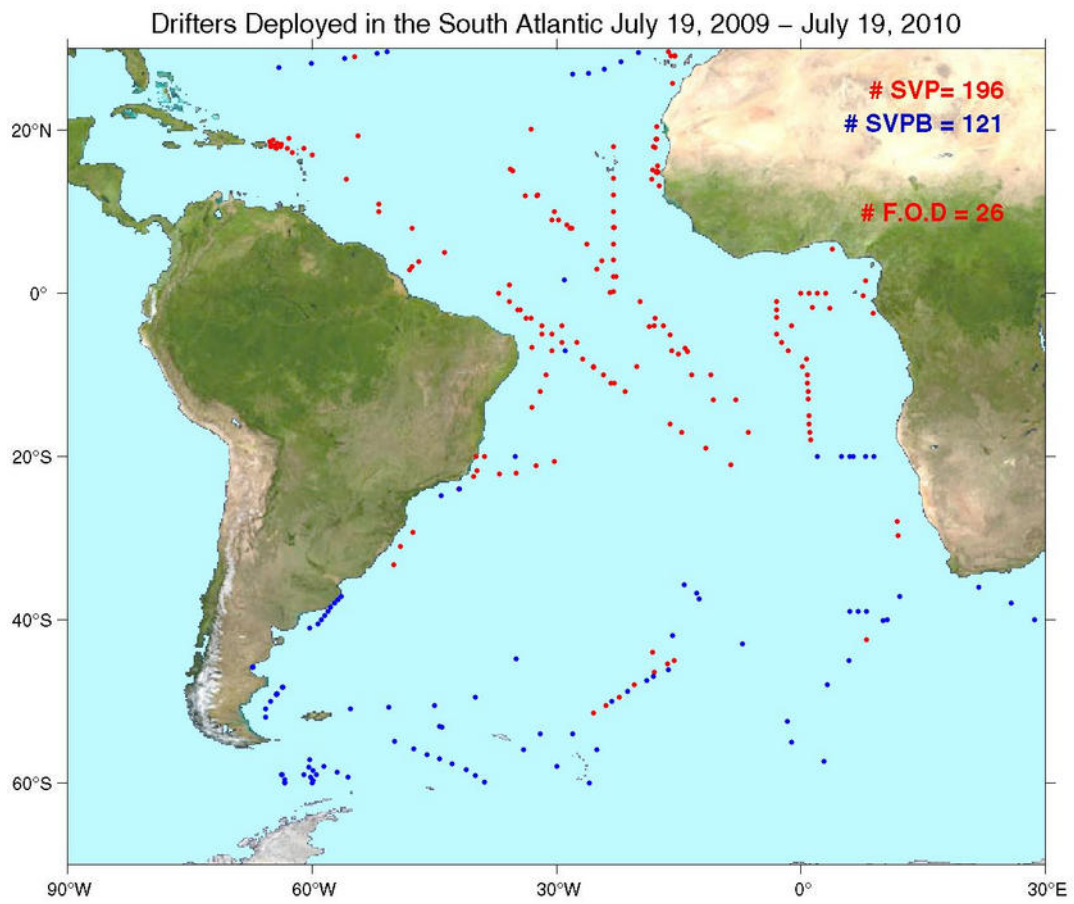


Figure 1: Deployment locations. A total of 317 drifters were deployed.

STATUS OF DRIFTER ARRAY

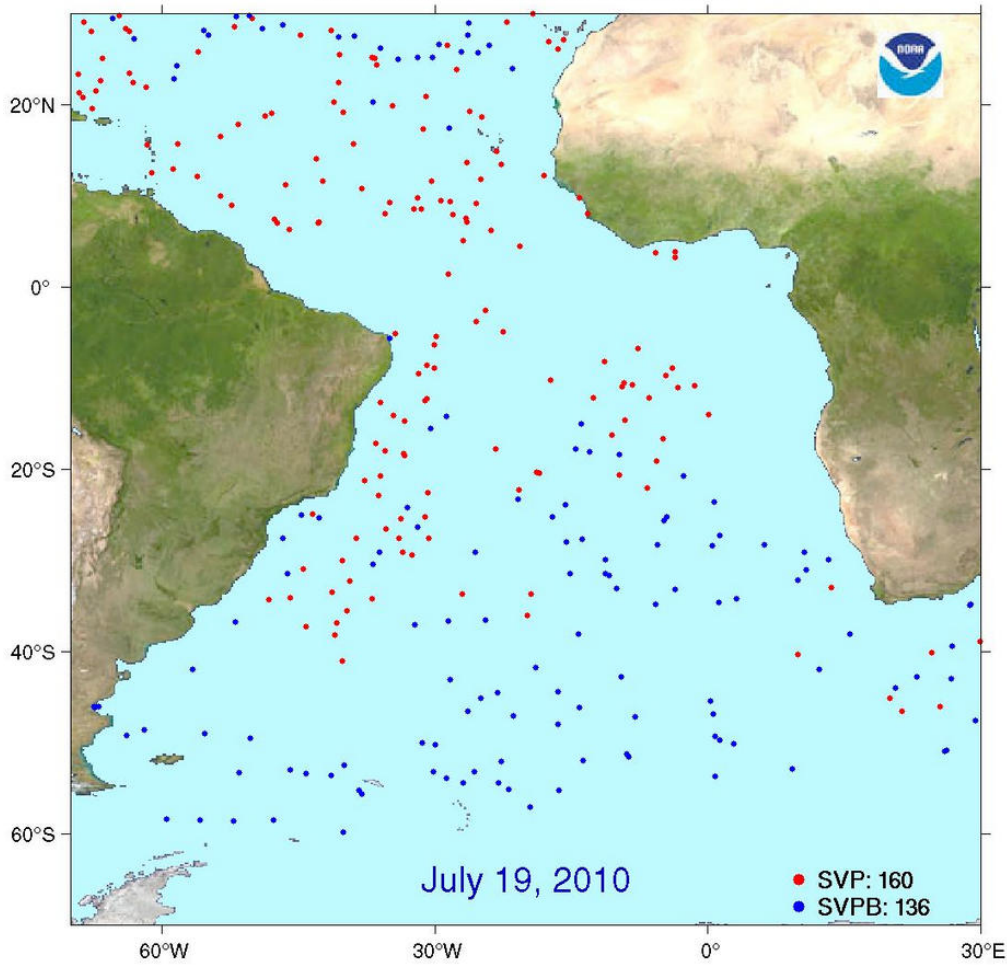


Figure 2: Status of the South Atlantic Array. A total of 296 drifters in the region

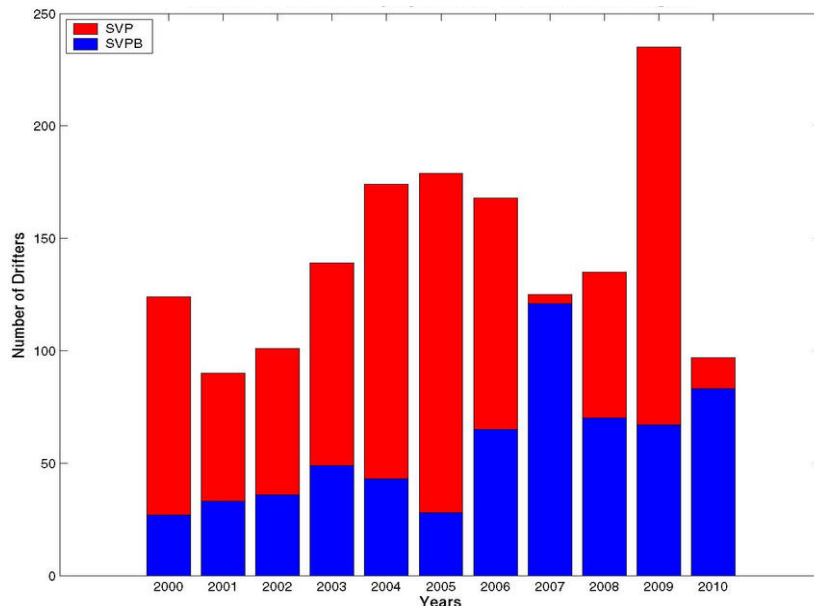


Figure 3: Number of Drifters Deployed in the South Atlantic per year

APPENDIX I

REPORT BY THE OCEAN SUSTAINED INTERDISCIPLINARY TIMESERIES ENVIRONMENT OBSERVATION SYSTEM (OCEANSITES)

Status and update on OceanSITES for DBCP-26

An update on OceanSITES had been prepared and provided only 5 months ago (April 2010) for the DBCP25 report, so not many additional new developments can be reported here. Most activities since DBCP25 were actually included in that report.

Additional activities took place at the Data Management and Project Office level. The Data Management Team has continued its monthly conference calls, and arrived at an agreed update to the OceanSITES data format, which is now being implemented by the current data providers. Data is flowing from most of the participants in the original OceanSITES Steering Team, and in some cases that is starting to include biogeochemical data (e.g. for EuroSITES). Steve Diggs from CCHDO visited BIOS/Bermuda to resolve technical issues in getting the data from there into the OceanSITES system.

The project office activities for OceanSITES continued to be carried out by Hester Viola together with some IT support, but Hester is leaving, and the funding for the project office is uncertain. Having the project office was the single most important factor that allowed OceanSITES to make real progress over the past 18 months, and without this we will be thrown back into stagnation. Hester visited Kiel in August to meet with Uwe Send, Doug Wallace, and Johannes Karstensen, and established a remaining to-do list to help the OceanSITES project office survive a period of vacuum.

Outreach, collaborations, and interfacing with other communities took place in various ways. Bob Weller represents the US OOI, is a member of OOPC, and attends many international meetings, building a connection to those. Uwe Send continues to inject OceanSITES into the OceanObs09 process, and it will be discussed whether OceanSITES could be a home for a global boundary current observing system. Uwe Send also represents OceanSITES in the Clivar GSOP panel, in US and international AMOC, and at other workshops/meetings (ASLO/AGU meeting in Portland 2010, POSTI International Symposium in Pohang 2010, OCB timeseries scoping workshop Honolulu 2010). Doug Wallace and Francisco Chavez continue to advocate the MOIN network of a subset of comparable minimal multi-disciplinary sites in the SOLAS and OCB communities.

APPENDIX J

REPORT BY THE INTERNATIONAL TSUNAMETER PARTNERSHIP (ITP)

Summary

Name of Action Group	The International Tsunameter Partnership (ITP)
Date of report	27 Sep 2010
Overview and main requirements addressed	The International Tsunameter Partnership was established under the auspices of the IOC Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (IGC/IOTWS). Its purpose is to support the establishment, effectiveness and on-going viability and enhancement of tsunami detection and warning systems using deep ocean monitoring stations (tsunameters). Its members are active in areas of tsunameter system development and qualification for moored and cabled systems; observation network establishment; data exchange and operational practices. Sustainability, including vandalism responses, will become an important focus.
Area of interest	All ocean basin or seas that are tsunami-vulnerable, with tsunami warning centres. There is a natural concentration on the Indian Ocean region because of the extent of new observation networks and the diversity of tsunameter product types in the IO and nearby east Asian seas.
Type of platform and variables measured	<u>Moored Buoys</u> : Sea Level (ocean column height): with some platforms also reporting met parameters and sub-surface parameters (product dependent) <u>Cabled Systems</u> : Sea Level (ocean column height) plus wide variety of node-dependent ocean, seismic and biogeochemical parameters.
Targeted horizontal resolution	Not applicable – purpose-designed networks matched to threat sources and warning requirements
Chairperson/Managers	Chair: Ken Jarrott, Australian Bureau of Meteorology Vice Chair: Ridwan Djameluddin – BPPT - Indonesia
Coordinator	Not applicable
Participants	Australia, Germany, India, Indonesia, Malaysia, USA, China, Korea, Thailand, with suppliers (USA, Italy, UK, Norway, and national R&D agencies). Expansion to new national network operators (Russia, Oman, Cyprus) to be welcomed in coming year.
Data centre(s)	National operator agencies for buoys with restricted national data distribution. NOAA – NDBC for Pacific Ocean, Caribbean and SW Atlantic DART™ stations.
Website	NDBC web site www.ndbc.noaa.gov for the large network of DART™ and DART-derivative products with global GTS data distribution. National warning centre web sites where applicable.
Meetings	ITP meets once a year, recently in conjunction with DBCP. ITP-5: Paris, Sep 2009; Informal meeting Banda Aceh, Indonesia, Apr 2010; ITP-6: Oban, Scotland, 1-2 Oct 2010
Current status (mid-2010)	54 tsunameters are operational across all ocean basins. The majority are in the Pacific Ocean, with 12 in the Indian Ocean region.
Summary of plans for 2011	6 new stations planned in Indian Ocean and east Asian seas (apart from restoration of stations at previously established sites). Global data exchange from non-DART platforms implemented. Sustaining activity for global networks across all basins ~ 80-90 sites

2 Deployments in 2010 and plans for 2011

Network establishment activities during the last year (September 2009 – September 2010) are:

- Indian network augmented with one (1) SAIC STB and is being re-seeded with updated Indian tsunameters
- Malaysia deployed 3rd (final) station
- Indonesia - 4 new stations deployed
- Australia deployed 7th station (experimental ETD in Fiji Basin)
- China - trial station deployment (Envirtech) June 2010
- Cyprus - cabled TWERC ocean observing nodes (4) deployed (pre-operational), Sep 2010

See network maps below:

Fig 1: Status of DART* Components of Global Tsunami Warning Networks

*globally transmitting DART™ and ETD-DART stations from NOAA, and DART-derivative and ETD-DART products supplied by SAIC. Stations operated by USA, Chile, Australia, Thailand, Indonesia.

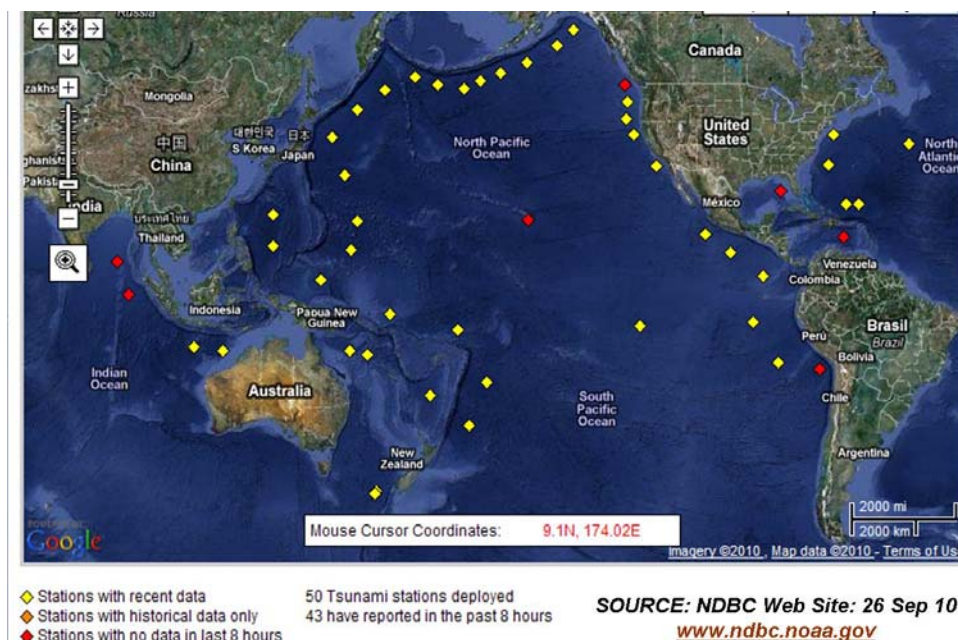


Fig 2: Planned and Deployed Networks – Indian Ocean and SE Asian Seas



Fig 3: Cabled Tsunameter Locations – Oman and Cyprus



Network Establishment plans for the next year (Sep 2010 – Sep 2011) are:

- China – two (2) test / trial stations to be deployed
- Russia to deploy one (1) station deployment – end 2010 – new network
- Australia and Indonesia to establish a joint trial ETD DART site in Indonesian waters
- Thailand to deploy (final) 2 stations by Dec 2010
- Korea – three (3) stations to be deployed (new network)
- India – one (1) extra station to be deployed in the Makran Trench
- Cyprus – to commission cabled system deployed in 2010

3 Data Management

3.1 Distribution of the data

Data is currently stored and managed locally, by national operating agencies. There is not yet a global data repository or linked set of national repositories. Neither is there a global metadata repository or consistent set of nationally managed metadata.

High resolution data sets for tsunami events (including seismic trigger events) are being provided to the US National Geophysical Data Center (NGDC) for access by researchers and

for post event analysis.

3.2 Real time data exchange

Regional and global dissemination of data remains an imperative for Indian Ocean stations, especially in circumstances where networks are not yet fully populated, and are impacted by technical issues and vandalism. The map below indicates the stations currently operational and the smaller set of those transmitting global data via the GTS.

Fig 3: Operational and Globally Transmitting Stations - IOTWS



While global data transmission for non-DART products remains a significant weakness, the status of global data transmission and progress is:

- Over 50 DART-derivative stations are delivering data on GTS
- All Australian stations are reporting on GTS in standard BUFR format
- India is at an advanced state of tsunameter data encoding in standard BUFR format – ready for a GTS transmission test
- SAIC has developed CREX data conversion for its tsunameter products.

3 Product Development and Instrument Practices

Many countries and suppliers are still active in tsunameter product development. During the year, the following developments occurred:

- Development of cabled systems for the Mediterranean (Cyprus TWERC)
- Re-configuration of Indian tsunameters for battery operation
- German GITEWS tsunameters manufactured with bottom pressure sensors
- Transition of the ETD DART product to commercial supply
