WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

Joint WMO-IOC Technical Commission For Oceanography And Marine Meteorology (JCOMM)
Observations Programme Area Coordination Group (OCG)

Fourth Session

Hobart, Australia, 18-20 April 2011

OCG-IV/Doc. 4.1.4
(05.IV.2011)

English only

Report by the Tropical Moored Buoy Implementation Panel (TIP)

submitted by Ken Ando, Michael McPhaden, and Paul Freitag

1) Summary

Date of report	1 April 2011
Overview and main requirements addressed	The Tropical Moored Buoys 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 on all surface moorings. Salinity profiles down to 120m on some surface moorings. Current velocity on some moorings.

	Subsurface ADCP moorings.
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 Dr. Kentaro Ando, JAMSTEC, Japan
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), National Institute of Oceanography (NOI), Agency for the Assessment and Application of Technology (BPPT), Ministry of Marine Affairs and Fisheries (KKP), 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	CLIVAR/GOOS Indian Ocean Panel 7th Session 12-16 July 2010, Perth, Australia TIP Workshop, 26 September 2010, Oban UK. PIRATA-16, Fernando de Noronha, Brazil, 14-18 March 2011
Current status (March 2011)	TAO/TRITON: 64 of 67 surface moorings reporting. 5 subsurface moorings deployed. PIRATA: 16 of 17 surface moorings reporting. 1 subsurface mooring deployed RAMA: 18 of 23 surface moorings reporting. 6 subsurface moorings deployed

Summary of plans for 2011	TAO/TRITON: Maintain 72 mooring array. PIRATA: Maintain 18 mooring array RAMA: Increase number of sites deployed from 29 to 30-32.

2 Deployment cruises for 2011

TAO: NDBC 8 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

Data from most surface moorings 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 additional 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/disdel/disdel.html), NDBC (tao.noaa.gov), JAMSTEC (www.jamstec.go.jp/jamstec/TRITON/real_time/php/top.php, http://www.jamstec.go.jp/iorgc/iomics/datadisplay/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 October 2009 through September 2010 the PMEL web pages had 18M hits and delivered more than 194K 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 period 1 October 2009 to 30 September 2010) was 87% for TAO/TRITON, 79% 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 lead to high vandalism rates. The survival rate for ATLAS moorings since the first deployments (2004) in RAMA 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 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 has developed a tropical mooring named TFlex which incorporates electronics first used on Ocean Climate Stations in higher latitudes. The system is designed for use both in RAMA and the Indonesian Global Ocean Observing System (InaGOOS). TFlex telemeters hourly surface and subsurface data via Iridium. The first prototype system was deployed in March 2011 next to an ATLAS mooring in RAMA near 12°S 93°E.

5) Other issues

5.1 RAMA Implementation:

As of March 2011 the number of RAMA sites implemented stands at 29 (63% complete). Three sites were first occupied in 2010 and 2011: US ATLAS moorings at 12°S 81°E (May 2010) and 12°S 93°E (March 2011); 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 32, or 70% completion of the IOP planned array, by the end of 2011.

In calendar year 2010, 109 sea days (66 by India, 22 by Indonesia, and 21 by ASCLME) were provided in support of ATLAS RAMA sites. Additional ship time was provided in 2010 by Japan in support of their m-TRITON moorings (14days) and by Indonesia in support of China's moorings (22 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 all 5 sites.

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) 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 IndOOS 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 hosted a technical training session on mooring systems for 2 Indonesian scientists in August, 2010 and another session in October 2011 for a Brazilian scientist.

The Korean Ocean Research & Development Institute (KORDI) deployed a surface mooring near 10°N 150°E in May 2010. How this site and other may be included within the established tropical moored buoy arrays was discussed at the TIP Workshop in Oban, UK, September 2010.

A TIP Technical Coordination Group has been established. The group will define a set of measurement standards for TAO/TRITON, PIRATA, and RAMA as more ATLAS-like and TRITON-like moored buoy systems are introduced by different operators. This group would also establish procedures to exchange information among moored buoy array participants about cruise schedules, field operations, calibration procedures and data processing; publish regular updates on array status; and communicate essential operational information to the TIP, the DBCP and other relevant organizations.

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. PMEL will enhance 2 PIRATA moorings with real-time, high-resolution, ADCPs during this experiment.

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 1 of 2 are presently operating) and producing sustained subsurface measurements, an adequate method of inhibiting vandalism upon surface met sensors has not yet been found.

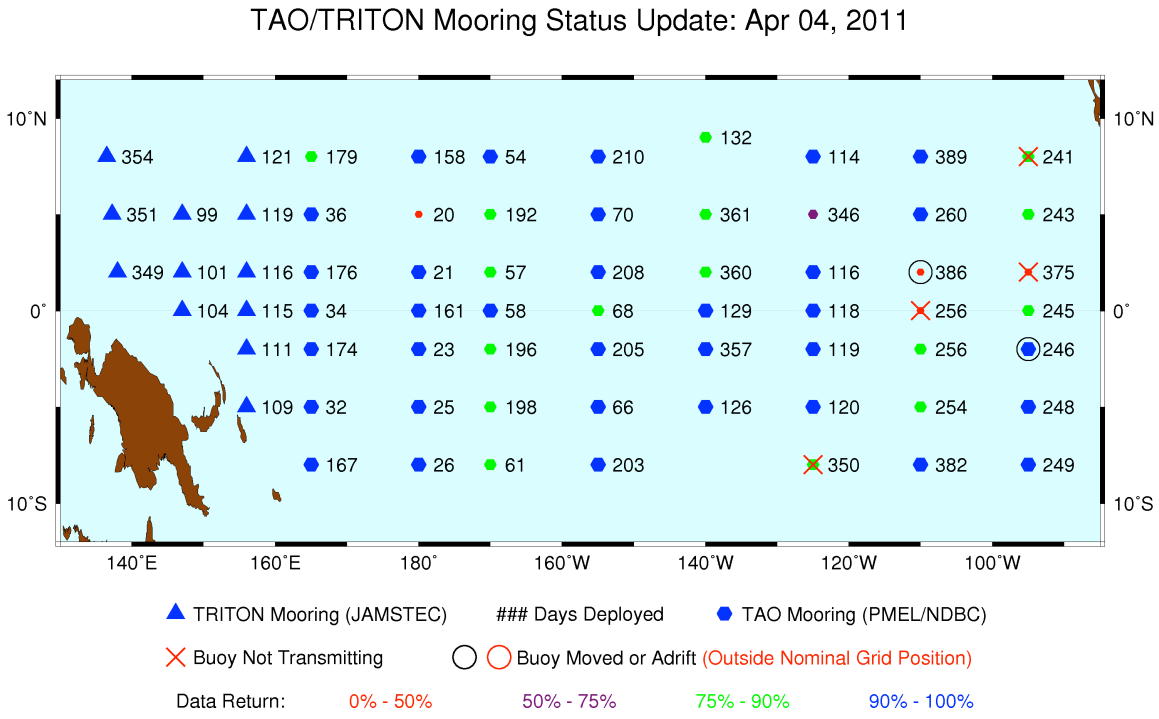
5.6 Piracy:

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 arranged for a Seychelles Coast Guard escort on an October 2010 cruise while in the Seychelles EEZ. Security zones defined by Lloyds of London and by the US Coast Guard extend to other sites in the western portion of RAMA. Security measures, such as that provided by ASCLME, will have to be provided before implementation can proceed in these areas.

_____

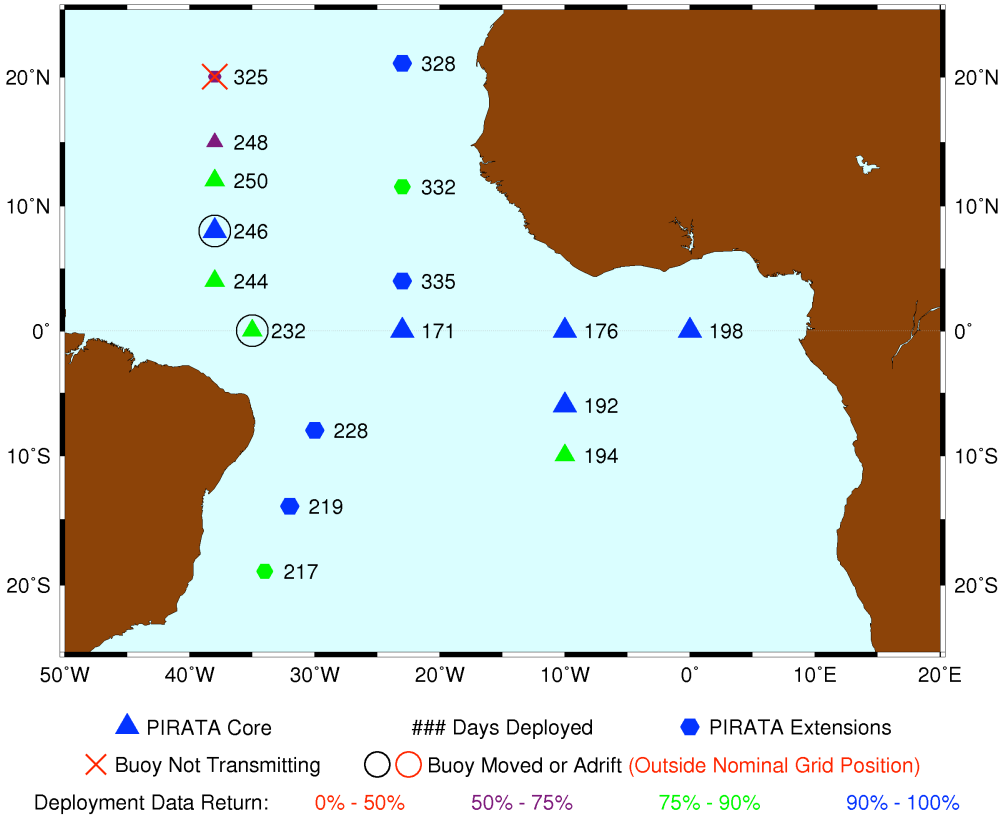
Annex

Status maps and graphics

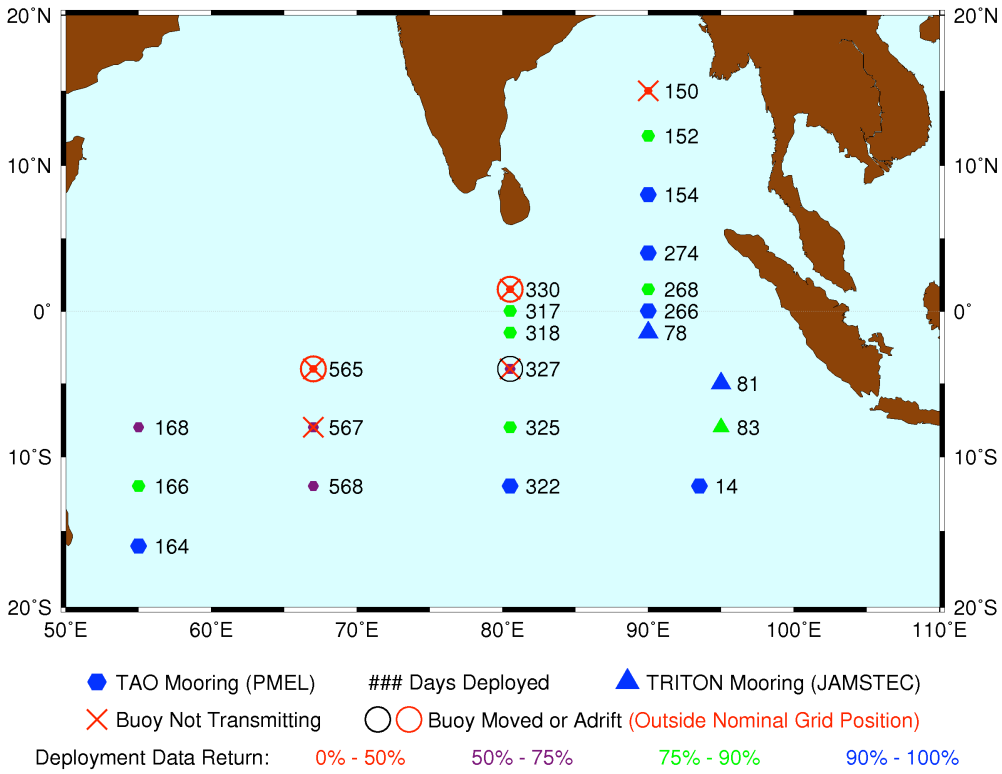


_____

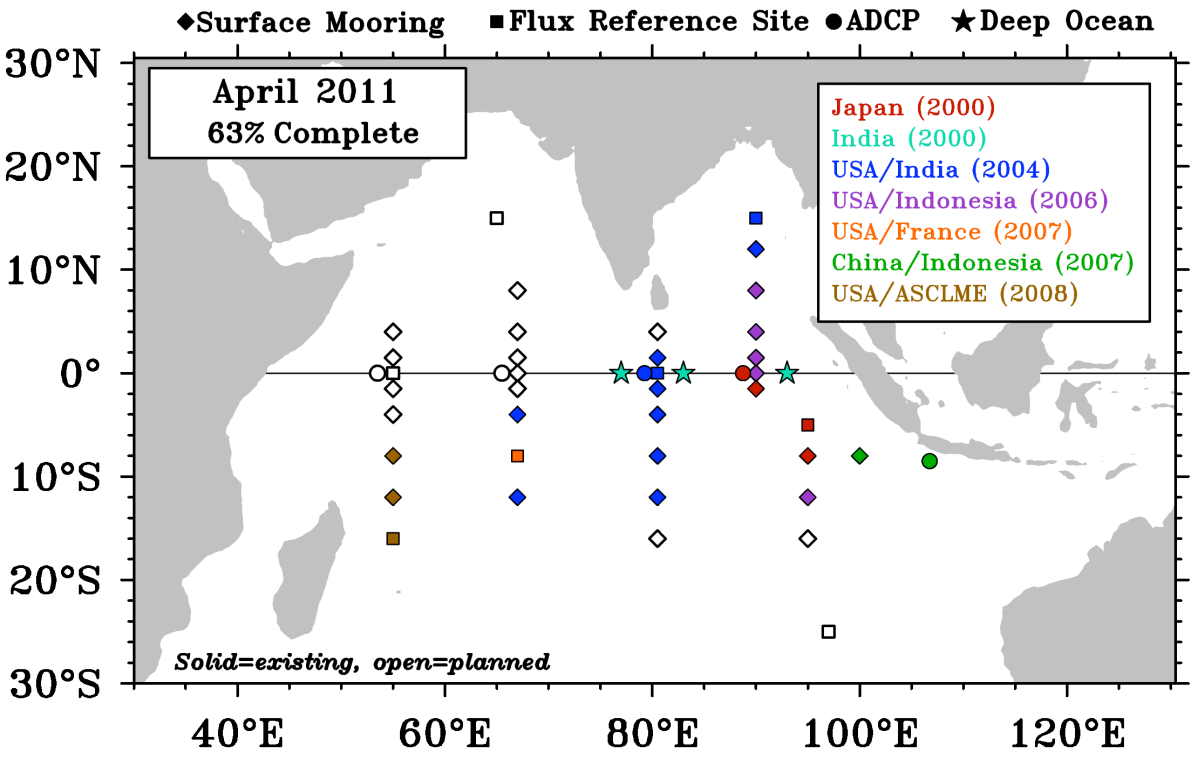
PIRATA Mooring Status Update: Apr 04, 2011



Indian Ocean Mooring Status Update: Apr 04, 2011



RAMA Implementation Status



Indian Ocean High Risk Piracy Zones set by Lloyds of London and the US Coast Guard