WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

DATA BUOY COOPERATION PANEL

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REPORT BY THE TASK TEAM ON MOORED BUOYS (TT-MB)

(Submitted by Jon Turton (UK), Chair, TT-MB)

SUMMARY AND PURPOSE OF DOCUMENT

This document contains the report by the chairperson of the DBCP Task Team on Moored Buoys.

ACTION PROPOSED

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

Appendices: **A.** Report by the Task Team on Moored Buoys

B. Terms of Reference of the DBCP Task Team on Moored Buoys

DISCUSSION

6.3.1 Mr Jon Turton (UK), Chairperson of the Task Team on Moored Buoys (TT-MB), reported on the Task Team activities during the last inter-sessional period. The Task Team has been involved in the validation of the new BUFR template (3 15 008) for moored buoy data, which is now operational. A new BUFR template for data from fixed platforms (e.g. offshore rigs) was submitted to the WMO IPET-DRMM in April and discussions on its progress are ongoing, this is desirable as neither the templates for moored buoys or ships (VOS) are really suited to fixed platforms.

6.3.2 Mr Turton explained that over recent years the metadata needing to be collected for moored buoy systems has been defined and formats for its submission to JCOMMOPS agreed. Initial metadata submissions have been made to JCOMMOPS to enable the TC to develop the capability to ingest the metadata and make it accessible via the JCOMMOPS web-site.

6.3.3 The Panel noted with appreciation that during the year a number of technical developments to the various moored buoy systems and networks have been made, including:

- Canada: A moored buoy was deployed during the summer of 2014 in the Beaufort Sea to assess the technical and logistical challenges as well as costs of operation. The buoy provides a suite of real time weather and ocean measurements, which in time could be expanded to include reports of sub-surface parameters.

- UK: further deployment of new design moored buoys with spectral wave capability to replace legacy designs and an additional system operated in conjunction with the National Oceanography Centre in the Celtic Sea (expected to be on-station for around a year) in support of a scientific research programme .

- US: two new moorings were added to the RAMA Array in the Indian Ocean, bringing the array’s implementation to 74% complete. CO2 and other biochemical instrumentation was added to a RAMA mooring in the Bay of Bengal.

- USACE: There is continued development, and integration of a 6N (NOMAD) buoy (collaborative effort between NOAA/NDBC and Environment Canada), where multiple sensor, and payload packages to be used for an intra-measurement evaluation. This study is to quantify observed differences between NOAA/NDBC and EC wave measurements identified in Durrant et al. (2009). The integration portion of the work is to be completed by late fall 2004, with scheduled deployment in early spring 2015 in Monterey Bay canyon as part of the WP-DBCP-WTWS Joint Pilot Project on Wave Measurement Evaluation and Testing.

6.3.4 The meeting agreed on the following:

1. [to be completed based on the Panel’s discussion]

6.3.5 The Panel thanked Mr Turton and the members of the Task Team for the report. The Panel re-elected Mr Turton to Chair the Task Team during the next inter-sessional period. The full report of the Task Team is provided in Appendix A of DBCP-30 preparatory document No. 6.3, and will be included in the DBCP Annual Report for 2014.

APPENDIX A

REPORT BY THE TASK TEAM ON MOORED BUOYS (TT-MB)

1. BUFR formats for buoy data

1.1 Following DBCP-29 the new BUFR templates for moored buoy data (3 15 008) and for drifter data (3 15 009) were successfully validated, with the templates becoming operational in May 2014, and are now approved Table D sequences. The WMO timescale for the cessation of the use of Traditional Alphanumeric Codes (TAC) on the GTS is still November 2014. The WMO IPET-DRMM (Inter-Programme Expert Team on Data Representation Maintenance and Monitoring), who met in April/May 2014 concluded that the November 2014 deadline is unlikely to be met, and discussed slipping the date by a year to November 2015, but this has not yet been formally ratified.

1.2 The WMO IPET-DRMM also endorsed the addition of a new class (41) for marine data to BUFR Master Table 0 (for meteorological data) as it was considered that Master Table 10 (for oceanographic data) was not yet suitable for operational use. The new class for marine data will facilitate the reporting of bio-geochemical measurements (which are made from some moored buoy networks) on the GTS.

2. Moored buoy metadata

2.1 At DBCP-29 the Panel agreed the use of simpler formats (tagged pairs and XML) as alternatives to netCDF for submitting the metadata to JCOMMOPS, when the Met Office and Environment Canada, who have both compiled some of their metadata, undertook to document the format and submit some metadata to JCOMMOPS by the end of the year. At the time of writing (July 2014) the Met Office have submitted some metadata to JCOMMOPS in tagged pairs and XML to test whether the TC is able import those data. Once the details of these formats has been tested and confirmed with the TC, example files will be made available to other moored operators to follow.

3. Technical developments

3.1 Environment Canada Moored Buoy Network

3.1.1 Environment Canada (EC) continues to operate a network of ~50 moored buoys, with 23 buoys deployed on a seasonal basis (in-land lakes, or ocean areas affected by ice). All Environment Canada buoys continue to utilize the Watchman100 “payload” provided by AXYS Technologies Inc. Overall network availability has fallen to 82% for the last 6 months of 2013, and 77% for the first 6 months of 2014 following some system failures, as well as mooring failures on the Atlantic Coast. The main cause in the significant drop in data availability (historically near 90% or better) is a 40% year over-year decrease in ship-time provided by Canadian Coast Guard buoy tenders. There are three buoys on the Atlantic coast which have not been serviced for 30 months, and one which is off station and has not been redeployed as of August 2014.

3.1.2 The EC moored buoy network was temporarily expanded in the summer of 2014 on the east coast of Canada with the deployment of 2 new seasonal moorings in the Gulf of St. Lawrence. Two 1.7 M WatchKeeper Buoys have been deployed in support of our Marine Weather Science Laboratory to help with the validation/verification of new coupled ocean atmosphere models. There is also a desire to validate the performance of wave model in shallow seas of the Gulf, with the results potentially improving predictions in northern waters such as the Beaufort Sea. In 2014, a new 1.7 M Watchkeeper buoy and a 2nd TRIAXYS directional wave buoy were deployed in Lake Ontario just south of Toronto, in support of the PanAM 2015 games. The buoy will report meteorological conditions every 15 minutes via cellular network, and wave data on hourly basis via Iridium satellite. The buoy is deployed in support of the sailing venue. In addition, one seasonal moored buoy has been deployed in the Beaufort Sea, just offshore of Tuktoyoktuk in the Northwest Territories. The buoy is allowing the EC to assess the technical and logistical challenges associated with a moored buoy deployment in Arctic waters. The resulting observations are also being utilized for coupled model verification given lack of in-situ wind and wave observations in this region.

3.1.3 Environment Canada has completed the implementation of SatLink2 GOES transmitters provided by SUTRON. The SatLink2 provides a higher power (40W) transmitter, ensuring reliable data transmission at higher data rates (300 or 1200 bps) with the existing omni-directional antenna (Harsh 14A). Over 70 units have been procured to date and the entire EC network has not been retrofitted with the new transmitters. The performance of the new transmitters has been very good to date, however we continue to monitor potential problems related to using 300 bps transfer rate in rough sea conditions, as there is some evidence of increased parity errors, and loss of data. We continue to examine the data record, and where possible compare the performance of near-by buoys and ship reports to try and correlate increases in parity errors with sea state in excess of ~3 m.

3.1.4 EC has also continued dialogue with the National Data Buoy Centre Engineers in the hopes of increasing the reliability of the Harsh antennas, as these components have been identified as a weak point in our data communications. The antennas are prone to water intrusion, and are often the cause of missing, or intermittent data transfers. There are also instances when the fragile antenna is damaged when a buoy is deployed or retrieved. We have begun work to improve the water sealing (use of silicon to improve seal) and are also evaluating an upgraded version of the Harsh antenna that uses a stainless base. Environment Canada Engineers have designed are testing an improved mounting collar that will both stabilize and improve the mounting of the antenna. Field testing is now underway, and we hope to deploy upgraded mounting kits into the operational network by the spring of 2015

3.1.5 An additional technological advancement which has been undertaken by the EC moored buoy network in the past year has seen the integration of an Iridium Short Burst Modem into the existing AXYS WatchMan100 “payload”. This has been achieved by adding a node of a WM500 processor within the Transmitter module of a standard EC buoy, with the WM500 in place to control the communications with the Iridium modem. Using bidirectional communications, it is possible to deliver commands to the primary WM100 payload via the WM500 (which is controlling the communications). This functionality will greatly enhance the amount of troubleshooting which can be done remotely, making it possible to reset power, reset the GOES transmitter, modify configurations, suppress sensors, change GOES ID etc. The Iridium SBD modem will also provide redundant communications for delivery of weather and wave data in the event of a failure to either the GOES transmitter or antenna. 11 buoys in the North Pacific and North Atlantic have been equipped with the new Iridium system. EC continues to assess their performance, and develop operational procedures for utilizing new functionality.

3.1.6 Finally EC is currently undertaking a competitive procurement process with the intention to replace the aging WM100 “payload” provided by AXYS Technologies. The WM100 is presently used in all moored buoy and AVOS (Automated Volunteer Observing Ship) installations. A Request for Information (RFI) was posted on the Canadian Government Tender System in early July 2012. An RFP (Request for Proposals, including pricing) will follow in 2014. The goal will be to procure a new system that can be easily integrated into the existing EC buoy hulls, and use both the existing suite of sensors as well as future measurement systems.

3.1.7 Environment Canada is actively engaged with the Canadian Coast Guard (CCG) to finalize an agreement on provision of buoy tendering ship-time services in support of the EC-MSC moored buoy network. Over the past two years, EC has seen a significant reduction in ship-time, as CCG are facing resource and capacity constraints. CCG is currently seeking an arrangement which will see EC pay incremental cost-recovery for ship-time. This new cost will likely need to be covered by the EC Atmospheric Monitoring Program, significantly increasing the “cost per observation” from the buoys and likely facilitating a review of options to rationalize or optimize the network through network design changes, new technologies or other initiatives. Note that there are no plans at this time to reduce the size of the existing ~50 buoy network.

3.2 Tropical Moored Buoy Array

3.2.1 As of August 2014 the number of Indian Ocean RAMA sites implemented stands at 34 (74% complete). The most recent additions to the array were an ATLAS and ADCP moorings deployed near the equator and 67°E.

3.2.2 Testing of PMEL's T-Flex mooring system, intended to replace the legacy ATLAS moorings in tropical research arrays, is ongoing. Seven prototype systems have been deployed for comparison with ATLAS systems. Replacement of some ATLAS systems in PIRATA and/or RAMA with T-Flex systems is planned for 2015.

3.2.3 CO_2 and additional biochemical (e.g., pH, O_2, chlorophyll, turbidity) measurements are made on several TAO moorings by PMEL (http://www.pmel.noaa.gov/co2/moorings/) 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). China's Bai-Long mooring in RAMA has included CO_2 measurements since 2012. A PMEL CO_2 system supported by the Bay of Bengal Large Marine Ecosystem Project (BOBLME) was deployed on a RAMA mooring in November 2013. The University of Tasmania has provided fluorometers for two RAMA moorings.

3.2.4 PMEL and the First Institute of Oceanography (FIO) are conducting a land-based inter-comparison of surface meteorological instrumentation used on ATLAS, T-Flex and FIO's Bai-Long to ensure uniformity of measurements in RAMA.

3.2.5 TAO data return continued to decline during the first half of the past year. Maintenance cruises in spring and summer 2014 have improved data return and NOAA has committed to bringing data to historical levels by the end of the calendar year. By that time nearly all (54 of 55) TAO sites will be instrumented with NDBC's Refresh ATLAS system.

3.2.6 The TPOS 2020 Workshop was held in January 2014 at Scripps Institution of Oceanography in La Jolla, United States. The international meeting was held to discuss methods to maintain, improve, expand and diversify the Tropical Pacific Observing System and to refine and improve understanding and prediction of tropical Pacific variability.

3.2.7 JAMSTEC has decommissioned 2 TRITON sites in the western Pacific due to budgetary and ship resource issues.

3.3 PMEL OCS Stations

3.3.1 In addition to the tropical arrays, PMEL Ocean Climate Stations (OCS) continues to contribute to the OceanSITES network of time series reference sites with two stations: the Kuroshio Extension Observatory (KEO), located south of the Kuroshio Extension at 144.6°E, 32.2°N, and Station Papa, located in the eastern subarctic Pacific at 145°W, 50°N. Both moorings carry a suite of sensors to monitor air-sea exchanges of carbon dioxide, heat, and freshwater; wind; upper ocean temperature, salinity, and near-surface currents; ocean acidification; important aspects of the carbon cycle in the surface water; and bottom water temperature and salinity. Moorings deployed in 2014 were instrumented with 2 PMEL Flex (similar to T-Flex) systems which provide duplication in most meteorological observations. Previous moorings included both Flex (which telemeters data via Iridium) and legacy ATLAS systems (which use Argos). The KEO mooring is maintained in partnership with JAMSTEC; Station Papa is maintained in partnership with the Canadian DFO Line P Program.

3.3.2 Most of the KEO and Station Papa data are available in near real-time through the project website: http://www.pmel.noaa.gov/OCS/, and through the GTS. Data telemetered via Iridium are coded into BFUR at PMEL and submitted to the GTS via an NWS gateway using Bulletin Headers IOBB18 KPML (KEO) and IOBC18 KPML (Papa) Their WMO numbers contain the digits "84" identifying them as reference stations (KEO's is 28401 and Papa's is 48400). It is recommended that these GTS reference data should be withheld from all data assimilations so that they can be used as independent validation of the numerical products.

3.4 USACE moored buoy network

3.4.1 The US Army Corps of Engineers (USACE) continues to operate ~60 buoys along the US coast, the Hawaiian Islands, Puerto Rico, Guam, Marshall, and Saipan, collaborated with other US Federal (US Navy, NOAA/IOOS), State (California, Virginia) agencies, Local, and industry partners. Data are disseminated via the Coastal Data Information Program (CDIP). All wave measurements are obtained from Datawell Directional Waverider buoys. IRIDIUM communications are used in 85% of the sites, with planned transition over the next two years to 100%. Real-time data return on the deployed buoys is ~95%. Complete data return (~99 to 100%) occurs when the on-board flash drive is recovered, processed, and analyzed. However with some partner buoys the return is slightly lower (data gaps amounting to days/weeks) because of delays in re-deployment of a replacement, bad batteries from the manufacturer, and/or weather delays. Failures of the system generally are a result from vessel collisions. In 2014 there was an increase of four buoys, three along the Atlantic coast, and one at Ketchikan, AK (US Navy supported).

3.5 Met Office moored buoy network

3.5.1 The Met Office moored buoy network presently includes seven operational deep ocean buoys to the west of the British Isles from the north of Scotland to Biscay (K7, K5, K4, K2, K1, Brittany and Gascogne). The two buoys in Biscay (Brittany and Gascogne) are operated in collaboration with Meteo-France. These buoys are funded through the Public Weather Service Programme, apart from K7 which is mainly funded by the offshore oil and gas industry. A further two buoys are operated off the coast of South Wales for the Milford Haven Port Authority (Turbot Bank) and QinetiQ (Aberporth). Additional moored buoys are operated in collaboration with the National Oceanography Centre (NOCS) at the OceanSITES Porcupine Abyssal Plain (PAP) site and in the Celtic Sea (in support of the CANDYFLOSS (Carbon and Nutrient Dynamics and Fluxes over Shelf systems) research programme, and with Plymouth Marine Laboratory at E1 in the Western Channel. The met and wave data are presently reported to GTS in WMO FM-13 SHIP format.

3.5.2 The winter of 2013/14 was notable for the number of severe storms that hit the UK, with the south-west coats in particular being battered by high waves. Unfortunately, all three offshore buoys in the south-west (K1, K2 and PAP) broke their moorings at some time during the winter season. This is believed to be due to a change made by the mooring suppliers in the design of the mooring thimbles, leading to increased wear on the rope. As a result the thimble design has been further modified which hopefully will alleviate this problem.

3.5.3 The network buoys, which were designed during the early 1990s, are increasingly difficult to maintain as some of their components are ageing/obsolete (e.g. CR10x/PC42 electronics and Meteosat DCPs) and a replacement programme is underway, where K1, K7 and E1 are now based on new design systems using the Axys Watchman 500 on Hydrosphere/Mobilis hulls. However, water ingress into the Watchman enclosures leading to corrosion is presently an issue being addressed. The new design buoy at K7 was replaced in March 2014, after being at sea over two winters, and had operated reliably without evidence of any damage to the hull.

3.5.4 Wave measurements have in the past been made using a Datawell heave sensor, however on K5, Brittany, Gascogne and Celtic Sea buoys Triaxys spectral wave systems are also fitted (enabling comparison of measurements). On K1, K7, E1 and PAP only a Triaxys is fitted. Issues encountered have been water ingress to the Triaxys enclosures and flash card failures. The Triaxys spectral wave data are presently reported to GTS in a short self-describing BUFR format. This will be superseded by the new moored buoy BUFR 3 15 008 sequence in due course.

3.5.5 The PAP and E1 buoys both have a single met system (rather than dual met systems) as the other side is used for the oceanographic system. The PAP buoy has an instrument frame suspended 30m below the buoy and the E1 buoy has a winching system designed to lower/raise PML's optical sensors out of the water for cleaning.

3.5.6 In addition Plymouth Marine Laboratory operate a moored buoy at their L4 station. During the year the meteorological system was replaced with a Met Office AMOS (Autonomous Marine Observing System – as deployed on ships) to provide more frequent (hourly real-time data). Discussions are also ongoing with Cefas (Centre for Environment, Fisheries and Aquaculture Science) on accessing real-time data from their SmartBuoy network which is operated for statutory monitoring of water quality.

3.6 Indian Moored Buoy Network

3.6.1 Ministry of Earth Sciences Government of India has evolved a comprehensive ocean observation network programme involving moored buoys both surface and sub surface measurements, waverider buoys, coastal met ocean buoys, AWS on board ships equatorial moorings, Argo floats, gliders, drifters, XBT, HF Radar, sea level gauges, tsunami monitoring buoys and ship borne observations in addition to support to RAMA programme. Further under Indo US programme of ASIRI/OMM, a joint observational activities in Bay of Bengal is being conducted using both Indian and US Research Vessels.

3.6.2 Considering the importance of ocean observations in terms of understanding the ocean environment and to utilize them for operational oceanography, moored buoys are deployed in the Indian Ocean, to acquire data on ocean variables in and around the Indian Seas. These observation systems succeeded in providing several time series data sets all of which are used in real time validation of ocean forecasts and assimilation into the models. Many useful insights about the Indian Ocean have been identified by extensively utilizing the data sets. NIOT-OOS Group is continuing the work for maintaining the moored buoy network in the Northern Indian Ocean. This network is performing successfully and providing valuable data too date despite many challenges faced.

3.6.3 During the period from September 2013 to August 2014 the OOS Group has completed the major task which includes 57 deployments/retrievals for which 12 cruises of 184 ship-days covering 20,000 nm (nautical miles) with 1,925 man-days were undertaken. These data sets are available on GTS through INCOIS Hyderabad

3.6.4 In order to calibrate and validate, ocean colour sensors of Indian Satellite INSAT, particularly for data products used in long-term multisensory time series studies, CAL VAL Buoy system comprising one met ocean buoy and an optical buoy with specially designed twin buoy system is installed in Arabian Sea.The new underwater structure has a phase shift of 15° between its two poles to avoid the shadow effect. Under CALVAL phase-II the buoy deployed in CALVAL site at 10.5N/72.25E position off Kavaratti for the calibration and validation of SAC data is performing satisfactorily too date and the data is disseminated to INCOIS.

3.6.5 Met Ocean buoy was interfaced with dual transceiver system (GPRS and INSAT) which was deployed in all coastal buoys. The main data transmission components consist of a data logger, a GPRS modem, INSAT transceiver and a receiving server. Every three hours (UTC) the raw data are collected by the sensors and processed by CPU and stored in the data logger. The stored data are sent through GPRS modem using GSM network as well as through INSAT communication to Mission Control Center.

3.6.6 NIOT has discus shape mooring buoy for the measurement of atmospheric, ocean and tsunami data collection. To increase the life time and to collect the redundant data, new buoy is designed along with numerical analysis for stability of the buoy and same has been compared with the existing discus buoy stability. The recently developed new generation buoy was deployed in the Bay of Bengal at the 17.5N/89.5E (TB09) location and is performing well.

3.6.7 Integrated Marine Surveillance System (IMSS) called as R-dharsh is introduced to have real time visual observation from a moored buoy far away from the Shore using 3G telemetry. Three cameras are installed on a mast at 3m height above mean sea level at 120° displacement covering 360° to capture video and still pictures of the entire surrounding of the buoy system. Apart from standard met-ocean and oceanographic measurements the buoy can also transmit real-time day and night video and still photographs of the surrounding environment that are captured using high resolution video camera encapsulated to work in hostile marine environment. The above facility would help to view the present sea conditions remotely, which would be more useful for the fishermen community. In addition, this feature helps to track the buoy system for its continuous functioning and also alert the respective authorities, in case of any disturbances to the buoy system. This buoy can also capture information about passing ships using Automatic Identification System (AIS).

3.8 Arctic Observation –IndARC Mooring

3.8.1 The first underwater moored observatory was deployed by India on 23rd July 2014 at Kongsfjorden Fjord in Arctic Ocean “indARC” at 78° 56 N & 12°E. The moored observatory consists of suite of oceanographic sensors to measure temperature, salinity, current profiles and other vital parameters. The information measured and recorded by the sensors would yield much needed data to understand the cause and impact of climate variability in a regional to global perspective. In future mooring systems will be deployed in the Southern Ocean and Antarctic Ocean

The Chair of the Task Team on Moored Buoys thanks members for their efforts in maintaining and improving their moored buoy networks and exchanging their data, and for the inputs provided for this report.

APPENDIX B

TERMS OF REFERENCE OF THE DBCP TASK TEAM ON MOORED BUOYS (TT-MB)

(as adopted at DBCP-24)

The DBCP Task Team on Moored Buoys shall:

1. Review and document operational moored buoy systems and their underlying requirements;

2. Liaise with the different communities deploying moorings, including TIP, OceanSITES, seabed observatories, as well as national moored buoy programmes (coastal and global), and promote the development of multi-disciplinary mooring systems;

3. Liaise with the GOOS Scientific Steering Committee (GSSC) and its technical sub-panel for Integrated Coastal Observations (PICO) to facilitate synergy between advances in GOOS implementation and the development of operational capabilities, in particular, for sustained coastal observations, analysis and related services by using mooring systems;

4. Liaise with the JCOMM Expert Team on Wind Waves and Storm Surges (ETWS) regarding the need for in situ wave observations;

5. Compile information on opportunities for the deployment and / or servicing of moored buoys;

6. Monitor technological developments for moored data buoys and liaise with the Task Team on Technological Developments on satellite data telecommunication aspects;

7. Review all relevant WMO and IOC Publications on Instrument Best Practices (e.g., JCOMM, CIMO) to make sure they are kept up to date, address WIGOS issues, and comply with Quality Management terminology;

8. Provide the DBCP Executive Board or the DBCP with technical advice needed for developing moored buoy programmes, including the issues above; and

9. Report to the DBCP Executive Board and the DBCP at its biennial Sessions, with periodically updated Workplans supporting implementation.

Membership:

The membership is open to all Panel members. The Chairperson[1], appointed by the Panel, has selected the following team members:

Mr Jon Turton, UK Met Office (TT Chairperson); (TT Vice-Chairperson – to be appointed)

Dr Robert Jensen, USACE
Mr Chris Meinig, NOAA / PMEL
Mr R. Venkatesan, NIOT, India
Dr Uwe Send, SIO
Mr Paul Freitag, NOAA / PMEL
Mr Chris Marshall, Environment Canada
Mr Ariel Troisi, SHN
Mr Al Wallace, MSC

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1 The Chair and Co-Chair of the Task Team should not be in a situation of conflict of interest.