Intergovernmental Oceanographic Commission of UNESCO

World Meteorological Organization

DATA BUOY COOPERATION PANEL

RECOMMENDATIONS/ACTIONS OF THE FIFTH CAPACITY BUILDING WORKSHOP OF THE DBCP FOR THE NORTH PACIFIC OCEAN AND ITS MARGINAL SEAS (NPOMS-5), TIANJIN, CHINA, 4-7 JULY 2017

Application of Regional Ocean Observations for Increasing Society's Understanding and Forecasting of Typhoons

DBCP Technical Document No. 135

– 2017 –

NPOMS-5 PARTICIPANTS

Intergovernmental Oceanographic Commission of UNESCO

World Meteorological Organization

DATA BUOY COOPERATION PANEL

RECOMMENDATIONS/ACTIONS OF THE FIFTH CAPACITY BUILDING WORKSHOP OF THE DBCP FOR THE NORTH PACIFIC OCEAN AND ITS MARGINAL SEAS (NPOMS-5), TIANJIN, CHINA, 4-7 JULY 2017

Application of Regional Ocean Observations for Increasing Society's Understanding and Forecasting of Typhoons

Hosted by
National Marine Data and Information Service (NMDIS)
State Oceanic Administration (SOA)
Tianjin, China

Venue: Tianjin Zhengxie Club Hotel
Tianjin, China

DBCP Technical Document No. 135

Error! Reference source not found.

[page left intentionally blank]

CONTENTS

[page left intentionally blank]

WORKSHOP REPORT

NPOMS-5 is a Workshop in a Series of IOC/WMO JCOMM PANGEA Workshops:

- 1st Western Indian Ocean Capacity Building Workshop
- 2nd Western Indian Ocean Capacity Building Workshop
- 3rd Western Indian Ocean Capacity Building Workshop
- 4th Western Indian Ocean Capacity Building Workshop
- 1st In-Region Capacity Building Workshop for Asian Countries
- 2nd Typhoon Workshop for the North Pacific Ocean and Marginal Seas (NPOMS-2)
- 5th Western Indian Ocean Capacity Building Workshop
- 3rd Typhoon Capacity Building Workshop for the North Pacific Ocean and Marginal Seas
- 1st Pacific Islands Training Workshop on Ocean Observations and Data Applications
- 4th Typhoon Capacity Building Workshop for the North Pacific Ocean and Marginal Seas
- 2ndt Pacific Islands Training Workshop on Ocean Observations and Data Applications

NPOMS-5 was Co-Sponsored by the IOC/WMO Data Buoy Cooperation Panel (DBCP), National Marine Data and Information Service (NMDIS) of China's State Oceanic Administration (SOA), US NOAA Ocean Observations and Monitoring Program and generously hosted by the National Marine Data and Information Service (NMDIS), at the Tianjin Zhengxie Club Hotel in Tianjin, China. The Terms of Reference of the workshop are provided in Annex 5. The composition of the Organizing Committee is provided in Annex 4.

Thirty three participants from nine countries participated at the workshop (see list of participants in Annex 3).

The workshop was chaired by Dr. Sidney Thurston, Chair of the DBCP Task Team on Capacity Building (CB-TT). After the opening remarks with keynotes from the Dr. Liu Kexiu from NMDIS on behalf of Dr Feng Jun, Department of International Cooperation of SOA, the WMO Secretariat representative, Ms Champika Gallage, the Chairperson of the DBCP CB-TT, Dr. Sidney Thurston, and DBCP Vice-Chair for Asia, Dr. Yu Ting (Julia) on behalf of Dr XIANG Wenxi from NMDIS, series of presentations were made, interleaved with key discussions on the workshop's theme, *Application of Regional Ocean Observations for Increasing Society's Understanding and Forecasting of Typhoons*. The following sessions took place (see complete agenda in Annex 1):

1. Session 1: Reviews of Relevant Research Programs and Regional Studies, chaired by Dr Sid Thurston;
2. Session 2: Applying Ocean Observation to Typhoon Research and Forecasts, chaired by Prof. Scott Glenn;
3. Session 3: Understanding the Processes and Mechanisms of Typhoon-Ocean Interaction, chaired by Dr. Joe Cione.

Summary of the presentations are available on Annex 2. The presentations are posted on the event website at www.jcomm.info/NPOMS-5.

A round table discussion was organized during the Session on Designing the Optimal Ocean Observing System for NPOMS Cyclogenesis Forecasting - Continuation from NPOMS-4.

All the participants agreed that the quality of the presentations and information at NPOMS-5 is growing with diverse participation from many subject areas; forecasting, modelling, research, data management and impact studies. Opportunities for collaboration was identified in all areas of work i.e. research, and operation etc. Presentations on tropical cyclone (TC) rapid intensification and de-intensification changes and Madden-Julian Oscillation (MJO) and Indian Ocean Dipole (IOD) influences by the Indian Ocean are some of the new areas discussed at this year's workshop. Site visits to Tianjin University and SOA's National Ocean Technology Center (NOTC) were very informative to all participants.

Following these discussions, the workshop made 28 Recommendations and 13 Actions, which are listed in Annex 6.

The participants wished to recognize with sincere gratitude the kind and warm hospitality and support of our local hosts the National Marine Data and Information Service (NMDIS) of State Oceanic Administration (SOA). Specifically we offer our sincere gratitude for the tireless efforts of Dr. Yu Ting (Julia), DBCP Vice-Chair for Aisa, and her team from NMDIS/SOA.

ANNEX 1

FINAL NPOMS-5 WORKSHOP AGENDA

(Note: Each Presentation Includes 10 Minutes for Q&A)

TIME	SUBJECT	LEAD
Day 1: **Tuesday 4 July** Opening Day Remarks, Reviews of Relevant Research Programs and Regional Studies Chair: Sidney Thurston (DBCP) Rapporteur: Siswanto (BMKG)		
09:30-10:00	Opening Ceremony VIP Welcoming Addresses	FENG Jun (SOA) ChampikaGallage (WMO) Sidney Thurston (DBCP) XIANG Wenxi (NMDIS)
10:00-10:30	Thermal Response to Stokes Drift and its Induced Mixing in the East of Luzon Strait on the Forced Edge of Super Typhoon HaiTang	ZHANG Xuefeng (NMDIS)
10:30-11:00	Coyote UAS and GPS Infrared Sea Surface Temperature Measurements from Hurricane Edouard (2014)	Joe Cione (NOAA Hurricane Research)
11:00-11:30	Tea Break & Group Photography – All Workshop Participants	
11:30-12:00	WMO Rolling Review of Requirements	Champika Gallage (WMO-Geneva)
12:00-12:30	Interactions among monsoon, tropical cyclone and the South China Sea	Wang Guihua (Fudan University)
12:30-13:00	Stratified Coastal Ocean Interactions with Tropical Cyclones	Scott Glenn (Rutgers COOL)
13:00-14:00	Lunch	
14:00-14:30	Pacific-Indian Ocean Throughflow and its Branch in the South China Sea	Wang Yonggang (First Institute of Oceanography/SOA)
14:30-15:00	Severe Weather, Flood, Landslides Due to Tropical Cyclone Mora	K.D. Sujeewa (Sri Lanka Met Service)
15:00-15:30	Use of Observations from Weather & Drifting Buoys, Oil Rigs, Ships and Aircraft Data for Tropical Cyclone Monitoring	Chan, S.T (Hong Kong Observatory)
15:30-16:00	Afternoon Tea Break	
16:00-16:30	BMKG Met-Ocean Development: Indonesia National Report	Bayu Edo (Indonesia BMKG)
16:30-17:00	Thailand National Report	Anucha Srerurngla
17:00-17:30	Upper ocean response to Typhoon Kalmaegi	Zhang Han (Second Institute of Oceanography/SOA)
17:30-18:00	Discussion of Today's Hot Topics	Sidney Thurston (DBCP)
18:00-20:00	Banquet Hosted by NMDIS	

TIME	SUBJECT	LEAD
Day 2: **Wednesday 5 July** Technology of Ocean Data Buoys, Applying Ocean Observation to Typhoon Research and Forecasts Chair: Scott Glenn Rapporteur: Tetsuya Takemi		
9:00	Review from Yesterday & Today's Planning Objectives	SidneyThurston (DBCP)
9:00-9:30	Autonomous Surface Drifting Buoys for Air-Sea Observations Under Tropical Cyclones	Luca Centurioni (Scripps Institution of Oceanography)
9:30-10:00	Effects of Convective Processes on the Evolution of Cyclone Pam (2015) in the Southern Pacific	Tetsuya Takemi (Japan DPRI)
10:00-10:30	Extreme cyclone genesis in Bay of Bengal	Dr. Weidong Yu (Nat. Marine Env. Forecasting Center/SOA)
10:30-11:00	Tea Break	
11:00-11:30	Coastal Ocean Circulation During Hurricane Sandy	Travis Miles (Rutgers COOL)
11:30-12:00	The Processing and Quality Control of Buoy Data	LIU Shouhua (NMDIS/SOA)
12:00-12:30	Exploring the Eastern Indian Ocean with InaPRIMA 2017 Field Campaign and the Use of RAMA Data	Siswanto (Indonesia BMKG)
12:30-13:30	Lunch	
13:30-14:00	Network Implementation and Targets: How to Engage in Network Implementation	Champika Gallage (WMO-Geneva)
14:00-14:30	Development of air-sea coupled model system for typhoon forecast	LING Tiejun (National Marine Environmental Forecasting Center/SOA)
14:30-15:00	WMO Tropical Cyclone Program (WMO TCP)	Anne-Claire Fontan (WMO TCP-Remote)
15:00-15:30	WESTPAC/DBCP TC-Ocean Working Group: A Prospectus	Sidney Thurston (DBCP)
15:30-16:00	Tea Break	
16:00-16:30	Progress of Experiment on Typhoon Intensity Chang in the Coastal Area (EXOTICCA)	Zeng Zhihua (Shanghai Typhoon Institute /CMA)
16:30-17:00	Impacts of Tropical Cyclones on Oceanic Processes in the Taiwan Strait	PAN Aijun (Third Institute of Oceanography/SOA)
17:00-17:30	Two decades of Ocean Observation	S. Ramasundaram, (National Institute of Ocean Technology, India)
17:30-18:00	Discussion of Today's Hot Topics	Sidney Thurston (DBCP) Joe Cione (NOAA)

TIME	SUBJECT	LEAD
Day 3: **Thursday 6 July** Understanding the Processes and Mechanisms of Typhoon-Ocean Interaction Chair: Joe Cione Rapporteur: Champika Gallage		
9:00	Review from Yesterday & Today's Planning Objectives	Sidney Thurston (DBCP)
9:00-9:30	Observing Sediment Resuspension and Transport from Ocean Gliders	Travis Miles (Rutgers COOL)
9:30-10:00	The technology and experiences of RMIC/AP on the data accuracy and assurance for the moored buoys and its sensors	YU Jianqing (National Center of Ocean Standards and Metrology/SOA)
10:00-10:30	Overview of Ocean Observation (HF Radar, Glider)	Prof Scott Glenn (Rutgers COOL)
11:00-11:30	Tea Break	
11:00-11:30	The Scenario Study of the Future Storm Surge in Qingdao	JIANG Wensheng (Ocean University of China)
11:30-12:00	Impacts of Surface Lagrangian Drifting Buoy Data in Numerical Weather Prediction and Climate	Luca Centurioni (Scripps Institution of Oceanography)
12:00-12:30	New Drifter Design	Ms. Li Xiaoxia (CMA)
12:30-13:00	Round Table Discussion: Designing the Optimal Ocean Observing System for NPOMS Cyclogenesis Forecasting - Continuation from NPOMS-4	Lead: Joe Cione, Scott Glenn – All Workshop Participants Please Prepare
13:30-14:00	Lunch	
14:00-17:00	Tour of Tianjin University and National Ocean Technology Center/SOA Tianjin University is the oldest institution of higher education in the modern history of China. Founded in 1895. The National Ocean Technology Center (NOTC), the former was institute of ocean technology founded in 1965, directly administrated by the State Ocean Administration (SOA), is a public institute. The main functions and basic tasks of NOTC are to take management for national ocean technology; offer technical guarantee and support for national oceanic plan, administration, capability construction and public service. It is also responsible for the research and development of high and new ocean technology in China, as well as basic and general technology.	All Workshop Participants

TIME	SUBJECT	LEAD
Day 4: **Friday 7 July** Designing the Optimal Ocean Observing System for NPOMS Cyclogenesis Forecasting, Concluding Remarks Chair: Sidney Thurston Rapporteur: Champika Gallage		
9:30	Review from Yesterday & Today's Planning Objectives	Sidney Thurston (DBCP)
9:30-10:30	Round Table Discussion: Designing the Optimal Ocean Observing System for NPOMS Cyclogenesis Forecasting - Continuation from NPOMS-4 (continued)	Lead: Joe Cione, Scott Glenn – All Workshop Participants Please Prepare
10:30-11:00	Morning Tea Break	
11:00-12:00	Round Table Discussion: NPOMS-5 Workshop Recommendations	Leader: Sidney Thurston (DBCP)
12:00-12:15	Certificate presentation ceremony (to all trainees)	Presented by: Liu Xiaoqiang (NMDIS) Sidney Thurston (DBCP)
12:15-12:30	Closing Remarks	Liu Xiaoqiang (NMDIS) Sidney Thurston (DBCP)
12:30	Conclude the Fifth DBCP NPOMS-5 Workshop	
	Lunch	

ANNEX 2
SUMMARY OF THE PRESENTATIONS

DAY 1: TUESDAY 04TH JULY 2017

Thermal Response to Stokes Drift and its Induced Mixing in the East of Luzon Strait on the Forced Edge of Super Typhoon Haitang by Dr. Zhang Xuefeng (NMDIS)

The presentation covers the introduction of the momentum and turbulence equation and wave breaking parameterization including Craig-Banner Boundary Condition and Modification of the turbulent mesoscale. Temperature Observation of the Yellow Sea indicated three layer structures that is surface, middle, and well-mixed bottom layer. Wave induced mixing has been studied in the case of Typhoon Haitang by POMgcs (generalized coordinated system) and SWAN simulation utilizing CORA (China Ocean Reanalysis) as boundary condition. Atmospheric Forcing employs CCMP & NCEP model with MCT Coupling. The strategy of two-way coupling is applied by sensitivity experiment of CTRL (no inclusion of Stoke Drift (SD)) and SPWAVE (with SD). The result shows that during forced stage colder anomaly near surface appears stronger with SD rather than without SD. The SPWAVE (implemented SD in the model) also results SST resemblance nearly to the observation data from Argo, similarly to the temperature profile result. Diagnostic Analysis for Normalized Coriolis Forcing such as
Barotropic gradient (BG), Coriolis-Stokes Forcing, Advection, Vortex Forcing has been done. It is concluded that when the Typhoon is in the departure stage BG broke down but Coriolis effect is increased followed by advection and vortex. After the typhoon and pre-relaxation stage the BG goes to resumption process.

Coyote UAS and GPS Infrared Sea Surface Temperature Measurements from Hurricane Edouard (2014) by Dr. Joe Cione (NOAA)

Part I: Coyote UAS and Infrared Sea Surface Temperature Measurements from Hurricane Edouard (2014); and Part II: Infrared Sea Surface Temperature Measurements from Hurricane Edouard (2014) using GPS Dropsondes) summarized results from two recent publications looking at recent observations from Coyote UAS in Hurricane Edouard (1) and from inter-comparisons between IR SST measurements from GPS dropsodens and paired AXBT observations:

1. J. A. Zhang, J. Cione, E. Kalina, T. Hock and J. Smith 2017: **Infrared measurements of sea surface temperature in Hurricane Edouard (2014) using GPS dropsondes.** *J. Ocean Atmos. Tech.*
2. Cione, J. J., E. Kalina, E. Uhlhorn, A. Farber and A. Damiano 2016**: Coyote Unmanned Aircraft System Observations in Hurricane Edouard (2014).** *Earth Space Sci. (AGU).*

In addition, I informed the DBCP community of our future plans in 2017 to use these two emerging technology platforms to sample Tropical Cyclones in Atlantic, Gulf of Mexico and Caribbean basins in 2017.

WMO Rolling Review of Requirements (WMO RRR) by Ms. Champika Gallage (WMO Secretariat)

Rolling Review of Requirements (RRR) process is defined by the Manual on the Global Observing System (WMO-No. 544) (Part II, Requirements for observational data).In RRR process the user requirements for observations are compared with the capabilities of present and planned observing systems.

User requirements are organized in a comprehensive, systematic and quantitative way in the WMO Observing Requirements database, which attempts to capture observational requirements to meet the needs of all WMO programmes.

The comparison of user requirements with observing system capabilities for a given application area is called a Critical Review. The output of this is reviewed by experts in the relevant application and used to prepare a Statement of Guidance (SOG), the main aim of which is to draw attention to the most important gaps between user requirements and observing system capabilities, in the context of the application.

The SoG are then reviewed, taking cost-effectiveness and priorities into account in the view to produce the Implementation Plan for the Evolution of global observing systems (EGOS-IP). This presentation also identified the actions on EGOS-IP that are related to the Ocean observation community.

Interactions among monsoon, tropical cyclone and the South China Sea by Dr. Wang Guihua (Fudan University)

The tropical cyclone (TC) over South China Sea (SCS) is divided into two types that is local type and non-local TC. There is a linkage between monsoon, tropical cyclone generation and SCS geographical setting. The local TC type is dominated by TC genesis in the boreal summer. Summer monsoon local TC in the SCS is developed due to a warmer SCS waters, southwest monsoon wind circulation, as well as the specific SCS vortices indicators. The vorticity over SCS is featured by a positive vorticity in the North SCS but negative vorticity appears in the southern SCS may be a key for a favourable condition for TC genesis.

Over the SCS, large scale circulation may act as a forcing such as monsoon, kuroshio, SCS eddies. Many mesoscale Eddy features are found in the SCS. The research question is then whether the TC affects meso-scale eddy?

The non-local TCs is mainly TCs generated from North West Pacific. The surface ocean roles in the TC track via the interaction of ocean - near surface atmosphere that can push (modulate) the TC track. It is also found a zonal shift of TSs track in November. The SCS is an ideal area to understand the interaction monsoon and TC.

Stratified Coastal Ocean Interactions with Tropical Cyclones by Prof. Scott Glenn (Rutgers COOL)

Please see the presentation on www.jcomm.info/NPOMS-5

Severe Weather, Flood, Landslides Due to Tropical Cyclone Mora by Mr. K.D. Sujeewa (Sri Lanka Met Service)

Please see the presentation on www.jcomm.info/NPOMS-5

Pacific-Indian Ocean Throughflow and its Branch in the South China Sea by Dr. Wang Yonggang (First Institute of Oceanography/SOA)

Please see the presentation on www.jcomm.info/NPOMS-5

Use of Observations from Weather & Drifting Buoys, Oil Rigs, Ships and Aircraft Data for Tropical Cyclone Monitoring by Mr. Chan, S.T (Hong Kong Observatory)

The Hong Kong Observatory (HKO) maintained a fleet of 67 voluntary observing ships up to the end of 2016. In the same year, a total of 5 drifting buoys upgraded with pressure sensors under the DBCP Barometer Upgrade Scheme were deployed over the South China

Sea. The drifters had provided valuable information in determining the location of tropical cyclones, especially the weak ones as in the case of genesis of Tropical Cyclone Dianmu close to Hong Kong in August 2016. HKO would seek to deploy more drifting buoys over the South China Sea in summer for monitoring tropical cyclones.

To further strengthen monitoring of tropical cyclones over the South China Sea, HKO also collaborated with the Hong Kong Government Flying Service (GFS) in installing a dropsonde launching system in the new Challenger 605 aircraft of GFS. The system was put into operation in March 2017. HKO planned to make available the dropsonde data on the GTS in the near future.

HKO also presented results of a study to review the interpretation of wind observations from various offshore platforms for tropical cyclone monitoring, with the focus put on the method to correct the observations taken at different altitudes. For wind measurements taken at an elevation of around 100 m or below, the log wind profile as recommended by WMO Guide to Meteorological Instruments and Methods of Observations (WMO-No.8) was considered suitable for operational deployment to retrieve the equivalent 10-m winds on open seas neighbouring to Hong Kong. While the roughness lengths applicable to open sea conditions ranged from 0.0002 m to 0.006 m in other implementations, the lower bound of 0.0002 m appeared to be the reasonable choice, as supported by the inter-comparison of observations taken by weather buoys, ships, oil rig platforms, and co-located ASCAT winds. For ship reports, the study revealed that the raw wind measurements from ships generally over-estimate the 10-m winds by about 10%. In the absence of detailed information about the method and height of observations to allow for a more accurate correction to be made, caution should be exercised to interpret the raw wind speed measurements from ships.

BMKG Met-Ocean Development: Indonesia National Report by Mr. Bayu Edo (Indonesia BMKG)

BMKG envisions an integrated system of observations, data processing, modelling and distribution of maritime weather. It is required that the maritime ocean and weather service will be able to meet the demands of the public and support the success and safety of maritime operations across Indonesia. To meet the public demands, it is crucial for BMKG to address the improvement of maritime operations proposed by the current government (Widodo 2014-2018). Improvements in and integration of observation, data collection, analysis, forecasting with improved automation and redundancy will result in actionable information. This development outcome is Availability of marine data observations that reliable, integrated, user friendly and accessible to the public and research, Improved accuracy of climate and weather information issued by BMKG especially marine weather and climate information, Improving the understanding of phenomena related to air-sea interaction and its role in the variability of the weather and climate in Indonesia, and could be contribute to the international program Global Ocean Observing System (GOOS), Tropical Pacific Ocean Observing System (TPOS) and NPOMS.

Thailand National Report by Mr. Anucha Srerurngla

Please see the presentation on www.jcomm.info/NPOMS-5

Upper Ocean Response to Typhoon Kalmaegi(2014) by Dr. Han Zhang

Typhoon Kalmaegi passed over an array of buoys and moorings in the northern South China Sea in September 2014, leaving a rare set of observations on typhoon-induced dynamical and thermohaline responses in the upper ocean. The dynamical response was characterized by strong near-inertial currents with opposite phases in the surface mixed layer and in the thermocline, indicating the dominance of the response by the excitation

of the first baroclinic mode. The thermohaline response showed considerable changes in the mean fields in addition to a near-inertial oscillation. In particular, temperature and salinity anomalies generally exhibited a three-layer vertical structure, with the surface layer becoming cooler and saltier, the subsurface layer warmer and fresher, and the lower layer cooler and saltier again. The response in the surface and subsurface layers was much stronger to the right of the typhoon track, while that in the lower layer was stronger along the track and to the left. These features of the upper ocean response were grossly reproduced by a three-dimensional numerical model. A model-based heat budget analysis suggests that vertical mixing was mainly responsible for the surface cooling and subsurface warming, while upwelling was the cause of cooling from below. Both observations and model results indicate that the whole upper ocean experienced an overall cooling in the wake of typhoon Kalmaegi.

DAY 2: WEDNESDAY 05TH JULY 2017

Autonomous Surface Drifting Buoys for Air-Sea Observations Under Tropical Cyclones by Dr. Luca Centurioni(Scripps Institution of Oceanography, USA)

The Global Drifter Program (GDP) maintains an air-deployable drifter array designed to observe meteo-marine variables in hurricanes that pose a threat to the US mainland. Such drifters are designed to measure sea surface temperature, subsurface temperature to a depth of 150 m, sea level air pressure, sea-level wind and directional wave spectra. The drifter observations are available in real-time trough Global Telecommunication System of the Worlds Weather Watch. Here we present a summary of the drifter technology, the observational methods and some results from observations collected in the north west Atlantic and north west Pacific Oceans.

Effects of Convective Processes on the Evolution of Cyclone Pam (2015) in the Southern Pacific by Dr. Tetsuya Takemi (DPRI, Japan)

A series of numerical simulations for the development of Cyclone Pam (2015) that evolved from the convective aggregations of MJO were conducted with the use of the Weather Research and Forecasting model to examine the sensitivity to cloud microphysical processes. It was shown that the rate of intensification of the cyclone depends on the choice of the microphysics scheme. The examination of environmental conditions demonstrated that the accumulation of a sufficient amount of CAPE is favorable for evolving from convective aggregations into a tropical cyclone.

Extreme cyclone genesis in Bay of Bengal by Dr. Weidong Yu (Nat. Marine Env. Forecasting Center/SOA)

Please see the presentation on www.jcomm.info/NPOMS-5

Coastal Ocean Circulation during Hurricane Sandy by Mr. Travis Miles (Rutgers COOL)

Hurricane Sandy (2012) was the second costliest tropical cyclone to impact the United States and resulted in numerous lives lost due to its high winds and catastrophic storm surges. Despite its impacts little research has been performed on the circulation on the continental shelf as Sandy made landfall. In this study integrated ocean observing assets and regional ocean modeling were used to investigate the coastal ocean response to Sandy's large wind field. Sandy's unique cross-shelf storm track, large size, and slow speed resulted in along-shelf wind stress over the coastal ocean for nearly 48 hours before the eye made landfall in southern New Jersey. Over the first inertial period (~18 hours) this along-shelf wind stress drove onshore flow in the surface of the stratified continental shelf and initiated a two-layer downwelling circulation. During the remaining storm forcing

period a bottom Ekman layer developed and the bottom Cold Pool was rapidly advected offshore ~70 kilometers. This offshore advection removed the bottom Cold Pool from the majority of the shallow continental shelf and limited ahead-of-eye-center sea surface temperature (SST) cooling, which has been observed in previous storms on the MAB such as Hurricane Irene (2011). This cross-shelf advective process has not been observed previously on continental shelves during tropical cyclones and highlights the need for combined ocean observing systems and regional modeling in order to further understand the range of coastal ocean responses to tropical cyclones.

The Processing and Quality Control of Buoy Data by LIU Shouhua (NMDIS/SOA)

This presentation provided an overview of China buoy observing system which consist of moored buoys, drifting buoys, and Argo. Data is transfer in real-time and delayed modes. Buoy data processing and QC are conducted based on the data formats and on the transfer mode. For real-time data, BBX format (used in VSAT network transmission), and XML formats are used. Data are quality controlled with primarily check on format, ID information, date, position, physical consistency, and abnormal values. A case study was done on QC significant wave height: outlier processing, sometimes automatic QC does not work and then required to do a statistical test.

Exploring the Eastern Indian Ocean with InaPRIMA 2017 Field Campaign and the Use of RAMA Data by Siswanto (Indonesia BMKG)

The presentation covers three topics that is the report of InaPRIMA 2017 and brief explanation of RAMA buoy in the Indian Ocean, the Eastern Indian Ocean features obtained from InaPRIMA2017 and Utilizing RAMA data to monitoring & study of oceanic response to Tropical Cyclone (TC) and Ocean model verification.

The InaPRIMA (Indonesia Program initiative on Maritime Observation and Analysis) is a ship time for Maintaining RAMA mooring buoy (ATLAS) and a field campaign to collect more data in Marine Meteorology, Geophysics, Oceanography and Air Quality Survey. InaPRIMA is part of BMKG – NOAA collaboration in ocean and climate observation and analysis under the Indonesia–USA Mutual of Understanding on Ocean Science Technology.

The InaPRIMA successfully mimics the oceanic features of the Eastern Indian Ocean by their obtained CTD and ADCP data such as the guessed water mass of Indonesian Trough Flow that penetrated further into Indian Ocean jointly with South Equatorial Current (SEC). The sub surface oceanic features during MJO event 22-28 Feb 2017 is also explored during the cruise. The data obtained from the survey also confirms the existence of Equatorial Undercurrent (EUC) and its characteristics together with the latitudinal feature of the Eastern Indian Ocean.

The data from RAMA buoy sites is used to study ocean response during TC Bertie-Alvin 18-28 Nov 2005 and very useful to verify the ocean model performance for sea surface temperature and current. The results show that the HYCOM+NCODA global analysis has a good performance in sea surface temperature but less accurate in sea surface current. The discussion with scientist from Rutgers university reveals that the less performance in sea surface current is due to bad simulated altimetry in the model.

Network Implementation and Targets: How to Engage in Network Implementation by Ms. Champika Gallage (WMO Secretariat)

Worldwide marine meteorological and oceanographic communities are working in partnership under the umbrella of the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology, in order to respond to interdisciplinary requirements for met/ocean observations, data management and service products. Out of three program areas of JCOMM, Observation Program Area (OPA) is responsible for the

development, coordination and maintenance of ocean observing networks i.e. moored buoy, drifting buoy, ship-based and space-based observational networks, Argo network, Global sea level network, OceanSITES network and related telecommunications facilities. OPA also monitors the efficiency of the overall observing system and, as necessary, recommends and coordinates changes designed to improve it.

Implementation targets are been established for most of the networks and the results are available through the JCOMM in-situ Observation Program Support (JCOMMOPS)Centre web portal. There are identified gaps in the observing systems in the region. It is understandable that not all countries in the region are able to contribute to the observing network equally. However there are many ways to engage in ocean observing network implementation; participation in barometer upgrade program, assistance with instrument logistics and deployments, providing ship-time, education and outreach in buoy vandalism, and increasing manual observations from ships are few of them.

Information material on Buoy vandalism is available through DBCP website at http://www.jcommops.org/dbcp/deployments/recovery.html. The draft document on "Outreach Strategy to Reduce Damage to Ocean Data Buoys From Vandalism or Interference" is under development and will be available through the same web link once finalized.

Development of air-sea coupled model system for typhoon forecast by Ms. LING Tiejun (National Marine Environmental Forecasting Center/SOA)

Please see the presentation on www.jcomm.info/NPOMS-5

WESTPAC/DBCP TC-Ocean Working Group: A Prospectus by Dr. Sidney Thurston (DBCP)

Please see the presentation on www.jcomm.info/NPOMS-5

WMO Tropical Cyclone Program (WMO TCP) by Ms. Anne-Claire Fontan(WMO TCP-Remote)

The WMO Tropical Cyclone Programme (TCP) assists and supports its Members to provide reliable and improved forecasts of tropical cyclone (TC) and related hazards with timely warnings through early warning systems. It is organized via five regional tropical cyclone bodies. The global coordination encompasses capacity development, training requirements transfer of technology and scientific knowledge to Members. In this regard, the ninth session of the quadrennial International workshop on Tropical Cyclones (ITWC) will be held in Honolulu late 2018. (https://www.wmo.int/pages/prog/www/tcp/Activities.html),

Heat extracted from oceans is a big driver for TC intensification and a key for TC intensity evolution. To be able to assess the ocean heat content is therefore very important. In this connection, TCP will be involved via the WMO Observing Systems Division in the Roller Review Requirements to attempt to capture observational requirements.

Progress of Experiment on Typhoon Intensity Chang in the Coastal Area (EXOTICCA) by Dr. Zeng Zhihua (Shanghai Typhoon Institute /CMA)

Please see the presentation on www.jcomm.info/NPOMS-5

Impacts of Tropical Cyclones on Oceanic Processes in the Taiwan Strait by Mr. PAN Aijun (Third Institute of Oceanography/SOA)

Please see the presentation on www.jcomm.info/NPOMS-5

Two decades of Ocean Observation by Mr. S. Ramasundaram, (National Institute of Ocean Technology, India)

Observations from tropical Indian Ocean is vital for the understanding of Indian Monsoon that drastically affects the livelihoods of more than a billion people in Indian Ocean rim countries. India with a long coast line of 7500 km and 2.02 million sq. km EEZ, offers immense scope for the utilization of marine resources and coastal zones.
Considering the importance of real-time data collection from Indian Seas, Ocean Observation Systems (OOS) under National Institute of Ocean Technology (NIOT) Chennai was established in 1997 by Ministry of Earth Sciences. Ocean Observation Systems (OOS) is now celebrating 20 years of service to the nation and very well evolved. An extensive network of buoys deployed in the Bay of Bengal and Arabian Sea provides continuous real time observations; vital for oceanographic research and disaster management. The data based on moored buoys have proven crucial for preparedness in events of extreme weather like cyclones and have immensely helped in providing accurate predictions of past 20 cyclones especially Phylin, HudHud, Vardha and Mora formed in the seas around India. These observations steered the better prediction of track, intensity and land fall of tropical cyclones leading to significant reduction in loss of life and property in cyclone hit areas. Besides, the tsunami buoy system is well equipped to ensure adequate early warning for entire Indian coastline. Also, the deployment of moored buoy in the Arctic has provided information about the cause of glacier melt in the Arctic fjord.

The Indian buoy programme has also brought out many technological developments, significantly improved the measurement capabilities and ensured the quality and continuity of data. Several patents have been filed and more than 125 papers published in refereed journals. The Indian team has successfully collaborated with many national and international institutions such as WHOI-USA, NDBC-NOAA-USA, JCOMM, JAMSTEC-Japan, Department of Environmental Affairs-South Africa, Peru and Norway. The expertise gained by the team further led to nurture young talents in the country and impart training to other countries such as South Africa under capacity building.

Sustaining the observational programme and ensuring the high quality data amidst multitude of challenges require enormous vision and team work. With rigorous research and technological development initiatives, Indian buoy programme continues to ensure and provide reliable high quality data to users and to the global community.

DAY 3: THURSDAY 06TH JULY 2017

Observing Sediment Resuspension and Transport from Ocean Gliders by Travis Miles (Rutgers COOL)

New technologies such as gliders and coupled ocean-atmosphere-wave-sediment transport models have been developed in an effort to investigate regional sediment resuspension and transport induced by tropical cyclones and coastal storms. These systems have evolved and been leveraged to support broad ocean observing needs including research, support of ocean data assimilation, and operational numerical weather prediction. Future typhoon and hurricane work should continue to develop connections with broad communities in order to entrain new technology, sensors, and methods to better understand tropical cyclone intensity.

The technology and experiences of RMIC/AP on the data accuracy and assurance for the moored buoys and its sensors by YU Jianqing (National Center of Ocean Standards and Metrology/SOA)

Please see the presentation on www.jcomm.info/NPOMS-5

Overview of Ocean Observation (HF Radar, Glider)by Prof. Scott Glenn (Rutgers COOL)

Please see the presentation on www.jcomm.info/NPOMS-5

The Scenario Study of the Future Storm Surge in Qingdao by Dr. JIANG Wensheng (Ocean University of China)

The storm surges caused by in Qingdao are studied for future scenarios. It is found that the increasing of the maximum wind speed and the sea level rise will increase the severity of the typhoon induced storm surge in Qingdao. The increase of the maximum wind speed is the leading factor over the sea level rise. The increase of the tidal amplitude, the peak surge elevation are of the same order as the sea level rise. The composite effect of the sea level rise and the increase of the maximum of the wind speed mostly intensify the surge elevation but may reduce it in some cases.

Impacts of Surface Lagrangian Drifting Buoy Data in Numerical Weather Prediction and Climate by Dr. Luca Centurioni (Scripps Institution of Oceanography)

The Global Drifter Program (GDP) is a global array of over 1,250 Lagrangian surface drifters that collect measurements of essential climate variables. Hourly measurements of sea surface temperature (SST), horizontal 15 m depth currents and sea level atmospheric pressure (SLP) are distributed to partners in real-time through the Global Telecommunication System of the Worlds Weather Watch.

The GDP array returns two orders of magnitude more SST data than the Argo array. The considerable positive impact of in-situ, high quality, SST drifter data on the calibration and validation of SST satellite products is discussed. Furthermore, the GDP array provides accurate SLP observations over the World's ocean and in many places the drifters are the only source of in-situ SLP observations. Notable examples include the Southern Ocean and vast extensions of the three major oceans that are not systematically covered by commercial shipping routes. The large positive impact of drifter SLP observations on Numerical Weather Prediction (NWP) is presented thorough results from a data denial study conducted in collaboration with the European Center for Medium-range Weather Forecasts. The beneficial effect of the drifters' data extends up to 5 days into the forecasts and vertically in the troposphere up to approximately 250 hPa. Forecast Sensitivity to Observation Impact methods reveal that, on a per-observation basis, SLP drifter data are one of the most important components of the entire observing system. As per WMO recommendations, every drifter in the global array should carry a barometer but, at present, only about 60% of the drifters satisfy this requirement. To meet this goal, the GDP offers to national and international partners the opportunity to upgrade drifters with barometers through its Barometer Upgrade Program.

New Drifter Design by Ms. Li Xiaoxia (CMA)

A cost-effective technology drifters have been designed in China. It is an important collaboration between meteorologists and oceanographers with regard to the drifters design. Effective cooperation has been put in place with drifters for various marine and meteorological elements. The drifters could observe surface salinity, Sea Surface Temperature (SST),sea level pressure, temperature, wind speed and direction(optional).

It has several characteristic. Firstly, the application of flexible solar panel technology to effectively extend the working time of the drifters. Secondly, with the continuous development of Beidou satellite system, the communication low-power technology, antenna technology, reliability research on the basis of Beidou satellite system have been developed to achieve drifter data transmission, while providing Argos satellite

communication interface. Thirdly, the Intelligent control of the instrument. The timing of data transmission can be customized according to the requirements. For example, when typhoon comes, you can transfer the data transmission frequency from 1 hour to 10 minutes. Fourthly a posture sensor is installed. Especially the wind measurement, including wind speed and wind direction, which is added the posture sensor information at present. Fifthly Real-time monitoring of the attitude sensor information and status information, such as motherboard temperature, power supply voltage and other information. The drifters have been tested in a series of laboratories and offshore tests, with good operating conditions and reliable data.

ANNEX 3

LIST OF NPOMS-5 PARTICIPANTS

CHINA

Dr. Jiang Wensheng
Ocean University of China
No. 238 Songling Road, Qingdao, China
Tel:+86-13606344196
Email: wsjang@ouc.edu.cn

Mr. Li Ruixiang
South China Sea Marine Survey and Technology Center/SOA
Tel: +86-15913133251
Email: liruixiang@smst.gz.cn

Dr. Li Xiaoxia
Meteorological Observation Center of CMA
Tel:+86-10-62105585
Email: lxxaoc@cma.gov.cn

Dr. Ling Tiejun
National Marine Environmental Forecasting Center/SOA
No.8 Da Huishi Road, BeiJing, China
Tel:+86-13711173181
Email: iron_ling@163.com

Dr. Liu Shouhua
National Marine Data and Information Service/SOA
No. 93 Liuwei Road, Tianjin, China, 300171
Tel: +86-22-24010850
Email:huazai950@hotmail.com

Dr. Pan Aijun
Third Institute of Oceanography/SOA
Xiamen, China
Email: aijunpan@tio.org.cn
Tel:+86-13696975729

Mr. Qi Qinghua
Third Institute of Oceanography, SOA
Xiamen, China
Tel:+86-13646024617
Email: qqh_2002@163.com

Dr. Wang Guihua
Fu Dan University
No. 220, Handan Road, Shanghai, China
Tel: +86-18358113525
Email:wanggh@fudan.edu.cn

Dr. Wang Yonggang
First Institute of Oceanography/SOA
No. 6 Xianxialing Road, Qingdao, China
Tel:+86-532-88967092
Email: Ygwang@fio.org.cn

Dr. Wang Dakui
National Marine Environmental Forecasting Center/SOA
No.8 DAHuishi Road, BeiJing, China
Tel:+86-13436818769
Email: dakui.nmefc@gmail.com

Mr. Xing Chuanxi
National Marine Environmental Monitoring Center/SOA
Tel:+86-15542317381
Email: cxxing@nmemc.org.cn

Dr. Yu Jianqing
Natioinal Center of Ocean Standards and Metrology/SOA
Tel:+86-18698017617
Email:yujianqing_82@163.com

Mr. Yu Shengbin
South China Sea Marine Prediction Center/SOA
Tel:+86-18520328808
Email: yu@hyyb.org

Dr. Yu Ting (Julia)
National Marine Data and Information Service/SOA
No. 93 Liuwei Road
Tianjin, 300171, China

Tel: +86-22-24010768
Email: julia_yu_nmdis@163.com
yuting@nmdis.org.cn

Dr. Yu Weidong
National Marine Environmental Forecasting Center/ SOA
No.8 Da Huishi Road, BeiJing, China
Tel: +86-13953205046
Email: wdyu@fio.org.cn

Dr. Zeng Zhihua
Shanghai Typhoon Institute /CMA
No. 166 Puxi Road, Shanghai 200030, China
Tel:+86-18918206103
Email: zengzh@mail.typhoon.gov.cn

Dr. Zhang Han
Second Institute of Oceanography/SOA
No.36, Bachubei Road, Hangzhou, China
Tel:+86-15372597838
Email: zhanghan@sio.org.cn

Dr. Zhang Xuefeng
National Marine Data and Information Service/SOA
No. 93 Liuwei Road, Tianjin, China
Tel:+86-15900288817
Email:xfz_nmdis@126.com

HONG KONG/CHINA

Mr. Sai-tick Chan
Senior Scientific Officer
Hong Kong Observatory
134A Nathan Road
Kowloon, Hong Kong
China
E-mail: stchan@hko.gov.hk

INDIA

Mr. Subramanian Ramasundaram
Ocean Observation Systems
National Institute of Ocean Technology
Velachery- Tambaram Road, Pallikaranai
Chennai- 600100
Tamilnadu
India
E-mail: sundar@niot.res.in
vsrams@yahoo.com

INDONESIA

Mr. Bayu Edo Pratama
Center for Marine Meteorology of BMKG
JalanAngkasa I No.2 Kemayoran
Jakarta 10720
DKI Jakarta
Indonesia
E-mail: bayu.edo@bmkg.go.id
bayuedo_bmg@yahoo.com

Mr. Siswanto Siswanto
Center for Marine Meteorology of BMKG
JalanAngkasa I No.2
Jakarta 10720
DKI Jakarta
Indonesia
E-mail: siswanto@bmkg.go.id
shizz.assisi@gmail.com

JAPAN

Dr. Tetsuya Takemi
Disaster Prevention Research Institute, Kyoto University
Gokasho, Uji, Kyoto, Japan 611-0011
Phone: +81-774-38-4160
E-mail: takemi@storm.dpri.kyoto-u.ac.jp

MALAYSIA

Mr. FathyKameelMohdFadzil
Senior Science Officer
Institute of Oceanography
University Malaysia Terengganu
21300, Kuala Terengganu
Terengganu
Malaysia
E-mail: fathykameel@yahoo.co.uk

SRI LANKA

Mr. Sujeewa Kanda Durage
Department of Meterology
BaudhdhalokaMawatha
Colombo 07
Sri Lanka

E-mail: knddrg@yahoo.com

THAILAND

Mr. Anucha Sreruangla
Meteorologist
Thai Meteorological Department
Sukhumvit Road
Bangna, 10260
Bangkok
Thailand
E-mail: theanucha@gmail.com
theanucha@hotmail.com

Mr. Pawat Siriyotha
Meteorologist
Thai Meteorological Department
Sukhumvit Road
Bangna, 10260
Bangkok
Thailand
E-mail: nine_wat@hotmail.com,
nanasaka@hotmail.com

UNITED STATES OF AMERICA

Dr. Joe Cione
Senior Research Scientist,
NOAA's Hurricane Research Division,
Earth System Research Laboratory
United States
E-mail: joe.cione@noaa.gov

Dr. Luca Centurioni
Associate Researcher and lecturer
University of California, San Diego,
Scripps Institution of Oceanography
Scripps Institution of Oceanography
La Jolla CA 92093-0213
United States
E-mail: lcenturioni@ucsd.edu

Dr Scott Glenn
Center for Ocean Observing Leadership
Department of Marina and Coastal Sciences
School of Environmental and Biological Sciences
Rutgers University
71 Dudley Road,
New Brunswick, NJ 08901-8521
United States
E-mail: glenn@marine.rutgers.edu

Dr Sidney W. Thurston
International Coordinator
NOAA, Climate Program Office
Climate Observations
SSMC3
Silver Spring MD 20910
United States
E-mail: sidney.thurston@noaa.gov

Dr. Travis Miles
Assistant Research Professor
Center for Ocean Observing Leadership
Department of Marine and Coastal Sciences
Rutgers University
New Brunswick, NJ 08901
United States
Email: tnmiles@marine.rutgers.edu

WMO Secretariat

Champika Gallage
Scientific Officer, Observing Systems Division
Observing and Information Systems Department
World Meteorology Organization
7 bis, avenue de la Paix
Case postale 2300
Email: cgallage@wmo.int

_____

ANNEX 4

NPOMS-5 ORGANIZING COMMITTEE

1. Yu Ting, DBCP Vice-Chair, National Marine Data and Information Service, China
2. JIANG Wensheng, Ocean University of China
3. WANG Guihua, Fudan University, China
4. WANG Yonggang, First Institute of Oceanography, China
5. Tetsuya Takemi, Co-Chair NPOMS-3, Disaster Prevention Research Institute,
6. Kyoto University, Japan
7. Joe Cione, Senior Research Scientist, NOAA's Hurricane Research Division, Earth System Research Laboratory, USA
8. Champika Gallage- WMO Secretariat, Geneva
9. Denis Chang Seng - IOC Secretariat, Paris
10. Sidney Thurston - DBCP Task Team Chairperson for Capacity Building, NOAA USA

ANNEX 5

TERMS OF REFERENCE OF THE NPOMS-5 WORKSHOP

The Following Goals and Associated Actions reflect the needs of this NPOMS-5 Workshop and of the long-term Ocean-Climate Monitoring Capacity for Cyclogenesis and Forecasting:

1. Continue to build regional collaboration to improve the implementation of ocean observations for improving typhoon track and intensity forecasts, and estimating the impacts of TCs on ocean environment,

2. Review recent, on-going and planned regional programs on typhoon and its interaction with the ocean,

3. Discuss new advances in our understanding of the processes and mechanisms of typhoon-ocean interaction,

4. Build Regional 1) human, 2) institutional and 3) infrastructure capacity needed to acquire, process and deliver rapid deployment, potentially from aircraft, of operational data buoys, floats, gliders, etc. for the collection of buoy data, and related data management, for improving typhoon forecast accuracy,

5. Demonstrate the crucial role of ocean observations in the Western Pacific, such as for understanding and predicting regional cyclogenesis,

6. Continue to learn practical implementation skills for the deployment of operational data Buoys at sea, the collection of buoy data, and related data sharing and management,

7. Continue to Align with Objectives of the *Global Framework for Climate Services* (GFCS), Global Framework for Ocean Observations and the Marine Climate Data System (MCDS) to Deliver Ocean Data to the End-User,

8. Enhance Coordination and Cooperation between the DBCP Task Team for Capacity Building (TT-CB), WMO Regional Associations (RA-II/V) and the IOC Sub-Commission for the Western Pacific (WESTPAC),

9. Additional from NPOMS-4 Recommendations.

ANNEX 6

NPOMS-5 WORKSHOP RECOMMENDATIONS/ACTION ITEMS

RECOMMENDATIONS

1. Ocean surface layer information is critical for an accurate Typhoon forecast. Currently there is not enough surface layer information. Based on the studies, it is apparent that the ocean cooling occurs before the eye pass of the hurricane in some regions. Thus more temperature observations from the mixing layer wold increase the typhoon/hurricane prediction.

2. Data and model mining experiences using historical storms is a new development in NPOMS-5. Case studies from TC **MUIFA** and 6 others in the same region, MEGI, **MORA** (because of Indian Ocean dipole), VARDHA, HAIYAN, **KALMAEGI** (973 typhoon array 2014).

3. Further investigate the MJO and Indian ocean dipole, influence of Indian ocean, TC in BoB, and generation of TC in Banda sea and Pacific.

4. Identify a mechanism to more broadly disseminate the outcome/results of NPOMS meetings to relevant WMO and IOC Members and Member states i.e. including modeling groups.

5. Studies show that the Bay of Bengal (BoB) has unique characteristics on monsoon onset process compared to other ocean basins. Further it shows that pressure gradient, and SST are the dominant factors in predicting the monsoons in BoB. Thus recommended to have more measurements from air-sea boundary layer particularly from the BoB.

6. IndOOS array will be reviewed in 2017. NPOMS members are been requested to provide their input in requirements related to the sensors which are needed in this region.

7. Recommended to document the processes influencing track and intensity changes of TCs/Hurricane for each Ocean basin as it is different in every region.

8. Current focus of the TC/Hurricane research community is on improving the intensity and track forecast. It is recommended that impact of storm serge and such should be focused in the future studies.

9. Requested to share the data collected during TCs Kalmaegi and Muifa from South China sea buoys "China 973" array with TC research and forecast community. Further recommended to create a data sharing database for NPOMS community. Such database will hold a repository of selected high impact TC/Hurricane events (i.e. MAUIFA, KALMAGEI, MORA) data for further collaborative studies and analysis. Explore synergies with IWTC in this regard.

10. China is in the process of sharing the VOS data from Chinese vessels on the GTS. It is recommended to use the BUFR format to share the data on the GTS.

11. Thermodynamic measurements are critical towards our efforts to estimate surface enthalpy flux in order to improve operational model surface layer physical processes. Thus requested the ocean buoy community to adopt a policy to include atmospheric temperature (Ta) and atmospheric moisture (Td) sensors on -all-

moored and possibly in drifting arrays existing and planned going forward. These should be insignificant extra cost (10s of us dollars each) with off the shelf, and readily available sensors, after development and testing completed. Experts in DBCP and NWS/NDBC partners can help with the specific sensor details. This should help better predict the intensification of Tropical Cyclones in all global basins.

12. Recommend to use the two emerging technology platforms GPS Drop sondes and Coyote technologies to sample Tropical Cyclones.

13. Glider network became a member of JCOMM Observation Coordination Group (OCG) at the OCG-8. Glider group has established four task teams on boundary currents, storms, deep water formation, crosscutting TT on data management at the last glider steering committee meeting. Currently there are no members from the NPOMS region in the Glider community and recommended to propose representatives from NPOMS to participate in Glider task team on storms.

14. WESTPAC has considered the proposal from the NPOMS at its previous meeting. It was recommended to have a white paper indicating the added value of NPOMS joining the WESTPAC; need to have an active members involved in the proposed group, Recommend to become a working group of WESTPAC

15. There were a number of interesting and important new technology and research developments were presented during NPOMS-5 workshop. The general recommendation is to collaborate in all areas of the work amongst each other in the NPOMS region.

16. HF Radar and Gliders are evolving JCOMM partner programs which can contribute to TC/Hurricane forecast and analysis. Encourage NPOMS community to become involve.

17. Recommended to develop collaboration between emerging glider communities in China and the international glider community and include them in OceanObs'19. Following Argo floats, glider represents the second breakthrough in 3-D ocean observation with the potential to significantly improve our understanding of the ocean and capacity of serving the users. To promote the pilot Glider observation study targeting the cyclone genesis regions across the basins. The candidate regions include, with the initial priority consideration:

    (1) Southwestern Indian Ocean Thermocline Dome, where the cyclone genesis are modulated by complex large scales processes including the Indian Ocean Dipole, EL Nino, monsoon seasonal cycle and its intra-seasonal oscillation (ISO) among many others. These cyclones head to La Reunion, Mauritius, Madagascar and eastern coast of Africa, where the community capacity of disaster prevention and mitigation is still low.

    (2) Bay of Bengal, where extreme cyclones have caused tremendous loss of lives and property. Particularly, northern BoB has wide shelf and experience from other shelf region like Mid-Atlantic Bight could be applied.

    (3) North-western Pacific region where the largest amount of typhoons are generated with strong inter-annual variability that are poorly predicted now.

18. Often storm surge modelling studies use the empirical typhoon model to drive the storm surge model. But it is found that there is no information of the radius of the maximum wind speed of typhoon. Therefore it is recommended to pay attention to the radius of the maximum wind speed parameter during the capability building.

19. The ship-time to maintain buoys will be more valuable if accompanied by a field campaign to collect more data. Data from a field campaign especially from CTD and ADCP along ship track can be more comprehensive and higher-resolution.

20. There is a good chance to endorse every country who is doing ship-time for buoy maintenance to share their campaign result, exchange data, and experience in the DBCP/NPOMS meeting. Collaboration and coordination on field campaign is recommended for countries within NPOMS area to address the data gap especially in the area of West Pacific North Papua, Indonesian sea waters, Indian Ocean west and south of Indonesia. These activities can be dedicated to study ocean processes of MJO and ITF as well as its connection to the atmosphere.

21. Include stakeholder talks on TC/Hurricane impacts i.e. storm surge,. in future NPOMS meetings while keeping the focus on TC intensity and track forecast improvement.

22. Recommended to have few keynote speakers and allow 30 min for a talks in future NPOMS workshops.

23. Recommended to have a science based organizing committee to proactively organize the next meeting targeting to arrange the talks in suggested major talks.

24. Host country take leadership early in the planning process to get the local institutes, organizations, universities and emergency managers to present primarily the evolving technologies in future NPOMS workshops.

25. Dedicate the first day for student only presentations. Adding an icebreaker the first day would be beneficial for better interaction.

26. Arrange intersessional (teleconferences/videoconference) meetings to make progress on recommendations/action items.

27. SLP, AT, winds, directional waves and RH measurements are critical parameters in TC/hurricane forecasting and operational model verification. There are observation gaps in ocean areas where TC/hurricane develops. Therefore it is recommended to promote the observation community to get more SLP, AT , wind and wave measurements in global oceans. Equip more drifters with pressure sensors and evaluate the impact of SST and winds from drifters on TC forecast and operational model verification.

28. Conduct the collaborative study on the multidisciplinary shelf ocean response to cyclone forcing. To explore the complex shelf ocean response to cyclone forcing, considering the regional diversity, weather/climate regime, oceanic stratification, shelf circulation, ecological habitat, fishery etc.. Collaborative study on various shelf ocean will help understand the full spectrum of the complex oceanic response process, with the aid of the multiple in situ observation platforms and numerical models with various complexity.

ACTION ITEMS

1. With reference to the recommendation 14, explore the possibilities to share the data from 5 typhoon platforms in South China Sea available to the NPOMS community prior to NPOMS-6. (Dr. Sidney Thurston, NPOMS-6)

2. Dr Cione to provide data collected from Coyote to Dr Takemi to test hypothesis that accumulated boundary layer CAPE is linked to subsequent TC rapid intensification. (Dr. Joe Cione, Dr. Tetsuya Takemi, NPOMS-6)

3. China mentioned that there is lack of knowledge and expertise on using the BUFR data format for SOT observations. Thus requested WMO to arrange required initial training through Ocean Teacher or in-house. (WMO Secretariat, before NPOMS-6)

4. Provide information material on buoy vandalism in the NPOMS-5 report. (WMO Secretariat, by NPOMS-5 report publication)

5. Provide OcenSITES, Gliders and HF Radar network contact information to Indonesian and Hong Kong(China) representatives. (WMO Secretariat, 30 July 2017)

6. Propose establishment of a new TC-Ocean working group to WESTPAC advisory committee. (Dr. Sidney Thurston, Dec 2017)

7. Dr. Joe Cione (NOAA-USA) and Dr. Zeng Zhihua (CMA-China) agreed to discuss further to share the data from unmanned aircraft during TC/Huricanes. (Dr. Joe Cione, Dr. Zeng Zhihua, NPOMS-6)

8. Create an NPOMS mailing list for future meetings. (WMO Secretariat/DBCP-TC, 06 months prior to NPOMS-6)

9. To explore the feasibility of RAMA buoy deployment at (80E, 4N). RAMA planned one buoy location at (80E, 4N), which is within Sri Lanka EEZ and was never occupied. This location is proposed to be dropped off in the recent review of RAMA. However, it is worth of exploring the deployment feasibility considering the Sri Lanka's Meteorology Service's presentation at NPOMS-5 emphasizing the severe landslide disaster caused recently by the cyclone during the monsoon onset phase. This strong disaster prevention and mitigation requirements should be addressed by the science community. It is then suggested that a letter be drafted and sent to the Director General of Sri Lanka's Meterology Service. If possible, FIO/SOA could help mobilize some ship time to this location. The buoy system needs further inputs, maybe through a NOAA-SOA collaboration. (Dr. Sidney Thurston, NPOMS-6)

10. Assemble the list of target datasets from TC MUIFA and 6 others in the same region, MEGI, MORA (because of Indian Ocean dipole), VARDHA, HAIYAN, KALMAEGI and present at NPOMS-6 special session on the agenda. (Dr Scott Glenn, Dr. Weidong Yu, Mr. Travis Miles, NPOMS-6)

11. Explore existing OSE groups to see impact of drifter SLP, SST and winds on TC forecast. (Dr Joe Cione, Dr. Luca Centurioni, NPOMS-6)

12. Contact PR of Philippine s, Bangladesh, Myanmar to NPOMS community. (Dr. Sidney Thurston, Dec 2017)

13. Recommended to have more countries involved in the NPOMS, thus further extend the invitation to a broader community who are impacted by TCs. Further recommended to include Region 5 and look for a host from the same region. (WMO Secretariat, NPOMS-6)

ANNEX 7

ACRONYMS

ADCP	Acoustic Doppler Current Profiler
AP	Atmospheric pressure
AT	Air Temperature
BMKG	Indonesian Agency for Meteorological, Climatological and Geophysics (Badan Meteorologi, Klimatologi, dan Geofisika)
BoB	Bay of Bengal
CMA	China Meteorological Administration
CTD	Conductivity, Temperature, and Depth
DBCP	Data Buoy Cooperation Panel
DPRI	Disaster Prevention Research Institute
EUC	Equatorial Undercurrent
FIO	First Institute of Oceanography/SOA
GDP	Global Drifter Program
GFCS	Global Framework for Climate Services
GOOS	Global Ocean Observing System
HKO	Hong Kong Observatory
IOC	Intergovernmental Oceanographic Commission of UENSCO
JCOMM	WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology
MJO	Madden-Julian Oscillation
NDBC	National Data Buoy Center/NOAA
MCDS	Marine Climate Data System
NMDIS	National Marine Data and Information Service
NOAA	National Oceanic and Atmospheric Administration
NPOMS	North Pacific Ocean and its Marginal Seas
NWP	Numerical Weather Prediction
NWS	National Weather Service
OCG	JCOMM Observation Coordination Group
PANGEA	Partnership for new GEOSS Applications
QC	Quality Control
SCS	South China Sea
SEC	South Equatorial Current
SIO	Second Institute of Oceanography/SOA
SLP	Sea Level pressure
SOA	State Oceanic Administration of China
SOG	Statement of Guidance
SST	Sea Surface Temperature
TC	Tropical Cyclone
TCP	WMO Tropical Cyclone Program
TPOS	Tropical Pacific Ocean Observing System
WESTPAC	IOC Sub-Commission for the Western Pacific
WMO	World Meteorological Organization