JMA/WMO WORKSHOP on EFFECTIVE TROPICAL CYCLONE WARNING in SOUTHEAST ASIA

Tokyo, Japan

11 to 14 March 2014

Final Report

Japan Meteorological Agency
World Meteorological Organization

1. Opening of the Workshop

1.1 The JMA/WMO Workshop on Effective Tropical Cyclone Warning in Southeast Asia was held in Tokyo, Japan from 11 to 14 March 2014. The opening session commenced at 0900 hours on Tuesday, 11 March 2014 at the Conference Hall of the Japan Meteorological Agency (JMA) in Tokyo.

1.2 Dr Mitsuhiko Hatori, Director-General of JMA, and Permanent Representative of Japan with WMO expressed his sincere appreciation to the World Meteorological Organization (WMO) for co-hosting the workshop and to NOAA National Weather Services (NWS) and Joint Typhoon Warning Centre (JTWC) for the provision of their expertise to the workshop. Dr Hatori also extended a warm welcome to the participants from nine Countries. Noting the recent major tropical cyclone disasters such as Typhoon Haiyan and increasing needs for national meteorological services, Dr Hatori underlined the importance of effective regional cooperation to further enhance tropical cyclone warning capacity in the western North Pacific and in this regard, expressed his expectation that the workshop will serve to further accelerate cooperative activities for mitigation of tropical cyclone disasters in the region.

1.3 Speaking on behalf of Mr Michel Jarraud, Secretary-General of WMO, Ms Nanette Lomarda, Senior Scientific Officer, World Weather Research Division, Research Department of WMO, expressed her deep appreciation to JMA for hosting this workshop. Ms Nanette emphasized that improvements of issuance of accurate and timely forecasts and warnings of tropical cyclones are essential for the welfare of countries affected by these hazardous weather phenomena. Ms Nanette also expressed her expectation that the workshop would identify forecast challenges of countries represented in this workshop which would result in the development of practical plans for the implementation of an effective tropical cyclone warning system in the region.

1.4 The Workshop was attended by 51 participants, comprising the representatives of WMO, invited lecturers from Regional Specialized Meteorological Centres (RSMCs) Honolulu and Miami, JTWC, and the Japan International Cooperation Agency (JICA), and experts from ten National Meteorological and Hydrological Services from East, South and Southeast Asia, including JMA. The list of the participants is given in **Appendix I**.

1.5 Mr Koide, Senior Scientific Officer, Forecast Division of Forecast Department of JMA, briefed the participants on the objectives of the workshop given below and the overall structure of the programme . The workshop programme is given in **Appendix II**.

- To promote understanding of participating countries on the latest tropical cyclone analysis/forecasting techniques and products;
- To identify challenges of those countries in improving their operational forecasting and warning services; and
- To discuss ways to address the challenges including external assistance.

1.6 All documents and presentations presented at the workshop are available online at the JMA website: (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/2014_Effective_TC_Warning/documents.html).

2. KEYNOTE LECTURES (Session 1)

Three keynote presentations were given by representatives of WMO and JICA.

2.1 Ms Nanette Lomarda, the representative of WMO, provided an overview of the Tropical Cyclone Programme (TCP) including its mission, general and regional components, and training activities. She highlighted the recent progress in the Storm Surge Watch Scheme (SSWS) was highlighted such as the provision of storm surge forecasts by RSMC Tokyo for Members of the Typhoon Committee in 2011, provision of graphical storm surge advisories by RSMC New Delhi in 2013 and plans of RSMC Miami to provide storm surge information in 2015. Major challenges were also presented and the need to develop human resources and communication capacity to reduce widening gaps between developing and developed countries was stressed. Noting that marine forecasting capacities are very limited in almost all countries, the importance of international and regional projects, such as SSWS, Coastal Inundation Forecasting Demonstration Project (CIFDP), and Synergized Standard Operating Procedures for Coastal Multi-Hazards Early Warning System (SSOP), was emphasized. The current working structure, recent major achievements, and planned activities of TCP were also presented.

2.2 Dr Tetsuo Nakazawa, the representative of WMO, provided recent activities of the World Weather Research Programme (WWRP) related to studies on high impact weather events. Dr Nakazawa stressed the importance of the role of research in helping society to cope with high impact weather events particularly in terms of 1) reduction of the level and degree of uncertainty in the accuracy and timeliness/lead time of forecasts/warnings and 2) development of methods for effectively incorporating uncertainties into the decision making process.

2.3 Mr Katsumata, an invited speaker from JICA, made a presentation on Japan's Official Development Assistance (ODA) for NMHSs in Southeast Asia. He outlined the framework of the ODA including the conceptual structure of its assistance to developing countries in the field of Disaster Risk Reduction and Management. JICA's support to NMHSs mainly aims to enhance the capacity for Disaster Risk Reduction (DRR) and Climate Change Adaptation consistent with WMO's strategic objectives and priority areas. Major recent achievements of JICA includes projects in countries such as Bangladesh, Cambodia, and the Philippines. An outline of several on-going and forth-coming projects were also shared. He also informed the participants that JICA plans to repair the PAGASA Doppler radar in Guiuan, Eastern Samar, damaged by the typhoon Haiyan in 2013. He emphasized the importance of the role of NMHSs within the DRR framework in terms of their responsibility in the issuance of early warnings leading to effective emergency responses with better preparedness. The workshop recognized that sharing regional cooperative activities/projects under the WMO framework, including a workshop of this kind, with JICA would help to enhance synergies between such regional activities/projects and JICA's bilateral cooperation projects.

3. COUNTRY REPORTS FROM INVITED MEMBERS (Session 2)

Experts from nine NMHSs in South and Southeast Asia were invited to provide the workshop with a country report on the current status, challenges and future plans of their operational forecasting service for tropical cyclones and other associated severe weather using a template given in **Appendix III**.

3.1 Mr Sayeed CHOUDHURY (Bangladesh) presentation focused on the geographical reasons for his country's vulnerability to storm surges, past severe storm surge events, and overview of TC operational services of the Bangladesh Meteorological Department (BMD). The Bangladeshi coast is one of the world's most storm surge prone areas due to the combination of several factors such as the funnelling coastal configuration of the Bay of Bengal, high astronomical tides, and shallow bathymetry. Almost all the loss of lives and damage to property during tropical cyclone events were due to storm surges. Thus, monitoring and timely issuance of warnings for tropical cyclone warnings and associated storm surges are the most important responsibility of BMD. BMD issues TC forecasts utilizing available resources such as weather radar/satellite data and NWP guidance from

RSMC New Delhi. BMD needs the introduction of Advanced Dvorak Technique (ADT) and more advanced NWP deterministic and ensemble guidance into its operation. Currently, two storm surge models, IIT-D and MRI are operationally used. Under the Coastal Inundation Forecast Demonstration Project (CIFDP) in Bangladesh, more sophisticated storm surge early warning system including inundation forecasts are planned to be developed.

3.2 Mr Monichoth SOIM (Cambodia) provided an overview of the current weather forecasting system of Cambodia's Department of Meteorology (DOM). The main natural disasters associated with tropical cyclones in Cambodia are river and flash floods. Tropical cyclones also indirectly affect Cambodia with strong winds and heavy rainfall even when they do not make landfall. Currently, DOM does not have the capacity to issue TC forecasts and monitor TC movements and uses as a reference products of other centres such as RSMC Tokyo and the Hong Kong Observatory (HKO). It issues tropical cyclone warnings based on observed precipitation amounts in a text format. Sudden changes in TC intensity after landfall in Viet Nam also makes it difficult for DOM to provide timely TC information to the public. Further, capacity development not only in weather forecasting but also in telecommunication and equipment management and maintenance are necessary.

3.3 Mr Achmad Fachri RADJAB (Indonesia) presented an overview of the Indonesia Agency for Meteorology, Climatology, and Geophysics (BMKG). It started the operation of the Jakarta Tropical Cyclone Warning Centre (TCWC) in 2008 and since then has provided TC forecasts and warnings within its area of responsibility. TC genesis forecasts are issued with the cyclogenesis check sheet developed by the Bureau of Meteorology Australia (BoM). Although few TCs make landfall in Indonesia, they have indirect/remote impacts on Indonesian weather. TC intensity analysis for weak and/or early stage TCs are difficult. TC intensity analysis for TCs near borders between BMKG and BoM are coordinated through e-mail or telephone discussion. The responsibility for TC warnings/advisories is transferred to BoM with a message in a bulletin stating that it is the last bulletin from BMKG for a tropical cyclone.

3.4 Mr Vanhday DOUANGMALA (Lao PDR) gave a presentation on the current TC operational status and challenges of the Department of Meteorology (DMH). It monitors tropical depressions with a potential to develop into TSs using satellite imageries and forecast products of other centres such as RSMC Tokyo, HKO, KMA, and JTWC. DMH do not make their own TC analysis and forecasts. Instead they refer to those issued by the aforementioned centres. When a TS or greater exists in the western North Pacific, one of three categories of TC warnings is issued according to the longitudinal position of the system (e.g. *Urgent Warning* is issued when a TS or greater crosses 110° E westward). Heavy rain warnings and river flood warnings are also issued based on the expected amount of rainfall and water levels respectively. DMH still lack the capacity to do operational TC analysis and forecasting. Rainfall associated with TDs often cause floods in Lao PDR, and thus the enhancement of TD monitoring and warning capacity is required.

3.5 Mr Muhammad Helmi ABDULLAH (Malaysia) introduced the TC operational service of the Malaysian Meteorological Department (MMD). Due to its geographical position, Malaysia is relatively safe from direct tropical cyclone hit. Only two tropical cyclones, Tropical Storm Greg (Dec 1996) and Typhoon Vamei (Dec 2001), had made landfall in Malaysia. However, TCs are severe weather phenomena which could directly and indirectly cause substantial damage and loss of lives. MMD provides TC forecasts, on an adhoc basis, with reference to RSMCs and JTWC. JMA's storm surge and wave models are operationally used with the technical assistance of JMA. The MMD's Multi-Hazard Early Warning Centre monitors the development of tropical cyclones which could impact the weather and sea conditions in Malaysia and its territorial waters, using satellite imageries (MTSAT, FY2, ASCAT), weather charts and NWP products from RSMCs and JTWC. Advisories/Warnings are issued based on criteria prescribed in MMD's Standard Operating Procedure. MMD's TC warning/advisory consists of two categories, one for TDs and another for TS or greater.

Provision of TD information by RSMCs will be beneficial for MMD to monitor behaviour of TDs and issue the said warning/advisory. MMD participates in the WMO's SWIdget Project. MMD's warnings/advisories, for instance for heavy rain, strong winds, TCs and storm surges, are available through SWIdget.

3.6 Mr Kyaw Lwin Oo (Myanmar) presented the history of Myanmar's Department of Meteorology and Hydrology (DMH), its mandate and functions, recent disasters related with cyclones, observation network, human resources and facilities for cyclone monitoring. DMH monitors TC genesis using satellite imageries, deterministic NWP models such as ECMWF, NCEP, JMA, and outlooks of JTWC and RSMC New Delhi. Genesis Potential Parameter (GPP) provided by RSMC New Delhi is also useful. TC analysis and forecasts of DMH are mainly based on products of RSMCs, CIMSS, and JTWC. Ensemble forecasts of major centres including ECMWF are also available. Operational use of Dvorak analysis is needed to enhance expertise of forecasters. DMH's TC product is available only in text format. Color-coded cyclone warnings are updated 3 times per day, 4 to 6 times per day when a TC is approaching Myanmar's coast. RSMC New Delhi provides storm surge information, while DMH also runs a couple of storm surge models including the JMA's model. Since mass media is familiar with JTWC products, the public is sometimes confused with the difference between information from the RSMCs and those issued by JTWC. Information on TDs including those crossing the forecast boundaries of RSMCs are essential for DMH's TC monitoring activities.

3.7 Mr Prawit JAMPANYA (Thailand) provided an introduction on the TC operational services of the Thai Meteorological Department (TMD) including its challenges and future plans. TMD issues 3 day TC track and intensity forecasts based on deterministic and ensemble NWP models of major centres such as ECMWF, NCEP, JMA, KMA, NOGAPS, and UKMO, and RSMCs and JTWC forecasts. TC analysis is based on RSMCs and JTWC but remains a challenge, particularly for weak or strongly sheared TCs. A storm surge model is also run using initial data from JMA. Three warning categories, Emergency Warning, Warning, Advisory are used depending on pre-determined thresholds of meteorological variables such as maximum sustained winds, and rainfall amount. Nowadays, mass media can easily access the forecast products of other centres but the development of more easy-to-understand and user-friendly graphical products are still required. Better access to NWP products of major centres and further utilization of NWP products are necessary for TMD to improve the accuracy of its TC forecasts.

3.8 Mr Mario PALAFOX (the Philippines) presented the operational TC forecast and warning services of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). PAGASA monitors cloud clusters lasting more than a day and recognize such systems as potential TDs when NWP models predict their intensification. To enhance capacity in TC genesis prediction and analysis, development of criteria for TC genesis and further training on satellite analysis including Dvorak technique for weak TCs especially at night are necessary. PAGASA issues 3 day TC track forecasts based on analogue methods (persistence and climatology), NWP models (e.g. WRF and COSMO) run by own and/or from other centres (e.g. GSM, NAVGEM, and GFS). It however does not issue TC intensity forecasts as it remains a challenging task to forecasters. There are needs for capacity development on the utilization of NWP outputs. PAGASA's storm surge information is based on the JMA's storm surge model. Public Storm Warning Signals consisting of 4 levels, i.e., No. 1 to 4, are issued in accordance with expected surface wind intensity and lead times. For the timely dissemination of TC products to end-users, TC workstations as well as automatic dissemination systems are desired.

3.9 Mr Van Huong NGUYEN (Viet Nam) provided an overview of the current status of the tropical cyclone forecasting system at Viet Nam's National Hydro-meteorological Service (NCHMF). Dvorak techniques are operationally used for TC monitoring and analysis. TC forecasting methods at NCHMF are based on synoptic charts, satellite/radar images, and

NWP products derived from both deterministic and ensemble prediction systems of major centres (e.g., NCEP, ECMWF, JMA, DWD, and CMC). Final forecasting bulletin is issued by forecaster and broadcasted to natural disaster preventing and preparedness units of the Government, mass media, and the public. At present, the quality of TC forecast and warning at NCHMF only has small error for 24hrs lead time, but still large for higher lead times such as 48hrs and 72hrs. In addition, there are some gaps in forecasting correctly severe weather phenomena associated with TCs such as wind-gust, heavy rainfall, storm surge and flash flood. NHCMF needs training of forecasters particularly on the interpretation of NWP products, as well as the development of standard TC forecasting procedures and high-resolution (2-5 km) regional models to capture thermo-dynamical characteristics of TCs. Early warning and prediction capacity for TC genesis and rapid intensification are also needed. Three storm surge models (JMA, CTS, and Delfd3D) are available at NHCMF. Easy-to-understand bulletins without too much technical/meteorological terms and better forecasts with longer lead times are always requested by the public and relevant disaster management authorities.

4. Tropical Cyclogenesis Monitoring/Prediction (Session 3)

4.1 Mr Mikio UENO, Senior Forecaster, Forecast Division of Forecast Department of JMA, introduced the activities of RSMC Tokyo for Typhoon Committee Members followed by an overview on the Early Dvorak Analysis (EDA) developed by RSMC Tokyo for analysis of developing TCs, an independent technique of the conventional Dvorak technique. RSMC Tokyo operates the Numerical Typhoon Prediction Website (NTP website) providing Dvorak and EDA results, deterministic TC guidance derived from major NWP centres, storm surge forecasts to the Typhoon Committee Members. EDA based T-number (0.0 to 2.0), with EIR imageries, for Organized Convective Cloud Systems (OCCSs) corresponds to possibilities of their developing into TSs. TC genesis and analysis of TDs by RSMC Tokyo are based on satellite data including ASCAT and OSCAT, EDA, and deterministic NWP models from major centres. Updated verification results of EDA would be beneficial for users.

4.2 Dr Munehiko YAMAGUCHI, Researcher of Meteorological Research Institute (MRI) of JMA, provided recent research progress on the evaluation of tropical cyclone genesis prediction on the medium-range timescale using the TIGGE data, under the North Western Pacific Tropical Cyclone Ensemble Forecast Project (NWP-TCEFP). The results show that the ensemble predictions from ECMWF, JMA, NCEP and UKMO have high skill in predicting TC activity over the western North Pacific with a lead time of up to 6 to 9 days. Moreover multi-center grand ensemble (MCGE) is found to possess a larger brier skill score than that of the best single-model ensemble. Regarding recent severe, high-impact TCs including Hurricane Sandy (2012), Cyclones Phailin (2013) and Nargis (2008), and Typhoon Haiyan (2013), MCGE predicted their landfall with high-confidence at least 5 days before the landfall. Such TC genesis prediction could be beneficial particularly to Members in lower latitudes who are often affected by TCs which develop very near the coast. Evaluation with smaller forecasting domains is encouraged for future works toward operational use. Dr Yamaguchi also mentioned benefits of MCGE forecasts, stressing that additional information on the uncertainty of TC forecasts provided by MCGE products gives forecasters the necessary level of confidence. It is an important role of forecasters to interpret ensemble products in easy to understand terms for users to be able to understand their meaning and respond appropriately.

4.3 Mr Edward FUKADA, Technical Adviser, JTWC, provided an overview of JTWC operations and details of the centre's tropical cyclone genesis monitoring procedures. JTWC operationally monitors the tropical Pacific and Indian Ocean for tropical cyclone development through the use of data provided via water vapour imageries of MET-7, MTSAT, and GOES, 12 hourly manual streamline analysis at 200 hPa and surface levels, and NWP fields of GFS, NAVGEM, and GSM. Additionally, data available from CIMSS (http://tropic.ssec.wisc.edu/)

and RAMMB (http://rammb.cira.colostate.edu/products/tc_realtime/) are used via the ATCF workstation to diagnose synoptic scale environment, and TC structure and its change respectively. For monitoring microwave data, FNMOC Satellite Data Tropical Cyclone Page (https://www.fnmoc.navy.mil/tcweb/cgi-bin/tc_home.cgi) and NRL Tropical Cyclone Page (http://www.nrlmry.navy.mil/TC.html) are also used. It was noted that “fixing” (DVORAK method position and intensity determination) on weak TCs can be difficult, and that numerical TC forecasts of GFS and NAVGEM using TC initialization input (positions, intensities and structure) from JTWC for weak TCs can be less accurate due to the poorly defined cloud pattern and weak convection. JTWC forecasters issue TC genesis information with comprehensive analysis of those data, taking into account operational aspects helping the U.S. Gov. to be ready for TC formation in a timely manner. To increase the objectivity in genesis forecast procedures, JTWC developed a worksheet which calculates Low/Medium/High development probabilities using LLCC symmetry, 850 hPa vorticity, Dvorak T number, global model developments, MJO OLR anomaly, vertical wind shear, upper level outflow pattern, and warm core temperature anomaly. Worksheet development is documented in Kucas et al. 2012.

4.4 Dr Lixion AVILA, Senior Hurricane Specialist of National Hurricane Centre (NHC) presented an overview of the activities of RSMC Miami and Tropical Weather Outlook (TWO). RSMC Miami operated by NHC is responsible for coordinating all the tropical cyclone watching and warnings from Africa to 140 W. The Hurricane Specialist Unit is in charge of developing, coordinating and issuing TC warnings, forecasts, and outlooks in text and graphical formats during the hurricane season. The Unit also conducts extensive outreach and public awareness programmes and undertakes applied research during off-season period. NHC issues various kinds of text and graphical products such as advisories, wind speed probabilities, forecast discussion. Storm surge warning, 7-day TC forecasts, watches and warnings before TC formation, and track and intensity forecasts for tropical disturbances are under development as future operational products. Since 2013, NHC has issued 5-day TWO including its outlook on TC formation during the next 48 hours and the entire 5 days. TWO primarily depends on deterministic global models, while ensemble guidance also often shows more consistency. GFS and ECMWF have greatest skills in TC genesis and their consensus has a low false alarm rate. Model performance is likely to have geographical biases and better skills when large-scale influences are the dominant TC genesis mechanism. TWO depends on the models and are still subjective. Forecasters are required to learn the model’s performance which could change annually every season. Users including the media are getting more interested in outlook on TC genesis as GFS is available on the Internet.

5. Tropical Cyclone Intensity Analysis (Session 4)

5.1 Mr Derek WROE, Hurricane Specialist, Central Pacific Hurricane Centre of NWS, gave an overview of the current operational techniques for TC analysis. Comprehensive and reliable analyses of tropical cyclones and their surrounding environment are the basis for TC forecasts. Satellite remote sensing plays an integral role in TC analysis, and forecasters need to develop an understanding of the capabilities and limitations of both geostationary and polar orbiting satellite data. The Dvorak Technique continues to provide effective analyses of tropical cyclone intensity and has remained virtually unchanged for 30 years. To reduce errors of TC intensity, forecasters have to bear in mind the importance of following the rules on the flowchart and reanalysis as a better option than breaking constraints. Differences in application of the technique between Members could sometimes result in TC intensity discrepancies. For instance, the Dvorak technique is applied to TCs over land neither by NWS nor by JTWC, while RSMC Tokyo applies the technique, if applicable, to TCs over land using adjusted CI-number rules it had developed. Difference in averaging periods for maximum sustained winds (MSWs) and conversion tables from CI-number into central pressures/MSWs could also be causes of such discrepancies.

5.2 Mr WROE also introduced the Advanced Dvorak Technique (ADT) and the use of microwave data for TC analysis. Striving to remove human subjectivity from the Dvorak technique, ADT, an automated algorithm that is patterned after the traditional Dvorak Technique, has been developed. ADT uses automated center finding in stronger systems while it uses those in weaker systems determined by NHC, JTWC, or CPHC. Microwave data are also used in developing systems, for instance, to search for developing eye structure under dense overcast. ADT still struggles with weak systems though its overall performance is being improved. In recent years, polar orbiting satellite data, particularly microwave data, have provided additional information regarding details on tropical cyclone structure and intensity. TC intensity derived from warm cores estimated AMSU are available on the CIMSS and CIRA website. SATllite CONsensus (SATCON), an ensemble estimate of TC intensity derived from CIMSS AMSU and ADT and CIRA AMSU with statistically determined weighting scheme to consider the strengths and weaknesses of each method, is also available on the CIMSS website.

5.3 Mr Ryo OYAMA, Researcher of MRI, introduced two methods for estimating tropical cyclone (TC) intensity based on satellite microwave observations, which were developed by the Meteorological Research Institute of JMA. One is for estimating TC maximum sustained wind (MSW) using brightness temperature (TB) observed by TRMM Microwave Imager (TMI), which represents ice/liquid rain and sea foams induced by winds. The other is for estimating TC minimum sea level pressure (MSLP) from TC warm core intensity which is derived from TBs observed by the Advanced Microwave Sounding Unit-A (AMSU-A) of NOAA and METOP satellites. The MSW and MSLP are estimated by using regression equations in reference to the best-track data. These two methods support TC intensity analysis at the RSMC Tokyo - Typhoon Centre, particularly when in situ observations are not available and TC intensity estimation error by Dvorak technique is relatively large. It was noted that such products would be helpful for other Members if available operationally. Details on the two methods will be published as RSMC Tokyo Technical Review in 2014.

5.3 Mr Yasushi IZUMIKAWA, Senior Scientific Officer, Satellite Program Division of JMA, introduced the JMA’s next generation meteorological satellites, Himawari-8/9. Himawari-8 will be launched in 2014 and start its operation in 2015 as a replacement for MTSAT-2. Himawari-9 will also be launched in 2016 as a backup and a successor satellite of Himawari-8. Both satellites with 16 bands will be located at around 140 degrees east, and will continue to observe the East Asia and Western Pacific regions for a period of 15 years. Three of these will be visible channels corresponding to red, green and blue to enable the creation of true colour images. Observation frequency will also be enhanced, with full disk imagery obtained every 10 minutes. In addition, rapid scanning will be conducted in several regions, one of which will be for targeted observation of tropical cyclones. All imagery derived from the satellites will be distributed via the Internet. JMA will also disseminate a primary data set of imagery for operational meteorological services, compatible with the current MTSAT data, as well as NWP products, surface observations, and ASCAT in SATAID format, via a communication satellite for users with limited Internet access. JMA tentatively plans to begin this service early in 2015 in parallel with the direct dissemination of imagery of MTSAT-2 via MTSAT-1R which will be terminated after the successful transition to Himawari-8.

6. Tropical Cyclone Track & Intensity Forecasting (Session 5)

6.1 Mr Masayuki NAKAGAWA, Senior Forecaster, Numerical Prediction Division of JMA presented recent progress in JMA’s NWP developments and contribution to the Working Group on Numerical Experimentation (WGNE). JMA upgraded its operational ensemble prediction systems (EPSs), namely One-week EPS (WEPS) and Typhoon EPS

(TEPS), and its operational deterministic global model (Global Spectral Model, GSM) in February and March 2014. The upgrade of the EPSs includes (i) enhancement of the resolution of the forecast model from TL319L60 to TL479L60 for the both EPSs, (ii) increase of the operation frequency from once to twice a day and the total daily ensemble size from 51 to 54 (from 51/initial to 27/initial) for WEPS, and (iii) increase of the ensemble size from 11 to 25 for TEPS. The upgrade of GSM includes enhancement of the number of the vertical layers from 60 to 100, raise of the model top level from 0.1hPa to 0.01hPa and revision of the several physical processes. At the same time, the assimilation of AMSU-A channel 14 and ground-based GNSS-ZTD (Zenith Total Delay) data were started, and GNSS RO (Radio Occultation) assimilation was revised from refractivity assimilation up to 30 km AMSL to bending angle assimilation up to 60 km AMSL in its global assimilation system. The results of the experiments for these upgrades on GSM show a positive impact on the forecast skill including its typhoon (track and intensity) forecast. WGNE, jointly established by WCRP and CAS, fosters the open exchange of information in a competitive NWP environment. JMA contributes to TC verification of WGNE by collecting forecast data from participating NWP centres, verifying TC track forecasts and reporting the verification results at the WGNE meeting every year. The results of TC verification show remarkable improvements of the operational Global NWP models in all the participating centres year by year, while TC intensity forecasts remain challenging mainly because of inadequate observations, resolutions and understanding physical process. It was noted that guidance of GSM will be helpful in the North Atlantic.

6.2 Mr FUKADA presented JTWC operational process for TC forecasting. JTWC mainly relies on the JTWC consensus forecast track aid, CONW, computed by averaging five global models, three mesoscale models, and two ensemble models. CONW overall outperforms any of those of 10 models used. JTWC updates operational track forecast ensuring reasoning for all decisions. Stressed was importance of carefully reviewing numerical model outputs along with previous forecasts in consideration with the consistency with previous forecasts. As for its intensity forecasts, JTWC reviews streamline analysis, synoptic patterns and phase change along numerical track forecasts, water vapour loop for monitoring upper tropospheric patterns, and statistical-dynamical and dynamical models (ST5D, SHIPS, S5XX, S5YY, and LGEM (since 2014)). Advantages and disadvantages of LGEM are explained (e.g., LGEM better responds to rapid intensification than SHIPS). ATCF provides contributions of individual predictors of SHIPS to TC intensity changes which help operational forecasters identify important factors for TC intensity forecasts. Rapid intensification (RI) prediction was also introduced with reference to an actual RI case. Dual channel outflow is a key factor of RI in many cases. RI index provide probabilities of RI with large-scale characteristics such as ocean heat contents, 200 hPa divergence, 850 hPa relative vorticity.

6.3 Dr AVILA gave an overview of the track and intensity forecasts issued by the NHC. For all operationally designated tropical or subtropical cyclones in the Atlantic and eastern North Pacific basins, NHC issues an “official” forecast of the cyclone’s center location and maximum 1-min surface wind speed. Primary dynamical models used at NHC are GFS, ECMWF, UKMET, CMC, GFDL, and HWRF. While consensus models such as TVCN and FSSE are as skilful as official forecasts, forecasters sometimes have to carefully verify and exclude certain models to make selective consensus when NWP guidance diverges. Maximum surface winds converted from flight level winds, GPS dropsondes and SFMR observations are obtained with aircraft reconnaissance when TCs have potential to affect lands. Important factors affecting TC intensity including SST/OHC, vertical wind shear, trough interactions, eyewall replacement, and temperature and moisture patterns in the storm environment were also explained. For TC intensity forecasts, statistical-dynamical models (SHIPS, DSHIPS, LGEM) and dynamical models (HWRF, GFDL, GFS, UKMET, NOGAPS, and ECMWF), as well as consensus models such as ICON are operationally available at NHC. The lecture was followed by a practical exercise on how TC advisories are produced. Using an actual TC case but virtually named “Nanette”, all participants experienced operational procedures at NHC one by one. At the end of exercise, they also practiced how to write a public advisory keeping in mind explicit and succinct descriptions on latest TC forecasts, putting emphasis on providing appropriate scientific evidences.

7. Effective Early Warning: Lessons Learnt from past TC Disasters(Session 6)

7.1 Mr Yosuke IGARASHI, Senior Forecaster of JMA, presented an overview of the warning system in Japan based on the lessons learnt from past TC disasters. In 2004, 10 named TCs hit Japan, resulting in more than 200 dead and missing. At that time, most municipalities did not have pre-determined specific criteria for evacuation order, and therefore mayors had difficulty in making appropriate decision for people to evacuate. The lessons learnt in 2004 were 1) warnings should be issued to each municipality, 2) warning criteria should be linked with those for emergency responses including evacuation order of municipalities. Through technical developments including Quantitative Precipitation Estimation/Forecast (QPE/QPF) and disaster related indices, JMA started the issuance of warnings at municipality level across the nation in 2010. As of 2012, more than half of municipalities have developed criteria for emergency responses for flood, storm surges, and sediment disasters. Mr Igarashi also introduced Typhoon Talas in 2011 which conveyed record-breaking accumulative rainfall to Kii Peninsula of Japan. Although the risks of landslides increased drastically due to continued heavy rainfall after the issuance of the JMA's warning, there were no effective ways to communicate with the residents, such catastrophic situations that we had never faced. Based on this lesson, since 2013, JMA has operated Emergency Warning to be issued when situations are expected to be as catastrophic as that of the worst of half a century. Stressed was the importance of continued efforts to improve warning systems according to lessons learnt from past disasters for the development of effective warnings.

7.2 Mr Nadao KOHNO, Group Leader, Office of Marine Prediction of JMA, presented JMA's international cooperation for more effective storm surge forecasts in Southeast Asia. The western North Pacific is one of the most active regions for tropical cyclones, and storm surges sometimes cause severe storm surge disasters. Thus, storm surge information is crucial for TC disaster managements, and JMA has started to issue storm surge products to the Typhoon Committee Members recently. The products will be further enhanced through, for instance, improvements in graphical display and forecast accuracies, and increase in time-series forecasting points. JMA is also cooperating in the implementation of the Coastal Inundation Forecast Demonstration Project (CIFDP) in Bangladesh. PAGASA's response to Haiyan was also introduced as one of the successful examples of JMA's technology transfer of its storm surge model.

7.3 Mr Renito PACIENTE, Assistant Weather Service Chief of PAGASA, reviewed the response to Haiyan by the Philippine Government including that of PAGASA and shared the lessons learnt from the event. It is worth noting that the track of Haiyan was well predicted. PAGASA started issued a Typhoon Bulletin even though Haiyan was still outside the Philippine Area of Responsibility. From 6 to 9 November 2013, PAGASA also conducted press conferences/briefings every six hours. When Haiyan was approaching the Philippines, the public paid more attention to the winds of the typhoon rather than to announcements of potential storm surges. The public were also not sufficiently aware of the destructive effects of storm surges. The Visayas area had in the past experienced the passage of strong typhoons which caused significant storm surge damage but not on a scale like those caused by Haiyan. Inspite of relatively well-informed local emergency managers on the phenomenon of storm surges they still faced difficulties in evacuating local residents to safe areas as the surge went farther inland than expected. This event brought forth, the importance of hazard/vulnerability/risks maps, annual drills, construction of storm surge barriers and emergency evacuation centres and ensuring the timely evacuation of local residents.

7.4 Viet Nam also provided its response to Haiyan and stressed the importance of early warning system for timely and appropriate emergency responses. Its NHMS enhanced its operational service by providing more frequent updated information on Haiyan once the typhoon was expected to make landfall in Viet Nam. All socio-political system from national levels (prime minister directly controlled all activities related to Haiyan) to local levels fully worked on disaster prevention/mitigation and emergency response. Also, all media outlets (television, paper, internet, social networks, etc.) provided up-to-date information on Haiyan from the NHMS, enabling emergency managers to make their decisions based on the latest forecast bulletins (e.g., evacuation advisories/orders were updated accordingly to change in movement of Haiyan).

7.5 Mr Jamie RHOME, Storm Surge Specialist/Lead of NHC, reviewed lessons learnt from recent hurricane disasters, and gave an overview of new graphic products and associated outreach activities aimed at improving storm surge communication. Hurricanes such as Katrina, Ike, and more recently Isaac and Sandy, have shown that communicating the storm surge hazard remains a challenge. Some people continue to put an unbalanced emphasis on the wind hazard and therefore are not sufficiently equipped to make sound decisions regarding preparation and evacuation ahead of an approaching storm. Social science research has repeatedly shown that the hesitation to prepare and evacuate from storm surge stems from a person's lack of understanding of what storm surge is, their inability to personalize the hazard, and an inability to understand that storm surge could occur where they live. Even in a more experienced location like southeastern Louisiana, some people were surprised when storm surge from Isaac flooded areas that remained dry during Katrina. To address these issues, the NHC has been working with social science researchers from disciplines such as sociology, communications, and geography to engage its users and partners to determine the best path forward. The social science research concluded that the implementation of a high-resolution storm surge inundation graphic was supported overwhelmingly by the emergency management and broadcast meteorologist communities, and that this new graphic would have great potential to increase the understanding and awareness of, and response to, the storm surge hazard. The National Hurricane Centre will commence a new experimental storm surge inundation graphic during the 2014 hurricane season. To address storm surges, particularly born in mind are 1) the importance of incorporation of social sciences, 2) clear/consistent communication, and 3) use of non-technical terms with consistent definitions and frames of reference to communicate with users.

8. Summary of the Workshop

The workshop clearly indicated that exchanging views on operational techniques, regional activities, and forecasting issues among weather services in the region are not only beneficial to the Members themselves but more especially to help the RSMC further enhance its service to the region. Furthermore, for JMA to effectively support Members, close cooperation between the agency and JICA in enhancing the synergies of bilateral activities with that of WMO is encouraged. The outcomes of the workshop are summarized below.

TC Genesis Monitoring & Prediction

- All members in Southeast and South Asia monitor TC genesis using meteorological satellites and NWP data. Only BMKG issues TC genesis information using the check sheet developed by BoM, Australia for TC genesis prediction. PAGASA monitors cloud clusters lasting one day within Low Pressure Areas, but there are no specific criteria developed for TC genesis information. TMD tries to acquire EDA, but it is still not successful.

- It would be beneficial to all the Members to enhance the capacity of RSMCs to issue probabilistic TC genesis information with longer lead times. Provision of more training opportunities on EDA is also helpful. Verification results of TC genesis information including EDA are also useful for their operations.

TD Monitoring and Analysis

- Southeast and South Asia is often severely affected by TDs and associated heavy rainfall. Some Members need adequate TD information from RSMCs for their monitoring and issuance of TD information.

- To increase their warning capacities for TDs, the enhancement of weather radar techniques, such as creation of radar composite maps and QPE/QPF products, is vital. More effective regional cooperative activities, including technology transfer of those techniques and the promotion of radar data exchanges, are also encouraged.

TC Analysis

- About half of the countries represented at the workshop (Indonesia, Myanmar, the Philippines and Viet Nam) operationally use Dvorak techniques for TC analysis. Satellite TC analysis is difficult particularly for weak TCs and/or at night. Almost all Members refer to TC intensity products of other centres such as RSMCs and JTWC for their TC intensity information.

- More training opportunities on TC analysis, including the Dvorak technique and microwave interpretation is needed. The enhancement of TC intensity related products from RSMCs, including TC intensity estimation with microwave data, will help the Member’s TC intensity analysis.

- Provision of technical guidance on the JMA’s next generation satellites, Himawari-8/9, is very important to ensure the Member's smooth transition to Himawari-8/9.

TC Forecast

- Most members issue their own TC track and/or intensity forecasts based on NWP products from other centres with reference to both RSMCs and JTWC forecasts, while some Members do not. TC forecasting capacities of the Members largely differ, mainly depending on the availability of NWP products, TC information processing systems, and skills of their forecasters.

- Enhancement of forecasting capacity for remote/indirect impacts of TCs which often cause severe damages to the Members is also necessary.

- To further enhance forecaster's skills in TC forecasts, an increase in training opportunity (e.g. RSMC training) as well as the enhancement of training materials on TC forecasts is encouraged. Also, RSMC’s provision of more forecast supporting products, including real-time deterministic/ensemble NWP guidance/products, is required.

Storm Surge Forecasts

- Many Members issue storm surge forecasts based on storm surge models such as the JMA’s storm surge model. Under SSWS, RSMCs New Deli and Tokyo also issue storm surge products which continue to be further enhanced for the Members.

- Provision of more opportunities on training on storm surge forecasts including technology transfer of the JMA's storm surge model is encouraged.

- For ordinary people, it tends to be difficult to understand the risk of storm surges. For easy-to-understand information, more practical one such as inundation information will be desirable. Development of storm surge forecasts with risks of inundation is encouraged.

Effective Warnings

- Roles and responsibilities of NMHSs and warning capacities differ by country. However, all the members have responsibilities for warnings for TCs, heavy rains, strong winds, and storm surges while about half of them have ones for floods.

- Almost all the members set the same warning criteria across the nation without due consideration with regional characteristics and coordination with relevant disaster management authorities. Also, accurate, timely, and easy-to-understand warning messages in both text/graphical formats are requested by media and emergency managers.

- Sharing, through training and/or workshop, lessons learnt, best practices and know-how on development of warning messages and coordination for setting warning criteria should be promoted in the region.

LIST OF APPENDICES

APPENDIX I	List of Participants
APPENDIX II	Programme
APPENDIX III	Country Report Template

APPENDIX I

LIST OF PARTICIPANTS

1. INVITED PARTICIPANTS

WMO

Ms. Nanette LOMARDA
Senior Scientific Officer
World Weather Research Division, Research Department
World Meteorological Organization, 7bis, avenue de la Paix, Case postale No. 2300, CH-1211 Geneva 2

Tel.: +41-22-730-83-84
Fax:

Email: nlomarda@wmo.int

WMO

Dr. Tetsuo Nakazawa
Chief
World Weather Research Division
Research Department
World Meteorological Organization, 7bis, avenue de la Paix, Case postale No. 2300, CH-1211 Geneva 2

Tel.:
Fax:

Email: tnakazawa@wmo.int

NWS/NOAA (Lecturer)

Dr. Lixion AVILA
Senior Hurricane Specialist
National Hurricane Center
National Weather Service, NOAA
11691 SW 17th Street
MIAMI, FL 33165
USA

Tel.: +1-305-229-4410
Fax:

Email: lixion.a.avila@noaa.gov

NWS/NOAA (Lecturer)

Dr. Jamie RHOME
Storm Surge Term Lead
National Hurricane Center
National Weather Service, NOAA
11691 SW 17th Street
MIAMI, FL 33165
USA

Tel.: +1-305-229-4444
Fax:

Email: jamie.r.rhome@noaa.gov

NWS/NOAA (Lecturer)

Mr. Derek WROE
Hurricane Specialist
Central Pacific Hurricane Center
National Weather Service, NOAA
2525 Correa Rd., Suite 250
HONOLULU, HI 96822
USA

Tel.: +1-808-973-5280
Fax: +1- 808-973-5281

Email: derek.wroe@noaa.gov

JTWC (Lecturer)

Mr. Edward M. FUKADA
Technical Adviser

Tel.: +1-808-474-5305
Fax: +1-808-471-4581

APPENDIX I

Joint Typhoon Warning Center
425 Luapele Road
Pearl Harbor, HI 96860
USA

Email: edward.fukada@navy.mil

JICA

Mr. Kota KATSUMATA
Disaster Management Division 1
Global Environment Department, JICA
Japan International Cooperation Agency
1-6th floor, Nibancho Center Building 5-25,
Niban-cho, Chiyoda-ku, Tokyo 102-8012,
Japan

Tel.: +81-3-5226-9577
Fax: +81-3-5226-6343

Email: Katsumata.Kota@jica.go.jp

JICA

Ms. Ruri HIDANO
Deputy Assistant Director
Economic Infrastructure Development and
Environment, Tokyo International Center,
Japan International Cooperation Agency
49-5, Nishihara 2-chome, Shibuya-ku, Tokyo
151-0066, Japan

Tel.: +81-3-3485-7075
Fax: +81-3-3485-7904

Email: Hidano.Ruri@jica.go.jp

JICA

Mr. Kunio AKATSU
Adviser
Global Environment Department
Japan International Cooperation Agency
1-6th floor, Nibancho Center Building 5-25,
Niban-cho, Chiyoda-ku, Tokyo 102-8012,
Japan

Tel.: +81-3-5226-9568
Fax:

Email: Akatsu-Kunio@jica.go.jp

BMD

Mr. Sayeed CHOUDHURY
Meteorologist, Sylhet Dependent
Meteorological office
Bangladesh Meteorological Department
Agargaon, Dhaka-1207
Bangladesh

Tel.: +88-0821-727438
Fax: +88-02-8118230

Email: sayeed1965@hotmail.com

BMD

Ms. Kawsar PARVIN
Meteorologist
Bangladesh Meteorological Department
Agargaon, Dhaka-1207
Bangladesh

Tel.: +88-02-9123838
Fax: +88-02-8118230

Email: Kawsar_pervin@yahoo.com

DOM

Mr. Monichoth SOIM
Duputy Director
Department of Meteorology

Tel.: +855-11-274-458
Fax: +855-23-213-490

#364 Monivong Bvld, Chamkarmorn,
PHNOM PENH
Cambodia

Email: monichoth@gmail.com

DOM

Mr. Soknara SAM OEURN
Chief of Administrative Office
Department of Meteorology
#364 Monivong BVD.
PHNOM PENH
Cambodia

Tel.: +855-23-725-989
Fax: +855-23-426-345
Email: samnaranara@yahoo.com

BMKG

Mr. Riris ADRIYANTO
Head of Division for Remote Sensing
(Rader&Satellite) Data Management
Indonesian Agency for Meteorology
Climatology and Geophysics(BMKG). Jl.
Angkasa I No. 2 Kemayoran, Jakarta 10720
Indonesia

Tel.: +62-21-4246321
Fax: +62-21-4246703
Email: ririsadriyanto@yahoo.com,
riris.adriyanto@gmail.com

BMKG

Mr. Achmad Fachri RADJAB
Head of Tropical Cyclone Sub Division
Indonesian Agency for Meteorology
Climatology and Geophysics(BMKG). Jl.
Angkasa I No. 2 Kemayoran, Jakarta 10720
Indonesia

Tel.: +62-21-6546315
Fax: +62-21-6546314
Email: fachriradjab@yahoo.com,
fachri.radjab@bmkg.go.id

DMH

Mr. Vanhdy DOUANGMALA
Head of Weather Forecasting and
Aeronautical Division
Department of Meteorology and Hydrology
Akarth village
Souphanouvong avenue
Sikhottabong district, Vientiane Capital
Lao PDR

Tel.: +856-21-215010
Tel.: +856-21-263657
Fax: +856-21-223446
Email: Vanhdy_dml@yahoo.com

DMH

Ms. Phetsakhone MISOMPHANE
Deputy Chief of Weather Forecast Unit
Department of Meteorology and Hydrology
Akarth village
Souphanouvong avenue
Sikhottabong district, Vientiane Capital
Lao PDR

Tel.: +856-21-215010
Tel.: +856-21-263657
Fax: +856-21-223446
Email: pmisomphane@yahoo.com

MMD

Mr. Muhammad Helmi ABDULLAH
Director of National Weather Centre

Tel.: +60-3-79678118
Fax: +60-3-79578052

Malaysian Meteorological Department
Jalan Sultan, 46667 Petaling Jaya, Selangor
Malaysia
Email: helmi@met.gov.my

MMD

Mr. Abd Malik TUSSIN
Director of Sabah Meteorological Office
Malaysian Meteorological Department
7th Floor, Wisma Dang Bandang,
Locked Bag 54, 88995 Kota Kinabalu, Sabah
Malaysia
Tel.: +60-88-256054
Fax: +60-88-211019
Email: malik@met.gov.my

DMH

Ms. May Khin Chaw
Deputy Director
Department of Meteorology and Hydrology
Office No. 5, Ministry of Transport,
Nay Pyi Taw
Myanmar
Tel.: +95-1-661684
Tel.: +95-9250-190161
Fax: +95-1-662808
Email: mkhinc@gmail.com

DMH

Mr. Kyaw Lwin Oo
Deputy Director
Department of Meteorology and Hydrology
Office No. 5, Ministry of Transport,
Nay Pyi Taw
Myanmar
Tel.: +95-67-411527
Tel.: (Mobile)+95-950-66182
Fax: +95-67-411527
Email: kyawlwinoo5@gmail.com

TMD

Mr. Prawit JAMPANYA
Director
Weather Forecast Bureau
Thai Meteorological Department
4353 Sukhumvit Rd.,
Bang-Na, BANGKOK 10260
Thailand
Tel.: +662-398-9830
Fax: +662-398-9836
Email: jampanya@tmd.go.th

TMD

Mr. Chukiat THAIJARATSATIAN
Senior meteorologist
Weather Forecast Bureau
Thai Meteorological Department
4353 Sukhumvit Rd.,
Bang-Na, BANGKOK 10260
Thailand
Tel.: +662-398-9830
Fax: +662-398-9836
Email: tan_1t2002@yahoo.com

PAGASA

Mr. Renito PACIENTE
Assistant Weather Services Chief
Weather Division
Philippine Atmospheric, Geophysical and
Tel.: +632-927-1541
Fax: +632-926-4258
Email: renito.paciente@yahoo.com

Astronomical Services Administration
Agham Road, Diliman
Quezon City 1101
Philippines

PAGASA

Mr. Mario PALAFOX
Senior Weather Specialist
Weather Division
Assistant Weather Services Chief
Philippine Atmospheric, Geophysical and Astronomical Services Administration
Agham Road, Diliman
Quezon City 1101
Philippines

Tel.: +632-927-1541
Fax: +632-926-4258

Email: maryopalafox@hotmail.com

NHMS

Mr. Van Hoa VO
Deputy Director, Central Hydro-meteorological Forecasting Center
National Hydro-Meteorological Service of Viet Nam
No. 4 Dang Thai Than street, Hoan Kiem district, Ha Noi
Viet Nam

Tel.: +84-4-3933-1681
Fax: +84-4-3824-4921

Email: Vovanhoa@nchmf.gov.vn
vovanhoa80@yahoo.com

NHMS

Mr. Van Huong NGUYEN
Deputy Chief, Short Range Meteorological Forecasting Division, Central Hydro-Meteorological Forecasting Center
National Hydro-Meteorological Service of Viet Nam
No. 4 Dang Thai Than street, Hoan Kiem district, Ha Noi
Viet Nam

Tel.: +84-4-3824-7002
Fax: +84-4-3825-4278

Email: nvhuonghanngan@gmail.com

2. JMA's PARTICIPANTS

Office of International Affairs

Mr. Yuki Honda
Senior Scientific Officer, Office of International Affairs, Administration Department
Email: honda.yuuki@met.kishou.go.jp

Mr. Takuya Hosomi
Senior Scientific Officer, Office of International Affairs, Administration Department
Email: hosomi@met.kishou.go.jp

Forecast Department

Mr. Yuichi Yamakoshi
Senior Scientific Officer, Administration Division, Forecast Department
Email: y-yamakoshi@met.kishou.go.jp

APPENDIX I

Mr. Yosuke Igarashi
Senior Forecaster, Office of Weather Disaster Mitigation, Forecast Division, Forecast Department
Email: yosuke.igarashi@met.kishou.go.jp

Mr. Tsukasa Fujita
Head, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: fujita.tsukasa@met.kishou.go.jp

Mr. Masaru Sasaki
Senior Forecaster, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: m.sasaki@met.kishou.go.jp

Mr. Nobuhide Nonaka
Senior Scientific Officer, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: nobuhide.nonaka-a@met.kishou.go.jp

Mr. Mikio Ueno
Senior Forecaster, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: wueno@met.kishou.go.jp

Mr. Masami Narita
Senior Forecaster, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: m_narita@met.kishou.go.jp

Mr. Kazuhiko Nagata
Senior Scientific Officer, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: k.nagata@met.kishou.go.jp

Mr. Naohisa Koide
Senior Scientific Officer, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: koide-n@met.kishou.go.jp

Mr. Koji Kato
Scientific Officer, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: k-katou@met.kishou.go.jp

Ms. Atsuko Mikami
Assistant Scientific Officer, Tokyo Typhoon Center, Forecast Division, Forecast Department
Email: atsuko_mikami@met.kishou.go.jp

Mr. Masayuki Nakagawa
Senior Forecaster, Numerical Prediction Division, Forecast Department
Email: m-nakagawa@met.kishou.go.jp

Mr. Kenji Tsunoda
Senior Scientific Officer, Numerical Prediction Division, Forecast Department
Email: tsunoda@met.kishou.go.jp

Observation Department
Mr. Yoshiro Tanaka
Senior Scientific Officer, Administration Division, Observation Department
Email: yoshiro.tanaka@met.kishou.go.jp

Mr. Yasushi Izumikawa
Senior Scientific Officer, Satellite Program Division, Observation Department
Email: y-izumikawa@met.kishou.go.jp

APPENDIX I

Global Environment and Marine Department
Mr. Nadao Kohno
Group Leader for Marine Modeling, Office of Marine Prediction, Marine Division, Global Environment and Marine Department
Email: nkono@met.kishou.go.jp

Typhoon Research Department/ MRI
Dr. Akiyoshi Wada
Senior Researcher, The first laboratory, Typhoon Research Department
Email: awada@mri-jma.go.jp

Dr. Munehiko Yamaguchi
Researcher, The first laboratory, Typhoon Research Department
Email: myamagu@mri-jma.go.jp

Dr. Naoko Kitabatake
Head, The second laboratory, Typhoon Research Department
Email: nkitabat@mri-jma.go.jp

Mr. Ryo Oyama
Researcher, The second laboratory, Typhoon Research Department
Email: royama@mri-jma.go.jp

Mr. Tomoaki Sakuragi
Researcher, The second laboratory, Typhoon Research Department
Email: sakuragi@mri-jma.go.jp

Mr. Udai Shimada
Researcher, The second laboratory, Typhoon Research Department
Email: ushimada@mri-jma.go.jp

APPENDIX II

JMA/WMO Workshop on
Effective Tropical Cyclone Warning in Southeast Asia
Tokyo, Japan, 11-14 March 2014

The objectives of the Workshop

- To promote understanding of participating countries on the latest tropical cyclone analysis/forecasting techniques and products.
- To identify challenges of those countries in improving their operational forecasting and warning services.
- To discuss ways to address the challenges including external assistance.

Programme

Time	***Item***	***Presenter***
Day 1, Tuesday 11 March		
9:00 - 10:00	**Opening (Chair: Mr FUJITA)**	
9:00 - 9:10	Welcome address	Dr Hatori Director-General (JMA)
9:10 - 9:15	Opening address	Ms Lomarda (WMO)
9:15 - 9:25	Self-Introduction	
9:25 - 9:40	Organization of the workshop	Mr Koide (JMA)
9:40 - 9:45	Group photo	
9:45 - 10:00	***Coffee Break***	
10:00 - 11:30	**Session 1: Keynote Lecturers (Chair: Mr FUJITA)**	
10:00 - 10:45	Tropical Cyclone Programme: Priority Issues and Future Challenges	Ms Lomarda (WMO)
10:45 - 11:30	Japan's ODA for NHMSs in Southeast Asia	Mr Katsumata (JICA)
	Lunch Break	
13:30 - 18:15	**Session 2: Country Reports from Invited Members (Chair: Mr KOIDE)**	
13:30 – 15:30	Country Reports (30 minutes for each Member)	Bangladesh Cambodia Indonesia Lao P.D.R.
15:30 - 15:45	***Coffee Break***	
15:45 - 18:15	Country Reports (30 minutes for each Member)	Malaysia Myanmar Thailand the Philippines Vietnam
19:00 -	***Welcome Reception***	
Day 2, Wednesday 12 March		
8:30 - 11:30	**Session 3: Tropical Cyclogenesis Monitoring/Prediction (Chair: Dr YAMAGUCHI)**	
8:30 - 9:20	Tropical Cyclogenesis Monitoring at RSMC Tokyo (Incl. Introduction to RSMC Tokyo) and Tropical Cyclogenesis Prediction using TIGGE data	Mr Ueno (JMA) Dr Yamaguchi (MRI/JMA)
9:20 - 10:05	JTWC TC Operations Overview & Tropical Cyclogenesis Monitoring	Mr. Fukada (JTWC)
10:05 - 10:20	***Coffee Break***	

10:20 - 11:05	An overview of RSMC Miami (incl. Tropical Weather Outlook)	Dr Avila (NWS)
11:05 – 11:30	Discussion	
Lunch Break		
13:00 - 16:30	**Session 4: Tropical Cyclone Analysis (Chair: Mr WROE)**	
13:00 - 14:45	TC Analysis (Introduction to Dvorak, ADT, and Microwave Data)	Mr Wroe (NWS)
14:45 - 15:30	Microwave-TC Intensity estimation	Mr Oyama (MRI/JMA)
15:30 - 15:45	***Coffee Break***	
15:45 - 16:15	Introduction to the JMA's next generation meteorological satellite, Himawari-8/9	Mr Izumikawa (JMA)
16:15 - 16:30	Discussion	
16:30 – 17:45	**Session 5: Tropical Cyclone Track & Intensity Forecasting (Chair: Mr FUJITA)**	
16:30 - 17:30	Recent Developments of JMA Operational NWP Systems and WGNE Intercomparison of Tropical Cyclone Track Forecast	Mr Nakagawa (JMA)
17:30 - 17:45	Discussion	
Day 3, Thursday 13 March		
8:30 - 12:00	**Session 5 (continued)**	
8:30 – 10:00	Overview of JTWC Track and Intensity Forecasting Procedures	Mr Fukada (JTWC)
10:00 - 10:10	***Coffee Break***	
10:10 - 12:00	Exercise of TC Forecasts using Web ATCF	Mr Fukada (JTWC)
Lunch Break		
13:30 -	**Session 5 (continued)**	
13:30 - 15:30	Introduction to TC Forecasts at NHC	Dr Avila (NHC)
15:30 - 15:50	***Coffee Break***	
15:50 -	Exercise of TC Forecasts	Dr Avila (NHC)
	Visit to Operation Room (If time permits)	
Day 4, Friday 14 March		
8:30 - 12:30	**Session 6: Effective Early Warning: Lessons learnt from past TC Disasters (Chair: Mr KOHNO and Mr FUJITA)**	
8:30 - 9:15	Early Warning System in Japan and Lessons learnt from recent TC disasters	Mr Igarashi (JMA)
9:15 - 10:00	JMA's International Cooperation in Storm Surge Forecasts in Southeast Asia	Mr Kohno (JMA)
10:00 - 10:15	***Coffee Break***	
10:15 - 11:00	Response to & Lessons learnt from Typhoon Haiyan	Mr Paciente (PAGASA)
11:00 - 11:45	NWS Improvement plan of Storm Surge Forecasts and Warnings based on Lessons Learnt from Sandy	Dr Rhome (NWS)
11:45 - 12:30	Discussion	

APPENDIX III

JMA/WMO WORKSHOP ON EFFECTIVE TROPICAL CYCLONE WARNING IN SOUTHEAST ASIA

Tokyo, Japan
11-14 March 2014

(COUNTRY REPORT TEMPLATE)

Title of Country Report

(Author(s):xxxx)

Summary

[Brief summary, 5-10 sentences]

APPENDIX III

A GUIDE TO PREPARE A COUNTRY REPORT AND PRESENTATION

You are kindly requested to provide a written country report (10-15 pages including figures) following the below template. In addition, please note that you are expected to give a 30-minute presentation using a PowerPoint file (including five minute Q&A) on the first day of the workshop in line with your country report. For succinct description, you can just refer to information described in existing written materials available in English via the Internet with the URLs, i.e., in that case, you do not necessarily have to state it within the country report. When you write the country report, please follow notes in square brackets ([ ]).

1. Tropical Cyclone Monitoring, Analysis and Forecasting

1.1 Tropical Cyclone Monitoring

1.1.1 Tropical Cyclogenesis Monitoring

[For early warnings for Tropical Cyclones (TCs), it is important to monitor tropical disturbances with potential to develop into severe Tropical Cyclones with intensity of Tropical Depression (TD) or higher for the purpose of starting up your TC operational services as soon as such risks are identified. (It would be particularly important for Members in Southeast Asia considering that TDs often cause severe damage. Please describe how your Service monitors tropical cyclogenesis to identify tropical disturbances with potential to develop into TD or more. For instance, the RSMC Tokyo monitors potential TCs using Early Dvorak Analysis whose results are available at JMA's Numerical Typhoon Prediction Website (https://tynwp-web.kishou.go.jp/; N.B. for Typhoon Committee Members only). Also, the Joint Typhoon Warning Center issues probabilistic information on TC formation at its website. If your Service refers to products of foreign centers for this purpose, please specify the sources.]

1.1.2 Tropical Depression (TD) Warnings

[Please describe how your Service issues TD warnings to your users.]

1.1.3 Challenges, Needs and Improvement Plans

[Please describe your challenges and needs (e.g. training, improvement of RSMC products, expert missions, etc.) regarding monitoring of tropical cyclogenesis and issuance of TD warnings.]

1.2 Tropical Cyclone Analysis

1.2.1 Parameters and Methods

[Please describe analyzed Tropical Cyclone (TC) parameters and methods used for analysis by filling out the below table.]

Parameter	Time (UTC)	Methods	Other sources
[Please specify analyzed TC parameters (e.g. position, speed, central pressure, maximum sustainable wind)]	*[Please specify analysis time]*	*[Please describe both satellite-based and non satellite-based methods used for analysis of respective parameters. For instance, Dvorak TC intensity estimation technique is the primary method for monitoring TC activities.]*	*Although TC analysis including Dvorak technique is still challenging for some Members, analytical results made by foreign centers, including those by RSMCs, are available via GTS and/or the Internet on a real-time basis. If your Service refers to such products by foreign centers, please specify them.*

1.2.2 Challenges, Needs and Improvement Plans

[Please describe your challenges, needs (e.g. training, improvement of RSMC products, expert missions, etc.) and, if any, improvement plans regarding TC analysis.]

1.3 Tropical Cyclone Forecasting

1.3.1 Parameter and Method

[Please describe how your Service makes TC track forecasts in the below format.]

Parameter	Issuance Time (UTC)	Lead time (hours)	Methods
[Please specify forecast TC parameters (e.g. track, central pressure, maximum sustainable wind, strong wind areas).]			*[Nowadays, operational TC track forecasts are generally based on numerical weather prediction (NWP) guidance. Such numerical weather prediction guidance products of major numerical centers are available for WMO Members (e.g. JMA provides numerical track guidance of major numerical centers for Western North Pacific to Typhoon Committee Members at JMA's Numerical Typhoon Prediction Website (https://tynwp-web.kishou.go.jp/)). If your Service refers to such numerical track guidance products of foreign Members, please specify sources and how you use them for your forecasts. As for TC Intensity forecasting, it still remains a difficult task, while TC track forecasts have been steadily improved because of advances in numerical weather prediction guidance. If your Service issues intensity forecasts, please describe how they are produced. If your Service refers to TC intensity forecasts of foreign Members, please specify them.]*

1.3.2 Challenges, Needs and Improvement Plans

[[Please describe your challenges, needs (e.g. training, improvement of RSMC products, expert missions, etc.) and, if any, improvement plans regarding TC forecasts.]

1.4 Tropical Cyclone Products

1.4.1 TC Products

[[Please describe your TC products issued to the public with sample graphics.]

1.4.2 Challenges, Needs and Improvement Plans

[Please describe your challenges, needs (e.g. training, improvement of RSMC products, expert missions, etc.) and, if any, improvement plans regarding TC products.]

1.5 Computing Platform (including software)
[Please describe operational platform (software) to make TC analysis, forecasts and products.]

2 Numerical Weather Prediction Status for Effective Warning
[In this section, you are invited to provide summaries on your NWP status for effective warnings.]

2.1 NWP in Operational Use
[You are invited to provide the current status in operational NWP use at your service.
Please describe NWP models in operational use at your Service. In the rightmost column, please specify whether your Service runs global/regional models on your own or by using models provided by foreign centers.]

Model	Domain (square degree)	Resolution (horizontal & vertical)	Initial Time	Forecast Range (hours)	Run by (own/foreign centers)

2.2 Application Techniques of NWP Products for Operational Forecasts
[Please describe application techniques of NWP products for very short-range (0-6 hrs) and/or short-range (0-72 hrs) operational forecasts (e.g. production of forecast guidance).]

2.3 Challenges, Needs and Improvement Plans
[Please describe your challenges, needs (e.g. training, expert missions, etc.) and, if any, improvement plans regarding operational use of NWP products.]

3. Storm Surge
[You are invited to describe your operational activity on storm surge information.]

1) Storm Surge Information
a. Issuing b. not issuing

(For those who answered "b." in 1))
2) What is the reason?
a. No use (inland / no storm surge) b. No forecast are available
c. Other ( )

(For those who answered "a." in 1))
3) How the information is issued?
a. Independent storm surge information b. Included in TC information
c. Other ( )

4) What products (observations /forecasts) are referred to?

5) If your Service runs a storm surge model by yourself, please describe the way in detail.

Model	Domain and	Forecast Range	Frequency	Considered factors (Tide/ensemble/

	resolution	(hours)		inundation, etc.)

6) **In case your Service issue storm surge forecast without your own model, please briefly explain the operational procedure.**

4. Effective Warnings

4.1 Emergency Response for TC Disasters

4.1.1 Legal Framework for TC Disaster Management

[Please describe the legal framework for the national disaster management for TC disasters.]

4.1.2 Emergency Response Mechanism

[Please describe the national emergency response mechanism when massive TC disasters are expected to occur.]

4.1.3 Organs Responsible for Warnings and Evacuation Orders

[Please describe organs responsible for warnings and evacuation orders when TCs and associated severe weather phenomena, i.e., heavy rainfall, strong wind, flood, inundation and storm surge, are expected to occur.]

Severe Weather Phenomena	Organs responsible for Warnings	Organs responsible for Evacuation Orders
Tropical Cyclone	*[Please specify organizations responsible for issuance of warnings for TCs.]*	*[Please specify organizations responsible for evacuation orders.]*
Heavy Rain		
Strong Wind		
River Flood		
Storm Surge		

4.2 Warnings/Advisories for Severe Weather Phenomena

[You are invited to provide details on warnings/advisories for tropical cyclones as well as associated severe weather phenomena, i.e., heavy rainfall, strong wind, flood, inundation and storm surge, in the following formats respectively.]

4.2.1 Tropical Cyclone

Warnings/Advisories and corresponding emergency responses	*[Please list warnings/advisories issued for tropical cyclones and corresponding emergency responses by relevant authorities and residents.]*
Potential Disaster Risks	*[Please describe potential disaster risks when the respective warnings/advisories listed above are issued.]*

Target (warning areas)	*[Please specify targeted warning areas (e.g. prefectural government).]*
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	*[Please describe meteorological variables/indices used for criteria/thresholds for warnings/advisories.]*
Criteria/Thresholds	*[Please describe how the above criteria/thresholds for warnings/advisories are determined.]*
Contents of Warning/Advisory Message	*[Please describe contents of warning/advisory message for a tropical cyclone.]*
Sample Warning/Advisory Message	*[Please provide a sample warning/advisory message for a tropical cyclone.]*

4.2.2 Heavy Rain

Warnings/Advisories and corresponding emergency responses	*[Please list warnings/advisories issued for heavy rain and corresponding emergency responses by relevant authorities and residents.]*
Potential Disaster Risks	*[Please describe potential disaster risks when the respective warnings/advisories listed above are issued.]*

Target (warning areas)	*[Please specify unit of warning areas (e.g. prefectural government).]*
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	*[Please describe meteorological variables/indices used for criteria/thresholds for warnings/advisories.]*
Criteria/Thresholds	*[Please describe how the above criteria/thresholds for warnings/advisories are determined.]*
Contents of Warning/Advisory Message	*[Please describe contents of warning/advisory message for heavy rain.]*
Sample Warning/Advisory Message	*[Please provide a sample warning/advisory message for heavy rain.]*

4.2.3 Strong Wind

Warnings/Advisories and corresponding emergency responses	*[Please list warnings/advisories issued for strong winds and corresponding emergency responses by relevant authorities and residents.]*
Potential Disaster Risks	*[Please describe potential disaster risks when the respective warnings/advisories listed above are issued.]*

Target (warning areas)	*[Please specify unit of warning areas (e.g. prefectural government).]*
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	*[Please describe meteorological variables/indices used for criteria/thresholds for warnings/advisories.]*
Criteria/Thresholds	*[Please describe how the above criteria/thresholds for warnings/advisories are determined.]*
Contents of Warning/Advisory Message	*[Please describe contents of warning/advisory message for strong winds.]*
Sample Warning/Advisory Message	*[Please provide a sample warning/advisory message for strong winds.]*

4.2.4 River Flood

Warnings/Advisories and corresponding emergency responses	*[Please list warnings/advisories issued for river floods and corresponding emergency responses by relevant authorities and residents.]*
Potential Disaster Risks	*[Please describe potential disaster risks when the respective warnings/advisories listed above are issued.]*

Target (warning areas)	*[Please specify unit of warning areas (e.g. prefectural government).]*
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	*[Please describe meteorological variables/indices used for criteria/thresholds for warnings/advisories.]*
Criteria/Thresholds	*[Please describe how the above criteria/thresholds for warnings/advisories are determined.]*
Contents of Warning/Advisory Message	*[Please describe contents of warning/advisory message for river floods.]*
Sample Warning/Advisory Message	*[Please provide a sample warning/advisory message for river floods.]*

4.2.5 Storm Surge

Warnings/Advisories and corresponding emergency responses	*[Please list warnings/advisories issued for storm surges and corresponding emergency responses by relevant authorities and residents.]*
Potential Disaster Risks	*[Please describe potential disaster risks when the respective warnings/advisories listed above are issued.]*

Target (warning areas)	*[Please specify unit of warning areas (e.g. prefectural government).]*
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	*[Please describe meteorological variables/indices used for criteria/thresholds for warnings/advisories.]*
Criteria/Thresholds	*[Please describe how the above criteria/thresholds for warnings/advisories are determined.]*
Contents of Warning/Advisory Message	*[Please describe contents of warning/advisory message for storm surges.]*
Sample Warning/Advisory Message	*[Please provide a sample warning/advisory message for storm surges.]*

4.3 Supporting Meteorological Information for Warning/Advisory Messages

[Please describe supporting meteorological information which provides supplementary explanation on warning/advisory messages to support emergency responses of recipients, if any.]

Name of Information	Potential Disaster Risks	Target (areas)	Issuance (update) Time	Contents
[Please describe name of information.]	*[Please describe potential disaster risks when the this information is issued.]*	*[Please specify unit of target areas (e.g. prefectural government).]*	*[Please describe timing of issuance of this information.]*	*[Please describe contents of this information.]*

4.4 Institutional Coordination

4.4.1 Coordination with Disaster Management Authorities

[In order for disaster management authorities to respond appropriately and timely to your warnings under emergency situations, contents of warnings should be well coordinated between your Service and those authorities. Also, dissemination of warning messages to them should be immediate and secure enough. Please describe your efforts for coordination of warning messages as well as establishment of secure dissemination of warning messages to the authorities.]

Warning Coordination	*[Please describe how your Service coordinates with disaster management authorities to improve your warnings and advisories (e.g. revision of warning criteria).]*
Needs from Disaster Management Authorities	*[Please describe needs from disaster management authorities for improvement of your warnings and advisories.]*

4.4.2 Partnership and Coordination with Media

[For the immediate and appropriate dissemination of your warnings/advisories to the public as an easy-to-understand message, close coordination with media on warnings/advisories is also vitally important. Please describe your efforts regarding coordination with media on a routine basis and in the case of emergency.]

Warning Coordination	*[Please describe how your Service coordinates with media to broadcast warnings and advisories promptly and accurately.]*
Needs from Media	*[Please describe needs from media for improvement of your warnings and advisories.]*

4.5 Challenges (and Future Plan)

[It is always a challenging task for NMHSs to make your warnings lead to appropriate emergency responses by relevant authorities. Please describe current challenges to establish effective warning systems in your country.]