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CAS/WWRP/TROPICAL METEOROLOGY RESEARCH REPORT

(Item 7- Coordination with other activities of the WMO TCP)

(Submitted by Prof. Elsberry Russell)

Summary and Purpose of Document**:**

This document describes the WMO/WWRP Working Group on Tropical Meteorology Research activities

Action Proposed

The Committee is invited to:

Note the major activities of the WMO/WWRP Working Group on Tropical Meteorology Research as summarized in the APPENDIX

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CAS/WWRP/Tropical Meteorology Research Report

42nd ESCAP/WMO Typhoon Committee Meeting

The Working Group on Tropical Meteorology Research (WGTMR) has two components: Tropical Cyclone Panel (R. L. Elsberry, Chair) and Monsoon Panel (C.-P. Chang, Chair). Both the tropical cyclone and monsoon components have the goal of supporting tropical meteorology research among the WMO Members that will lead to improved observation, analysis, forecast, and warning systems for high-impact tropical weather events, and thus contribute to disaster prevention and mitigation. The tropical cyclone component of WGTMR greatly values the long and fruitful working relationship with the World Weather Watch (WWW) Tropical Cyclone Program (TCP) and the NMHSs of the WMO members affected by tropical cyclones. We appreciate this opportunity to update the Typhoon Committee on the progress made during the past year.

International Workshop on Tropical Cyclones (IWTC-VII)

This workshop, which is co-sponsored with the WWW/TCP, will be held in La Reunion on 15-20 November 2010. The Co-Directors of IWTC-VII are Chris Velden of the University of Wisconsin (USA) and Jeff Kepert of the Australian Bureau of Meteorology. An International Organizing committee has been appointed to guide the IWTC-VII. As in previous IWTCs, the objectives are to bring forecasters and researchers together to review progress in tropical cyclone research and forecasting, discuss opportunities for forecasting advances from new research and technology, and formulate specific recommendations for future research activities.

It is requested that the Typhoon Committee work with the WWW/TCP and the WGTMR to identify forecasters who would contribute to the objectives of IWTC-VII by serving as Rapporteurs or as members of the working groups who prepare the pre-workshop materials, and by actively participating in the plenary sessions and discussion groups. These forecaster inputs are essential to the success of IWTC-VII. A certain number of forecasters from the Typhoon Committee will be supported by WMO funds. It is requested that individual Typhoon Committee members also support the attendance of other forecasters and researchers at IWTC-VII. Early identification of the forecasters from the Typhoon Committee is strongly encouraged, and the names should be submitted to the Co-Directors.

Finally, it is requested that the Typhoon Committee consider supporting the attendance of hydrologists since tropical cyclone-related flooding is expected to be an important topic at IWTC-VII.

Tropical cyclone field experiments

The WGTMR organized a major field experiment in the western North Pacific during August and September 2008 called Tropical Cyclone Structure (TCS-08). In collaboration with the THORPEX Pacific Asian Regional Campaign (T-PARC), the TCS-08 collected atmospheric and oceanographic observations and numerical weather prediction products to study tropical cyclone formation, structure and structure change, recurvature, extratropical transition, and downstream impacts. A unique set of aircraft (radar, Stepped Frequency Microwave Radiometer, wind lidar, and dropsonde) and satellite (including rapid scan periods) observations was collected. One objective was to gather *in situ* observations of tropical cyclone intensity to validate the many satellite-based techniques that have been developed since 1990. This test indicated that the automated satellite intensity techniques were competitive with those by human analysts when compared with the intensities observed from the reconnaissance aircraft. As presented at the 2009 Typhoon Committee meeting, it has been documented (*Asia-Pacific Journal Atmospheric Science*, **45**, pages 357-373) that a four global model forecast consensus was able to predict the formation of tropical cyclones that would later become typhoons. A manuscript in review documents that the ECMWF monthly ensemble forecast made once a week was able to predict western North Pacific tropical cyclone formations and tracks on 2-4 week timescales for typhoons and strong tropical storms during the peak of the season. Other publications from TCS-08/T-PARC that are relevant to operational typhoon prediction are expected to become available in the next few months.

A sequel to the TCS-08 field experiment will occur from 20 August to 20 October 2010 in conjunction with the Interacting Typhoon-Ocean Program (ITOP). This major oceanographic field experiment will deploy a number of instruments to observe the ocean response to typhoons, including how the cold water wake behind the typhoon develops and decays. Since two of the U. S. Air Force Hurricane Hunter aircraft will be participating in ITOP, this is an opportunity (called TCS-10) to continue *in situ* observations of typhoon formation, intensity, structure and structure change as was done in TCS-08. These observations will again be available on the GTS as was the case during TCS-08, and all of the atmospheric observations will be freely available to researchers who want to study the typhoons during TCS-10.

A major research program called Hurricane Forecast Improvement Program (HFIP) has been initiated by NOAA in the U. S. Because the central focus of HFIP is to observe, analyze, and forecast rapid intensification events, which was identified by forecasters at IWTC-VI as their highest priority need, the WGTMR is establishing an affiliation with HFIP. The objectives are to bring researchers from other countries in WMO Region IV into the HFIP, facilitate special observations by those countries, and facilitate the participation of their tropical cyclone forecasters as appropriate (e.g., by organizing a mini-Forecast Demonstration Project).

One field experiment in the Atlantic being carried out during 2010 is a NASA program that will include prototype satellite instrument validation from one manned aircraft and the high-altitude, long-duration, unmanned Global Hawk aircraft. A second Atlantic field experiment will test a new hypothesis on tropical cyclone formation, and will involve a high-altitude manned aircraft in conjunction with other middle-troposphere manned research aircraft.

Tropical cyclone mesoscale model intercomparison

One of the top achievements of the Tropical Cyclone Structure (TCS-08) and THORPEX Pacific Asian Regional Campaign (T-PARC) was to collect a series of observations in Typhoon Sinlaku prior to a period of strong interaction with the Central Mountain Range of Taiwan and then a later period in which the tropical storm re-intensifies to a typhoon and finally underwent extratropical transition. The period leading up to the interaction with the Central Mountain Range is particularly important because all four of the aircraft associated with the combined TCS-08 and T-PARC field experiment were flying in the storm, and thus the structure of the typhoon can be defined upstream of the land.

The availability of the upstream TCS-08/T-PARC aircraft observations upstream of Taiwan represent a unique opportunity to carry out a mesoscale model intercomparison of a typhoon interacting with the topography of Taiwan since for the first time an accurate specification of the upstream conditions is possible. In addition, the advanced meteorological observation network over Taiwan can provide the necessary validation data set for the models. The objectives of the proposed model intercomparison are to: (i) advance understanding of the typhoon-topography interaction (which included a slowing and looping motion); (ii) advance understanding of the role of model physical representations for tropical cyclone landfall prediction; (iii) explore the minimum model representation (e.g., model horizontal and vertical resolution) for accurate predictions of the landfall impacts such as the heavy precipitation; and (iv) shed light on the limits of predictability in such complex typhoon-topography interaction scenarios.

This WGTMR initiative is still in the development stage as arrangements are made to prepare the initial conditions for the model intercomparison. A WGTMR representative will participate in the International Workshop on Typhoon Research with a Focus on Typhoon Morakot (2009) on 25-26 March 2010 to determine if a cooperative program can be arranged.

Climate effects on tropical cyclones

The controversial topic of tropical cyclones and climate change was a central focus of IWTC-VI. A comprehensive review was prepared and discussions by researchers and forecasters at the workshop led to a Statement on Tropical Cyclones and Climate Change that was widely distributed (and accepted as an official statement by the American Meteorological Society). The WGTMR Expert Team on Climate Impacts on

Tropical Cyclones is tasked to continue these studies. An updated review has been prepared and will appear in the book from IWTC-VI that is expected to be published at the end of January 2010. This Expert Team participated in the first International Conference on Indian Ocean Tropical Cyclones and Climate Change in Oman during March 2009. The Expert Team has prepared an assessment "Tropical Cyclones and Climate Change" that is expected to be published in *Nature Geoscience* early in 2010. A near-final draft was provided to the Typhoon Committee in December 2009.

The key conclusions from the abstract that may be useful guidance to the NHMSs in responding to questions from media and government officials are: Future projections based on theory and high-resolution dynamical models consistently suggest that greenhouse warming will cause the globally averaged intensity of tropical cyclones to shift toward stronger storms, with intensity increase of 2 to 11% by 2100. Existing modeling studies also consistently project decreases in the globally averaged frequency of tropical cyclones, by 6 to 34%. Balanced against this, higher resolution modeling studies typically project increases in the frequency of the most intense cyclones, and increases of the order of 20% in the precipitation rate within 100 km of the storm center. For all cyclone parameters, projected changes for individual basins show large differences among different modeling studies.

A new Statement on Tropical Cyclones and Climate Change summarizing the status based on this assessment is expected to be prepared by the Expert Team and circulated by WMO during 2010.

Seasonal forecasts of tropical cyclone activity

Based on a recommendation from IWTC-VI, a review of the status of seasonal forecasts of tropical cyclone was published in the WMO Bulletin. In addition, a workshop was sponsored to plan a website that would contain seasonal tropical cyclone forecasts that are consistent in areal and temporal coverage, and would be updated at common times. The prototype website was established at WMO prior to the 2009 season, and the updated forecasts during August were loaded. Assessments of the performance of the 2009 forecasts are in progress. It is expected that additional forecasts will be added in 2010 and made available to operational forecasters.

Second International Workshop on Tropical Cyclone Landfall Processes

The highest research priority for the WGTMR Tropical Cyclone Panel is to advance understanding and capability to forecast tropical cyclone landfall and its impacts. The ultimate goal is to demonstrate how improved tropical cyclone landfall forecasts would have large societal, economic, and environmental benefits since a more effective warning system that would elicit the proper response by the public would save lives and mitigate the damage in many countries.

In conjunction with the WWW/TCP, the WGTMR sponsored the second International Workshop on Tropical Cyclone Landfall Processes (IWTCLP-II) during October 2009. The participation of forecasters from many countries was helpful in the discussion of the landfall impacts, and specifically on the importance of tropical cyclone-related precipitation and flooding. Action items from this discussion include the mesoscale model intercomparison for Typhoon Sinlaku (discussed above) and a possible research program related to a tropical cyclone interacting with the terrain of Madagascar as a component of the proposed Southwest Indian Ocean Cyclone Experiment (SWICE) field experiment during January and February 2011. Opportunities to cooperate with a five-year national basic research program on tropical cyclone landfall in China are also to be explored. The Typhoon Committee has been a leader in studies of the hydrological aspects of tropical cyclone landfall. The WGTMR will be involved in the organization of the Third International Quantitative Precipitation Estimation/Qualitative Precipitation Forecasting Workshop during 2010, and ensure the participation of hydrologists who are studying tropical cyclone precipitation-related floods.

The forecasters attending IWTCLP-II also emphasized the importance of wind structure and structure change (including intensity change). This topic necessarily includes air-sea interaction at high wind speeds, and the two-way interaction between the tropical cyclone and the ocean. The WGTMR will explore international cooperation in a global Ocean Heat Content (OHC) product to be developed during 2009-2012. In addition to the ITOP field experiment described above, a major ocean observing program to document the ocean response to hurricane passage is expected to provide new understanding of the ocean contribution to intensity changes.

A major contribution by forecasters at IWTCLP-II was provision of rankings of the operational needs of the tropical cyclone warning centers. Forecasters from Japan, Taiwan, China, Bangladesh, India, Cuba, Sri Lanka, and Fiji provided rankings. Important differences between the developed and the developing countries, and between island countries and large land countries, were revealed. These surveys will be useful in prioritizing and directing the future research activities of the WGTMR Tropical Cyclone Panel.

Publication products

The updated book *Global Perspectives on Tropical Cyclones* co-edited by J. Chan and J. Kepert based on materials from IWTC-VI is expected to be published in late January 2010.

A new schedule for completing a website version of the updated *Global Guide on Tropical Cyclone Forecasting* has been issued by Editor C. Guard. It is expected that a hard copy version will be prepared after the website version is completed in September 2010.