

WWRP 2007 - 4

Report of WMO/CAS Working Group  
on Tropical Meteorology Research

(Guangzhou, China, 22 - 24 March 2007)

# WORLD METEOROLOGICAL ORGANIZATION

## WORLD WEATHER RESEARCH PROGRAMME

WWRP 2007- 4

### REPORT of WMO/CAS WORKING GROUP on TROPICAL METEOROLOGY RESEARCH

(Guangzhou, China, 22 - 24 March 2007)



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## **1. OPENING OF THE MEETING**

At the kind invitation of the Government of China, the meeting of the WMO/CAS Working Group on Tropical Meteorology Research (WGTMR) was held from 22 to 24 March 2007 at the Guangzhou Meteorological Training Center. The meeting opened at 10:00am on Thursday, 22 March 2007.

Mr Yu Yong, Director-General of the Guangzhou Regional Meteorological Center, China Meteorological Administration (CMA), in his opening address extended his warm welcome to all the participants of the workshop. He mentioned that Guangzhou is the region in China most prone to tropical cyclone passage which is essentially why the improvement of tropical cyclone forecasting is the top priority of the Guangzhou Regional Meteorological Centre's operational services. In this connection, the CMA and the provincial governments have made a strong commitment to support the Center in the improvement of the forecasting infrastructure in this region. For effective and timely monitoring and forecasting of tropical cyclone landfall, a lot of effort have been invested in setting up a modern observational network in step with advances in science and technology. In Guangdong province, the government had established a dense surface observation network with the deployment of over 600 AWS (Automatic Weather Stations) in the Pearl River Delta and along the coast, a Doppler Weather Radar surveillance network covering the whole Guangdong and part of its adjacent provinces, a lightning surveillance network in the Pearl River Delta area in cooperation with Hong Kong, China et al. Furthermore, a new five-year programme to enhance capability and capacity of monitoring severe weather events such as tropical cyclones has been recently implemented. After completion of the programme, it is expected that a modern, effective, timely and three dimensional monitoring and observing system will be established. In step with the upgrade of the infrastructure, the CMA and the local governments have committed their strong and solid support to research activities in understanding the physical fundamentals of tropical cyclones structure and in the development of advanced tropical cyclone forecasting techniques. In this connection, the CMA has set up a specialized research institute in this region, i.e. the Guangzhou Institute of Tropical and Marine Meteorology. Many research programmes have been carried out there to support tropical cyclone prediction, for example, two numerical models for typhoon prediction are running routinely, with assimilation of non-conventional observing data acquired by the aforesaid advanced observational systems. In addition to these, staff scientists of the center have conducted their researches with international cooperation by way of academic exchange and technical development.

Prof. Lianshou Chen, Chairman of the WGTMR, welcomed and thanked all the experts participating in the meeting (Annex I: List of Participants).

## **2. ADOPTION OF THE AGENDA**

The working group adopted the agenda as given in Annex II.

## **3. BRIEFING ON RELEVANT CAS-XIV RESOLUTION**

The participants were informed by Dr Len Barrie, Director of WMO's Atmospheric Research and Environment Programme of the resolutions of CAS-XIV (Cape Town, 16-24

February 2006) relevant to the work of the Working Group and the meeting was conducted under the guidance of these resolutions.

#### **4. REPORT OF THE CHAIRMAN ON WGTMR**

Prof. Chen, Chairman of the WGTMR, presented a comprehensive report on the main activities and progress achieved by the working group since its last meeting (Shenzhen, 12-16 December 2005). The Chairman reported to the meeting that:

- He represented the WGTMR at CAS XIV (Cape Town, February 2006)
- A proposal for a Forecast Demonstration Project – Development of an Advanced Tropical Cyclone Early Warning System for the Philippines was submitted to the Third Early Warning Conference (Bonn, March 2006). This project was one of the four recommendations of the International Workshop on Tropical Cyclone Landfall Processes that was held in Macao in 2005. The project proposal was given a top rating of 5 and was one of 14 selected out of 105 proposals.
- Over 100 participants attended the International Symposium on Winter MONEX that was held from 4 to 7 April 2006 in Kuala Lumpur, Malaysia and chaired by Prof. C.P. Chang. There were a total of 75 scientific presentations on topics such as observations and variations of monsoon, modeling studies and forecasting and predictability of monsoons etc. The theme of the Panel discussion was “Developing Future Scientific Cooperation.”
- The Sixth International Workshop on Tropical Cyclones that was held from 21 to 30 November 2006 in San Jose, Costa Rica brought together 130 tropical cyclone forecasters and researchers from 34 WMO Members. The workshop co-chairs, Mr C.Y. Lam and Prof. Johnny Chan designed the programme in such a way as to engage the participants in discussions on each of 6 main topics and 7 special focus topics, do a review of the current status and future of the science of tropical cyclone forecasting and share the latest technological knowledge with special emphasis on encouraging the application of research results to improve operational activities. The IWTC-VI participants adopted at the close of the workshop, a Statement on Tropical Cyclones and Climate Change. A press release was later issued by WMO based on this statement.
- Preparations had been made to conduct an International Training Workshop on Tropical Cyclone Disaster Reduction here in Guangzhou from 26 to 31 March 2007. Sixty participants from 12 WMO Members affected by tropical cyclones are expected to attend the six-day workshop. Objectives of the workshop are:
  - To provide training and experiences on new knowledge gained from recent advances on tropical cyclone research ;
  - To apply these to operational prediction in order to raise the capability of tropical cyclone forecasts and warnings ; and
  - To be aware of the issues associated with early warning systems and disaster mitigation.

The Chairman also presented to the group the new working structure of CAS as approved by CAS-IV (see Annex III). Other issues mentioned in the Chairman's report will be discussed under the relevant agenda items of the meeting.

## **5. REPORTS ON THE MAJOR COMPONENTS OF WGTMR**

Rapporteurs of the major components of WGTMR provided reports on developments since the last Working Group Meeting (Shenzhen, December 2005), and the future plan/s of their respective areas.

### **5.1 Tropical Cyclone Project**

Prof. Russell ELSBERRY (USA) presented a report on the activities under the Tropical Cyclone Project.

Four main activities of the tropical cyclone component:

- (a) Develop improved and cost-effective forecasting techniques with emphasis on high-impact weather and promote their application among Members;
- (b) Enable governments, societies and economic sectors to realize fully the benefit of weather-related information in critical decision-making;
- (c) Demonstrate improvements in the prediction of high-impact weather through the exploitation of advances in scientific understanding, new observing systems, observational network design, data assimilation and modeling techniques, and information systems; and
- (d) Demonstrate the benefits of improved global, mesoscale, and nowcasting forecast systems to all societies.

Overarching goal of the tropical cyclone project: Contribute to the WMO Multi-Hazard Prevention Strategy of reducing by 50% over the decade 2010-2019 the number of fatalities caused by tropical cyclones compared with the 10-year average fatalities during 1995-2004.

New focus of the tropical cyclone component: tropical cyclone disasters associated with landfall.

Outcome of the First International Workshop on Tropical Cyclone Landfall Processes (IWTCLP) Macao, China,

Identified priority items to provide better warnings of tropical cyclone landfall-related disasters:

- (a) Improved track forecasts to better indicate the location and timing of the landfall;
- (b) Improved precipitation analyses and quantitative precipitation forecasts (QPF);
- (c) Improved intensity forecasts; and
- (d) Improved storm surge forecasts.

Endorsed the following programmes:

- (a) An intercomparison of the recently developed advanced numerical modeling systems for the prediction of tropical cyclone structure/intensity changes,
- (b) A forecast demonstration project to implement a state-of-the-art and an end-to-end warning system for tropical cyclone precipitation in the Philippines,
- (c) A tropical cyclone field programme for the western north Pacific that would include targeted observations and advanced models to improve landfall forecasts, and
- (d) A focused programme of extratropical transition of tropical cyclones that would address forecast issues as well as new research efforts to better understand the complex, inter-related processes that occur during the transition from a tropical cyclone to an intense extratropical cyclone.

In summary, the future efforts of the tropical cyclone component have been developed in response to the needs of the tropical cyclone forecast community.

### ***Implementing Strategy***

Achieving the overarching goal will require an integrated approach of advancing the tropical cyclone track forecasting while also improving the capability to predict the storm structure/intensity, precipitation, and the ocean surface waves and thermal structure under the storm. These meteorological fields then must be coupled to the impacts modules such as the storm tide/surge, hydrological elements of flooding, landslides, and debris flow, etc. In the next step, this information has to flow smoothly into the emergency management system in a timely, user-friendly manner, and site-specific (i.e. GIS-based) format that can be easily accessed. Finally, the warnings must be communicated in a language and in an action-oriented format that will elicit the desired and appropriate response to the warning.

### ***IWTC-VI***

Prof. Johnny Chan (Hong Kong, China), co-chair of International Programme Committee for the Sixth International Workshop on Tropical Cyclones (IWTC-VI) presented at the meeting the major outcome of the said workshop.

The Workshop has successfully achieved its objective of facilitating the exchange of information between tropical cyclone researchers and forecasters with the goal of reducing the associated risk and damage caused by tropical cyclones through improved prediction. In total, 125 participants from 34 countries attended the workshop. All the Tropical Cyclone Regional Specialized Meteorological Centres (TC RSMCs) and Tropical Cyclone Warning Centres (TCWCs) were represented at the workshop. A set of recommendations was formulated by the workshop participants which were addressed to the tropical cyclone research community, to operational tropical cyclone forecasters and to WMO, focused on an expanded approach for sustained efforts in further improving tropical cyclone prediction to consequently reduce the damaging effects of these natural weather hazard to mankind. To ensure that follow-up actions will be done, a number of focal points were designated mainly to serve as a coordinator for activities that could lead to the accomplishment of the recommendations. The coordination will be done with the help of the PTR/AREP staff. During the workshop, a Special Focus Topic session chaired by Dr John McBride (Australia) came up with an updated statement on the possible effects of climate change

on tropical cyclone activity/intensity. The IWTC-VI participants finally adopted the said statement at the close of the workshop. The summary and the full statement are available online at [http://www.wmo.ch/pages/prog/arep/index\\_en.html](http://www.wmo.ch/pages/prog/arep/index_en.html).

## 5.2 Monsoon Studies

The Chairman of International Panel for East Asian Monsoon, Prof. C.P. Chang (USA), reported the panel's recent activities including the organization of the International Workshop on Monsoons in 2004, the publication of WMO TD-1266 in 2005, "The Global Monsoon System: Research and Forecast" as a reference book for monsoon region NMHSs, the organization of the Asian Monsoon Symposium "Winter MONEX: A Quarter Century and Beyond" in April 2006, and the publication of the meeting report in the Bulletin of the American Meteorological Society in March 2007. The panel also cooperated with the World Scientific Publishing Company to launch a Book Series on Meteorology of East Asia, which has published three hard cover volumes and the fourth volume on tropical cyclone dynamics is in preparation.

With the reorganization of WGTMR within the WWRP, Professor Chang proposed the following plan for the activities involving monsoon studies:

(a) The top priority and overall goal is to reduce disaster damages through improved forecast. The main approach is to facilitate research-forecaster interactions, with the keystone activity being the quadrennial series of International Workshop on Monsoons (IWM) to provide a forum for these interactions and to transfer new science and technology to NMHSs, including updating the document WMO TD1266 produced at IWM-3 in Hangzhou, China, November 2004. The panel will also discuss ways to foster and encourage relevant research in monsoon regions. This activity will include reviewing relevant activities in the regions, encouraging national programmes and regional and international cooperation that can help the NMHSs improve their forecast capability. In addition, the panel will hear reports from the three monsoon activity centers, and will interact with the Tropical Cyclone panel.

(b) The panel will change its name from IPEAM (International Panel for East Asian Monsoon) to IPM (International Panel for Monsoons), with activities previously conducted by IPEAM/M1, M2, and M3 projects merged into the IPM. The new panel will:

1. Retain the existing structure of an Executive Committee (members from major monsoon activities) and Corresponding Members (members from other monsoon countries); and retain the existing co-sponsorship with the Scientific Committee on Meteorology of the Pacific Science Association.
2. Establish two Expert Teams: ET on Severe Monsoon Weather (ETSMW), and ET on Climate Impacts on Monsoon Weather (ETCIMW).
3. The ETMW will focus on studies of severe monsoon weather, which particularly involves convection and heavy rainfall leading to the possibility of floods. Understanding and forecasting monsoon systems ranging from convection and mesoscale up to synoptic and intraseasonal oscillations are the main interest of this team.
4. The ETCIMW will focus on the climate variations that may impact monsoon weather. Understanding and forecasting monsoon systems ranging from Climate change, decadal and interannual variations down to intraseasonal oscillations are the main interest of this

team. The ETCIMW will work closely with WCRP to cooperate with and support CLIVAR and GEWEX monsoon activities.

Dr Jun Matsumoto (Japan) presented at the meeting an update on the activities related to the Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative (MAHASRI) and Asian Monsoon Year 2008 (AMY'08). The objective of MAHASRI is to establish a hydro-meteorological prediction system, particularly up to seasonal time-scale, through better understanding of Asian monsoon variability. Phase I which will focus on building-up new observation systems will be conducted from October 2006 to March 2010, Phase II will be from 2011 to 2014 with AMY'08 in 2008. It is expected that the project will be finished by 2015. The key science issues of MAHASRI includes: atmosphere-ocean-land interactions in the Asian monsoon system, scale interactions among diurnal, synoptic, intra-seasonal and seasonal variability of Asian monsoon rainfall. effect of various scale orography on monsoon rainfall and effect of human influences (i.e., aerosols, land-use change, and greenhouse-gas increase) on hydro-meteorological variations in Asian monsoon regions. He also mentioned some cross-cutting themes/common targets such as: trend/gap detection of changing environments (quantity/extremes, characteristics/cause/attribution, hydro-meteorological and other variables, share information and statistical tool, integrate knowledge all over the monsoon Asia); diurnal cycle and multi-scale interaction (peak time/amplitude, dependence on intra-seasonal variation, seasonal change, using both in-situ and satellite data, integrate knowledge all over the monsoon Asia); and feasibility studies on seasonal prediction data (hindcast/forecast data from the APEC Climate Centre (APCC)/Multi-model Ensemble (MME) (and/or JMA), assessing/evaluating current and potential values for social application in each region with downscaling). He reported that involved in the new field observation plan for AMY'08 and MAHASRI are Japan EOS Promotion Programme (JEPP), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)/ **Institute of Observational Research for Global Change (IORGC)**, China-973 Asia and Indian-Pacific Ocean (AIPO), India-Severe Thunderstorms-Observations and Regional Modeling (STORM)/Continental Tropical Convergence Zone (CTCZ) and THORPEX-Year of Tropical Convection (YOTC). He presented a brief overview of each of the aforementioned projects. The objective of AMY'08 is to improve Asian monsoon predictions, in particular, in intraseasonal and seasonal time scales and to be able to attain its goal research studies are to be conducted to clarify multi-scale interactions among diurnal, synoptic and intra-seasonal variations of Asian monsoon, clarify land surface processes related with Asian monsoon variability and clarify the role of aerosol on Asian monsoon variability. AMY'08 is planned to take place from April 2008 to March 2009. Lastly, he provided the meeting with the meeting schedule in 2007 for MAHASRI and AMY-08.

Dr Jean-Philippe Lafore (France) presented to the meeting an overview of the African Monsoon Multidisciplinary Analyses (AMMA) project and related THORPEX-Africa activities. AMMA is a coordinated international project to improve our knowledge and understanding of the West African monsoon (WAM) and its variability with an emphasis on daily-to-interannual timescales. AMMA is motivated by an interest in fundamental scientific issues and by the societal need for improved prediction of the WAM and its impacts on West African nations. Vulnerability of West African societies to climate variability is likely to increase in the next decades as demands on resources increase in association with one of the World's most rapidly growing populations. Vulnerability may be further increased in association with the effects of climate change and other

factors linked to the fast growing population such as land degradation and water pollution. Recognising the societal need to develop strategies that reduce the socioeconomic impacts of the variability of the WAM, AMMA will facilitate the multidisciplinary research required to provide improved predictions of the WAM and its impacts. Its aims are to improve our understanding of the WAM and its influence on the physical, chemical and biological environment regionally and globally, to provide the underpinning science that relates climate variability to issues of health, water resources and food security and defining the relevant monitoring strategies, and to ensure that the multidisciplinary research carried out in AMMA is effectively integrated with prediction and decision making activity. AMMA will promote international coordination of ongoing activities, basic research and a multi-year field campaign over West Africa and the tropical Atlantic. AMMA will develop close partnerships between those involved in basic research of the WAM, operational forecasting and decision making, and it will establish blended training and education activities for African technical institutions and schools. Currently scientists from more than 25 countries, representing more than 140 national and pan-national agencies and institutions are involved in AMMA. The number of active scientists is in the order of 400 to 500. A network of African scientists linked to AMMA has been established (AMMANET or AMMA Africa) which will help to consolidate existing collaborations in Africa and to federate initiatives through a pan-African partnership. AMMA is endorsed by the World Climate Research Programme (WCRP) and continues to develop in association with Climate Variability And Predictability (CLIVAR) and Global Energy and Water Cycle Experiment (GEWEX). AMMA has also been endorsed by two projects within the International Geosphere-Biosphere Programme (IGBP), International Global Atmospheric Chemistry (IGAC) and Integrated Land Ecosystem-Atmosphere Processes Study (ILEAPS). AMMA is working with other international projects and programmes to achieve its aims including Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS) and The Observing system Research and Predictability EXperiment (THORPEX). AMMA is planned to be a multi-year project and involves 3 nested observation periods. The enhancement of observations during these periods will provide a unique opportunity to determine future operational monitoring necessary to improve weather and climate forecasts over the West African region. A high priority for AMMA is to establish this operational network of observations providing a visible legacy for the international AMMA programme. AMMA has been carefully conceived to improve our fundamental understanding of the West African monsoon and its societal impacts and to make sustainable improvements to monitoring and prediction of the West African environment. Its activities are embedded within a 'Long-term Observing Period' (LOP) structure, which will ensure that AMMA's intensive activities are directed towards systematic improvements in monitoring and prediction over the coming decades. AMMA will develop and upgrade two important land-based atmospheric monitoring systems (for the upper air and surface fluxes), and over the LOP the responsibility for these networks will be transferred to the local African agencies. In addition, ocean monitoring systems surrounding West Africa that have been shown to improve both weather and climate forecasts will continue to provide data to these groups. These networks of observations are of enormous value both to global prediction systems and to local forecasting systems, based in Africa. Mr Lafore also presented at the meeting the achievements of the AMMA-AOC Forecasters Training Course (Niamey, Niger, 22 May to 2 June 2006) which was attended by 18 forecasters and was organized to prepare for the operation of the AMMA Operational Forecasting Centre (AOC-F). Lastly, he mentioned the setting up of the Severe Weather Forecasting Demonstration Project aimed at demonstrating how co-operative work among meteorological centers can be further implemented in order to enhance the forecasting process of several types of

severe weather and to improve the warning services at the NMHSs. The Demonstration project offers an opportunity to prepare many NMHSs and all GDPFS centres to implement and benefit from the outcomes of the THORPEX research and development programme.

### ***Presentations on the Monsoon Activity Centres***

#### *Monsoon Activity Centre (Kuala Lumpur)*

Dr Kang Thean Shong (Malaysia) presented an overview of the activities of the Kuala Lumpur Monsoon Activity Centre which includes: Development of the Fire Danger Rating System for ASEAN; Participation at the Joint Meeting of Seasonal Prediction on East Asian Summer Monsoon; Hosting of Symposium on the Asian Winter Monsoon: Quarter Century and Beyond in Kuala Lumpur, 4 to 7 April 2006; Publication of the ASEAN Compendium of Climatic Statistics in February 2004; Attendance at the Joint Meeting of Seasonal Prediction on East Asian Winter Monsoon; Hosting of the WMO Regional Seminar On Enhancing Service Delivery By National Meteorological And Hydrological Services In WMO RA V (2-6 April '07); Hosting of the Informal Regional Ministerial Consultation on Climate and Extreme Weather Impacts and Predictability (16-19 April 2007) and enhancing activities of the Centre through international collaboration.

#### *Monsoon Activity Centre (New Delhi)*

Dr H.R. HATWAR (India) made a presentation of the activities of the Indian Meteorological Department (IMD) related to tropical cyclones and monsoons. He emphasized that the IMD accords great importance on the development of: tools/techniques for monitoring and forecasting severe weather systems like cyclones, thunderstorms, and heavy precipitation events, very high resolution numerical models to predict tropical cyclone development, intensity, movement and storm surge/inundation, and dynamical models for prediction of various phases of monsoon. IMD recognizes that need: to utilise non-conventional data - satellite products, radar inputs, for systematic analysis of climate data and model predictions/projections and for impact studies in respect of climate change and global warming. Lastly, IMD also participates in the development of disaster management policies and preparedness strategies.

#### *Monsoon Activity Centre (Beijing)*

Dr Zuqiang Zhang (China) presented a report on the current status of the East Asian Monsoon Activity Centre (EAMAC) and its future work. The EAMAC was endorsed by the 14th session of WMO CAS in February 2006 to improve operational capabilities on East Asian monsoon monitoring, prediction and services, to provide training related to the Asian monsoon and to organize and coordinate activities on East Asian monsoon research. He mentioned that one of the ongoing activities of EAMAC is the preparation of the Third FOCAII, a forum which will be held in Beijing from 4 to 6 April 2006. So far, 36 experts from 18 countries had registered. EAMAC will also participate at the 8th joint meeting of seasonal prediction on East Asian winter monsoon. Three visiting scholars are currently in EAMAC doing research work on monsoons for a three month period. On capacity building, a multi-model ensemble system for Seasonal and Interannual prediction in East Asia is being developed in EAMAC, a proposal was submitted to the Chinese Ministry of Forestry (CMOF) for improving East Asian monsoon prediction under the

umbrella of COPES/WRCP and another proposal was submitted to the Chinese Ministry of Science and Technology (CMOST) for raising capability in monitoring, predicting and warning of extreme climate events in China, EAMAC will soon establish its scientific steering group and complete its web site. A scientist from Hawaii University will be invited by EAMAC to develop a daily monitoring system for East Asian monsoon.

As one of the task of the working group, it was decided that the role of the three monsoon activity centres be reviewed and reformulated.

### **5.3 Numerical Modelling in the tropics**

Dr Hiroto KITAGAWA (Japan) presented a report on the current status of the operational limited area model. In the case of the UK Met office Unified Model the current UM operational specification is 12 km L38 for North Atlantic and Europe (NAE) area. For analysis, 4D-Var has been implemented since March 2006 for the regional model. Another high resolution nested model which covers UK domain with the resolution of 4 km L38 has been run additionally. DWD (Germany) has started to operate a nonhydrostatic limited area model LM (Lokal-Modell) on 1997. Since September 2005, the number of model levels has been enhanced from 35 to 40 and the domain has been enlarged from 325x325 to 665x667. Lateral boundary condition is supplied by the Icosahedral grid global model GME. The Japan Meteorological Agency (JMA) replaced a hydrostatic spectral mesoscale model with a nonhydrostatic model (JMA-NHM) in September 2004. Since March 2006, the resolution has been enhanced from 10 km L40 to 5 km L50. As for data assimilation, the Meso 4D-Var has been implemented since March 2002. National Centres for Environmental Predictions (NCEP-USA) has been running a regional model 4 times a day for the NAM (Northern American Mesoscale) domain with a resolution of 12 km L60. In June 2006 the nonhydrostatic WRF-NMM replaced the hydrostatic Eta model. In the NAM domain, high resolution limited area models have been nested for domains called HiRes Window. Meteorological Service of Canada has developed a SI-SL global unified model GEM (Global Environmental Multiscale Model). Using a variable grid mesh, the horizontal resolution over Canada domain is enhanced without lateral boundary conditions. A 4D-Var data assimilation system has been implemented since March 2005 for the uniform resolution assimilation cycle. In summary, he stated that most of numerical models show a steady improvement on predicting tropical storm tracks and that multi-model ensemble may provide more reliable predictions, However, there are specific error characteristics commonly seen by many models. He presented some case studies on the parameterization problem and stated that physical parameterizations are still key issues of numerical modelling over tropics, the ratio between parameterized (subgrid-scale) and non-parameterized (grid-scale) precipitation is uncertain and that observation from satellites can give useful information to improve physical processes of model. (ex. TRMM, CloudSat, ...).

### ***T-PARC***

Dr Dehui Chen provided the meeting with an overview of the THORPEX Pacific Asian Regional Campaign (T-PARC), a major international research campaign called that will have a field phase in 2008. T-PARC is the community's first scale interaction experiment aimed at medium range weather prediction. The goals of T-PARC are to increase understanding of the factors that limit our ability to predict both high-impact weather over the densely populated regions

of East Asia's Pacific Rim and the downstream effects of these processes on weather events over North America. T-PARC is mainly motivated from the Asian and North American perspective: Societal and economic impacts from the High Impact Weather, such as heavy rainfall associated with the Meiyu front, convective systems, tropical cyclone (typhoon), extra-tropical transition (ET) and winter wind storms. Its scientific objectives includes : Advance knowledge of the factors that limit the predictability of HIW events over the Asia-Pacific (e.g, p. deep convection, TCs, ETs, and other heavy rainfall); Improve understanding of forecast error growth and the role of multi-scale interactions; Develop the data assimilation strategies; to test new strategies and observational systems for adaptive observing and modeling; To quantitatively predict the reduction in forecast error variance due to supplemental / targeted observations; Test the improvement in local forecast skill afforded by HR\_NH modeling of the HIW events; Improving the interpretation and utility of ensemble forecast systems; Advancing knowledge of the dynamics that produce HIW events over the Asia-Pacific; Understand and improve society's response to weather disasters. He mentioned that the Science Plan Overview and the Experiment Design Overview was submitted to the National Science Foundation in January 2006 and received very strong scientific reviews. It included letters-of-intent from approximately 30 investigators and was approved to allow submission of a detailed facility request document. Further, the Facility Request for NSF/EOL supported platforms was submitted September 2006. Lastly, he mentioned that in the spirit of A-TREC, the North America and Asian Regional Committees encourage scientific participation from other regions. Based on the Cardinali (ECMWF) and Weissmann (DLR) results, the DLR Doppler lidar on HIAPER is the highest (and currently only) observational system requested from the EU. It is a high priority for T-PARC, but may be difficult to fully fund. The group had requested TIGGE in "real-time" for the field phase and had asked that the operational centers in the EU consider data impact and denial studies for T-PARC. It is hoped that some of the research expertise from the EU academic, operational and research laboratories become entrained into T-PARC in the areas of ET, Rossby wave dynamics, data assimilation and other fields. This is happening already and T-PARC, like other THORPEX efforts, will have a relatively open data policy.

#### **5.4 Impact of climate change on tropical weather systems**

Dr John McBRIDE (Australia) presented a summary of the activities/accomplishments of the project TC-2: Impact of Climate Change on Tropical cyclones, the main purpose of which was to report to WMO on developments in this area, for the purpose of giving advice to NMHS's. It's main activity therefore was to issue an expert statement by prominent tropical cyclone researchers from around the world summarising the current state of knowledge on tropical cyclones and climate change. In 1998, a statement was released by the group headed by Dr Ann Henderson Sellers which was published in the Bulletin of American Meteorological Society. In late 2005, Dr McBride reformed the Committee in late 2005 whose purpose is to provide an updated assessment of the current state of knowledge of the impact of anthropogenically induced climate change on tropical cyclones. The members of the Committee are: John McBride (Australia, Committee Chair); Kerry Emanuel, Thomas Knutson, Chris Landsea, Greg Holland, Hugh Willoughby (USA); Johnny Chan, C-Y Lam (Hong Kong, China); Julian Heming (United Kingdom), and Jeff Kepert (Australia). The Committee issued a 4-page statement that was circulated to all Permanent Representatives attending CAS-XIV (CapeTown, Feb 2006). In late 2006, a statement on tropical cyclones and climate change was issued during the IWTC-VI (San Jose, Nov 2006). This statement was authored by participants of the said workshop and was the result of

discussions and review made through the two weeks of the workshop. The process was overseen by the WMO Tropical Meteorology Research Programme TMRP Committee TC2: Impact of Climate Change on Tropical Cyclones. The members of the group includes: John McBride (Australia, Committee Chair); Kerry Emanuel, Thomas Knutson, Chris Landsea, Greg Holland, Hugh Willoughby (USA); Johnny Chan, C-Y Lam (Hong Kong, China); Julian Heming (United Kingdom), Jeff Kepert (Australia). The by invitation-only workshop is sixth in the series held every four years to bring together researchers and practitioners in the field of tropical cyclone forecasting. The Sixth Workshop was attended by 125 delegates from 34 different countries and regions. The Statement has been requested by WMO leadership and many heads of National Meteorological and Hydrological Services so they can respond to questions from the media, and also to assist in advising their governments on future activities and how to respond to climate change effects. A press release was issued by WMO and the statement was made available online on the WMO web site. Subsequently the American Meteorological Society (AMS) adopted the statement, word for word, as their own statement on the topic: the link appeared on the AMS web page under "Statements of the AMS". The Working Group I of the Intergovernmental Panel on Climate Change (IPCC), issued their Summary for Policy Makers (SMP) Feb 2007 and great care was taken to ensure that the SMP was consistent with the IWTC-VI statement. Dr McBride then proposed at the meeting that the Committee for Climate Change Aspects of Tropical Cyclones continue and be given some official status, that the members be the same as those in the group formed in November 2005, that the committee report to WMO on the topic every two years and its report to be published as a WMO TMRP Series report, with a WMO Technical Document number, and if possible, the committee should meet in person every couple of years to develop strategies for which aspects to report on in this cycle. Lastly, he posed a question on what will the working group do about other aspects of tropical weather systems under climate change such as tropical droughts and changes in the monsoon pattern.

All of the above reports were taken into consideration in the formulation of WGTMRs future work plans.

## **6. STRATEGIC FRAMEWORK FOR IMPLEMENTATION OF WGTMR ACTIVITIES**

The achievements/shortcomings of the working group were reviewed, and put into the context of the WMO strategic orientation toward the promotion of natural disaster prevention and mitigation policies. Using the draft outline of the WWRP Strategic Plan: 2008-2015 prepared for the upcoming meeting of the Joint Steering Committee of WWRP (Geneva, 23 to 25 April 2007), the group began to define a strategic framework for implementation of future activities of WGTMR, with stated goals, approaches, metrics (how to measure whether the projects are successful or not), time-line and designated focal points/rapporteurs.

The WGTMR considered the section of the draft WWRP Strategic Plan related to the WGTMR which is outlined in sections A-F below.

- A. Scope**
  - Research Goals
  - Objectives

## **B. Terms of Reference**

(The following terms of reference from CAS-XIV were considered and will be revised in consideration of the proposed structure of the WGTMR in section 7 below after that proposed structure is approved by the JSC-WWRP in April 2007.

(a) To monitor the implementation of existing priority projects within the WMO Tropical Meteorology Research Programme (TMRP) and to further develop other appropriate research projects as the need arises, under the following main programme components:

- (i) Tropical cyclones;
- (ii) Monsoon studies (on regional and global scales);
- (iii) Tropical drought and rain-producing systems;
- (iv) Limited-area modelling in the tropics;
- (v) Interaction between tropical and mid-latitude weather systems;
- (vi) Tropical meteorology and climate.

(b) To identify and support research initiatives of NMHSs in tropical countries, generally including collaboration with groups in universities or research institutes, which are likely to lead to economic benefits, particularly in agriculture and water resources management;

(c) To keep under continuous review developments in research aspects of the WMO Tropical Cyclone Programme (TCP) by maintaining close liaison with TCP regional bodies and to facilitate coordination of research at regional levels.

## **C. Tropical Cyclone Research**

## **D. Monsoon Research**

## **E. Impacts of Climate Change on Tropical Cyclones and Monsoons**

## **F. Products and Services**

The group also made the following recommendations related to non-TMRP sections of the draft Strategic Plan outline:

- a. Merge nowcasting (3.2) and mesoscale weather forecasting (3.3) of mid-latitude weather systems into a single working group.
- b. Move Societal and Economic Applications (3.6) to section 4 (Common Research Issues) and incorporate Societal and Economic Applications into each of the working group structures.
- c. Replace subsection 3.4.6 Products and Services with Research Outputs.
- d. Move Forecast Verification (3.5) into section 4 (Common Research Issues) and consider forecast verification into each working group.

## **7. REVISED STRUCTURE OF WGTMR**

To provide a more structured programme to carry out its objectives cost-effectively in the near term, the working group proposed the revised structure of WGTMR as shown in Annex IV.

The working group also felt that the name of the working group should be maintained as “Working Group on Tropical Meteorology Research” with the acronym WGTMR.

In line with the focus of WMO/CAS on improving the scientific knowledge on natural hazards and strengthening natural disaster reduction capacities through early warning systems, special emphasis will be placed on further improving forecasts of high impact weather related to tropical cyclone landfall and monsoon as well as possible impacts of climate change on tropical cyclones.

## **8. WORK PLAN (2007 – 2009)**

A primary task is to provide further inputs to the draft WWRP Strategic Plan during the next 18 months. The Panel Chairs in the proposed WGTMR structure above will summarize the inputs from the participants received at the meetings seek inputs from other experts, and then prepare a first draft of their respective sections. After agreement among these contributors is reached, the revised draft will be provided to the WGTMR Chair, who will produce a combined draft. After another iteration among all contributors, the WGTMR will submit the revised draft to the WWRP for blending with drafts from the other WWRP Working Groups. Additional iterations may be necessary to complete the WWRP Strategic Plan within the deadline of 18 months.

The meeting reviewed the objectives and structure of the quadrennial International Workshop on Tropical Cyclones (IWTC) and International Workshop on Monsoons (IWM). The meeting considered these workshops to be keystone activities of the WGTMR and strongly endorsed the holding of the Fourth IWM in 2008 and the Seventh IWTC in 2010.

The meeting requested the WMO Disaster Prevention and Mitigation Programme to continue to secure funding from donor countries/agencies for the forecast demonstration project for the Philippines.

The meeting reviewed the preparations for the upcoming International Training Workshop on Tropical Cyclone Disaster Reduction (March 2007).

It was decided to let the concerned Panels decide on the following possible activities:

- 8th Training Workshop on Monsoons (2008).
- Workshop on effect of climate change on tropical cyclone activity (2008).
- OJT and Roving Seminar on LAM NWP in the tropics (2007-2008).
- QPE/QPF with TC and Monsoons (2009).

## **9. CLOSING OF THE MEETING**

The report of the meeting was adopted at 11:50am on 24 March 2007.

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**REPORT of THE WMO/CAS WORKING GROUP  
on TROPICAL METEOROLOGY RESEARCH  
(Guangzhou, China, 22 – 24 March 2007)**

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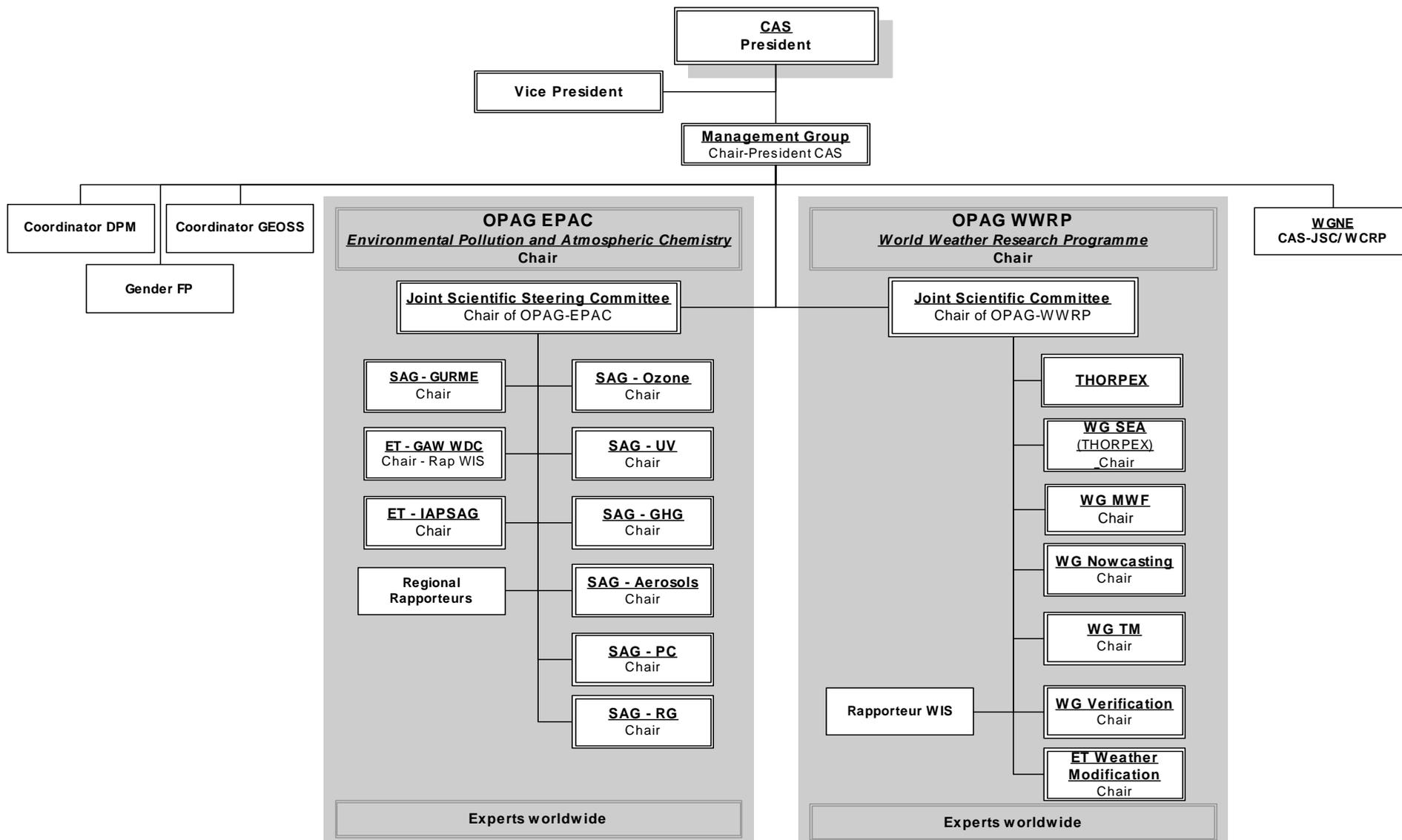
**REPORT of THE WMO/CAS WORKING GROUP  
on TROPICAL METEOROLOGY RESEARCH  
(Guangzhou, China, 22 – 24 March 2007)**

**Agenda**

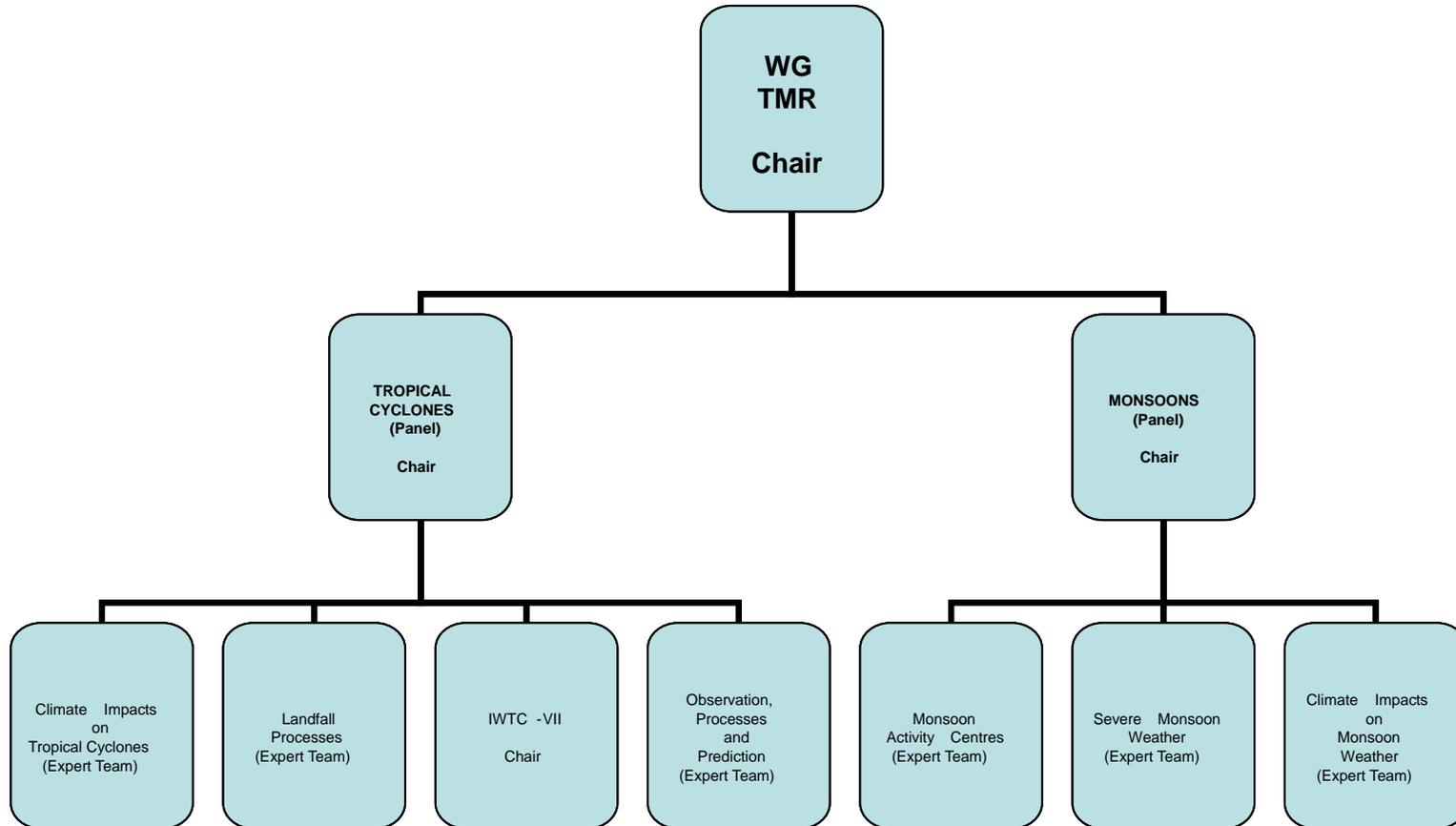
- 1. Opening of the Meeting**
- 2. Adoption of the Agenda**
- 3. Briefing on Relevant CAS-XIV Resolution**
- 4. Report of the Working Group Chair**
- 5. Report on the Major Programmes of WG on TMR**
  - 5.1 Tropical Cyclone Research
  - 5.2 Monsoon Studies
  - 5.3 Numerical Modeling in the Tropics
  - 5.4 Impact of Climate Change on Tropical Cyclones
- 6. Structure of WG of TMR**
- 7. Strategy or Future Direction of the WG on TMR**
- 8. Activity Plan for the Next Three Years**
- 9. Closing of the Meeting**

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Working Structure of the Commission of Atmospheric Sciences (CAS)



Revised Structure of the Working Group on Tropical Meteorology Research (WGTMR)



## **World Weather Research Programme (WWRP)**

### **Report Series 2007**

Sixth WMO International Workshop on Tropical Cyclones (IWTC-VI), San Jose, Costa Rica, 21-30 November 2006 (WMO TD No. 1383) **(WWRP 2007 - 1)**.

Third WMO International Verification Workshop Emphasizing Training Aspects, ECMWF, Reading, UK, 29 January - 2 February 2007) (WMO TD No. 1391) **(WWRP 2007 - 2)**.

WMO International Training Workshop on Tropical Cyclone Disaster Reduction (Guangzhou, China, 26 - 31 March 2007) (WMO TD No. 1392) **(WWRP 2007 - 3)**.

Report of the WMO/CAS Working Group on Tropical Meteorology Research, Guangzhou, China, 22-24 March 2007 (WMO TD No. 1393) **(WWRP 2007 - 4)**.