



World Meteorological Organization

Working together in weather, climate and water

# WMO's TROPICAL CYCLONE PROGRAMME (TCP)

JMA/WMO Workshop on Effective TC Warning in SE Asia (Tokyo, 2014)



# Outline

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- 1. Statutory Status and Coordinating Structure**
- 2. Support to Operational Forecasting**
- 3. Capacity Development**
- 4. Challenging Issues**



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## Overview

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The **Tropical Cyclone Programme** (TCP) is a part of WMO's Weather and Disaster Risk Reduction Services Department tasked to establish national and regionally coordinated systems to ensure that the loss of life and damage caused by tropical cyclones are reduced to a minimum.

**TCP** is effected on both national and regional levels through cooperative action. It covers activities of Members, WMO regional associations, other international and regional bodies and the WMO Secretariat.



# TCP's Vision

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...that the national and regionally coordinated systems that it had helped establish will ensure that the loss of life and damage caused by tropical cyclones are reduced to a minimum.



# TCP's Mission

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to encourage and assist its Members to:

- Establish and upgrade **early warning systems** with multi-hazard configuration;
- provide **forecasts and assessments of floods** associated with tropical cyclones;
- promote **awareness to warnings** and carry out activities at the interface between the warning systems and the users of warnings, including public information, education and awareness;
- provide the **required basic meteorological and hydrological data and advice** to support hazard assessment and risk evaluation of tropical cyclone disasters; and
- establish **national disaster risk management and reduction mechanisms**.



# TCP Components

❑ **General Component** is concerned with methodology like transfer of technology, information and scientific knowledge to Members, towards meeting the objectives of the TCP. It also encompasses the broader training requirements of the TCP.





# TCP Components

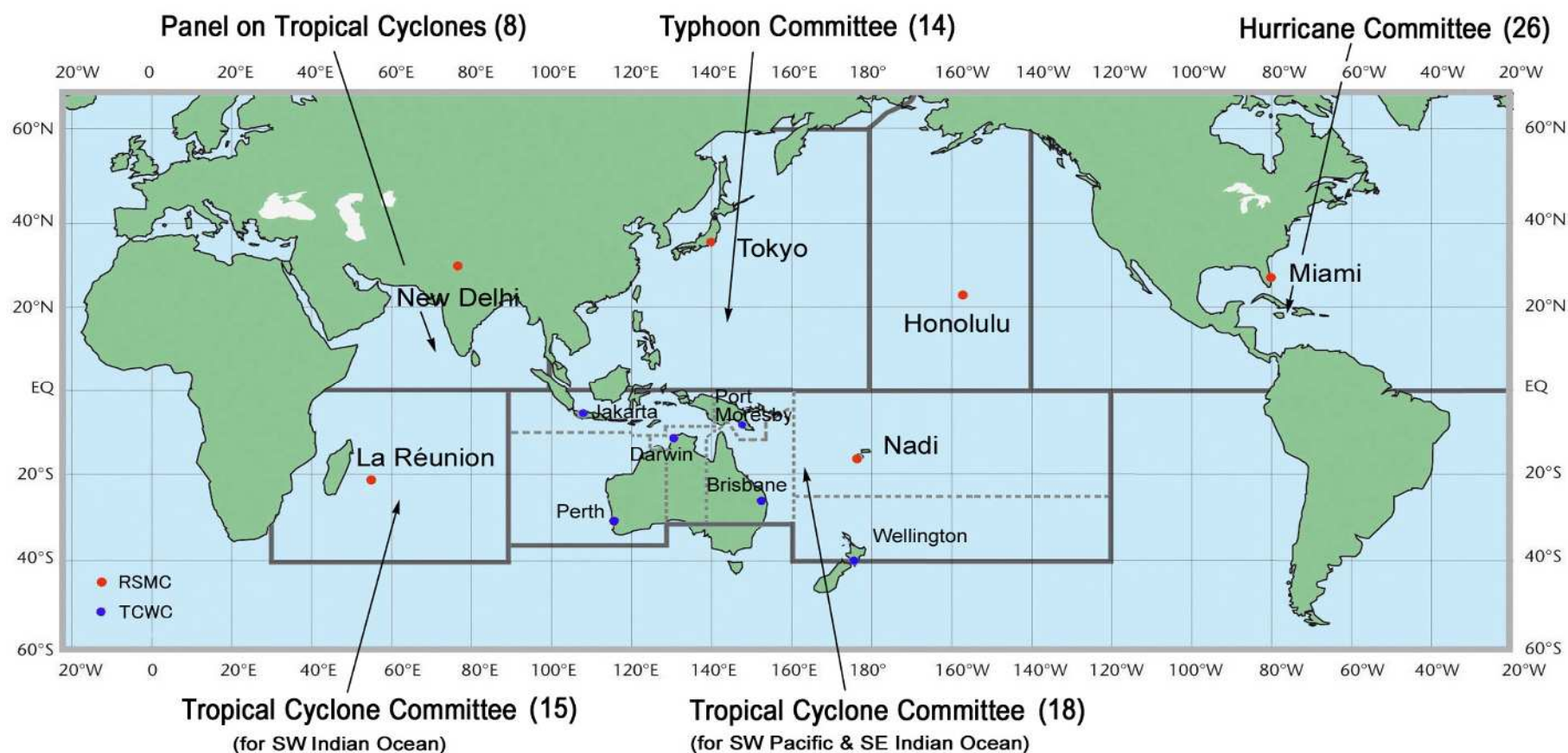
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❑ **Regional Component** comprises the planning and implementation of the programmes of the TCP Regional Bodies. Each of the five Regional Bodies has an Operational Plan or Manual which records the agreements reached on the sharing of responsibilities for the warning services, and their infrastructures, throughout its region.





# TC Regional Warning Centres and TC Regional Committees



JMA/WMO Workshop on Effective TC Warning in SE Asia (Tokyo, 2014)



# TCP's Scope

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- *Operational Meteorology*
- *Hydrology*
- *Prevention and Preparedness*

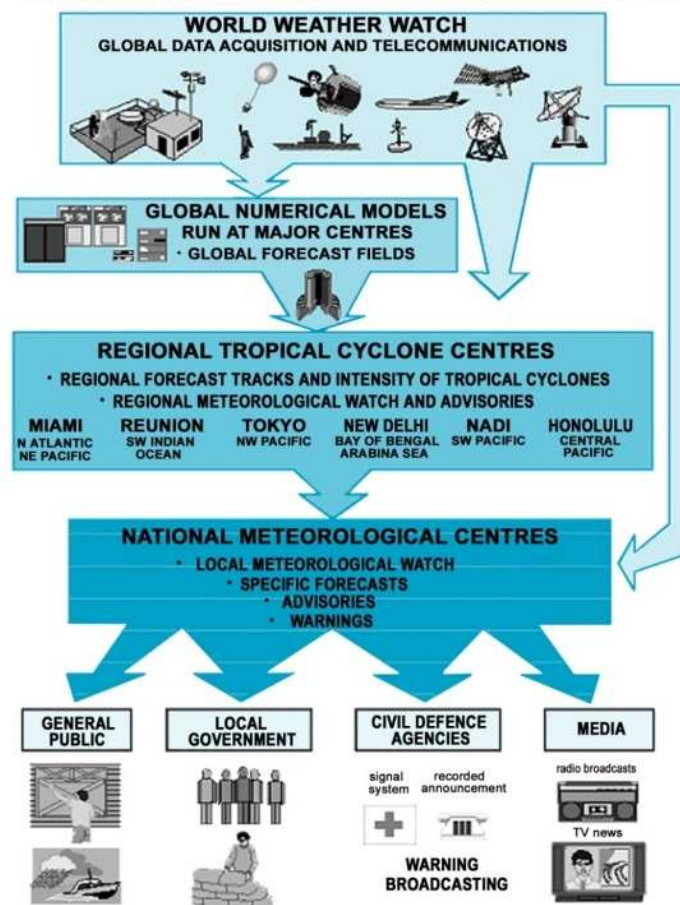


# Tropical Cyclone Warning Service

## Cascading Warning Process

- Data from **Global Observation System** to TC Regional Centres and to Numerical Weather Prediction (NWP) Centres;
- **NWP Centres** to provide NWP products of TC track and intensity forecasts;
- **Regional Centres** to make analyses & forecast and prepare regional advisories for NMCs;
- **NMCs** to issue alerts, advisories and warnings and to liaise with Disaster Management Offices.

## GLOBAL NETWORK OF TROPICAL CYCLONE EARLY WARNING SYSTEM

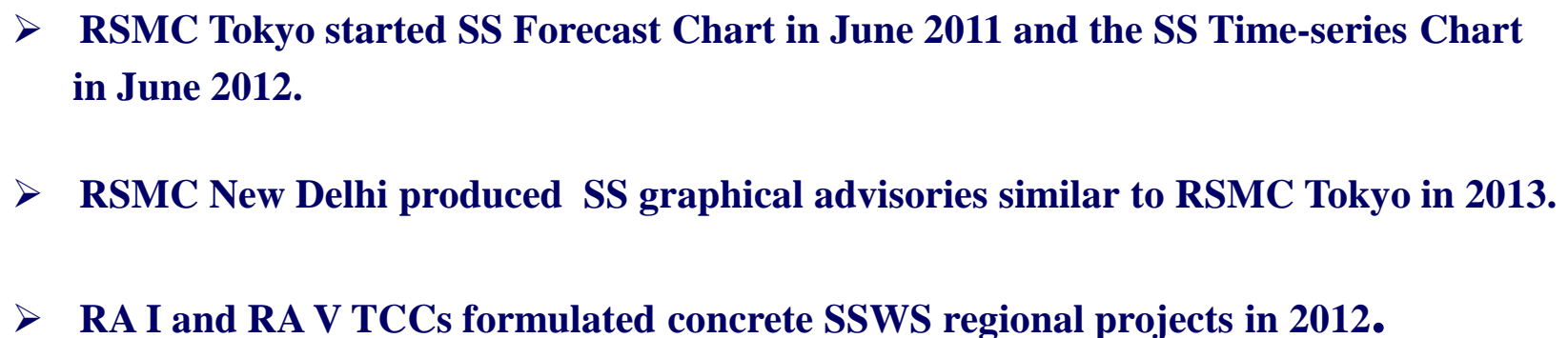




## Regular Session of TC Regional Bodies (*Operational Plan*)

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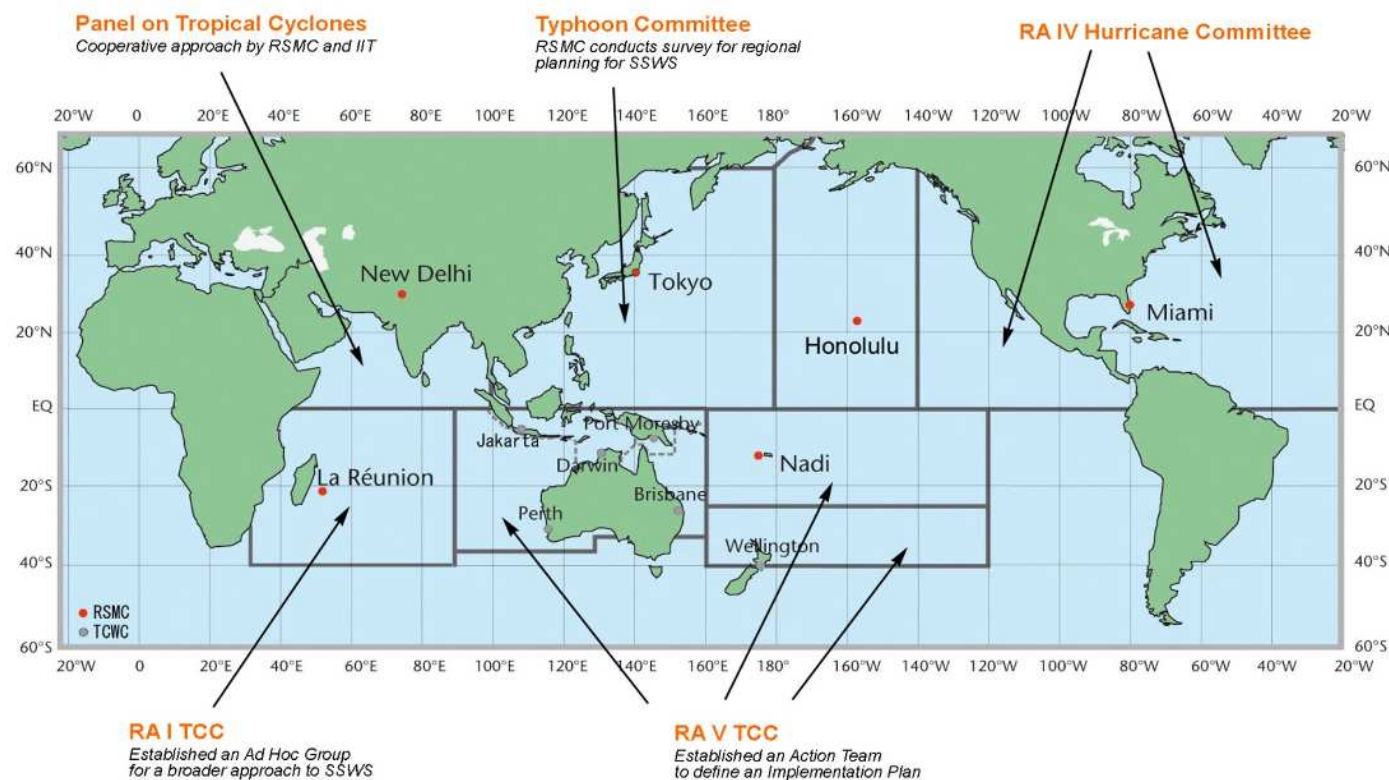
- **ESCAP/WMO Typhoon Committee (*annual*)**  
*(46<sup>th</sup> Session, 10 - 13 February 2014, Bangkok, Thailand)*
- **WMO/ESCAP Panel on Tropical Cyclones (*annual*)**  
*(41<sup>st</sup> Session, 2 - 6 March 2014, Dhaka, Bangladesh)*
- **RA V Tropical Cyclone Committee (*biennial*)**  
*(15<sup>th</sup> Session, 26 - 29 May 2014, Vanuatu)*
- **RA I Tropical Cyclone Committee (*biennial*)**  
*(21<sup>st</sup> Session, TBD)*
- **RA IV Hurricane Committee Session (*annual*)**  
*(36<sup>th</sup> Session, 7 - 10 April 2014, Cancun, Mexico)*







# Storm Surge Watch Scheme



➤ *Actions were taken in all the basins  
on the initiative of RSMCs.*



## Decisions of Cg-16 (*related to TCP*)

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1. Assist Members in their efforts to implement TCP activities to safeguard life and property from tropical cyclones and related hazards to the maximum extent possible within the available budgetary resources;
2. Continue to support the capacity building programmes for developing countries, especially for Least Developed Countries and Small Island Developing States;
3. Maintain and further enhance the collaboration between the Tropical Cyclone Programme and relevant WMO Programmes and Technical Commissions, particularly in relation to the development of tropical cyclone forecasting competencies;
4. Continue close cooperation with other international as well as relevant national organizations at the global and regional levels to promote a multidisciplinary and multi-hazard approach towards the attainment of the humanitarian goals of the Programme.



# Outline

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1. **Statutory Status and Coordinating Structure**
2. **Support to Operational Forecasting**
3. **Capacity Development**
4. **Challenging Issues**





# Application of Research and Development

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## TCP/WWRP joint activities

- *International Workshop on Tropical Cyclones and IWTC Landfall Processes Series*
- *International Workshop on Satellite Analysis of Tropical Cyclones (IWSATC)*  
*- Honolulu, Hawaii, USA, 13 to 16 April 2011*
- *International Workshop on Rapid Change Phenomena in Tropical Cyclones*  
*- Haikou, China, 5 – 9 November 2012*



# Application of R&D (cont'd)

## International Workshop on Satellite Analysis of Tropical Cyclones (IWSATC)

### General Outcomes

- Much greater interagency understanding. This workshop was an “eye opener” to many of the attendees.
- Significant documentation of some of the causes of interagency differences in intensity estimates.
- Important feedback from forecasters to developers of the emerging objective techniques.
- Dialogue started between researchers and operational centres regarding the sharing of observational datasets.





## Application of R&D (cont'd)

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### *Major Recommendations of IWSATC*

- Based on findings from the IWSATC, **develop guidelines** for the improvement of satellite analysis globally
- Strongly encourage the **sharing of national TC datasets** to allow improved validation of existing satellite intensity estimation methods
- Create and maintain **a centralized web site** hosted by WMO/TCP, with documentation summarizing regional TC satellite analyses and availability/upgrades to advancing objective methods.
- Expand **training material** focused on helping forecasters make optimal use of the available satellite-based intensity estimates.
- Hold **another WMO-sponsored IWSATC** in two or three years, synchronized with the next IBTrACS meeting if possible



# Transfer of R&D into Operation (cont'd)

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## ➤ Typhoon Landfall Forecast Demonstration Project

### *Objective*

- To demonstrate the performance of the most advanced forecasting techniques on landfalling typhoons.

## ➤ NW-Pacific TC Ensemble Forecast Project\*

### *Objective*

- To examine the utility of ensemble forecasts to operational typhoon forecasting.



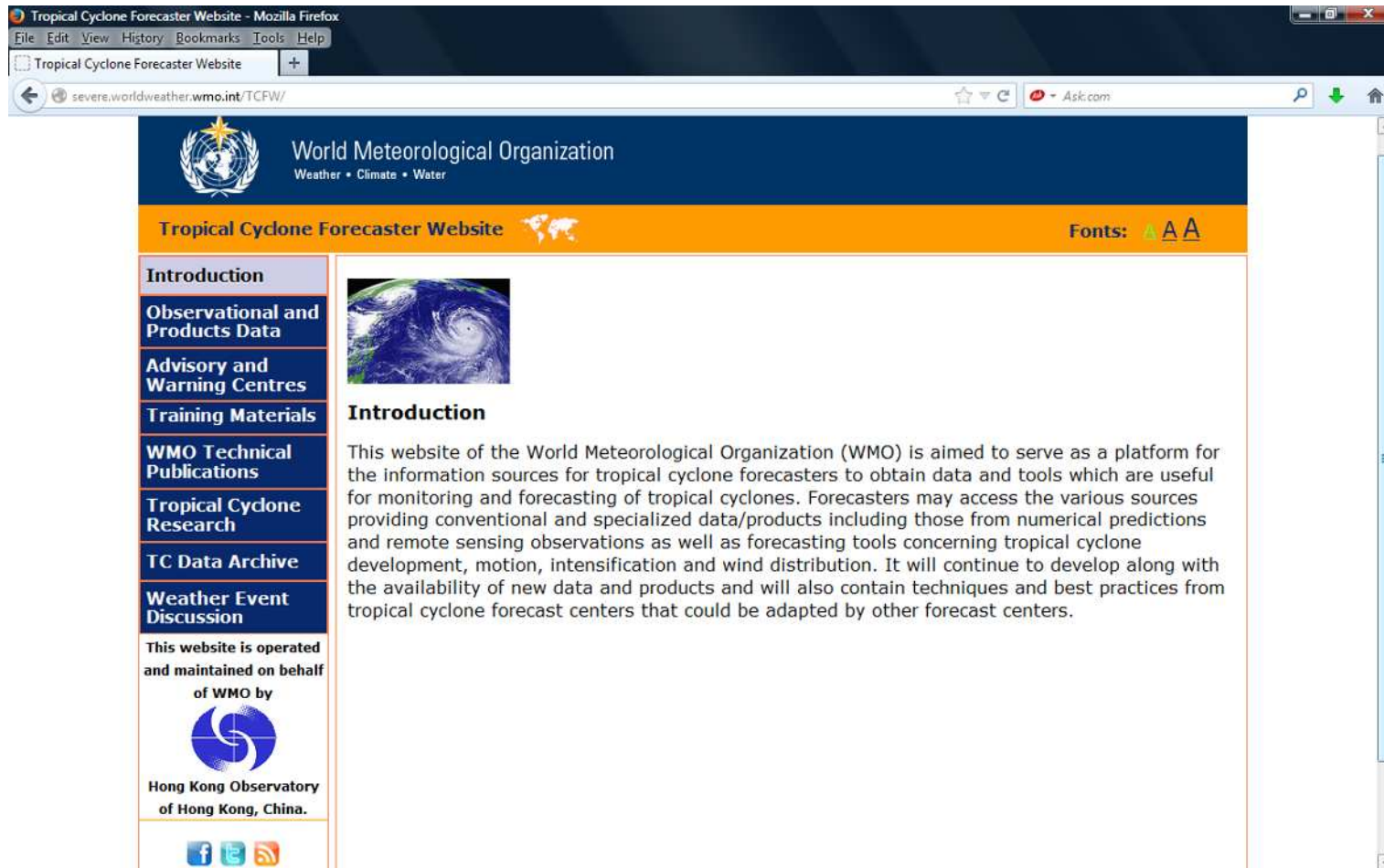
## ➤ **TC Forecaster Website**

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- Hong Kong, China agreed to host the TC Forecaster Website
- Management of the website was transferred from WMO/TCP to Hong Kong Observatory
- The website was established before the 2012 TC season in the S-Hemisphere.



## ➤ TC Forecaster Website

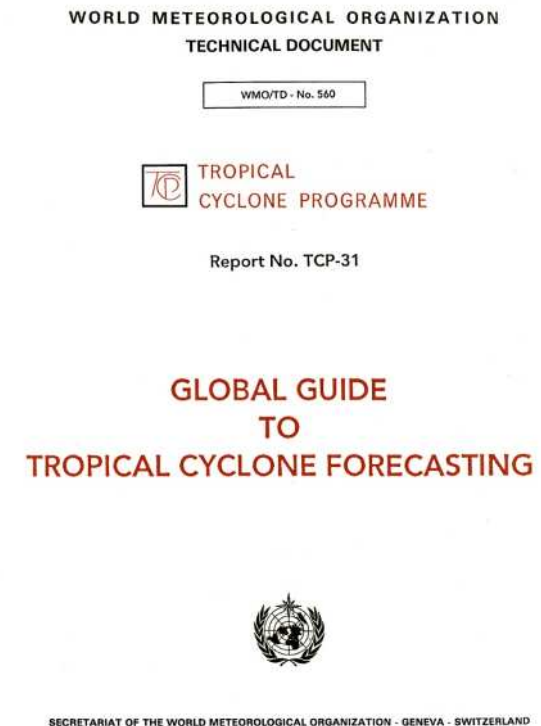


JMA/WMO Workshop on Effective TC Warning in SE Asia (Tokyo, 2014)



## ➤ Global Guide to TC Forecasting

- Update of Global Guide to TC Forecasting is being carried out under the initiative of Chip Guard
- Tailored for developing countries and “smaller” RSMCs/TCWCs
- It will be web-based and closely linked with TCP website and TCF website.



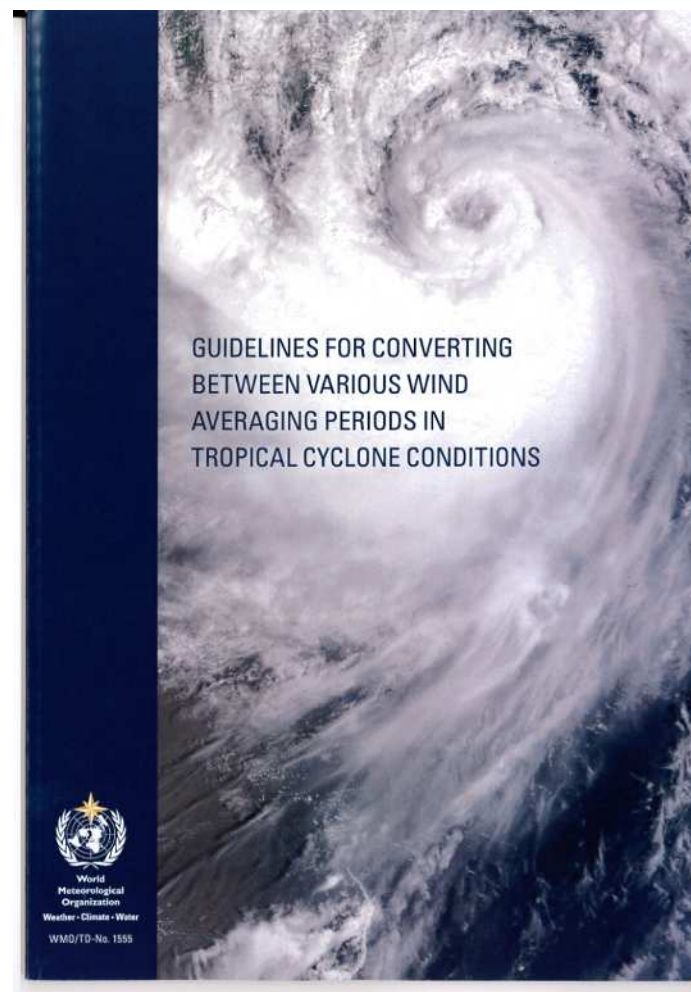




# Guidelines for Converting between Various Wind Averaging Periods

## *Defined averaging periods in the regions*

Committee	Region	Average Wind Speed
RA I Tropical Cyclone Committee	SW Indian Ocean	<b>10-min</b>
Panel on Tropical Cyclones	N Indian Ocean	<b>10-min</b> (recording) <b>3-min</b> (non-recording)
RA IV Hurricane Committee	Atlantic and NE Pacific	<b>1-min</b> (recording and non-recording)
RA V Tropical Cyclone Committee	S Pacific and SE Indian Ocean	<b>10-min</b> (1-min for USA territories)
Typhoon Committee	NW Pacific	<b>10-min, 2-min</b> (recording) <b>3-min</b> (non-recording)







## Guidelines for Converting between Various Wind Averaging Periods

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### Recommended Conversion Factors

$V_{max600}=K$ $V_{max60}$	At-Sea	Off-Sea	Off-land	In-Land
<b><i>K</i></b>	<b>0.93</b>	<b>0.90</b>	<b>0.87</b>	<b>0.84</b>
<b><i>Traditional</i></b>	<b>0.88*</b>	-	-	-

\*Bureau of Meteorology (1978)



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# Regular Training Course/Workshop

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- **RA I Training Course on Tropical Cyclones**  
*- La Reunion, France (biennial)*
- **Southern Hemisphere Training Course on Tropical Cyclones and Workshop on PWS**  
*- Melbourne, Australia (biennial)*
- **RA IV Workshop on Hurricane Forecasting and Warning**  
*- Miami, Florida, (annual)*
- **Training Workshop on Wave and Storm Surge Forecasting**  
*- annual, but in rotation by TC basins*





# Regular Attachment Training

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**RSMC Miami**

*- for RA IV Hurricane Committee*

**RSMC Tokyo**

*- for Typhoon Committee*

**IIT Delhi (storm surge)**

*- for Panel on Tropical Cyclones*

**RSMC New Delhi**

*- for Panel on Tropical Cyclones*

**RSMC Honolulu (Pacific Int'l Desk Training Program)**

*- for RA V Tropical Cyclone Committee*

**NOAA/NCEP (Tropical Training Desk Program)**

*- for RA IV (Central-America and Caribbean)*





# Storm Surge Watch Scheme

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- **RSMC New Delhi (2009)**
- **RSMC Tokyo (2012)**
- **RSMC Miami (planned in 2015)**





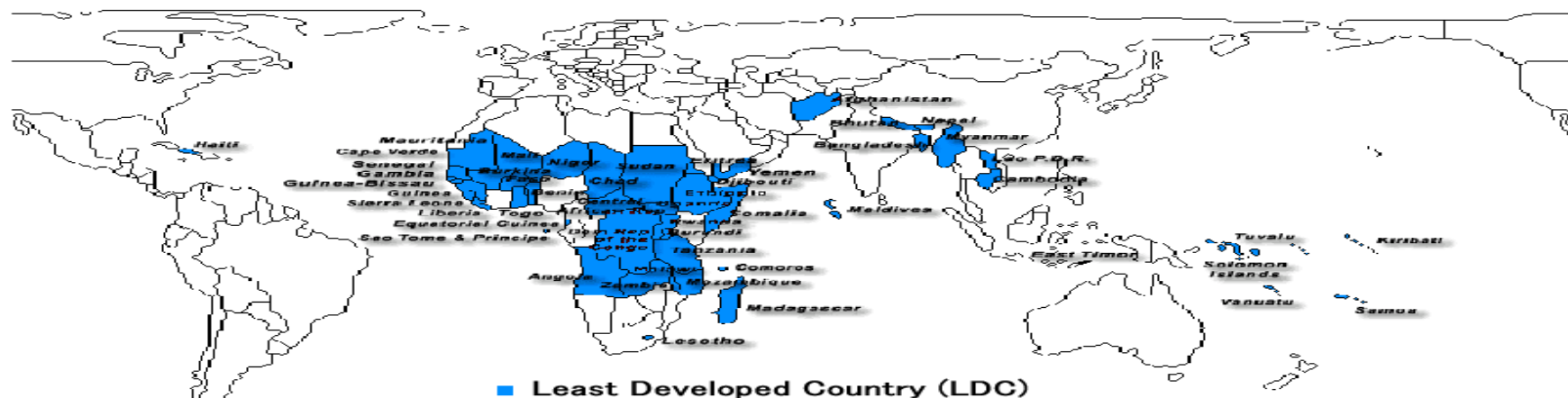
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# Challenges



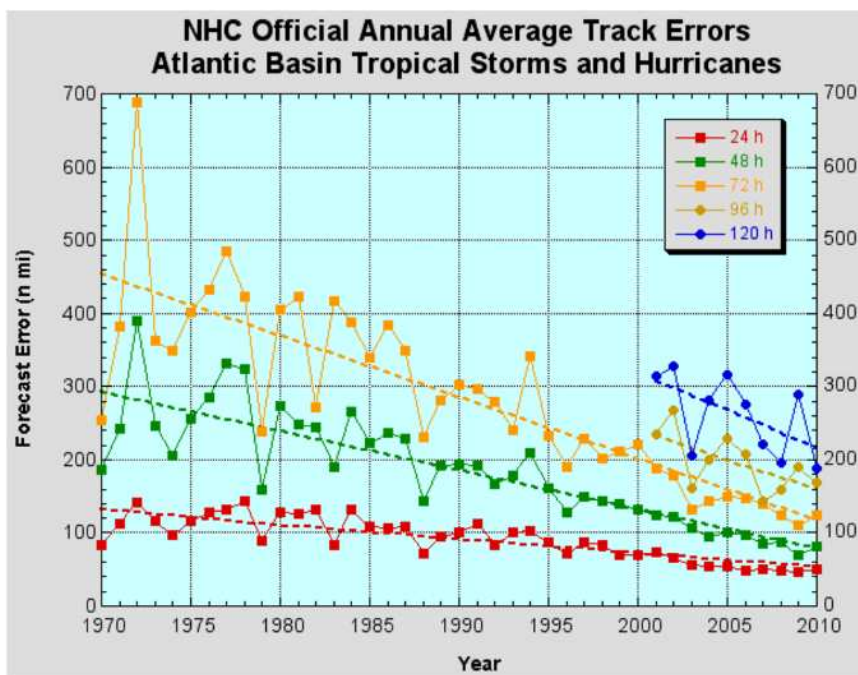
- Most of the members of TC Regional Committees are developing countries and LDCs/SIDSs.
- Gap is widening between developing and developed countries.

*Needs to develop human resources and communication capacity*  
→ *Enhancement of capacity building activities*  
*From GTS to WIS (WMO's communication infrastructure)*



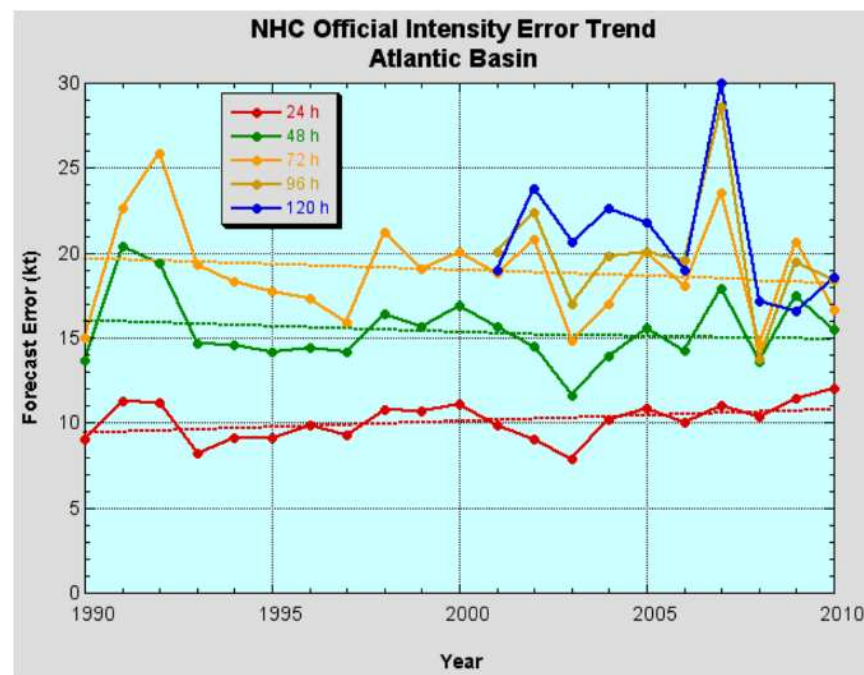
# Challenges

- Track forecast has been improved, while intensity forecast still is a serious challenge.



*Track Forecast Errors*

**(RSMC Miami)**



*Intensity Forecast Errors*





# Challenges

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- **Rapid changes of TC movement (speed and direction), particularly during landfall**
- **Forecast of rainfall/flooding (remotely) associated with TCs (e.g. QPE/QPF)**



# Challenges

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## Storm Surge Watch Scheme

- Marine forecasting capabilities are very limited in almost all countries.
- Local / regional storms surge, wave and tsunami models and modeling capabilities are in general non-existent.



# Priority Areas

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## Capacity Building

- Warning capabilities of the Members improved through TCP/PWS joint training workshops in RAs I, IV and V, and the attachment trainings.
- Cooperative linkage established with the Severe Weather Forecast Demonstration Project (SWFDP).
- Requirement for human resources still pressing in developing countries, especially SIDS and LDCs. Competency Standards

## Support to Operational Forecasting

- Increasing need to support forecasters to meet user's demand through efficient utilization of advanced technologies, data and products.
- Need for early update of the Global Guide to Tropical Cyclone Forecasting and enhancement of the WMO Tropical Cyclone Forecaster Website.



# Priority Areas

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## Application of Research and Development

- Cooperative interaction promoted between forecasters and researchers through TCP/WWRP joint workshops.
- As its outcome, projects launched aiming to operationalize R&D achievements and to improve satellite analyses and database.
- Need to further strengthen the cooperation on both global and regional bases.

## Storm Surge Watch Scheme (SSWS)

- Through collaboration with JCOMM, regional SSWSs implemented in all the cyclone basins with the initiative of TC RSMCs.
- Need to develop the warning capability also on a national level through capacity building to establish the SSWS globally.



# Priority Areas

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## Global Coordination

- Demands are growing for enhanced sharing of technologies and standardization of procedures/products across the regions.

## Regional Tropical Cyclone Bodies

- Regional TC bodies taking increasing roles as platforms for various regional projects of WMO Programmes including DRR, DPFS, MMOP, WWRP and HWR as well as for Tsunami EWS projects of ICG.
- Need to ensure active involvement of hydrologists and DRR experts to strengthen the link between the three key areas of the regional activities – meteorology, hydrology and disaster risk reduction.



# Planned TCP Actions for 2014

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1. Capacity building  
*Workshop on Hurricane Forecasting and Warnings and Public Weather Services*  
*(Mar.RSMC Miami)*  
*Attachment Training (RSMCs Tokyo/New Delhi/Honolulu)*  
*Competency Standards*
2. Application of R&D outcomes  
*Int'l Best Tracks Archive for Data Stewardship (IBTrACS) (TBD)*  
*8th Int'l Workshop on Tropical Cyclones & IWTCLP-III\_ (Dec.2-10, Jeju, Korea)*  
*Implementation of Typhoon Landfall FDP*  
*Implementation of NW Pacific Ensemble Forecast Project*  
*Workshop on High Impact Weather*
3. Storm Surge Watch Scheme  
*Storm Surge Workshop (TBD)*  
*Attachment Training at IIT*
4. Support to operational forecasters  
*Publication of Global Guide (Web version and hard copy (limited number))*  
*Improvement of TC Forecaster Website*



# TCP's Partners



United Nations  
International Strategy for Disaster Reduction



United Nations  
Educational, Scientific and  
Cultural Organization



Intergovernmental  
Oceanographic  
Commission



International Federation  
of Red Cross and Red Crescent Societies



## WMO Programmes

- PWS
- DPFS
- MMO
- DRR
- SP
- AEM
- HWR
- RP
- ETR



## **WORLD WEATHER RESEARCH PROGRAMME**

Develops improved and cost effective weather forecasting techniques, with emphasis on high impact weather and promotes their application among Member States.







# TCP's Partners



	<b>WORLD WEATHER RESEARCH PROGRAMME</b> Develops improved and cost effective weather forecasting techniques, with emphasis on high impact weather and promotes their application among Member States.
	<b>SYNOPTIC PREDICTABILITIES (THORPEX)</b> A 10-year international research and development programme to accelerate improvements in the accuracy of one-day to two-week high impact weather forecasts for the benefit of society, the economy and the environment.
	<b>Mesoscale Weather Forecasting Research</b> Promotes, organizes and/or endorses end-to-end weather research and development projects (RDPs) including understanding of weather processes, improving forecasting techniques and the utility of forecast information with an emphasis on high-impact weather.
	<b>Tropical Meteorology Research</b> Identifies and supports the research initiatives of NMHSs in tropical countries, generally including collaboration with groups in universities or research institutes, which are likely to lead to social and economic benefits, particularly in the prevention of disasters during severe weather associated with tropical cyclone and monsoon rainfall anomalies.
	<b>Nowcasting Research</b> Promotes and aids the implementation of nowcasting in the WWRP framework and within NMSs and among their end-users, including the potential use of numerical modelling and assimilation of very high resolution data.
	<b>Verification Research</b> Facilitates the development and application of improved diagnostic verification methods to assess and enable improvement of the quality of weather forecasts, including forecasts from numerical weather and climate models.
	<b>Societal and Economic Research Applications</b> Advances the science of the social and economic application of weather-related information and services and reviews and assists in the development and promotion of societal and economic-related demonstration projects.

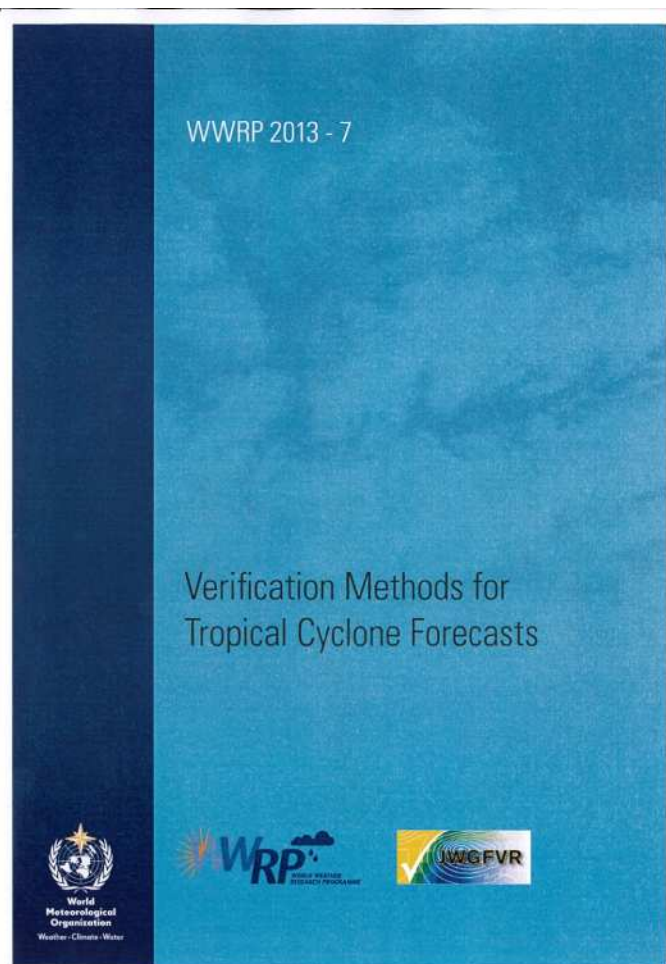


## **Joint Working Group on Forecast Verification Research**

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Facilitates the development and application of improved diagnostic verification methods to assess and enable improvement of the quality of weather forecasts, including forecasts from numerical weather and climate models.



# WWRP 2013-7 Verification Methods for Tropical Cyclone Forecasts

JMA/WMO Workshop on Effective TC Warning in SE Asia (Tokyo, 2014)



## **Working Group on Societal and Economic Research Applications**

Advances the science of the social and economic application of weather-related information and services and reviews and assists in the development and promotion of societal and economic-related demonstration projects.



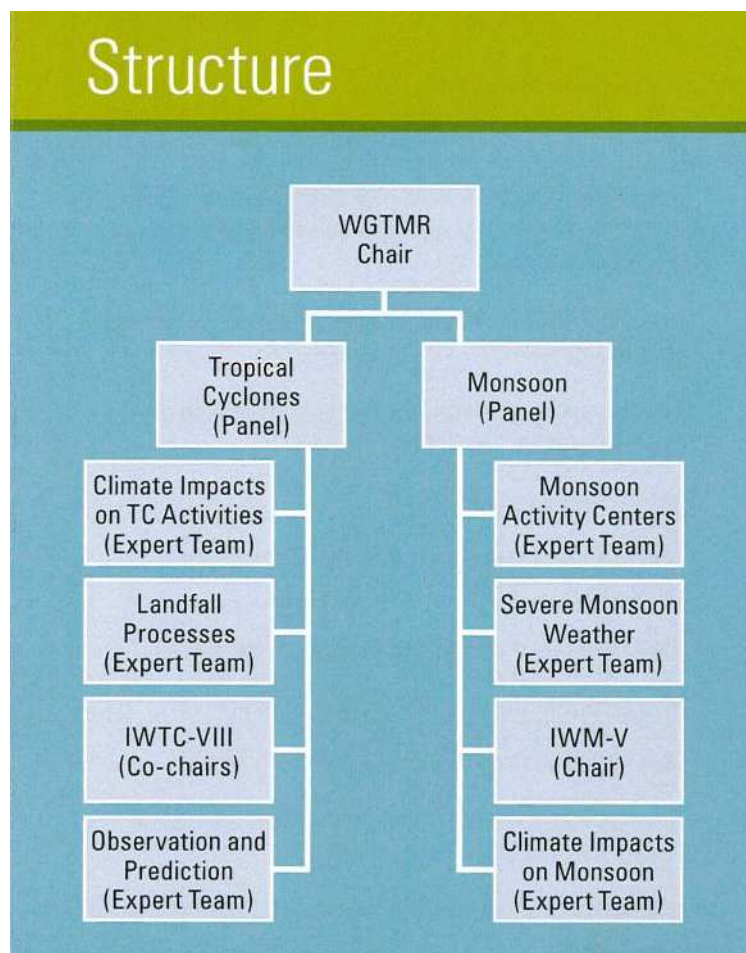


## **Working Group on Tropical Meteorology Research**

Identifies and supports the 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.







Dr Yihong DUAN (China)  
Chair, WGTM



## WGTMR Tropical Cyclone Panel



**Professor Johnny CHAN**  
(HK, China)  
**Chair, TC Panel/WGTMR**

**Expert Team on Tropical  
Cyclone Landfall Processes**

**Expert Team on Climate  
Impacts on Tropical Cyclones**

**Expert Team on Seasonal  
Tropical Cyclone Forecasts**



# WGTMR Tropical Cyclone Panel Activities

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- **International Workshops on Tropical Cyclones**
- **International Workshop on Tropical Cyclone Landfall Processes**
- **Expert Meeting to Evaluate Skill of Tropical Cyclone Seasonal Forecasts**
- **International Conference on Indian Tropical Cyclones and Climate Change**
- **Tropical Cyclone Structure Experiment 2008**
- **Global Perspectives on Tropical Cyclones (WMO/TD No. 693)**
- **Tropical Cyclone Website (for Researchers) (a project of IWTC-VI)**





WWRP/TCP



## TECHNOLOGY TRANSFER

2nd International Workshop on TC Landfall Processes (IWTCLP-II)  
Shanghai, China 19-23 Oct 2009



65 papers related to landfall tropical cyclone rainfall, structure and intensity change, terrain effects on tropical cyclone rainfall and T-PARC/TCS-08 were presented in plenary

“Typhoon Landfall Forecast Demonstration Project” was proposed in this workshop. The FDP aims to improve the typhoon forecast capabilities and to give better service towards Shanghai EXPO 2010. The FDP was endorsed by WMO/CAS-15 (Incheon, Korea, 2009).



Weather • Climate • Water

JMA/WMO Workshop on Effective TC Warning in SE Asia (Tokyo, 2014)



WWRP/TCP



## TECHNOLOGY TRANSFER

**7th International Workshop on Tropical Cyclones (IWTC-VII)  
St.Denis, La Reunion, France, 15-20 Nov 2010**



59 recommendations (including 12 high priority recommendations for future WMO activities, forecaster needs, and research opportunities)

A new summary statement of Tropical cyclone and climate change was issued for WMO and NMHSs use during the workshop

IWTC VII final report is on the WWRP website.



Weather • Climate • Water

JMA/WMO Workshop on Effective TC Warning in SE Asia (Tokyo, 2014)



# IWTC-VIII & IWTCLP-III

## 8<sup>th</sup> International Workshop on Tropical Cyclones

Jeju, Republic of Korea, 2 to 10 December 2014

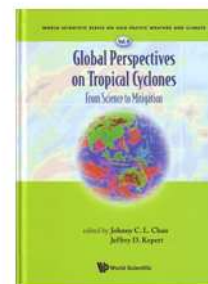
In conjunction with 3<sup>rd</sup> International Workshop on TC Landfall Processes



Jenni Evans  
Co-chairs IWTC-VIII



Andrew Burton



Global Perspectives  
on  
Tropical Cyclones



Robert Rogers  
Chair IWTCLP-III


The IWTC is one of WMO's major quadrennial workshop series organized by its WWRP and Tropical Cyclone Programme (TCP) and is a special and unique gathering of tropical cyclone researchers and warning specialists from all regions affected by tropical cyclones, including those from Members belonging to the TCP regional bodies.

### Main objectives:

- 1) to examine current knowledge, forecasting and research trends on tropical cyclones from an integrated global perspective and
- 2) to report on these aspects and to offer recommendations for future forecasting studies and research with special regard to the varying needs of different regions.



Weather • Climate • Water



**8th WMO International Workshop on Tropical Cyclones**

**3rd WMO International Workshop on Tropical Cyclone Landfall Processes**

**2 – 10 December 2014**  
**To be held in Jeju, Republic of Korea**

**ABOUT THE EVENT**

The IWTC is one of WMO's major quadrennial workshop series organized by its World Weather Research Programme (WWRP) and Tropical Cyclone Programme (TCP). It is a special and unique gathering of tropical cyclone researchers and warning specialists from all regions affected by tropical cyclones, including those from Members belonging to the WMO TCP regional bodies. The main objectives of these workshops are 1) to examine current knowledge, forecasting and research trends on tropical cyclones from an integrated global perspective and 2) to report on these aspects and to offer recommendations for future forecasting studies and research with special regard to the varying needs of different regions.




The IWTCPLP is another of WMO's quadrennial workshop series also organized by both WWRP and TCP which is focused on tropical cyclone landfall impacts and the required meteorological variables that must be observed, analyzed and predicted. Its main objective is to provide a forum for experts to share recent research results that have led to improvement in tropical cyclone forecasting and also the achievements of the forecasting sector over the past four years.

**INTERNATIONAL ORGANIZING COMMITTEE**

Jenni EVANS (USA) co-Chair (IWTC-8)  
Andrew BURTON (Australia) co-Chair (IWTC-8)  
Robert Rogers (USA) Chair (IWTCPLP-III)  
Yihong DUAN (China)  
Johnny CHAN (HK, China)  
Prof Lianshou CHEN (China)  
Jeff KEPERT (Australia)  
Chris VELDEN (USA)  
John McBRIDE (Australia)  
Suzana CAMARGO (USA)  
Lixion AVILA (USA)  
Mike BERGIN (Australia)  
Philippe CAROFF (France)  
M. MOHAPATRA (India)  
Tsukasa FUJITA (Japan)  
Hwi-Rin KIM (Republic of Korea)  
Shahir DUBE (India)  
QIAN Chuanhai (China)  
Do-Shick SHIN (Republic of Korea)

**FURTHER INFORMATION**

Further details about the workshops can be found at:  
[http://www.wmo.int/pages/prog/arep/wwrp/tm/iw/WTCS\\_IWTCPLP3.html](http://www.wmo.int/pages/prog/arep/wwrp/tm/iw/WTCS_IWTCPLP3.html)

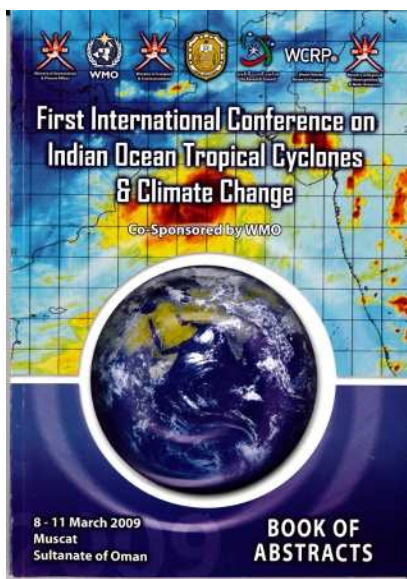
  

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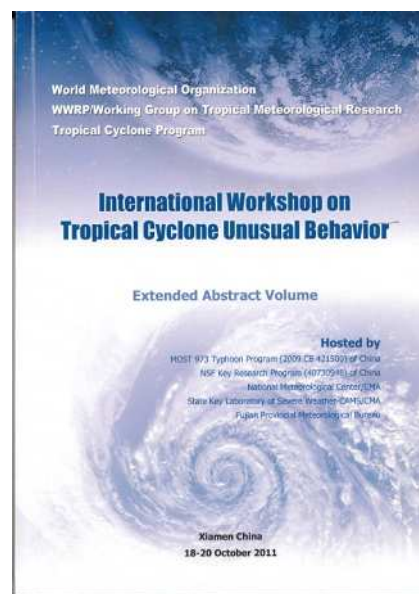




# TCP & WWRP



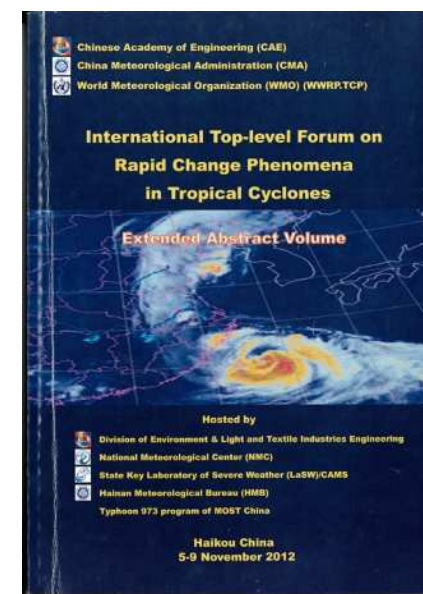
Muscat 2009



Xiamen 2011



New Delhi 2012



Haikou 2012

JMA/WMO Workshop on Effective TC Warning in SE Asia (Tokyo, 2014)



# **Typhoon Landfall Forecast Demonstration Project**

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## **Objective**

- **To demonstrate the performance of the most advanced forecasting techniques for landfalling typhoons.**

## **Action Taken**

- **Training Workshop organized in May 2010 (Shanghai)**
- **Real-time collection/display systems of forecast products developed**
- **Real time verification system set-up**

## **Planned Action(extended to 2015)**

- **To improve the project website (<http://tlfdp.typhoon.gov.cn>)**
- **To provide real-time products to all TC Members**
- **To develop a total verification system**



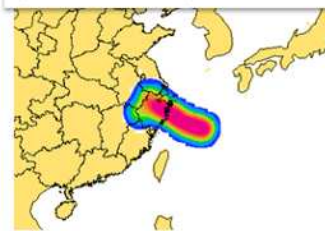
# Typhoon Landfall Forecast Demonstration Project

Sample  
images  
on the  
Web

FY-2E Satellite images



Striking probability  
(EPS and super-ensemble)



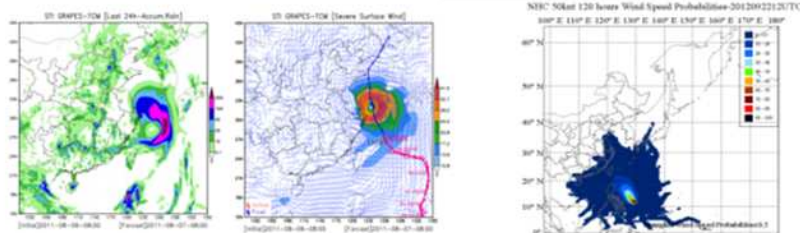
Track & intensity forecast and real time verification



Gridded model output



High winds striking prob.





# Typhoon Landfall Forecast Demonstration Project

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The TLFDP was **extended to 2015** for the following reasons:

- to apply in the operational mode the **forecast evaluation methods** designed for the project,
- to **conduct further tests** on the stability of the operational performance of each **typhoon forecast product and technique**,
- to enhance **integration of the forecast products** with services for users,
- and to include studies on the **tropical cyclone pre-formation** period.





# Typhoon Landfall Forecast Demonstration Project

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- to enhance **integration of the forecast products** with services for users,
- and to include studies on the **tropical cyclone pre-formation** period.



# TFID

**A new measure (the Track Forecast Integral Deviation; TFID) for the verification of tropical cyclone (TC) track forecasts is proposed, based on the mathematical consideration that a “good” forecast has a small distance to the observed track not only at zero-order but also at higher orders. The TFID is the mean of two sub-scores, which are respectively calculated for latitude and longitude and defined to be the average value of the mean absolute error and mean absolute deviation of relative errors from the mean relative error along a track. By definition, the smaller the TFID, the more accurate the forecast track. A perfect forecast has zero TFID. It is suggested that such a measure is superior to the widely-used position error (PE) in terms of reflecting the accuracy of the whole track instead of just one position. In an experimental application, TFID was calculated for the track forecasts from the ECMWF-IFS during 2010–2012. A comparison with PE showed that TFID can work as a good supplement to the PE in discriminating good or bad track forecasts, as there are generally some forecasts with small PE but large TFID, or vice versa. The binned characteristics of TFID and PE of ECMWF-IFS were also analyzed based on several traits of the TC or its environment at the initial time of the forecast. It was found that the model performs better for initially strong and large TCs, or those with weak vertical wind shear at lead times shorter than 48 h.**



# Typhoon Landfall Forecast Demonstration Project

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The TLFDP was **extended to 2015** for the following reasons:

- to apply in the operational mode the **forecast evaluation methods** designed for the project,
- to **conduct further tests** on the stability of the operational performance of each **typhoon forecast product and technique**,
- to enhance **integration of the forecast products** with services for users,
- and to include studies on the **tropical cyclone pre-formation** period.