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WORLD WEATHER RESEARCH PROGRAMME

WWRP 2010 - 3

TRAINING WORKSHOP ON TROPICAL CYCLONE FORECASTING

WMO TYPHOON LANDFALL FORECAST DEMONSTRATION PROJECT

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The Global Model for TC Prediction in NMC and It's Application

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Abstract

The Global model for TC track prediction was upgraded based on the new data assimilation system and the new vortex initialization scheme. The data assimilation system was upgraded from IO to 3Dvar system and the satellite data could be assimilated directly. The application of the satellite data could improve the background circulation particularly over the ocean where the observation was sparse and made a positive contribution to the reduction of the TC track errors. The upgrading of the vortex initialization scheme made another contribution. The new vortex initialization scheme includes three parts: bogus vortex, vortex relocation and the intensity modification but the old vortex initialization scheme only included the BOGUS vortex. The application of the above two new techniques greatly improves the performance of the global TC track prediction system and provides useful references to the forecasts.

The distribution of mean track errors from 2006-2009 was analyzed in order to provide the characteristics of this system. The results show that the global model for TC track prediction has better performance for the following two kinds of TC tracks: one is the TCs that moved north-west ward and turn to north or northeast ward to west of 120E, the other one is the TCs that moved west ward and disappeared in south China sea or made landfall in Vietnam. But for the other two kinds of TCs that moved north-west ward and made landfall in the province along the coast line of South China Sea, and moved northeast ward, the system has larger track errors.

The distribution of TC track errors within the 48h and 24h warning areas was also analyzed. The global model has better performance for the northwest ward moving TC especially with 24h warning areas.

We also analyze the performance of the global model system in prediction of the abnormal TC tracks. The results show that this system could provide better forecast to the TCs that west or northwest ward moved and made sharp turning to the northeast. For the TCs with regressional path, the global model system couldn't provide persistent prediction during the period of regressional stage.

JMA Global Model and Its Application in Operational Tropical Cyclone Forecast

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Abstract

The Japan Meteorological Agency (JMA) provides a variety of numerical weather prediction (NWP) products that play a vital role in both national and international weather services. Among these, tropical cyclone (TC) track and intensity forecasts are the most important for disaster prevention and preparedness activities.

In November 2007, JMA upgraded the spatial resolution of the Global Spectral Model (GSM) from the previous TL319L40 (approximately 60 km in the horizontal and 40 layers up to 0.4 hPa in the vertical) to TL959L60 (approximately 20 km in the horizontal and 60 layers up to 0.1 hPa in the vertical). Since then, TC forecasts in JMA have been supported only by GSM covering the entire globe. GSM provides high resolution NWP products four times a day for all TCs worldwide.

This lecture will describe the major features and specifications of GSM, and examples and statistical scores of typhoon track and intensity forecasts. It will also discuss other NWP models such as Ensemble Prediction System (EPS) used in JMA, the NWP products, and their application in the operational TC forecast.

Verification: basic concepts and application to tropical cyclones

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Abstract

We will start by looking at some basic concepts of verification in order to be able to identify the type of questions our verification methods should address, and to touch on ideas like users' needs and uncertainty.

The first part of the lecture will be dedicated to introduce verification methodologies and exploratory methods for deterministic forecasts. We will be looking at standard verifications of continuous and dichotomous forecasts, as well as at spatial verifications. New methodologies that account for location and timing uncertainties and provide information of errors in physical terms will be introduced.

The second part of the lecture will discuss methods for verification of probability forecasts. Standard methodologies will be presented to introduce the students to the complex field of verification of probabilistic/ensemble forecasts. There will be a simple hands-on session aimed at putting into practice the concepts learnt in the lecture (a pocket calculator, if available, would be an advantage)

华东热带气旋特点和预报难点探讨

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摘要

华东地区热带气旋预报的难点主要是：（1）路径预报中的疑难路径（方向和速度的突变）；（2） 影响台风路径和强度的环境（地形、周围系统、引导气流）；（3）台风造成的影响（风雨、次生灾害）。

通过典型个例 0716 号超强台风”罗莎”（Krosa）、0707 号强热带风暴“帕布”、0605 台风“格美”（Kaemi）的回顾，引出华东地区热带气旋预报的难点问题，并针对台湾岛地形的影响、台风与热带低压（或双台风）的相互作用、海上台风强度的变化、台风登陆后的路径及降水预报问题，运用个例分析、统计、非常规资料的应用等方法，归纳总结，给出一些初步的结论和启示。

台湾岛地形对热带气旋路径的影响可以分为两类：第一类是出现打转或停滞的热带气旋，主要与弱引导气流、登陆点的纬度、登陆时的强度相关；第二类是快速“穿过”的热带气旋，出现在引导气流较强时，快速“穿过”可以表现为先停滞、后加速，在整体路径上速度并没有减速的现象。

台风与临近天气系统（热带低压、云团、高空冷涡等）的相互作用也是路径预报的关键。在预报着眼点上需密切关注台风周边系统的演变发展。

在海上常规资料缺乏的情况下，充分利用卫星反演资料等非常规资料，在海上台风分析、强度变化的应用中能起到较好的作用。

台风登陆后与复杂的地形、周围天气系统相互作用，降水分布不均匀，仍是目前预报中的难点。

江西台风暴雨分析与预报

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摘要

统计 1949-2008 年，影响江西的台风（以下简称台风）出现在 5—11 月，以 7-9 月最为集中，约占全年的 82%，8 月为全年之最，占 39%，7 月次之。统计表明，1949-2008 年有 92 个台风（含减弱后的低压，下文相同）进入江西，平均每年 1.5 个，尤以 1975 年和 1994 年为最多，分别有 5 个台风进入江西。其中有 79 个（86%）生成于西北太平洋，有 13 个（14%）生成于南海。

台风登陆的地点差异和登陆后强度变化带来的影响是不同的，福建登陆对我省影响最大，其次是广东，再次是浙江。进入江西的 92 个台风中，在福建沿海登陆的 53 个（57.6%），在广东沿海登陆的 32 个（34.7%），仅有 7 个在浙江沿海（杭州湾以南）登陆（7.6%）。进入江西的 92 个台风中，有 5 个强度达强热带风暴等级（5.4%），23 个达热带风暴等级（25%），其余都减弱为热带低压。

台风进入江西的地点，南部多于北部，集中在江西东南部的赣州和抚州两市，尤其以赣州市最多。进入江西的台风约 2/3 移出我省，1/3 在江西境内填塞。

江西地形复杂，丘陵山地多，台风对江西的影响最大的是强降水，强度一般暴雨到大暴雨，甚至特大暴雨，从而引发山洪、泥石流、洪涝，风的影响比雨的影响要弱一些。

进入内陆的台风降水大小与台风路径、强度、结构、移动速度、地形及台风与中低纬度天气系统密切相关。

（1）台风移动对降水的影响

统计经验表明，进入江西台风，按照台风路径之不同，可以分成四大类：

①转向类台风：这类台风，大多数在西北太平洋生成，生成后向西北偏西方向移动，经福建进入江西，在赣江以东转向北上。其降水主要在我省的东北部，暴雨中心多数在上饶地区东南部和庐山附近。

②西行类台风：这类台风，大多数来自西北太平洋，取西北偏西路径，经福建或广东，在吉安以南穿过江西，或从广东北部穿过。其降水主要在赣中、赣南，暴雨中心多数在赣州地区南部和吉安地区西南部（井冈山附近）。如：0604“碧利斯”，0605“格美”。而 0414“云娜”是从浙江南部西折进入江西鄱阳湖地区，暴雨大暴雨偏北，位于赣北和赣中北部。

③西北行类台风：这类台风，在太平洋生成后，向西北方向移动，经福建或广东进入江西，在江西的特殊地形作用下，降水区和暴雨中心偏向台风的左侧或地面低压附近。如 0513“泰利”、0608“桑美”0709 “圣帕”，0808“凤凰”

④北上类台风：这类台风多数在南海生成，少数在菲律宾以东洋面上生成后进入南海，在南海的台风向北移动，经广东进入江西，降水往往是全省性的，暴雨中心多数在我省西部和南部。如 0806“风神”。

台风登陆后，影响其移动的因素增多了，但大型气压场对台风移动仍是主导因素。 副高形态和演变的不同，使得引导气流的变化，造成各台风路径变化不同。0414“云娜”台风路径在登陆时发生西折的主要原因是由于在 500hPa 副高调整为带状分布，台风北侧的东风气流明

显加强，而且台风北侧最大东风风速与南侧的最大西风风速之差陡增是导致其西折的主要原因。0604 碧利斯登陆后，副高加强西伸至台风的西北侧，并形成闭合大陆高压，使台风转为偏西路径和西南路径，且移速减慢。格美登陆后，随副高西脊点西伸，长江中游低槽北收，使格美继续受副高脊线南侧东南风的引导，格美登陆后仍向偏西北偏西方向移动。0608“桑美”0709 “圣帕”，0808“凤凰”等台风受稳定的副高南侧的东南气流引导，一直沿着副高边缘西北行。

（2）近 10 年影响进入江西台风个例分析表明，台风内部结构对降水强度影响是显者的。当有完整的闭合低压环流经过江西，850hPa 或 925hPa 上台风中心内侧有≥12m/s 西南风或东南风，在云图上，进入江西前为台风为实心结构，会形成区域性暴雨和大暴雨，如： 0608 “桑美”和 0808 “凤凰”。 而 0505“海棠”在海上及刚登陆时台风云系呈密蔽圆形状，登陆后台风中心小风速且范围还不断扩大，台风中心云系出现松散空心结构，降水云系在海上与深入内陆台风中心分离；水汽输送条件变差，尽管“海棠”从进入江西北部穿过，但没有带来大范围暴雨，只在庐山这样特殊地形条件下产生了大暴雨。

（3）个例研究表明，当进入内陆（江西）台风与外部环流系统相互作用时，降水强度会加大。若有强度适中的冷空气侵入台风环流西北侧，台风移速减慢和“半冷半暖”的斜压结构等作用均使得降水比平均加大一个量级。如 0414 “云娜”台风及 0519 年“龙王”台风、0513 “泰利”台风登陆进入江西后，均有明显冷空气对降水的增幅作用。以“泰利”台风最明显。0604“碧利斯”台风进入内陆后，与西南季风共同作用，在湘赣中南部造成了大范围的大暴雨到，局部特大暴雨。

（4）地形对登陆台风的降水影响也是显著的，迎风坡产生上升气流加大导致降水加强。如庐山、罗霄山脉、武夷山脉和赣南南部山区的地形使得降水加强。另外，1949 年-2006 年中心经过鄱阳湖区的 16 个热带气旋进行统计分析后，发现中心经过鄱阳湖区的 16 个台风中，有 12 个台风（占 75%）经过鄱阳湖时降水明显加强，其中比较典型的有“云娜”台风。“云娜”在进入翻阳湖地区后，鄱阳湖夜间地面暖中心引起的对流不稳定和湖陆风辐合作用使得鄱阳湖附近降水加强，期间垂直运动、散度、水汽通量散度等各物理量场均表现出有利于降水加大的特征。这与下垫面的热量和水汽交换作用密切相关。

Operational tools for tropical cyclone forecast

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Abstract

The basic tools in the operational TC forecast would be introduced in this lecture, which including the platform and the website of TC Warning Center of SMB, which provide almost of the products of the TC operational forecast process, from the TC satellite imagery, Climate background, TC genesis forecast and the real-time TC track forecast, intensity forecast, and also the TC warning delivering, the public service suggestion. Secondly, The TC searching tool could help users to know more about the climate background and find out the most analogical TC from the year 1949 to 2008 of the northwest Pacific, meanwhile, the impact of TC such as rainfall and wind are also supplied. The next tool is known well by forecasters in China, the MICAPS system (Meteorology information synthesis analysis processing system for short). TC module is developed based on MICAPS, which is emphasis on the interactive function for user to produce and deliver the final forecasts. In addition, two web based BBS, one is for the public in Chinese version, another is for the Typhoon Committee members in English version, are welcome more people to the online discussion.

Key words: operational tool, tropical cyclone, TC Warning System, MICAPS

Forecast of tropical cyclone wind and rainfall in Hong Kong

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Abstract

In this lecture, the methodology of forecasting wind and rainfall associated with tropical cyclone in Hong Kong will be discussed. This includes the use of numerical model, nowcasting based on satellite and radar observation, and climatological-based forecasting technique. A statistical forecasting tool used for years in forecasting the probability of occurrence of strong, gale and hurricane force winds in Hong Kong in relation to the forecast track of tropical cyclone will also be introduced. In this connection, ways of forecasting the track of tropical cyclone being used operationally in Hong Kong will be discussed. Last but not least, the lecture will also show some operational computer tools used for tropical cyclone forecasting in Hong Kong.

Tropical Cyclone track, intensity, and rainfall forecast in the U. S.

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Abstract

The US Weather Research Program Joint Hurricane Testbed (JHT) was established in 2001. The mission of the JHT is to bridge the gap between tropical cyclone research and forecast communities, and to expedite the transfer of new research results or techniques from research to operations.

Since both wind and rainfall forecasts depend on the track forecast, the presenter will first show the improvement in track forecasts at the National Hurricane Center (NHC). NHC records show that improvements in dynamical models have been the main source for operational track forecast improvement. In recent years the multi-model track consensus forecast has outperformed individual model forecasts and has contributed to the steady improvement in NHC forecasts.

For intensity forecast, the Statistical Hurricane Prediction System (SHIPS or STIPS in the NWPAC), developed by Mark DeMaria of NOAA, remains the top performer. Over the past 10 years changes in the predictors, such as using ocean heat content (OHC), satellite brightness data, eye SST feedback, have improved the scheme steadily. A statistical method used to estimate the potential of rapid intensification (wind speed increases by 30 Kt or more in less than 24 hours) is also discussed.

The NHC does not consider itself capable of making accurate wind radii forecasts at this moment. There are not enough observations to allow for an accurate analysis and there is no adequate data to verify past forecasts. A climatology and persistence wind radii forecast method was developed and is being used by some forecasters to make wind radii forecasts. A decay SHIPS model is used to forecast wind intensity over land.

There are several methods used in the U.S. to estimate rain rate and accumulated rainfall. Most of these techniques use derived rain rate from satellite sensors and extrapolate them in time using forecast track, speed, and intensity. Rainfall forecasts by numerical models are used in conjunction with satellite estimated rain rate to derive quantitative precipitation forecasts. Overall the skill in forecasting heavy rainfall associated with tropical cyclones decreases with increasing rainfall amount, and is highly dependent on the track forecast. Rapid updates using observed rainfall could mitigate some of the shortfall.

The NHC has implemented a probabilistic wind forecast scheme to show probability of winds exceeding 34 Kt, 50 Kt, or 64 Kt at individual geographical locations. A Monte Carlo model that combines the official forecast with historical errors associated with track, intensity, and radii forecast was developed. The product provides quantitative guidance of the likelihood a location will encounter winds of those thresholds.

An introduction on the GRAPES-TCM model system

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Abstract

An operational tropical cyclone (TC) numerical model, developed by Shanghai Typhoon Institute (STI) on the basis of Global/Regional Assimilation and PrEdiction System (GRAPES) and named GRAPES-TCM, is introduced.

The GRAPES-TCM model, designed with special emphasis on TC vortex initialization and data assimilation, was put into operation in STI since the year 2005. Based on a four-years operational run and several updates on vortex initialization schemes, the original GFDL vortex relocation scheme used by GRAPES-TCM was replaced by a Cycled-Vortex-Assimilation (CVA) scheme similar in conception to that of Bogus Data Assimilation (BDA) in 2009. In the CVA scheme, however, a Model-Controlled 3DVAR (MC-3DVAR) scheme of STI is employed to assimilate the three-dimension vortex generated by a previous GRAPES-TCM forecast according to the real-time TC observation, instead of vortex 4DVAR. Preliminary verification shows that the CVA scheme improves the 0-48h TC track prediction by about 20% relative to the GFDL relocation scheme. In addition to the model-generated bogus data, various satellite datasets (such as satellite cloud drift wind, AMSU temperature, and QuikSCAT sea winds) were also incorporated to GRAPES-TCM in numerical experiments to improve the analysis of TC.

During 2005-2009, model physical schemes (i.e., subgrid convective parameterization, PBL parameterization) were also updated for the simulation of TC. Specifically, a new Kain-Fritsch convection trigger scheme is designed to reduce rainfall overestimation under the circumstance of weak environmental forcing (i.e., because of topography and mid-latitude multi- system interaction during TC landfall). The original roughness parameterization scheme is updated to accommodate the “drag coefficients/roughness length - surface wind” relationship for the situation of TC strong winds (particularly in the vicinity of TC inner-core region).

With the joint consideration of physics parameterization and TC initialization, a vortex initialization approach termed VIRV (vortex initialization with the assimilation of retrieved variables) is presented. This approach improves TC intensity prediction by initializing the TC model with dynamical-balanced gradient winds and pressure (instead of the geostrophic constraint of 3DVAR that not appropriate for TC) retrieved from a reversed PBL parameterization scheme/model.

For the future development of GRAPES-TCM, the first concerned is still the vortex initialization issue (i.e., design of dynamical constraints that appropriate for TC, efficient approach for the assimilation of composite datasets, satellite data in particular). Special treatment on ocean-atmosphere interaction is also desired, by dynamical coupling between GRAPES-TCM and ocean numerical model, and incorporation of ocean-associated datasets. Preliminary experiments have shown promising results.

Key words: GRAPES-TCM, Tropical Cyclone, Model, Vortex Initialization

An Overview of SMB Numerical Modeling System in Expo 2010 Weather Service

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Abstract

An overview of numerical modeling system used in the weather service operation of the SMB, especially the service to be provided for the Expo 2010 will be presented. Following the concept of seamless weather prediction, we have developed various meso-scale data assimilation and modeling systems including STI-WARR (STI WRF RAPID REFRESH for 0-12h forecast), STI-WARMS (STI WRF-ADAS-Real-time Modeling System for 0-72h forecast) and STI-EnWARMS (STI Ensemble WARMS for forecast up to 120h) as well as a real-time validation package. A detailed description of the systems along with their products will be given. In addition, the local applications of ECMWF high-resolution model as well as the ensemble prediction products from the TIGGE will be mentioned. Finally, some aspects about practical usages of 3D-VAR data assimilation scheme in our system will be also discussed.

Basis and Operational Application of Typhoon Ensemble Forecast

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THORPEX (http://www.wmo.int/thorpex) is the international research program under the World Meteorological Organization, to accelerate improvements in the accuracy of 1-day to 2-week high-impact weather forecasts for the benefit of humanity. THORPEX Interactive Global Grand Ensemble (TIGGE) is a key component of THORPEX. It accumulates global ensemble forecasts, generated by a number of major operational forecast centers in real time and delivers the data to the scientific community for research and education with 48-hour delay through three TIGGE Archie Centers (ECMWF, NCAR and CMA). The data is accumulating at a daily rate of approximately 500 GB from ten data providers around the world. The data accumulation started in October 2006 in some data providers. Total forecast members in a day are now close to 500.

Using the TIGGE global ensemble forecast data, we would like to first understand the characteristics of the TIGGE database and quickly transfer our knowledge to operational forecast purposes, especially for typhoon forecast.

In my talk, I will present the following topics.

- Current status of the TIGGE database
- What is the advantage of utilizing ensemble forecasts?
- Example of the TIGGE database for typhoon forecast

WMO TYPHOON LANDFALL FORECAST DEMONSTRATION PROJECT
Training Workshop on Operational Tropical Cyclone Forecast
(24-28 May, 2010)

Programme

Monday, 24 May 2010

0800-0845 Registration
0900-0930 Opening Ceremony

Chair: Dr. Xiaotu Lei
Director of Shanghai Typhoon Institute/CMA

Welcome Speech	Dr. Xu Tang Director-General of SMB
Opening Address	Ms. Nanette Lomarda Scientific Officer of WWRP/WMO
Opening Address	Mr. Koji Kuroiwa Chief of TCP/WMO
Opening Address	Prof. Lianshou Chen Chair of TMRP/WMO

0930-0950 Group Photo

	MON. - MAY 24	TUE. – MAY 25	WED. – MAY 26	THU. – MAY 27	FRI. – MAY 28
AM Break	**OPENING CEREMONY** CMA Global model and its application in operational tropical cyclone forecast **Dr. Suhong MA (NMC/CMA)** Recap & Discussion	Verification **Dr. Anna GHELLI (ECMWF)** Recap & Discussion	Forecast of tropical cyclone wind and rainfall in Hongkong **Dr. L.S. LEE (HKO)** Recap & Discussion	Basis and operational application of typhoon ensemble forecast **Dr. Tetsuo NAKAZAWA (JMA)** Recap & Discussion	Discussion and Forecast Drill
Lunch					
PM Break	JMA Global model and its application in operational tropical cyclone forecast **Mr. Masakazu HIGAKI (JMA)** Recap & Discussion	Forecast of tropical cyclone wind and rainfall in Shanghai **Mr. Zhiqiang CHEN (SMC)** Forecast of tropical cyclone rainfall in Jiangxi **Ms. Aihua XU (JMC)** Operational Tools for Tropical cyclone forecast **Ms. Yan TAN (STI)** Recap & Discussion	Forecast of tropical cyclone track, intensity and rainfall in the USA **Dr. Jianngwo JIING (NHC)** Recap & Discussion	GRAPES_TCM and its application **Dr. Leiming MA (STI)** Regional NWP for ECR **Dr. Baode CHEN (STI)** Recap & Discussion	Discussion and Forecast Drill **CLOSING**

Class Hours

Class Duration: 3 hrs.
Break Duration: 15 min.
Lunch Duration: 1 hr. 30 min.

Morning: 9:00 AM - 10:30 AM
10:45 AM - 12:00 PM
Afternoon: 1:30 PM - 3:00 PM
3:15 PM - 4:30 PM

World Weather Research Programme (WWRP) Report Series

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).

Report of the First Session of the Joint Scientific Committee (JSC) for the World Weather Research Programme (WWRP), (Geneva, Switzerland, 23-25 April 2007) (WMO TD No. 1412) (WWRP 2007 – 5).

Report of the CAS Working Group on Tropical Meteorology Research (Shenzhen, China, 12-16 December 2005) (WMO TD No. 1414) (WWRP 2007 – 6).

Preprints of Abstracts of Papers for the Fourth WMO International Workshop on Monsoons (IWM-IV) (Beijing, China, 20-25 October 2008) (WMO TD No. 1446) (WWRP 2008 – 1).

Proceedings of the Fourth WMO International Workshop on Monsoons (IWM-IV) (Beijing, China, 20-25 October 2008) (WMO TD No. 1447) (WWRP 2008 – 2).

WMO Training Workshop on Operational Monsoon Research and Forecast Issues – Lecture Notes, Beijing, China, 24-25 October 2008 (WMO TD No. 1453) (WWRP 2008 – 3).

Expert Meeting to Evaluate Skill of Tropical Cyclone Seasonal Forecasts (Boulder, Colorado, USA, 24-25 April 2008) (WMO TD No. 1455) (WWRP 2008 – 4).

Recommendations for the Verification and Intercomparison of QPFS and PQPFS from Operational NWP Models – Revision 2 - October 2008 (WMO TD No. 1485) (WWRP 2009 - 1).

Strategic Plan for the Implementation of WMO's World Weather Research Programme (WWRP): 2009-2017 (WMO TD No. 1505) (WWRP 2009 – 2).

4th WMO International Verification Methods Workshop, Helsinki, Finland, 8-10 June 2009 (WMO TD No. 1540) (WWRP 2010-1)

1st WMO International Conference on Indian Ocean Tropical Cyclones and Climate Change, Muscat, Sultanate of Oman, 8-11 March 2009 (WMO TD No. 1541) (WWRP 2010-2)