FORTY-THIRD SESSION

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AGENDA ITEM 5

Original: ENGLISH

TRAINING & RESEARCH COORDINATION GROUP (TRCG)

(submitted by TRCG Chair)

Summary and Purpose of Document**:**

This document reviews past activities, progress and future plans of TRCG.

Action Proposed

The Committee is invited to:

(a) note the major activities and development progress of TRCG as summarized in the APPENDIX;

(b) endorse the training and research priority areas as outlined in Section 5 of the APPENDIX; and

(c) endorse the future plans of TRCG as outlined in Section 6 and Annex V of the APPENDIX.

APPENDIX: TRCG Annual Report 2010

TRAINING & RESEARCH COORDINATION GROUP (TRCG) ANNUAL REPORT 2010

Edwin S.T. Lai (TRCG Chair)
Hong Kong, China

1. Introduction

1.1   According to the Terms of Reference, TRCG is to promote research and training activities on various aspects of tropical cyclone analysis and forecasting, including assessment of tropical cyclones' impacts on Members' socio-economic development processes, and to encourage cooperation of efforts among Members. Towards this end, TRCG is expected to assist in: (a) identifying scientific and technical problems in the analysis and forecasting of tropical cyclones and their impacts on water resources and measures for disaster prevention and preparedness; (b) facilitating the exchange of experience and knowledge on the latest development and techniques related to the above problems; (c) initiating activities and programmes aimed at improving the technical capacity and capability of Members to better serve the people in the region; and (d) recommending to the Committee priority areas and long-term plans for cooperation in research and training in support of the various KRAs of the Committee's Strategic Plan.

2. Membership

2.1   As at 31 October 2010, the composition and members list of TRCG are:

Chair:	Mr. Edwin S.T. LAI (Hong Kong, China)
Vice Chair:	Mr. Mitsuru UENO (Japan)
Members:	Ms. Seth VANNARETH (Cambodia)
	Mr. XU Yinglong (China)
	Mr. KANG Bom Jin (DPR Korea)
	Mr. Bounteum SYSOUPHANTHAVONG (Lao PDR)
	Mr. LEONG Weng Kun Ivan (Macao, China)
	Dr. Wan Azli WAN HASSAN (Malaysia)
	Dr. Vicente B. MALANO (Philippines)
	Dr. KiRyong KANG (Rep. of Korea)
	Mr. Chien Wan THAM (Singapore)
	Mr. Sampan THAIKRUAWAN (Thailand)
	Mr. Roger EDSON (USA)
	Mr. NGUYEN Dai Khanh (Viet Nam)

3. Major TRCG Activities in 2010

Roving Seminar / Visiting Lecturers Programme

3.1   Roving seminars have been arranged for capacity building purposes on both research and operational aspects. Knowledgeable experts travel to Members' countries and deliver lectures focused on subjects of current interest to operational centers. A record of all roving seminars previously organized can be found in Annex I.

3.2   The Roving Seminar 2010 was held at the Sunee Grand Hotel and Convention Center in Ubon Ratchathani, Thailand on 30 Nov – 3 Dec. It was organized with generous support by the Thai Meteorological Department and the Typhoon Committee Trust Fund. The selected theme was on tropical cyclone genesis and large scale interaction with the following three sub-topics:

Topic A: Tropical cyclone genesis and seasonal prediction of cyclone activities
Topic B: Effects of tropical cyclone interaction with monsoon, with emphasis on enhanced rainfall
Topic C: Tropical cyclone satellite analysis, including microwave images

3.3   In the evaluation process, the participants expressed a warm appreciation of the outstanding presentations, which provided them with new insight on the topics discussed. Most felt that skills and knowledge learnt would lead to operational benefits in their services within the next 2 - 5 years. A summary report of the seminar can be found in Annex II.

Forecasters' Training Attachment

3.4   Two women forecasters from Hong Kong, China and Singapore successfully completed a training attachment at RSMC Tokyo on 21 - 30 July, details of which can also be found in the RSMC Tokyo annual report.

Research Fellowship Scheme

3.5   The Research Fellowships have been awarded to Members to promote joint research through the exchange of visiting scientists on a short-term basis with voluntary funding and logistic support by host Members. One of the merits of the scheme is that the visiting fellow has a chance to work closely with experienced scientists at the host centre, providing an opportunity to transfer knowledge and latest research findings to operational applications. The scheme has worked well on the basis of bilateral cooperation mutually agreed between the host and the applicant.

3.6   In 2010, fellowships were offered by China; Hong Kong, China; and Republic of Korea. Details of the latest projects under the scheme, as well as a summary of previous fellowships awarded, can be found in Annex III. Reports or papers since published in connection with the scheme are listed in Annex IV.

5th Typhoon Committee Integrated Workshop (Macao, China)

3.7   A brief report on TRCG activities in 2010 was presented. Following discussion during

the workshop, the TRCG Work Plan for 2010 – 2013 was updated and a budget based on the 2011 AOP was proposed (see Annex V for details). The emphasis was on the potential link-up of the Roving Seminar 2011 with WGH and WGDPP to pool resources and focus on the cross-cutting project on Urban Flood Risk Management, with expressed interest in research topics and capacity building areas such as QPE and QPF.

4.   Recent Research and Training Activities of Members

4.1   A wide range of research activities was undertaken by Members. Highlights of major projects and achievement as provided by individual Members can be found in Annex VI – XII.

4.2   Resource persons or contact points on specialized research subjects provided by some Members are tabulated for reference in Annex XIII.

4.3   Started in March 2001 and up to December 2010, the International Pacific Desk programme has trained 61 participants from 17 countries, including Typhoon Committee Members such as Viet Nam (3), Philippines (3), Malaysia (2) and Cambodia (1). The Pacific Desk programme is operated by the USA National Weather Service and the training is provided in Honolulu, Hawaii. Six times each year, two interns from the same country or neighboring ones spend six weeks in Honolulu for basic forecaster training involving satellite interpretation, numerical model analysis, use of observations, general climatology of the interns' area, and other practical aspects of operational forecasting. Each intern is given a PC for use during the training, and then the PC is shipped to his or her affiliated meteorological service back home for further use in a sustained effort of capacity building. Six classes will again be held in 2011 for interns from the Pacific and southeast Asia region.

5.   Prioritization of Training and Research Areas

5.1   Taking into consideration comments made by the resource persons in the Roving Seminar 2010, the list of priority research topics is re-established as follows:

(A) Meteorology
   (a)   rainfall forecasting: development of nowcasting and very short range forecasting techniques, and understanding of interaction between tropical cyclones and monsoon;
   (b)   application of Dvorak and microwave satellite image analysis techniques;
   (c)   application of radar-based analysis/products for landfalling tropical cyclones;
   (d)   application of ensembles of guidance from dynamical models, conceptual models, statistical models and systematic knowledge-based approach;
   (e)   use of high resolution numerical models with advanced data assimilation techniques;
   (f)   better understanding of TC-related issues across different spatial and time scales, from mesoscale and synoptic analysis for track prediction, to climatological impact arising from El Nino/La Nina and global warming/climate change;

(B) Meteorology and Hydrology
   (g)   application of meteorological information for forecasting of river flooding and urban flash flood;
   (h)   better understanding of wave, storm surge and marine forecasting;

(C) Meteorology and DPP

    (i)   development of technical procedures to quantify forecast uncertainties and to convert probabilistic information into effective warnings; and

    (j)   development of decision-making tools for DPP purpose, including the integration of forecast information with GIS and the use of automated information processing systems.

5.2   In view of the devastating impact of tropical cyclones that affected Members in recent years, attention should also be given to capacity-building in the following aspects:

    (1)   understanding and assessment of rain-induced geological hazards such as landslides and mudflow;

    (2)   forecasting and warning systems for better coastal protection from hazards such as storm surge, river delta inundation and urban flooding; and

    (3)   effective communication of warning messages to stakeholders, DPP users and communities at risk.

6.   Future Directions and Strategies

6.1   On new directions and possibilities, TRCG will try to set up more follow-up activities in support of training/research topics covered in roving seminars and ad hoc workshops; e.g. through more purposely planned research fellowship projects. For high priority research areas, the idea of setting up dedicated expert teams comprising nominated experts from Members or through mobilization of TRCG list of resource persons will be further explored.

6.2   TRCG supports plans to have more cross-cutting training and research initiatives with the hydrological and DPP components, including the organization of joint meetings/activities. Members also encouraged to promote such initiatives through proactive involvement of respective hydrological and DPP counterparts in their countries.

Summary of Roving Seminars

Year	Dates	Venue	Topic	Lecturers
2003	20 – 21 Oct	Seoul	Interpretation of Typhoon Forecasts and Analyses	Dr. H-J Kwon Mr. Nobutaka Mannoji
	22 – 24 Oct	Hong Kong	Interpretation of Satellite Data and Use of Radar Data in Operational Tropical Cyclone Forecasting	Dr. Mark Lander Dr. P.W. Li Dr. B.-J. Sohn
	27 – 29 Oct	Shanghai	Interpretation of Satellite Data and Use of Radar Data in Operational Tropical Cyclone Forecasting	Dr. Mark Lander Dr. P.W. Li
2004	22 – 24 Nov	Beijing	Operational Application of Multi-model Ensemble Typhoon Forecasts	Prof. Johnny C.L. Chan Mr. Nobutaka Mannoji
	25 – 27 Nov	Kuala Lumpur	Operational Application of Multi-Model Ensemble Typhoon Forecasts	Prof. Johnny C.L. Chan Mr. Nobutaka Mannoji
2006	4 – 7 Sep	Ha Noi	Tropical Cyclone Motion and Intensity, and Principles of Dvorak Method	Prof. Johnny C.L. Chan Mr. Joe Courtney Dr. B.-J. Kim
2007	5 – 8 Sep	Manila	Satellite and Radar Analysis Techniques, and Tropical Cyclone Interaction with Monsoon Systems	Mr. Roger Edson Mr. Bart Hagemeyer Dr. Tetsuo Nakazawa
2009	16 – 19 Nov	Nanjing	Forecasting of High-impact Weather associated with Tropical Cyclones, and Formulation and Communication of Warning Messages	Mr. S.T. Chan Mr. Chip Guard Mr. Sam Muchemi
2010	30 Nov – 3 Dec	Ubon Ratchathani	Tropical Cyclone Genesis and Large Scale Interaction	Mr. S.M. Lee Prof. Zhang Qinghong Dr. Mark Lander

SUMMARY OF TYPHOON COMMITTEE ROVING SEMINAR 2010
(Ubon Ratchathani, Thailand, 30 Nov – 3 Dec)

I. Organization

1. The Roving Seminar 2010 was held at the Sunee Grand Hotel and Convention Center in Ubon Ratchathani, Thailand on 30 Nov – 3 Dec. It was organized with generous support by the Thai Meteorological Department and the Typhoon Committee Trust Fund. The general theme was on tropical cyclone genesis and large scale interaction.

2. It was attended by 10 participants from Cambodia; Hong Kong, China; Lao PDR; Macao, China; Malaysia, Philippines, Singapore and Viet Nam; plus 15 local participants from Thailand.

II. Opening

1. The TC Roving Seminar was declared open by Mr. Thosakdi Vanichkajorn, Deputy Director-General, Acting Director-General of Thai Meteorological Department on 30 November 2010.

2. Mr. Surapol Saiphan, the Governor of Ubon Ratachathani Province delivered the welcoming speech in which he welcomed and wished all the participants a very successful training.

3. Mr. Derek Leong, Meteorologist of the Typhoon Committee, delivered the opening message addressing the significance of the seminar and also expressing his appreciation to the generous support of Thai Meteorological Department in hosting the seminar, the excellent arrangement of the Local Organizing Committee as well as the support from the resource persons.

4. Mr. Thosakdi Vanichkajorn, Deputy Director-General, Acting Director-General of TMD delivered the welcoming message, expressing TMD's strong support to Typhoon Committee training activities and his appreciation to the resource persons as well as TCS.

III.   Seminar Programme

1. Mr. S.M. Lee (Hong Kong Observatory) presented Topic A on "Tropical cyclone genesis and seasonal prediction of cyclone activities".

2. Professor Zhang Qinghong (Peking University) presented Topic B on "Effects of tropical cyclone interaction with monsoon, with emphasis on enhanced rainfall".

3. Dr. Mark Lander (University of Guam) presented Topic C on "Tropical cyclone satellite analysis, including microwave images" and tutorial sessions.

IV.   Proposals and Recommendations

1. The participants expressed a warm appreciation to the three resource persons for their outstanding presentations, which provided the

participants with new insight on the topics discussed. They considered information relating to Dvorak techniques, moisture analysis for tropical cyclone genesis, interaction with monsoon, NWP and other methods for analyzing and predicting high impact weather such as heavy rainfall associated with tropical cyclones particularly useful. In their feedback, around 50% of the respondents felt that skills and knowledge learnt would lead to operational benefits in their services in the next 2 - 5 years; 25% indicated that it could be less than two years for potential applications; but then significantly the other 25% suggested that operational benefits within the next five years would be rather unlikely.

2. Suggestions from the resource persons for future reference include: (a) gathering of information on Members'   needs in operational tropical cyclone forecasting; (b) more capacity building in best-track post analysis and severe weather forecasting and warning systems; and (c) meteorological and forecasting services should be given access to all data sources of satellite imagery products and numerical guidance.

V.   Closing

1. The resource persons and participants expressed their gratitude and appreciation to the Thai Meteorological Department and the Local Organizing Committee for the successful hosting of the Roving Seminar and for their warm hospitality.

2. The closing remarks were given by Ms. Chongkolnee Yusabye, Director of Meteorological Development Bureau, followed by the presentation of attendance certificates to the participants.

3. The Roving Seminar was closed on 2 December 2010, and a post-seminar visit to the local meteorological facilities took place on 3 December 2010.

Summary of Awarded Research Fellowships

Subject	Fellow	Host	Period
Analysis of evolution of landfalling tropical cyclones with a view to developing forecast guidance for wind and rain	Mr. XUE, Jianjun (China)	Hong Kong Observatory	1 Feb – 31 Mar. 2001
TC track forecasting with use of super-ensemble	Dr. PENG, Taoyong (China)	Korea Meteorological Administration	15 Jun – 15 Nov 2001
Near real-time analysis of the wind structure of tropical cyclones	Dr. Nathaniel T. SERVANDO (Philippines)	Hong Kong Observatory	5 May – 4 Jul 2002
Numerical modelling on typhoon intensity change	Miss YU, Hui (China)	Kongju National University and Korea Meteorological Administration	15 Jul –15 Sep 2002
Tropical cyclone track forecasting method	Dr. KANG, Bom Jin Dr. KIM, Tae Jin (DPR Korea)	Shanghai Typhoon Institute	Feb – Mar 2001 Oct – Nov 2002
Analyses on the responses of extratropical transition of tropical cyclone to its environment	Dr. Vicente B. MALANO (Philippines)	Korea Meteorological Administration	Jun – Aug 2004
Effect of tropical cyclone bogussing on model analysis and forecasts	Ms. WANG, Dongliang (China)	Hong Kong Observatory	11 Oct – 10 Dec 2004
Evaluation of the model performance in typhoon prediction in the high-resolution global model (T426L40)	Ms. Sugunyanee YAVINCHAN (Thailand)	Kongju National University and Korea Meteorological Administration	1 Aug – 30 Oct 2005

Impact study of Moisture Data on TC forecasting in South China Sea and Western North Pacific	Dr. Vicente B. MALANO (Philippines)	Hong Kong Observatory	20 Sep – 19 Nov 2005
Using ensemble prediction system (EPS) information in tropical cyclone forecasting	Ms. CHEN, Peiyan (China)	Hong Kong Observatory	13 Oct – 12 Dec 2006
Numerical simulation of Typhoon RUSA with a very high resolution mesoscale model, and calibration of intensity of typhoon with Kalman filtering	Mr. HOA, Vo Van (Viet Nam)	Korea Meteorological Administration	Jun – Aug 2006
Use of EPS information in TC forecasting	Mr. NGUYEN, Dang Quang (Viet Nam)	Hong Kong Observatory	15 Sep – 14 Nov 2007
Seasonality of Tropical Cyclone Activities over the Western North Pacific	Ms. YING, Ming	Korea Meteorological Administration	22 Sep – 20 Dec 2008
Study of high resolution non-hydrostatic model in prediction of landfalling tropical cyclones	Mr. Santi SUMDIN (Thailand)	Hong Kong Observatory	20 Oct – 19 Dec 2008
Tropical cyclone bogus in NHM and its impact on forecast track and intensity	Mr. QU, Anxiang (China)	Hong Kong Observatory	29 Oct – 28 Dec 2009
Typhoon Vortex Initialization Scheme and typhoon Ensemble Forecast Techniques	Ms. NGUYEN Thi Minh Phuong (Viet Nam) Mr. Chatchai CHAIYASAEN (Thailand)	National Meteorological Center, China Meteorological Administration	Early Dec 2009 – Early Feb 2010
Improvement of typhoon analysis and forecast with KMA's TAPS	Mr. TRAN Quang Nang (Viet Nam)	Korea Meteorological Administration	1 Sep – 27 Nov 2010
Study on the tropical cyclone genesis in the northwestern Pacific	Mr. Kamol Promasakha Na SAKOLNAKHON (Thailand)	Korea Meteorological Administration	1 Sep – 27 Nov 2010

Typhoon Information Processing System	Mr. NGUYEN Manh Linh (Viet Nam) and Ms. Kamolrat SARINGKARNPHASIT (Thailand)	National Meteorological Center, China Meteorological Administration	8 Oct – 8 Dec 2010
Can the extreme rainfall associated with Typhoon Morakot (0908) happen in Hong Kong?	Mr. HUANG, Yiwu (China)	Hong Kong Observatory	29 Oct – 28 Dec 2010

TRCG Publications / Papers

Xue, J.J., 2002: Structural and Diagnostic Analyses of Landfalling Tropical Cyclones near Hong Kong in 1999 and 2000. Typhoon Committee Annual Review 2001, pp. 153-161

Servando, N.T., P.W. Li and E.S.T. Lai, 2003: Near Real-time Analysis of the Wind Structure of Tropical Cyclones. Typhoon Committee Annual Review 2002 (in CD form)

Peng, T.-Y., H.-J. Kwon, W.-J. Lee, and J.-H. Lim, 2005: A systematic approach to tropical cyclone track. *The International Journal of Systems & Cybernetics.* **34**, 681-693.

Wang, D.L., W.K. Wong and E.S.T. Lai, 2005: A Study on Tropical Cyclone Bogussing Strategies in NWP Model Analysis and Forecast. Typhoon Committee Annual Review 2004.

Yu, Hui and H. Joe Kwon, 2005: Effect of TC–Trough Interaction on the Intensity Change of Two Typhoons. *Weather and Forecasting.* **20**, 199–211.

Malano, V.B., W.K. Wong and E.S.T. Lai 2006: Effect of Moisture Data to the Numerical Simulation of Tropical Cyclone in the Western North Pacific. Typhoon Committee Annual Review 2005, pp. 242 – 251.

Chen, P.Y. and S.T. Chan, 2009: Use of the JMA Ensemble Prediction System for Tropical Cyclone Intensity Forecasting. Typhoon Committee Annual Review 2008, pp. 276-285.

Nguyen, D.Q. and S.T. Chan, 2009: Study on Application of Ensemble Prediction System Information in Tropical Cyclone Track Forecasting. Typhoon Committee Annual Review 2008, pp. 286-291.

TRCG Work Plans (2010 – 2013) – updated as at 31 October 2010
Training and research activities directly organized by TRCG

2010	Q1	TC-42 (Singapore)	
	Q2	WMO Storm Surge Workshop (Macao)	postponed
	Q3	RSMC Tokyo attachment Research Fellowship Integrated Workshop (Macao)	**Attended by Hong Kong and Singapore** TIPS / EPS; data assimilation
	Q4	Roving Seminar (Ubon Ratchathani) Research Fellowship IWTC-7 (La Reunion)	**Seasonal forecast; TC genesis; satellite analysis** TIPS / EPS; data assimilation **TC representation**
2011	Q1	TC-43 (Jeju)	
	Q2	Roving Seminar (timing to be confirmed)	**Urban/coastal flooding + TC QPF; wave and swell** (with WGH / WGM?)
	Q3	RSMC Tokyo attachment Research Fellowship	**To be attended by Macao and Lao PDR** Seasonal forecast; TC genesis; TIPS
	Q4	Integrated Workshop (Viet Nam) Research Fellowship	**Seasonal forecast; TC genesis; TIPS**
2012	Q1	TC-44	
	Q2		
	Q3	RSMC Tokyo attachment Research Fellowship	**To be attended by Viet Nam and Cambodia** Urban/coastal flooding + TC QPF; Wave and swell
	Q4	Integrated Workshop Roving Seminar Research Fellowship	**Damage assessment methodology and pre-evaluation (with WGDPP?)** Urban/coastal flooding + TC QPF; Wave and swell
2013	Q1	TC-45	
	Q2	2nd TRCG Forum / Meeting	(theme to be confirmed)
	Q3	RSMC Tokyo attachment Research Fellowship	**To be attended by Philippines and Thailand** TC damage assessment methodology and pre-evaluation
	Q4	Integrated Workshop Research Fellowship	**TC damage assessment methodology and pre-evaluation**

TRCG Budget for 2011 (from Typhoon Committee Trust Fund)

Roving Seminar   USD 16,500
RSMC Tokyo attachment   USD   4,000
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        Total   **USD 20,500**

Research and Training Activities in China Meteorological Administration (CMA)

1. The Tropical Cyclone Information Display and Processing System (TIPS):

The Tropical Cyclone Information Display and Processing System (TIPS) project in CMA was initiated in March 2010. Elaborately designed and carefully developed, the platform has been put into operational test. Implemented functions include:

1) real-time monitoring and forecasting, allowing the overlay of tropical cyclone strike probability information derived from the various NWP models, to facilitate the formulation of the subjective warning track;

2) automatic distribution of operational productions and calculation of forecast error statistics satisfying basic operational requirement;

3) database of historical tropical cyclones in the western North Pacific and global tropical cyclone information, and database of short-term climate prediction factors, with retrieval function expected to be implemented by end of the year.

2. Research progress on tropical cyclone related numerical models:

1) Improvement on global and regional tropical cyclone numerical model.

With the introduction of a new initialization system in the T213L31-SSI global model, intensity adjustment techniques in vortex initialization have been improved. Results showed that the adjustment had contributed to an improvement in tropical cyclone track prediction.

2) Ensemble prediction of tropical cyclone track implemented.

Based on TIGGE data, strike probability algorithm for the comprehensive use of multi-model and multi-initial data ensemble prediction has been improved. Multi-model integrated prediction products including tropical cyclone track and intensity based on T213-ATOVS, T639, UKMO, ECMWF and JMA models have been developed and put into use.

3. Training courses and international conferences in 2010:

"Advanced training course for numerical weather prediction model" summer school was successfully held in July in Beijing. The training course aimed at the comprehensive development of participants' ability in NWP skills, covering basic numerical discretization methods and analysis theories, parameterization schemes of physical

processes and their applications in NWP models, and the GRAPES model and its recent advances.

Invited by the Ministry of Natural Resources and Environment, Viet Nam, meteorological experts from CMA gave lectures in a one-week training course in Ha Noi on 29 Mar – 2 Apr, covering topics such as the application of satellite images in tropical cyclone forecasting and warning, tropical cyclone warning system, numerical models in NMC of CMA, and landfall tropical cyclone precipitation category and theory.

As an important part of WMO-TLFDP, a training workshop was held on 24 – 28 May during the Shanghai EXPO 2010. The WMO-TLFDP, jointly supported by WMO's World Weather Research Programme (WWRP), Tropical Cyclone Programme (TCP) and Public Weather Service Programme (PWS), was undertaken to support the Shanghai MHEWS project and was a collaborative effort with the THORPEX Western North Pacific Tropical Cyclone Track Ensemble Forecast Research Project. The training workshop aimed to improve tropical cyclone forecasting skills and performances, with more than 30 participants and 11 well-known experts serving as lecturers.

The Third WMO International Conference on Quantitative Precipitation Estimation (QPE) and Quantitative Precipitation Forecasting (QPF) and Hydrology (QPE/QPFIII) was convened at the WMO Regional Training Centre in Nanjing, China on 18 – 22 Oct. The overarching objective of this conference was to improve QPF capabilities and to advance the use of these capabilities in hydrological prediction with an emphasis on high impact events. The conference covered a wide range of issues, including new observational approaches and technique development for QPE, advances in data assimilation, modelling and verification for QPF, and the challenges of operational QPF to meet users' needs.

4. Research projects conducted in 2010:

Two projects supported by the Ministry of Science and Technology of China were initiated in 2010: (a) short-term forecasting and nowcasting of tropical cyclone rainstorms; and (b) reliability estimation of tropical cyclone forecasts.

According to the schedule of WMO-TLFDP, the tropical cyclone forecast evaluation system was implemented in 2010. Evaluation tools for basic verification of track and intensity were developed, and a website was launched to provide verification information in real time for testing by operational forecasters in Shanghai.

5. Typhoon Committee Research Fellowships offered in 2010:

Typhoon Committee Research Fellowships were awarded to Mr. NGUYEN Manh Linh from Viet Nam and Ms. Kamolrat SARINGKARNPHASIT from Thailand to work on the project "Typhoon Information Processing System" at the National Meteorological Center, CMA on 8 Oct – 8 Dec.

Research Activities in Hong Kong Observatory (HKO)

The Tropical Cyclone Information Processing System (TIPS) was enhanced:

i) to incorporate track forecasts by HKO's mesoscale non-hydrostatic model (meso-NHM);

ii) to incorporate ensemble mean tracks of China Meteorological Administration (CMA), UK Met. Office (EGRR) and Korea Meteorological Administration (KMA) based on data from the THORPEX GIFS-TIGGE project; and

iii) to allow the overlay of tropical cyclone strike probability information derived from CMA EPS, in addition to ECMWF EPS and JMA EPS, for the formulation of subjective warning track.

The new generation numerical weather prediction (NWP) system of the HKO has been put into operation since June 2010. The system, named as the Atmospheric Integrated Rapid cycle (AIR) forecast model, is based on the Non-hydrostatic Model (NHM) of JMA. It provides 72 hours and 15 hours of forecasts at horizontal resolutions of 10 km and 2 km respectively. With improved model physics and higher horizontal resolution, AIR was able o support the prediction of high-impact weather due to tropical cyclones. New products like distribution of surface wind and gusts have been developed for reference by forecasters to assess the change of wind intensity over coastal areas of southern China.

The satellite-based tropical cyclone rainfall forecast tool combining the QMORPH precipitation analysis from the Climate Prediction Center of NOAA and subjective tropical cyclone forecast track was enhanced prior to the start of the tropical cyclone season in 2010. Output of perturbed tracks from the EPS of ECMWF were used to generate probabilistic rainfall predictions with respect to various rainfall thresholds.

Verification of the track predictions from the multi-model ensemble and each of the member models, namely ECMWF, JMA, UKMO and NCEP, was conducted using all cases of tropical cyclones at or above tropical depression strength within the western North Pacific during 2008-2009. The results showed that ECMWF outperformed all other members from T+24 to T+120 forecasts (at 0.05 level of significance and serial correlation removed).

A paper on the benefits of tropical cyclones from the Hong Kong perspective was presented in the 5th ESCAP/WMO Typhoon Committee's Integrated Workshop "Urban Flood Risk Management in a Changing Climate: Sustainable and Adaptation Challenges" held in September 2010. The study showed that rainfall associated with tropical cyclones

accounted for a significant portion of Hong Kong's annual total rainfall. Furthermore, some tropical cyclones provided a net cooling effect and brought enhanced potential wind energy to Hong Kong.

A method using the principal components of dynamical climate model data as predictors to forecast the monthly/seasonal number of tropical cyclones coming within a certain range of a city has been developed. A keynote lecture was presented at the 5th ESCAP/WMO Typhoon Committee Integrated Workshop "Urban Flood Risk Management in a Changing Climate: Sustainable and Adaptation Challenges".

As part of HKO's contribution to the WMO Typhoon Landfall Forecast Demonstration Project (WMO-TLFDP), an in-house developed satellite-based tropical cyclone rainfall forecast tool was adapted to the eastern China region and provided to the Shanghai Typhoon Institute for real-time evaluation since September 2010.

A forecaster from the National Meteorological Centre of CMA was attached to HKO as a visiting fellow for two months starting from late October 2010 under the Typhoon Committee Research Fellowship Scheme. The research topic was "Can the extreme rainfall associated with Typhoon Morakot (0908) happen in Hong Kong?" and involved numerical experiments in which the vortex of Morakot and its associated environmental conditions were transplanted to study the impact on rainfall distribution over the northern part of the South China Sea and hence Hong Kong.

Dynamic hydrological and hydraulic computer models for the drainage systems in Hong Kong managed by the Drainage Service Department were developed to provide quantitative information on the risk of flooding, impacts of development and the performance of various flood loss mitigation options. In particular, all the trunk and major branch river channels in the most flood-prone river basins in the northern part of Hong Kong had been digitized into the computational hydraulic model which was used for the review of the hydrological criteria for the release of basin-wide flood warning in the region. A computerized stormwater drainage asset inventory and maintenance system had been developed. In the past year, the Drainage Service Department had completed several research studies including a review on the triggering criteria for the Special Announcement on Flooding in the northern New Territories, a sensitivity analysis of the hydraulic effect of mangrove growth in river estuary, an analysis of effects of climate change on stormwater drainage system, the use of local rainfall forecasts to mobilize maintenance staff to deal with flooding, and a study to identify the critical input parameters of the MIKE11 model and to quantify their uncertainties and sensitivities on the flood risk assessment.

Research Activities in Japan Meteorological Agency (JMA)

1. Improvements on the initial perturbation of JMA Typhoon Ensemble Prediction System (TEPS)

Since February 2008, JMA has operated Typhoon Ensemble Prediction System (TEPS) to contribute to the operational 5-day tropical cyclone forecast at RSMC Tokyo – Typhoon Center. The forecast model of TEPS is the low-resolution version (TL319L60) of JMA Global Spectral Model (GSM). It runs four times a day with 11 members (one control member + 10 perturbed members) up to 132-hour forecast when tropical cyclones of TS/STS/TY intensity are present or are expected to appear in the area of responsibility (0˚N–60˚N, 100˚E–180˚E).

The initial perturbations of TEPS are created with Singular Vector (SV) method. Two types of SV spatial target areas are defined to capture the uncertainty of track forecasts. One is the western North Pacific area (20˚N -60˚N, 100˚E -180˚E: RSMC target area), and the others are around the forecast positions of tropical cyclones (three at the maximum: TC target area). To further improve the performance of TEPS, JMA also revised the method of making the initial perturbations.   These revisions were implemented in TEPS in May 2010, with the expectation that they would contribute to making proper distribution of initial perturbations and improving the spread-skill relationship of track forecasts.

2. An Improvement of the Initialization Scheme for Tropical Cyclones

In view of the recent improvement in the accuracy of the first guess fields in the operational analyses through the assimilation of increased satellite data and the sophistication of data assimilation system, a bogus data adjusting function has recently been introduced. The number of deployed bogus observations is determined by the function, based on the distance between the analyzed cyclone position and the one in the first guess field. When the function is applied, the number of bogus observations is greatly decreased in most cases in such a way that they are deployed only in the vicinity of the cyclone centre. It was found from a series of global data assimilation and forecast experiments that the modified bogus scheme could remarkably reduce the errors of track prediction.   Responding to the results, the new scheme was implemented in the operational global analysis in April 2010 and the operational meso-scale analysis in September 2010.

3. Using TIGGE Data to Diagnose Initial Perturbations and their Growth for Tropical Cyclone Ensemble Forecasts

Ensemble initial perturbations around Typhoon Sinlaku (2008) produced by ECMWF, NCEP, and JMA ensembles were compared using THORPEX TIGGE data,

and the dynamical mechanisms of perturbation growth associated with cyclone motion were investigated for the ECMWF and NCEP ensembles. It was found that the vertical and horizontal distributions of initial perturbations as well as the amplitude were quite different among the three NWP centres before, during, and after the recurvature of Sinlaku. Such variations gave rise to differences in cyclone motion not only at the initial time but also during the subsequent forecast period. Statistical verification showed that the ensemble spread of track predictions in NCEP (ECMWF) was on average larger than ECMWF (NCEP) for 1- (3-) day forecasts. It was inferred that while the ECMWF ensemble started from a relatively small amplitude of initial perturbations, the growth of the perturbations helped to amplify the ensemble spread of tracks. On the other hand, a relatively large amplitude of initial perturbations seemed to play a role in producing the spread of tracks in the NCEP ensemble.

4. Impacts of Oceanic Pre-existing Conditions and Wave-ocean Interaction on the Prediction of Typhoon Haitang (2005)

Impact of variations in oceanic pre-existing conditions and wave-ocean interaction on the prediction of Typhoon Haitang (2005) was studied using a coupled atmosphere-ocean model with 6-km horizontal resolution and a coupled atmosphere-wave-ocean model with 3-km horizontal resolution. Variations in oceanic pre-existing conditions caused variations in predicted central pressure, which were comparable with the variations in predicted central pressure caused by Haitang-induced sea surface cooling. The cooling effect negatively affected the eyewall through a reduction in latent heat flux and precipitation, whereas variations in oceanic pre-existing conditions remarkably affected the spiral rainbands. The introduction of breaking surface waves into the coupled atmosphere-wave-ocean model reproduced more realistically the evolution of Haitang's central pressure and sea surface temperature distribution. Haitang tend to intensify when the initial mixed layer was relatively deep along its track.

5. Relationship between Near-core Surface Wind and Rainfall Asymmetries in Tropical Cyclones

Traditionally wind fields in a typhoon have been approximated by adding its movement velocity to the associated swirling winds, which results in stronger winds on the right than the left side of the track. A recent study revealed that environmental vertical wind shear (i.e., large-scale wind difference between upper and lower tropospheric levels) could also contribute to the wind asymmetries. The vertical shear affected near-surface wind fields in such a way that azimuthal winds increased (decreased) on the left (right) side of the shear vector (looking down shear).

As an extension of the shear-based study, the effect of inner-core rainfall asymmetry was examined using the 10-year data of coincident QuikSCAT winds and radiometer rainfall estimates. The results showed that the relation between shear and surface wind asymmetry could also be described in terms of rainfall asymmetry, suggesting that the asymmetric features of over-ocean wind fields could be estimated to some degree using information on cyclone motion and rainfall asymmetry.

Research Activities in Korea Meteorological Administration (KMA)

1. Developing WRF-based Ensemble Prediction System for Typhoon Track

WRF-based ensemble prediction system with five members was developed through the perturbation of background field. GFDL type tropical cyclone bogus was adopted to provide more accurate vortex representation in the background field. Other initial variables such as temperature, humidity, and geopotential height were prepared by FDDA with 12-hour nudging interval. The ensemble system runs two times (00 UTC and 12 UTC) each day to generate five-day forecasts for tropical cyclones in the western North Pacific area. Case studies showed that the ensemble prediction system was able to reduce track errors by 65% and 51% for 48-hour and 120-hour forecasts respectively.

2. Comparing Ensemble Methods for Summer-Time Numerical Weather Prediction over East Asia

Summer-time short- to medium-range predictability of precipitation, 500-hPa geopotential height, and wind fields over East Asia were investigated by comparing three ensemble configurations: multi-analysis, multi-convection, and multi-model ensemble systems. Each system has six members. Ensemble forecast skills were verified in both deterministic and probabilistic senses using the ECMWF analyses and the TRMM Microwave Imager (TMI) 2A12 rain estimates. It was found that an optimal set of ensemble members was the multi-model configuration that considered both initial condition and model uncertainties. The bias corrected ensemble and superensemble both showed similar predictability, but slightly better skill was obtained from the latter.

3. Effect of Tropical Sea Surface Temperature on the Western North Pacific Subtropical Anticyclone. Part II: What Determines the Type of Rossby Wave Propagation?

Tropical sea surface temperature (SST) forcing affects the regional climate of East Asia in summer. Kang and Kimura (2003), Part I of this study, used massive data analysis and MM5-based numerical experiments to classify two types of free Rossby wave propagation: one was the typical type propagating meridionally, and the other was the atypical type propagating zonally. However, what determined the types of free Rossby wave propagation was not studied.

To investigate the main factors that determined the types of free (or forced) Rossby wave propagation excited by tropical SST forcing (or mountain drag), two approaches were adopted: one was a numerical approach (NCEP GSM and NCAR MM5), and the other was an analytic approach (linearized shallow water equation) for free and forced Rossby waves respectively. The two approaches required different triggers to excite the propagation of Rossby waves: baroclinic instability (i.e., vertical shear) caused by

tropical SST forcing and barotropic instability (i.e., horizontal shear only) caused by mountain drag were the triggers for free and forced Rossby waves respectively. According to the main results of the two approaches, the direction of background inflow at the upstream region of the trigger (tropical SST forcing, mountain drag) commonly determined the types of Rossby wave propagations. The agreement of the two approaches indicated that the dynamics of baroclinic free Rossby wave propagation could be explained by the dynamics of barotropic forced Rossby waves.

Specifically, the numerical approach showed that the meridional component of the background inflow (low-level jet) at the upstream region of the tropical SST forcing domain (around the Philippine islands) was the main factor that determined the type of free Rossby wave propagation. The change from the typical type to the atypical type occurred when the direction of the background inflow changed from meridional to zonal direction, and vice versa. Free Rossby waves propagated more effectively under favourable conditions such as strong SST forcing and inflow over the forcing domain. The shape and location of the triggers in the models were of secondary importance.

According to the analytic approach results, the type of forced Rossby wave propagation was the same as the numerical approach results. The inflow direction at the upstream topography region was the main factor that determined the type of forced Rossby wave propagation. Similar to free Rossby waves, the direction of forced Rossby waves propagation followed the background inflow direction. The shape of the mountain was of secondary importance in determining the propagation type.

4. Possible Connection between Summer Tropical Cyclone Frequency and Spring Arctic Oscillation over East Asia

Studies by the National Typhoon Center showed that the frequency of summer tropical cyclone in the areas of Japan, Korea, and Taiwan (JKT) over the mid latitudes of East Asia had a positive correlation with Arctic Oscillation (AO) in the preceding spring, while tropical cyclone frequency in the Philippines (PH) located in the lower latitudes had a negative correlation. In the positive AO phase, with the anomalous anticyclone over the mid-latitudes of East Asia, an anomalous cyclone developed not only over high latitudes but also over the low latitudes from the preceding spring to summer. With this change, while the southeasterlies on the periphery of the mid-latitude anticyclone played a role in steering tropical cyclones toward the JKT area, the northwesterlies that strengthened as a result of the low latitude cyclone prevented tropical cyclones from moving toward the PH area. In addition, due to this distribution of pressure systems in the positive AO phase, tropical cyclones tend to occur, move and recurve further toward the northeastern part of the western North Pacific than in a negative AO phase.

Research and Training Activities in Malaysian Meteorological Department (MMD)

1.   Training

Officers from MMD attended the Asia Pacific Typhoon Workshop in Manila, the Philippines on 27 – 28 Jan and the Typhoon Committee Roving Seminar in Ubon Ratchathani, Thailand on 30 Nov – 3 Dec.

2.   NWP Development

The Shanghai Typhoon Institute's Bogus Data Assimilation (BDA) Typhoon Bogussing Scheme was successfully implemented on an operational basis in December 2009 to improve the cyclone vortex representation in the MM5 model at MMD. In the BDA scheme, bogus sea level pressure data are ingested as an observation field based on the Fujita's formula, and all model fields will be adjusted accordingly under the constraints of the MM5 model. Tropical cyclone analysis data from CMA are used to update the cyclone's central pressure, maximum wind speed and location. Currently, the bogussing scheme is configured for the Southeast Asian domain from 90°E to 130°E and 0N° to 20°N. The bogussing scheme will be turned on whenever a tropical cyclone with central pressure of less than 1000 hPa is located within the domain.

The MM5 with the BDA Typhoon Bogussing Scheme has performed well during the passages of Chantu, Dianmu, Mindulle and Megi over the South China Sea in 2010. The tracks of these tropical cyclones were more accurately predicted compared to the MM5 model without the bogussing scheme. More verification of track forecasts is being conducted and further research in cyclone intensity and structural changes, landfall processes, ensemble prediction techniques of cyclone tracks and assimilation of non-conventional data (radar and satellite) will be undertaken in the near future to improve the bogussing scheme's performance.

3.   Research

The Research Section in the Technical Development Division of MMD recently completed a study entitled 'The Impact of Tropical Cyclone in the Bay of Bengal on the Rainfall in Peninsular Malaysia'. Other ongoing research studies related to tropical cyclone activities are as follows:

i)   Influence of Tropical Cyclones in the Western Pacific Ocean and South China Sea on the Tropospheric Circulation and Weather Pattern over the Asian Monsoon Region during the Pre-monsoon, Monsoon and Post-monsoon Seasons;
ii) Storm Surge Modeling Results for Typhoon Hagibis and Vamei;
iii) The Impact of Tropical Cyclones on the Rainfall in Sabah during Southwest Monsoon; and
iv) ENSO Events and Tropical Storms over West Pacific Ocean 1945-2009.

Research Activities (input from the US representative)

The **WMO THORPEX Pacific Asian Regional Campaign (T-PARC)** program continued again this past year with the **TCS10/ITOP (Impact of Typhoons on the Ocean in the Pacific Ocean)** field experiment that held in the western North Pacific between 20 Aug and 20 Oct. The scientific goals for THORPEX include examining the interaction of various scales of motion in order to improve the description and prediction of medium range weather phenomena.

This summer, the TCS10/ITOP experiment focused on the impact and response of the ocean to the passages of tropical cyclones. These impacts included the examination and measurement of cold wakes from strong typhoons, air-sea interactions, and the study of ocean eddies. A continuation of some of the TCS08 objectives included the study of how the environment affected tropical cyclone genesis as well as intensification and movement. Mission centers were on Guam, as well as in Taiwan and Monterey, California. Multiple international agency cooperation was again required to coordinate the complex mix of aircraft, research vessels, satellite and land-based observations.

The following web site explains the goals and objectives of the program: http://www.eol.ucar.edu/projects/itop/. The data sets are now freely available on the NCAR EOL catalog. A description of the TCS10/ITOP data is located in: http://catalog.eol.ucar.edu/itop_2010/index.html.

Research and Training Activities in
National Hydro-Meteorological Service of Viet Nam

In 2010, the National Hydro-Meteorological Service of Viet Nam assigned the following personnel to undertake training and research activities relating to tropical cyclones:

1. Ms. Tran Ngoc Van from Central Hydro-Meteorological Forecasting Center and Ms. Bui Thi Hanh Phuc from Southern Regional Hydro-Meteorological Center attended the Training Workshop on Mesoscale Numerical Weather Prediction - Phase I for all ASEAN Member States in Seoul, Republic of Korea on 27 Sep – 8 Oct.

2. Under the Typhoon Committee Research Fellowship Scheme, Mr. Tran Quang Nang from Central Hydro-Meteorological Forecasting Center conducted a study on the improvement of tropical cyclone analysis and forecast system with the Typhoon Analysis and Prediction System (TAPS) at KMA from September to November, and Mr. Nguyen Manh Linh from Central Hydro-Meteorological Forecasting Center undertook a research project on TIPS development at the National Meteorological Center, China from October to December.

3. Mr. Du Duc Tien took part in the 7th WMO International Workshop on Tropical Cyclones (IWTC-VII) held in St. Denis, La Reunion on 15 – 20 Nov.

4. Mr. Nguyen Van Luong, Deputy Director of the North Central Regional Hydro-Meteorological Center, and Mr. Cao Van Thanh from Mid-Central Regional Hydro-Meteorological Center attended the Typhoon Committee Roving Seminar in Ubon Ratchathani, Thailand on 30 Nov – 3 Dec.

List of Resource Persons (as at 31 October 2010)

Member	Specialties	Name	E-mail	Affiliation
(A) Data Assimilation				
China	TC vortex initialization	LIANG, Xudong	Liangxd@mail.typhoon.gov.cn	Shanghai Typhoon Institute
	TC intensity estimation by radar, satellite, SSMI and QuikScat	GAO, Shuanzhu ZHOU, Bing	gaosz1129@sina.com bingz@cma.gov.cn	National Meteorological Center
	Radar data quality control and assimilation scheme	GONG, Jiandong	gongjd@cma.gov.cn	National Meteorological Center
Hong Kong, China	TC data assimilation	W.K. WONG	wkwong@hko.gov.hk	Hong Kong Observatory
Japan	Satellite data analysis	Naotaka UEKIYO	n-uekiyo@mri-jma.go.jp	Meteorological Research Institute
	TC intensity estimation	Shunsuke HOSHINO	shoshino@mri-jma.go.jp	Meteorological Research Institute
	Data analysis related to extratropical transition	Naoko KITABATAKE	nkitabat@mri-jma.go.jp	Meteorological Research Institute

Member	Specialties	Name	E-mail	Affiliation
(A) Data Assimilation (cont'd)				
Republic of Korea	Typhoon bogussing	YOO, Hee Dong	hyoo@kma.go.kr	Korea Meteorological Administration
		KWON, H. Joe	hjkwon@kongju.ac.kr	Kongju National University
	Satellite data analysis	PARK, Jong Seo	jspark@kma.go.kr	Korea Meteorological Administration
	Radar data analysis	LEE, Jong Ho	jhlee@kma.go.kr	Korea Meteorological Administration
USA (western North Pacific)	TC analysis, satellite interpretation, use of microwave imagery and scatterometer data	Roger EDSON	roger.edson@noaa.gov	NOAA National Weather Service Guam
(B) Modelling				
China	Numerical schemes of TC model	DUAN, Yihong	duanyh@mail.typhoon.gov.cn	Shanghai Typhoon Institute
	TC model physics and bogussing schemes	MA, Suhong	mash@cma.gov.cn	National Meteorological Center
	Ensemble track forecasting	ZHOU, Xiaqiong	zhouxq@mail.typhoon.gov.cn	Shanghai Typhoon Institute
	Typhoon modelling	LIANG, Xudong	Liangxd@mail.typhoon.gov.cn	Shanghai Typhoon Institute

Member	Specialties	Name	E-mail	Affiliation
(B) Modelling (cont'd)				
Hong Kong, China	TC modelling and bogussing schemes	W.K. WONG	wkwong@hko.gov.hk	Hong Kong Observatory
Japan	Ensemble track forecasting	Munehiko YAMAGUCHI	myamagu@mri-jma.go.jp	Meteorological Research Institute
	TC-ocean interaction (incl. mixed-layer ocean and ocean surface wave modelling)	Akiyoshi WADA	awada@mri-jma.go.jp	Meteorological Research Institute
	Storm surge modelling	Nadao KOHNO	nkono@met.kishou.go.jp	Japan Meteorological Agency
Republic of Korea	Global NWP model tracks	YOO, Hee Dong	hyoo@kma.go.kr	Korea Meteorological Administration
	Ensemble track forecasting	YOO, Hee Dong	hyoo@kma.go.kr	Korea Meteorological Administration
	Typhoon modelling	YOO, Hee Dong	hyoo@kma.go.kr	Korea Meteorological Administration
		KWON, H. Joe	hjkwon@kongju.ac.kr	Kongju National University
		BAIK, Jong Jin	jjbaik@snu.ac.kr	Seoul National University
Viet Nam	Computational fluid dynamics and modelling	LE, Duc	leducvn@yahoo.com	National Hydro-Meteorological Service of Viet Nam

Member	Specialties	Name	E-mail	Affiliation
(C) Forecasting				
China	Track and intensity forecasting	LEI, Xiaotu	Leixt@mail.typhoon.gov.cn	Shanghai Typhoon Institute
	Long-range prediction of typhoon	XU, Ming	Xum@mail.typhoon.gov.cn	Shanghai Typhoon Institute
Hong Kong, China	TC climatology and best track analysis	W.H. LUI	whlui@hko.gov.hk	Hong Kong Observatory
	TC intensity, structure and landfall impact	S.T. Chan	stchan@hko.gov.hk	Hong Kong Observatory
	Long-range forecasting of TCs	S.M. LEE	smlee@hko.gov.hk	Hong Kong Observatory
	TC motion, intensity, size, modelling and seasonal prediction	Johnny C.L. CHAN	Johnny.Chan@cityu.edu.hk	City University of Hong Kong.
Republic of Korea	Track and intensity forecasting	YOO, Hee Dong	hyoo@kma.go.kr	Korea Meteorological Administration
		KWON, H. Joe	hjkwon@kongju.ac.kr	Kongju National University
		BAIK, Jong Jin	jjbaik@snu.ac.kr	Seoul National University
		SOHN, Keon Tae	ktsohn@pusan.ac.kr	Pusan National University

Member	Specialties	Name	E-mail	Affiliation
(C) Forecasting (cont'd)				
Republic of Korea	Long-range prediction of typhoon	KWON, H. Joe	hjkwon@kongju.ac.kr	Kongju National University
		SOHN, Keon Tae	ktsohn@pusan.ac.kr	Pusan National University
Singapore	Seasonal prediction of typhoon	LIM, Tian Kuay	LIM_Tian_Kuay@nea.gov.sg	Meteorological Services Division, National Environment Agency
USA (western North Pacific)	TC analysis and forecasting, seasonal prediction, use of microwave imagery and scatterometer data, Dvorak technique	Mark LANDER	mlander@uguam.uog.edu	University of Guam (WERI)
	Satellite data analysis, use of microwave imagery	Jeff HAWKINS	Jeff.Hawkins@nrlmry.navy.mil	Navy Research Laboratory, Monterey
	Satellite data analysis, use of microwave imagery, automated Dvorak Technique, AMSU	Chris VELDEN	chris.velden@ssec.wisc.edu	CIMSS, University of Wisconsin-Madison
	Satellite data analysis, use of microwave imagery, AMSU	John KNAFF	knaff@CIRA.colostate.edu	CIRA, Colorado State University

Member	Specialties	Name	E-mail	Affiliation
(D) Application				
Hong Kong, China	TC warning systems and operations	Edwin S.T. LAI	stlai@hko.gov.hk	Hong Kong Observatory
	TC information visualization and display systems	L.S. LEE	lslee@hko.gov.hk	Hong Kong Observatory
USA (western North Pacific)	TC warning and disaster preparedness, seasonal prediction, Dvorak technique	Chip GUARD	chip.guard@noaa.gov	NOAA National Weather Service Guam