ESCAP/WMO Typhoon Committee

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AGENDA ITEM 5

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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 of the APPENDIX.

APPENDIX: TRCG Annual Report 2009

APPENDIX

TRAINING & RESEARCH COORDINATION GROUP (TRCG) ANNUAL REPORT 2009

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 2009, 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 2009

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 eighth Roving Seminar of the Typhoon Committee was held at the WMO RTC Nanjing at the Nanjing University of Information Science & Technology (NUIST) in Nanjing, China on 16 - 19 November 2009. It was organized with the generous support by WMO Public Weather Services Programme, Tropical Cyclone Programme and the Typhoon Committee Trust Fund. The selected theme was on tropical cyclone warning services with the following three sub-topics:

Topic A: Analysis and forecasting of high-impact weather associated with tropical cyclones
Topic B: Formulation and compilation of tropical cyclone warning messages
Topic C: Communication and broadcasting of warning messages through the mass media

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 five years. A summary report of the seminar can be found in Annex II.

Forecasters' Training Attachment

3.4 Two women forecasters from China and Malaysia successfully completed a training attachment at RSMC Tokyo on 22 - 31 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. A record of fellowships awarded can be found in Annex III; reports or papers since published in connection with the scheme are listed in Annex IV.

3.6 In 2009, fellowships were offered by China and Hong Kong, China. The China offer was taken up by Ms. NGUYEN Thi Minh Phuong (National Hydro-Meteorological Service of Viet Nam) and Mr. Chatchai CHAIYASAEN (Thai Meteorological Department) for the study of typhoon vortex initialization scheme and typhoon ensemble forecast techniques. The Hong Kong offer was taken up by Mr QU Anxiang (National Meteorological Center, China Meteorological

Administration) who spent two months (29 Oct – 28 Dec 2009) at the Hong Kong Observatory to study tropical cyclone bogus in NHM and its impact on forecast track and intensity.

1st TRCG Technical Forum

3.7 The Typhoon Committee, in organizing TRCG's first meeting for the planning of training and research activities in the coming cycle, decided to hold a parallel technical forum on the themes of "Consensus Forecast, EPS and TIPS" with a coordinated programme that allowed TIPS developers and forecasters, the key users of TIPS, to interact and exchange ideas. Apart from a series of lectures on the relevant topics, the forum has also been purposely designed with practical and discussion sessions on TIPS as well as other forecasting techniques to actively encourage such interaction and exchanges. Through such interaction, the ultimate aim is to transfer sustainable technology to the developing countries for operational adaptation to improve their forecasting and warning services.

3.8 TRCG took the lead in organizing the Technical Forum and received enthusiastic contribution and support from several sources. The WMO Tropical Cyclone Programme, actively encouraging the use of EPS and other consensus techniques among WMO Members, took the initiative to engage and fund the attendance of two resource persons for the event. WGM, meanwhile, offered to coordinate the participation of TIPS systems currently operated by Typhoon Committee Members. And last but not least, the Korea Meteorological Administration (KMA) made everything possible by offering to host the event at Seogwipo City in Jeju on 12 – 15 May, with the added attraction of an enlightening visit and live TAPS (KMA version of TIPS) tutorial session at their recently established National Typhoon Center on the island.

3.9 Apart from TIPS system specialists, two experts were also invited to deliver lectures on selected topics relating to ensemble forecasting, namely Professor Russell Elsberry from the Naval Postgraduate School and Mr. Takuya Komori from the Japan Meteorological Agency. About 20 participants from 12 Members, including quite a number from the developing countries, attended the lectures and TIPS sessions. Participants generally appreciated the objectives of the technical contents and considered the presented material useful for future adaptation and implementation. Two-thirds of the respondents felt that derived operational benefits could be felt within the next couple of years. A summary report can be found in Annex V.

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 – X.

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

5. Prioritization of Training and Research Areas

5.1 Taking into consideration comments made by the resource persons in the Roving Seminar 2009, the list of priority research topics is updated 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 in Myanmar, Philippines, Viet Nam and Taiwan in the past few years, sometimes despite the best intention of fairly accurate forecasts, 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 Plans and Activities

6.1 During the TRCG planning meeting organized in parallel with the 1st TRCG Technical Forum in Jeju on 12 – 15 May 2009, TRCG members generally supported the idea of regularly held meetings for long-term planning purpose. It was also proposed that such TRCG meetings be held more frequently, say with one review meeting held in parallel with the Integrated Workshop in between the 4-yearly TRCG Technical Forum. PRs of TC Members are also encouraged to release nominated TRCG members to travel to future TRCG-related meetings/activities as far as possible so that good continuity in TRCG work can be maintained.

6.2 On new directions and possibilities, the TRCG work plan would try to set up more follow-up activities in support of training/research topics covered in short-duration 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.

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

6.4 Meeting notes of the TRCG planning meeting and work plan outline for the 4-year cycle of 2009 – 2012 can be found in Annex XII. Proposed TRCG activities and their resource implications are included in the overall AOP for 2010 compiled and submitted by AWG.

Annex I

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

Annex II

SUMMARY OF TYPHOON COMMITTEE ROVING SEMINAR 2009
(Nanjing, China, 16 - 19 November 2009)

I. Organization

1. The Eighth Roving Seminar of the Typhoon Committee was held at the WMO RTC Nanjing at the Nanjing University of Information Science & Technology (NUIST) in Nanjing, China on 16 - 19 November 2009. It was organized with the generous support of WMO Public Weather Services Programme, Tropical Cyclone Programme and the Typhoon Committee Trust Fund.

2. It was attended by a total of 14 participants: two each from DPR Korea; Philippines; Republic of Korea; Thailand and Viet Nam; and one each from Hong Kong, China; Macao, China; Malaysia and Singapore.

II. Opening

1. The TC Roving Seminar was declared open by Prof. ZHI Xiefei, Deputy Director of RTC Nanjing at the NUIST on 16 November 2009.

2. Mr. Derek LEONG, Meteorologist of the Typhoon Committee, delivered the opening message addressing the significance of the Seminar and also expressing his appreciation to CMA, RTC Nanjing and the resource persons.

3. Prof. ZHI Xiefei, Deputy Director of RTC Nanjing, delivered the welcoming message, expressing RTC's strong support to various WMO training activities and his appreciation to the resource persons as well as TCS.

III. Seminar Programme

1. Mr. S.T. CHAN of HKO presented Topic A on "Analysis and forecasting of high-impact weather associated with tropical cyclones".

2. Mr. Chip GUARD of NOAA presented Topic B on "Formulation and compilation of tropical cyclone warning messages".

3. Mr. Sam MUCHEMI of WMO presented Topic C on “Communication and broadcasting of tropical cyclone warning messages through the mass media”, including studio sessions for on-camera presentation skills.

IV. Proposals and Recommendations

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

2. Suggestions from the resource persons for future reference: (a) selection of participants with relevant background and reasonable mastery of English to facilitate the training process; (b) satellite analysis topics including hands-on training; (c) synoptic and mesoscale analyses for tropical cyclone predictions; (d) skills in briefing the disaster community; and (e) nowcasting and very short range forecasting of tropical cyclone rainfall.

V. Closing

1. The resource persons and participants expressed their gratitude and appreciation to the CMA and NUIST for the successful hosting of the Roving Seminar and for their warm hospitality.

2. The closing remarks were given by Prof. ZHI Xiefei, Deputy Director of RTC Nanjing, followed by the presentation of attendance certificates to the participants.

3. The Roving Seminar was closed on 19 November 2009.

Annex III

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

Summary of Awarded Research Fellowships (cont'd)

Subject	Fellow	Host	Period
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

Annex IV

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 (in print).

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 (in print).

Annex V

Summary Report on 1st TRCG Technical Forum
12 – 15 May 2009, Jeju Island, Republic of Korea

Edwin S.T. Lai, TRCG Chair

The Typhoon Committee, in organizing TRCG's first meeting for the planning of training and research activities in the coming cycle, decided to hold a parallel technical forum on the themes of "Consensus Forecast, EPS and TIPS". Rather than treating all the topics as separate issues, the chance of having a coordinated programme that allowed TIPS developers and forecasters, the key users of TIPS, to interact and exchange ideas was too good to miss. As such, apart from a series of lectures on the relevant topics, the forum has also been purposely designed with practical and discussion sessions on TIPS as well as other forecasting techniques to actively encourage such interaction and exchanges. Through such interaction, the ultimate aim is to transfer sustainable technology to the developing countries for operational adaptation to improve their forecasting and warning services.

While TRCG took the lead in organizing the Technical Forum, it also received enthusiastic contribution and support from several sources. The WMO Tropical Cyclone Programme, actively encouraging the use of EPS and other consensus techniques among WMO Members, took the initiative to engage and fund the attendance of two resource persons for the event. WGM, meanwhile, offered to coordinate the participation of TIPS systems currently operated by Typhoon Committee Members. WGDPP, noting the potential benefits to disaster mitigation effort, also expressed an interest for a joint session with their annual gathering. The idea was only dropped because of the difficulty in finding a mutually convenient date. And last but not least, the Korea Meteorological Administration (KMA) made everything possible by offering to host the event at Seogwipo City in Jeju, with the added attraction of an enlightening visit and live TAPS (KMA version of TIPS) tutorial session at their recently established National Typhoon Center on the island.

The collective effort and pooling of resources paid off handsomely. For the first time in many years, TRCG had the opportunity to actually meet and make strategic plans for future training and research development. Out of 14 Members, 11 were represented in the meeting and a work programme for the coming 4-year cycle was formulated. Apart from TRCG members attending the planning meeting and two invited experts delivering the lectures, namely Professor Russell Elsberry from the Naval Postgraduate School and Mr. Takuya Komori from the Japan Meteorological Agency, about 20 participants from 12 Members, including quite a number from the developing countries, attended the lectures and TIPS sessions. In addition to local participants from KMA, researchers and students from the Cheju National University also sat in during the lectures, demonstrating that the essentially operational and practical subjects presented in the forum also attracted a lot of academic interest.

From feedback collected in a post-event survey, the forum was considered to be very well run in the organizational aspects, in particular the host's friendliness and helpfulness deserved a lot of recognition and praise. Ready access to the internet is fast becoming a popular demand in

the consideration of hotel and venue arrangement; and complex funding arrangement, as in the case of the Jeju event, may require more TCS attention in the future. Participants generally appreciated the objectives of the technical contents and considered the presented material useful for future adaptation and implementation. Two-thirds of the respondents felt that the derived operational benefits could be felt within the next couple of years. For the topics covered in the forum, the feeling was that some came unprepared for the TIPS sessions; hence the expectation level varied and the final outcome less definitive. While TRCG in their planning meeting took note of the need for more follow-up activities in the promotion of TIPS, WGM may also need to review and identify specific demands and needs for the advance and transfer of such technology in an effective and sustainable manner.

Annex VI

Research Activities in China Meteorological Administration (CMA)

The following tropical cyclone related training and research projects were undertaken at CMA in 2009:

(a) A 10-day training course on TC analysis and forecast was held by NMC during 13-24 April, chief forecasters reviewed and discussed the success and failures of the operations forecasts over the past 5 years cases.

(b) CMA initiated a 3-year research project on Typhoon Forecast and Warning System in 2009, 8 sub-systems are included: 1) TIPS; 2)Typhoon track and intensity forecast; 3)Typhoon winds and rainfall forecast; 4) Typhoon forecast and warning products generation and dissemination; 5)Typhoon disaster analysis and pre-assessment; 6) Global tropical cyclones monitoring; 7) Typhoon climate prediction; 8) Typhoon NWP.

(c) The Typhoon Committee Research Fellowships offered by CMA in 2009 are planning to be awarded to Mr. Chatchai Chaiyasaen (Thai Meteorological Department) to conduct a study on Typhoon Vortex Initialization Scheme in NWP model, and to Ms. Nguyen Thi Minh Phuong (Central Hydro-Meteorological Forecasting Center, NHMS of Viet Nam) on Typhoon Vortex Initialization Scheme and Typhoon Ensemble Forecast Techniques.

Annex VII

Research Activities in Hong Kong Observatory (HKO)

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

i) to support the construction of multi-model ensemble forecast track using the 'Motion Vector Consensus' method as an alternative to position-based consensus to cater for incomplete forecasts from individual ensemble members;

ii) to incorporate the ensemble mean track predictions by the Typhoon Ensemble Prediction System (EPS) of JMA; and

iii) to allow the overlay of tropical cyclone strike probability information derived from the JMA One-week EPS, in addition to ECMWF EPS, to facilitate the formulation of the subjective warning track.

To enhance typhoon rainfall forecast, a new forecast tool "QMORPH Tropical Cyclone Rainfall Forecast" was developed and launched for operational use in the 2009 typhoon season. The tool provides rainfall predictions up to 3 days ahead by extrapolating the microwave satellite rain rate estimate "QMORPH" from NOAA Climate Prediction Center along the subjective forecast track. A study was conducted to examine the potential application of EPS tropical cyclone track information for probability forecast of heavy rain using QMORPH. Results showed that the EPS tracks could provide some hints on the uncertainty of the rainfall predictions but a gross over-confidence was apparent in the probability forecasts thus generated.

An inter-comparison of WRF and an adapted version of the NHM from JMA was conducted for a number of tropical cyclone cases that affected Hong Kong in 2008. Preliminary results revealed that the forecast skill of both models, in terms of the track and intensity of tropical cyclone, were in general comparable. Nevertheless, WRF was found to be computationally more efficient than NHM.

Significant eastward biases were registered with nearly all the global models in the forecast track of Fengshen (0806). In a numerical study using WRF, with the introduction of a suitably constructed tropical cyclone bogus, the bias was largely corrected. The results highlighted the importance of proper initialization of tropical cyclone in NWP models to track predictions.

Based on numerical experiments of several tropical cyclone cases in 2008, it was found that NHM showed promising results in simulating the structure of intense tropical cyclones like Typhoon Hagupit. A new scheme of surface flux exchange coefficients and roughness length over sea surface was developed. It was demonstrated that the scheme had positive impact on the forecast of wind distribution of tropical cyclones.

A multiple regression model to correlate tropical cyclone wind structure parameters including strong/gale/storm/hurricane wind radii in different quadrants to the tropical cyclone intensity, latitudinal position, 6-hour speed of movement and the radius of maximum wind was developed based on the multi-platform satellite surface wind analysis data generated by the National Oceanic and Atmospheric Administration (NOAA) for tropical cyclones over the western North Pacific and the South China Sea during 2006-2008. Coupled with the tropical cyclone forecast track and intensity as well as surface characteristics information, the model could help generate wind forecasts at specific locations during the passage of the tropical cyclone. Its performance in forecasting surface wind at the Hong Kong International Airport was evaluated using tropical cyclone datasets for 2008 and 2009. Verification results showed that the mean RMS error for 24-hour forecast was about 13 km/h (7 knots). This tool would be put into operational trial in 2010.

A recent analysis of tropical cyclone activity in western North Pacific and South China Sea reveals that the annual total number of tropical cyclones decreased from about 35 in the 1960s to about 27 after 2000. Closer to Hong Kong, the annual number of tropical cyclones making landfall along the south China coast within 300 km of the Observatory Headquarters in the past 40 years or so (1961–2008) had decreased from about 3 tropical cyclones in the 1960s to about 2.5 between 1990 and 2008, but the rate of change is not statistically significant. The total number of typhoons, severe typhoons and super typhoons making landfall within 300 kilometers of Hong Kong remained unchanged at around one per year during the period 1961-2008.

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 MIKE11 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 flooding, 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.

Annex VIII

Research Activities in Japan Meteorological Agency (JMA)

1. Development of a Coupled Atmosphere-Ocean Model for Forecasts of Tropical Cyclones

Since November 2007, JMA has operated a high resolution (TL959L60) version of Global Spectral Model (GSM), and with its high resolution the model results are also used for the tropical cyclone (TC) prediction. To further improve TC intensity prediction, the interaction between TC and upper parts of ocean should be considered properly. Therefore, JMA has been developing coupled atmosphere-ocean models for TC forecast in recent years. The coupled model currently studied consists of the GSM as the atmospheric part and an ocean general circulation model developed by Meteorological Research Institute. The ocean model is formulated using the primitive equations of ocean and uses the Boussinesq approximation. Through the atmosphere-ocean interface, the ocean model provides predicted sea surface temperature (SST) to the GSM, while it gets momentum fluxes, heat fluxes and radiation from the GSM. Preliminary experiments were carried out for several recent TC events to assess the impact of the coupled model on TC forecasts. For the case of Typhoon Morakot in 2009, in which the operational (uncoupled) GSM tended to overestimate the TC intensity, the coupled model reproduced the TC intensity that agrees well with the analysis by representing sea surface cooling caused by the passage of the typhoon. This suggests the effectiveness of the coupled model in the TC intensity prediction.

2. Possible control of near-surface wind distributions in typhoons by environmental vertical wind shear

It is well known that a translating typhoon tends to have stronger winds relative to the earth on the right side of the direction of motion presumably due to addition of the translation velocity to the storm circulation. However, the physical basis for this is not very clear, considering that the storm motion does not necessarily coincide with the relevant environmental flow in vertically sheared environments. Moreover, recent observational and modeling studies strongly suggest that environmental vertical wind shear (EVWS) plays a dominant role in the azimuthal wave number-one rainfall asymmetry in the eyewall region not only over open oceans but also over lands. Considering that boundary layer convergence is the main source of vertical mass flow into the eyewall cloud, the close connection between EVWS and rainfall asymmetry leads to the speculation that low-level wind distributions in the typhoon inner-core region may be strongly modulated by EVWS. To confirm the speculation, azimuthal wavenumber-one structures of near-surface wind fields are investigated attempting both theoretical and statistical approaches. In the theoretical approach, a set of analytical formulae that relate the asymmetries of radial and tangential winds to convective asymmetry in the eyewall region are derived by applying a scaling argument to the result

from a numerical simulation of Typhoon Chaba (2004). The formulae predict that the maximum in storm-relative tangential wind occurs 90 degree azimuthally downwind of the enhanced updraft region. On the other hand, the statistical approach is based on the operational mesoscale analyses from the Japan Meteorological Agency (JMA) and QuikSCAT wind data for the four typhoon seasons from 2004 to 2007. The statistical approach reveals that the azimuthal location of tangential wind maximum relative to storm direction is determined by the directional difference between EVWS and storm motion, under relatively strong EVWS conditions, and the wind maximum, contrary to the majority of cases, tends to occur to the left of motion in cases where the directional difference is very small. Considering the strong dependence of convective asymmetry in the inner-core region on EVWS, the results are in line with expectations from the analytic theory.

3. Development of a Coupled Atmosphere-Wave-Ocean Model based on a Nonhydrostatic Atmospheric Model

A coupled atmosphere-wave-ocean model is developed at Meteorological Research Institute (MRI) based on a nonhydrostatic atmospheric model (NHM) which has been developed jointly by Numerical Prediction Division of Japan Meteorological Agency (JMA) and MRI. The coupled model consists of NHM, the third generation wave model developed at MRI (MRI-III), and a slab mixed-layer ocean model with a scheme for reproducing a variation of skin sea surface temperature (SST). Some preliminary numerical experiments using the coupled model are performed for Typhoon Hai-Tang in 2005. Roughness length over the ocean is calculated from wave steepness in the preliminary model runs though it can alternatively be calculated from wave height or wave age. The effect of wave-induced stress calculated by the MRI-III on turbulent mixing is a topic of future study. It is found from the preliminary numerical experiments that among sea surface cooling, sea state, oceanic precondition and diurnal variation of SST, the first item has the largest impact on the central pressure prediction. The impact of sea state on the central pressure prediction is comparable in magnitude to that of oceanic precondition, and larger than that of diurnal variation of SST. However, some caution may be necessary in the comparison because the impacts of both sea state and diurnal variation of SST depend on the oceanic precondition.

Annex IX

Research Activities in Korea Meteorological Administration (KMA)

1. Development of a WRF-based typhoon model for dynamical forecast

KMA implemented a research project for developing WRF-based typhoon model (hereafter TWRF) in November 2008. The goal was a feasibility study of KWRF (KMA Weather Research and Forecast Model) for applying typhoon forecast. To enhance the predictability of typhoon by TWRF, a series of research were conducted. GFDL type TC (Tropical Cyclone) initialization is adopted to represent more accurate TC vortex in TWRF initial conditions. Numerical experiments with three initial fields (GDAPS, GFS, and NOGAPS) were carried to evaluate the sensitivity of TWRF against different initial field. Sensitivity experiments on various physics options and dynamic conditions were also conducted to choose optimized model configuration for 72-hour forecast. According to the numerical experiments, track and intensity errors are sensitive to the types of physics, background field and data assimilation method. Optimized TWRF physics for microphysics, radiation, land surface, cumulus convection, and PBL are WSM 6-class, RRTM / Dudhia, Noah LSM, New Kain-Fritsch, YSU PBL scheme, respectively. Since FDDA with bogus vortex based on the direct observation data such as T-PARC data definitely can reduce both track and intensity errors in the typhoon forecast, this scheme will also be used to setup the 5-day forecast in terms of typhoon dynamics

2. Study of the tropical SST effect on the regional circulation of East Asia in summer

Tropical sea surface temperature (SST) forcing influences the regional circulation of East Asia by propagating Rossby wave from equatorial region to middle latitude in summer. The propagation can be classified into two types like meridional and zonal from equatorial region. There was linearity between the strength of free Rossby wave propagation and the magnitude of the tropical SST forcing for the typical type. Nonlinearity increases if there is a tropical depression, or typhoon in the North Western Pacific region. In order to investigate the main factor that determines the types of free (or forced) Rossby wave propagation excited by tropical SST forcing (or mountain drag), two approaches are adopted; one is a numerical approach (NCEP GSM and NCAR MM5), and the other is an analytic approach (linearized shallow water equation) for free and forced Rossby waves, respectively. The two approaches need different triggers to excite the propagation of each Rossby wave. Baroclinic instability (i.e., vertical shear) caused by tropical SST forcing and barotropic instability (i.e., horizontal shear only) caused by mountain drag are the triggers for free and forced Rossby waves, respectively.

The direction of background inflow at the upstream region of each trigger (tropical SST forcing, mountain drag) commonly determines the types of both Rossby wave propagations. The agreement of the two approaches indicates that the dynamics of baroclinic free Rossby wave propagation can be explained by the dynamics of barotropic

forced Rossby waves. The meridional component of the background inflow (low-level jet) at the upstream region of the tropical SST forcing domain (around the Philippine Islands) is the main factor that determines the type of free Rossby wave propagation. The type (or, direction) of free Rossby wave propagation is determined by the direction of the background inflow at the upstream region of the tropical SST forcing domain. The change from the typical type to the atypical type occurs when the direction of the background inflow changes from the meridional to the zonal direction, and vice versa. The free Rossby wave can propagate more effectively under favorable conditions such as strong SST forcing and inflow at forcing domain. The shape and location of the triggers in the models are secondary important which determine the direction of free Rossby wave propagation. The linearity of free Rossby wave propagation found by the RCM results still exists in the GCM results. This finding reconfirms that the linearity comes only from tropical SST forcing in the RCM domain, and atmospheric circulation anomalies (including the SST anomaly) outside the lateral boundary do not affect the linear response of free Rossby wave propagation against the linear increase of SST forcing around the Philippine Islands. According to the analytic approach results, the type of forced Rossby wave propagation is the same as the numerical approach results. The inflow direction at the upstream topography region is the main factor that determines the type of forced Rossby wave propagation. Similar to the free Rossby wave, the direction of the forced Rossby wave propagation follows the background inflow direction. The shape of the mountain is of secondary importance when determining the propagation type.

3. Study on the Prediction of Tropical Cyclone Intensity and Track over the Western North Pacific using the Artificial Neural Network Method

A statistical prediction model for the typhoon intensity and track in the Northwestern Pacific area was developed based on the artificial neural network scheme. Specifically, this model is focused on the 5-day prediction after tropical cyclone formation, and used the CLIPPER parameters (genesis location, intensity, and date), dynamic parameters (vertical wind shear between 200 and 850 hPa, upper-level divergence, and lower-level relative vorticity), and thermal parameters such as the upper-level equivalent potential temperature, ENSO, 200-hPa air temperature, mid-level relative humidity. Based on the characteristics of predictors, a total of seven artificial neural network models were developed. The best one was the case that combined the CLIPPER parameters and thermal parameters. This case showed higher predictability during the summer season than the winter season, and the forecast error also depended on the location: The intensity error rate increases when the genesis location moves to Southeastern area and the track error increases when it moves to Northwestern area.

Annex X

Research Activities in Malaysian Meteorological Department (MMD)

Training and Capacity Building on Typhoon Bogussing Technique Run on MM5 numerical weather prediction (NWP) model

Two experts from the Shanghai Typhoon Institute (STI), China Meteorological Administration (CMA) was invited to be attached at the Malaysian Meteorological Department (MMD) for one month each in March and April 2009. The purposes of the experts' attachment are that to help MMD in the implementation of Typhoon bogussing scheme run on MM5 NWP models, to enhance the initial data input for the models and to train MMD staff to run the MM5 NWP models to forecast typhoon track over South China Sea region in operational mode when there is typhoon event.

At the end of the attachment, a tropical cyclones initialization scheme based on the NCAR-AFWA (Air Force Weather Agency) tropical cyclone bogussing scheme (N-A bogus scheme) and MM5-4Dvar system was implemented on the SGI high performance computer at MMD. Preliminary result of test case shows that this scheme modifies the initial structure of typhoon reasonably well and may help in improving the performance of tropical cyclones forecast in terms of location, intensity and structure of tropical cyclone. The performance of the scheme in detail can be evaluated by a series of quasi-operational experiments.

The typhoon initialization process was introduced into the MMD MM5 NWP system. The MMD staffs are able to run the MM5 model with the typhoon bogussing scheme when there is a typhoon event in the vicinity of the South China Sea. Otherwise, the MM5 model will run without the typhoon bogussing scheme.

Annex XI

List of Resource Persons (as at 31 October 2009)

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	TC vortex initialization	Mitsuru UENO Masaru KUNII	mueno@mri-jma.go.jp mkunii@mri-jma.go.jp	Meteorological Research Institute
	Satellite data analysis	Tetsuo NAKAZAWA	nakazawa@mri-jma.go.jp	Meteorological Research Institute
	TC intensity estimation	Tetsuo NAKAZAWA	nakazawa@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	Numerical schemes of TC model	Wataru MASHIKO	wmashiko@mri-jma.go.jp	Meteorological Research Institute
	Physical processes of TC model	Mitsuru UENO Akihiko MURATA	mueno@mri-jma.go.jp amurata@mri-jma.go.jp	Meteorological Research Institute
	TC-ocean interaction (incl. mixed-layer ocean and ocean surface wave modelling)	Nadao KOHNO Akiyoshi WADA	nkohno@mri-jma.go.jp awada@mri-jma.go.jp	Meteorological Research Institute
	Storm surge modelling	Nadao KOHNO	nkohno@mri-jma.go.jp	Meteorological Research Institute
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

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

Annex XII

TRCG Meeting Notes
Jeju, Republic of Korea (12-15 May 2009)

In attendance:

Chair:	LAI, Sau Tak Edwin	Hong Kong, China
Vice-chair:	UENO, Mitsuru	Japan
Members:	EDSON, Roger	USA
	KANG, KiRyong	Republic of Korea
	MALANO, Vicente B.	Philippines
	NGUYEN, Dai Khanh	Viet Nam
	QIAN, Chuanhai	China
	SETH, Vannareth (Ms.)	Cambodia
	SYSOUPHANTHAVONG, Bounteum	Lao PDR
	THAIKRUAWAN, Sampan	Thailand
	WAN HASSAN, Wan Azli	Malaysia

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1. TRCG Chair thanked all present for making an effort to attend the very first TRCG meeting in Jeju. Suggestions were made that through discussion at the annual Typhoon Committee (TC) sessions, PRs of TC Members should be encouraged to release nominated TRCG members to travel to future TRCG-related meetings/activities as far as possible.

2. Reference was made to the tentative agenda sent out by TRCG Chair on 16 April, as well as the presentation made by TRCG Chair during the morning session on 12 May and the TRCG annual report as presented at the 41st TC Session at Chiang Mai, Thailand in January 2009. Participants generally supported the idea of a regularly held TRCG meeting for more long-term planning purpose; it was also proposed that the TRCG meeting be held more frequently, say with one review meeting held in parallel with the Integrated Workshop in between the 4-yearly TRCG Technical Forum.

3. In the review of past and present TRCG activities, participants considered the Roving Seminars useful and that the programme should continue. It was further proposed that after the departure of non-local participants, the resource persons should be retained for an extended stay to tour local facilities for more constructive interaction with forecasters and operational personnel and, in conjunction with a local facilitator assigned by the host countries who would digest and summarize the seminar material in the native language, conduct more comprehensive and in-depth discussion with local participants. External participants when back in their own

countries could also take the initiative to extend invitation to the relevant resource person for further training, either directly or through TRCG. Malaysia, Thailand and Viet Nam expressed preliminary interest in hosting future roving seminars in 2011 and 2012.

4. Despite the restricted research fellowship opportunities in recent years, participants felt the scheme should continue since several Members were able to make offers on a fairly regular basis and the resource implications on TC were relatively limited. However, it was suggested that the practice of soliciting Members' requests for fellowship opportunities should be discontinued as the chances of meeting specific research needs of individual Members were rather low. Participants were encouraged to explore instead internship opportunities in collaboration with research institutes or universities in their own countries.

5. On the review of training and research priority areas, it was suggested that cyclone formation and extratropical transition should be added. Data assimilation techniques should include AWS as well as other remote sensing data; and for satellite analysis techniques, scatterometer should be explicitly mentioned. While the importance of climate change issues was recognized, the subject should be dealt with separately for specific target groups and roving seminars for training purposes were better suited to matters with more immediate operational concerns.

6. On new directions and possibilities, the TRCG work plan would try to set up more follow-up activities in support of training/research topics covered in short-duration 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. Other tentative suggestions yet to be fully explored: (a) forecasters exchange programme; (b) more operational centres (e.g. China, Hong Kong, Australia) for forecasters' attachment; and (c) more systematic paper review and publishing processes.

7. While participants were encouraged to provide input to the TRCG-managed knowledge database resource portal soon to be launched on the TCS website, it was agreed that dynamic upload of information from Members would await further development at a later stage. It was proposed, however, that links to other useful e-resources websites such as COMET be included as far as possible.

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

9. In consideration of the aforementioned discussion, TRCG work plan outline for 2009 – 2012 was drafted as attached in Table 1.

10. For more effective communication and mobilization, participants updated their contacts with backup email addresses or fax. News of future TRCG activities sent to PRs will be copied to TRCG members. Participants were also reminded to update the list of resource persons (and means of contacts) on an annual basis.

Table 1

TC & Related Activities interlaced with TRCG Work Plan Outline (2009 – 2012)
(activities managed and organized by TRCG shaded or highlighted in yellow marker)

2009	**Q1**	TC-41 (Chiang Mai)	
	Q2	1st TRCG Technical Forum (Jeju)	Consensus forecast, EPS and TIPS
	Q3	RSMC Tokyo attachment Research Fellowship (Beijing) Integrated Workshop (Cebu)	Attended by China and Malaysia Attended by Thailand and Viet Nam
	Q4	Roving Seminar (Nanjing) Research Fellowship (Hong Kong)	Warning presentation and media skill Attended by China
2010	**Q1**	TC-42 (Singapore)	
	Q2	WMO Storm Surge Workshop	
	Q3	RSMC attachment Research Fellowship Pacific Desk Internship Integrated Workshop	Attended by Hong Kong and Singapore TIPS/EPS; data assimilation
	Q4	Roving Seminar Research Fellowship IWTC-7 (La Reunion)	TC genesis + MJO TIPS / EPS; data assimilation TC / TRCG representation?
2011	**Q1**	TC-43	
	Q2		
	Q3	RSMC attachment Research Fellowship Pacific Desk Internship Integrated Workshop	Attended by Macao and Lao PDR TC genesis + MJO (also climate influence) TRCG review meeting?
	Q4	Roving Seminar Research Fellowship	Urban/coastal flooding + TC QPF; Wave and swell TC genesis + MJO (also climate influence)
2012	**Q1**	TC-44	
	Q2		
	Q3	RSMC attachment Research Fellowship Pacific Desk Internship Integrated Workshop	Attended by Viet Nam and Cambodia TC QPF, flooding and coastal inundation
	Q4	Roving Seminar Research Fellowship	Seasonal forecast; TC damage pre-evaluation TC QPF, flooding and coastal inundation