MEMBER REPORT

ESCAP/WMO Typhoon Committee

42nd Session

25–29 January 2010

Singapore

People's Republic of China

CONTENTS

I. Overview of tropical cyclones which have affected/impacted Member's area in 2009

In 2009, totally 9 tropical cyclones landed on China. They were severe tropical storm Linfa (0903), tropical storm Nangka (0904) and Soudelor (0905), Typhoon Molave (0906), tropical storm Goni (0907), typhoon Morakot (0908), tropical storm Mujigae (0913), typhoon Koppu (0915) and super typhoon Parma (0917) respectively.

1. Meteorological Assessment (highlighting forecasting issues/impacts)

(1) LINFA (0903)

LINFA formed as a tropical depression over South China Sea at 06:00 UTC 17 June 2009. It developed into a tropical storm and a severe tropical storm at 06:00 UTC 18 June and 03:00 UTC 20 June respectively. LINFA started to move northwards. As it was gradually approaching to the coast of the Fujian province, its intensity was greatly reduced to be a tropical storm category. LINFA landed on Jinjiang of the Fujian province, China at 12:30 UTC 21 June with the maximum wind at 23m/s near its centre. After landfall, LINFA turned northeast. It entered Fujian off-shore area at 04:00 UTC 22 June. It weakened into a tropical depression at 09:00 UTC 22 June. At last LINFA faded away in Zhejiang off-shore at 18:00 UTC 22 June.

6 people died. The direct economic loss was estimated about RMB 0.641 billion *Yuan*.

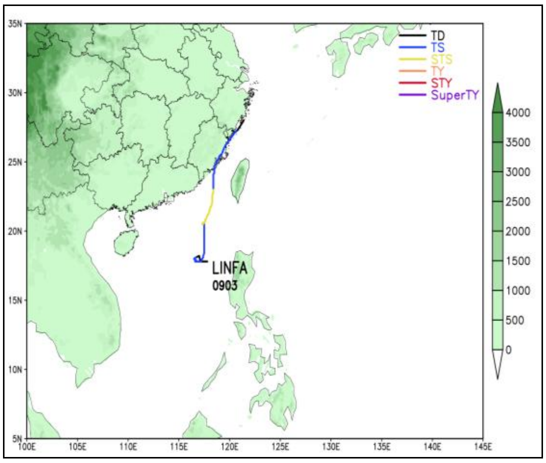


Fig. 1a: Track of LINFA (0903)

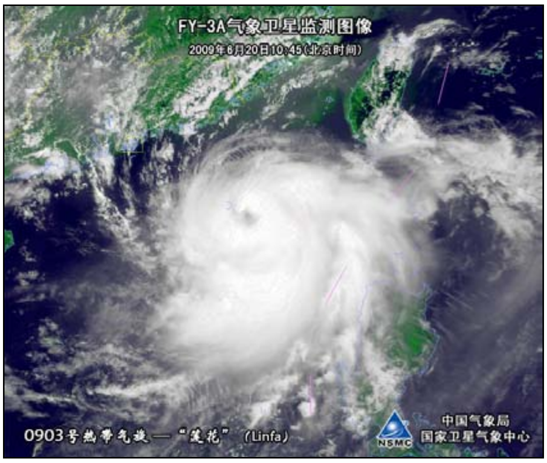


Fig. 1b: FY-3A Image at 02:45 UTC 20 June 2009

(2) NANGKA (0904)

Tropical storm NANGKA formed at 06:00 UTC 23 June 2009 over eastern offing of the Philippines. Afterwards it moved northwestwards and entered the South China Sea. Then it turned north-northwest and approached to the coast of the Guangdong province, China. NANGKA landed in Huidong of Guangdong province at 14:50 UTC 26 June with the maximum wind at 20m/s near its centre. After landing, it turned northwards with its intensity being reduced quickly. It became a tropical depression at 18:00 UTC 26 June. At last NANGKA disappeared in the Guangdong province at 03:00 UTC 27 June.

No person died during its landfall in China. The direct economic loss was estimated about RMB 0.037 billion *Yuan*.

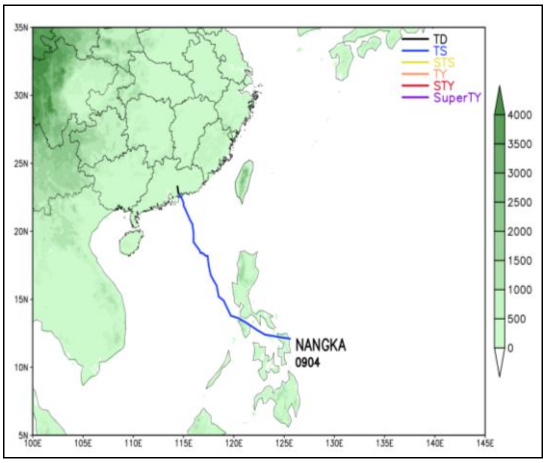


Fig. 2a: Track of NANGKA (0904)

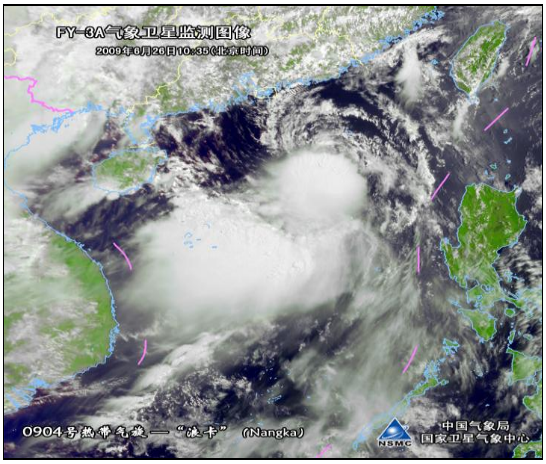


Fig. 2b: FY-3A Image, 02:35 UTC 26 June 2009

(3) SOUDELOR (0905)

It was formed as a tropical depression over the northern offing of the Philippines at 00:00 UTC 10 July 2009. Afterwards it moved west-northwest and entered the northern part of the South China Sea. Then it moved west-northwest steadily with its intensity being intensified gradually. SOUDELOR became a tropical storm at 06:00 UTC 11 July. It approached gradually to the eastern coast of the Hainan province. At 21:30 UTC 11 July it landed in Wenchang of the Hainan province with the maximum winds of 18m/s near its centre. Then it landed in Xuwen of the Guangdong province at 00:20UTC 12 July with the maximum winds of 18m/s near centre. Thereafter it moved west-northwest and entered the Beibu Gulf. It landed once again on Vietnam on 12 July. At last it faded away over Vietnam on 12 July.

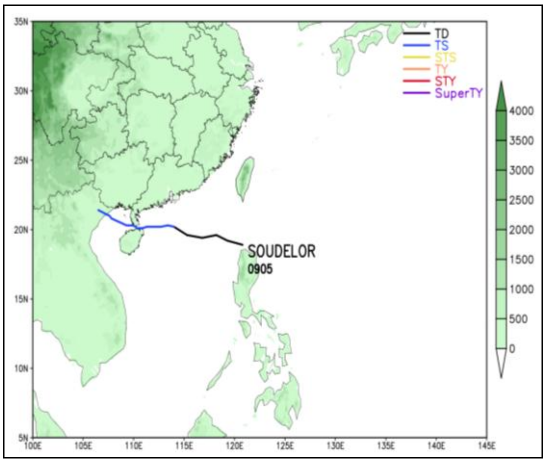


Fig. 3a: Track of SOUDELOR (0905)

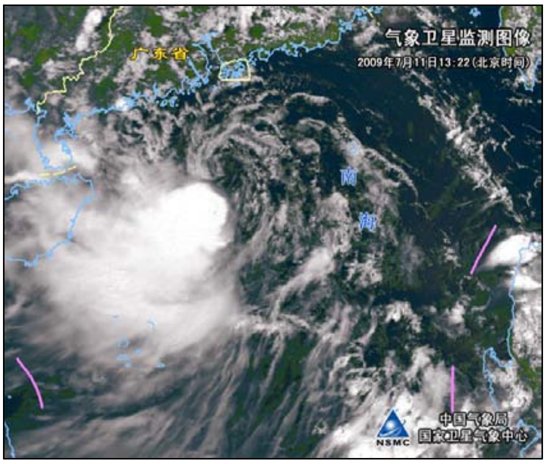


Fig. 3b: Satellite Image at 05:22 UTC 11 July 2009

(4) MOLAVE (0906)

Tropical depression MOLAVE emerged to the east of the Philippines at 12:00 UTC 15 July 2009. Moving northwestward, it was strengthened into a tropical storm at 12:00 UTC 16 July. It intensified gradually and become a typhoon over the northeastern part of the South China Sea at 21:00 UTC 17 July. Then it began to move west-northwest. Eventually, MOLAVE landed on Shenzhen of the Guangdong province at 16:50 UTC 18 July with the maximum wind of 38m/s near its centre. After landing, MOLAVE moved west-northwest with its intensity being weakened quickly. It weakened into a tropical depression at 07:00 UTC 19 July in Guangxi Autonomous Region (AR). At last it disappeared over the Guangxi AR at 18:00 UTC 19 July.

5 people died. The direct economic loss was estimated about RMB 0.63 billion *Yuan*.

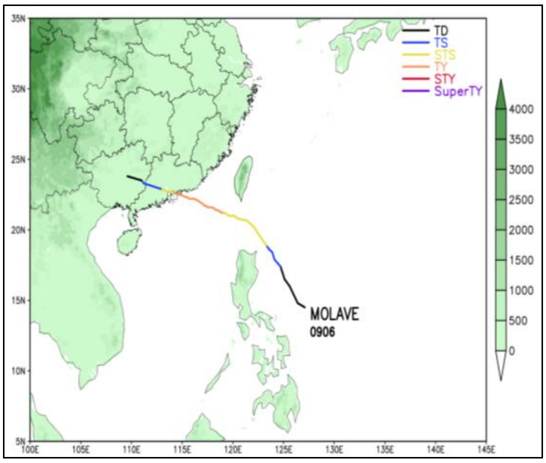


Fig. 4a: Track of MOLAVE (0906)

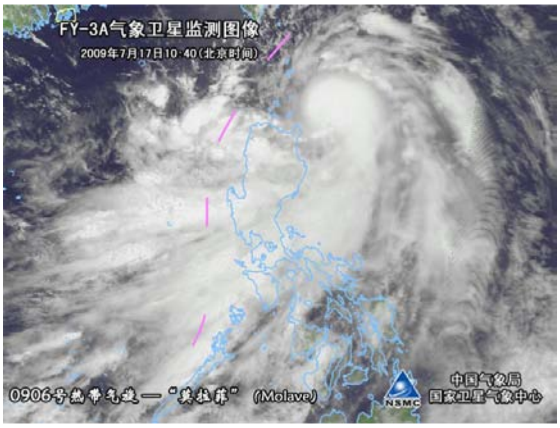
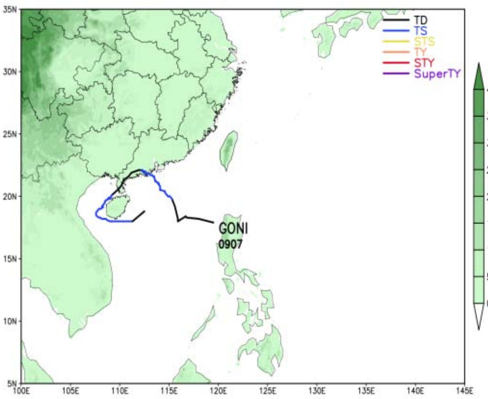


Fig. 4b: FY-3A Image at 02:40 UTC 17 July 2009

(5) GONI (0907)

It turned out to be a tropical depression over the eastern part of the South China Sea at 18:00 UTC 1 August 2009. Afterwards it moved westwards and then it turned north-northwest. It developed into a tropical storm at 12:00 UTC 3 August and it turned in northwestward direction. It approached gradually to the coast of the Guangdong province. GONI landed in Taishan of Guangdong province at 22:20 UTC 4 August, with the maximum wind up to 23m/s near its centre. After landing, it was reduced into a tropical depression rapidly. Then GONI turned southwestwards and entered the Beibu Gulf, where it developed into a tropical storm at 06:00 UTC 7 August again. Over the southern part of the Beibu Gulf, it turned east-southeastwards. It weakened into a tropical depression over northwestern part of the South China Sea at 22:00 UTC 8 August, where GONI faded away at 09:00 UTC 9 August.

6 people died. The direct economic loss was estimated about RMB 1.71 billion *Yuan*.



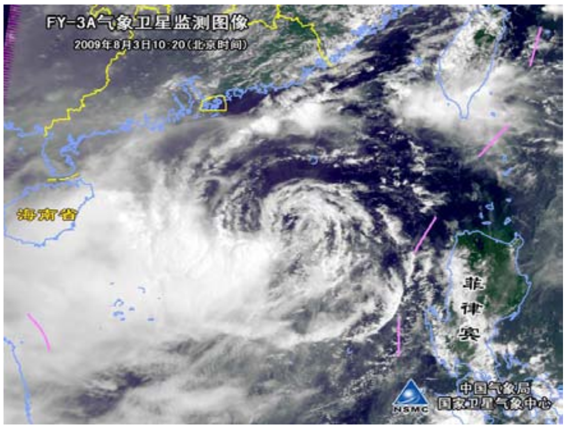


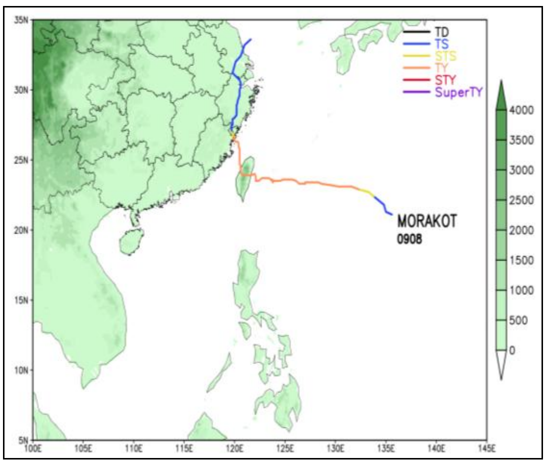
Fig. 5a Track of GONI (0907)

Fig. 5b FY-3A Image at 02:20 UTC 3 August 2009

(6) MORAKOT (0908)

Tropical storm MORAKOT formed at 18:00 UTC 3 August 2009 over the Northwest Pacific. Afterwards it moved northwestwards. Its intensity increased into typhoon category at 06:00 UTC 5 August. Then it turned westwards. It approached gradually to the eastern coast of the Taiwan province, China. MORAKOT landed in Hualian of the Taiwan province, China at 15:45 UTC 7 August with the maximum winds reaching 40m/s near its centre. After landing, it moved westward. Then it crossed the Taiwan province and entered Taiwan Strait. It turned to north-northwest direction at a slow pace afterwards. Later MORAKOT landed once again in Xiapu of the Fujian province at 08:20 UTC 9 August, with the maximum winds of 33m/s near its centre. After its second landfall, it moved northwards with its intensity being reduced quickly. It became a tropical storm over northeastern part of the Fujian province at 18:00 UTC 9 August. Then it moved north-northeast and crossed the Zhejiang and Jiangsu provinces. At last it entered the Yellow Sea and gradually disappeared over southwestern part of the Yellow Sea at 18:00 UTC 11 August.

628 people died, 79 missing, the direct economic loss was estimated about RMB 16.26 billion *Yuan*.



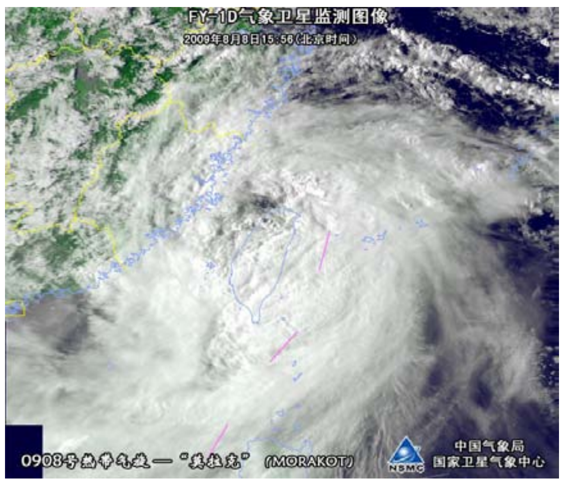


Fig. 6a: Track of MORAKOT (0908)

Fig. 6b: FY-1D Image at 07:56 UTC 8 August 2009

(7) MUJIGAE (0913)

MUJIGAE emerged as a tropical depression over the South China Sea at 06:00 UTC 8 September 2009. Moving northwest, it was intensified into a tropical storm at 21:00 UTC 9 September.

It approached to the eastern coast of the Hainan province. MUJIGAE landed in Wenchang of the Hainan province at 18:20 UTC 10 September with the maximum wind reaching 20m/s near its centre. After landing, MUJIGAE moved westward. Then it crossed the Hainan province and entered the Beibu Gulf. At last MUJIGAE landed again on Vietnam on 12 September.

No person died during its landfall on China. The direct economic loss was estimated about RMB 0.04 billion *Yuan*.

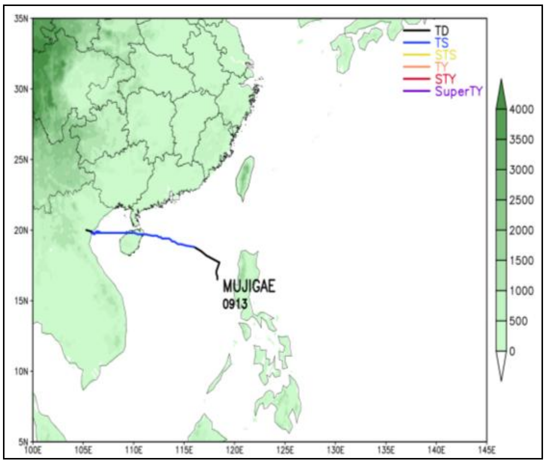


Fig. 7a: Track of MUJIGAE (0913)

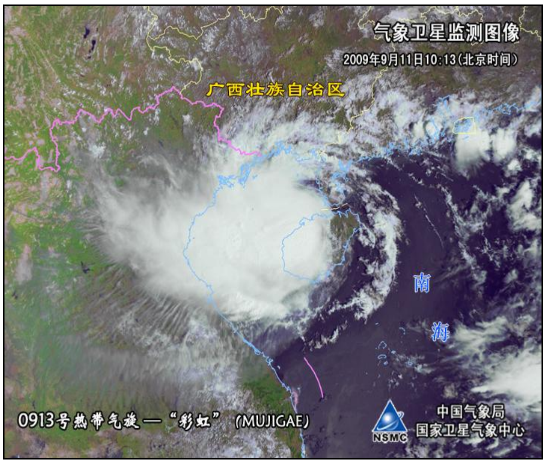


Fig. 7b: Satellite Image at 02:13 UTC 11 September 2009

(8) KOPPU (0915)

Tropical storm KOPPU formed at 18:00 UTC 12 September 2009 over the northern offing of Philippines. Afterwards it moved west-northwest with its intensity upgrading to severe tropical storm and typhoon at 02:00 UTC 14 September and at 09:00 UTC 14 September respectively. It approached gradually to the coast of Guangdong province, China. Finally KOPPU landed in Taishan of Guangdong province, China with the maximum winds of 35m/s near centre at 23:00 UTC 14 September 2009. After landing, its intensity weakened rapidly. It reduced to a tropical depression at 15:00 UTC 15 September. At last KOPPU faded away in Guangxi Zhuang Autonomous Region at 00:00 UTC 16 September.

11 people died. The direct economic loss was estimated about RMB 2.27 billion *Yuan*.

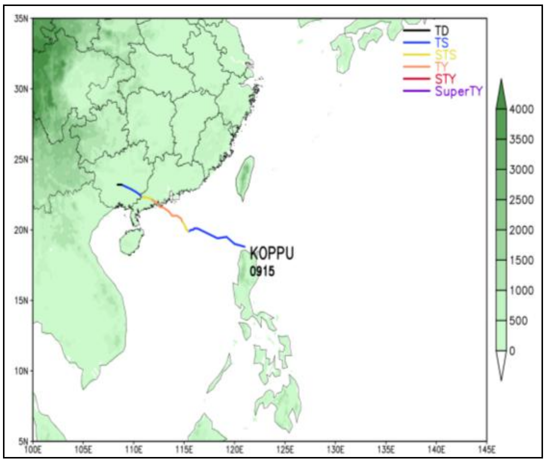


Fig. 8a Track of KOPPU (0915)

Fig. 8b Satellite Image at 05:40 UTC 14 September,2009

(9) PARMA (0917)

Tropical storm PARMA formed at 00:00 UTC 29 September 2009 over the Northwest Pacific. Afterwards it moved northwest. Its intensity was increased up to a super typhoon category at 03:00 UTC 1 October. Then it approached gradually to LUZON of the Philippines with its intensity being weakened gradually. PARMA hovered near LUZON from 3 to 8 October. Then it entered the South China Sea and began to move west-northwest. It approached gradually to the southeastern coast of the Hainan province. PARMA landed on Wanning of the Hainan province at 01:50 UTC 12 October with the maximum wind up to 23m/s near its centre. After landing, it moved northwestward. Then it crossed the Hainan province and entered the Beibu Gulf. At last PARMA landed again on Vietnam on 14 October.

7 people died, 10 missing, with the direct economic loss being estimated about RMB 0.459 billion *Yuan*.

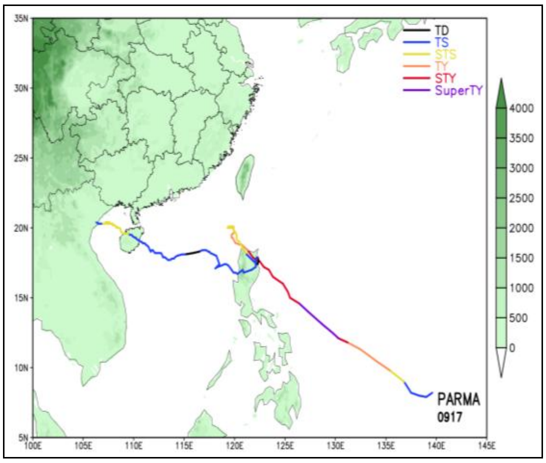


Fig. 9a: Track of PARMA (0917)

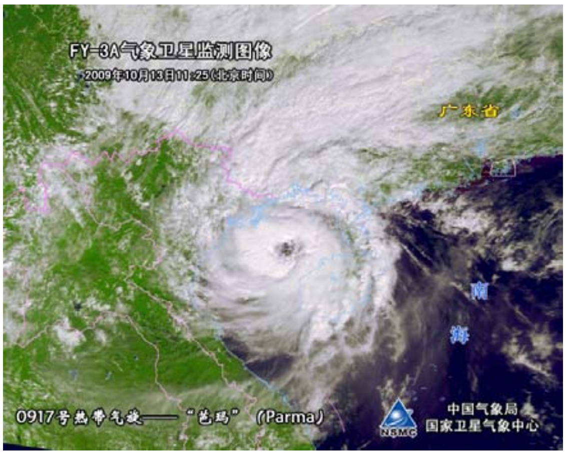


Fig. 9b : FY-3A Image at 03:25UTC 13 October 2009

2. Hydrological Assessment (highlighting water-related issues/impact)

The year 2009 witnessed occurrence of drought and flood, with serious flash floods and drought happening in some parts of China. In the flood-prone season, precipitation nationwide was slightly lower than normal, but the rainfall is highly uneven distributed in time and space. Water inflow from major rivers was less than normal, and serious drought happened in northern China in the mid summer, while serious autumn drought occurred in the middle and upper reaches of the Yangtze River and in the areas around the Dongting Lake and the Poyang Lake. Major river flows were smooth in general. However, the warning water levels were reached in the main branches of the Xijiang River, in the mainstream of the Yangtze River in its upper reaches, and in the Taihu Lake. Rain storm-induced floods occurred frequently in medium and small-sized rivers, and multiple rivers met record-breaking floods.

The Hydrological Conditions in 2009 can be categorized as follows:

(1) There were more moving rainfall events with highly uneven rainfall distribution in time and space. In the flood-prone season of 2009, there were many precipitation processes across the country, which were mostly moving from one place to another, thus without creating continuous rainfall on a large scale. In July, there were 13 such rainfall processes which were unevenly distributed in time and space. In northern China, rainfall in the Heilongjiang Province prior to June 1st was significantly less than normal (50% - 90% less than normal); persistent rainfalls occurred in both June and July, with rainfall amounts exceeding normal values by 50% up to 2 fold; From late July to mid August, rainfall became less than normal years again. In southern China, continuous heavy rainfalls occurred in Liujiang of the Pearl River basin at the end of June and early July, in the Taihu Lake basin, Sichuan Province and Chongqing City in later July and early August. During the last ten days of August, however, rain was less than normal in most parts of China to the south of the Yangtze River.

(2) Hydrological conditions were generally stable in major rivers while floods frequently occurred in medium-small rivers. Except for the mainstream of the upper reaches of the Yangtze River and Taihu Lake where water exceeded alert levels, the other major rivers in China were stable in general. However, due to intensive rainfall induced by extreme weather, floods happened in over 210 medium-small rivers in 6 major river basins with exception of the Haihe River basin. Major and record floods took place in Longjiang River – a branch of the Liujiang River, in Ruqigou outlet from the Zhangshui branch of Ganjiang River in the upper reaches of the Yellow River, in the branch Nangang of the Aojiang River in Zhejiang Province, and in the Huangzejiang branch of the Cao'e'jiang River; the Yuanhe branch of the Ganjiang River and Qianhe branch of the Hanjiang River met the second biggest flood in history, and Hulan branch of the Songhua River saw the biggest flood since 1998.

(3) Less river inflow across China and insufficient water retention in reservoirs in the northern China. Less water inflows were measured in the seven major rivers in China. To be specific, water inflow was 10-20% less than normal in the mainstream

of the Yangtze River and the upper reaches of the Yellow River, 30-70% less in other major rivers, and the South Juma River in the Haihe River basin was basically dry, breaking the least inflow record for the same period. According to water storage statistics in 100 reservoirs in 8 provinces (municipalities), i.e. Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, and Heilongjiang, the total water storage on October 1st accounted for 31.9 billion cubic meters, which was 5.8 billion cubic meters or 15% less than that of the previous year, or 7.21 billion cubic meters or 18% less than normal years.

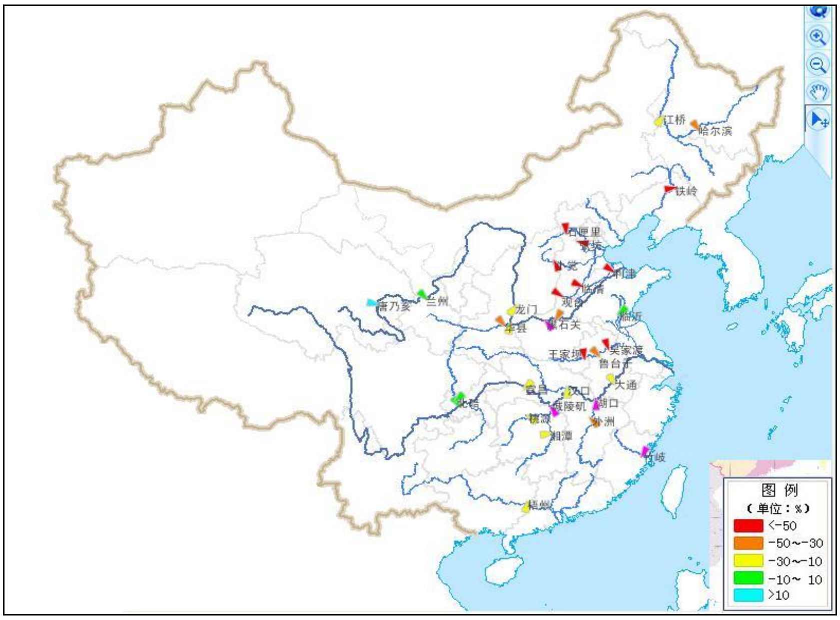


Fig. 10: Anomalies of the accumulated water inflows in major rivers in 2009.

(4) Less rainfall in periods, plus severe local droughts. In northern China, rainfall in flood-prone season was 30-70% less than normal, and this figure is 50% for rivers. Reservoirs had insufficient water storage, soil moisture and ground water table kept decreasing, and 54 rivers ran dry in 11 provinces (municipalities or ARs) in the northern China. From mid August, the southern part of the Yangtze River, northern part of the South China, and southeastern part of the Southwest China experienced continuous high temperature and little rain, with rainfall and water inflows being significantly less than normal, which led to dropping water levels in rivers and fast spread of drought. The most serious situations were found in the lower reaches of the Ganjiang River in the Poyang Lake basin and the Fuhe River, both of which saw the lowest water levels in history.

3. Socio-Economic Assessment (highlighting socio-economic and DPP issues/impacts)

Totally 9 typhoons or tropical storms landed on China in 2009. From prospective of regional impacts, typhoon Morakot (0908) was most severe for its widespread impacts. It was estimated that it affected the area of about 1.238 million km^2, with total rainfall reaching 27.5 km^3. Furthermore, Morakot and tropical storm GONI

(0907) were the major rainfall producers in comparison with others, binging about 69.7 km^3 and 41.3 km^3, and affecting the total areas of 1.022 million km^2 and 0.721 million km^2 respectively.

In 2009, TCs brought abundant precipitation to China, and abated the agricultural drought and impacts of hot weather in most southern area of middle and lower reaches of the Yangtze River basin and the South China, and they increased the water storage in reservoirs. However, the high wind, heavy rain in connection with astronomical tides also caused severe losses in the coastal areas during this year. According to the preliminary statistics, nearly 24 million people were affected, out of which 663 people were killed and 111 people were missing. The total direct economic loss was up to 22 billion *Yuan*.

Table1: Tropical Cyclones Landing over China in 2009

TCs' Name (Number)	Landing date	Landing place	Max wind speed when landing (m/s)	Affected area	Affected people (in10,000)	Death (person)	Missing (person)	Economic losses (billion *Yuan*)
Linfa (0903)	21 June	Jinjiang, Fujian	23		23.42	6	——	0.641
Nangka (0904)	26 June	Huidong, Guangdong	20	Guangdong	3.50	——	——	0.037
Soudelor (0905)	12 July	Wenchang, Hainan Xuwen, Guangdong	18 18	——	——	——	——	——
Molave (0906)	19 July	Shenzhen, Guangdong	38	Guangdong, Guangxi, Yunnan	203.8	5	——	0.63
Goni (0907)	5 Aug.	Taishan, Guangdong	23	Guangdong Guangxi, Hainan	291.0	6	14	1.71
Morakot (0908)	7 Aug. 9 Aug.	Hualian, Taiwan Xipu, Fujian	40 33	Taiwan Fujian, Zhejiang Jiangxi, Anhui Jiangsu, Shanghai	1461.0	628	79	16.26

Mujigae (0913)	11 Sep.	Wenchang, Hainan	20	Hainan	16.8	——	——	0.04
Koppu (0915)	15 Sep.	Taishan, Guangdong	35	Guangdong, Guangxi	209.4	11	8	2.27
Parma (0917)	12 Oct.	Wanning, Hainan	23	Hainan, Guangdong	166.9	7	10	0.459
Total	——	——	——	——	2375.82	663	111	22.047

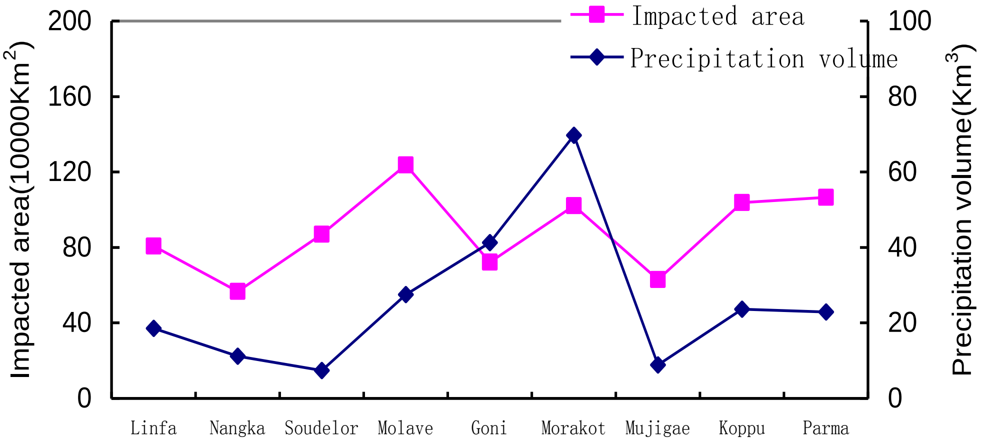


Fig. 11: The estimated precipitation volumes and impacted areas of typhoons or severe tropical storms which landed in China during Jan. to Oct. 2009.

4. Regional Cooperation Assessment (highlighting regional cooperation successes and challenges)
N/A

II. Summary of progress in Key Result Areas (For achievements/results which apply to more than one Key Result Area, please describe them under the most applicable Key Result Area. Then, at the end of the description, place in parentheses the other applicable Key Result Areas)

1. Progress on Key Result Area 1: Reduced Loss of Life from Typhoon-related Disasters. (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2009 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

✧ **Improvement in Typhoon Warning System**

In 2009, Meteorological establishments servicing 5 provinces issued 234 typhoon warnings and 127 typhoon alarm signals on their potential impacts during the typhoon season. Additionally, 1926 TC warning messages (SMS) were disseminated via mobile phone networks to about 466 million people. The other means of dissemination include TV, radio, electronic display screens, newspapers, dedicated telephone (phone number 12121),,weather websites, community-targeted broadcasts & SMS, marine radio, DAB alarm radios and meteorological information delivery by volunteers etc.

✧ **Improvement in TC warning and advisories**

In order to improve the time validity of the operational typhoon forecasts and early warnings, National Meteorological Centre (NMC) began to issue official forecasts for 96-hour TC tracks in 2009, and it conducted operational experiment on 120-hour TC track forecasting. NMC will issue operational 120-hour TC track forecasts starting from the next year.

✧ **Revision of Typhoon Operation Standard**

In order to meet the refined services and demands of national agencies and general public for TC-induced disaster prevention and preparedness, CMA revised typhoon operation standard in 2009 and it plans to put into operation in the next typhoon season. The revised contents mainly include:

- The TC warning zone has been enlarged, including the whole South China Sea, waters east of Taiwan, China and the sea east of the Luzon Island.
- The forecasts for all depressions developed over the Western North Pacific and the South China Sea will be issued starting from the next year.
- Intensive upper observations during any emergency.

b. Hydrological Achievements/Results

To enhance flood alert and prediction capacity, the Hydrological Bureau under the Ministry of Water Resources upgraded existing operational flood forecasting system in 2009. The upgraded system is able to simulate floods in areas where neither monitoring stations nor data are available. The capability has been enhanced in breaking flood forecasting during such emergencies as the earthquake in Sichuan in 2008 and the landslides in Tibet. Emergency flood prediction module has been developed which facilitate decision-making for addressing any breaking water events. Moreover, the Hydrological Bureaus at all levels, in coordination with river basin management authorities, revised the flood forecast scheme for key sections in major rivers so as to improve forecast accuracy and to extend the lead time of the forecasts.

In 2009, the Ministry of Water Resources prepared and released the technical the Guidelines for Mapping Flood Risks (on trial basis), which greatly promoted the applications of flood risk mapping technique in China.

c. Disaster Prevention and Preparedness Achievements/Results

✧ **Emergency response and typhoon-induced disasters relief**

In 2009, the Ministry of Civil Affairs (MCA) further improved emergency disasters management mechanisms, and improved the warning mechanism in response to typhoon disasters focusing on the characteristics of the work in addressing typhoon-induced disasters. In 2009, nine tropical cyclones landed on China. The National Committee for Disaster Reduction (NCDR) and MCA initiated 9 emergency response actions, and overall measures & deployments regarding personnel coordination, supply of goods and clothes, information delivery and emergency commanding to prevent, mitigate and relieve typhoon disasters. Due to accurate and timely forecasts/warning and effective measures, notable success was achieved in response to typhoon "Morakot", NCDR together with MCA initiated category-IV emergency response plan in Fujian, Zhejiang, Jiangxi and Anhui provinces, and 4 working groups were dispatched to the disaster area to guide disaster relief work. 6 provinces including Zhejiang, Fujian, Jiangsu, Anhui and others moved more than 1.5 million people urgently to safety, which minimized possible casualties. Local governments initiated contingency plans at once and got rescue & relief teams ready when called on. The proven experiences and knowledge in combating typhoons from those at the grass-roots levels including community residents proved to be useful to avoid human casualties and building damages by strong wind associated with typhoons, which reduced houses ruins and properties substantively.

✧ **Emergency standard of living of disaster victims**

Both NCDR and MCA continued to enhance emergency goods supply mechanism to ensure daily life of the affected population, to improve their living quality. For those who were evacuated in emergency typhoon responses, the local Civil Affairs Bureaus at various levels followed the people-centreed policy and mandates of delivering "food to eat, clothes to wear, places to live, clean water to drink, timely health caret ", and they mobilized human material and financial resources in time to help overcome temporary difficulties for the displaced population. MCA also urged its local establishments to strengthen their efforts in reserving relief goods and materials. At present, 10 warehouses of disaster rescue & relief goods have been established by Central and, local governments, each having their own storages, including tents, clothes and other goods needed by affected people in the disaster zones. Local governments have agreement with supermarkets and other institutions for food supply to disaster victims. In order to ensure safety of local residents who are exposed to typhoon threats, the provincial Bureaus of Civil Affairs in Zhejiang and Fujian have set up emergency disaster response networks to ensure every community has a certified shelter safe enough to avoid secondary causalities therein.

d. Research, Training, and Other Achievements/Results - Shanghai Typhoon Institute, Chinese Academy of Meteorological Sciences, and National Meteorological Centre,

N/A

e. Regional Cooperation Achievements/Results

✧ **International Training Courses and Academic meeting**

The international training courses on early warning of natural disasters were held in Nanjing, China in June 2009. It was organized by Nanjing University of Information and Technology This event provided training and experience on new knowledge and techniques on forecasts and warnings of natural disasters, including tropical cyclones.

f. Identified Opportunities/Challenges for Future Achievements/Results

N/A

2. Progress on Key Result Area 2: Minimized Typhoon-related Social and Economic Impacts. (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2009 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

The climate prediction in relation to the frequency of tropical cyclone (TC) released in Early April 2009 was as follows:

It was estimated total TC number would be within 25 ~ 27 in 2009 in the Northwest Pacific and the South China Sea, which would be less than normal compared to the climatology (27 for 1971-2000 on average), while more than that in 2008 (22). The numbers of landing TCs on China would be 7 to 9, slightly more than normal (7). The initial landing date would be earlier than normal (June 29) and the last landing time would be near normal (October 7).

In fact, the total number of TC was 21 over the Northwest Pacific and the South China Sea up to mid-November, 2009, which was less than normal. The number of landing TC was above normal (9). The initial landing time of TC on China was June 21, which was earlier than normal.

The correct predictors can be analyzed as follows:

✧ According to the interannual and decadal TC variations, the number of TCs in 2009 fall in the less-than-normal phase, while number of landing TCs is in its above-normal phase. The initial landing time is in the earlier phase, and the final landing time is in the later phase.
✧ The summer troposphere vertical wind shear index (weaker) and 850hPa vorticity by the dynamic model indicates the numbers of TC would be less than normal in 2009.
✧ Considering the relationship between the landing TC numbers and SLP in previous winter, the numbers of landing TC would be more than normal in 2009.

- ✧ According to statistical analysis, when the Northwest Pacific Subtropical High is stronger in summer, the landing TCs tend to be more than normal.

b. Hydrological Achievements/Results

During the 41st meeting of the Typhoon Committee held in 19-24 Jan. 2009 in Chiang Mai, Thailand, the Typhoon Committee approved the new project proposal from the hydrological working panel and launched the new project led by China, i.e., Urban Flood Risk Management for Members of the Typhoon Committee. The project aims to exchange and share experiences in urban flood management among Members, including urban flood monitoring, prediction and warning technologies, and ultimately improve the capacity for urban flood control in the region.

In 2009 China has completed a survey in Phase 1 as planned, which is to understand current practices for Member in managing urban floods and urgent problems to be addressed in urban flood control. In March 2009, the Hydrological Bureau of China prepared a questionnaire and disseminated it to Members through the Typhoon Committee. 5 countries (regions) have provided feedbacks, including Hong Kong, China, Japan, the Philippines, Vietnam and China. Based on the feedbacks, the Hydrological Bureau prepared an investigation report, summarizing the current status and key issues to be attended, and proposing a work plan for next phase.

c. Disaster Prevention and Preparedness Achievements/Results
N/A

d. Research, Training, and Other Achievements/Results

In 2009, to meet the needs for the seasonal TC predictions over the Northwest Pacific, the National Climate Centre studied the relationship between TC tracks, intensity, frequency and genesis location and large-scale atmospheric circulations. Furthermore, a seasonal ensemble prediction system was developed for Northwest Pacific TC modeling with WRF.

e. Regional Cooperation Achievements/Results

Since 2005, the seasonal TC forecasts for the Western Pacific and the South China Sea were discussed at the Forum on Regional Climate Monitoring, Assessment and Prediction for Asia (FOCRAII) with the experts from Hadley Centre, IRI, Korea, China and other countries/regions. The meeting addressed the seasonal scale circulations in relation to quantification of TC tracks, intensity, genesis and frequency

f. Identified Opportunities/Challenges for Future Achievements/Results

N/A

3. Progress on Key Result Area 3: Enhanced Beneficial Typhoon-related Effects for the Betterment of Quality of life. (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2009 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results
N/A

b. Hydrological Achievements/Results

In 2009, altogether 9 TCs landed on China. To do a better job in disaster prevention and mitigation in this connection, the Ministry of Water Resources enhanced flood-control through video consultations or conferences, during which hydrological predictions were provided targeting to the areas under possible impacts of a typhoon. The prediction not only helped reduce loss caused by typhoons, but also effectively guided local authorities to take advantage of the typhoon-induced rainfall for drought relief and water storage in reservoirs. For example, large reservoirs in Hainan and Guangxi increased water retention in major reservoirs following the landfall of Typhoon Parma (No. 17). Compared to that prior to the typhoon landing, the total volume in 6 large reservoirs in Hainan alone was increased by 340 million m^3, and that in 28 major reservoirs in Guangxi AR was increased by 160 million m^3.

c. Disaster Prevention and Preparedness Achievements/Results
N/A

d. Research, Training, and Other Achievements/Results
N/A

e. Regional Cooperation Achievements/Results
N/A

f. Identified Opportunities/Challenges for Future Achievements/Results
N/A

4. Progress on Key Result Area 4: Improved Typhoon-related Disaster Risk Management in Various Sectors. (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2009 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

Meteorological departments strengthened the management of typhoon risks. For the high-risk areas under typhoon threats, such as Guangdong, Guangxi, Fujian, Zhejiang and Hainan, The, pre-assessments on and early warning of typhoon risks were provided to enhance typhoon risk management, to reduce the typhoon impact on the urban population, agriculture, transportation, electricity supply, dam safety, etc. Based on different risk areas and typhoon risk rating, disaster prevention and mitigation measures were proposed for the governments at various levels in managing typhoon emergencies, and to mitigate the impact of typhoon disasters, as useful information for decision-making process.

✧ **Technical specification for typhoon disaster impact assessment**

A composite index for calculating typhoon damages (TDCI) was developed based on damage data collected in 1984-2008, which was used to analyze the characteristics of inter-annual disasters in terms of deaths and missing, affected crop area, ruined houses, and immediate economic loss by using EOF method. Typhoon disaster impact rating and classification criteria at national and provincial levels were also defined. The meteorological standard - "Technical Specification for Typhoon Disaster Impact Assessment" was prepared and submitted for approval.

✧ **The improvement in typhoon damage assessment system**

The typhoon damage assessment system has been improved for quasi-operational use. Main improvements of system are as follows: adding a pre-assessment module for TCs over seas; adding a processing module for TCs with time being numbered is less than 24 hours before the initial prediction time; and improved module to process incorrect surface data. The quasi-operational typhoon damage assessment system is started at 9:00 AM each day. It provides 9 pre-assessment damage information, including possible ruined houses, affected crop areas, immediate economic loss/rate, disaster index (TDCI), and severity categories. There are 4 options in pre-assessment scenarios such as using model precipitation or not, and overlapping damages calculated at national level with individual provincial data or not, etc. Outputs of all models are timely displayed in diagrams (histogram and 2-D pattern) on web. The module outcomes are still under further improvements.

✧ **TC activities and its impacts**

Climatology and interannual variation in TC intensity, track and locations of landfall on China from the Northwest Pacific (WNP) are statistically analyzed, using 28 years (1979—2006) TC dataset from the U.S. Joint Typhoon Warming Centre. The results indicate that landing TCs are mostly originated in the western part of the WNP and the mid-northern part of the South China Sea. The landing locations of TCs in coastal China show a trend of northeastward shift, leading to the increase of landed TC number to the north of Xiamen (Fujian province) and the decrease in south of Xiamen. TC activities have greater impacts on other rainfall-producing weather systems. A statistical analysis is used investigate the relationship between typhoon in the western North Pacific and *meiyu* in the Yangtze and Huaihe valleys from 1949 to 2005. It is found that there is an obvious negative correlation between plum rainfall (called *meiyu* in China, *baiu* or *tsuyu* in Japan or *jangma* in Korea) and typhoon frequency both annually and in typhoon season. It could be attributed to the different positions of monsoon trough, and the changes in intensity and locations of subtropical high. Typhoon tends to be inactive in the year when *meiyu* rainfall is abundant, and vice versa (i.e. number of typhoons landed on China would be doubled when meiyu rainfall is short).

b. Hydrological Achievements/Results

In 2009, for establishing a Flood Disaster Preparedness Index,- a project under the Working Group on Hydrology, the Ministry of Water Resources actively collected and compiled relevant data, prepared an questionnaire for a survey, and submitted to Japan.

c. Disaster Prevention and Preparedness Achievements/Results

✧ **Typhoon disasters monitoring, warning and information management**

Making decisions in emergency disaster management rely on disaster information. In 2009, MCA further improved typhoon monitoring, warning and evaluation mechanism. Firstly, it improved disaster monitoring mechanism in 24 hours to collect real-time warning and forecasts on typhoons from meteorological and oceanic agencies, to track and monitor typhoon-induced disasters nationwide. Secondly, it launched typhoon monitoring, warning and assessments on typhoon risks by tracking typhoon motions, evaluating possible losses, preparing and delivering typhoon impact and disaster situation information & products. In 2009, NDRCC/MCA issued 20 typhoon risk monitoring products and 12 risk early warning & assessment reports. Thirdly, MCA enhanced cooperation with agencies under coordination of the National Committee for Disaster Reduction, Each day, it delivered information about disaster situation, rescue & relief work through its bulletins like *Disaster Situation Yesterday*, *Disasters Express*, *Emergence Response Report* in support to decision making by central government. Fourthly, it set up information delivery system and associated certification system for recruiting qualified staff. Under these systems, professional disaster information delivery teams have been set up across the country, which provide a solid basis for further enhancing and improving management in disaster information delivery.

d. Research, Training, and Other Achievements/Results

N/A

e. Regional Cooperation Achievements/Results

✧ **International cooperation on typhoon disasters reduction**

In 2009, the Ministry of Civil Affairs (MCA) enhanced the international cooperation and exchanges in the field of disasters reduction with UN agencies in China, emergency disaster management institutions in other countries, international entities for disaster risk management, which also promoted the technological R&D. In August, at the request of United Nation agencies in China, in cooperation with the Ministry of Commerce, MCA organized an assessment on impacts of typhoon "Morakot" in disaster areas for humanitarian aid. An assessment working group was set up with 4 experts from OCHA and UNDP. During investigations, the UN working group would know the specific needs for humanitarian aid to the affected population and urgent technique problems to be addressed after disasters. Related authorities in Zhejiang and Fujian provided some specific requirements for the ongoing rescue & relief work. At the same time, they also provided the Working Group with some successful experiences and practices. In September, NDRCC of MCA negotiated with U.S RMS Company, they planed to jointly develop disaster pre-assessment techniques used for typhoon risk management, which will improve the typhoon-induced warning and assessment techniques in China.

f. Identified Opportunities/Challenges for Future Achievements/Results - National Meteorological Centre, CMA Training Centre, Shanghai Typhoon Institute, Guangzhou Institute of Tropical and Oceanic Meteorology, and Chinese Academy of Meteorological Sciences.

N/A

5. Progress on Key Result Area 5: Strengthened Resilience of Communities to Typhoon-related Disasters. (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2009 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

✧ **Establishment of Shanghai Typhoon Warning Centre**

As a component of the Multiple Hazard Early Warning System (MHEWS), the Shanghai Typhoon Warning Centre was established in May 2009. This centre is jointly supported by Shanghai Typhoon Institute, Shanghai Meteorological Centre, Shanghai Satellite Remote Sensing and Monitoring Application Centre, to more effectively use the available resources for improving typhoon forecasting and warning services.

b. Hydrological Achievements/Results

In recent years, China has enhanced research on flash flood early warning system. In December 2007, the Hydrological Bureau of MWR launched a dedicated research project of Monitoring and Prediction Technology Research for Flash Flood in Medium and Small-sized River Basins which was funded by MWR for public good. The project results provided a basis for developing a GIS-based Central Rivers Flash Flood Prediction and Warning Prototype. Currently the System can be used for automatic prediction of flash flood and warning with 4 functions, i.e., static critical rainfall flash flood warning, soil moisture-based dynamic and rainfall-induced critical flash flood warning, flash flood warning based on distributed hydrological model outputs, and flash flood warning based on simple forecast practices.

c. Disaster Prevention and Preparedness Achievements/Results

✧ **Disaster prevention and reduction in communities**

Combined with the efforts in building up civilized communities in urban areas and new villages in rural areas, Ministry of Civil Affairs (MCA) vigorously promoted disasters reduction activities in communities, schools and villages. Billboards, showcases, plates and pamphlets (e.g. handout for self-relief measures in prevention of risks and disasters) were put up or made available in residential blocks for public outreach in the social communities and for increasing public awareness to avoid risks and dangers. During the “Disasters Reduction Month”, “International day for Disasters Reduction”, and the “Disaster Prevention and Reduction Day”, in order to enhance public capabilities to handle emergencies, organized public outreach activities and drills. To ensure emergency safety of community residents, MCA promoted the set-ups of local emergency response network for disaster prevention in cities and countryside, to enable every community to provide a safe and reliable public shelter, in which emergency necessities must be prepared to secure their daily life. In response to national emergency action plans for natural disasters at all levels, MCA establishments at all levels mobilized urban and rural communities to set up contingency plans in case of natural disasters and to enhance management of disaster prevention and relief activities. Through public outreach for preventative measures in prevention and reduction of disasters, in conjunction with network-buildup and community-oriented early warning system, the urban and rural residents especially those who live in the areas frequently hit by typhoons have increased capacities to combat typhoons, with casualties and property losses being decreased sharply.

d. Research, Training, and Other Achievements/Results

N/A

e. Regional Cooperation Achievements/Results

N/A

f. Identified Opportunities/Challenges for Future Achievements/Results

N/A

6. Progress on Key Result Area 6: Improved Capacity to Generate and Provide Accurate, Timely, and understandable Information on Typhoon-related Threats. (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2009 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

✧ **Improvement in Marine Observation System**

By the end of 2009, 191 Shore-based stations and 84 island AWSs had been set up. Recently, 17 buoys, 2 storm surge stations, 6 oil drilling platform-based stations and 4 ship stations are under construction, out of which the 6 buoy stations become operational.

✧ **Improvement in Upper Air Observing System**

In 2009, 27 upper air stations were up-graded by L-band radar-based upper air observing systems.

✧ **Improvement in Radar Observing System**

156 Doppler weather radars have been already installed in China for observing precipitation, rainstorms and typhoons by 2009. They further improved the capability in monitoring typhoons along the Chinese southeast coasts, among others.

In 2009, a plan for installing additional 58 new-generation Doppler weather radars has been approved by government to improve monitoring, forecasting and warning of severe weather events. According to the latest plan, 8 CINRAD radars will be set up in 2010.

✧ **Improvement in Satellite Observing System**

The FY-2E satellite of the FY-2 geostationary meteorological satellite series has been delivered to the China Meteorological Administration (CMA) from the State Administration of Science, Technology and Industry for National Defense on 19 May 2009. FY-2E is the third satellite of the FY-2 series and is the successor of FY-2C and FY-2D. FY-2E has been successfully launched in Xichang Satellite Launch Centre on 23 December 2008 and located at 123.5℃E in the orbit on 27 December 2008. The satellite has such features as follows:

①Observation ability: satellite-borne scanning radiometer.

② Able to obtain a panoramic picture an hour in the none-flooding season and a picture half an hour in the flooding season covered about 1/3 earth.

③Data collection ability: various ground data collection platform deliver meteorology, hydrology, ocean and environment data et al, then digitize all kinds of obtained data, modulate UHF frequency and send to application system via FY-2E satellite. Receive and demodulate data in the CDAS, then deliver them to the data processing centre.
④Production distribution ability: application system applies the stretching and section pictures, quantitative product and platform data produced by the satellite observation data to the user via broadcasting-satellite channel and other means of communication.
⑤Stretched picture broadcasting ability: stretching picture broadcasting is generated by the application system while the satellite scanning and observing the earth. The application system processes the observation data and then produces original resolution figure information that can be used by the user.
⑥ Low-velocity data broadcasting ability: low-velocity data broadcasting deliver figures and data production processed by the DPC to the users via satellite low-velocity data broadcasting channel.
During the flooding season of this year, in order to satisfy the demands of TCs' analysis, NSMC switches on the multi-temporal twin-satellite observational mode as usual i.e., 96 pictures can be obtained (one quarter an hour) everyday from the FY-2C and FY-2D satellites. Through the higher temporal resolution satellite data, we can be better to catch the characteristic of TCs, such as their occurrences, developments and evolutions. NMC and meteorological observatories in coastal areas give a high evaluation to the twin-satellite data according to there behavior in monitoring and forecasting TCs in this flood-prone season.

✧ **Improvement of Tele-communication System**

CMA's DVB-S data broadcasting system extended its receiving stations from 430 to 649 in 2009. And, the satellite-based data transmission services were switched from AsiaSat-2 to AsiaSat-5 successfully, which greatly increases the received S/N ratio. At present, the total broadcasting rate for the new system is 8.5Mbps, and the daily broadcasting data volume is over 36GB. The new data which is available via CMA's DVB-S includes CMA's NWP products generated by T639 model, FY-3 satellite observations and products, etc.

To support the typhoon-related services, CMA has made the following data and products available in its real-time database, and established the quality control system for the automatic precipitation observations obtained from regional stations. Automatic quality control and manually checked are being made for precipitation observations in real-time to ensure the high reliability for the data.

- Automatic weather station sunshine observations
- AMDAR data in BUFR codes
- Automatic soil moisture observations
- FY3A L1C products
- Hourly precipitation observations with quality information obtained from regional automatic stations in flood season

- Dropsound and Dripsound data
- Lightning location data

CMA's video conference system has strengthened the backup function, several sub-meeting rooms such as the CAAC venue is constructed, and standardization work is also improved significantly.

The design and manufacture of the dual-band emergency vehicle for meteorological service delivery were completed, and the construction of portable stations was accomplished, which improved CMA's emergency response capabilities.

CMA has upgraded its metadata from WMO profile version 0.2 to version 1.1, and it developed the OAI-PMH based metadata synchronization, DAR and data subscription in its WIS/GISC system.

✧ **Operational Run of Guangzhou Tropical Cyclone Model**

A next-generation NWP system for the South China Sea area (Guangzhou Tropical Cyclone Model, referred to as "GZTCM"), was developed by the Guangzhou Institute of Tropical and Oceanic Meteorology, and it was put into operational run in 2009. The GZTCM's resolution was increased to 0.36° and the forecast period extended to 120 hours. Bogus and typhoon re-positioning were used for the initialization of GZTCM and 3-dimensional variational assimilation (of GRAPES_3D-Var) was adopted to further improve the pattern of water vapor advection program and re-adjust the physics schemes. Thus, GZTCM has improved the forecasts of TC tracks and intensities and it is also capable to forecast TC formation process to some extent.

✧ **A mesoscale reanalysis system was established during the intensive observation period (IOP)**

Based on the operational GRAPES model, a system was set up for hourly cycle and assimilation, which assimilated conventional surface, upper air, radar, aircraft data, cloud-derived wind, satellite-based thickness, etc. Figures 12 and 13 show TS Goni (0907) and TY Koppu (0915) in the hourly field of assimilation and analysis, respectively. Figures 12 (a) (b) (c) shows Goni 10 hours before, during and 26 hours after landing overlapped with 850hPa wind field and radar echoes, which relatively well captured TC wind field structure and precipitation. Figures 13 (a) (b) (c) shows 850hPa wind field plus radar echoes of TS Goni 11 hours before, during landing and 7 hours after landing, which gave good description of TC wind field structure and precipitation.

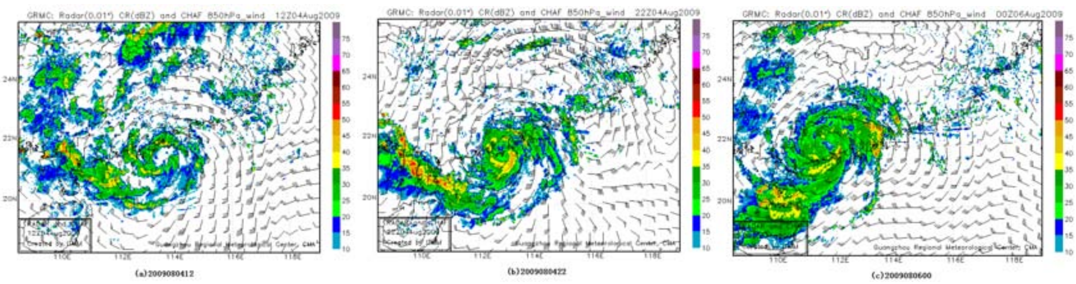


Fig. 12: 850hPa Wind and Radar Echo (shade) of Goni (0907) through Assimilation Analysis

(a)10 hours before landing , (b)landing, (c)26 hours after landing.

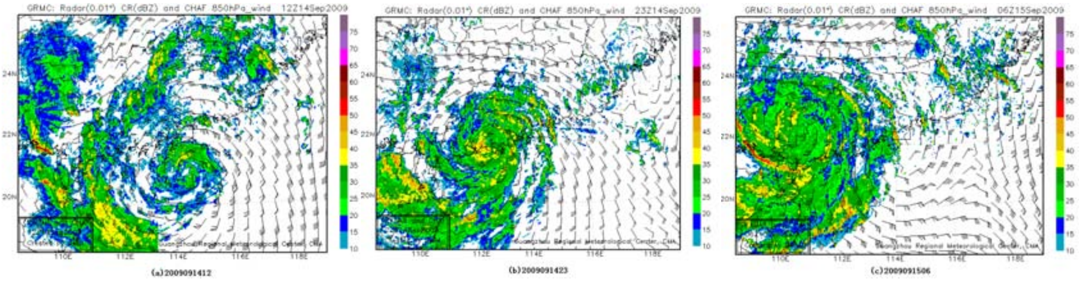


Fig. 13: 850hPa Wind and Radar Echo (shade) of Koppu (0915) through Assimilation Analysis (a)11 hours before landing; (b)landing; (c)7 hours after landing.

- **A field observation experiment**

An outfield observation experiment was launched in 2008 and 2009 and tropical cyclones Kammuri, Nuri, and Hagupit in 2008 as well as Goni and Koppu in 2009 were obtained regarding their motions. Observational data was acquired at the Maoming scientific experiment base. Field experiments were conducted and observational data were collected, and other cooperators assisted in selecting observation sites and conducting observations. Main field observation equipment used in the 2008 field experiments included a wind profiler, a microwave radiometer, and a mobile microwave radiometer at Beishan station, in Maoming base. Main outfield observation equipment used in the 2009 experiments consisted of 4 fixed wind profilers (Beishan of Maoming, Zhuhai and Shenzhen), a mobile observing system (including a mobile wind profiler and ultrasonic pulse instrument), and a GPS sounding set.

Figure 4 shows that the mobile wind profiler at Taishan, Guangdong province, captured the TS Goni as it passed the observation site and the wind speed decreased and then increased, indicating that the centre of the typhoon was going through the site and began to tilt at 2,500 m level.

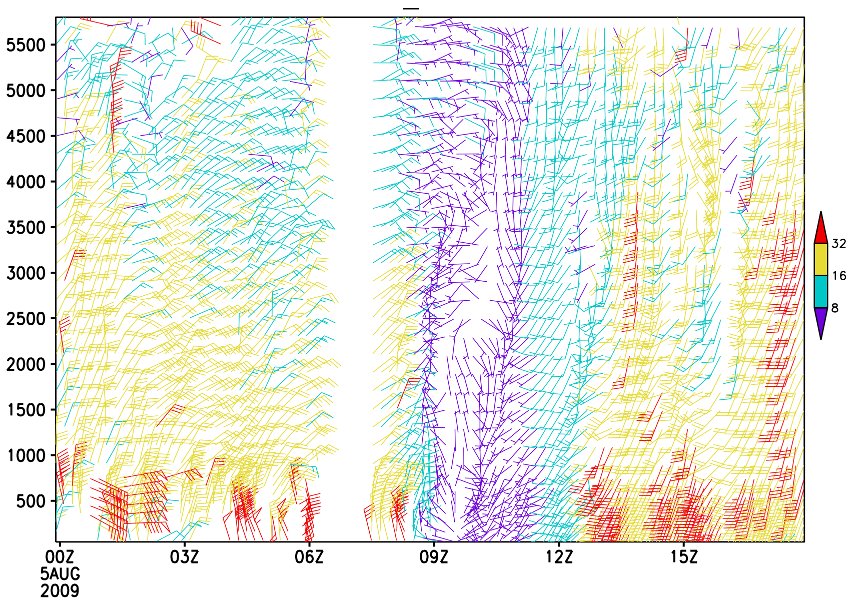


Fig. 14: The Vertical Wind Profile of TS Goni (0907) by Mobile Radar Wind Profiler

Figure 5 shows, under the impact of Koppu, the mobile observation system on Hailing Island of Yangjiang recorded significant deflection in wind direction without showing any TC-eye structure, at the observation point.

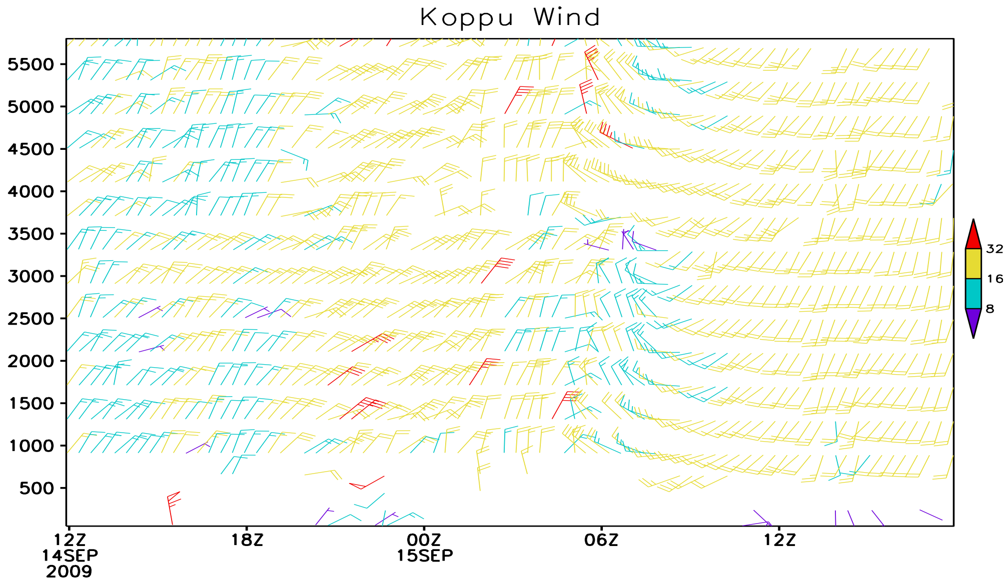


Fig. 15: Vertical Wind Profile of TS Koppu (0915) from mobile radar wind profiler

Shanghai Typhoon Institute, CMA carried out the field experiment on typhoon "Morakot " that landed in southern China at 21:10, August 6 2009 and at 7:46 on August 10 2009. The mobile radar observation was made at Sports Centre in Ningde City of Fujian Province (119.3295° E, 26.3975° N). A variety of weather information about typhoon "Morakot" (August 6-10) and the atmospheric boundary layer before and after landing were obtained, including GPS data observed about every 3 hours, as long as 80 hours or more consecutive wind profiler radar, ultrasonic anemometer-thermometer system, automatic weather stations, laser raindrop spectrometer, as well as multi-channel microwave radiometer observations.

b. Hydrological Achievements/Results - Ministry of Water Resources (MWR)

To improve capacity of hydrological service, the Hydrological Bureau, MWR upgraded its comprehensive operational hydrological systems across the country and organized Phase 2 project for establishing a National Flood Control and Drought Relief Database. Breaking events monitoring display and teleconference functions were added to address urgent water-related public events. The function of flash flood warning and feedback module was improved to achieve automatic retrieval of warning information and automatic feedbacks. GIS functionality was upgraded and improved to enhance inquiry efficiency in flood control. Rainfall distribution mapping system suitable for PDA devices was developed, which provides new functions for accessing rainfall.. Warning information access was also enabled, while existing geographic information and data were improved.

Moreover, the Hydrological Bureau organized and held workshops and seminars on hydrological information prediction at different levels and for different practitioners aimed at enhancing local hydrological service capabilities. For example, Hydrological Prediction Training Course for Tibetans was held in September 2009 in Linzhi, Tibet AR. Over 30 local hydrological staff attended it. In October, a National Hydrological Information Prediction Capacity Workshop was held in Xining, Qinghai Province, and representatives from hydrological establishments in 31 provinces, river basin authorities and Xinjiang Production and Construction Corps attended it.

c. Disaster Prevention and Preparedness Achievements/Results

N/A

d. Research, Training, and Other Achievements/Results

✧ **Research progress on typhoon mechanisms**

① Unusual Variation of Landing Tropical Cyclone Behavior and Associated Physical Mechanism - A National Basic Research Program of China (2009 - 2013)

A 5-year project entitled “Unusual Variation of Landing Tropical Cyclone Behavior and Associated Physical Mechanism” is funded by the Chinese National Basic Research Program in 2009, aiming to improve the forecast ability of landing TCs by studying the mechanism of unusual change of landing TC behaviors, including track, intensity, high wind and heavy precipitation. Leading institute of the project is Shanghai Typhoon Institute/CMA in collaboration with the Chinese Academy of Meteorological Sciences, National Meteorological Centre, Institute of Tropical and Marine Meteorology under CMA, Institute of Atmospheric Physics/CAS, Nanjing University, Beijing University and Nanjing Information Science and Technology University. The main goals are to: (1) reveal the ocean-land-atmosphere interaction characteristics during TC landing process; (2) understand the role of ocean-land-atmosphere interaction that leads to unusual change of landing TC behavior including the its track, intensity and torrential rain; (3) develop an ocean-land-atmosphere coupled TC model and ensemble TC prediction system; (4) improve the theory and models for landing TC prediction, including the landing point, intensity change, high-wind and heavy precipitation and related disasters; (5) set up a high resolution four dimensional analyses system for the fine structure of landing TC and provide high-quality re-analyses datasets for typical landing TCs.

②Research progress on rain bands associated with tropical cyclones

Fine-scale spiral rain bands at a length ranging from 10 to nearly 100 km with a band width varying from 5 to 15 km have been simulated in the inner-core region of a typhoon using a high-resolution model. The fine-scale rain bands have two types: one intersecting the eyewall and causing damaging wind streaks, and the other distributed azimuthally along the inner edge of the eyewall with a relatively short lifetime. The formation of the high-velocity wind streaks results from the interaction of the azimuthal flow with the banded vertical vorticity structure triggered by tilting of the horizontal vorticity. The vertical advection of azimuthal momentum also leads to acceleration of tangential flow at a relatively high altitude. Further investigation suggests that the boundary inflection points are related tightly to the development of the fine-scale rain bands. In particular, the presence of the level of inflow reversal in the boundary layer is a crucial factor controlling the formation of these bands. The near-surface wavy peaks of vertical vorticity always follow the inflection points in radial flow. The mesoscale vortices and associated convective updrafts in the eyewall are believed to strengthen the activity of fine-scale bands, and the updrafts can trigger the formation of the bands as they reside in the environment with inflow reversal in the boundary layer.

③Research progress on inner-dynamic core evolution of tropical cyclones

Eyewall contraction, breakdown, and reformation of a typhoon are successfully simulated by a high-resolution numerical model. The eyewall accordantly shrinks through the whole troposphere prior to landfall, while it presents different changes in the lower and upper troposphere, respectively, after landing. It is found that the dry air advected into the storm inner core through a low-θe channel, the reduced surface latent heat transfer, and the increased inflows in the coastal region are associated with the eyewall contraction. Accompanied with the high-to-low wavenumber change in the vortex Rossby waves, the initial polygonal eyewall transforms to an elliptical one. Such a wavenumber change is likely associated with the change of interaction between the rain bands and the eyewall. A corresponding tangential wind budget indicates that a strong acceleration due to the total contribution of the eddy and mean circulation is located in the lower layer in the eyewall during pre-landfall, and the mean contributions to the change in the tendency of the azimuthally averaged tangential wind counteract the eddy contributions.

By analyzing the results of a high-resolution numerical simulation, it is found that the meso- vortices form only in the lower troposphere in the eyewall in the presence of the non-unidirectional vertical shear. Both closed and unclosed circulations associated with these vortices are observed. In addition, some of the meso-vortices are accompanied by small-scale updrafts, while no updrafts are found in the other vortices. If the environmental inflow meets the outflow of the vortex circulations, or if the vortices themselves act as obstacles to prevent the inflow, small-scale updrafts associated with the mesovortices occur. The mesovortices and corresponding updrafts move cyclonically along the eyewall, characterized by the behavior of vortex Rossby waves. When moving in the down-shear direction, the convective updrafts strengthen, so that the associated mesovortices also become stronger by stretching the vorticity tubes. By contrast, the updrafts weaken as they proceed towards the upshear direction. At the middle and upper levels of the eyewall, there are no meso-vortices and the strongest convection with the small-scale intense updrafts is concentrated on the southeastern side of the eyewall. The updrafts > 1 and 2 m/s occupy only 14% and 7% of the eyewall region, respectively. However, the updrafts >1 m/s contribute to 30% of the mass transport in the eyewall. This indicates that, although these small-scale intense updrafts occupy relative smaller areas in the eyewall, they play an important role in the mass transport in the eyewall. It is further found that the active updrafts may appear positively buoyant. In addition, the locations of the buoyancy of large magnitude are superposed with the strongest upward motions, a further indicative of the significant role of the small-scale intensive updrafts.

An observational analysis of satellite blackbody temperature data and radar images suggests that the mesoscale vortex generation and merging process appeared to be essential for a tropical-depression (TD)-related heavy rain in Shanghai, China. A numerical simulation reproduced the observed mesoscale vortex generation and merging process and the corresponding rain pattern, and then the model outputs were used to study the related dynamics through diagnosing the potential vorticity (PV) equation. The TD was found to weaken firstly at the lower levels and then at the upper levels due to negative horizontal PV advection and diabatic heating effects. The meso-vortices developed gradually also from the lower to the upper levels as a result of positive horizontal PV advection and diabatic heating effects on the left downshear quadrant of the TD. One of these newly-generated vortices replaced the TD ultimately, while others merged due to the horizontal PV advection process. This triggered the very heavy rain in Shanghai.

A new parameterization scheme of sea surface momentum roughness length for all wind regimes including high winds under tropical cyclone conditions is constructed based on measurements from Global Positioning System dropsondes. It reproduces the observed regime transition, namely, an increase of the drag coefficient with the increase of wind speed up to 40 ms^{-1}followed by a decrease with further increase of wind speed. The effect of this parameterization on the structure and intensity of tropical cyclones is evaluated using TCM4. The results show that the final intensity is increased by 10.5% (8.9%) in the maximum surface wind speed and by 8.1 hPa (5.9 hPa) increase in the minimum sea surface pressure drop with (without) dissipative heating. This intensity increase is found to be mainly due to the reduced frictional dissipation in the surface layer and with little to do with either the surface enthalpy flux or latent heat release in the eyewall convection. The effect of the new parameterization on the storm structure is found insignificant and occur only in the inner core region with the increase in tangential winds in the eyewall and the increase in temperature anomalies in the eye. This is because the difference in drag coefficient appears only in a small area under the eyewall.

④Impact of large-scale environments on tropical cyclone activity

Based on the 1°×1°NCEP reanalysis data, the track and intensity of typhoon Neoguri (2008) were analyzed. The results indicate that the change of the track of Neoguri was closely related to the change of the subtropical high. Besides the inner-core structure, environmental flow, and surface influences, the vortex scale contributed to the intensity change. The abnormally northward ridge line of the subtropical high and the abnormally high SST in the South China Sea caused by the former La Nina event were the main reasons for the formation and development of typhoon Noguri. Additionally, using the 1°×1°NCEP reanalysis data, 2.5°×2.5°NECP reanalysis data, and 1°×1° NOAA SST data, we find that, the movement of Fengshen was associated with the subtropical high. The intensity change was not only related to its asymmetric structure and environment flow, but also to the invasion of cold air at the low levels from south, which weakened Typhoon Fengshen.

⑤Research progress on wind and precipitation structure associated with tropical cyclones

Through analyzing hourly rainfall dataset from raingauge observations and radar-derived rainfall, it was found that typhoon Saomai (2006) had dual concentric eyewalls before its landfall, and during the period, the inner and outer eyewalls as well as its rain band were dominated with heavy rainfall, and rainfall rate increased with time, the mean rainfall rate in the outer-eyewall region was higher than that in the inner-eyewall region, but the rainfall rate did not decrease as the radius of outer eye-wall became smaller. However, the rainfall rate of the outer rain band changed little with time, although it was slightly reduced. The mean rainfall rate in the inner-core region abruptly increased about three hours before Saomai's landfall, and then it was weakened, with its rainfall rate being rapidly decreased after landing. The precipitation of typhoon Saomai was in an asymmetric structure. Before landing, the maximum rainfall occurred in the right quadrant relative to its track. After landing, heaviest precipitation appeared in the rear quadrant of the inner- and outer eye-walls.

Based on the results of a high-resolution simulation with the finest grid size of 600 meters, the evolution of the energy cascade between different scales and the circulation structure in landfall was examined. The helicity on different scales is also investigated, accompanied with diagnostic analysis of vertical shear, convective available potential energy, and potential vorticity. A boundary dynamic and thermodynamic mechanism for heavy rainfall induced by landing tropical cyclones and an associated conceptual model are provided.

The thermodynamic and dynamic structure of a landing tropical depression (TD) was analyzed based on high-resolution model output. It was found that contours of generalized equivalent potential temperature (θ^*) near the TD centre were almost vertical to the horizontal surface. Then, a new vector, namely the generalized convective vorticity vector (CVV*), was used to diagnose the rainfall process associated with the landing TD. Since CVV* could reflect both the secondary circulation and the variation of horizontal moist baroclinicity, it was found that the vertical integration of CVV* can reflect the rainfall areas better, with high values corresponding to heavy rain areas. By carrying out a sensitivity numerical experiment of removing the HangzhouBay, it was also found that the CVV* was weaker than the control experiment, corresponding with the decrease of rainfall. Further analyses showed that the HangzhouBayprovides good water vapor channel and flux of latent heat and sensible heat to the TD system and therefore, it created a favourable condition for the genesis and development of meso-scale cloud clusters around the TD and its rainfall.

Through investigating the temporal and spatial variations of precipitation structure within 300 km in radius of the typhoon centre by using reflectivity data taken from Doppler radars located at Wenzhou and Taiwan, six typhoons landed on southeast coast of China in 2004~2007 were selected to examine the change of precipitation distributions about 18 h before landfall and 6 h after landfall. The axial-symmetric component of typhoon rainfall, represented by the radial distribution of azimuthal mean reflectivity, revealed that the maximum rainfall occurred in the eyewall and that the next maximum rainfall took place in the outer rain bands about 9-18 hours before landing. With increasing storm intensity, the maximum rainfall rate increased, while its radius from the typhoon centre decreased. When typhoons are approaching the coast, the mean rainfall rate in the inner-core region increases abruptly, accompanied with the rapid contraction of the precipitation toward the typhoon centre. The highest strengthening rate of the mean rain rate in the inner core of the six typhoons reaches to 3.2. The precipitation of the peripheral rain bands concentrates to the typhoon centre simultaneously, and the rate of contraction decrease with the intensification of storms. After landing, the eye is filled by rain, thus the intensity decreases quickly and the precipitation shrinks continuously. As a result, the amount of rainfall in the inner core attenuates gradually. Finally, a model was proposed to fit the observed precipitation curve before TC landfall. This model can be used to quantitatively describe the outline of azimuthal mean rain of typhoons, and gives out the characteristics of two-peak profiles of the outline. The maximum of the RMSE between the observed curves and the fitnesses was 5.3 mm/h, while the minimum was only 0.46 mm/h, thus the model can fit the real profile of typhoon precipitation.

Water vapor, cloud, and surface rainfall budgets associated with the landing Typhoon Krosa (2007) were analyzed based on a two-dimensional cloud-resolving model simulation. The simulation data that were validated with observations were examined to study physical causes associated with surface rainfall processes during the landfall. The time- and domain-mean analysis showed that when Krosa approached the eastern coast of China, the water vapor convergence over land caused a local atmospheric moistening and a net condensation that further produced surface rainfall and an increase of cloud hydrometeor concentration. Meanwhile, latent heating was balanced by advective cooling and local atmospheric warming. One day later, the enhancement of net condensation led to an increase of surface rainfall and local atmospheric drying, while the water vapor convergence weakened as a result of the landfall-induced deprivation of water vapor flux. At the same time, the latent heating is mainly compensated by the advective cooling. Further weakening of vapor convergence enhanced the local atmospheric drying, while the net condensation and associated surface rainfall was maintained. The latent heating was ballanced by advective cooling and a local atmospheric cooling.

⑥Landing TC intensity change

Some typhoons become intensified rapidly when they approach the land, which is a big challenge to forecasting. Typhoon Saomei (0608) was a typical case. A dynamic analysis was made on its abrupt intensification. The results showed that the total kinetic energy in the lower troposphere increased suddenly, mainly depending on the increasing rotational kinetic energy. Meanwhile, these two energies in the upper levels significantly decrease while the divergent kinetic energy rises. The downward transport of the upper tropospheric kinetic energy is a major reason behind a rapid intensification.

After TC landfall, the intensity could be changed with the variation of the underlying features such as lakes. Statistical study was carried on TC activity from 1949 to 2001. Results demonstrate that a total of 36 TCs moved deep into land and passed through lakes in this 53 years, and all occur in June-September. These TCs have long duration over land and are usually strong during landfall. The lakes tends to delay the intensity reduction, in other words, when passing through inland lakes, most of them maintain or decrease their central pressure while increasing wind speed. However, this is just the statistics based on observations, and the mechanism of this phenomenon needs further studies.

⑦TC mesoscale structure and rainstorm

The development of models provides a good platform for meso-scale TC researches. The characteristics of quasi-balanced and unbalanced vertical circulations are diagnosed by applying the PV-ω equation system to a high-resolution simulation of Typhoon Nari (0116) in order to gain insight into their relative roles in organizing process of deep moist convection in tropical storms. Results show that quasi-balanced flows represent well the organized circulations in the storm. The spatial and temporal distributions of short waves indicate that the unbalance flow is nonstationary and associated with the dispersion of gravity-inertia1 wave. It is found that when the low-level weak updrafts caused by the quasi-balanced dynamic forcing are intense enough, the release of latent heat results in the superimposition of quasi-balanced and unbalanced updrafts, which form the strong updrafts in the eyewall. This process, together with the compensating and adjusting processes of unbalanced flows, plays important roles in creating deep moist convection in tropical storms.

Based on modeling of Typhoon Aere (0418), using band-pass filter and numerical modeling to separate the large- and meso-scale system, a vorticity equation was derived, which includes interactions mechanism of various scales to diagnose and analyze the main factors for the development of meso-scale systems and the interaction mechanism of the large- and meso-scale systems. Results indicate that the interactions are an important mechanism for development and intensification. When the meso-scale systems develop to the certain stage, divergence and twisting terms dominated by the allocation of the divergence, vorticity and vertical velocity fields of the meso-scale systems may cause the dissipation of the meso-scales. The inner adjusting mechanism determines the meso-scale character of the heavy rain from temporal prospective.

The study on the local heavy rainfall caused by meso-scale convective system (MCS) was a focus of attention in the past. High resolution satellite data showed that MCS associated with heavy rainfall caused by Typhoon Bilis (0604) developed quickly and kept active, but distributed asymmetrically. After Bilis landfall, structure transfered into asymmetric baroclinic gradually impacted by the mid-latitude baroclinic atmosphere. Thermal wind deviation force, induced by dynamic and thermodynamic unbalance, produced a secondary circulation, in which triggered the development of MCS in unstable stratification. Sensitivity experiments are performed in simulating Bilis (0604). Results indicated that the influence of environmental vertical wind shear on wave number-1 asymmetric rainfall structure of Bilis was significantly more important than the terrain, underlying surface properties during landfall, and storm speeds. But the factors that have impacts on convection pattern may vary from one to another. For instance, the stronger convection was located in the eastern and northern quadrants for both TCs Chanchu (0601) and Prapiroon (0606). But the former is mainly associated with the influences of a strong environmental vertical wind shear and low-level horizontal wind shear, while the latter is influenced by low-level convergence and divergence.

⑧Oceanic effects

Statistical characteristics of the multi-year variation of the frequency of TCs activity in 1949-2003 over the Northwest Pacific and the relationship with sea surface temperature (SST) were studied, and it was found that they had good correlation. The negative SST anomaly in equatorial eastern Pacific would result in early positive anomaly of TCs over West Pacific at later stage, which was related to abnormality in atmospheric circulation. However, SST of the Northwest Pacific had a lag-correlation with TC frequency. By analyzing the effective vertical diffusion and temperature abnormality induced by cyclone, it was found that this phenomena was caused by stirring and mixing processes in the upper layer.

The SST pattern not only affects TC frequency, but also their tracks, intensity, etc... Sensitivity modeling experiments for Typhoons Chanchu (0601) demonstrated that decreasing SST could change a TC track in a complicated way and the lowest TC pressure would change about 16hPa when SST varies in about 1°C. The wind field of Typhoon Dujuan (0313) was very sensitive to SST, strong wind could be induced rapidly by high SST. Both studies suggested that the influence of different SST on TC was mainly done by the changing sensible heat flux and latent heat flux between the sea and the atmosphere. The closer it is to a TC centre, the more evident the effect would be.

✧ **Progress on typhoon prediction techniques**

①Error analysis of operational forecasting of typhoon tracks

Through the detailed analysis of the subjective forecasts issued by CMA, JMA, and JTWC, the operational TC track forecasts had been largely improved in the last 12 years (1997-2008). Much improvement was made in 48-h forecast than the 24-h forecast. However, most improvement in TC track forecast was noted in early 21st century (2000-2004), little progress was made in recent years (2005-2008). Further analysis shows that the 24h TC track forecast error of weak typhoons is 40-50 km, which is larger than that of the stronger typhoons, and the TC track forecasts over the Yellow Sea and the ocean east to Japan is found less reliable than those made for the other regions. For the typhoons over the South China Sea, the 24-hour TC track forecasts issued by CMA and JTWC seem to more accurate than those from JMA, and JTWC forecasts are better in the 48 hour forecasts.

② Dynamic Similitude Scheme for TC Quantitative Precipitation Forecasts

A prediction scheme based on the dynamic similarity was proposed for TC quantitative precipitation forecasts. The scheme adopts initial TC parameters, initial and historical weather patterns, physical fields and other NWP products, to provide an objective and multivariate similarity criteria for judging current large-scale atmospheric environments, and their future trends. A similarity index is set up by using a successive dynamic method, which is nonlinear in nature and can quantitatively describe the degree of similarity. According to this index, several historical tropical cyclones were identified as the samples similar to the predicted ones. 6-48 precipitation predictions were made at each station using the weighted similarity index from historical precipitation records. Tests demonstrated that this technique showed a certain prediction skill in terms of quantitative precipitation at specific sites, compared with the climatology and persistency method.

③Vortex Cycle Assimilation in GRAPES-TCM

Based on MC-3DVAR approach (Liang et al., 2007a, b), vortex cycle assimilation was implemented on the IBM supercomputer for the initialization of GRAPES-TCM. The real time verification on the new scheme, in comparison with the original operational vortex relocation scheme, showed that the new scheme improved the 24-48h TC track forecasts in 2009 to some extent.

④Advances of Physics Parameterization Schemes for GRAPES-TCM

An improved Kain-Fritsch scheme (Ma and Tan, 2009) was implanted in GRAPES-TCM. In addition, in an effort to improve the TC intensity prediction, the original roughness drag parameterization scheme in GRAPES-TCM was improved according to a number of recent observational and numerical studies (Powell et al. 2003; Moon et al. 2007).

⑤Tropical Cyclone Initialization based on UWPBL Model

A new approach was proposed to improve the initialization of regional TC prediction model. This approach first modified the roughness according to the TC-induced high wind in the planetary boundary layer model. Then the QuikSCAT sea surface winds were used to satisfy the related gradient winds, and wind pressure fields controlled by the secondary circulations and thermal stratification in the boundary layer. Finally, the 3DVAR was used to assimilate the wind fields in the meso-scale model, to improve initialization of TC circulation and prediction. . The numerical sensitivity experiments on two typical typhoons suggested that this approach improved TC initial wind fields and intensity at sea level while maintaining the non-geostrophic equilibrium between TC wind fields and the steering flow.

⑥Development on Regional Ocean-Atmosphere Coupled Model

A Regional Ocean-Land-Atmosphere Coupled Model was preliminary developed in combination with an advanced ocean model, GRAPES-TCM, and a numerical coupler for dynamical and energy transition. Numerical experiments on this coupled model showed promising results.

⑦TC Ensemble prediction

The sensitivity of TC rainfall and intensity prediction to physics parameterization was preliminary investigated. Results provided a basis for upgrading the Shanghai Typhoon Ensemble Prediction System.

⑧ Research was carried out to apply dropwindsondes and intensive sounding data in typhoon forecasting models.

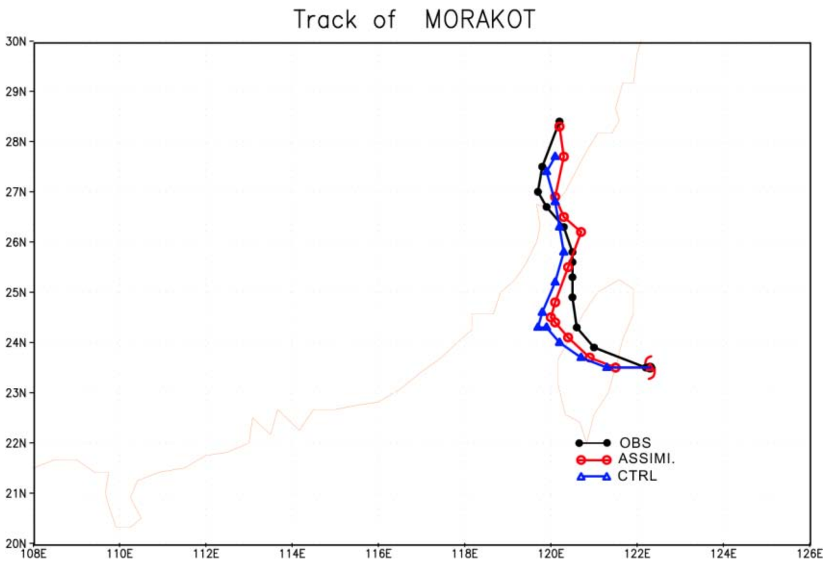


Fig. 16: The Track of Typhoon Morakot (0908)

(Red curve: assimilation tests; blue curve: control test; black curve: observations)

For the control test (i.e., in the operational model), the typhoon track prediction was satisfactory for 72 h. For the 06-24 h forecasts, the largest error was 91 km. The maximum error appeared in 30 h (137 km). For the forecast from then on to 72-h, the error was less than 80 km, suggesting that GZTCM was relatively accurate in forecasting the tracks of Typhoon Morakot. Compared with the control test, the assimilation test was more than 30 km larger in the 66-h forecast error but smaller in the other time periods than those in the control test. Clearly, with the assimilation of dropwindsondes, the typhoon path was forecasted much better within 72 hours. For typhoon intensity prediction, the two tests were weaker than observation for the time within 54 hours but stronger than it beyond 54 hours, as shown in Figure 12. Within 72 hours, except for being a bit poorer in 24-36 hours in the assimilation test than in the control, the forecast was closer to reality at other times.

✧ **Progress on short-term climate prediction in relation to typhoon activity**

New schemes for seasonal prediction of frequencies of TCs affecting China, South China and East China, which are determined by the CMA's specialized wind and precipitation observational dataset for Tropical Cyclones, have been developed and put into quasi-operational run in Shanghai Typhoon Institute of CMA.

✧ **Progress in storm surges and sea waves**

A numerical forecast system for storm surges in the coastal area of China was established by the Shanghai Typhoon Institute based on the 3-D baroclinic ocean circulation model POM. The typhoon model wind field was constructed considering asymmetry of wind fields and it adopted a more reliable equation for sea surface wind stress under strong wind. Many storm surges over past years were well re-represented and the model showed good performance in real time forecast. Apart from graphic displays of prediction outputs, other displays in MICAPS (Meteorological Information Comprehensive Analysis and Process System) format was also used to meet the needs for the operational platform.

The operational wave forecast system was established based on the third generation wave model of WAVEWATCH III (WW3). And the SWAN nesting with WaveWatch was used for wave forecast in coastal seas.

- ✧ **Training Course on Meteorological Satellite data application in the weather analysis and forecast**

From January to October, 2009, a training course was held in CMATC on Meteorological Satellite data application in the weather analysis and forecast for 62 participants. The training mainly includes fundamental principle of satellite meteorology; application of multi-channel observation to weather and climate analysis and forecasting; satellite monitoring and application of mesoscale system; creation and application of TOVS data; derived gust products from geostationary meteorological satellite; typhoon location and intensity estimation with satellite images; precipitation estimation techniques with satellite data; analysis application of water vapor imagery; analysis application of TBB; generation and application of OLR data; FY-2 satellite cloud product introduction; FY-2 satellite sand storm monitoring principle and product introduction; large scale cloud system analysis; FY-2 satellite dense fog monitoring principle and product introduction; FY-2 satellite image interpretation in the nowcasting; the operational use of FY-2 satellite data in South China weather forecasting.

- ✧ **Distance Training on Basic Meteorological Satellite data analysis and application**

From January to October, 2009, CMATC held one distance training course on basic meteorological satellite data analysis and application. Course mainly covered development and detection principle of meteorological satellite; image classification and their major characters; methods for identifying satellite image; common cloud types and cloud system characteristics identification in cloud imagery in mid and high latitudes; tropical cyclone and other tropical weather cloud system; rainfall analysis and forecasting with satellite image; analysis and forecasting of heavy rain and strong convection; satellite monitoring and products application of mesoscale system; TBB data in the application of typhoon and other tropical system; large scale cloud system analysis method; satellite data analysis to sustained torrential rainfall caused by severe tropical storm Bilis; Satellite picture analysis in summer in Huaihe river basin; mesoscale analysis on Jinan; excessively heavy rainfall in "7.18 case"; a preliminary analysis of features and causes of the snow storm over southern China in January 2008.

- ✧ **Training course on the application of new generation Doppler weather radar**

From January to October in 2009, the CMATC organized two training courses on the application of new generation Doppler weather radar for 95 trainees, the training courses mainly covered：the principle of Doppler radar, identification of velocity chart, quality control of radar data, the characteristics of radar echo in convective storm, radar products and algorithms, nowcasting in strong convective weather.

- ✧ **A distance training course on the application of new generation weather radar data on meteorological operations**

From January to October in 2009, the CMATC organized a distance training course on the application of new generation weather radar data to meteorological operations. The training course mainly covered: introduction of the principles of new generation weather radar and operation application; character and significance of the speed echo data, analysis and application of speed echo in large-scale precipitation; features of speed echo in meso and micro-scale strong convective weather; characteristics of Doppler velocity of typhoons; analysis and applications of spectral width data; analysis of radar reflectivity and Secondary products.

- ✧ **Advanced training seminar on theory and method of meteorological data assimilation**

From January to October in 2009, the CMATC organized an advanced training seminar on theory and method of meteorological data assimilation for 60 participants, the training mainly included mathematical interpolation and meteorological interpolation; the noise filtering and mathematical methods; optimal estimation theory and application in statistics; variational theory and application in calculus; optimization theory, methods and applications; the definition, development and application of the adjoint model; different data assimilation methods and their approximate assumptions; characteristics of GPS occultation data and its assimilation method; characteristics of satellite radiation data and its assimilation methods; purposes, methods and cases of quality control.

- ✧ **Advance Training course on Sea-land-atmosphere interaction, assess interaction and assessment techniques**

From January to October in 2009, the CMATC organized an advanced training course on Sea-land-atmosphere interaction, assess interaction and assessment techniques for 40 participants, the training mainly included the prior knowledge of sea-land-atmosphere interaction; feedback process and its effect on tropical sea - atmosphere interaction; climate noise and its effects on local sea - atmosphere interaction with comprehensive feedback process of the sea–land system.

e. Regional Cooperation Achievements/Results - National Meteorological Centre, National Climate Centre, National Satellite Meteorological Centre, CMA Training Centre, Shanghai Typhoon Institute, Guangzhou Institute of Tropical and Oceanic Meteorology, and Chinese Academy of Meteorological Sciences.

- ✧ **Improvement in GTS**

The Beijing-Hanoi link was upgraded from 75baud ASYNC circuit to 64kbps IP link in November, 2009. The upgrade of Beijing-Ulan Bator GTS circuit is ongoing. RTH Beijing backup connections via internet for exchanging GTS data with NMC

Hanoi and NMC Ulan Bator.

✧ **The Second International Workshop on TC Landing Processes (IWTCLP-II)**

WMO IWTCLP-II was held in Shanghai China from 10 to 19 October 2009. The purpose of this meeting is to assess the recent findings and forecast advances since last session and to improve forecast and early warning on landing TCs. This event was also a forum to transfer new science and technology to National Meteorological and Hydrological Services in TC landing countries in the world. The workshop focused on reduction of disaster risks through improved forecast of landing TCs.

f. Identified Opportunities/Challenges for Future Achievements/Results

N/A

7. Progress on Key Result Area 7: Enhanced Typhoon Committee's Effectiveness and International Collaboration. (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2009 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

N/A

b. Hydrological Achievements/Results

Entrusted by ESCAP TC /WMO, the Hydrological Bureau of the Pearl River Water Resources Commission collaborated with the Department of Geography Planning of the Sun Yat-Sen University for a workshop and training program oriented at Thai Meteorological Department (TMD) from July 20- 26, 2009. Over 20 representatives from secretariat of TC, TMD Hydrologic and Meteorological Research Centre, the Bureau of Hydrology and the Foreign Affairs Office of the Pearl River Water Resources Commission, the Sun Yat-Sen University attended the event. Experts of the University and the Pearl River Water Resources Commission gave lectures to TMD representatives on prediction technique, made field tour along the mainstream of Xijiang River, and visited local hydrological departments in Guangxi AR and Guangdong province.

Fig. 17: The training workshop held at Thai Meteorological Department (TMD) hosted by the Pearl River Water Resources Commission collaborated with the Department of Geography Planning of the Sun Yat-Sen University

To further promote the flood prediction technology of China, the Bureau of Hydrology of the Ministry of Water Resources of China completed the joint project of OFFSIA and provided at free software, technical report and instruction for users (English versions) to TC secretariat who publicized the documents on its website for its member countries/cities to download and use. China will continue to provide technical support for use of China Flood Forecasting System by TC members.

In 2009, the Hydrological Bureau under the Ministry of Water Resources sent 2 professionals to the OJB training program held in Malaysia.

c. Disaster Prevention and Preparedness Achievements/Results

N/A

d. Research, Training, and Other Achievements/Results

N/A

e. Regional Cooperation Achievements/Results

✧ **Assessment of the impact of climate change on TC frequency and intensity**

A scientist of the Shanghai Typhoon Institute (STI) participated in the ‘Assessment of the impact of climate change on TC frequency and intensity’ as a member of the expert group. Up to now, literature references and recent related progress in China have been provided to the coordinator, as well as suggestions on data differences and correct usage of statistical parameters and methods in assessment.

✧ **Typhoon Forum**

The Typhoon Forum, which is oriented to Members of the Typhoon Committee, was officially set up in July 2009. It is open to all nominated users and the Shanghai Typhoon Institute (STI) has appointed a coordinator for it. The objectives of the forum are to provide a real-time communication platform for forecasters and researchers within the Asia and Pacific Typhoon committee, to exchange information about ongoing TC track, associated wind & rainfall, forecasts and impacts, to share and access data, to make on-line discussions on TC related scientific issues, all aimed at improving the TC forecast accuracy and reducing the potential damage by TCs. The forum is divided into 3 sections, i.e. 'TC real time information and forecast', 'History cases' and 'Forecast verification'. So far, it has 38 registered users in the Typhoon Forum, coming from 11 Members of Typhoon Committee.

✧ **Workshop on Typhoon Information Processing System (TIPS)**

A STI scientist participated in the workshop on TIPS held in Jeju Island, Republic of Korea in April 2009 and he took this opportunity to introduce to the Typhoon Committee Members the Typhoon Forecast Tool - a module of MICAPS3 (Meteorological Information Comprehensive Analysis and Process System).

f. Identified Opportunities/Challenges for Future Achievements/Results

N/A

III. Resource Mobilization Activities

N/A

IV. Update of Members' Working Groups representatives

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