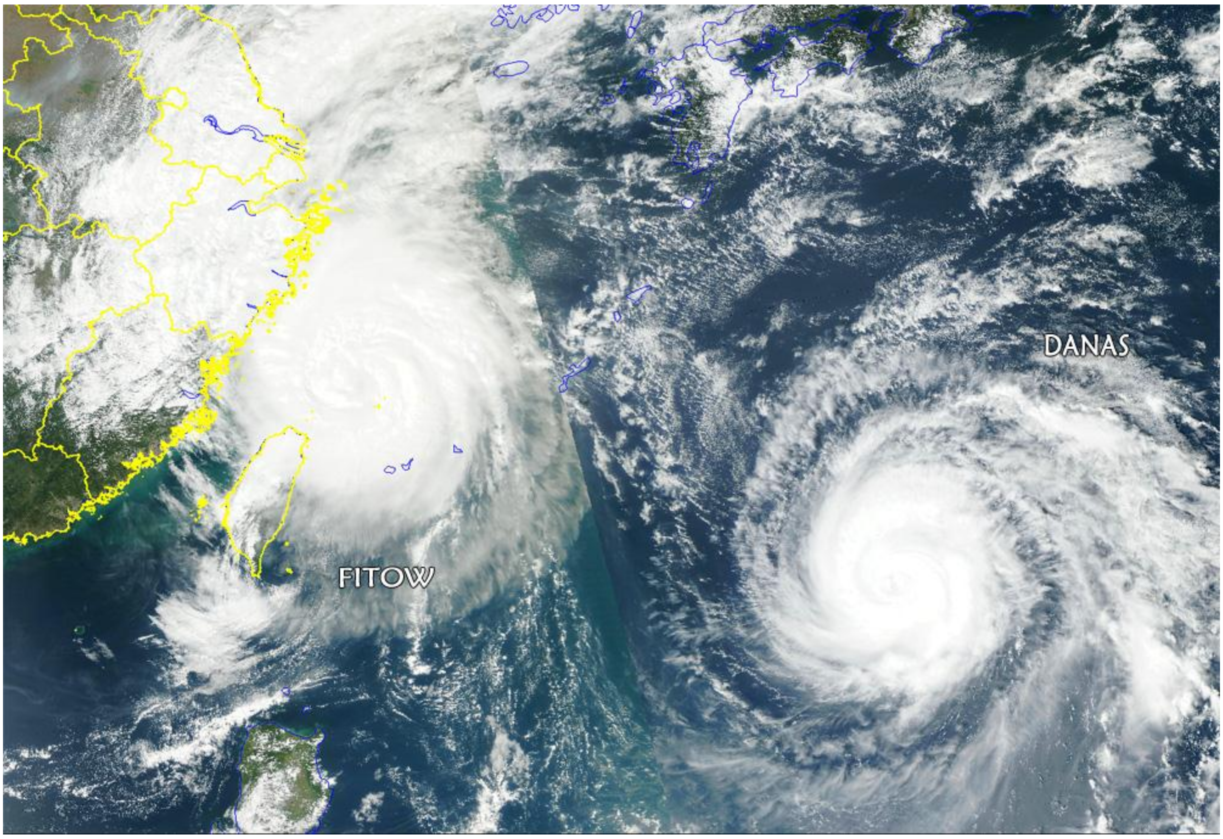
MEMBER REPORT
(2013)

ESCAP/WMO Typhoon Committee
8th Integrated Workshop/2nd TRCG Forum



China

Macao, China
2 - 6 December 2013

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I. Overview of Tropical Cyclones Which Have Affected/Impacted Member's Area in 2013

1.1 Meteorological and Hydrological Assessment

In the typhoon season of 2013, the sea temperature in the warm pool in vicinity of the equatorial West Pacific was warmer than that in the same periods in normal years, and the convective activities were abnormally stronger, which were favorable for typhoon genesis, increasing typhoon intensity when approaching offshore, leading to severe typhoons at their landfall. Furthermore, the East Asia Summer Monsoon was significantly stronger than usual during the typhoon active season, which was favorable for north- or west-moving of the tropical cyclones that developed over the western North Pacific and the South China Sea, eventually affecting China. Meanwhile, the intensity of the monsoon trough was found stronger than usual, which was another factor for typhoon genesis. Additionally, the stronger convective activities over the tropical West Pacific region and the northward shift of its subtropical high pressure also led to north-shifting location of the monsoon trough, which in turn made the active typhoons from the two waters more easily land on China.

From 1 January to 12 November 2013, in total 30 tropical cyclones (including tropical storms, severe tropical storms, typhoons, severe typhoons and super typhoons) were formed over the western North Pacific or the South China Sea, or moved into the region from the eastern North Pacific (Fig. 1.1). Out of 30, 9 tropical cyclones made landfall over the coasts of East China or South China (Fig. 1.2). More specifically, these landed tropical cyclones were tropical storm BEBINCA (No. 1305), severe tropical storm RUMBIA (No. 1306), super typhoon SOULIK (No. 1307), tropical storm CIMARON (No. 1308), severe tropical storm JEBI (No. 1309), super typhoon UTOR (No. 1311), typhoon TRAMI (No. 1312), super typhoon USAGI (No. 1319), and severe typhoon FITOW (No.1323).

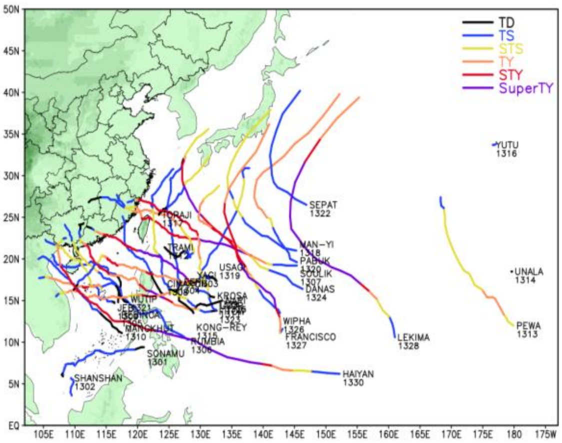

Fig 1.1 Tracks of TCs over the western North Pacific and the South China Sea from 1 Jan. to 12 Nov. 2013

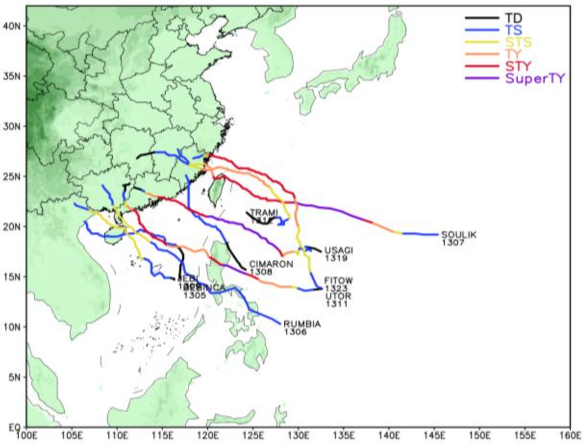

Fig 1.2 Tracks of TCs that made landfall over China from 1 Jan. to 12 Nov. 2013

1.1.1 Characteristics of the tropical cyclones in 2013

The characteristics of the tropical cyclones in 2013 are described as follows:

1) More TCs' geneses with more landing events

By 12 November 2013, totally 30 tropical cyclones over the western North Pacific and the South China Sea had been numbered, which were apparently larger than the historical average number (24.6) in the same periods. 9 of them landed on China's coasts, which were again higher than the annual average number (6.7) of the landed TCs in the same historical periods. Relative to historical averages, TCs were formed most in September followed by July; and the largest number of the landed TCs was found in July-August, both exceeding the normal averages.

The 30 tropical cyclones that were totally formed in 1 Jan.-12 Nov. 2013 were more than the normal average number (24.6). However, there were relatively less TCs with high intensity. For example, there were altogether 13 TCs in typhoon category or above, which were clearly less than the normal average number (14.85). From another perspective, the percentage of TCs in typhoon category or beyond relative to the total number of TCs developed so far was rather smaller, accounting for 43.3% only, compared with the normal 61.9%.

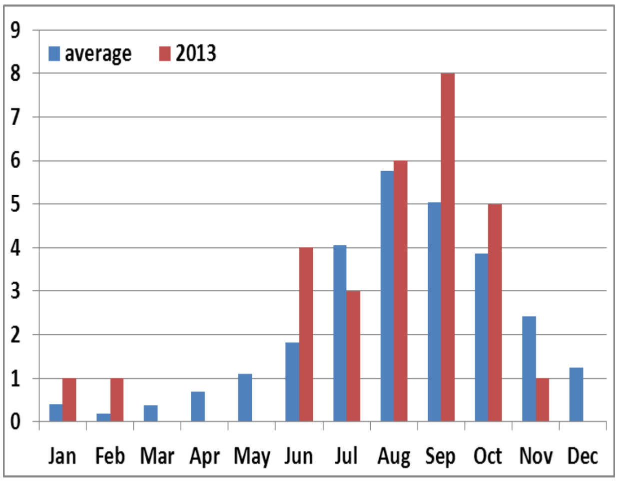

Fig 1.3 Normal monthly TC averages (1 Jan.-12 Nov.) compared with monthly TCs developed in 2013 (1 Jan.-12 Nov.) (Unit: digit)

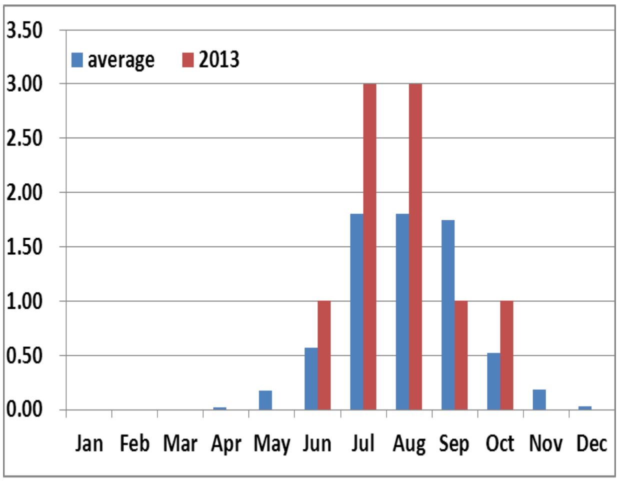

Fig 1.4 Normal monthly TC averages (1 Jan.-12 Nov.) compared with monthly TCs landed on China's coasts in 2013 (1 Jan.-12 Nov.) (Unit: digit)

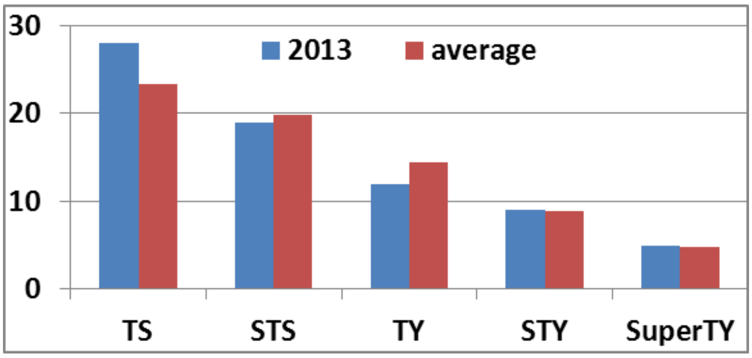

Fig 1.5 Total number of TCs in different intensity categories developed in 2003 compared with the normal averages (1949-2012) in the same periods (1 Jan.-12 Nov.)

2) Landing sites concentrated on China's south coast, and TC intensity was higher at time of landfall

By 12 Nov., 2013, 9 TCs landed on China (i.e. 2 on Hainan, 3 on Guangdong, 1 on Taiwan island, and 4 on Fujian respectively), out of which the typhoon SOULIK (No. 1307) landed on Taiwan island first and made its second landfall on Fujian. However, no single tropical cyclone landed on and to the northern coasts of Zhejiang province. Therefore, TC landing sites mostly concentrated on the south coast of China.

The intensities of the 9 tropical cyclones at the time of landing were 23m/s for BEBINCA, 28m/s for RUMBIA, 45m/s for SOULIK, 20m/s for CIMARON, 30m/s for JEBI, 42m/s for UTOR, 35m/s for TRAMI, 45m/s for USAGI, and 42m/s for FITOW respectively. The averaged landing TC intensity was 34.6m/s, which was just slightly higher than the mean value (32.6m/s) of all TCs that landed on China according to the historical records.

3) TC sources mostly concentrated on the common TC-generating regions

Within the western North Pacific and the South China Sea, there are mainly 3 regions where tropical cyclones are mostly generated: (1) northern part of the South China Sea; (2) ocean to the east of the Philippines; and (3) ocean near the Mariana Islands. In 2013, most tropical cyclones were generated in or close to the 3 regions. What differed most from the normal was that up to 2 TCs moved from the Northeast Pacific into the western North Pacific, which was rare in the historical records.

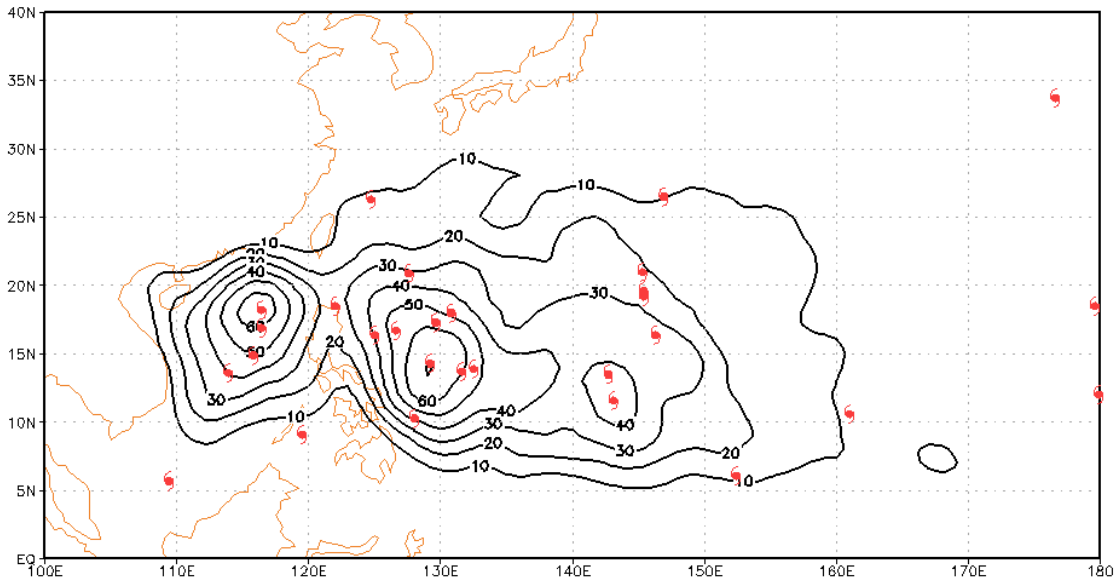

Fig 1.6 Distribution of TC-generating source density in NW Pacific and South China Sea in 1949-2012 (Unit: digit/πR^2, R=250km) compared with TC genesis locations in 1 Jan.-12 Nov. 2013

4) More rapidly-intensified typhoons

In January-October 2013, there were 9 typhoons that had experienced rapid intensification (with wind speed increased by 15m/s in 24 hours), and they were severe typhoons WUTIP (No.1321), KROSA (No.1329), and super typhoons SOULIK (No.1307), UTOR (No.1311), USAGI (No.1319), DANAS (No.1324), FRANCISCO (No.1327), LEKIMA (No.1328) and HAIYAN (No.1330). Three TCs once reached the super typhoon category, i.e. SOULIK (No.1307), UTOR (No.1311) and USAGI (No.1319) before they landed on Taiwan, Fujian and Guangdong provinces respectively. But at the time of their landfalls, their intensities were all reduced to severe typhoon category.

1.1.2 Operational Forecast

During the past 5 years, the biases of the subjective TC track forecasts in the China

Meteorological Administration (CMA) showed a declining tendency. By 12 November 2013, the mean biases of TC track forecasts were 82.3km for 24 hours, 134.0km for 48 hours, 193.2km for 72 hours, 278.5km for 96 hours and 444.0km for 120 hours respectively, which were far below the normal mean biases.

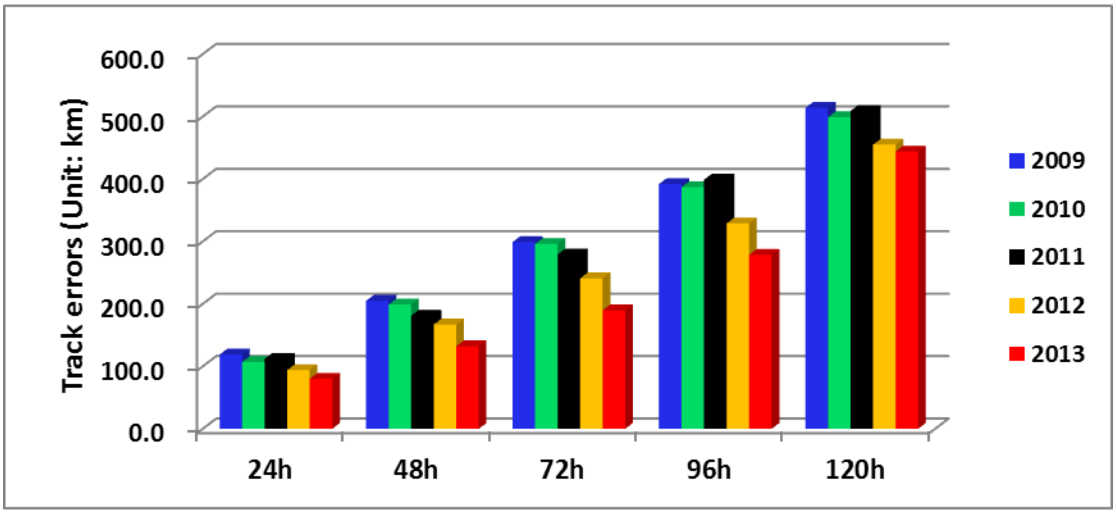

Fig 1.7 Biases of CMA's subjective TC track forecasts in past 5 years

1.1.3 Characteristics of major typhoon-induced rainfall that impacted China in 2013

In 2013, the major typhoon-associated heavy rain and floods that affected China can be characterized as follows:

1) Concentrated heavy precipitation events. Typhoon SOULIK, UTOR, TRAMI and USAGI brought about heavy precipitation to Guangdong, Fujian and Guangxi among other places consecutively.

2) Widespread floods with more rivers exceeding alert water levels. Floods were extensive affecting 8 provinces, and totally more than 80 rivers in Guangdong, Guangxi and Hunan exceeded the alert water levels, causing floods. Altogether, over 30 coastal tide gauges reported high tides beyond the alarming levels.

3) Record breaking severe floods. Under influence of UTOR, extensive regional floods took place in the Pearl River basin, the *Beijiang* River in Guangdong met the 1-in-20-year severe flood and beyond; the first flood occurred in the *Dongjiang* River in 2013; the Lianjiang River-a branch of the *Beijiang* River, *Qinjiang* River-a branch of the *Hanjiang* River, and *Xizhijiang* River-a branch of the *Dongjiang* River all broke their historical water level records.

1.1.4 Narrative on Tropical Cyclones

1) Tropical storm BEBINCA (No.1305)

At around 21:00 UTC on 19 June 2013, a tropical depression developed over the central South China Sea. It moved north afterwards. At about 18:00 UTC on 20 June, it began to move northwestwards, and gradually got strengthened. At 00:00 UTC on 21 June, the tropical storm BEBINCA was numbered 1305, and it further moved to the west-northwest, gradually approaching the east coast of Hainan; and BEBINCA landedon the coast of Qionghai, Hainan Province at 03:10

UTC on 22 June, with maximum wind speed reaching Force 9 (23m/s) near its centre at the landing time, with its central minimum pressure down to 984hPa. After its landfall, BEBINCA moved westwards and crossed the Hainan Island before entering the Beibu Gulf, then it turned northwest and was gradually approaching the coast of northern Viet Nam; BEBINCA made its second landfall on the coast of Thái Bình Province of Viet Nam at 14:30 UTC on the 23 June. After the second landing, it weakened and became a weaker tropical depression within Viet Nam at 15:00 UTC. The Central Meteorological Observatory stopped the TC numbering at 18:00 UTC all on the same day,

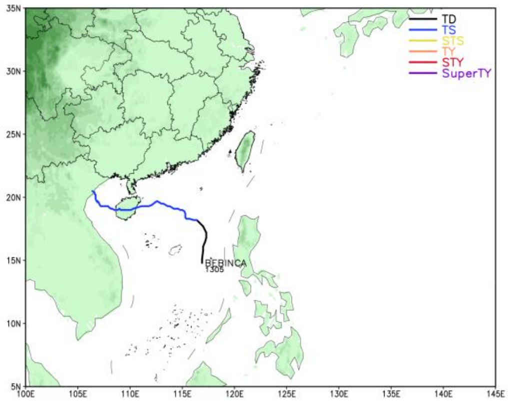

Fig.1.8a Track of tropical storm BEBINCA

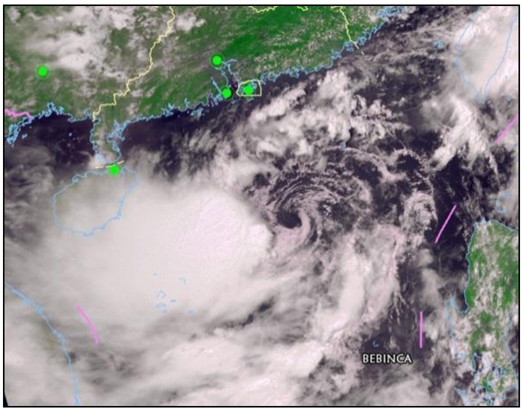

Fig.1.8b FY-3B image, 05:35 UTC, 21 June 2013

2) Severe tropical storm RUMBIA (No.1306)

The tropical storm RUMBIA was formed over the western North Pacific to the east of the Philippines at 12:00 UTC on 28 June 2013, then it steadily moved in the northwest direction, and after crossing the Philippines it entered the eastern part of the South China Sea. At 02:00 UTC on 1 July, RUMBIA was strengthening and became a severe tropical storm over the northwestern South China Sea, gradually approaching the west coast of Guangdong Province. Around 21:30 UTC on 1 July, RUMBIA landed on Zhanjiang of Guangdong with maximum wind speed near its centre reaching Force 10 (28m/s), with the minimum pressure at its centre being down to 976hPa. After its landfall, RUMBIA continued to move north-northwest, with intensity being gradually decreased; it entered the southeastern Guangxi at 01:00 UTC on 2 July. It was weakened into a tropical depression within Guangxi at 12:00 UTC, and the Central Meteorological Observatory stopped the TC numbering at 15:00 UTC on the same day.

Under the impact of RUMBIA, the strong gust associated with it reached 44.7m/s (Force 14) on the Donghai Island off Zhanjiang, Guangdong. Similarly, the gust wind was up to 42.3m/s (Force 14) on the Qizhou Islands of the Hainan Province.

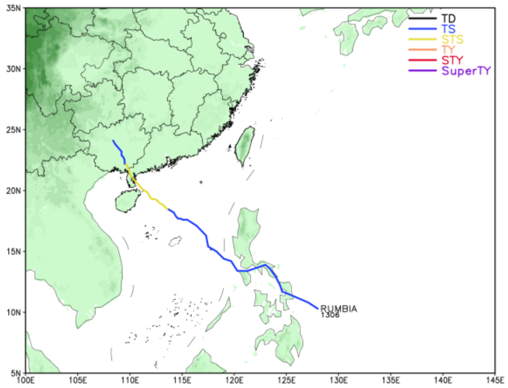

Fig.1.9a Track of severe tropical storm RUMBIA

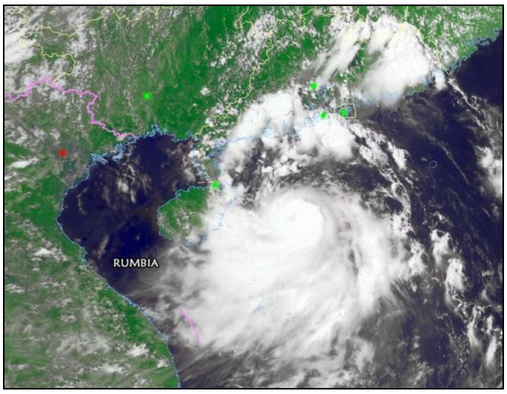

Fig.1.9b FY-3B image, 05:50 UTC, 1 July 2013

3) Super typhoon SOULIK (No.1307)

The tropical storm SOULIK developed over the western North Pacific at about 00:00 UTC on 8 July 2013. After its formation, it was moving in west-northwest direction, while getting strengthened rapidly. SOULIK was intensified into a severe tropical storm at 18:00 UTC on 8 July, it became a typhoon at around 00:00 UTC, a severe typhoon at 09:00 UTC , and a super typhoon at 18:00 UTC all on 9 July, while continuing to move west-northwest, and approaching the north coast of Taiwan, China. SOULIK landed on the border of the Xinbei City (New Taipei City) and the Yilan County, Taiwan Province at 19:00 UTC on 12 July, with the maximum wind speed near its centre reaching Force 14 (45m/s) at landing time, with the minimum pressure at its centre down to 945hPa. Then, SOULIK swept through the northern Taiwan and entered the Taiwan Strait, while continuing to move northwest. At 08:00 UTC on 13 July, SOULIK landed once again on Lianjiang of Fujian Province, with the maximum wind speed at its centre reaching Force 12 (33m/s), with the minimum central pressure being down to 975hPa. After its landfall, SOULIK was weakened soon, and it became a tropical depression in Jiangxi at 21:00 UTC on 13 July. The Central Meteorological Observatory stopped the TC numbering at 00:00 UTC on 14 July.

The transient wind speed reached 57.5m/s (Force 17) on the Pengjia Islet, and 45.3m/s (Force 14) on Cangnan and Shipin counties, Zhejiang Province.

In 08:00 on 12 July-08:00 on 15 July, heavy rain fell in Fujian, Zhejiang, Guangdong and Jiangxi provinces, and excessively heavy rain occurred in some localities. The total areas with heavy rainfall exceeding 100mm and 50mm were 83600km^2 and 183700 km^2 respectively.

Under the SOULIK-associated heavy rainfall, 14 rivers flooded, exceeding the alarm water level by a range of 0.18-2.31m.

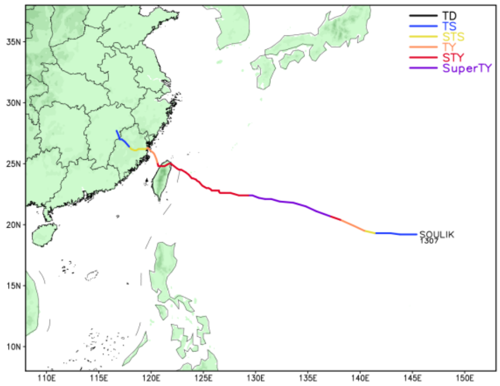

Fig.1.10a Track of super typhoon SOULIK

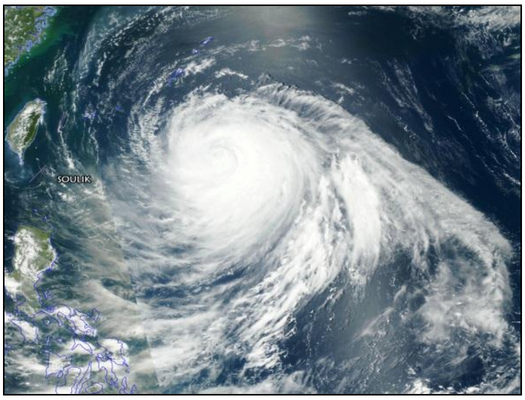

Fig.1.10b FY-3B image, 04:25 UTC, 11 July 2013

4) Tropical storm CIMARON (No.1308)

At 03:00 UTC on 16 July 2013, a tropical depression was generated over the western North Pacific to the east of the Luzon Island of the Philippines. After its genesis, it moved in the northwest direction, and after its first landfall on the northern Luzon Island, it entered the Bashi Channel, where its intensity was gradually increased. At 00:00 UTC on 17 July, CIMARON became a tropical storm. CIMARON continued to move northwest and entered the northeastern South China Sea, where it was turning north and approaching the south coast of Fujian. CIMARON landed on the coast of the Zhangpu County, Fujian Province at 12:30 UTC on 18 July, with the maximum wind speed at its centre reaching Force 8 (20m/s) at landing time, with the minimum central pressure being down to 995hPa. After landing, CIMARON continued to move in a north-northwest direction, with its intensity decreasing rapidly, and it was weakened into a tropical depression within Fujian at 18:00 UTC on 18 July. The Central Meteorological Observatory stopped the TC numbering at 21:00 UTC on 18 July.

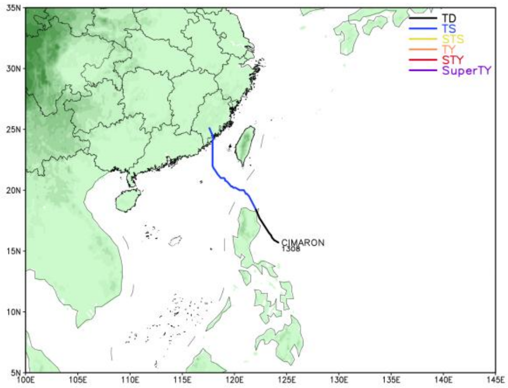

Fig.1.11a Track of tropical storm CIMARON

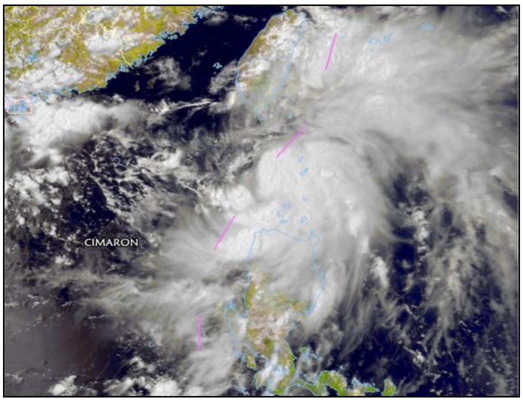

Fig.1.11b FY-3B image, 05:55 UTC, 17 July 2013

5) Severe tropical storm JEBI (No.1309)

JEBI emerged as a tropical depression over the central South China Sea at 18:00 UTC on 30 July 2013. After its genesis, it moved in the west-northwest direction, and its intensity increased rapidly. It developed into the tropical storm JEBI at 00:00 UTC on 31 July, and it gradually moved northwest. JEBI intensified into a severe tropical storm at 15:00 UTC on 1 August. Its motion became quickened starting from 2 August, gradually approaching the northeastern coast of Hainan. JEBI landed on the coast of the Wenchang City of the Hainan Province at 11: 30 UTC on 2 August, with the maximum wind speed at its centre reaching Force 11 (30m/s) at landing time, with the minimum central pressure down to 980hPa. After crossing the northern Hainan, JEBI moved onto the eastern waters of the Beibu Gulf. JEBI was moving in the west-northwest direction, and gradually approaching the off-shore coast of the China-Viet Nam border. JEBI made its landfall on the coast of the border at 02:00 UTC on 3 August, with the maximum wind speed at its centre reaching Force 11 (30m/s) at landing time, with the minimum central pressure down to 980hPa. Soon after its landing, JEBI was weakened rapidly, and it became a tropical storm at 06:00 UTC, later on a tropical depression at 12:00 UTC all on 3 August. The Central Meteorological Observatory stopped the TC numbering at 15:00 UTC on the same day.

Being subject to the combined influences of JEBI and Southwest Monsoon, strong gusts beyond Force 7 sustained for long time in both Guangdong and Guangxi provinces. The high wind lasted for about 43 hours in Guangdong, and the strong wind persisted for approximately 39 hours in the Guangxi Zhuang Autonomous Region.

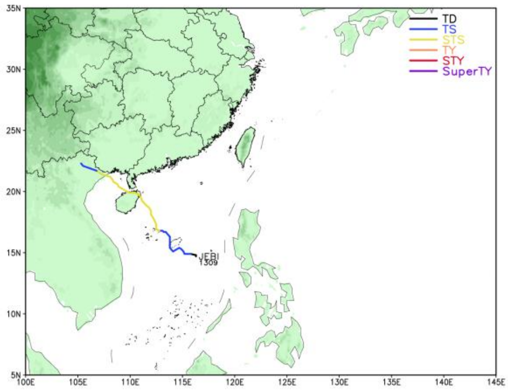

Fig.1.12a Track of severe tropical storm JEBI

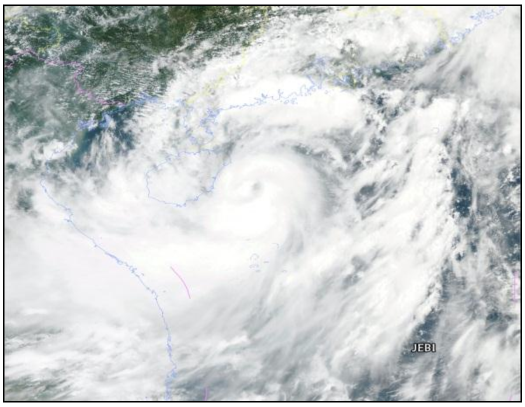

Fig.1.12b FY-3B image, 06:00 UTC, 2 August 2013

6) Super typhoon UTOR (No.1311)

The tropical storm UTOR was generated over the western North Pacific to the east of the Philippines at 18:00 UTC on 9 August 2013. After its genesis, UTOR moved in the west-northwest direction, and its intensity increased rapidly. It developed into a severe tropical storm at 03:00 UTC on 10 August, a typhoon at 06:00 UTC on the same day, a severe typhoon at 03:00 UTC, and a super typhoon at 09:00 UTC on 11 August. UTOR first landed on the east coast of the Luzon Island of the Philippines at 19:00 UTC on 11 August. After its landfall, UTOR crossed the Luzon Island, with its intensity being gradually weakened. It became a severe typhoon at 21:00 UTC on 11 August, and an ordinary typhoon at 02:00 UTC on 12 August. UTOR moved out of the Luzon Island and entered the eastern South China Sea at 06:00 UTC on 12 August, continuing to move in the west-northwest direction. UTOR redeveloped into a severe typhoon over the northern South China Sea at around 00:00 UTC on 13 August, and its motion turned to the northwest direction, gradually approaching the west coast of Guangdong. UTOR made its second landfall on the coast of the Yangxi County, Guangdong Province at 07:50 UTC on 14 August, with the maximum wind speed at its centre reaching Force 14 (42m/s) at landing time, with the minimum central pressure down to 955hPa. After landing, UTOR was gradually weakened, and became a severe tropical storm within

Guangdong at 15:00 UTC on 14 August. Later on, UTOR turned to north in motion, and entered the southeastern Guangxi at 20:00 UTC on the same day, while being weakened into a tropical storm. UTOR was weak enough to become a tropical depression lingering in Guangxi at 06:00 UTC on 15 August. The Central Meteorological Observatory stopped the TC numbering at 21:00 UTC on the same day.

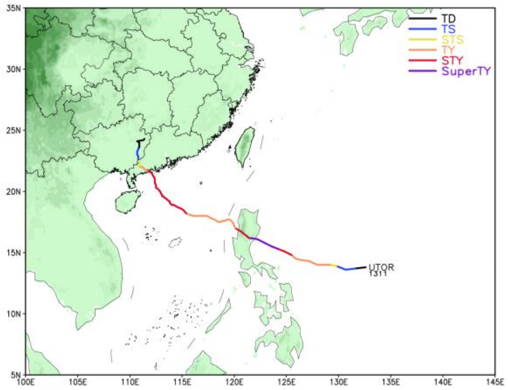

Fig.1.13a Track of super typhoon UTOR

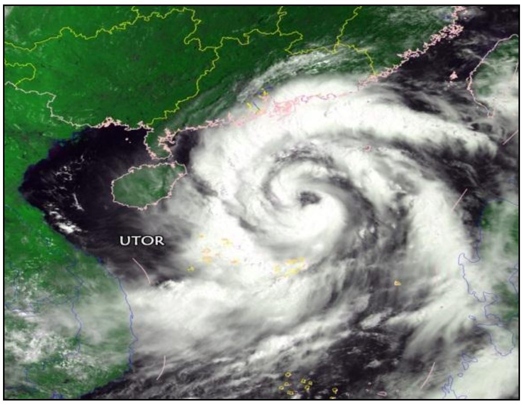

Fig.1.13b FY-3A image, 02:30 UTC, 13 August 2013

The Yangdong County in Guangdong Province witnessed the high wind with mean velocity at 47.8m/s (Force 15) and strong gust at 60.5m/s (Force 17). Heavy rain fell in Guangdong, Guangxi, Hainan and Fujian, and excessively heavy rainfall occurred in the coast of Guangdong, southeastern Guangxi, south coast of Fujian. The areal-rainfall was 307mm in Guangdong alone, and the maximum point rainfall of 936mm was recorded at Luojingba station in the Luhe County of the Shanwei City, Guangdong Province.

Under the influence of UTOR, extensive regional floods took place in the Pearl River basin; 1-in-20-year flood occurred in the *Beijiang* River, Guangdong; the first flood in 2013 happened along the *Dongjiang* River; the 3 small- and medium-sized rivers (i.e. *Lianjiang* River - a branch of the *Beijiang* River, *Qinjiang* River – a tributary of the *Hanjiang* River, and *Xizhijiang* River – a branch of the *Dongjiang* River) saw record-breaking floods; 40 rivers in Guangdong Guangxi and Hunan among others were overflown, exceeding their respective alarm water levels ranging from 0.02 to 7.13 meters.

7) Typhoon TRAMI (No.1312)

A tropical depression was generated over the western North Pacific to the east of Taiwan, China at 00:00 UTC on 17 August 2013. After its genesis, it moved in the east- southeast direction, with its intensity being gradually increased. It became the tropical storm TRAMI at 03:00 UTC on 18 August, and then it lingered around in the same location until 18:00 UTC on 19 August when it developed into a severe tropical storm, and began to move in the northwest direction. TRAMI became a typhoon at 14:00 UTC on 20 August, and turned to the west-northwest direction in its movement. Passing through the waters to the north of the Taiwan Island, TRAMI turned to the southwest direction and entered the Taiwan Strait on 21 August, from where it was approaching the central coast of Fujian. TRAMI landed on the coast of the Fuqing City in Fujian at 18:40 UTC on the same day, with the maximum wind speed at its centre reaching Force 12 (35m/s) at landing time, with the minimum central pressure down to 958hPa. After its landfall, TRAMI was slowly weakened to a severe tropical storm at 21:00 UTC on 21 August, and a tropical storm at 03:00 UTC on 22 August. TRAMI entered the Jiangxi Province at 08:00 UTC, and it was weakened to a tropical depression within the Jiangxi province at 21:00 UTC all on the same day. Later on, TRAMI entered the Hunan province, and moved west, becoming increasingly weaker. The Central Meteorological Observatory stopped the TC numbering at 09:00 UTC on 23 August.

Under impacts of TRAMI landfall, the total areas with heavy rainfall exceeding 50mm and 100mm were 1020000 km^2 and 220000 km^2 respectively.

Under the combined influences of TRAMI and the astronomical tide, 12 small- and medium-sized rivers plus 19 tide gauges in the Zhejiang/Fujian coastal zone reported alarm water/tide levels which exceeded the warning lines ranging from 0.03 to 1.16 meter. Under the influence of heavy rain, 12 rivers in the Zhejiang coastal zone, Fujian and Guangdong were flooded, exceeding the alarm water levels ranging from 0.03 to 1.16 meter. The measurements from 19 tide gauges in the Zhejiang/Fujian coastal zone exceeded the warning levels in the range of 0.21-1.07 meter, out of which the tide gauge at the Baiyantan station recorded the maximum tide level of 4.24 meters at 00:00 on 22 August, which exceeded the alarm tide level (3.49 meter) by 0.75 meter, ranking the second since 1955 (only next to 1998 historical record of 4.44 meter).

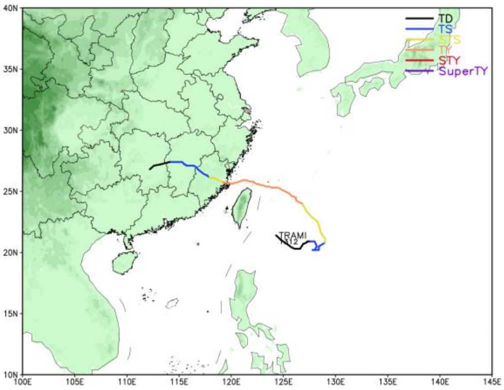

Fig.1.14a Track of typhoon TRAMI

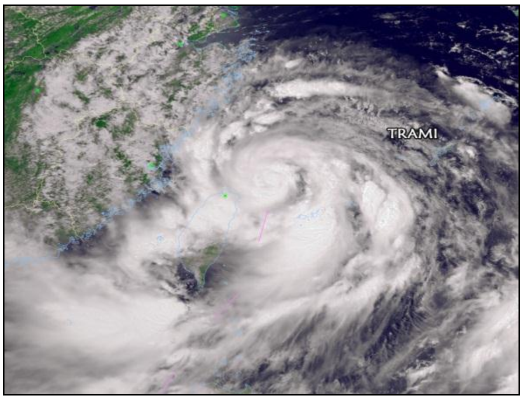

Fig.1.14b FY-3B image, 05:05 UTC, 21 August 2013

8) Super typhoon USAGI (No.1319)

A tropical depression was generated over the western North Pacific on 16 September 2013. After its genesis, it began to move in the north direction, and it developed into the tropical storm USAGI at 18:00 UTC on the same day, being numbered 1319. USAGI developed into a severe tropical storm at 21:00 UTC on 17 September, a typhoon at 12:00 UTC on 18 September, a severe typhoon at 03:00 UTC, and a super typhoon at 09:00 UTC on 19 September, USAGI maintained its intensity of super typhoon category for 30 hours, during which its peak wind speed reached 60m/s (Force 17), with its central minimum pressure down to 915hPa. Since then, USAGI began weakening into a severe typhoon at 12:00 UTC on 21 September, and it was gradually approaching the central and eastern coasts of Guangdong Province. USAGI made its landfall on the coast of the Shanwei City in Guangdong Province at 11:40 UTC on 22 September, with the maximum wind speed at its centre reaching Force 14 (45m/s) at landing time, with the minimum central pressure down to 935hPa.

After landing, USAGI continued to move in the west-northwest direction, with its intensity being gradually weakened. USAGI weakened into typhoon at 16:00 UTC, a severe tropical storm at 21:00 UTC, a tropical storm at 22:00 UTC on 22 September, and eventually a tropical depression within the Guangdong Province at around 00:00 UTC on 23 September. USAGI entered Guangxi at 04:00 UTC on 23 September. The Central Meteorological Observatory stopped the TC numbering at 06:00 UTC on the same day.

Being influenced by USAGI, central and eastern Guangdong and southern Fujian met heavy and very heavy rain respectively. The two highest point rainfalls were 407mm recorded in the Liangshan mountain in Zhangpu County, Fujian Province, and 308mm measured in the Gaojiping village, Shunfeng County, Guangdong Province.

In 23-25 September, 15 rivers in Fujian, Guangdong, Hunan, Jiangxi were flooded, exceeding their alarm water levels ranging from 0.01 to 2.19 meter. The measurements from 9 tide gauges along the coasts of Zhejiang, Fujian and Guangdong exceeded respective alarm levels in a range of 0.03-1.39 meter. Out of the 9, the Jiuzhen tide gauge in Zhangpu County of Fujian and the Haimen tide gauge in Shantou City of Guangdong reported the highest tide levels on records.

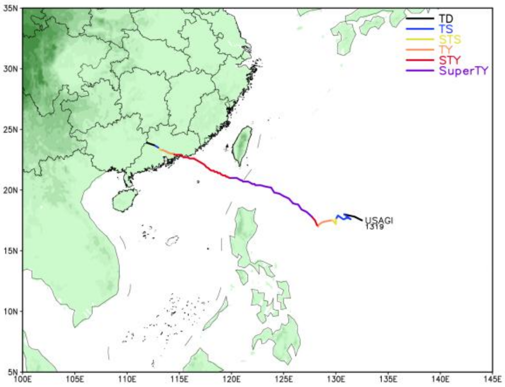

Fig.1.15a Track of super typhoon USAGI

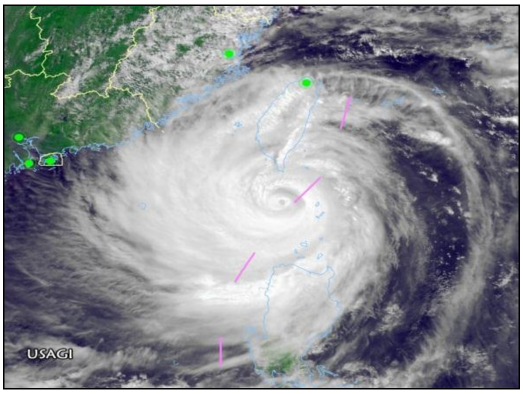

Fig.1.15b FY-3B image, 05:30 UTC, 21 Sept. 2013

9) Severe typhoon WUTIP (No.1321)

A tropical depression was formed over the eastern South China Sea on 26 September 2013. After its formation, it moved in the northwest direction, and it developed into the tropical storm WUTIP at 06:00 UTC on 27 September. Later, WUTIP moved west, and its intensity increased gradually. WUTIP became a severe tropical storm at 21:00 UTC on the same day, a typhoon at 06:00 UTC on 28 September, and a severe typhoon at 03:00 UTC on 29 September. The severe typhoon maintained for 9 hours before its intensity gradually declined. WUTIP was weakened down to a normal typhoon at 12:00 UTC on 29 September, and it moved in the west-northwest direction, gradually approaching coast of central Viet Nam. WUTIP landed on coast of the northern part of the Quang Bình province in central Viet Nam at 09:45 UTC on 30 September. After landing, WUTIP was gradually weakened, and it became a tropical storm at about 15:00 UTC on the same day. The Central Meteorological Observatory stopped the TC numbering at 21:00 UTC on 30 September.

The maximum gust up to Force 15 (47.4m/s) was measured on the Beijiao Reef in the Xisha Islands. Heavy or excessively heavy rainfall occurred on various reefs of the Sansha Islands, especially it exceeded 500mm on the Beijiao Reef (515.2mm) and the Duncan Island (510.5mm).

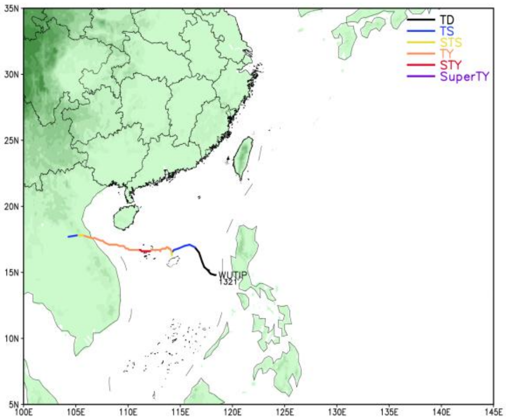

Fig.1.16a Track of severe typhoon WUTIP

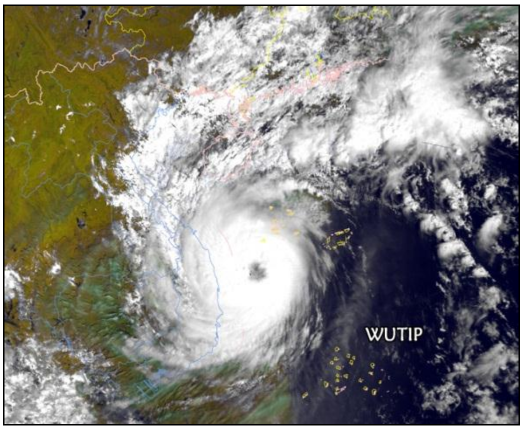

Fig.1.16b FY-3A image, 02:45 UTC, 30 Setp 2013

10) Severe typhoon FITOW (No.1323)

The tropical storm FITOW was generated over the western North Pacific to the east of the Philippines at around 12:00 UTC on 30 September. After its genesis, it moved in the north-northwest direction, and its intensity increased gradually. FITOW developed into a severe tropical storm at 09:00 UTC on 1 October, a typhoon at 21:00 UTC on 2 October , a severe typhoon at around 09:00 UTC on 4 October. Soon afterwards, FITOW turned to west-northwest in its motion, gradually approaching the north coast of the Fujian Province, and it landed on coast of the Fuding City in Fujian at 17:15 UTC on 6 October, with the maximum wind speed at its centre reaching Force 14 (42m/s) at landing time, with the minimum central pressure down to 955hPa. After landing, FITOW moved in the west- southwest direction, and its intensity declined rapidly. FITOW became a tropical depression in Fujian at about 01:00 UTC on 7 October. The Central Meteorological Observatory stopped the TC numbering at 03:00 UTC on the same day.

FITOW landed on Fujian as a severe typhoon in terms of intensity, and it was the strongest typhoon that has landed on mainland China in October since 1949 (except Taiwan and Hainan islands). The FITOW-associated high wind in Force 12-14 over the southeast coast of Zhejiang sustained for about 11 hours, with extreme transient wind speed reaching Force 15-17 on some islands and in mountainous regions. The transient wind speeds even reached 76.1m/s and 73.1m/s in the Shiping and Wangzhou mountains, which all broke the historical record of the Zhejiang Province.

Under the combined impacts of FITOW and invading cold air, heavy rain fell on the Jiangnan and Jianghuai regions in 6-7 October, in which Shanghai, Zhejiang, Jiangsu met very heavy rain, with the total areas with heavy rainfall exceeding 250mm, 100mm and 50mm were 38000 km^2, 122000 km^2 and 175000 km^2 respectively.

The FITOW-induced heavy rainfall had caused floods in 17 small- and medium-sized rivers, with their water levels exceeding the warning lines in a range of 0.09-2.79 meters. Among these flooded rivers, the *Yaojiang* River, a tributary of the *Yongjiang* River in the Zhejiang Province witnessed the record-breaking flood in its history. 32 hydrological or water-level measurement stations, which were deployed across river network around the Taihu Lake, reported alarm water levels exceeding their respective warning lines by 0.09-2.30 meters. 17 out of the 32 stations reported that the safety water levels were exceeded by a range of 0.07-1.30 meter. On 8 October, the water level of the Taihu Lake rose to 3.60 meters, which was below the warning level (3.80 meters).

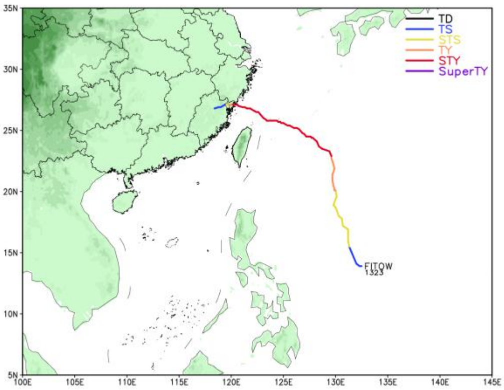

Fig.1.17a Track of severe typhoon FITOW

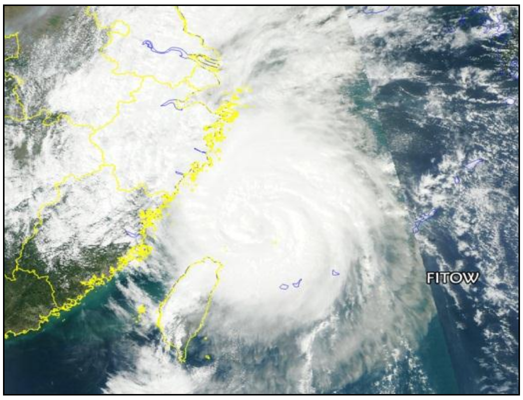

Fig.1.17b FY-3B image, 05:55 UTC, 6 Oct. 2013

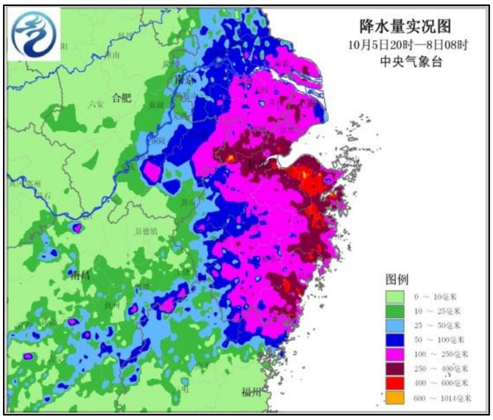

Fig.1.17c Distribution of FITOW-induced rainfall

Fig.1.17d Hazards of FITOW in Zhejiang

11) Super typhoon HAIYAN (local name: YOLANDA, No.1330)

The tropical storm HAIYAN was generated over the western North Pacific at 00:00 UTC on 4 November 2013. After its genesis, HAIYAN began to move in the west-northwest direction, with its intensity being increased rapidly. It developed into a severe tropical storm at 18:00 UTC on the same day, a typhoon at around 06:00 UTC, then a severe typhoon at 18:00 UTC on 5 November, and a super typhoon at approximately 00:00 UTC on 6 November. Soon after, HAIYAN quickened its pace of movement toward the central Philippines at a speed of 40km/hour. HAIYAN made its first landfall on the coast of northern Leyte Island of the Philippines at 23:00 UTC on 7 November, with the maximum wind speed at its centre reaching Force 17 (75m/s) at landing time, with the minimum central pressure down to 890hPa. After landing, HAIYAN swept through the central Philippine Islands, with its intensity being gradually decreased, which was weakened to a severe typhoon category at 06:00 UTC on 8 November. HAIYAN entered the southeastern South China Sea at 15:00 UTC on 8 November, and moved in the west-northwest direction. HAIYAN began turning to northwest at about 01:00 UTC on 9 November, and it was gradually approaching coast of the southwestern Hainan. HAIYAN narrowly passed through the southwestern coast of the Hainan Island at 08:00 UTC on 10 November before entering the Beibu Gulf, from where HAIYAN moved in the north-northwest direction. Eventually, HAIYAN made its second landfall on the coast of the

Quang Ninh Province in northeastern Viet Nam at 21:00 UTC on 10 November, with the maximum wind speed at its centre reaching Force 13 (38m/s) at landing time, with the minimum central pressure down to 965hPa. After landing, HAIYAN was moving north, and entered the Guangxi, China at roughly 01:00 UTC on 11 November. HAIYAN was weakened into a severe tropical storm at about 02:00 UTC on the same day, and it was moving northeast soon after, with its intensity being rapidly decreased. HAIYAN became a tropical storm at 08:00 UTC, and a tropical depression within Guangxi at around 12:00 UTC all on 11 November. The Central Meteorological Observatory stopped the TC numbering at 15:00 UTC on that day.

During 9-11 November, heavy and very heavy rain fell on Hainan, most Guangxi and western Guangdong. Excessively heavy rainfall occurred in southern Hainan, southeastern Guangxi among other localities. Additionally, Hunan, central and northern Jiangxi, northern Fujian had measured moderate up to heavy rain. The total areas with heavy rainfall exceeding 250mm, 100mm and 50mm were 23000 km^2, 173000 km^2 and 467000 km^2 respectively.

The 20 rivers in Hainan, Guangxi and Guangdong among others were overwhelmed exceeding the alarm water levels by a range of 0.03-5.00 meters, out of which the upper-reaches of the *Wanquan* River in Hainan met the largest flood on record since 1959. During the floods, there were totally 9 reservoirs in both Hainan and Guangxi, water levels of which exceeded their designed storage capacities by a range of 0.03-2.01 meters. On the other hand, nearly 210 medium-sized and large reservoirs had increased water storage by approximately 2 billion cubic meters in total.

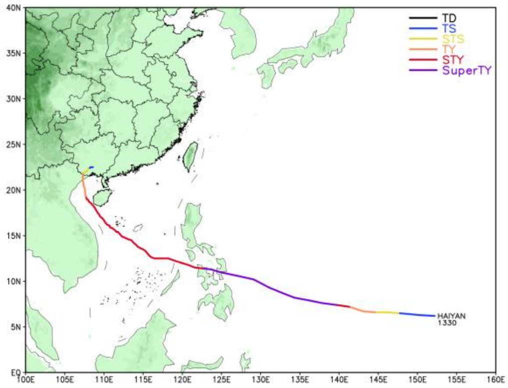

Fig.1.18a Track of super typhoon HAIYAN

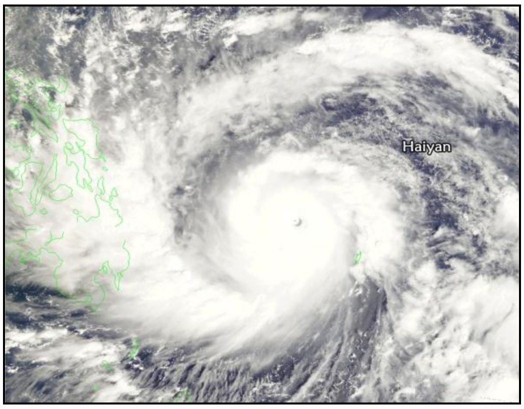

Fig.1.18b FY-3A image, 01:00 UTC, 7 Nov. 2013

1.2 Socio-Economic Assessment

By 30 November 2013, altogether 13 tropical cyclones had affected China, 9 of which landed on the mainland China respectively. Among the landed typhoons, USAGI (No.1319) was the strongest one. FITOW (No.1323) was the strongest typhoon that landed on mainland China in October since 1949 (with exception of Taiwan and Hainan islands). These landed typhoons caused most direct economic losses. Overall, the losses as result of typhoon-induced hazards and even disasters in 2013 were relatively heavier than usual years (see Table 1.1).

Considering the fact that the tropical cyclones which affected China in 2013 had made their landfalls in a certain concentrated time frame, and that TC-induced rainfall intensities were higher and TC-associated wind forces were stronger in some areas of China, they had caused certain casualties and economic losses. According to incomplete statistics available, the typhoon-related hazards or disasters in 2013 had totally affected **49.227** million people in 11 provinces (municipalities or autonomous regions), including Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Hunan, Guangdong, Guangxi, Hainan and Taiwan, claiming **199** lives with **67** people missing plus **5.554** million person-times being evacuated for safety in emergency responses (Fig.1.19). In 2013, the total area of affected crops was 2.6984 million hectares, among which 300600 hectares of crops completely failed. Furthermore, 89000 houses collapsed and 357000 houses were damaged to a varying degree. The total direct economic loss was 126.29 billion RMB in 2013. In comparison with others, both Guangdong and Zhejiang suffered most from the typhoon-associated hazards or disasters.

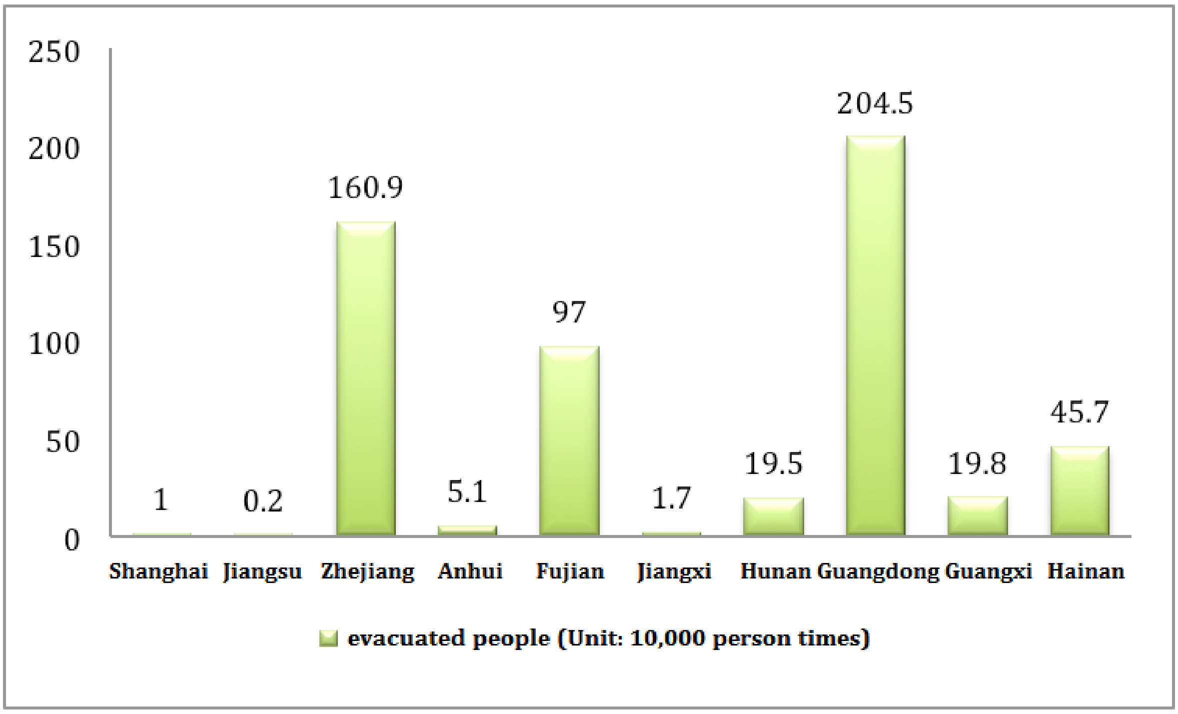

Fig.1.19 Statistics of evacuated people in emergency responses to potential typhoon-induced disasters in 2013

Table 1.1 Typhoon Impacts and Losses in 2013

TC No. & Name	Landing Site	Landing Date	Max. Wind Force Near TC Centre When Landing	Affected Province (municipality, AR)	Affected Population (10,000)	Death Tolls	Direct Economic Loss (100 m RMB)
1305 BEBINCA	Wenchang, Hainan	22 June	9 (23m/s)	Hainan	21.7	/	0.1
1306 RUMBIA	Zhanjiang, Guangdong	2 July	10 (28m/s)	Guangdong, Guangxi	213.4	/	11.7
1307 SOULIK	Lianjiang, Fujian	13 July	12 (33m/s)	Fujian, Guangdong, Zhejiang, Jiangxi, Anhui, Taiwan	242.8	11	33.9
1308 CIMARON	Zhangpu, Fujian	18 July	8 (20m/s)	Fujian	30.8	4	19.8
1309 JEBI	Wenchang, Hainan	2 August	11 (30m/s)	Hainan, Guangdong, Guangxi	101.8	/	4.9
1311 UTOR	Yangjiang, Guangdong	14 August	14 (42m/s)	Hunan, Guangdong, Guangxi, Hainan	1176	86 (9 missing)	215
1312 TRAMI	Fuqing, Fujian	22 August	12 (35m/s)	Zhejiang, Fujian, Jiangxi, Hunan, Guangxi, Taiwan	301.4	2 (1 missing)	34.3
1315 KONG-REY	/	/	/	Fujian, Taiwan	1.9	6 (1 missing)	1.3
1319 USAGI	Shanwei, Guangdong	22 Sept.	14 (45m/s)	Guangdong, Fujian, Hunan, Jiangxi, Guangxi, Taiwan	1169.3	35 (1 missing)	264
1321 WUTIP	/	/	/	Hainan	0.1	14 (48 missing)	0.2
1323 FITOW	Fuding, Fujian	7 October	14 (42m/s)	Zhejiang, Fujian, Shanghai, Jiangsu	1216	11 (1 missing)	631.4
1325 NARI	/	/	/	Hainan	24.9	/	0.5
1330 HAIYAN (YOLANDA)	/	/	/	Guangxi, Guangdong, Hainan, Taiwan	422.6	30 (6 missing)	45.8

1.3 Regional Cooperation Assessment

1.3.1 International scientific forum on tropical cyclones

The International TOP-level Forum on Rapid Change Phenomena in Tropical Cyclones was held in Hainan Province, China in from 5 to 9 November 2012. This meeting was co-sponsored by the Chinese Academy of Engineering, China Meteorological Administration (CMA) and World Meteorological Organization (WMO). Apart from the well-known scientists from the United States, Australia, India, the Philippines, Thailand, Nigeria among other countries, about 110 experts on typhoon research in various forefront fields from 9 Chinese universities and institutions including Peking University, Nanjing University, Institute of Atmospheric Physics under the Chinese Academy of Science, and Chinese Academy of Meteorological Sciences, as well as from 17 CMA operational centres including the National Meteorological Centre attended the forum.

Focusing on 5 themes: (1) abrupt changes of TC tracks; (2) abrupt changes of TC structure and intensity; (3) impacts of abrupt changes of landing TCs on rainfall intensity; (4) techniques for predicting abrupt TC changes; and (5) research on hazards induced by abrupt TC changes, academic exchanges and in-depth discussions were made in the forum on findings from recent studies on TC rapid change phenomena worldwide. It was recommended that relevant Research Development Projects be developed within WMO framework to promote studies on TC rapid change phenomena, and to facilitate international cooperation in this field.

1.3.2 The 6th China-Korea Joint Workshop on Tropical Cyclones

The 6th China-Korea Joint Workshop on Tropical Cyclones was held in Shanghai on 27-28 May 2013. Aimed at improving analysis and prognosis of TC intensity and TC mesoscale structures, the workshop brought together 38 TC forecasting experts and scientists from CMA, KMA and universities including University of Maryland and University of Hawaii for academic exchange and exploratory discussions, in order to further enhance the exchanges on TC research and operations between China and Republic of Korea.

Fig.1.20 The 6th China-Korea Joint Workshop on Tropical Cyclones

1.3.3 Training workshops on Dvorak technique

The Training Workshop on Dvorak Technique was organized by the Shanghai Typhoon Institute from 28 to 30 May 2013. Mr. S. T. Chan, Senior Scientific Officer from the Hong Kong Observatory, was invited to give lectures. 18 operational staff from the Eastern China Regional Administration and the Shanghai Service among other units participated in the training on development of Dvorak technique, operational procedures, applications and case analyses, etc.

A 2-week training seminar on operational applications of Dvorak Technique in TC intensity analysis was successfully convened by the CMA Typhoon and Marine Meteorological Centre from 4 to 16 August 2013. Prof. Mark. A. Lander from the University of Guam gave a series of lectures, provided training on historical cases in combination with on-site TC guidance and analysis, and helped the Central Meteorological Observatory improve its existing operational procedures for estimating TC intensities using Dvorak technique.

Fig.1.21 Training Seminar on TC intensity analysis using Dvorak technique

1.3.4 Collaborative Research & Development

Through nominations by Members of the Typhoon Committee, and selections by both the Typhoon Committee Secretariat and the Shanghai Typhoon Institute, Ms. Le Thi Hai Yen from the National Hydro-Meteorological Service of Viet Nam visited the Shanghai Typhoon Institute for academic and operational exchanges in September-October 2013. She was involved in collaborative research and development of TC genesis prediction products based on global models and ensemble forecasts, which were uploaded onto the website of the landing typhoon demonstration project for operational uses on a trial basis; studies on TC-genesis probability predictions; and experimental verifications of TC-genesis predictions.

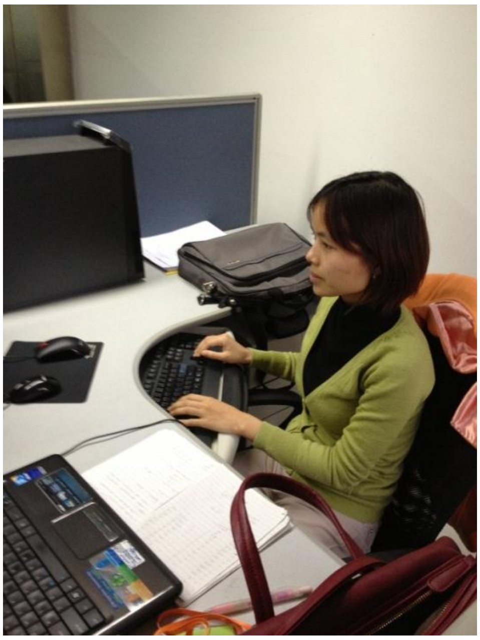

Fig.1.22 Ms. Le Thi Hai Yen at work

II. Summary of Advances in Key Result Areas

2.1 Improvement of ensemble forecast-based bias correction method for typhoon track forecasts and establishment of seasonal typhoon quantitative prediction system

1) In 2013, the typhoon forecasting team of the National Meteorological Centre (NMC) continued to develop the ensemble forecast-based bias correction method for objective typhoon track forecasts (ensemble forecast-based bias correction method). This approach is based on the following concept: the Central Meteorological Observatory selects a group of members which shows better effectiveness for short-range forecasts from ECMWF real-time ensemble forecast-based TC tracks. Then, they are extrapolated to the current time based on the averaged tracks. As it is found from statistic studies on ensemble forecast data in recent 5 years, corrections of ensemble TC forecasts prove most effective by selecting an appropriate number of members from various time validities like 24-h and 48-h predictions.

Based on this finding, the operational ensemble forecast-based bias correction method was improved in 2013. By the end of October, the biases for 24-, 48-, 72-, and 96-h TC track forecasts using this method were 81, 132, 190, 288 km respectively, which were significantly improved compared to the results from objective TC track predictions with the previous correction method used on trial basis in 2012 (see Fig.2.1). The biases for above time validities were reduced by 11%, 19%, 19% and 11% respectively.

2) Based on existing climate prediction system used at national level, the National Climate Centre (NCC) has developed a model-based seasonal quantitative TC prediction system. Using CFSV2-based monthly oceanic and atmospheric circulation hindcasts from NCEP Climate Forecast System, NCC has developed a prediction model to make objective forecasts on typhoon genesis by establishing the relationship of these hindcasts with seasonal typhoon genesis, and by selecting some physically meaningful predictors. Provision of such seasonal quantitative prediction products for typhoon activities over the NW Pacific on a regular basis, and active promotion of operational seasonal quantitative TC predictions have provided strong support to governments and relevant agencies at various levels for disaster prevention and preparedness.

Identified opportunities/challenges, if any, for further development or collaboration:

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√					
Hydrology							
DRR		√					
Training and research							
Resource mobilization or regional collaboration							

Member: China

Name of contact for this item: Qian Qifeng

Telephone: +86-10-58995840

Email: qianqf@cma.gov.cn

2.2 Advances in numerical typhoon prediction models and data assimilation

1) The TC vorticity initialization technique used for global T639L60 model-based typhoon track prediction has been improved. As T639L60 model system shows systematic biases featuring evident north-shift tendency in predicting early genesis and tracks of typhoons that move west or northwest over the western North Pacific before their landfalls. NMC has developed the BDA-based technique to initialize TC vorticity structure in replacement of BOGUS-based vorticity structure in the original initialization scheme, to improve T639L60's predictability of such typhoon tracks (sea Fig. 2.2).

2) The regional model-based typhoon prediction system (GRAPES_TYM) covering the western North Pacific becomes operational. GRAPES_TYM has a horizontal resolution of 0.15 º, and 31 layers vertically. The system runs twice per day, and makes 3-day forecasts.

3) GRAPES_TYM's capability for typhoon predictions has been improved. NMC has improved GRAPES_TYM's vorticity initialization technique and its convection parameterization. The time range of GRAPES_TYM predictions has been extended up to 5 days, running 4 times per day. The capability for predicting TC tracks and intensities has been improved significantly.

4) The Shanghai Typhoon Institute (STI) has evaluated the Northwest Pacific TC track outputs from 6 global models in 2010-2012.

5) STI has recently developed a high-resolution typhoon modeling system-SHA-THRAPS. Currently, this system is in the quasi-operational test phase, and it is designed to provide abundant refined TC prediction products.

6) STI has incorporated ensemble prediction information in the Grid-point Statistical Interpolation System (GSI), and STI has established a hybrid data assimilation system that links to WRF, and combines the ensemble Kalman filter (EnKF) with 3DVAR. All this has significantly improved the TC track forecasts.

7) The South China Sea Typhoon Model (TRAMS) developed by the Guangzhou Institute of Tropical Meteorology has been used operationally. This model adopts non-hydrostatic equilibrium, with horizontal resolution of 0.36º, 55 levels in vertical direction. In 2013, the model was used to make 120-h typhoon track, intensity and high wind forecasts. So far, its TC track forecast bias is about 125km for 48 hours and within 200km for 72 hours, and the model better captured the most TC motion tracks in 2013.

In 2013, some progress has been made in studies on sea surface drag coefficient and convection parameterization for the TRAMS model (see Fig. 2.3). The convective and stratus cloud coupling mechanism has been incorporated in the convection parameterization scheme, which can effectively improve model skills for TC track and intensity prediction, especially for 48-72 hour forecasts, with TC track bias being reduced by about 90km at best (see Fig. 2.4).

Identified opportunities/challenges, if any, for further development or collaboration:

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√	√	√	√	√	√
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

Member:	China	Name of contact for this item:	Chen Zitong Zeng Zhihua
Telephone:	+86-20-87654569 +86-21-54896103	Email:	ztchen@grmc.gov.cn zengzh@mail.typhoon.gov.cn

2.3 Advances in scientific research on typhoons

1) Using a WRF model, numerical modeling studies have been made on impact of sea temperature on intensity changes of TC *Goni* (No. 0907) over sea.

2) With GRAPES-TCM as an experimental model, sensitivity test studies have been made on typhoon *Muifa* (No. 1109) by using 2 boundary layer parameterization schemes (MRF and YSU).

3) A study has been made on typhoon *Vicente* (2012) which underwent rapid intensification just in 24 hours before landing. Both radar and satellite data showed that in its pre-landing phase, the convective system to the north of the *Vicente's* eye was developing quickly, and it was just located on right side of the down-shear.

4) Characteristic analysis was made on the secondary centre induced by Taiwan island when TC was passing through. The surface observational data from the Taiwan region have confirmed whether or not a sub-pressure centre exists, when a TC is approaching or passing through the Taiwan island, as reported in CMA Typhoon Annual in the past. Some studies have been made on mechanisms and characteristics for the sub-centre genesis.

5) Research has been made on impacts of sea temperature gradients in both south and north hemispheres on typhoon frequency over the western North Pacific. Analyses have been made on effects of the sea temperature gradients between the warm pools in the Southwest Pacific and western North Pacific on TC frequency over the western North Pacific and their physic mechanisms. The findings show that such gradients may curb TC genesis over the western North Pacific.

6) Using China's new generation Doppler radar data and the Wufen Mountain radar data from the Central Weather Bureau in Taiwan island as well as JMA reanalysis data, analyses have been made on asymmetric distribution of precipitation characteristics of the six TCs (*Saomai, Khanun, Wipha, Matsa, Rananim* and *Krosa*) that landed on the East China region in 2004-2007 either before or after their landfalls.

7) By assimilating the wind measurements from an off-shore 300-meter tower, the wind speed change coefficients at various levels have been rectified, so that measurements from AWSs deployed on all islands with elevations of 76 and 86 meters above sea level are corrected accordingly. With the corrected reference, the intensity of typhoon *Haikui* (No. 1211) at landing was re-defined. Based on this research finding, after necessary corrections, measurements from AWSs operating under non-homogeneous conditions can also be used for estimating typhoon intensity on operational basis. This means that greater attention should be given to, and more in-depth analysis should be made on AWS measurements taken on islands when they are used operationally for defining TC intensity.

Identified opportunities/challenges, if any, for further development or collaboration:

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√	√	√	√	√	√
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

Member: China

Name of contact for this item: Zeng Zhihua

Telephone: +86-21-54896103

Email: zengzh@mail.typhoon.gov.cn

2.4 Ocean observing system and outfield typhoon observation experiment

1) Ocean Observing System

By October 2013, the current National Ocean Observing System in operation has 167 island weather stations, 18 buoys, 39 ship stations, 15 platform stations, 29 coastal wind profilers, 266 coastal GPS/MET stations, 17 visibility measurement stations, and 55 new generation Doppler weather radars. Before the typhoon season, all types of instruments used in the ocean observing system will be properly maintained. This ocean observing system may be launched for multiple intensified observations in emergency responses to typhoon landfalls, thus having achieved good social benefits.

2) Outfield Typhoon Observation Experiment

Through continual efforts made in several years, the Shanghai Typhoon Institute has put its second generation mobile typhoon-tracking platform into operational applications in 2013 (see Fig. 2.5). The instruments on board include a ultrasonic anemometer, a raindrop spectrometer, a microwave radiometer, AWS instruments, a wind profiler and GPS sounder, etc. During the typhoon season in 2013, the Shanghai Typhoon Institute participated in in-situ observations of two typhoons (i.e. SOULIK and FITOW) that eventually landed on the coast of eastern China.

3) The Guangzhou Institute of Tropical Meteorology analyzed the persistence of gust wind speeds, and characteristics of turbulence structures at different levels above sea surface in high wind processes using observational data acquired from an off-shore platform equipped with 4-level ultrasonic anemometers (type: Gill R3-50). It also addressed such aspects as the behaviors of near-surface turbulent momentum transfer under high background wind in the upper boundary layer, as well as the behaviors of near-sea-surface friction velocity that change with horizontal wind speed during high winds (see Fig. 2.6). Based on these efforts, a near-sea-surface high wind parameterization scheme has been developed on a preliminary basis.

Identified opportunities/challenges, if any, for further development or collaboration:

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√	√				
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

Member:	China	Name of contact for this item:	GuoZhimei Zeng Zhihua Chen Zitong
Telephone:	+86-10-58993703 +86-21-54896103 +86-20-87654569	Email:	gzmaoc@cma.gov.cn zengzh@mail.typhoon.gov.cn ztchen@grmc.gov.cn

2.5 Improved calibrations methodology and satellite-based regional quick-scans

1) Application of new on-orbit operational calibration approach – CIBLE in FY-2D/E/F satellites has significantly improved precision for defining TC location and intensity.

The approach known as 'Calibration of Inner-Blackbody corrected by Lunar Emission' (CIBLE), which focuses on in-orbit inner-blackbody and lunar calibrations, has become a novel method that has been independently developed for in-orbit calibrations of FY-2 satellites, instead of the traditional cross-calibrations depending on foreign satellites completely. This new method has fundamentally solved the problem of underestimated brightness temperature in the low-temperature region of infrared band, which has adverse effects on the outcome of typhoon intensity analysis. After being tested in monitoring 30 numbered TCs over both West Pacific and South China Sea in 2013, it is found that the accuracy of infrared calibration is better than 1.5K@220K.

After being calibrated with CIBLE method, the brightness temperature measurements from the infrared band are used for TC intensity analysis with objective DVORAK technique. This can significantly improve the accuracy for defining TC's Current Intensity (CI) index. Meanwhile, the accuracies of CIBLE calibration-based satellite products have also been improved by a big margin, including atmospheric motion vector (AMV), temperature of black-body (TBB), outgoing long-wave radiation (OLR), cloud classification (CLC), which are commonly used for TC monitoring and analysis as matured satellite products. For example, the bias of AMV speed from FY-2E water vapor band has been reduced by 3-4m/s. All these enhanced products have played a crucial role in improving accuracies of TC monitoring and analysis, and have demonstrated their value and usefulness in operational typhoon forecasts.

2) More frequent region-specific observations with FY-2F geostationary satellite can be initiated at any time in response to operational requests, which have significantly improved the timeliness for defining TC locations and intensities.

In June-October 2013, in responses to processes of 10 high impact typhoons (i.e. RUMBIA, SOULIK, CIMARON, UTOR, TRAMI, USAGI, WUTIP, FITOW, DANAS and KROSA), the National Satellite Meteorological Centre, CMA had initiated the intensified region-specific observations with FY-2F, and its maximum frequency of observations being increased, focusing on the same targeted region for up to 6 minutes per time, providing more frequent images for typhoon forecasters. This allows forecasters to identify a typhoon's location and intensity 10-15 minutes earlier than usual, to ensure consistency, integrity and continuity of TC positioning, to give forecasters more lead time for effectively identifying TC location and intensity on an hourly basis, to provide more detailed evolution of TC cloud systems, to improve monitoring of TC intensity and track changes, and to provide effective support for updating typhoon early warnings in a more timely manner.

Identified opportunities/challenges, if any, for further development or collaboration:

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√					
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

Member: China

Name of contact for this item: Wang Xin

Telephone: +86-10-68409395

Email: xinwang@cma.gov.cn

2.6 Successful launch of FY-3C and deployment of SWAP platform

1) The successful launch of FY-3C polar orbiting satellite, its entry into the constellation of FY-3A/B for coordinated observations from space, and its higher resolution (250-meter) true color imagery have enhanced the capability for detecting the refined internal structures of a typhoon.

The FY-3C polar orbiter was launched in the Taiyuan launching centre at 11:07 Beijing Time on 23 September 2013, as a new comer in China's FY-3 satellite series. After on-orbit tests, FY-3C would replace FY-3A operating in the morning orbit, as a main operational satellite, and it would maintain the constellation with FY-3B, making observations with overpass time of every 6 hours.

Based on data from the Medium Resolution Spectral Imager (MERSI) on board the FY-3A/B/C polar orbiters, the true color synthetic imagery with a spatial resolution of 250 meters is generated, which can be used to reveal the detailed internal structures of a typhoon cloud system, including those of typhoon eye and evolution from genesis to dissipation of its internal meso-scale systems. The image applications in combination with the high temporal resolution data from FY-2F have largely improved the comprehensive capability for typhoon detection and monitoring with higher temporal and spatial resolutions.

In addition, compared with FY-3A/B, the FY-3C's technical performance has been improved, and its Microwave Temperature Sounder and Microwave Humidity Sounder have been upgraded to type II, with its precision of observation from space being improved. After tests, FY-3C will have potential capability to capture 3-demensional temperature and humidity structures of a typhoon.

2) The Satellite Weather Application Platform（SWAP）version 1.0 has been put into operational applications, playing stronger support to TC monitoring and analysis.

SWAP version 1.0 was officially released in May 2013, and it was soon deployed nationwide in May-October for operational uses in multiple national operational centres and local meteorological establishments in the provinces subject to influences of high-impact typhoons.

In June-October 2013, SWAP 1.0 became localized in typhoon monitoring and forecasting in many coastal provinces alike, and their specialized TC analysis modules effectively ensured proper applications of satellite data in local typhoon and associated heavy rain forecasts and services in an easier, more intuitive and quantitative manner, providing stronger support to TC monitoring and analysis.

Meanwhile, SWAP 1.0 has provided operational forecasters and remote sensing technicians with satellite data, application- and service-oriented products, localized conversion and analysis tools, to ensure standard approach for satellite data applications in typhoon monitoring and forecasting and consistent conclusions, highlighting localizations and their priorities.

Identified opportunities/challenges, if any, for further development or collaboration:

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√					
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

Member: China

Name of contact for this item: Wang Xin

Telephone: +86-10-68409395

Email: xinwang@cma.gov.cn

2.7 Improved CMACast, WIS and MICAPS systems

1) CMACast is a DVB-S2 standard satellite data broadcast system of the China Meteorological Administration (CMA). CMACast became operational in June 2012. It is maintained by CMA National Meteorological Information Centre. It serves as the main channel for domestic and international meteorological data distribution. It is also one of the data dissemination systems of the Global Information System Centre (GISC) Beijing. Now, more than 2600 meteorological offices at provincial, prefectural and county levels receive in real time the routine meteorological data and products provided by CMA via the system for weather forecasts, climate prediction, and service delivery. Meanwhile, CMACast also provides data broadcasting services for 24 users from 20 WMO Members in RA II and RA V at large, with daily data broadcast volume exceeding 210GB, including observational data from both China and overseas, CMA T639 NWP products, satellite data or products from FY-2D/E and FY-3A/B, EUMETSAT satellite products among others. In combination with the Meteorological Information Comprehensive Analysis and Processing System (MICAPS) – a data/product platform developed by CMA, the efficient and effective CMACast data and product applications can be capitalized to a largest extent.

2) CMA actively participated in and promoted implementation of the WMO Information System (WIS). After the GISC Beijing became operational on 15 August 2011, CMA's other four Data Collection or Production Centres (DCPC) also began to function on operational basis by the end of 2012. The following data and products can be accessible via the GISC Beijing portal: data and products from FY-2D/E, FY-3A/B and other satellites, climate products like global monthly mean temperature and precipitation anomalies and distribution patterns, as well as T213-based ensemble forecast products, typhoon model ensemble forecasts, etc. So far, the GISC Beijing provides data discovery and access services for Mongolia, Nepal, Pakistan, Hong Kong China, Macao China and other Members within its responsible area, as well as for other WMO Members in the Asia and Pacific region via its portal. The GISC Beijing has released over 200,000 metadata, and it has 72 registered users, with more than 80,000 log-ins in 2013 alone.

Identified opportunities/challenges, if any, for further development or collaboration:
Users of the CMACast, MICAPS and WIS Beijing are requested to provide feedbacks in order for CMA to improve its service.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration	√	√					

Member: China

Name of contact for this item: Li Xiang

Telephone: +86-10-64806275

Email: lixiang@cma.gov.cn

2.8 Strategies and actions for typhoon preparedness of the China Meteorological Administration

The China Meteorological Administration (CMA) always gives priority to prevention and preparedness for typhoon-induced disasters or hazards. Relying on scientific & technological advances, and innovative means of service delivery, CMA provides forecasts and predictions with improved accuracies of annual typhoon trends, individual typhoon tracks, intensities and landing time, and delivers timely services.

1) Government leadership is an important assurance for effective and efficient prevention and preparedness for typhoon-related hazards or disasters. Generally, CMA presents its forecasts and relevant information of typhoon genesis, development and potential landfall to the central government, State Flood Control and Drought Relief Headquarters and relevant government agencies 3-5 days in advance. CMA also provides advisories for decision-making by governments and departments concerned at various levels, and more lead time they need for organizing and deploying preventative actions against possible typhoon-induced hazards and disasters. Since the beginning of 2013, CMA has delivered more than 80 service materials to governments for decision making to get prepared for typhoon threats, over 200 early warnings, 5000 e-mail messages and nearly 1000 mobile phone SMS messages about landing typhoons to various ministries and their focal points.

2) Public mobilization and participation are an ultimate basis for prevention and preparedness for typhoon-associated hazards and disasters. Since the beginning of 2013, CMA's early warning information about invading typhoons has reached 1.1 billion person-times in a timely manner, as a whole. Meanwhile, CMA has also disseminated typhoon forecasts and warnings, as well as updates of on-going hazards or disasters and scientific knowledge for disaster prevention and preparedness through mass media, e.g. China Weather TV, Weather China (www.weather.com.cn), China Agro-met Net (www.xn121.com), and China Typhoon Weather Net (www.typhoon.weather.com.cn). Up to now, the total number of hits to Weather China is beyond several tens of millions. The local meteorological establishments have delivered live TC forecasts and warnings including TC-associated wind and rainfall status to public by such means as 'MicroBlog', marine radios, mobile platforms in emergency response to extreme events. For example, the Hainan Provincial Meteorological Service provides marine weather services to vessels operating or routing on the South China Sea by using China's BeiDou (COMPASS) Navigation Satellite System. All these have effectively raised public awareness and capability in response to invading typhoons on the one hand, and improved service delivery skills on the other.

3) Inter-agency joint actions are an effective way to prevent and prepare for typhoon-induced hazards or disasters. CMA has enhanced typhoon information sharing and joint emergency responses with other government agencies for water resources, civil affairs, transport and communication, tourism, oceanic authorities among others (see Table 2.1). After typhoon forecast or warning is issued by CMA or its local office, the relevant authorities will launch

emergency responses in a timely fashion by making thoughtful arrangements, and by taking urgent measures or actions. Especially, in case of typhoon FITOW, the State Flood Control and Drought Relief Headquarters immediately initiated the Category II Emergency Responses to Typhoon and Flood associated with it. CMA also launched its Category II Emergency Responses to Severe Meteorological Disasters (Typhoon). Accordingly, the competent authorities in both Zhejiang and Fujian provinces took their Category I Emergency Responses to Typhoon respectively. Although FITOW intensity in terms of wind and rainfall was so rarely high in historical records, it was due to the fortified preventative measures taken well in advance and proper urgent handlings that the casualties and social impacts were far less compared with similar typhoons in history.

Identified opportunities/challenges, if any, for further development or collaboration:
The experience in above strategies and actions could be shared among TC Members.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√						
Hydrology							
DRR	√	√	√				
Training and research							
Resource mobilization or regional collaboration		√	√				

Member: China

Name of contact for this item: Wu Ruixia

Telephone: +86-10-58995471

Email: wurx@cma.gov.cn

2.9 Anti-typhoon measures taken by the Ministry of Civil Affairs and their effectiveness

1) Measures taken to reduce casualties and results

1.1) According to the forecasts from the meteorological departments, the civil affair authorities at various levels launched their early-warning responses to remind masses in the potentially affected regions of making necessary preparations, to assist in doing such preventative work as replacing people operating at sea and exposing to potential risks to safety, and to call vessels at sea back to wind sheltering ports. The National Commission for Disaster Reduction of China in association with the Ministry of Civil Affairs has launched 7 early-warning responses so far.

1.2) The commission has revised the *National Model Community Standard for Integrated Disaster Reduction*.

Totally, there are 4116 model communities for integrated disaster reduction nationwide.

1.3) Planning for outreach and education activities and enhancing disaster risk management.

The theme of the National Disaster Prevention and Reduction Day in 2013 was to “Recognize Disaster Risks, Master Disaster Reduction Skills”. During the day, more than 46 million public outreach handouts were disseminated, nearly 6000 training events were organized, over 40000 drills were carried out, and over 300 million SMS messages were delivered, with up to 49 million person-times were directly benefited from these activities.

2) Measures taken to mitigate socio-economic impacts and results

Compared with house damages in the same periods since 2000, the total number of ruined houses by typhoons decreased by 43.7% in 2013.

2.1) So far in 2013, five national emergency responses for natural disaster relief have been launched. In total, 4.216 billion RMB Yuan have been allocated in 37 batches as disaster relief funds, out of which 328 million RMB Yuan have targeted to typhoon disaster relief.

2.2) 12 assessments have been made on early warning of typhoon-induced disasters and losses. On average, each assessment should be completed in 3-5 hours, mainly focusing on scope of impact, risk of loss, ruined and damaged houses, emergency replacement of people to safety among others, in order to inform decision makers for reference.

3) Information technology measures and results

3.1) China's natural disaster management system is operating smoothly, which has over 10000 users, and it receives about 100000 disaster reports annually. By September, the mobile phone-based disaster reporting system has been launched (see Fig. 2.7), which allows on-site users at county level to deliver disaster information and photos in real time.

3.2) The project entitled Operational Management of the Small Satellite Constellation for Environment and Disaster Monitoring & Forecasting and Disaster Reduction Application System is under implementation. So far, the 3 components of the system (i.e. engineering, technical and archival subsystems) have just undergone their validation and acceptance on a preliminary basis.

Identified opportunities/challenges, if any, for further development or collaboration:

The above experience could be shared among TC Members.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√	√				
Hydrology							
DRR	√	√	√	√			
Training and research							
Resource mobilization or regional collaboration				√			

Member: China

Name of contact for this item: Wang Yang

Telephone: +86-10-52811135

Email: wangyang@ndrcc.gov.cn

2.10 Assessment and research on benefits from preparedness and reduction of typhoon-induced hazards, and typhoon risk mapping

1) The National Climate Centre (NCC) took the lead in accomplishing the project - *Assessment on Benefits of Actions to Prevent and Prepare for Typhoon-induced Disasters*. Under this project, typhoon disaster prevention and preparedness-related policies, laws, regulations, responses of social communities and personal actions in various regions were collected. Based on these actions, a set of indicators were proposed, and a questionnaire was prepared targeting to governments, agencies and general public. The analysis of the in-situ survey results gives the estimates of the assessed economic and work-life benefits that generated from actions to prevent and get prepared for typhoon *Saola*. The assessed benefit index of responses to typhoon *Saola* was 105.2, showing a higher rating.

2) Under the project - *Meteorological Support to Prevention and Preparedness for Flash Flood-induced Geological Disasters*, as a first group of constructive actions in 2013, the mapping of heavy rain, floods, drought and typhoon-related disaster risks was officially launched in August. In aspect of typhoon-induced disaster risk mapping, as it is planned under this project, investigations and analyses will be made on past disasters caused by typhoons including heavy rain-related floods (e.g. local river overflows, flash floods, inundations in plain areas), wind hazards, geological disasters and storm surges. 1 county has been selected as a pilot target zone in Fujian and Guangdong province each. In context of different demands, a series of risk maps will be drawn for various disaster-bearing objects that are exposed to corresponding typhoon-induced floods, wind hazards, geological disasters and storm surges, etc. The high or low risk areas can be easily identified from the maps as advices for preventing and preparing for typhoon-induced disasters. Based on risk mapping, guidelines will be prepared for making typhoon-related disaster risk surveys, and for establishing technical indicators and practices for risk mapping. The technical guidance will be finalized for wider applications.

3) Development of Integrated Typhoon Index

The Tropical Cyclone Potential Impact Index (TCPI) was proposed in 2011, which has been recently improved to include not only TC frequency, sustaining time, impact intensity, impact area in certain regions, but also TC-induced rainfall and wind speed. The improved index has a broad prospect for application in typhoon pre- and post-assessments.

4) Guidelines for typhoon-induced disaster impact assessments

Under the auspices of the project entitled *Technical Guidelines for Meteorological Disaster Risk Assessment*, the preparation of the *Technical Guidelines for Typhoon-induced Disaster Impact Assessment* has been initiated, and so far the first draft of this document has been completed. The latter gives overview of major methodologies for typhoon-related disaster impact assessments available both in China and overseas, and presents case analyses that may be useful for those who wish to quickly master these methods.

5) Training on methodologies for typhoon-related disaster impact assessments

On 11 September 2013, a training course - “Methodology for Typhoon-induced Disaster Impact Assessment” was provided in Hubei Province, and the trainees were mainly the operational staff involved in climate monitoring and disaster impact assessment in various meteorological services.

Identified opportunities/challenges, if any, for further development or collaboration:

Through evaluations and inter-comparisons of benefits from various actions under the project, a preliminary conclusion has been made that these actions require “government leadership, inter-agency collaboration, and social participation”. We shall further expand the scope of surveys in 2014, improve statistical methods, and provide stronger technical support to decision-making for prevention and preparedness of typhoon-related disasters.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√	√	√	√		
Hydrology							
DRR	√	√	√	√	√		
Training and research	√	√		√	√		
Resource mobilization or regional collaboration	√	√	√				

Member: China

Name of contact for this item: Sun Chenghu

Telephone: +86-10-58993769

Email: chsun@cma.gov.cn

2.11 Reservoir water level monitoring and flood forecasting

In 2013, focusing on flood prevention and drought relief, apart from traditional hydrological information delivery to governments, the China’s hydrological department particularly enhanced the hydrological information reporting and delivery from medium-sized and small reservoirs across the country. In March 2013, the State Flood Control and Drought Relief Headquarters disseminated the Task Statement in printed form to various units, in which it was requested to report flood and drought information. Based on the similar Task Statement issued in 2012, the task of reporting hydrological information about medium-sized and small reservoirs was added in the statement issued in 2013. The new statement clearly specified such items as the elements to be reported and reporting frequency, etc. Up to now, the national centre is in a position to receive real-time hydrological information from nearly 6000 large, medium-sized and small reservoirs in the country, and number of reporting reservoirs has been increased by 4 times relative to last year. Basically, the hydrological information is reported in real time from all large and medium-sized reservoirs. Based on all this, the Bureau of Hydrology of the Ministry of Water Resources has used the China’s flood forecasting system as a platform to further improve computation, prediction and early warning of rain-water storage capacities of large and medium-sized reservoirs, which have significantly enhanced the hydrological support to decision-making for flood control and drought relief.

Additionally, in terms of typhoon-related hydrological services, the Bureau of the Hydrology of MWR has enhanced its flood forecasting operations targeted to typhoon-affected areas in 2013. The hydrological offices at various levels in the typhoon-affected regions have continuously updated catchment cross-section forecasts and predictions, according to real-time water level and rainfall measurements, in combination with numerical weather predictions among others. Their forecasts are transmitted to the State Flood Control and Drought Relief Headquarters in timely manner, according the mechanism for sharing flood forecasts. By the end of flood season in 2013, the hydrological authorities in the typhoon-affected regions had issued real-time flood forecasts for more than 2100 station-times, which was doubled or even beyond compared with those in last year, providing strong supports to the flood control and drought relief authorities at various levels for their decision-making in flood control.

Identified opportunities/challenges, if any, for further development or collaboration:
The quality control of automatic water level monitoring needs to be improved, so does the rainfall and flood forecasting accuracy.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology	√						
DRR							
Training and research							
Resource mobilization or regional collaboration							

Member: China

Name of contact for this item: Hou Aizhong

Telephone: +86-10-63202379

Email: houaizhong@mwr.gov.cn

2.12 Regulations on publicizing hydrological early warning signals and relevant management

1) To regulate issuance of flood or low-flow early warnings within the hydrological sector or through mass media e.g. radio, television, newspapers, websites, etc., according to needs of hydrological services for flood control and drought relief, the Ministry of Water Resources has developed both *National Standard Hydrological Early Warning Signals* and the *Measures for Publicizing Hydrological Early Warning Signals and Relevant Management*.

2013 is the first year during which the above standard and measures have been implemented on a trial basis. From the beginning of this year to the flood-prone season, some catchment management authorities and hydrological departments in almost 10 provinces (autonomous regions or municipalities) had formulated their own management measures for issuance of hydrological information at local levels. So far, the hydrological offices of relevant departments have issued totally over 100 flood or low-flow early warnings according to their respective management measures for publicizing hydrological information. Such early warning signals have substantively raised public awareness of preparedness for potential floods and low river flows, and to some extent they also play a role in mitigating damages and losses caused by floods and low flows. Meanwhile, the launch of hydrological early warning signals has also increased public understanding of hydrological sector, which facilitates further development of hydrological service.

2) At 42nd Session of the Typhoon Committee, the Urban Flood Risk Management (UFRM) project, which was initiated and led by China, was endorsed by the committee as a cross-cutting project involving all 3 working groups on meteorology, hydrology, and disaster risk reduction. Shanghai (China), Anseong (Korea) and Yokohama (Japan) were identified as demonstration cities under the project, and other 5 pilot cities, i.e. Bangkok (Thailand), Manila (Philippines), Hanoi (Viet Nam), Kuala Lumpur (Malaysia), and Guangzhou (China) actively participated in the project.

In 2012, the Ministry of Water Resources actively organized relevant activities for the project, and completed the preparation of the *Guidelines on Urban Flood Risk Management*. In February-April 2013, the team of the project gathered comments and recommendations from pilot cities. Based on their inputs, it took 5 months for the team to revise and further improve the *Guidelines on Urban Flood Risk Management*, which would be printed in October as a publication of the Typhoon Committee.

Identified opportunities/challenges, if any, for further development or collaboration:
Such aspects as the hydrological information releasing entity, contents to be released, information release procedure, as well as early warning categories still need to be further standardized.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology	√	√					
DRR	√	√					
Training and research		√					
Resource mobilization or regional collaboration							

Member: China

Name of contact for this item: Hou Aizhong

Telephone: +86-10-63202379

Email: houaizhong@mwr.gov.cn

2.13 Regional joint efforts in response to super-typhoon HAIYAN (YOLANDA)

The typhoon HAIYAN (local name: YOLANDA; No. 2013) reached its maximum intensity in the afternoon on 7 November, with the maximum wind speed near its centre exceeding Force 17 (75m/s), becoming the most severe typhoon over the western North Pacific in recent 23 years. At about 23:00 UTC on 7 November, HAIYAN made its first landfall on the Leyte Island in the central Philippines, cutting through it leaving a devastating trail. After crossing the central Philippine islands, HAIYAN was directly approaching the coast of mid-north Viet Nam.

Confronting with the devastating HAIYAN, the National Hydro-Meteorological Service of Viet Nam requested for advices on typhoon-related hazard impact assessment, as how to mobilize social forces for effective preparedness, how to address media and general public at large, etc. At its request, CMA called NMC and the Guangdong Provincial Meteorological Service to keep close contacts with their counterpart in Viet Nam, in order to offer relevant technical support. In this period, the forecasting office of the Guangzhou Regional Meteorological Centre convened a tele-consultation with its counterpart, and both sides also discussed about the TC movements and potential impacts several times through exchanging e-mail messages. NMC offered hourly location and intensity, as well as updated ensemble products from ECMWF and NCEP on timely manner to the Vietnamese forecasters via e-mail. In the afternoon of 9 November, NMC latest forecasting hints were delivered. In the morning of 10 November, in its e-mail message, NMC clearly suggested that HAIYAN would land on the northern Viet Nam between Hai Phong and Quang Ninh provinces in the morning on 11 November, with its pre-landing intensity declining down to around 35m/s, with its motion pace also slowing down; and that after landing, HAIYAN would turn north, with total rainfall amount likely ranging from 100 to 200mm, even reaching 250-350mm in some localities. Moreover, the Hong Kong Observatory and Japan Meteorological Agency also offered relevant technical supports. Such joint emergency interactions between Members in the region by sharing forecasts and experience for disaster risk reduction have played a demonstrative role in responding to similar meteorological hazards in the near future.

Identified opportunities/challenges, if any, for further development or collaboration:

It is recommended that successful collaboration in the region in case of HAIYAN be promoted and some sort of mechanism be developed in the future.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√						
Hydrology							
DRR	√						
Training and research	√						
Resource mobilization or regional collaboration							

Member:	China	Name of contact for this item:	Qian Chuanhai
Telephone:	+86-10-68409321	Email:	chqian@cma.gov.cn

2.14 Activities of the Training Centre of the Typhoon Committee

In 2012, WMO Regional Training Centre Nanjing was designated a Training Centre of the Typhoon Committee. On 26 November 2012, more than 100 representatives from 14 Members of the Typhoon Committee participated in the 7th Integrated Workshop of the Typhoon Committee and the inauguration ceremony of the Typhoon Committee Training Centre Nanjing.

To assist weather forecasters from broad developing countries, especially from the Asia and Pacific region, in more systematic and in-depth understanding of TC structure, genesis, motion and TC-induced secondary hazards, The International Training Course on Tropical Cyclone Forecast was organized on 14-25 October 2013 in Nanjing. Several experts on typhoon forecasting were invited to give lectures in the training. 14 trainees from 11 countries in Asia, Africa and South America participated in the training course.

In 2013, in the International Training Course on Tropical Cyclone Forecast, a series of lectures was given to the trainees on frontier knowledge about tropical cyclones and natural hazards they may bring about in a systematic approach. To further improve skills of operational forecasters and managerial staff in producing refined observation, forecasts, warnings, and in managing disaster risks using various technical tools, the training centre also organized a number of training courses in 2012-2013, e.g. “Training Course on Radar Meteorology for Developing Countries”, “Training Seminar on Application of Meteorological Satellite in Disaster Risk Reduction and Environment”, “Training Course for Aeronautical Meteorology Forecasters”, “Training Course on Multi-Hazard Early Warning”, “Training Seminar on Meteorological Disaster Management and Meteorological Information Service for Emergency Responses”, etc. The above training events all referred to monitoring tropical cyclones and their convective systems with radars and satellites, improvement of TC nowcasting and early warning skills, timely release of public information, scientific planning and decision-making, improved early warning and management, and effective reduction of damages and losses from typhoon-related hazards. In 2013, altogether 229 trainees from 77 countries or regions participated in the above training courses, out of which 82 trainees were from 11 Members of the Typhoon Committee.

Identified opportunities/challenges, if any, for further development or collaboration:
The training centre will continue, as always, to enhance exchanges and cooperation with the Typhoon Committee Members, in order to make even greater contribution to the cooperation in the field of TC forecasting and early warning within the region.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology	√						
DRR	√						
Training and research	√						
Resource mobilization or regional collaboration							

Member: China

Name of contact for this item: Yu Jun

Telephone: +86-10-68406662

Email: yj@cma.gov.cn

2.15 Application of the *Xinanjiang* hydrological model to the *Segamat* basin in Malaysia

In response to the proposal by the Typhoon Committee at its 45th session, the regional cooperative project of the Working Group on Hydrology - "*Extension of Xin'anjiang Model Application in selected River Basins inTC Members*" was smoothly implemented in 2013. It was planned that the model would be applied in the Segamat basin in Malaysia this year on a trial basis. In this regard, the Hydrological Bureau of the Ministry of Water Resources in association with the Hohai University sent 2 experts to give lectures in the training course on flood forecasting held in Kuala Lumpur in 21-25 October 2013. During the training event, they presented the principles of the Xinanjiang model and applied it in the Segamat catchment, and the trainees were engineers from the Department of Irrigation and Drainage (DID) of Malaysia.

About 20 people from Malaysia attended the 5-day training course (Fig 2.8), during which the Chinese experts elaborated on water cycle, hydrological model, principles of the Xinanjiang model, parameter estimation methodology, data requirements, and key hints for software operation, etc. Both sides also shared practices and experience in respective flood forecasting and control.

The engineers from DID basically understood the principles of the Xinanjiang model and application approach, aimed at enhancing the flood forecasting capability. Malaysia is planning to apply the model in other larger catchments. Meanwhile, they hope that China may continue to share with them the accomplishments in hydraulic models, and urban flood modeling, and that experts from Malaysia visit China for learning and academic exchanges.

Identified opportunities/challenges, if any, for further development or collaboration:

Malaysia wishes to continue enhancing cooperation with China and other Members of the Typhoon Committee by sharing knowledge and experience in the fields of hydrological models, hydraulic models, urban flood management, among others.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology							
DRR							
Training and research	√						
Resource mobilization or regional collaboration	√						

Member: China

Name of contact for this item: Hou Aizhong

Telephone: +86-10-63202379

Email: houaizhong@mwr.gov.cn

Appendix

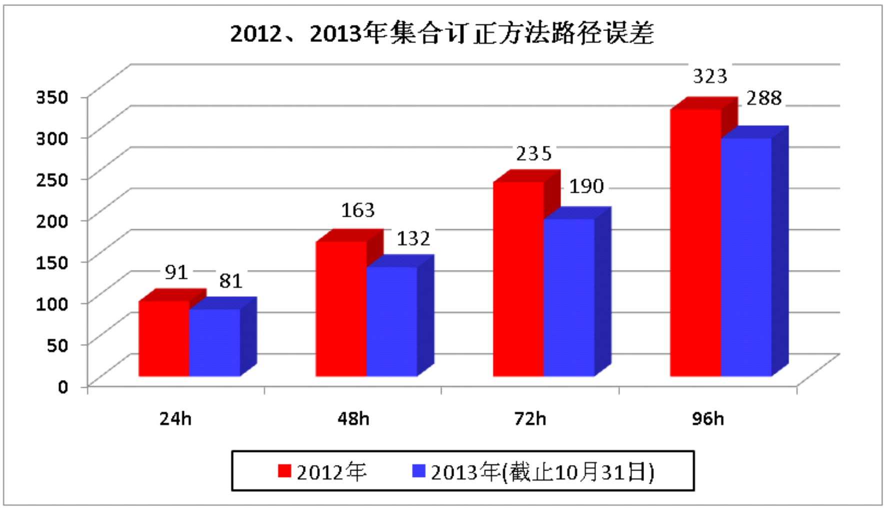

Fig.2.1 TC track errors in 2012 and 2013 using ensemble-based bias correction method

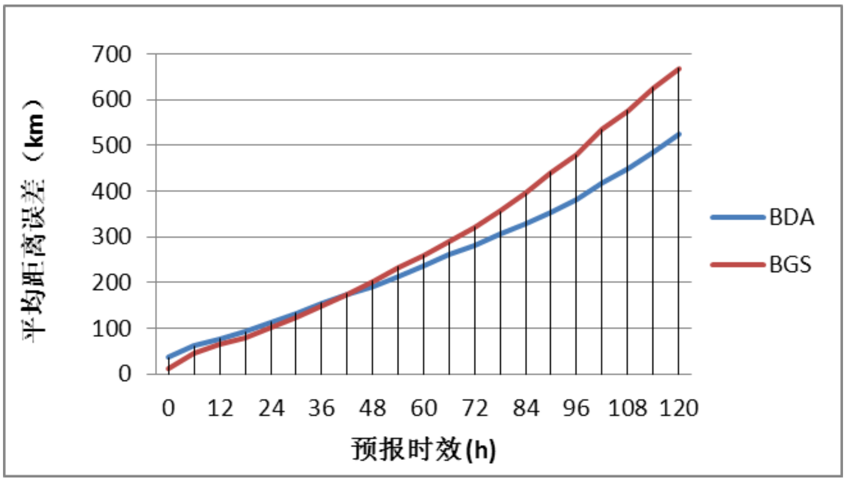

Fig.2.2 Statistic TC track biases in T639L60.

BDA: initial eddy generated by BDA; BGS: initial eddy generated with BOGUS technique

Fig.2.3 Mean typhoon path and intensity forecast errors in 2012

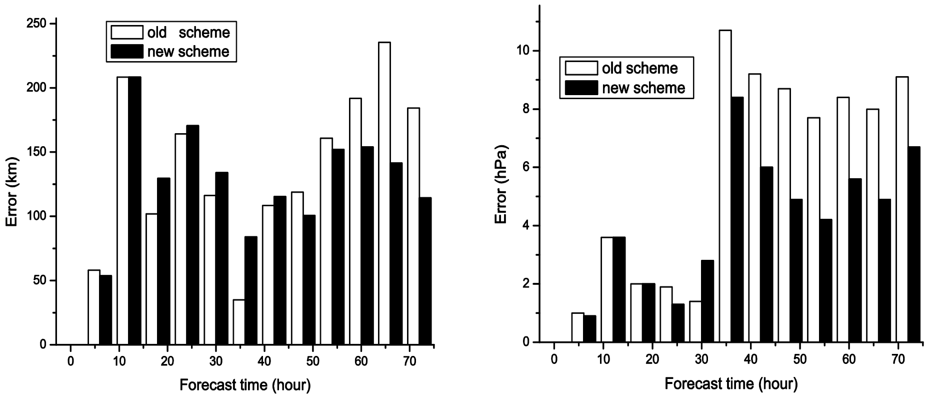

Fig.2.4 Impact of improved cumulus parameterization scheme on track and intensity of typhoon *Guchoul*: (a) improved TC track forecast; (b) improved TC intensity forecast.

Fig.2.5 2nd generation typhoon observing vehicle developed by Shanghai Typhoon Institute

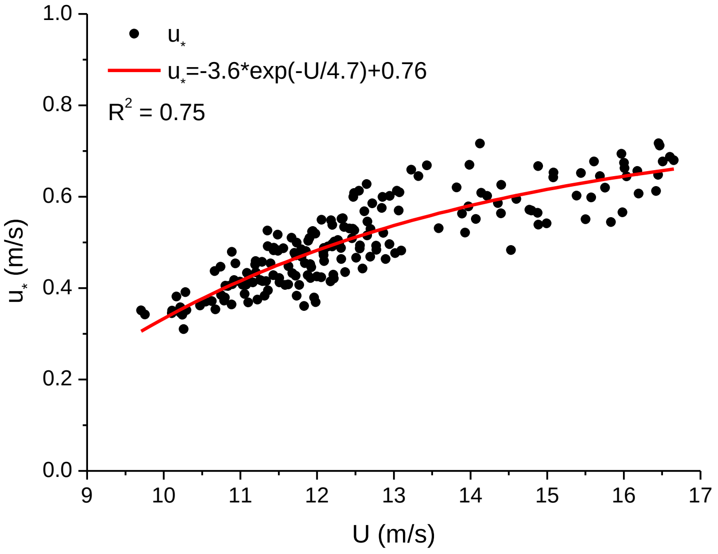

Fig.2.6 Friction velocity near sea surface changes with horizontal wind speed

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Fig.2.7 Mobile phone-based natual disaster information reporting system

Fig.2.8 Group photo of the participants in the Xin'anjiang training course in KL

Table 2.1 Emergency response categories and TC early warning services from CMA in 2013

TC no.	TC name	No. of TC warnings issued	Categories of emergency responses to met. disasters (TC) launched by CMA	National emergency response by SFCDRH
1305	BEBINCA	9		
1306	RUMBIA	9	Category III	
1307	SOULIK	12	Category II	
1308	CIMARON	6	Category IV	
1309	JEBI	10	Category IV	
1311	UTOR	11	Category III	
1312	TRAMI	9	Category III	
1319	USAGI	12		
1321	WUTIP	11	Category IV	Category IV
1323	FITOW	15	Category II	Category II
1330	HAIYAN	13	Category III	