MEMBER
REPORT
[China]

ESCAP/WMO Typhoon Committee
13th Integrated Workshop
Chiang Mai, Thailand
5-9 November 2018

CONTENTS

I. Overview of tropical cyclones which have affected/impacted China in 2018

II. Summary of Progress in Priorities supporting Key Result Areas

I. Overview of tropical cyclones which have affected/impacted China in 2018

1.1 Meteorological and Hydrological Assessment

During the period of January 1- October 18, 2018, the western North Pacific and the South China Sea had witnessed the genesis of 25 tropical cyclones (TCs), including tropical storms, severe tropical storms, typhoons, severe typhoons and super typhoons. Of them, 10 tropical cyclones made landfall in China's coastal areas, including tropical storm EWINIAR (1804), super typhoon MARIA (1808), tropical storm SON-TINH (1809), severe tropical storm AMPIL (1810), typhoon JONGDARI (1812), severe tropical storm YAGI (1814), severe tropical storm BEBINCA (1816), severe tropical storm RUMBIA (1818), super typhoon MANGKHUT (1822), and tropical storm BARIJAT (1823).

From January to April of 2018, the central and eastern equatorial Pacific was characterized by La Niña, followed by the gradual transition from a weakening colder-than-normal to slightly warmer-than-normal phase from May to September; the sea surface temperature (SST) for the western Pacific lingered in throughout the warmer-than-normal state while that for the Indian Ocean turned gradually to the colder-than-normal since April. Relatively more tropical cyclones for this year can be attributed mainly to active convection over the western Pacific warm pool and stronger summer monsoon, while the northerly generate sites, the northerly moving tracks and the large number of landfalls over Zhejiang and Shanghai coasts for this year, attributed to the strong and significantly northerly western Pacific subtropical high.

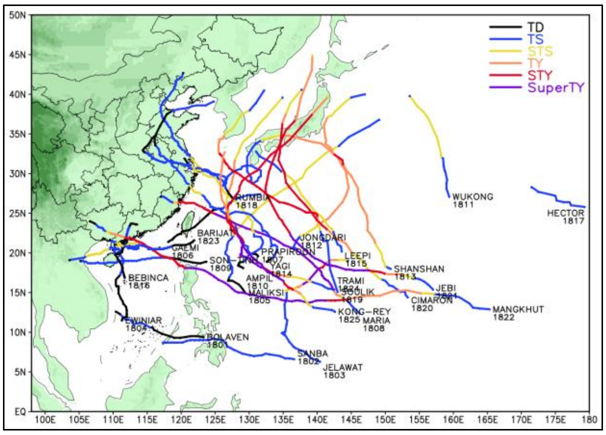

Fig. 1.1. Tracks of TCs over the western North Pacific and South China Sea from January 1to October 18, 2018.

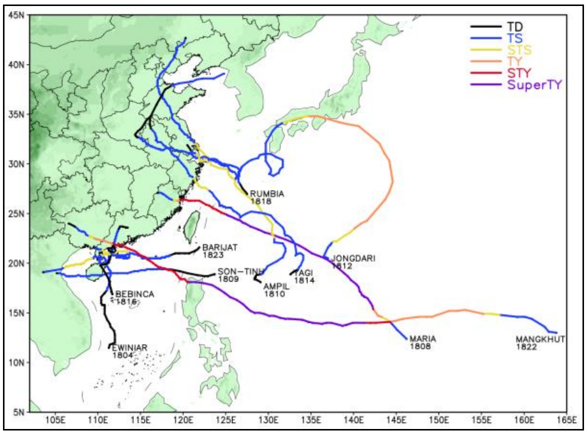

Fig. 1.2. Tracks of TCs that made landfall over China from January 1to October 18, 2018

1.1.1 Characteristics of the Tropical Cyclones in 2018

1) Slightly more TCs' geneses with more landing events

By 18 October 2018, 25 TCs have been registered for the western North Pacific and the South China Sea (Figure 1.3), being 3.0 more than normal (22.0); including 10 landfalling ones (Figure 1.4), which is 3.4 more than normal (6.6). In particular, there had been 18 TCs occurrences in this summer (June to August), being 6.5 more than normal (11.5).

2) Further north landfall positions, and unusually more landfalls in Shanghai

TCs made obviously further north landfalls this year. Three TCs (AMPIL, JONGDARI, and RUMBIA) landed in Shanghai (Figure 1.2), marking the largest number of landfalls since 1949 (landfalls came up to a total of 6 from 1949 to 2017, including 2 direct landfalls and 4 second-strikes).

3) More TCs moving northward after landfall with significant rainfall impacts

AMPIL, YAGI and RUMBIA landed in succession in East China and moved further north inland in one single month, which is very rare in history, with ensuing rainfall impacts on 17 provinces across East, North and Northeast China.

4) Weak landing strength on average

Among the 10 TCs that made landfall in China, only two (MARIA and MANGKHUT) reached the scale of severe typhoon upon landing, and the remaining 8 were either tropical storms or severe tropical storms. The landing strengths averaged 27.8m/s, weaker compared with the multi-year mean of 32.8 m/s.

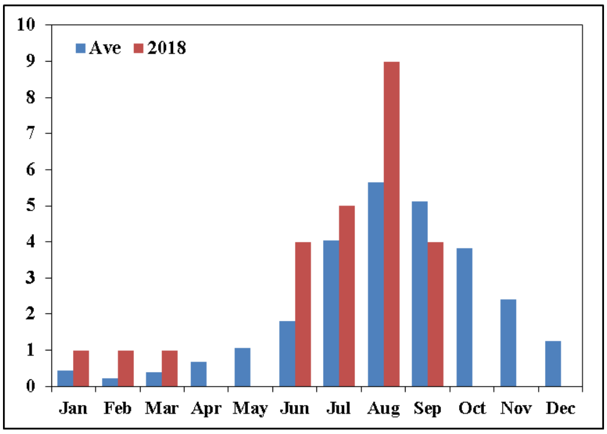

Fig. 1.3 Multi-year average and 2018 TC incidences by month (as of Oct. 18, 2018)

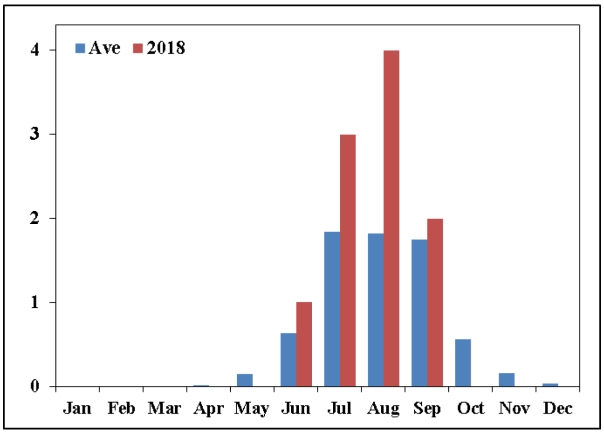

Fig. 1.4 Multi-year average and 2018 TC landfalls by month (as of Oct. 18, 2018)

5) Further north origins

Within the western North Pacific and the South China Sea, there are mainly 3 regions where TCs are mostly generated: a) the northern and central waters of the South China Sea, b) waters east of the Philippines, and c) waters nearing the Mariana Islands. For now TCs' generated position is 17.7 °N and 138.0 °E in average, which is approximately 1.6 latitudes further north than normal years (Figure 1.5), and only 6 originated to the south of 15 °N.

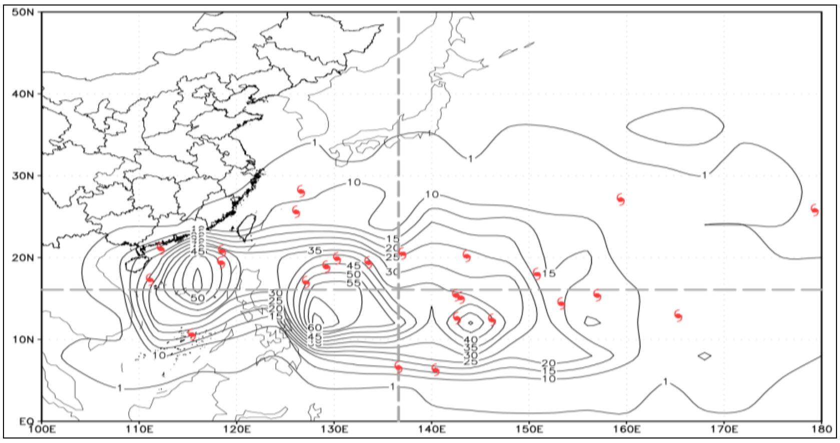

Fig. 1.5 Distribution of TC-generating source density in western North Pacific and the South China Sea, 1949- 2017 (digit/πR^2, R = 250km), and the origins of TCs generated during January 1- October 18 of 2018. The dash lines indicate the averaged latitude and longitude in normal years.

1.1.2 Operational Forecast

As of October 18, 2018, CMA 24-120h TC track forecast errors are 72.6, 126.2, 185.0, 268.0 and

381.9 kilometers respectively, marking a drop against 2017 in terms of the all forecast period track forecast (Figure 1.6). Meanwhile, the 24-120h TC intensity forecast errors were kept to 3.5, 5.1, 5.7, 7.1, and 7.2m/s respectively.

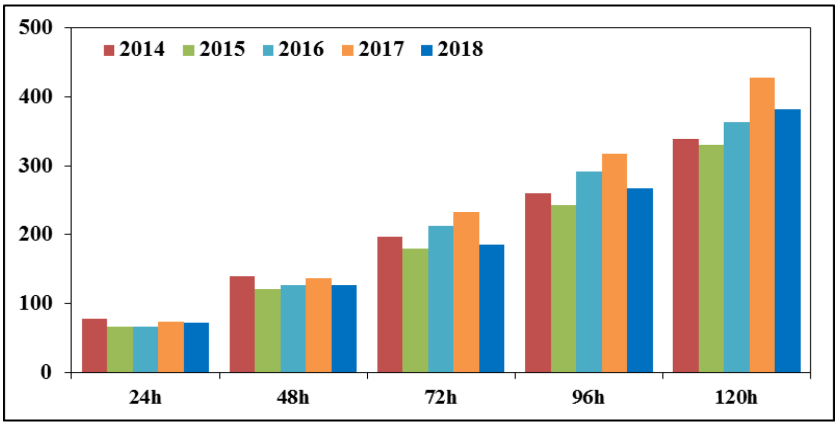

Fig. 1.6 CMA's subjective TC track forecast errors from 2014 to 2018 (as of Oct. 18, 2018)

1.1.3 Characteristics of Major Typhoon Rainfall that Affected China in 2018

2018 registered 25 TCs incidences, 10 of which made landfall in China: 5 in between western Guangdong and eastern Hainan and 5 in Zhejiang, Fujian and Shanghai. Of them, EWINIAR (1804), RUMBIA (1818), and MANGKHUT (1822) were the ones that cast significant impacts on subsequent rainfall in China. The rainfall brought by typhoons landing this year exhibited the following two features:

1) **Widened rainfall area and prominent rainfall intensity.** In 2018, typhoons affected 22 provinces or municipalities, including Hainan, Taiwan, Guangdong, Guangxi, Yunnan, Guizhou, Hunan, Jiangxi, Fujian, Zhejiang, Jiangsu, Shanghai, Anhui, Hubei, Henan, Shandong, Hebei, Beijing, Tianjin, Liaoning, Jilin and Heilongjiang. AMPIL (1810), JONGDARI (1812), and RUMBIA (1818) landed in Shanghai one after another within 26 days, which has been a case unprecedented since 1949. EWINIAR (1804), AMPIL (1810), BEBINCA (1816), and RUMBIA (1818) had their influence felt with ensuing heavy rainfalls that lasted for more than 5 days. Under the impact of EWINIAR (1804), the eastern and southern parts of South China reported a heavy rainfall process that ran on for 7 days from June 4 to 10, with 300mm and above rainfalls in 9 prefectural cities and a highest combined rainfall of 852 mm at Luotang Reservoir in Jiangmen, Guangdong. Under the impact of RUMBIA (1818), the Jianghuai and Huanghuai areas were struck by heavy rainfalls in succession, with 250 mm and above rainfalls spreading across an area of 27,000 square kilometers and record-breaking daily rainfalls reported for 7 counties and cities in Shandong.

2) **Many rivers exceeding warning levels with some record-breaking.**

Typhoon-induced rainfalls led to reports of exceeding the warning levels for over 200 rivers across 13 provinces including Guangdong, Jiangsu, Anhui, Shandong, Jiangxi and Heilongjiang. Shuhe River, one of the Huaihe River tributaries, was hit by the largest flash flood since 2010; Chaohe River, one of Haihe River tributaries, also hit by the largest flood since 1998; record-breaking floods struck Kuihe and Suihe Rivers of the northern Huaihe River tributaries in Anhui, Xinbianhe River of the Hongze Lake tributary in Jiangsu, the coastal Mihe River in Shandong, Shushui River of the mid-Ganjiang River tributary in Jiangxi, and Hulan River of the Songhua River tributary in Heilongjiang. Tidal waves exceeding the historical records of 0.04~0.56m were reported for 12 tidal wave stations including Zhuhai-based Baijiao, Guangzhou-based Zhongda, Dongguan-based Dasheng, and Zhongshan-based Hengmen Stations in

Guangdong province.

1.1.4 Tropical Cyclones that Affected China

1) Tropical storm EWINIAR (1804)

A tropical depression formed at 0600 UTC on June 2 on the southwestern waters of the South China Sea, moved northward following its formation, and intensified itself into Tropical Storm EWINIAR (1804) at 0000 UTC of June 5 over central South China Sea to move further north. EWINIAR whirled about over waters nearing northeastern Hainan Island and Leizhou Peninsula of Guangdong before making its first landfall (20m/s, 995hPa) in Xuwen, Guangdong at 2225 UTC of June 5 and a second one (18m/s, 995hPa) in Haikou, Hainan at 0650 UTC of June 6. Then it entered the northern waters of the South China Sea from northeastern Wenchang, Hainan towards the coast of Yangjiang, Guangdong to be ready for a third landfall (20m/s, 995hPa) there at 1230 UTC of June 7. At 0900 UTC of June 8 it downgraded into a tropical depression in Zhaoqing, Guangdong.

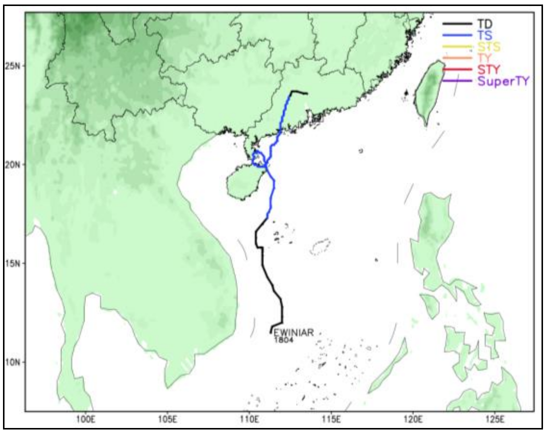

Figure1.7a Track of EWINIAR

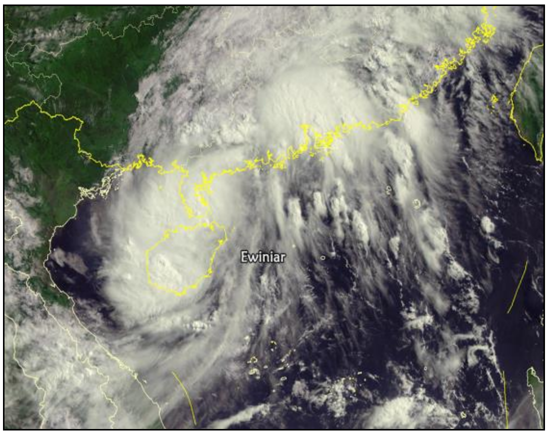

Figure1.7b FY-4A Image of EWINIAR

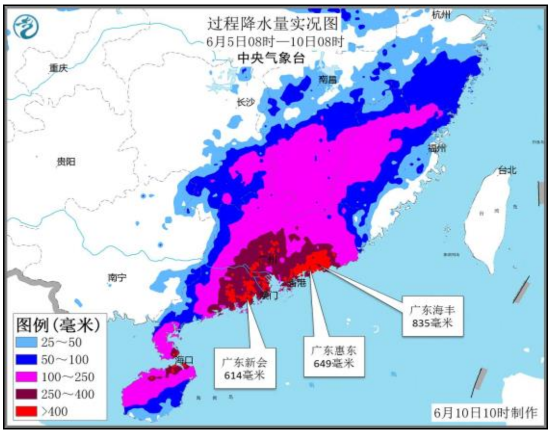

Fig1.7c EWINIAR rainfall
(00 UTC 5 to 00 UTC 10 June)

Figure1.7d Hazards of EWINIAR

Under the joint impacts of EWINIAR and the monsoon, central and northern Hainan, Guangdong, southern Hunan, central and southern Jiangxi, western and northern Fujian, and southern Zhejiang registered cumulative rainfall of 100 mm and above; central and southern Guangdong and some parts of northern Hainan Island, 250-450 mm; Jiangmen, Huizhou, Shanwei, Yunfu and Guangzhou of Guangdong, local rainfalls of 500-700 mm; and Haifeng County of Shanwei, 835 mm. There had been areas of 307,000 and 66,000 square kilometers having cumulative rainfalls above 100mm and 250 mm respectively. Eight cities/counties in Guangdong, Hunan, Hainan and Jiangxi reported daily rainfalls that broke historical highest record for June while Yunfu, Guangdong, the highest in its history. Within this period, there had been winds up to 6-8 Beaufort scales over the northwestern waters of the South China Sea, Qiongzhou Strait, eastern and northern Hainan Island, Guangdong coasts, Pearl River mouth and neighboring waters and areas; gust up to 9-10 Beaufort scales over the northwestern waters of the South China Sea, western coasts of Guangdong, some waters and areas near the Pearl River mouth.

The rainfalls brought flash floods 0.01~4.45m above the warning levels to 31 rivers in the five provinces of Hainan, Guangdong, Fujian, Zhejiang and Jiangxi. The floods had been record-setting in the case of the upper and middle reaches of the Beijiang River and in the case of Shushui River of the mid-Ganjiang River tributary in Jiangxi.

2) Super typhoon MARIA (1808)

Tropical cyclone MARIA (1808) formed at 1200 UTC on July 4. It moved northwest and growing gradually in intensity to become a super typhoon at 2100 UTC on July 5. On July 11, it made landfall (42m/s, 960hPa) over the coast of the Huangqi Peninsula in Lianjiang County, Fujian at 0110 UTC and moved into Jiangxi at 1200 UTC to weaken into a tropical depression.

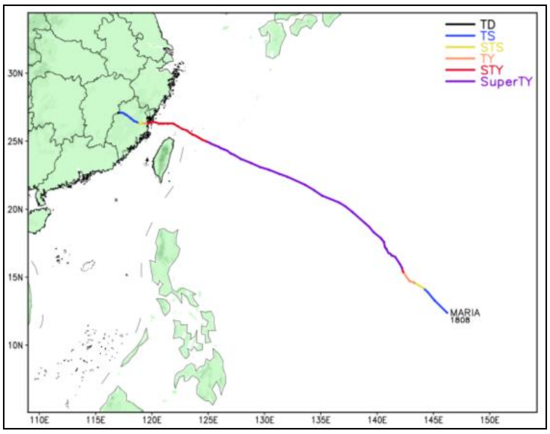

Figure 1.8a Track of MARIA

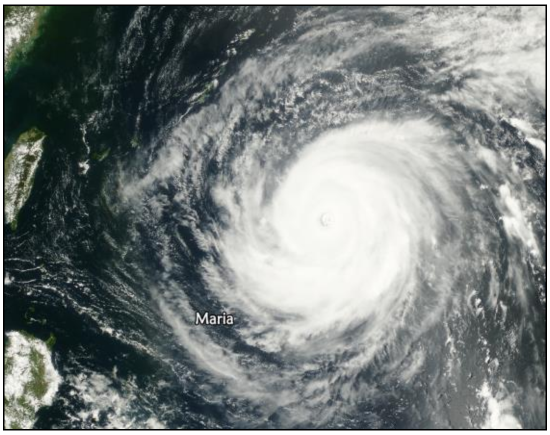

Figure 1.8b FY3D Image of MARIA

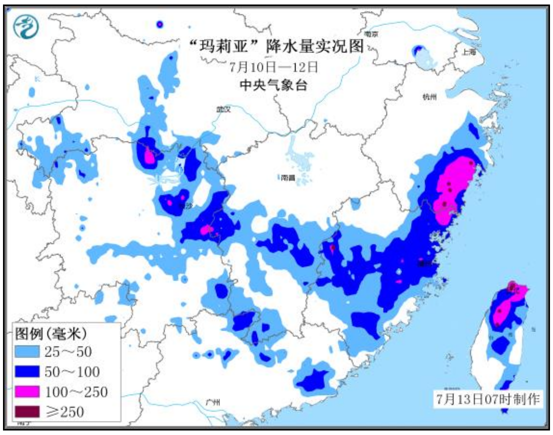

Figure 1.8c MARIA rainfall (July 10-12)


Figure 1.8d Hazards of MARIA

Affected by MARIA, central and northern Taiwan Island, northeastern and central Fujian, southeastern Zhejiang, central Jiangxi and northeastern Hunan witnessed large to heavy rainfalls or local exceptionally heavy rainfalls, with combined rainfalls ranging between 50 and 150 mm in some areas; between 200 and 250 mm in some localities in Wenzhou of Zhejiang, Sanming of Fujian and Changsha of Hunan; 313mm in some localities in Lishui of Zhejiang. Meanwhile, coastal areas in Fujian, Zhejiang and

Taiwan saw gust up to 10~13 Beaufort scales; offshore islands, 14~16 Beaufort scales. Sansha of Xiapu and Shacheng town of Fuding in Fujian as well as Liuqi'ao village of Cangnan in Zhejiang were struck by gust up to 17 Beaufort scale with a respective wind speed of 59.3, 58.8 and 57.8m/s. Scale 12 and above gust lingered in coastal Fuzhou, Ningde and Wenzhou for 3~6 hours while 9 counties/cities in Fujian set new meteorological records for highest wind speed in July while downtown Luoyuan and Ningde set new historical records.

Under the joint impacts of MARIA and the astronomical tidal waves, 7 tidal wave observing sites including Wenzhou, Rui'an and Aojiang of Zhejiang and Shacheng, Guantou, Meihua and Baiyantan of Fujian reported tides exceeding warning levels by 0.01-0.93 m at maximum. Of them, Shacheng (Fuding, Fujian) struck the highest since its operation in 1956 with a maximum of 4.4 m.

3) Tropical storm SON-TINH (1809)

A tropical depression was generated on July 16 at 0600 UTC offshore the northeastern Philippines. It then moved westward to grow into a tropical storm SON-TINH (1809) over the northeastern South China Sea at 0000 UTC on July 17, which then continued its westward movement to approach the eastern coasts of Hainan Island. At 1250UTC on July 17 SON-TINH made landing (23m/s, 983hPa) over the coast of Wancheng Town, Wanning City, Hainan Province and ran across the island into the Beibu Gulf before making a second landfall in Vinh city of Vietnam with a rapidly weakening intensity.

Affected by SON-TINH, Hainan, central and western coasts of Guangdong saw large to heavy rainfall, with a respective area of 5,000 and 38,000 square kilometers reporting above 100 and 50 mm rainfalls. The largest combined rainfall struck 241 mm in Lingshui of Hainan, 151 mm in Fangchenggang of Guangxi and 114 mm in Doumen, Zhuhai of Guangdong. As a result of these rainfalls, some medium-sized and small rivers in parts of Hainan and Guangdong reported raised water levels about 1 meter, which however did not exceed the alerting level.

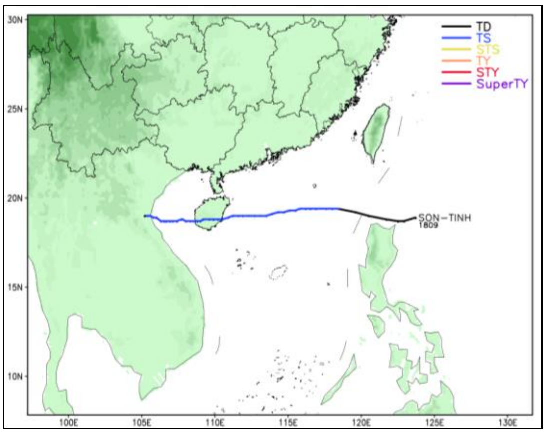

Figure 1.9a Track of SON-TINH

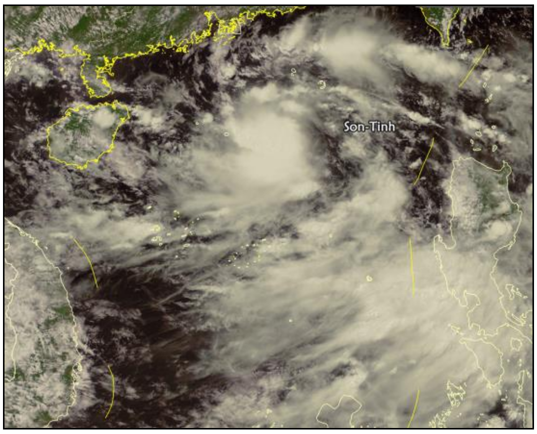

Figure 1.9b FY4A image of SON-TINH

4) Severe tropical storm AMPIL (1810)

Tropical storm AMPIL (1810) made its debut on July 18 at 1200 UTC and developed into a severe tropical storm on July 20. It made landfall (28m/s, 982hPa) on the coast of Chongming Island of Shanghai. It then ran through the provinces of Jiangsu, Shandong, Hebei, Tianjin and Liaoning and gradually transformed into an extratropical cyclone in Inner Mongolia upon daybreak on July 25.

Under its influence, part of East China, Beijing-Tianjin-Hebei conglomerate, eastern Inner Mongolia and western Northeast China were struck by heavy or exceptionally heavy rainfalls, with combined rainfalls ranging between 200 and 300 mm for Rizhao of Shandong, downtown and northern Tianjin, Chengde and Qinhuangdao of Hebei and peaking at 324 mm in Qinglong County of Qinhuangdao; coastal East China and the coastal belt surrounding Bohai Bay reported gust up to 10-11 Beaufort scales and Zhoushan Islands, gust up to 12-13 Beaufort scales.

The heavy rainfalls raised the water levels of 17 Songhua River tributaries including Hulan, Tangwang and Xinglong Rivers up above the alerting level by a maximum range of 0.01-2.01m. Of these rivers, there are 8 including Tangwang and Hulan Rivers reported flash floods above guaranteed water levels. Hulan River had the largest ever floods in its history; Chaohe River, one of the Haihe River tributaries, the largest since 1998.

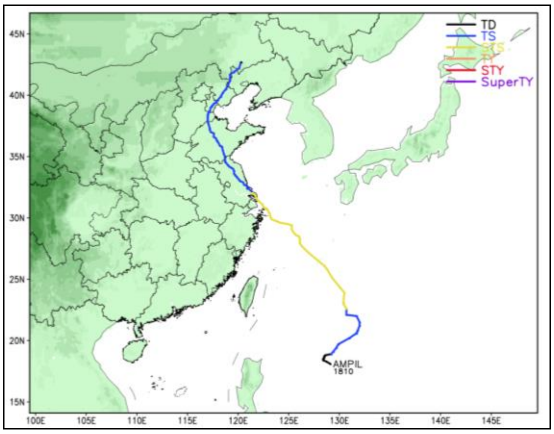

Figure 1.10a Track of AMPIL

Figure 1.10b FY-3D image of AMPIL

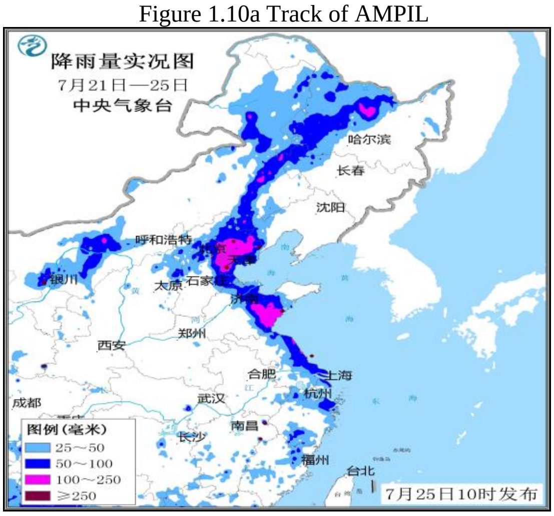

Figure 1.10c AMPIL rainfall (July 21-25)

Figure 1.10d Damages caused by AMPIL

5) Typhoon JONGDARI (1812)

JONGDARI began itself as tropical storm 1812 on the waters of northwestern Pacific at 2100 UTC on July 24, grew increasingly stronger as it moved northeastward to become a typhoon at 1200 UTC on July 26. Then it gradually shifted to a northwestward movement before making landfall over the southern coast of Honshu Island, Japan at 1600 UTC of July 28. After landfall, the westward-moving typhoon turned southward to enter the northwestern Pacific again whirling around on the southwestern waters of Japan. Afterwards, it headed westward to approach the coast of Shanghai to make landfall (23m/s, 985hPa) over its coast of Jinshan District at 0230 UTC on August 3. It headed northwestward after landfall, with a weakening intensity.

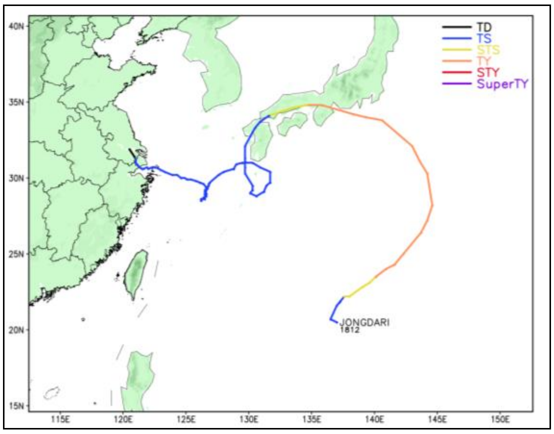

Figure 1.11a Track of JONGDARI

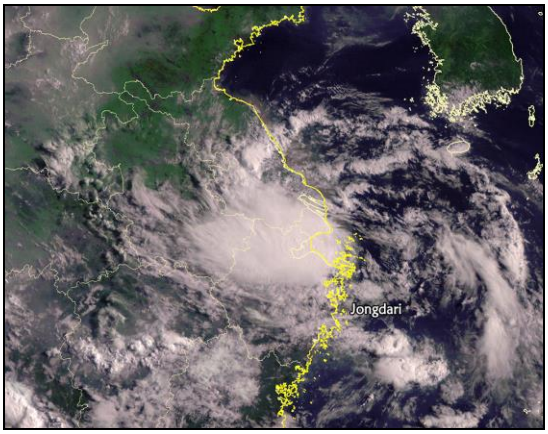

Figure 1.11b FY-4A image of JONGDARI

Under its impact, northeastern Jiangnan and central Jianghuai were hit by large to torrential rains or local exceptionally heavy rains from August 2 to 4, with a respective of 6,000 and 43,000 square kilometers of above 100 and 50 mm rainfalls. Haiyan, Jianxing of Zhejiang registered a largest cumulative rainfall up to 239 mm; Fenghuangjing Sluice of Chaohu Lake in Anhui, 136 mm; Shantou Reservoir in Nanjing, Jiangsu, 107 mm and Fengwei in Shanghai, 103mm.

The rainfalls resulted in water levels 0.05-1.15m above the warning line for Xinchang River of the Qiantang River tributary, Ditang of the Shaoxi River tributary, and some Yongjiang River tributaries in Zhejiang, 5 rivers including Taipu River and 15 stations in the Hangjia part of the Taihu Lake in Jaingsu. In particular, 10 stations on the Zhejiang side of the Hangjia Lake reported flash floods above guaranteed water levels, by a maximum range of 0.24-0.65m.

6) Severe tropical storm YAGI (1814)

YAGI formed as tropical storm 1814 on the northwestern Pacific waters at 0600 UTC on August 8, entered the East China Sea on August 11, grew stronger to become a severe tropical storm at 0900 UTC on August 12. It made landfall (28m/s, 980hPa) over Wenling coast in Zhejiang at 1535 UTC on August 12 before entering Anhui to weaken into a tropical depression at 1500 UTC the next day.

YAGI caused rainfalls up to 100-200 mm in eastern and northern Zhejiang, northeastern Anhui, northwest Jiangsu, central west Shandong, southern and eastern Hebei; rainfalls ranging between 250~380 mm in Liu'an and Anqing of Anhui, Xuzhou of Jiangsu, Weifang od Shandong and Cangzhou of Hebei; a rainfall of 443 mm in Jiawang District of Xuzhou. Meanwhile, it also resulted in gusts up to 7-9 Beaufort scales along East China coasts. Besides, its remnant clouds brought gusts up to 7-9 Beaufort scales, and 11-13 scales in some parts, along the coasts of Bohai Bay, northeastern Shandong, eastern Hebei, and southern Liaoning.

The rainfalls raised water levels to a maximum of 0.01~2.00m above the warning line for Zhuxi River of the Jiaojiang River tributary and the river network area of Hangjia Lake in Zhejiang, Suihe River of the Hongze Lake tributary in Jaingsu, and nine medium and small-sized rivers including the Dayang and Biliu Rivers on the Liaodong Peninsula. There are 23 tidal wave observing sites along East China coasts reporting tidal waves above alerting levels, by 0.10-0.84m.

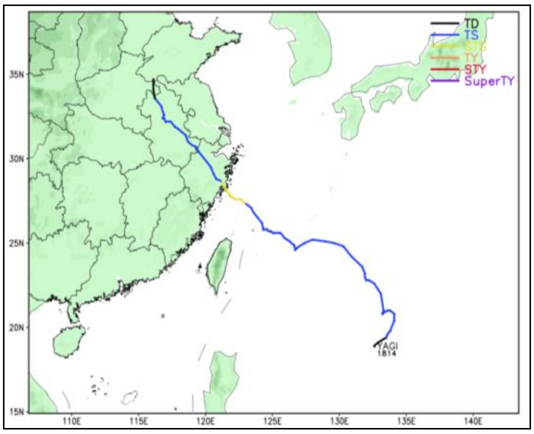

Figure 1.12a Track of YAGI

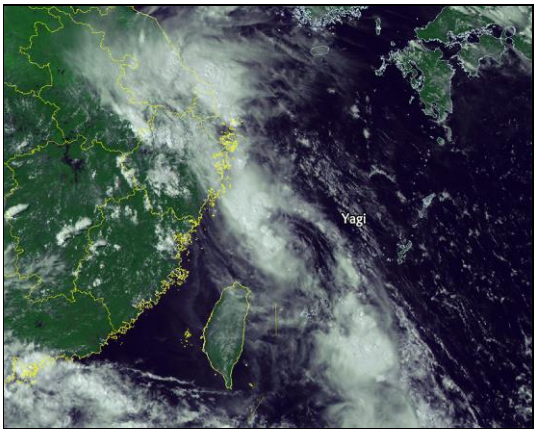

Figure 1.12b FY-4A image of YAGI

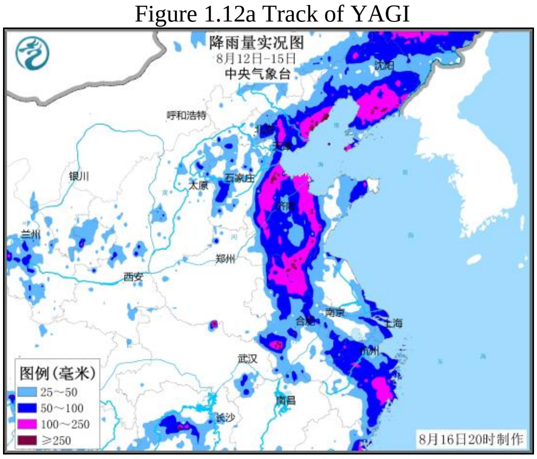

Figure 1.12c YAGI rainfall (August 12-15)

Figure 1.12d Damages caused by YAGI

7) Severe tropical storm BEBINCA (1816)

A tropical depression formed at 0000 UTC on August 9 over the South China Sea waters about 310 kilometers to the south-southeast of Wenchang, Hainan. It made a first landfall (15m/s, 998hPa) in Qionghai City, Hainan Province at 0100 UTC on August 10 and a second one (15m/s, 998hPa) in Hailing Island of Yangjiang, Guangdong at 0235 UTC on August 11. At 0600 UTC on August 12, this South China Sea tropical depression developed into severe tropical storm BEBINCA (1816) off the coast of southern Yangjiang, Guangdong, with an ensuing lingering off the coast of western Guangxi. At 1340 UTC of August 15 BEBINCA made a third landfall (23m/s, 985hPa) over the Leizhou coast in Guangdong before a westward movement to approach the Beibu Gulf and make another landfall over Vietnam coasts in the morning of August 17. After that it weakened into a tropical depression within the Laos.

Under the impact of BEBINCA, southwestern Guangdong, southern Leizhou Peninsula and central-northern Hainan Island reported combined rainfalls of 200~500 mm; northern Hainan Island and Zhuhai of Guangdong, 600~700 mm; Haikou of Hainan, 934mm; Lin'gao, 915mm. Heavy rainfall concentrated in the periods of August 9 to 11 and of August 15. Meanwhile, the coasts of central-western Guangdong, Guangxi, and Hainan Island had gales measuring 7-9 Beaufort scales as some islands saw peaks measuring 10-11 Beaufort scales.

Heavy rainfalls led to flash floods exceeding alerting lines by a maximum of 0.04~3.71m in the upper reaches of the Nandu River in Hainan and over 26 medium and small-sized rivers including the Moyang and Luoding Rivers, Caojiang of the Jianjiang River tributaries and Meihua Rivers in Guangdong; Mingjiang and Pailian Rivers of the Zuojiang River tributaries as well as the coastal Dazhi River in

Guangxi; and Jiayi River of the Lujiang River tributary in Yunnan. There were 11 tidal wave observing sites along Guangdong coast reporting tidal heights exceeding the warning level by a maximum of 0.03~0.65m.

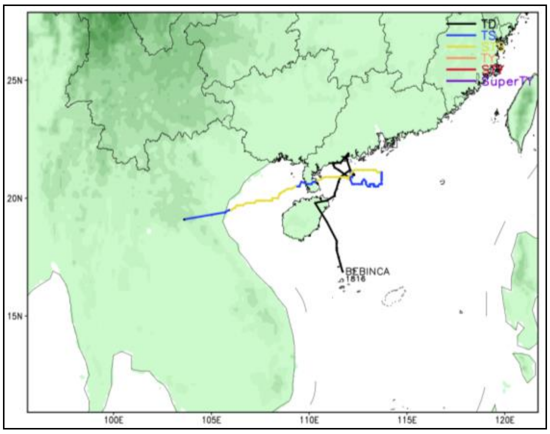

Figure 1.13a Track of BEBINCA

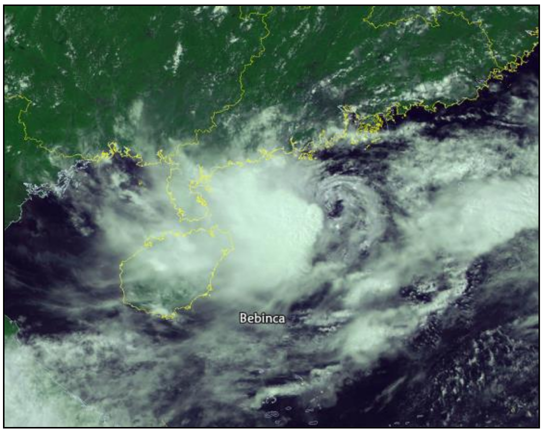

Figure 1.13b FY-4A image of BEBINCA

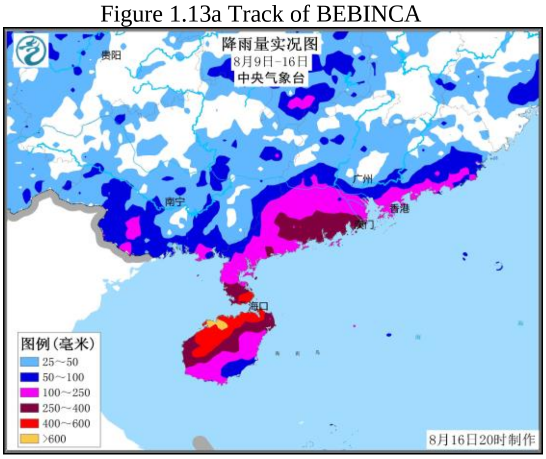

Figure 1.13c BEBINCA rainfall (August 9-16)

Figure 1.13d Damages caused by BEBINCA

8) Severe tropical storm RUMBIA (1818)

A tropical depression formed over the northwestern Pacific waters at 0000 UTC on August 15, which developed into tropical storm RUMBIA (1818) at 0600 UTC on the same day. At 2000 UTC on August 16, it made landfall (23m/s, 985hPa) over the coast of southern Pudong New District of Shanghai before weakening into a tropical depression within Henan Province in the afternoon of August 18, changing into a extratropical cyclone in northern Shandong Province and further weakening over the northern waters of the Yellow Sea on the night of August 20.

Subject to the impact of RUMBIA, northern Zhejiang, Shanghai, Jiangsu, Anhui, Henan, Shandong and eastern Liaoning and southeastern Jilin were struck by heavy or torrential heavy rains; eastern Henan, northern Jiangsu and Anhui, central-western Shandong and Dalian of Liaoning, by exceptionally heavy rains. Shangqiu and Zhoukou in Henan; Ji'ning, Tai'an, Zibo, Linyi and Dongying in Shandong; Suizhou and Huaibei in Anhui, Xuzhou in Jiangsu and Dalian in Liaoning reported combined rainfalls up to 300~480mm. Zhecheng of Shangqiu, Henan saw the highest rainfall, or 554mm. There were concentrated precipitation between August 16 night to August 17 (local time) in Shanghai, Zhejiang and southern Jiangsu and Anhui; from August 18 to 19 in Henan, Shandong, and northern Jiangsu and Anhui; from August 20 to 21 in different localities in Jilin and Liaoning. Meanwhile, gust measuring 10~12 Beaufort scales struck the Zhoushan Islands in Zhejiang, the coast of eastern Jiangsu, the coast of Shandong Peninsula, the coast and neighboring islands of Liaodong Peninsula. Besides, Sanbao Town, Tongshan

District, Xuzhou, Jiangsu was hit by tornado twice on the evening of August 18.

Heavy rainfalls raised water levels above the alerting lines for 32 rivers in the six provinces of Zhejiang, Jiangsu, Anhui, Shandong, Liaoning and Jilin: above the guaranteed water levels for 7 of them; setting new records for 4 of them, namely, Kuihe and Suihe Rivers of the northern Huaihe River tributaries in Anhui, Xinbian River of the Hongze Lake tributary in Jiangsu and the coastal Mihe River in Shandong; first flood strike in 2018 and the largest one since 2010 for Shuhe River of the Huaihe River tributary. In areas surrounding the Taihu Lake and the river network area of the Hangjia Lake, 36 stations reported above the alerting lines by a maximum of 0.02~0.58m; 6 of which, 0.01~0.17m above the guaranteed water levels.

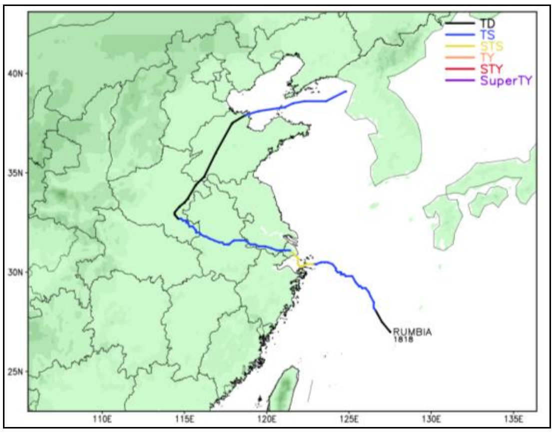

Figure 1.14a Track of RUMBIA

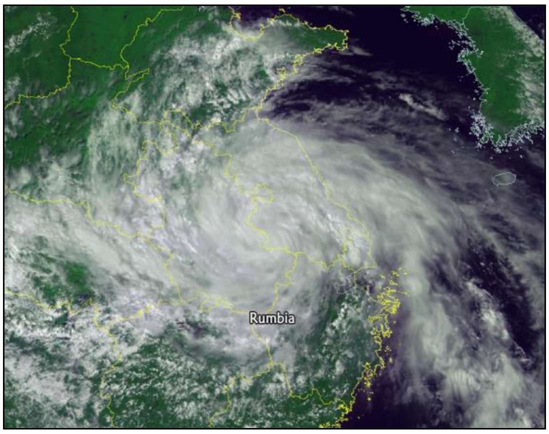

Figure 1.14b FY-4A image of RUMBIA

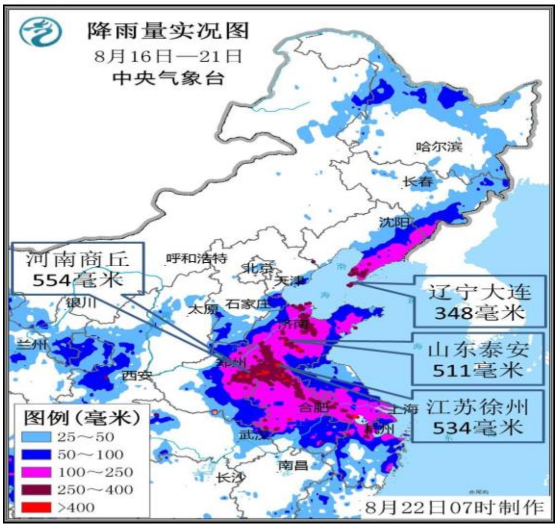

Figure 1.14c RUMBIA rainfall (August 16-21)

Figure 1.14d Damages caused by RUMBIA

9) Super typhoon MANGKHUT (1822)

Tropical storm MANGKHUT (1822) formed over the western Pacific at 1200 UTC on September 7 and grew stronger as it moved westward to become a super typhoon at 0000 UTC on September 11. It made landfall over the coast of northeastern Luzon Island in the Philippines and then entered into the northeastern waters of South China Sea. It moved northwestward to approach the coast of western Guangdong and land (45m/s, 955hPa) again over the coast of Taishan, Jiangmen City, Guangdong. After landfall, it weakened gradually as it moved northwestward into Guangxi province.

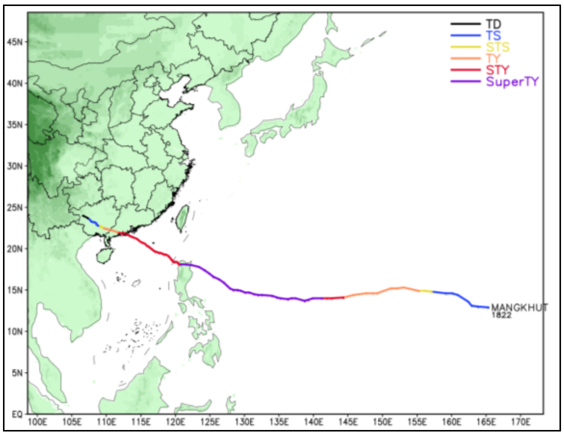

Figure 1.15a Track of MANGKHUT

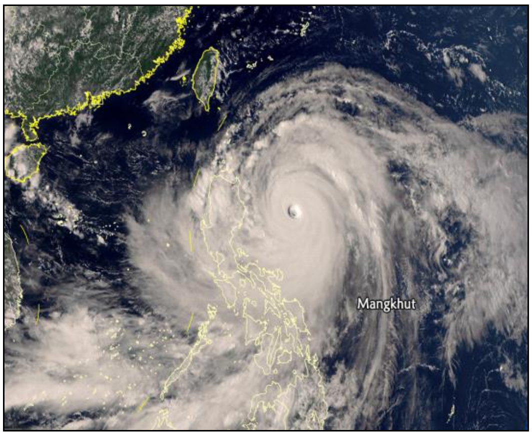

Figure 1.15b FY-4A image of MANGKHUT

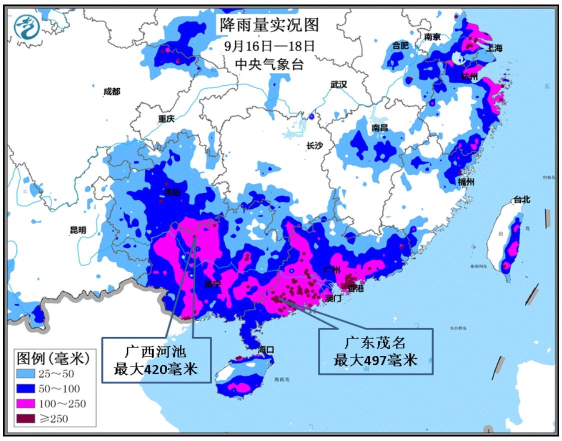

Figure 1.15c MANGKHUT rainfall
(September 16-18)

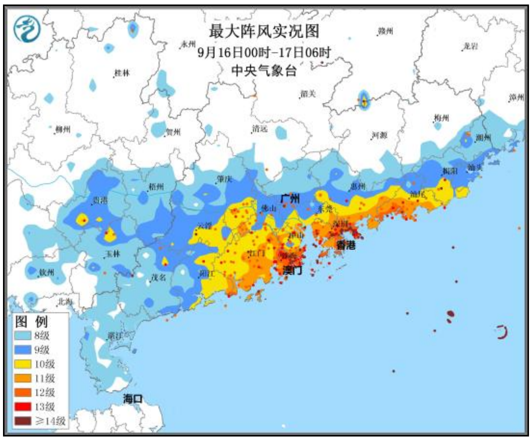

Figure 1.15d MANGKHUT gust
(16UTC 15 - 22UTC 16 September)


Figure 1.15e Damages caused by MANGKHUT


Figure 1.15f Damages caused by MANGKHUT

As a result of its influence, central-southern and most coasts of Guangdong, central-eastern Guangxi, and eastern and southern Fujian were haunted by gusts measuring 8-11 Beaufort scales throughout day and night on September 16; the Pearl River mouth area and central coasts in Guangdong, and some parts in Yulin, Guangxi, 12~13; Jiangmen, Zhongshan, Zhuhai, Shenzhen, Huizhou, Shanwei, Hong Kong, and Macao, local gusts measuring 14-17 Beaufort scales and peaking at 62.8m/s (above scale 17) over the Tuoning Islands of Huizhou. From September 16 to 18, central-western Guangdong, central Guangxi, northern Hainan Island, southeastern Guizhou as well as southeastern Jiangsu, northern and eastern Zhejiang, northeastern Fujian registered combined rainfalls up to 100~280 mm; Maoming, Yangjiang, Yunfu, Jiangmen, Shenzhen, and Huizhou in Guangdong as well as Lin’gao of Hainan and Hechi and Laibin of Guangxi, 300~497mm. In some parts of eastern Taiwan, the combined rainfall measured

300~650mm while in some localities of Pingdong, over 1500 mm. Meanwhile, from afternoon to night August 16, some coastal areas between Huizhou and Yangjiang of Guangdong reported storm surges of 1~2m; in places around the Pearl River mouth, 2~3.4m.

Heavy rainfalls raised water levels above the alerting lines by 0.01~3.39m over 89 medium and small-sized rivers across the 5 provinces of Guangdong, Guangxi, Jiangsu, Zhejiang and Fujian; above the guaranteed water levels over 9 stations near the Taihu Lake and in the Hangjia Lake area. Moyang River in Guangdong was hit by the largest flood in the last 30 years. Along the Guangdong coast, there were 24 tidal wave observing sites reporting tidal waves 0.09~1.78m above the alerting line. Of them, 12 sites including Baijiao in Zhuhai, Zhongda in Guangzhou, Dasheng in Dongguan and Hengmen in Zhongshan, 0.04~0.56m above their record highs.

10) Tropical storm BARIJAT (1823)

A tropical depression formed over the Bashi Strait at 0000 UTC on September 10. It then moved westward to grow into the tropical storm No.1823 over the northeastern waters of the South China Sea at 0000 UTC on September 11. After that, it continued its westward movement to approach the coast of western Guangdong and grew further in intensity to become a severe tropical storm offshore western Guangdong at 2100 UTC on September 12. BARIJAT made landfall (23m/s) over the coast of Zhanjiang, Guangdong at 0030 UTC on September 13 and weakened rapidly after landfall.

BARIJAT brought rainfalls ranging 10~30mm over the coast of central-western Guangdong and some parts in southeastern Guangxi, in particular, rainfalls ranging 40~60 mm in some parts of Yangjiang, Jiangmen, Guangdong and peaking at 121 mm over the Guozaiyuan Reservoir in Jiangmen, Guangdong. Water level surged within 1 m for a few medium and small-sized rivers without exceeding the alerting line.

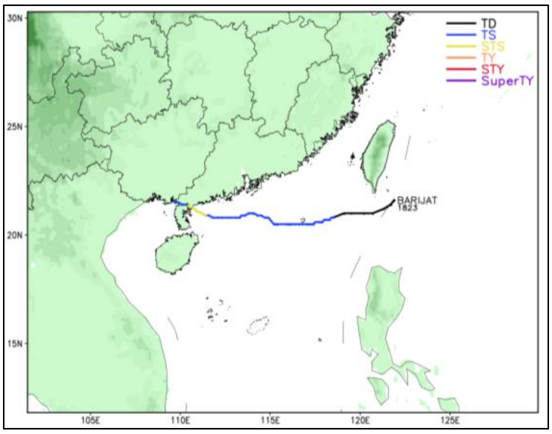

Figure 1.16a Track of BARIJAT

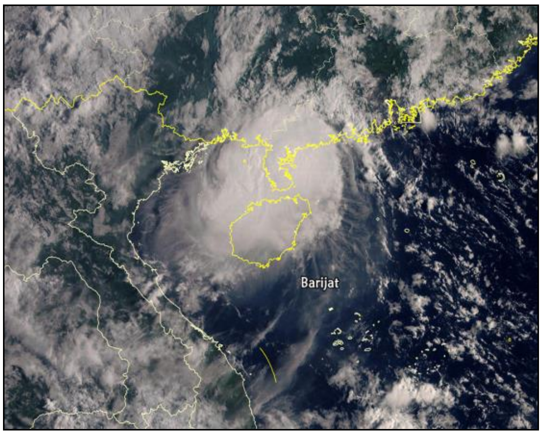

Figure 1.16b FY-4A image of BARIJAT

1.2 Socio-Economic Assessment

As of October 18, 2018, According to preliminary statistics, the total affected a population of 31.972 million in 22 provinces (autonomous regions or municipalities), with 80 people dead, 3 missing, and 3,613,000 evacuated while collapsing 26,000 houses, destroying 44,000 and damaging another 162,000 to different degrees, with a direct economic loss of RMB 67.1 billion Yuan (Table 1.1). The disasters caused this year are much more serious than last year, with the number of the dead and missing and the displaced being 1 and 5 times higher than that of last year respectively. Of all, severe tropical storm RUMBIA (1818) caused the heaviest casualties with 53 deaths and missing, caused mostly by drowning; super typhoon MANGKHUT (1822) was the strongest landfall typhoon, causing millions of evacuations in Guangdong, Guangxi and Hainan.

Table 1.1 Typhoon Impacts and Disasters in 2018 (as of Oct. 18, 2018)

Typhoon Name and Number	**Landing Sites**	**Landing Date (MM-DD)**	**Max. Landing Wind Scale (Speed) near center**	**Affected Areas**	**Population Affected (10,000 persons/times)**	**Number of the Dead and the Missing**	**Direct Economic Losses (RMB billion)**
EWINIAR (1804)	Xuwen of Guangdong Haikou of Hainan Yangjiang of Guangdong	6-6 6-6 6-7	8 (20m/s) 8 (18m/s) 8 (20m/s)	Hunan, Guangdong, Guangxi, Fujian, Hainan	194.7	13	5.19
MARIA (1808)	Lianjiang of Fujian	7-11	14 (42m/s	Jiangxi, Zhejiang, Fujian, Hunan	142.4	1	4.16
SON-TINH (1809)	Wanning of Hainan	7-17	9 (23m/s)	Guangxi, Hainan, Yunnan	27.5	0	0.24
AMPIL (1810)	Chongming of Shanghai	7-22	10 (28m/s)	Beijing,Tianjin, Hebei, Inner Mongolia, Liaoning, Jilin, Shanghai, Jiangsu, Zhejiang, Shandong	233.4	1	1.63
JONGDARI (1812)	Jinshan of Shanghai	8-3	9 (23m/s)	Zhejiang, Jiangsu, Shanghai	33.1	0	0.42
YAGI (1814)	Wenling of Zhejiang	8-12	10 (28m/s)	Henan, Hebei, Shandong, Anhui, Jiangsu, Zhejiang, Shanghai, Liaoning	237.3	3	2.51
BEBINCA (1816)	Leizhou of Guangdong	8-15	9 (23m/s)	Guangdong, Hainan	58.2	6	2.31
RUMBIA (1818)	Pudong District of Shanghai	8-17	9 (23m/s)	Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Anhui, Shandong, Henan	1800.2	53	36.91
MANGKHUT (1822)	Taishan of Guangdong	9-16	14 (45m/s)	Yunnan, Guizhou, Guangxi, Hunan, Hainan, Taiwan, Guangdong,	464.1	6	13.68
BARIJAT (1823)	Zhanjiang of Guangdong	9-13	9 (23m/s)	Guangdong	6.3	0	0.05
TOTAL					**3197.2**	**83**	**67.10**

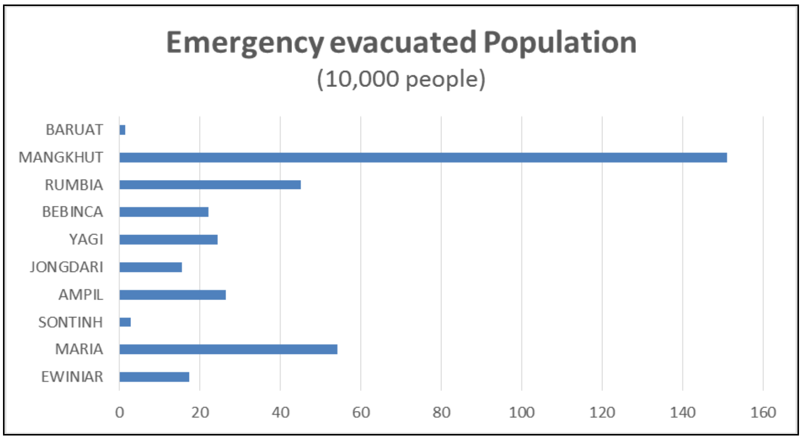

Figure 1.17 Typhoon evacuations (those for risk avoidance included) in 2018

1.3 Regional Cooperation Assessment

1.3.1 1st WGM Annual Meeting

On July 9, 2018 the Working Group on Meteorology (WGM) of the ESCAP/WMO Typhoon Committee successfully convened its first meeting in Shanghai. Hosted by Shanghai Typhoon Institute, CMA, nearly 20 experts from the Hong Kong Observatory, Japan Meteorological Agency, Lao Department of Meteorology and Hydrology, Macao Meteorological and Geophysical Bureau, Malaysian Meteorological Department, Korea Meteorological Administration, Thai Meteorological Department and China Meteorological Administration attended the meeting. Dr. LEI Xiaotu, chair of the WGM, overviewed the progress of WGM in the recent 10 years. Representatives of each Member gave 2018 progress reports. Participants also discussed the new preliminary projects (PP) in 2019.

Figure 1.18 First WGM Meeting held in Shanghai

1.3.2 Meeting of the WWRP Projects

From July 10 to 11, the 2018 Project Meeting of the World Weather Research Programme (WWRP) was successfully held in Shanghai, with discussions on the progress and future plan for the WWRP TLFDP (Typhoon Landfall Forecast Demonstration Project) and UPDRAFT (Understanding and PreDiction of Rainfall Associated with landFalling Tropical cyclones) as well as the ESCAP/WMO Typhoon Committee Project EXOTICCA (Experiment of Typhoon Intensity Change in Coastal Area).

This meeting brought together more than 40 experts from the WMO, University of Reading, US National Hurricane Center, US Hurricane Research Division, National Center for Atmospheric Research (NCAR), New Zealand Disaster Prevention and Mitigation Research Center, India Meteorological Department, Hong Kong Observatory, Nanjing University, the Institute of Atmospheric Physics of the Chinese Academy of Sciences, and the National Meteorological Center of China.

Figure 1.19 WWRP Project Meeting Held in Shanghai

1.3.3 First Joint Video Conference on MANGKHUT among CMA, HKO and SMG

MANGKHUT is the strongest typhoon that made landfall in China this year. On the morning of September 13 super typhoon MANGKHUT (1822) was at a position to the east of the Luzon Island in the Philippines, heading steadily west-northwestward and being still far from the coast of South China To judge MANGKHUT's track, intensity change and possible landfall sites, the National Meteorological Center/CMA, together with the Hong Kong Observatory and the Macao Meteorological and Geophysical Bureau held the first ever joint typhoon video conference. At 1500 UTC on September 15 the three sides held another video conference to discuss MANGKHUT's impact on South China coast, with particular regard to the wind, rain and tidal waves in the Pearl River Delta. Forecasters from the three sides fully exchanged viewpoints regarding ocean surface observation, satellite data analysis and numerical prediction, to reach a joint conclusion. The joint video conferences held over MANGKHUT prove to be a valuable exploration into the possibility of establishing a regular consultation mechanism on weather extremes such as typhoon

Figure 1.20 First Joint Video Conference on MANGKHUT among CMA, HKO and SMG

and torrential rain and for better forecast services with higher accuracy in forecasting and consistency in warnings issuance.

1.3.4 Joint Video Conference with Vietnam on MANGKHUT

On September 16, in order to discuss the possible strong winds and severe rainfalls brought by MANGKHUT in the South China Sea and offshore Vietnam, forecasters from the National Meteorological Center (NMC) of China and Guangzhou Regional Meteorological Center talked about MANGKHUT track, intensity, winds and rain impacts with Vietnam forecasters of the National Hydro-Meteorological Service of Viet Nam (NHMS) in a joint video conference (SKYPE), with much attention to storm surge and tidal wave forecasts upon typhoon landfalling.

Figure 1.21 NMC and NHMS in Joint Video Conference

1.3.5 The *Tropical Cyclone Research and Review* Journal

From January to September, the *Tropical Cyclone Research and Review* (TCRR) journal had over 38000 downloads in full text, marking a 58% increase over 2017. Supported by the ESCAP/Typhoon Committee Scholarship Program, 2 visiting editors from Thailand and Vietnam worked in the editors' office for a week. In 2018, a special edition was published in celebration of the 50th anniversary of the founding of the ESCAP/Typhoon Committee, including 17 articles in 3 issues. The second issue was published specially on the occasion of WMO IWTCLP-4 (the 4th International Workshop on Tropical Cyclone Landfall Processes), receiving great support from a number of internationally-renowned typhoon experts, including Russell Elsberry, Robert Rogers, Kevin Cheung, Nadao Kohno, Marie-Dominique Leroux, Peter Otto and so on.

Member editors attended the 50th TC Session and Teco in Vietnam in February and the European Geosciences Union (EGU) General Assembly 2018 in Austria for global promotion of the journal. By now, TCRR has been included in the CNKI (China National Knowledge Infrastructure) database and ESCI (Emerging Sources Citation Index). Currently, TCRR's inclusion in ScienceDirect proceeded smoothly, after the completion TCRR will sharing the same database with Elsevier's 2500 journals, 12000 books and 11000 multi-media resources.

II. Summary of Progress in Priorities supporting Key Result Areas

2.1 Typhoon Science Popularization Facilitating Early-Warning Service and Disaster Prevention and Mitigation

Main text:

Before the active typhoon season in 2018, the National Meteorological Center organized chief typhoon forecasters and experts on a visit to Hainan for typhoon science popularization purpose, explaining to full-time junior and senior middle school students the basics about typhoon, early warning, and disaster types. This was intended to add vigor to campus safety education, helping students to gain better awareness of disaster prevention and mitigation and to better save themselves and others (Figure 2.1). Meanwhile, the National Meteorological Center had typhoon popular science tips put up on its new media platform during the typhoon season.

The coast line stretches about 18,800 kilometers in China, which signifies that it is prone to typhoon strikes. Since 2011, there have been 16 typhoons either landfall as a severe/super typhoon or causing direct economic losses of RMB 10 billion or more, affecting 152.2 million people, adding the dead and missing up to 611, forcing 17.009 million people to evacuate for safety purpose, and aggregating to a total direct economic loss of RMB 524.6 billion. Forecasters elaborated on the attributes of disasters caused by typhoon and on the interpretation and use of the typhoon forecast and early-warning products. They also made a questionnaire survey on the public satisfaction for typhoon warnings released by the meteorological services and public awareness and knowledge of DRR. These outreach activities greatly enhanced the awareness of the students and the general public and well prepared them, which would in turn facilitate the warning services and disaster prevention and mitigation efforts.

Priority Areas Addressed:

Enhance activities to develop impact-based forecasts and risk-based warning.

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2.2 Advances in Typhoon Forecasting Techniques

Main text:

1) FY-4A observations in GRAPES Empowers Operational Forecasts

FY-4A is capable of providing selected areas with GIIRS observations every 15 minutes. On July 10, 2018 GRAPES used the 4Dvar assimilation system in assimilating high temporal resolution GIIRS observations for the assessment of typhoon MARIA intensity forecast, which yielded very satisfying results. Assimilation of the typhoon warm core data into the NWP models demonstrates potential value of GIIRS observation in facilitating typhoon forecasts (Figure 2.2).

2) Landfalling Typhoon Precipitation Forecast Model R&D

The Track Similarity Area Index, TSAI was developed and applied to landfalling typhoon precipitation forecasting experiments, on the basis of which the LTP_DSEF (track similarity-based Landfalling Tropical cyclone Precipitation Dynamical -Statistical Ensemble Forecast) model was built and is being tested for its operation in the landfalling typhoon precipitation forecast in NMC/CMA.

Priority Areas Addressed:

Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.

Develop and enhance typhoon analysis and forecast technique from short- to long-term.

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2.3 Advances in Typhoon Numerical Modeling and Data Assimilation

Main text:

1) The impact of vertical resolution of the South China Sea Typhoon Model on typhoon forecast results has been studied, with the technical upgrading and initial assessment of the new-version typhoon model accomplished. In addition to a higher resolution, a comprehensive upgrading has been made of the previous operational typhoon modelling techniques, which includes a simplification of the initialization process to cut down the initialization time, a use of the second order accuracy vertical differential scheme as the dynamic framework plus a further improvement of the 3D reference atmospheric scheme, an improvement of the physical process mainly regarding the convective parameterization and boundary layer schemes and an upgrading of the radiation scheme.

The typhoon initializing scheme has been researched on. In response to the initial typhoon position and intensity deviations of the global model from the actual situation, a set of simple initializing techniques were developed to gear the deviations back to actual observation results. Subject to preliminary tests, it improves the 48h track and intensity predictions.

2) Research has also been made on the typhoon dynamic initialization under topographic influence. The original typhoon dynamic initializing scheme was expanded to cover topographic influences. At a typhoon center distance of 150 to 450 km from the landform, topography-related signals are eliminated from the newly-changed topography variable using a filter algorithm before being put under vortex separation. At a typhoon center distance of 150 to 300 km from the landform plus a landform height above 1 km or at a distance of less than 150 km, the topography-free semi-ideal numerical integration is used to reinforce the axisymmetric vortex before being combined with large-scale analysis field for recovery of the original topographic signals. Return tests have been conducted on 9 typhoons of 2015 under topographical influences in the northwestern Pacific. Test results indicate that the new dynamic initializing scheme can cut down the initial position and intensity errors for small typhoons to a large extent. And the typhoon core structure and rain belt distribution generated are closer to satellite and radar observations.

Priority Areas Addressed:

Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.

Develop and enhance typhoon analysis and forecast technique from short- to long-term.

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2.4 Subjective and Numerical Prediction Results Assessment

Main text:

Assessments have been made of the track and intensity prediction results stemming from subjective predictions and numerical deterministic predictions:

1) Track Prediction Assessment

Error ranges of the official 24h, 48h, 72h, 96h and 120h typhoon track subjective predictions stand between 80.3~97.3km, 137.6~161.9km, 216.9~261.2km, 295.0~330.9km and 347.2~423.0km respectively. A vertical comparison of the 24h, 48h, and 72h typhoon track prediction errors made by various official typhoon prediction agencies indicates that the 24h and 48h track prediction performance dipped further in 2017 against the slight drop from 2015 in 2016 while the 72h and above track prediction performance, though better from the previous year, is far inferior to that of 2015 overall.

Error ranges of the 24h, 48h, 72h, 96h and 120h typhoon track predictions generated by the 6 global models stand respectively at 68.9~101.4km, 108.9~191.8km, 193.9~318.6km, 264.6~515.3km, and 323.0~811.5km while for the regional models the error ranges are 64.9~92.3km, 111.7~53.1km, 212.8~254.7km, 312.8~474.8km, and 368.5~695.5km (Figure 2.4).

2) Intensity Prediction Assessment

In 2017 the absolute average error ranges of the five official subjective 24h, 48h, 72h, 96h and 120h intensity predictions stand at 3.42~5.00m/s, 5.13~6.44m/s, 5.14~7.07m/s, 5.55~7.37m/s, and 6.37~8.37m/s, marking an overall better performance against 2016.

Statistical prediction stands out from the objective predictions with a slight overall better performance than the numerical intensity predictions, but the gap has been narrowing by the latter one.

Priority Areas Addressed:

Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.

Develop and enhance typhoon analysis and forecast technique from short- to long-term.

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2.5 Newly-launched FY-3D and FY-2H Play an Important Role in Typhoon Monitoring

Main text:

FY-3D, which is the fourth one of China's second-generation polar-orbiting meteorological satellites, was successfully launched at the Taiyuan Satellite Launch Center on 15 November 2017. It is installed with such remote sensing instruments as the improved medium resolution spectral imager, microwave thermometer, microwave hygrometer and the new infrared hyperspectral atmospheric vertical detector. Among them, the medium resolution spectral imager can provide a cloud image with a resolution of 250 m, with the microwave temperature and humidity profiles obtained by the microwave thermometer and the microwave hygrometer through fusion and inversion penetrating cloud and rain to generate remote sensing information of three-dimensional thermal structure on typhoon. During its on-orbit testing, the data and products from FY-3D's high-performance instruments provided clearly visible true color images of Maria and MANGKHUT, the ongoing typhoons that it was watching. The microwave cloud water content, microwave heavy precipitation, and temperature profile from the fused microwave thermometer and hygrometer constitute effective primary observations for an analysis of the changing typhoon intensity in terms of cloud water, warm-core structure and three-dimensional thermal structure, hence an important decision enabler in support of typhoon monitoring, analysis and forecasting.

In addition, FY-2H, which is used as a geostationary meteorological satellite serving countries and regions along the Belt and Road, is located at 79 ˚E for its sub-satellite point so that it can monitor cyclonic storms in the Indian Ocean and Bengal more clearly to provide valuable satellite information for the monitoring and analysis of such an event in the above seas, contributing substantially to the forecasting and management of a cyclonic disaster.

Priority Areas Addressed:

Enhance collaborative activities with other regional/intemational frameworks/organizations, including TC and PTC cooperation mechanism.

Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.

Evaluate socio-economic benefits of disaster risk reduction for typhoon-related disasters.

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2.6 Development and Application of Typhoon Observation Production using Weather Radar

Main text:

The Meteorological Observation Center (MOC) launched a range of integrated meteorological observation products in June 2018 through the improvement and addition of multiple data quality controls and observational product algorithms as a strong support to typhoon observation and services. The range covers a wide variety of weather radar networking products and multi-source data fusion products, which were employed to provide high-efficiency and high-resolution 3D observations for the monitoring of typhoon weather processes like MARIA and MANGKHUT, including weather radars' combined reflectivity vertical profiles and layering. These products improve China's performance in observing and analyzing typhoon weather processes.

Priority Areas Addressed:

Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.

Promote communication among typhoon operational forecast and research communities in Typhoon committee region.

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2.7 Advances in Scientific Research on Typhoons

Main text:

1) Progress in boundary layer observation research. The high-frequency wind data of the three typhoons from the 100-m high offshore tower have been analyzed. Based on the actual observations, the magnitude of the increased frictional effect such as the turbulent diffusion coefficient during the typhoon landing process is firstly quantified as scientific and objective information for the parameterization scheme for the subsequent typhoon models' boundary layer.

2) The study of the distribution and mechanism of typhoon associated precipitation in China gives a systematical review of how the LTC associated precipitation is distributed and evolves during landing in possibly physical terms. Moreover, it proposes a conceptual model for the effects and differences of LTC precipitation arising from the large-scale environmental field and underlying surface.

3) The statistical study of the relationship between the changing typhoon intensity and the initial structure of sea temperature and cyclone in the northwestern Pacific gives a statistical analysis of such features as the intensity change rate, sea surface temperature, initial cyclone intensity and maximum wind radius of the typhoons in the Northwest Pacific (1982-2015).

4) The study of the relationship between typhoon structure and its changing intensity. Using high-resolution numerical ideal experiments, it is concluded that in the case of the same initial vortex strength, the rate of rapid expansion of a smaller vortex is significantly faster than that of a larger scale, with the initial vortex of the velocity profile attenuating outwards (toward the eye area) more slowly along the maximum velocity.

5) Analysis of wind characteristics of near-surface engineering under the influence of typhoon. A case study of observation finds that the wind angle of attack in the typhoon eye wall area increases significantly, exceeding the recommended value of the angle of attack under high wind speed in the design specification ($\pm 3^{o}$). When the eye wall and the spiral cloud belt are affected, the wind speed profile does not meet the power exponential distribution recommended by the specification. The turbulence intensity and the turbulent energy spectrum of the downwind are significantly increased when the eye wall and the spiral cloud pass, no longer satisfying the assumption of turbulent isotropic and the -5/3 law.

6) The study of the relationship between the changing typhoon intensity and the zonal wind shear (VWS) in different directions in the northwestern Pacific. The correlation between westerly wind shear and typhoon intensity is significantly greater than that of easterly wind shear, which is related to the significant correlation between SST and zonal wind shear, while SST acts as an important modulator of the typhoon intensity when affected by a wind shear in two directions.

7) The typhoon disaster assessment. The typhoon disaster risk zoning and economic loss standardization have been studied to define disaster-prone zones in coastal provinces and cities at a county-based resolution, taking into account the exposure to typhoon associated precipitation and wind and the vulnerability of local populations as well as the analysis of hazard factors along the coastal China. A standard approach based on disaster footprints has been proposed as a result. In addition, the dynamics and

statistics are combined to study the method of over-threshold risk probability prediction for typhoon-induced precipitation. According to the characteristics of wind farms, wind energy resources have been assessed, the particularity of typhoons and the impact of storm surges in coastal Fujian reviewed.

8) Field scientific typhoon experiment. In September 2018, the Chinese Academy of Meteorological Sciences (CAMS) in partnership with the Institute of Tropical Meteorology (ITM), the Guangdong Meteorological Service (GMS), and the Maoming Meteorological Service (MMS) conducted a scientific experiment on the coordinated observation of MANGKHUT at the Bohe Typhoon Observation Experiment Base in Guangdong. In the campaign, GPS sounding was launched every three hours, with video sounding-based observations made. The mobile Doppler radar of Nanjing University succeeded in capturing the outer rain belt of MANGKHUT, with the offshore observation platform working normally. At the same time, in partnership with the Hong Kong Observatory, it released dropsondes for the sounding observation. As MANGKHUT approached, the entire observational experiment was switched into an unmanned mode for an uninterrupted observation.

Priority Areas Addressed:

Strengthen cross-cutting activities among working groups in the Committee.

Develop and enhance typhoon analysis and forecast technique from short- to long-term.

Promote communication among typhoon operational forecast and research communities in Typhoon committee region.

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2.8 Publication of the *Climatological Atlas for Northwestern Pacific Tropical Cyclones*

Main text:

The Climatological Atlas of Tropical Cyclones over the Western North Pacific (1981-2010), edited by CMA STI, was successfully published by the Science Press under the auspices of the CMA Department for Forecasting and Networking. The Atlas presents the characteristics of tropical cyclone activity from 1981 to 2010, including four parts: the 'occurrence, development and disappearance of tropical cyclones', 'pathways and movements of tropical cyclones', 'tropical cyclones affecting and landing in China' and 'tropical cyclone climate statistics in table'. It reviews the activity (covering the evolution, movement, intensity and its variation, bi- and multi-tropical cyclones, movement paths and their variation, movement speed and direction and distribution of re-curvature points, anomalous paths, etc.) of tropical cyclones in the western Pacific Ocean (including the South China Sea) and summarizes the impact of tropical cyclones on China (including those affecting and landing in China and the intensity and distribution of their associated wind and rain). The Atlas, which is informative in content, complete in data and illustrative in chart, is a useful source of reference and inspiration for those engaged in typhoon research, operation and services.

Priority Areas Addressed:

Promote communication among typhoon operational forecast and research communities in Typhoon committee region.

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2.9 Enhancement of Typhoon Disaster Risk Management Capacity by Emergence Management Authorities

Main text:

1) The Ministry of Emergency Management is officially inaugurated.

On 16 April 2018, the Ministry of Emergency Management (MEM) of the People's Republic of China was officially inaugurated. The newly established MEM has integrated the duties and responsibilities of nine organizations and those of the National Flood Control and Drought Relief Headquarters, the National Disaster Reduction Commission, the State Council Earthquake Relief Headquarters, and the National Forest Fire Prevention Headquarters as well to further consolidate and streamline the national emergency response resources and strengths, harnessing and harmonizing the overall capabilities in this connection, as a dedicated framework featuring unification in commanding, consistency in power and responsibility, and authority and efficiency.

2.) The natural disaster and damage reporting system is put into operation in all townships and towns throughout the country.

A major breakthrough has been made in the development of the disaster information team of 750,000 messengers by practicing an IT-based and dynamic management of all the urban and rural communities in the country to make specified messages accessible for the last mile. The National Natural Disaster and Damage Reporting System has been put into operation in all townships and towns to enable a general disaster to be reported within 6 hours and a major disaster within 2 hours from the site. The Beidou Disaster Reporting Terminal has been widely adopted in disaster-prone areas, with nearly 50,000 ones of various types distributed, which is an effective solution to the on-site disaster emergency reporting and communication at a time when telecommunication is interrupted following a disaster.

Priority Areas Addressed:

Provide reliable statistics of mortality and direct disaster economic loss caused by typhoon-related disasters for monitoring the targets of the Typhoon Committee.

Enhance Members' disaster reduction techniques and management strategies.

Evaluate socio-economic benefits of disaster risk reduction for typhoon-related disasters.

Promote international cooperation of DRR implementation project.

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2.10 Active Delivery of Typhoon Warning Services and Disaster Emergency Rescue and Relief by CMA and MEM

Main text:

CMA has strengthened information sharing and concerted emergency response with other ministries including MEM (Ministry of Emergency Management), MWR (Ministry of Water Resources) and MCA (Ministry of Civil Affairs). It also provides forecasting and warning information for ministries of security supervision, education, agriculture, fishery and maritime affairs through the information sharing mechanism in a timely fashion as a strong support to the effective organization of security supervision, student risk aversion, mass transfer/evacuation, maritime search and rescue, etc., a practice that proves remarkable in the context of disaster prevention and mitigation.

A scientific judgment of an ongoing disaster and a timely analysis and reporting of its damages ensure the initiation of emergency response and the provision of guidance to local response and relief. Before and after a typhoon lands, the emergency managers would enter into an emergency state in an all-round way by discussing and judging the situation with their partners for meteorology, seismology, water and natural resources, specifically analyzing the potential rainfall, water flow and flooding. MEM has hosted the video conference on several occasions by interconnecting the typhoon vulnerable jurisdictions and the National Flood Control Office, CMA and other authorities to schedule and understand the progress of and the preparations against the typhoons, coordinating and directing the response campaigns upon their landing, including arrangements and guidance on emergency rescue and relief. In the case of the 10 typhoons that landed in China this year, NCDR and MEM received a total of more than 9,300 messages of initial, ongoing and checked reporting of disasters sent by the relief offices at the provincial, municipal and county levels.

Funds have been transferred to ensure the basic livelihood of the affected people. NCDR and MEM actively consulted the Ministry of Finance (MOF) to calculate and earmark relief funds from the central source. In response to the disaster of typhoon, MOF and MEM have allocated to the provinces of Zhejiang, Anhui, Fujian and Shandong 480 million yuan from the central fiscal basket to subsidize the well-being compromised by natural disasters this year, an amount earmarked for the urgent transfer and resettlement of victims of typhoons and their associated rainstorms and floods, the life assistance during the transitional period, and the restoration of damaged houses, all of which were aimed to meet the needs of people’s livelihood and support the governments in the stricken areas in their efforts to combat and relieve disasters.

Forecasts and warnings have been released in multiple channels, while public meteorological services delivered in a timely and effective manner, public awareness and outreach enhanced to create a good disaster relief atmosphere. Devices such as weather.com.cn, weathertv.cn, client of 3g.weather.com.cn, CMA’s official Weibo and WeChat, as well as TV, radio, website, SMS, electronic display, voice call, rural loud-speaker, warning tower, bus- and subway-borne mobile TV, and village-based communicator and siren have been used to provide forecasting and warning information to the public, while channels such as the Xinhua News Agency, People's Daily, CCTV, ministerial website and the WeChat public account to release the disaster and relief related information in a real-time manner. In particular, the front-line working group of MEM actively voiced itself on the first line in the stricken areas by receiving media interviews to publicize and introduce MEM’s arrangements and specific measures for the preparedness and response. At the same time, the publicity and outreach were increased in frequency and intensity to bring in coincidence the public campaign and emergency response, which proved impressive. The timely initiation of early warning and loss assessment did contribute to the mitigation of damages.

Priority Areas Addressed:

Provide reliable statistics of mortality and direct disaster economic loss caused by typhoon-related disasters for monitoring the targets of the Typhoon Committee.

Enhance Members’ disaster reduction techniques and management strategies.

Evaluate socio-economic benefits of disaster risk reduction for typhoon-related disasters.

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2.11 CMA Integrated Marine Meteorological Support Project

Main text:

In order to meet the demand for meteorological services in support of marine meteorological disaster prevention, marine economic development, marine rights and interests protection, climate change response and marine ecological/environmental protection, CMA officially launched the project of integrated marine meteorological support in 2018. The project aims to comprehensively upgrade China's integrated capabilities in marine meteorological observation, marine meteorological forecasting and warning, marine meteorological service delivery, marine meteorological facility operation and data sharing. It is a project of three phases: The first phase extends from 2018 to 2019, the second one from 2020 to 2022 and the third from 2023 to 2025. By 2025, the system of marine meteorological operation featuring a balanced pattern, an appropriate scale and a complete function will come into being to fully cover offshore public services, monitor all weather conditions in open seas and warn when needed, with the meteorological support to the ocean-going missions significantly improved.

Priority Areas Addressed:

Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.

Develop and enhance typhoon analysis and forecast technique from short- to long-term.Promote communication among typhoon operational forecast and research communities in Typhoon committee region.

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2.12 FY Satellite Emergency Response Mechanism Released

Main text:

In 2018, CMA established an emergency response mechanism for disaster prevention and mitigation of FY meteorological satellites for international users. Under this mechanism, international users, including members of the Typhoon Committee, can provide observational requirements. CMA will provide satellite regional intensive observation services and products at intervals of 5 to 6 minutes. This satellite intensive service can help members of the Typhoon Committee in extreme weather forecasting services such as typhoons.

Priority Areas Addressed:

Enhance collaborative activities with other regional/international frameworks/organizations, including TC and PTC cooperation mechanism.

Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.

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2.13 CMA Tropical Cyclone Training Progress

Main text:

In 2018, the China Meteorological Administration held a training workshop on typhoon, which focused on improving the forecasters' skill in operational application and promoting the application of new methods and new data to typhoon forecasting as well.

1) From March to July 2018, the techniques of Dvorak, Tropical Weather Analysis and Typhoon Monitoring and Forecasting were presented to 38 trainees in the 60th Induction Training Workshop for Weather Forecasters. The course included 8 hours' lecturing and 8 hours' exercise.

2) In June 2018, the International Training Workshop on FY-4 Satellite Products was successfully held, a program that has been run for 10 consecutive sessions. Recruited were 22 international participants from 15 countries and regions, including Mongolia, Algeria, Belize and DPRK. Among them, seven were Belt and Road countries and three were SCO countries. The training contents were: the application of FY meteorological satellite products, including that of satellite data to typhoon operation; SWAP application system platform; and WMO satellite program.

3) From 16 to 22 September 2018, 43 participants attended the 19th Training Workshop on the Application of Satellite Data to Weather Analysis and Prediction. The main contents of the training included: the outlined developments and application principles of FY-4 satellite and the application of its products to weather analysis and numerical prediction and other services. Four hours were devoted to the application of such products to typhoon and associated storm monitoring, including the application methods of domestic and foreign meteorological satellites in typhoon monitoring and the application potential of FY-4 geostationary meteorological satellite products in this connection.

4) An international training course on the application of radar data in the forecasting of high-impact weather will be held from 19 to 30 November 2018. The training includes: the basic principles of meteorological radar detection, and the influence of radar data products on typhoon. Plan to improve the ability on application of meteorological radar data in the operational work of trainees.

5) CMA is planned to recruit 4 forecasters from the Typhoon Committee and 2 forecasters from the Panel on Tropical Cyclones (PTC) to conduct typhoon and marine monitoring and forecasting training during 10 to 19 December 2018. The training content mainly includes: the progress of typhoon and ocean forecast, the application of FY meteorological satellites and products in typhoon and ocean forecast, the wave forecasting operation and mode, and the storm surge forecasting.

Priority Areas Addressed:

Enhance collaborative activities with other regional/international frameworks/organizations, including TC and PTC cooperation mechanism.

Enhance in cooperation with TRCG, training activities in accordance with Typhoon Committee forecast competency, knowledge sharing and exchange of latest development and new techniques.

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Annexes

Figure 2.1 NMC's Typhoon Outreach Program (May 2018, Hainan)

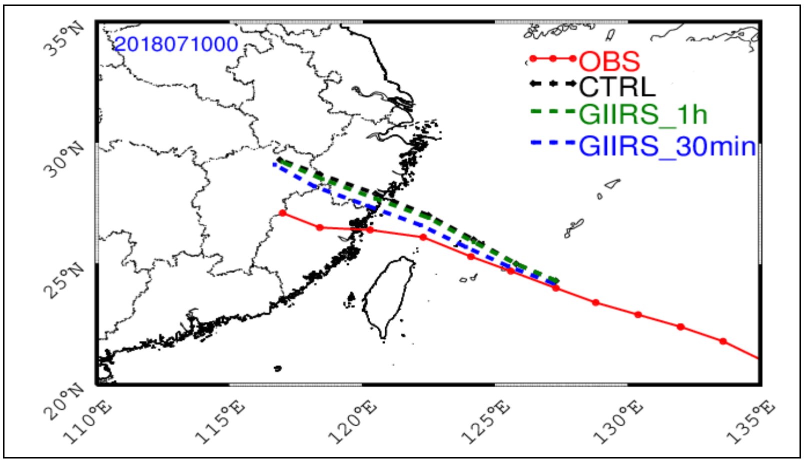

Figure 2.2 GRAPES Assimilating GIIRS Observations for Assessment of Typhoon MARIA Tracks Forecast

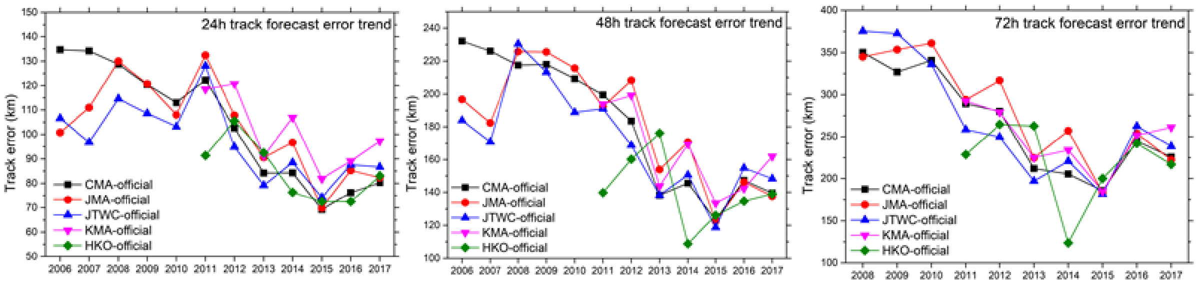

Figure 2.3 Historical 24h, 48h and 72h Average Track Prediction Error Trends of NMC, JMA, JTWC, KMA and HKO

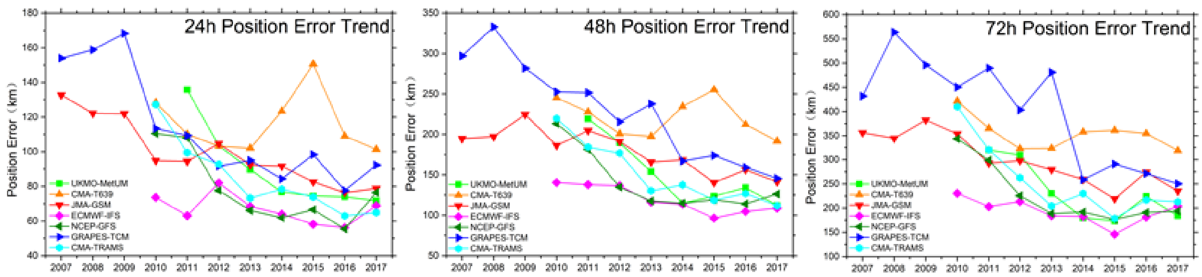

Figure 2.4 Historical 24h, 48h and 72h Average Track Prediction Error Trends of the Global and Regional Models

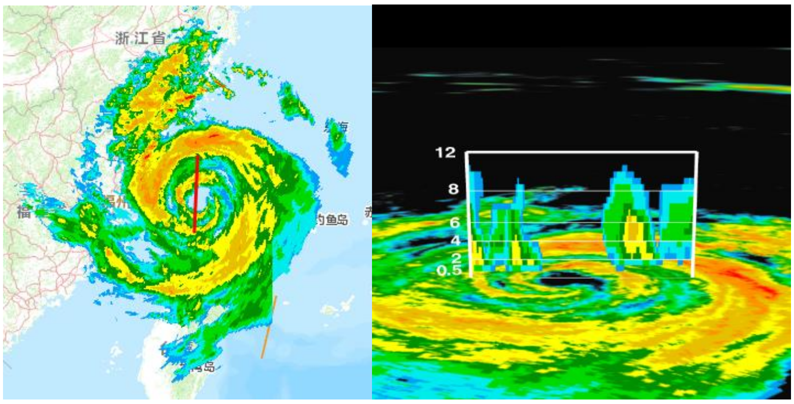

Figure 2.5 Radar networking mosiac showing a profile of typhoon structure

Figure 2.5 Climatological Atlas of Tropical Cyclones over the Western North Pacific

Figure 2.6 National Natural Disaster and Damage Reporting System

Figure 2.7 Database of National Disaster Messengers