

# **MEMBER REPORT**

## **[China]**

ESCAP/WMO Typhoon Committee  
12th Integrated Workshop  
Jeju, Republic of Korea  
30 October – 3 November 2017

# CONTENTS

## **I. Overview of tropical cyclones which have affected/impacted China since the last Committee Session**

- |   |       |
|---|-------|
| 1. Meteorological and Hydrological Assessment | P. 1  |
| 2. Socio-Economic Assessment                  | P. 13 |
| 3. Regional Cooperation Assessment            | P. 15 |

## **II. Summary of Progress in Priorities supporting Key Result Areas**

- |   |       |
|---|-------|
| 1. Typhoon information spread on social media   | P. 19 |
| 2. Advances in typhoon forecasting techniques   | P. 21 |
| 3. Advances in Typhoon numerical modeling and data assimilation   | P. 23 |
| 4. Subjective and numerical prediction results assessment   | P. 25 |
| 5. FY-4A's role in typhoon monitoring in 2017   | P. 26 |
| 6. Ocean observing system and experiment  | P. 27 |
| 7. Advances in scientific research on typhoons  | P. 28 |
| 8. Advancement on CMACast and WIS   | P. 30 |
| 9. Ministry of Civil affairs strengthened typhoon disaster risk management and disaster response/relief | P. 31 |
| 10. Big data based smart typhoon application system   | P. 33 |
| 11. CMA tropical cyclone training   | P. 34 |
| Annexes   | P. 35 |



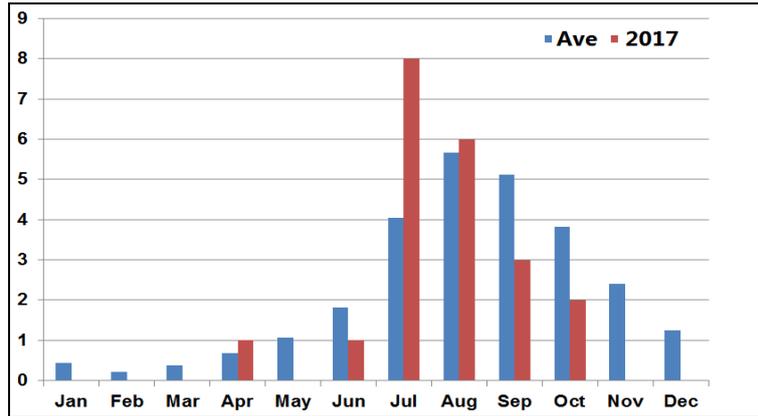


Fig. 1.3. Averaged tropical cyclone incidences by month in multi-years as well as in 2017.

### 3) Abnormally weak peak intensity

By 23 October, 2017, 21 TCs had an averaged intensity of 33.4 m/s as peak intensity, significantly weaker compared with the multi-year average of 40.3 m/s. Lan (1721) makes the strongest typhoon in the year with an extreme up to 58 m/s and 925 hPa.

### 4) Weak landing strength than usual

By 23 October, 2017, the 8 TCs that made landfall in China reported an averaged landing intensity of 29.0 m/s, weaker compared with the multi-year average of 32.8 m/s. HATO (1713) is the strongest landing typhoon in the year with a landing strength up to 45 m/s and 950hPa.

### 5) TCs sources concentrated to the west

There are mainly three regions over the western North Pacific and the South China Sea where TCs are mostly generated: a) the northern part of the South China Sea, b) ocean east of the Philippines, and c) ocean nearing the Mariana Islands. The typhoons generated in 2017 inclined to have a westerly origin. For example, 6 typhoons were generated over the South China Sea, or 1.3 more compared with a normal year that would accommodate 4.7 typhoons on the South China Sea.

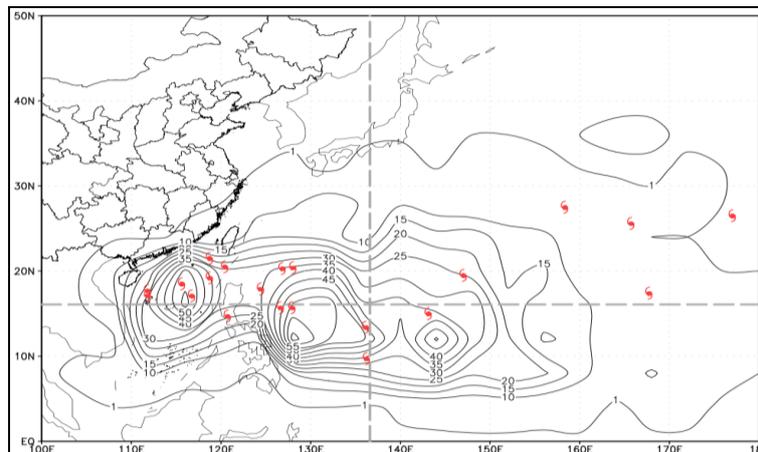


Fig. 1.4. Distribution of TCs generated on the western North Pacific and the South China Sea, 1949- 2016 ( $\text{digit}/\pi R^2$ ,  $R = 250$  km) compare with TC genesis locations in 1 Jan. to 23 Oct. 2017.

## 1.2 Operational Forecast

By 23 October, 2017, the subjective typhoon 24-hr to 120-hr track forecast errors of NMC/CMA reached 75.0、149.7、256.6、352.2 和 464.0 km, which is larger than that of 2016.

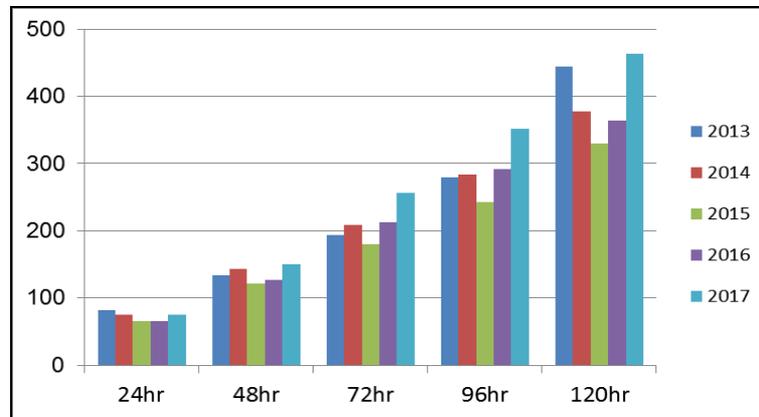


Fig. 1.5. China's typhoon track prediction errors during 2013-2017, released by NMC/CMA.

## 1.3 Characteristics of major typhoon-induced rainfall that impacted China in 2017

8 tropical cyclones made landfall in China, and tropical cyclones over South China Sea appear more active this year. Of them, HATO (1713) and KHANUN (1720) had the prominently large impact on the subsequent rainfall in China. The rainfall brought by the landing tropical cyclones in the year had the following two features:

1) Widespread rainfall area and enhanced heavy rain intensity. In 2017, typhoons have affected 19 provinces or municipalities. According to the monitoring results released by Chinese hydrological authorities (the same below), under the combined influence of NESAT and HAITANG that landed in China at heels one after another and the influence of cold air, the central and eastern part of China reported an extensive heavy rainfall process with the area that had a combined rainfall higher than 250 mm and 100 mm accounted for 12,000 and 348,000 square kilometers, respectively. The Jianxin Reservoir in Fuzhou, Fujian registered the largest combined rainfall up to 542 mm, with Majiapuzi, part of Anshan in Liaoning having a rare daily rainfall up to 410 mm.

2) Major rivers' water levels were stable with some small rivers exceeding the warning level. Typhoon HATO and KHANUN brought floods to 6 provinces. Some 40 small and medium rivers reported the attacks of floods exceeding the warning level. Of them, 10 small and medium rivers exceeded the guaranteed water level. The Fengma Temple Observing Site at the Pearl River Delta Estuary of Guangdong reported a record water level. Meanwhile, 16 tidal wave stations along China's coasts have measured exceeding-warning high tidal wave levels. 6 tidal wave stations reported the record high tidal waves.

## 1.4 Narrative on Tropical Cyclones

## 1) Severe tropical storm MERBOK (1702)

A tropical depression was generated on June 10 at 0600 UTC over the eastern part of the South China Sea. It strengthened at 0600 UTC of June 11, and the tropical storm MERBOK was numbered 1702. And it further moved north-northwest before turning north with a steadily enhanced strength. It was upgraded to a severe tropical storm at 0400 UTC of June 12. MERBOK weakened to a tropical storm at 1500 UTC of June 12, and made landing on the Dapeng Peninsula, part of Shenzhen, Guangdong at 1510 UTC with maximum wind speed reaching 9 Beaufort scales (23 m/s) nearing the center and a minimum central pressure of 990 hPa. After landing, MERBOK moved north-northeast and dissipated in Guangdong.

Under the influence of MERBOK, the central and eastern coasts of Guangdong and the eastern coasts of Fujian reported gales up to 8-9 Beaufort scales, with the strong gales up to 10-12 Beaufort scales. During June 12-13, the central and eastern part of Guangdong, the southern part of Fujian and the southern part of Jiangxi had a local rainfall up to 100-200 mm, with some parts exceeding 250 mm. The Huizhou coastal area of Guangdong reported a rainfall up to 427 mm. The above-mentioned areas registered a maximum hourly rainfall up to 50-70 mm and a maximum 3-hour rainfall up to 100-149 mm. The area having 50-mm and 100 mm rainfall reached 13,000 and 62,000 square kilometers, respectively.

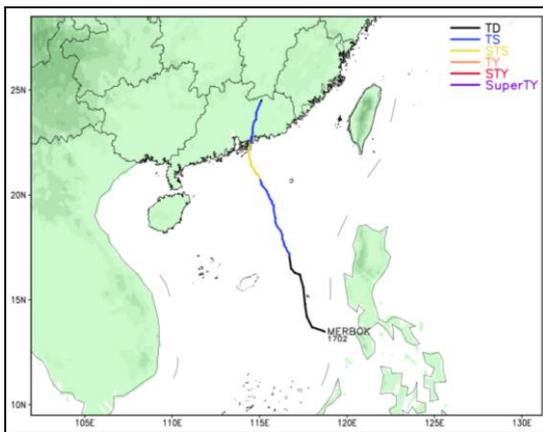


Fig. 1.6a. Track of MERBOK.

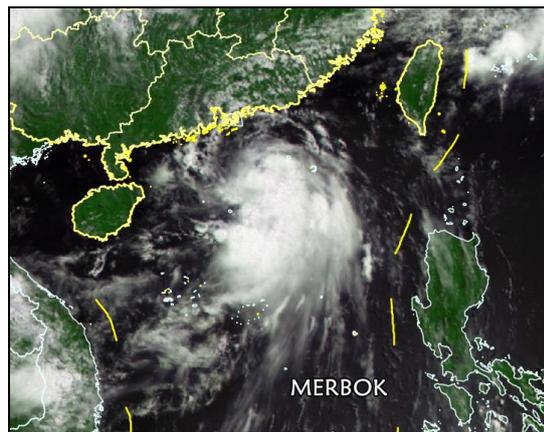


Fig. 1.6b. FY-4A image of MERBOK.

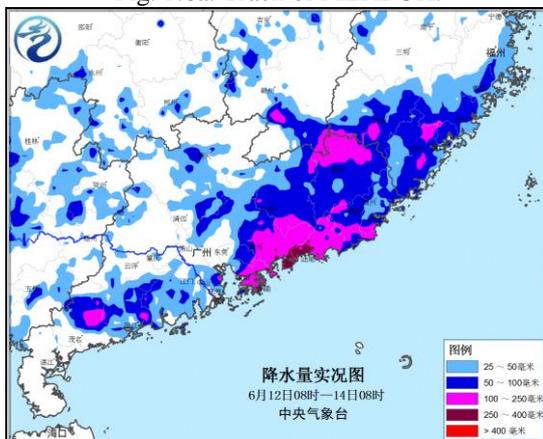


Fig. 1.6c. MERBOK-induced rainfall,  
From 00 UTC, 12 June to 00 UTC 14 June.



Fig. 1.6d. Hazards of MERBOK.

Meanwhile, MERBOK caused chaos to Shenzhen, Huizhou and Shanwei, including

submerged roads, blocked traffic, power outage and the close of kindergartens and schools. A strip from the Pearl River Estuary to the eastern coasts of Guangdong reported a storm induced rainfall up to 20-60 mm. The Jiao River in Fujian and two small rivers exceed their warning levels by 0.06-0.49 m.

**2) Tropical storm TALAS (1704)**

A tropical depression formed on July 14 at 1200 UTC over the central water of the South China Sea. It moved northwest, and became a tropical storm named TALAS (1704) heading west-northwest at 0900 UTC of July 15. It bypassed over the sea south to Hainan Island in the morning of July 16, with 45-km distance from the nearest coasts. It strengthened to a severe tropical storm at 0600 UTC of July 16, and made landfall as a severe tropical storm in Tinh Nghệ An, part of Vietnam at 1800 UTC of July 16. After landing, it weakened and dissipated in the central part of Laos.

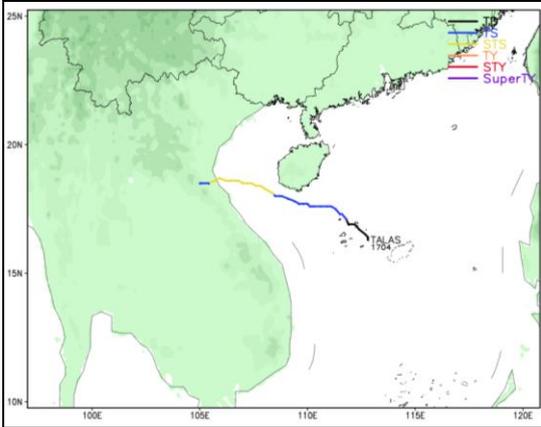


Fig. 1.7a. Track of TALAS.

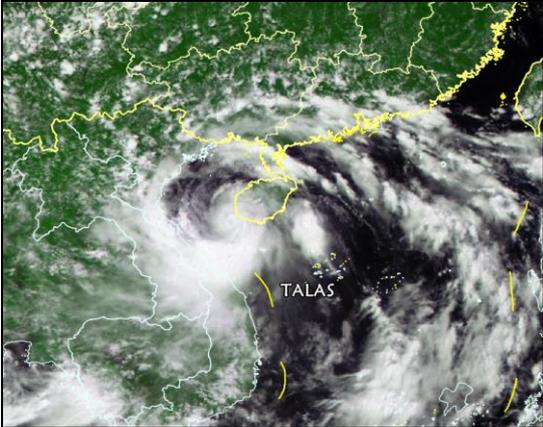


Fig. 1.7b. FY-4A image of TALAS.

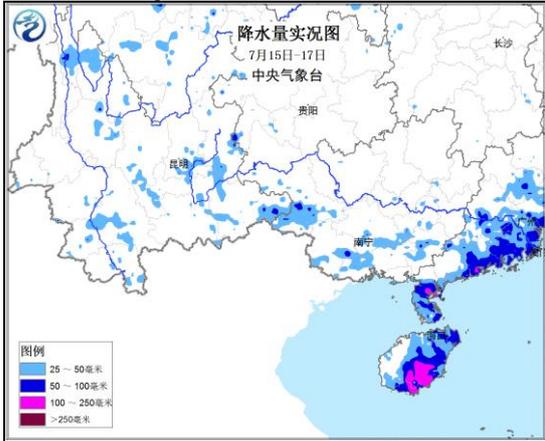


Fig. 1.7c. TALAS-induced rainfall from 15-17 July,



Fig. 1.7d. Hazards of TALAS.

Under the influence of TALAS, local rainfall exceeding 50 mm, with 150-250 mm for southeastern Hainan and 253-262 mm for Baoting and Lingshui, also part of Hainan. Gales up to 8-9 Beaufort scales, with the southwestern coasts of Guangdong and the southeastern coastal areas of Hainan Island had strong gales up to 10-11 Beaufort scales.

**3) Tropical storm ROKE (1707)**

A tropical depression formed on July 22 at 0000 UTC over the water of the Bashi Channel. It strengthened and named tropical storm ROKE at 0900 UTC of July 22. Then it moved west-northwest with a stable strength and made landfall on the northeastern coast of Hong Kong at around 0150 UTC on July 23, with a maximum wind speed up to 8 Beaufort scales (20 m/s) and a minimum central pressure of 995 hPa. After cutting through the Pearl River Estuary, ROKE became weakened, and eventually dissipated in the central part of Guangdong.

Affected by ROKE, it reported a combined rainfall of 25-100 mm during July 22-25, and some other localities exceeding 100 mm. The Shunzhou Observing Station in Shanwei, Guangdong claimed the maximum 199 mm rainfall. As a consequence, the affected areas were able to maintain relatively stable river water levels without exceeding the warning level.

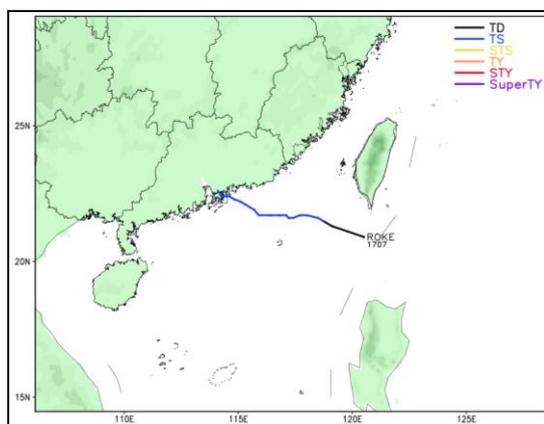


Fig. 1.8a. Track of ROKE.

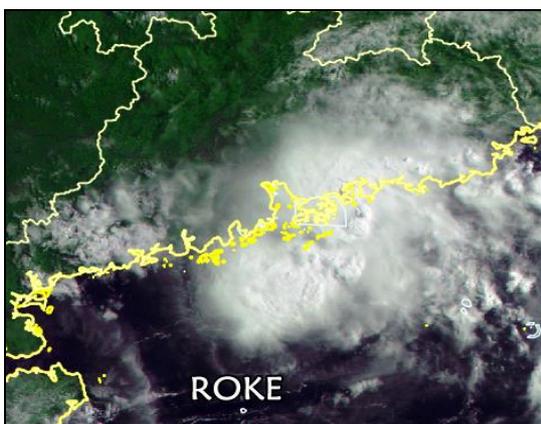


Fig. 1.8b. FY-4A image of ROKE.

#### 4) Typhoon NESAT (1709) and tropical storm HAITANG (1710)

A tropical depression formed on July 25 at 1500 UTC over the ocean to the east of the Philippines. It moved west-northwest before turning north with an increased intensity. And it developed to tropical storm NESAT (1709) at 0300 UTC of July 26, then a severe tropical storm at 0300 UTC on July 27. It moved in a northwest direction and gradually intensified to a typhoon at 0900 UTC on July 28 when approaching the northeastern coasts of Taiwan. NESAT landed in the eastern coast of Yilan County, part of Taiwan at 1140 UTC of July 29, with a maximum wind speed up to 40 m/s and a minimum central pressure of 960 hPa. After that it weakened when passing Taiwan, and downgraded as a severe tropical storm in the Taiwan Strait at 1500 UTC on July 29. However, it intensified to typhoon when approaching the coastal areas. NESAT made landfall on Fuqing City, part of Fujian Province at 2200 UTC on July 29, with a maximum wind speed nearing center of 33 m/s and a minimum central pressure of 975 hPa.

In the time when NESAT was heading for Taiwan, another tropical depression got developed on July 28 at 0600 UTC on the northeastern part of the South China Sea. It strengthened to tropical storm HAITANG (1710) at 1200 UTC on July 28. And it moved slowly in a counterclockwise manner with before geared up its moving speed around 0000 UTC on July 30, heading north-northeast and approaching the southern coast of Taiwan.

HAITANG made landfall in Pingtung County, Taiwan at 0930 UTC on July 30, with a maximum wind speed nearing center of 23 m/s and a minimum central pressure of 984 hPa. After landing in Taiwan, it moved northward and entered the Taiwan Strait at 1500 on July 30. Then it secondly landed in Fuqing City, Fujian Province around 1850 UTC, with a maximum wind speed nearing center of 18 m/s and a minimum central pressure of 990 hPa.

After landing in Fujian, the north-heading HAITANG merged with the residual circulations of NESAT and interact with the cold air. The combined circulations induced heavy rainfall over 18 provinces, autonomous regions or municipalities. Fuzhou and Ningde in Fujian, Wenzhou in Zhejiang, Xinyang in Henan, Cangzhou in Hebei, and Anshan in Liaoning reported a local rainfall up to 300-500 mm, with the coastal area of Fuzhou having a rainfall up to 552 mm (Fig. 1.9e). 16 meteorological observing sites in Hebei, Liaoning, Jilin and Heilongjiang reported a rainfall exceeding the historical record of August. Of them, 6 sites claimed a rainfall exceeding the historical extremes. In addition, Pingtung, Kaohsiung and Yilan in Taiwan Province had a combined rainfall exceeding 500 mm, with 1,160 mm of rainfall in Dahanshan of Pingtung. Meanwhile, observed gales up to 8-9 Beaufort scales, with the eastern coast of Fujian having strong gales up to 10-11 Beaufort scales.

Under the combined influence of NESTA and HAITANG, the Tingjiang River, a tributary of the Han River and the eastern coast of Guangdong reported raised water levels by 1-2 meters, though fortunately without exceeding the warning level.

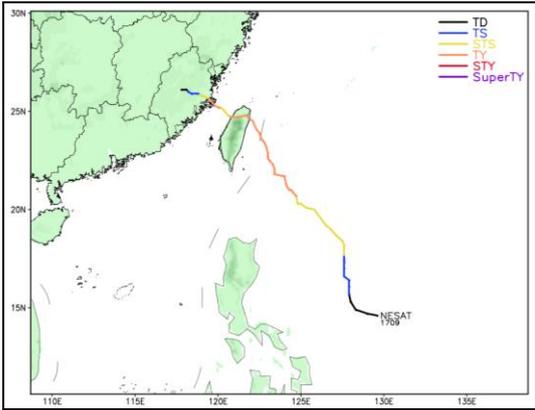


Fig. 1.9a. Track of NESAT.



Fig. 1.9b. Track of HAITANG.

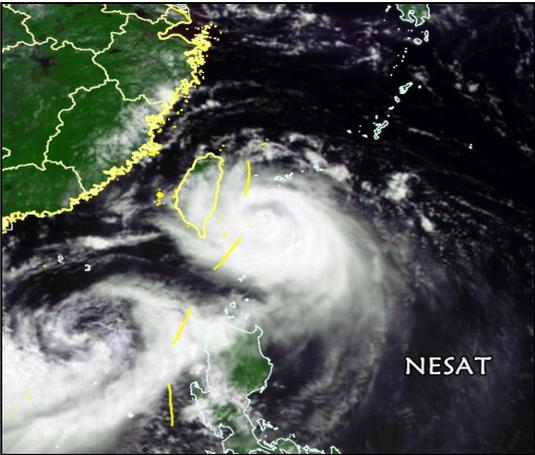


Fig. 1.9c. FY-4A image of NESAT.



Fig. 1.9d. FY-4A image of HAITANG.

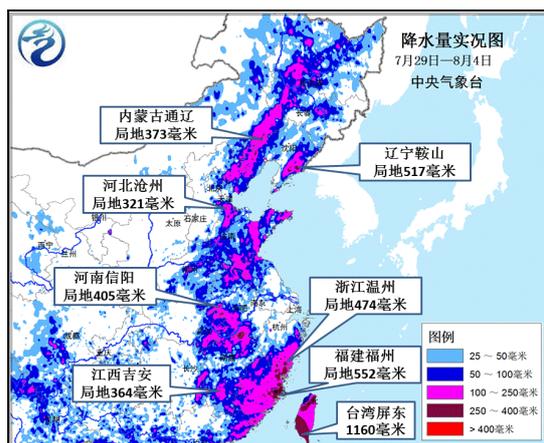


Fig. 1.9e. Distribution of rainfall induced by NESAT and HAITANG from 29 Jul. to 4 Aug..



Fig. 1.9f. Hazards of NESAT and HAITANG

## 5) Severe typhoon HATO (1713)

A tropical depression was formed on August 19 at 1800 UTC over the ocean to the east of the Philippines. It moved northwest with steadily increased intensity. And it developed to tropical storm HATO (1713) at 0600 UTC on August 20, turned to move westward. HATO was upgraded at 0000 UTC on August 22 to a severe tropical storm moving west-northwest with further increased intensity. It was further upgraded to a typhoon at 0700 UTC on August 22, and then a severe typhoon at 2300 UTC of August 22 when approaching the southern coast of Guangdong. It made landfall in the southern coast of Zhuhai, Guangdong around 0450 UTC on August 23, with a maximum wind speed nearing center up to 45 m/s and a minimum central pressure of 950 hPa. HATO has so far been the most intense typhoon that had made landfall in China this year. After landing, it continued its west-northwest journey heading for Guangdong and Guangxi with gradually weakened intensity. And it died down in the southeastern part of Yunnan.

The coastal areas of Guangdong, the Pearl River Estuary, southeastern Guangxi and the coastal areas of Guangxi reported gales up to 8-10 Beaufort scales. Among them the strong gales up to 11-13 Beaufort scales. Zhuhai, Macao, Hong Kong and the Pearl River Estuary claimed exceptional strong gales up to 16-17 Beaufort scales on the sea surface or on the islands, with some localities exceeding 17 Beaufort scales (the Guishan Island, part of Zhuhai, measured a maximum wind speed up to 66.9 m/s).

During 1200 UTC August 22 to 1400 UTC August 25, it reported a combined rainfall up to 100-400 mm, with Changjiang of Hainan having a rainfall up to 473 mm. The area having a 100-mm and 50-mm heavy rainfall reached 60,000 and 193,000 square kilometers. 34 small and medium-sized rivers in Guangdong, Guangxi, Yunnan, Sichuan and other provinces reported the flash floods that made the rivers exceed their warning levels by 0.02-6.92 meters. Of them, 6 rivers reported the exceeding of the guaranteed water level by 0.01-2.82 meters. Fengma Temple Observing Station in the Pearl River Delta Estuary claimed a raised water level exceeding the historical record.

Since the time of HATO's landing got coincided with the astronomical tidal waves. Strong winds and storm surges resulted in the intrusion of sea or river water into the urban areas. Some cities, including Macao and Zhuhai, reported urban waterlogging and broken

trees. 16 tidal wave observing sites in the eastern coasts of Guangdong and the Pearl River Delta Estuary reported the warning level being exceeded by 0.16- 1.29 meters. Of them, 6 sites in the Pearl River Delta Estuary recoded the historical high tidal waves.



Fig. 1.10a. Track of HATO.

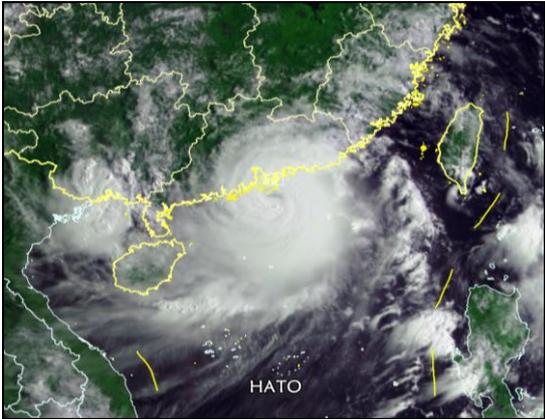


Fig. 1.10b. FY-4A image of HATO.

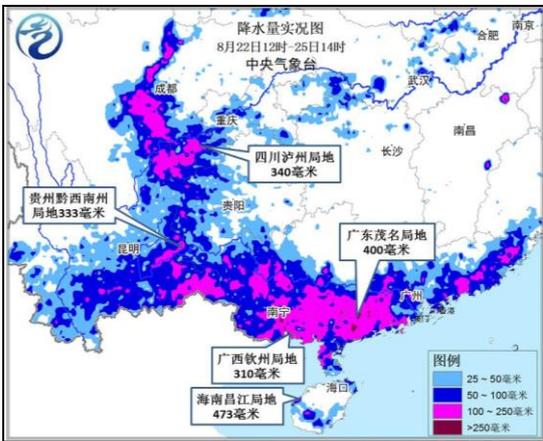


Fig. 1.10c. HATO-induced rainfall from 0400 UTC 22 Aug. to 0600 UTC 25 Aug.

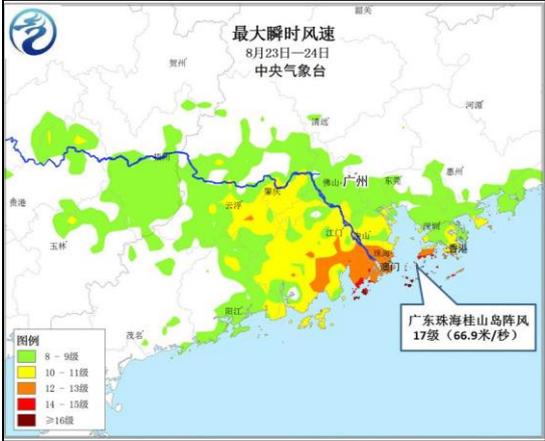


Fig. 1.10d. Gale of HATO during 23 Aug. to 24 Aug.



Fig. 1.10e. Hazards of HATO.



Fig. 1.10f. Hazards of HATO.

**6) Typhoon PAKHAR (1714)**

A tropical depression formed at 0600 UTC of August 24 over the ocean to the east of the Philippines. It strengthened and developed to tropical storm PAKHAR (1714) at 1200 UTC of

August 12. And it moved westward before turning northwestward. PAKHAR swept through the northern part of Luzon, and entered the eastern part of the South China Sea at 1300 UTC on August 26, where it geared up when approaching the southern coast of Guangdong. It developed to severe tropical storm at 1300 UTC on August 26, and was upgraded to a typhoon around 0000 UTC on August 27. PAKHAR made landfall on Taishan, Guangdong, with a maximum wind speed nearing center up to 33 m/s and a minimum central pressure of 978 hPa. After landing, PAKHAR weakened to a tropical depression in Guangxi at 12:00 UTC on August 27.

PAKHAR jointed with the Southwest Monsoon to cause extensive heavy rainfall over Guangdong, Guangxi and Guizhou province. From August 26 to 28, it reported a combined rainfall of 100-350 mm, the observing sites in Huizhou and Huiyang claimed a combined rainfall up to 417 mm. The area of rainfall exceeding 50 mm and 100 mm accounted for 158,000 and 30,000 square kilometers, respectively. The Danshui River, a secondary tributary of the Dong River in Guangdong reported a flood that made the river exceed the warning level.

Influenced by PAKHAR, an observing site on the midway of the Pearl River Delta navigation route reported a tidal wave exceeding the warning level. Meanwhile, the Pearl River Estuary area and the counties/cities in eastern Guangdong had strong gales up to 8-12 Beaufort scales. The Dapeng Sanmen Island, part of Shenzhen, measured a strong gale up to 43.9 m/s (14 Beaufort scales), with an averaged wind up to 36.6 m/s (12 Beaufort scales).



Fig. 1.11a. Track of PAKHAR.



Fig. 1.11b. FY-4A image of PAKHAR.

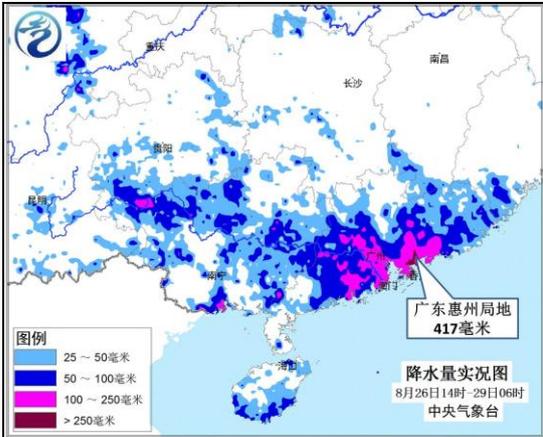


Fig. 1.11c. PAKHAR-induced rainfall from 0600 UTC 26 Aug. to 2200 UTC 28 Aug..



Fig. 1.11d. Hazards of PAKHAR.

## 7) Severe tropical storm MAWAR (1716)

A tropical depression formed at 2100 UTC of August 30 on the northeastern part of the South China Sea west of the Bashi Channel. And it developed to tropical storm MAWAR (1716) at 1800 UTC on August 31. Then it moved northwestward and upgraded to a severe tropical storm at 0700 UTC on September 2 when approaching Guangdong. MAWAR weakened to a tropical storm at 1200 UTC on September 3 before made landfall around 1330 UTC in Shanwei, Guangdong. With a maximum wind speed nearing center up to 20 m/s and a minimum central pressure of 995 hPa. MAWAR dissipated over Guangdong after landfall.

Influenced by MAWAR, the eastern part of South China had moderate or heavy rainfall during September 2-3. It reported local heavy rainfall reaching 225 mm in the urban area of Zhuhai. Meanwhile, some small and medium rivers in the eastern coasts of Guangdong and the Jin and Jiulong Rivers in Fujian saw a raised water level by 0.5 meters without exceeding the warning level.

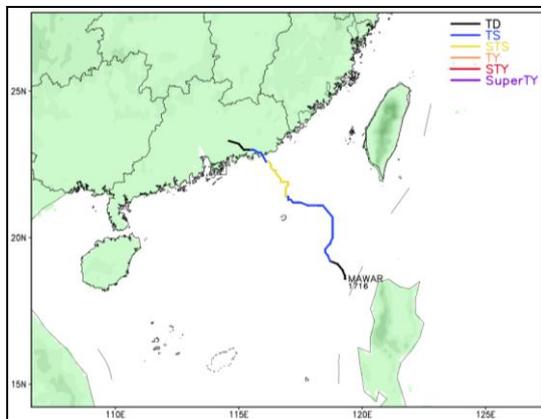


Fig. 1.12a. Track of MAWAR.

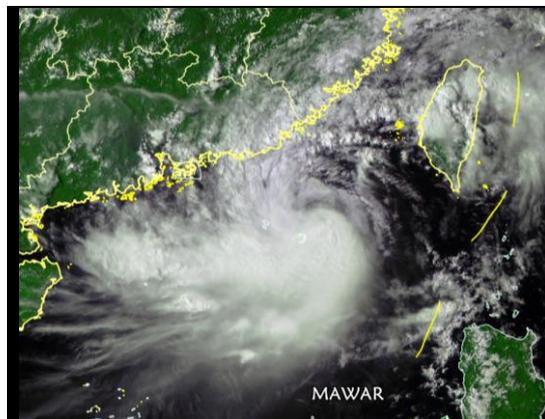


Fig.1.12b. FY-4A image of MAWAR.

## 8) Severe typhoon DOKSURI (1719)

A tropical depression was formed on September 11 at 0300 UTC on the water east of Luzon Island. It moved westward and swept through the middle part of Luzon and developed to tropical storm DOKSURI (1719) at 0600 UTC on September 12. After that it entered the central-eastern part of the South China Sea at 1200 UTC of December 12, moving westward then turned to west-northwest. DOKSURI intensified to a severe tropical storm at 2100 UTC on September 13, and was further upgraded to a typhoon at 0600 UTC on September 14. It swept south of Hainan island and then became a severe typhoon at 2000 UTC on September 14 when approaching the central coast of Vietnam. DOKSURI made landfall in the northern part of Tỉnh Quảng B ình, part of Vietnam at 0415 UTC of September 15, with a maximum wind speed nearing center up to 45 m/s and a minimum central pressure of 950 hPa. After landing, it weakened when traveling west-northwest through Vietnam and Laos. And it dissipated over Thailand on September 16.

Under the impacts of DOKSURI, southern Hainan and northeastern Zhejiang reported heavy rainfall or exceptional heavy rainfall during September 14-15. Qionghai and Baoting, part of Hainan, registered a rainfall up to 200- 228 mm, or 50-70 mm for the maximum hourly rainfall. And it reported strong gales up to 8-11 Beaufort scales, with 12-13 for the southern

coasts of Hainan Island.

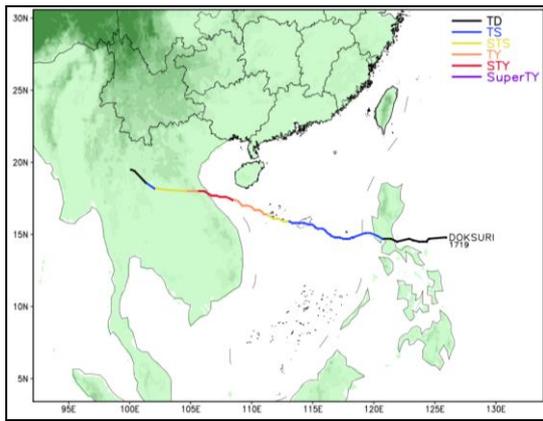


Fig.1.13a. Track of DOKSURI.

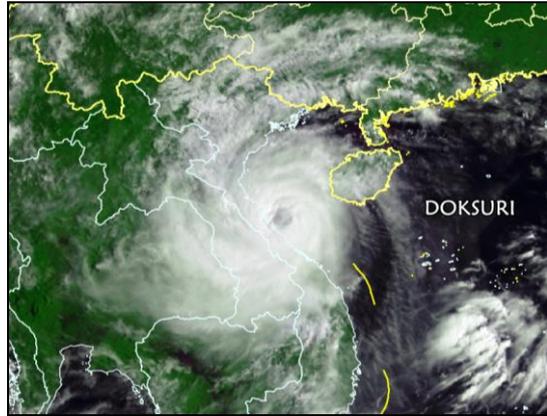


Fig.1.13b. FY-4A image of DOKSURI.

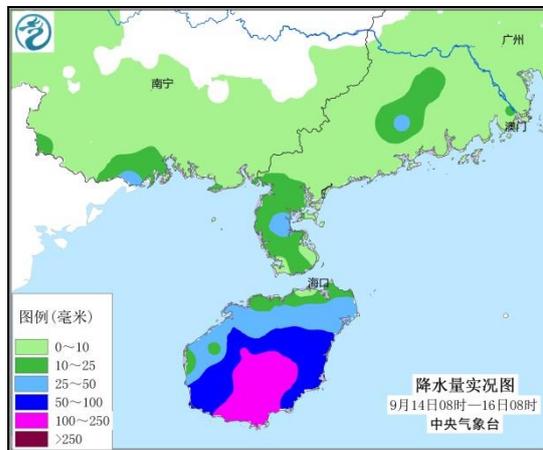


Fig. 1.13c. DOKSURI-induced rainfall from 0000 UTC 14 Sept. to 0000 UTC 16 Sept..



Fig. 1.13d. Hazards of DOKSURI.

### 9) Severe typhoon KHANUN (1720)

A tropical depression was formed on October 11 at 1200 UTC on the water east of Luzon Island. It moved westward and developed to tropical storm KHANUN (1720) at 0900 UTC on October 12. After that it swept the northern part of Luzon Island and entered the central-eastern part of the South China Sea. KHANUN intensified to a severe tropical storm at 1400 UTC on October 13, and was further upgraded to a typhoon at 1400 UTC on October 14, turned to west-northwest direction afterward. As it approaching Guangdong, KHANUN got weaken and degraded as a typhoon at 0900 UTC on October 15, and as a severe tropical storm eight hours later. KHANUN made landfall on Xuwen, Guangdong, with a maximum wind speed nearing center up to 28 m/s and a minimum central pressure of 988 hPa. After landing, PAKHAR moved west-southwestward and dissipated over the Beibu Gulf.

Under the impacts of KHANUN and its interaction with the cold air, it reported heavy rainfall of 100-500 mm, the observing sites in Xiangshan of Zhejiang claimed 417 mm, and Dawushan of Taiwan reached 1238 mm. Due to the heavy rainfall, 13 mid-small rivers in Zhejiang province reported floods that exceeded the warning level, with a range of 0.07 to 1.18 m. Among them, 4 Rivers reported severe floods that exceeded the guaranteed level, with

a range of 0.04 to 0.68 m. The water level in river network area of the Taihu Lake has risen in general, and there were 12 stations reported floods that exceeded the warning level, with a range of 0.01 to 0.47 m. Besides, the storage capacity of large-mid reservoirs in Zhejiang province has increased 0.23 billion.

Influenced by KHANUN, it reported strong gales up to 8-12 Beaufort scales. The Panyu oil platform recorded a strong gale up to 14 Beaufort scales.



Fig.1.14a. Track of KHANUN.

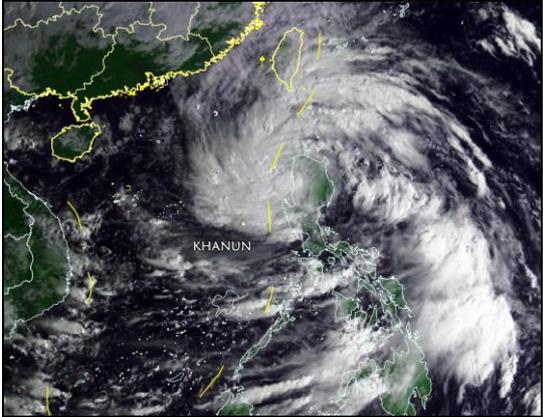


Fig.1.14b. FY-4A image of KHANUN.

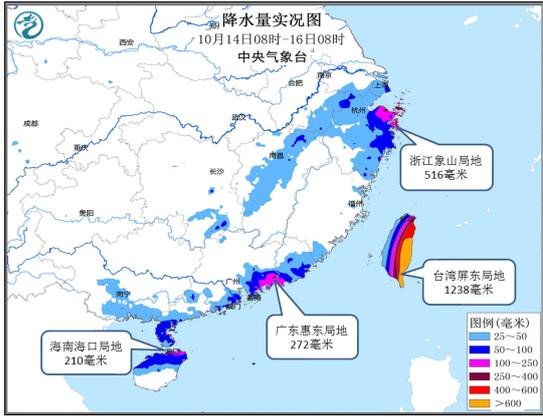


Fig. 1.13c. KHANUN-induced rainfall from 0000 UTC 14 Oct. to 0000 UTC 16 Oct..

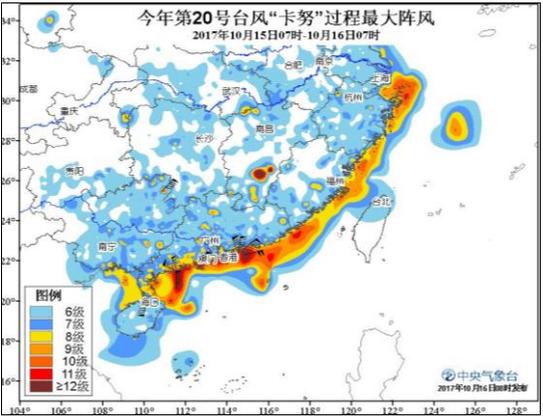


Fig. 1.13d. Hazards of KHANUN.

**2. Socio-economic Assessment**

By October 23, 2017, 8 tropical cyclones have made landfall in China. Among them, HATO was the strongest in this year and affected China the most. It made landfall at Zhuhai, Guangzhou on August 23, which caused the most affected population, fatalities, homeless population, collapsed and damaged houses, and direct economic loss. PAKHAR made landfall at Taishan, Guangzhou on August 27. Within 4 days, two typhoons made successive landfalls on economically developed and densely populated Pearl River Delta region, which caused repeated damage and huge impact.

According to preliminary statistics, TCs in this year have affected 12 provinces, including Beijing, Hebei, Fujian, Jiangxi, Shandong, Henan, Hunan, Guangdong, Guangxi, Hainan, Guizhou, and Yunnan. The total statistics read an affected population of 5.891 million, with 35 deaths, 10 missing, and evacuations of 1,100,000 thousand. Meanwhile, 3,700

collapsed and 39,000 damaged houses. The affected crop area accounted for 456,100 hectares, of which 200,000 hectares destroyed with a direct economic loss up to RMB 34.73 billion. Guangdong suffered the most, which accounted for 85% of the national direct economic losses and 40% of the total affected population, fatalities, homeless population, and damaged houses.

Table 1.1. Typhoon impacts and disasters in 2017

Typhoon Name & No.	Landing Site	Landing Date	Max. Wind Near TC Center When Landing	Affected Province (municipality, AR)	Affected Population (10,000)	Death & Missing person	Direct Economic losses (RMB 100 million)
MERBOK (1702)	Shenzhen, Guangdong	12 Jun.	23 m/s	Fujian, Jiangxi, Guangdong	22.4	/	6.0
TALAS (1704)	/	/	/	Hainan, Yunnan	21.1	/	0.6
ROKE (1707)	Hong Kong	23 Jul.	20 m/s	Hong Kong	/	/	/
NESAT (1709)	Yilan of Taiwan & Fuqing of Fujian	29 Jul. 30 Jul.	40 m/s 33 m/s	Beijing, Hebei, Fujian, Shandong, Henan, Hunan, Guangdong, Yunnan, Taiwan	126.9	1	18.3
HAITANG (1710)	Pingtung, Taiwan & Fuqing, Fujian	30 Jul. 31 Jul.	23 m/s 18 m/s				
HATO (1713)	Zhuhai, Guangdong	23 Aug.	45 m/s	Fujian, Hunan, Guangdong, Guangxi, Guizhou, Yunnan	245.9	32	289.1
PAKHAR (1714)	Taishan, Guangdong	27 Aug.	33 m/s	Guangdong, Guangxi, Guizhou, Yunnan	14.6	12	7.6
MAWAR (1716)	Shanwei, Guangdong	3 Sept.	20 m/s	Fujian, Guangdong	3.6	/	0.1
DOKSURI (1719)	/	/	/	Hainan	18.3	/	1.0
KHANUN (1720)	Xuwen, Guangdong	16 Oct.	28 m/s	Zhejiang, Fujian, Guangdong, Guangxi, Yunnan, Taiwan	136.3	/	24.6
<b>Total</b>					<b>589.1</b>	<b>45</b>	<b>347.3</b>

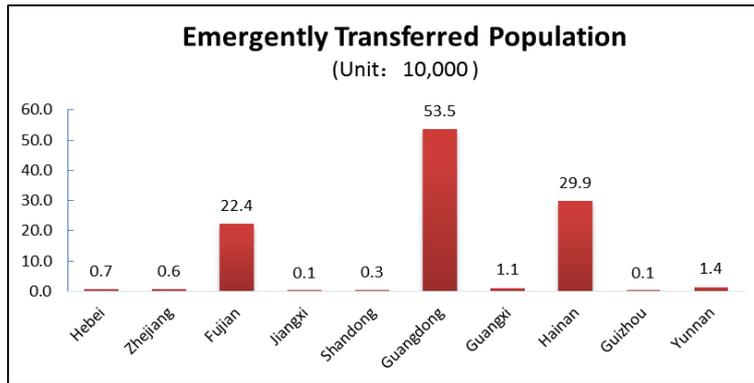


Fig. 1.15. Evacuated persons/times due to typhoon disasters in 2017, including the evacuations for risk avoidance (in 10,000 persons/times).

### 3. Regional cooperation assessment

#### 3.1 Experiment of Typhoon Intensity Change in Coastal Area (EXOTICCA)

The 2nd Organizing Committee Meeting of Experiment of Typhoon Intensity Change in Coastal Area was held in Shanghai on 7-8 September 2017. More than 20 experts attend the meeting. The major progress and issues in implementing the project has been reported during the meeting. For further information, please refer to <http://www.typhooncommittee.org/exoticca/>.



Fig. 1.16. The 2nd Organizing Committee Meeting of EXOTICCA.



Fig. 1.17. EXOTICCA's Fellowship program.

Mr. Jaral Yiemwech from Thai Meteorological Department and Ms. Khanh Hoa Bui Thi from the National Hydro-Meteorological Service of Viet Nam stayed in Shanghai Typhoon Institute from 1-30 September to conduct this year's Typhoon Committee Fellowship Project.

### **3.2 TC Research Fellowship**

Under the 2017 Annual Operating Plan of the Working Group on Disaster Risk Reduction, the Project of Benefit Evaluation of Typhoon Disaster Prevention and Preparation has been conducted by Shanghai Typhoon Institute. The objective of the fellowship is introducing the techniques for evaluating benefits of tropical cyclone disaster prevention and preparation to the Members. Mr. Nursalleh Chang from Malaysia Meteorological Department was chosen and visited Shanghai Typhoon Institute from 4-17 September, 2017. Under the 2017 Annual Operating Plan of the Working Group on Meteorology – Verification of Tropical Cyclone Operational Forecast and Tropical Cyclone Research and Review in which it was proposed an offer of Research Fellowship as one of its actions. STI is waiting for the nominations from Members.

### **3.3 10th China-Korea Joint workshop on tropical cyclones**

The 10th China-Korea Joint Workshop on Tropical Cyclones was held in Shanghai, China on 16-17, 2017. The workshop is co-organized by China Meteorological Administration (CMA) and Korea Meteorological Administration (KMA), while Shanghai Meteorological Service and Shanghai Typhoon Institute (STI) hosted it. The meeting focused on tropical cyclone observation research, numerical prediction techniques, tropical cyclone intensity and frequency, early warning, etc. Around 40 typhoon experts from CMA, KMA, and renowned university, such as Fudan University, the Army Engineering University of PLA, Zhejiang Normal University, Wuhan University of Science and Technology attended the meeting. This annual event promotes the mutual exchange of the latest progress in tropical cyclone research and operation between Korea and China. It also enhances bilateral cooperation on tropical cyclone forecasting techniques.

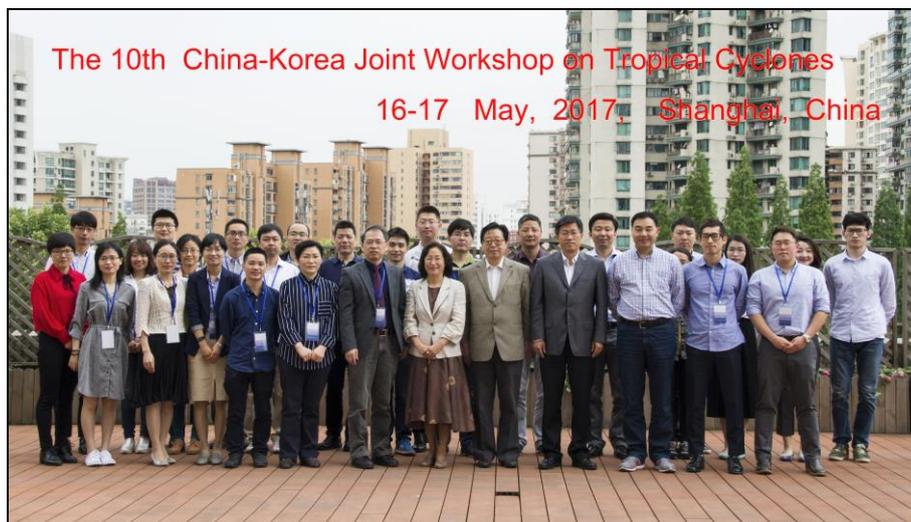


Fig. 1.18. 10<sup>th</sup> China-South Korea Tropical Cyclone Seminar.

### 3.4 Assist Macao to implement disaster assessment for typhoon HATO

From September 13 to 16, invited by the Macao S.A.R. and supported by the Hong Kong and Macao Affairs Office of the State Council and the Liaison Office of the Central People's Government in the Macao S.A.R., the National Commission for Disaster Reduction organized a team of experts to assist Macao to implement disaster assessment for typhoon HATO. The expert team consisted of 22 experts from 15 departments and agencies, covering disaster prevention and disaster relief planning, disaster warning, meteorology, water resources, housing construction, electricity, communication, and fire protection, to name just a few. During their stay in Macao, the experts thoroughly reviewed meteorological and disaster relief works in Macao and consulted relevant information about typhoon caused damages. They also visited the civil defense operation center and other departments and made field survey of disaster scenes. By comparative analysis, evaluation and summary, the expert team submitted an assessment report to Macao, which was released to the public on September 27.



Fig. 1.19. A group photo of the HATO assessment team and Macao government officials.

### 3.5 Civil affairs activities promotes exchange

A China-ASEAN Seminar on Scientific & Technological Innovation for Typhoon Disaster Response, co-sponsored by the Chinese Ministry of Civil Affairs National Disaster Reduction Center and Guangxi Zhuang Autonomous Region Civil Affairs Department, was held on September 14 of 2017 in Nanning, Guangxi. Representatives, from the ASEAN countries, the ASEAN Secretariat, the United Nations Food Program and other international/regional organizations, and Chinese experts/scholars had an in-depth discussion of a range of related issues at the meeting. The seminar, the second of its kind since the first meeting held in 2016 under the framework of China-ASEAN Expo, was organized to discuss the issues of disaster risk management at a high-level forum. Participants had extensive and in-depth dialogues on a range of issues regarding disaster prevention and mitigation, including the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030, raising the level of scientific disaster reduction and enhancing the capacity of

disaster risk transfer, among others.



Fig. 1.20. China-ASEAN Seminar on Scientific and Technological Innovation for Typhoon Disaster Response.

### 3.6 CMA International Training Course on Typhoon Monitoring and Forecast in 2017

An international training event on typhoon monitoring and forecast, sponsored by the China Meteorological Administration, was staged during September 18-27 to promote the Typhoon Committee's regional cooperation and to enhance the typhoon monitoring and warning capability of the members in the region. The 10-day training course covered rich contents, including the latest developments in the areas of satellite imagery based tropical cyclone and marine weather analysis, quantitative precipitation forecast, severe weather forecast, sea wave forecast and storm surge forecast, in addition to DVORAK practices and operations. Ton Thi Thao from Vietnam, Phatcharee Pratead from Thailand and Aldczar D. Aurelio the Philippines, attended the training.

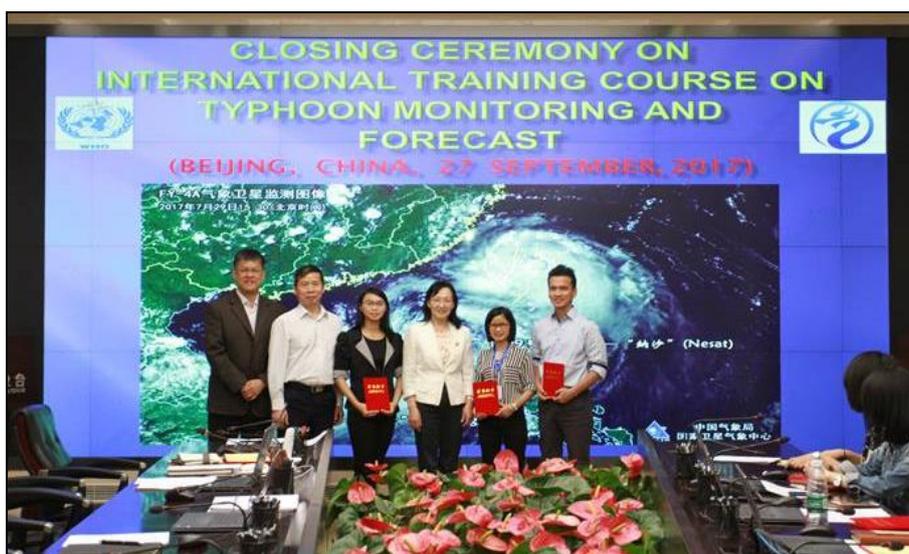


Fig. 1.21. International training course on typhoon monitoring and forecast of CMA in 2017.

## **II. Summary of Progress in Priorities supporting Key Result Areas**

### **1. Typhoon information spread on social media**

#### **Main Text:**

Thanks to the rapid development of new media in China represented by microblog (Weibo) and WeChat, China's Central Meteorological Observatory (another saying of National Meteorological Center, NMC) has worked hard to attract more public attentions taking advantage of the social media platforms and diversified means. Social media helps it disseminate typhoon related scientific knowledge, forecast and disaster prevention/mitigation information in a timely manner.

At present, microblogging makes the largest social media in China. NMC has attracted 850,000 fans for the daily weather forecast, weather disaster warning, weather conditions, weather related scientific knowledge. Recently, NMC launched a typhoon naming activity on its microblog last September. The activity has attracted great attention of the public as it is supposed to select a name for typhoon. The activity resulted in 57 million webpage views, 137,000 discussions, 18 million per microblog entry views, and the participation of more than 100,000 Chinese netizens. The NMC microblog won the Award of Top Ten Government Service Cases in 2017 at a government influence summit held in Tianjin. The Award is created to encourage the fine government microblogs that have improved government services, innovative applications and the transparency of government affairs (Figure 2.1).

The NMC WeChat with 200,000 subscribers is another effective platform for enhancing the public awareness of meteorological sciences. Taking advantage of the easy-going features of new media, the platform releases weather details/forecasts and meteorological knowledge packed in simple and popular languages. WeChat annually releases some 200 articles, 20% of which are popular science articles, with typhoon-related popular science articles topping the list. For example, it published two popular articles on the three typhoons' marine dogfight that makes track forecast more difficult and on why super typhoon SOUDELOR has won an inland tour in 2015, an article on why we had a long delayed typhoon in 2016, and an article briefing the merging battle between typhoons HAITANG and NESAT that eventually contributed to a week-long rainfall in 2017.

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

Releasing weather news via social media enjoys the merit of much reduced restrictions that imposed on the orthodox journalism that only releases simple and concise weather forecasts. Now one can air an in-depth analysis of weather situation, and explain to the public the possibility and uncertainty embedded in the forecast in a true-to-the-fact and objective manner, which enhances the public understanding of meteorological forecast and avoids unnecessary misunderstanding.

#### **Priority Areas Addressed:**

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

**Contact information:**

Member: China

Name of contact for this item: Liu Xinzhu, National Meteorological Center of CMA.

Telephone: +86-10-58995859

Email:liuxz@cma.gov.cn

## **2. Advances in typhoon forecasting techniques**

### **Main Text:**

#### **1) Member optimization based typhoon precipitation correction technique**

Ensemble numerical prediction, as a technique, allows one to estimate prediction errors in a quantitative manner. It makes a dynamic method for predicting the uncertainty. In this context, it has a role to play in preparing the prediction products that may produce large errors, such as heavy rain prediction. The National Meteorological Center has developed an advanced real-time typhoon precipitation correction method built on the real-time typhoon track correction technique and statistical precipitation products. The new technique has achieved fine results in prediction operations. The member optimization correction technique is able to enhance the traditional ensemble statistical products that would be used in predicting the possible rainfall in a typhoon process. When predicting a heavy rainfall, the member optimization products have shown some advantages over the ECMWF's products, and may serve as a reference to the forecasters. The member optimization technique enables short-term prediction to see more improvement, compared with the medium-term prediction. In the same context, it enables exceptional heavy rainfall prediction to see more improvement, compared with large or heavy rainfall prediction (Figure 2.2).

#### **2) Real-time run of TEDAPS system**

TEDAPS, or the Typhoon Ensemble Data Assimilation and Prediction System, developed based on GSI-hybrid data assimilation system, has been put into real-time test since the year of 2015. It runs twice daily for GSI-hybrid data assimilation and WRF model 72h forecast with 21 ensemble members and 27km resolution. Besides deterministic forecast, uncertainty forecast products are provided including TC hit probability, cumulative wind probability, precipitation probability, ensemble spread, etc. The evaluations show the track error are 66.2 km (70.6 km) of 24h forecast, 112.43 km (128.2 km) of 48h forecast and 180.6 km (234.0 km) of 72h forecast in 2015 (2016) typhoon season, respectively.

#### **3) Ensemble prediction experiments for Typhoon track and intensity**

The GRAPES-TCM is used to make ensemble prediction experiments for Typhoon Muifa (1109) in 2011. Three kinds of ensemble schemes are designed for the experiments. Every scheme has six ensemble members, which reflect the uncertainty of the model. The method of multiple physics (MP) is used to form the members of Scheme 1. The method of stochastic total tendency perturbation (STTP) is used to form the members of Scheme 3. Both the MP method and the STTP method are used to form the members of Scheme 2. Thirty-six experiments are made and the integration time is 72 h.

#### **4) Storm surge prediction**

A storm surge model, developed by meteorologists in Guangdong, has played a role in predicting the storm surges caused by typhoons in 2017. It made a prediction 36 hours in advance that typhoon HATO would cause a peak storm surge up to 2m in Xiangzhou, part of Zhuhai, or a peak water level up to 3.5m when the impact of astronomical tide is taken into account, exceeding the local red warning level by 3.15m. The observed results showed that the tidal wave level reached the red warning line in Zhuhai. In addition, it made a prediction 48 hours in advance that typhoon PAKHAR would cause a peak storm surge up to 2m in the coastal area of Taishan, part of Guangdong. The observed results

showed the coasts of Taishan having a peak storm surge up to 1.7m.

**Priority Areas Addressed:**

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

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

Enhance RSMC capacity to provide regional guidance including storm surge, responding to Member's needs.

**Contact information:**

Member: China

Name of contact for this item: Cao Yong, National Meteorological Center of CMA.

Telephone: +86-10-58995149

Email: caoyong@cma.gov.cn

Zeng Zhihua, Shanghai Typhoon Institute of CMA.

Telephone: +86-21-54896103

Email: zengzh@mail.typhoon.gov.cn

Chen Zitong, Guangzhou Tropical Institute of CMA.

Telephone: +86-20-39456551

Email: ztchen@grmc.gov.cn

### **3. Advances in Typhoon numerical modeling and data assimilation**

#### **Main Text:**

#### **1) High resolution South China Sea typhoon model**

A South China Sea typhoon model was put into operation in 2016 with a stable prediction performance. The model's horizontal resolution has been increased to 9km, based on the TRAMS 2.0 version. With an unchanged coverage, the model optimized its dynamic framework to enhance the accuracy of differential calculation and air pressure gradient calculation. One-year tests showed that the new version model enjoys a prediction performance that is better than the existing version, with a noticeable improvement of severe typhoon prediction that used to be weak in performance.

#### **2) Improved precipitation conversion parameters in the convective parameterization scheme**

Researchers improved precipitation conversion parameters of a convective parameterization scheme in the South China Sea Typhoon Model, based on the simulation results of cloud resolution modeling. The improved parameterization scheme is applied to test the sensitivity of typhoon prediction to the precipitation conversion rate. In the former SAS version, precipitation conversion rate was assumed a constant that does not vary over height. The modified parameter can be reduced with height in the context of condensation. It means less upper-air hydrates would be converted to precipitation, compared with the former version. Statistical results show that the new scheme is able to improve the model's typhoon track and intensity prediction.

#### **3) Sea surface temperature parameterization**

In the former version of South China Sea Typhoon Model, sea surface temperature was provided by the model's initial field assuming it was a constant when preparing the prediction. The simplification, as such, is unreasonable for simulating an ocean-atmosphere interaction process, and would compromise the calculation of sea surface flux and the results of typhoon prediction. In this context, researchers introduced in the model a simple sea surface temperature prediction scheme based on the sea surface energy balance. Experimental results showed that the combined application of the sea surface temperature parameterization scheme and the use of the sea surface temperature derived from satellite observations as initial sea surface temperature can improve typhoon track and intensity prediction, especially at later stages.

#### **4) Typhoon regional assimilation prediction system (T-RAPS)**

Development of typhoon regional assimilation and prediction system (T-RAPS) : The couple of regional ocean model (ROMS) and atmosphere model is achieved on T-RAPS. The operational TC forecast with assimilation is established and used in the real-time forecast for TC during 2015 to 2016.

#### **5) WRF based typhoon wind engineering modeling and application**

Based on the Weather Research and Forecasting (WRF) model for TCs (EMTC) is developed for engineering wind-resistant design. Results show that the EMTC model could output fine-scale wind fields, which are similar to the observations. And they could be used to calculate engineering wind parameters to provide quantitative references for wind-resistant design.

## **6) Advances in global typhoon model development**

A WRF global model was successfully run, initialized with 0.25 degree FNL reanalysis data, disabled the read of boundary condition. The model is quadruple nested, with the resolution of 10, 30, 90 and 270km (global resolution), from inner to outer. For the single typhoon cases, the predicted  $\leq 7$  days tracks of the global model are closer to the best track, better than the regional model. The next step is to simulate more typhoon cases to evaluate the global model performance in typhoon prediction, and to improve vortex initial field by carrying out sensitivity experiments.

### **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.

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

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

### **Contact information:**

Member: China

Name of contact for this item: Li Ying, the Chinese Academy of Meteorological Sciences.

Telephone: +86-10-68405830

Email: liying@camsma.cn

Chen Zitong, Guangzhou Tropical Institute of CMA.

Telephone: +86-20-39456551

Email: ztchen@grmc.gov.cn

## 4. Subjective and numerical prediction results assessment

### Main Text:

Researchers assessed the track and intensity prediction results stemmed from subjective prediction, numerical deterministic prediction and ensemble prediction as follows:

#### 1) Track prediction

Figure 2.3 shows the errors derived from the official 24h-120h subjective predictions along track (AT) and cross track (CT). Both AT and CT did not see noticeable deviations within 48h. However, both JTWC and KMA have predicted the tracks that would be faster and more right over time compared with the observed results. Meanwhile, HKO and JMA have generated the results that are noticeably more right with CMA being slower and more left compared with the observed results. Comparing with the official track prediction results, the models presented uneven prediction results. In 2016, the majority of the models would confine their 24-h track prediction errors to 80 km or below, though there are two models having an error larger than 100 km. ECMWF-IFS has enjoyed a steady improvement of its prediction performance during the past six years. Its 120-h track prediction error was only 326.7km in 2016, the smallest amid all the prediction methods tested.

The assessment also presents the averaged ensemble track errors of 6 ensemble prediction methods during 2016. In 2016, ECMWF, UKMO and NCEP were rated as the three best prediction systems in terms of their track prediction performance. Meanwhile, the ECMWF and UKMO had an averaged ensemble track prediction error less than 400km for 120-h.

#### 2) Intensity prediction

Table 2.1 shows the absolute maximum wind speed errors stemmed from different prediction systems in 2016. It is important to note that all the wind speed data have been, before the test, converted to an averaged 10-minute wind speed in line with WMO's documentation. Figure 2.4 shows the BS scores derived from the same and different samples comparisons among the 6 ensemble prediction systems in 2016. Results showed that the ECMWF's ensemble intensity prediction is much better compared with the remaining five ensemble prediction systems as far as the short term is concerned. The performance became more prominent in the same samples comparison. Comparing with 2015, ensemble intensity prediction has seen laudable progresses in performance, with an improvement ranging from 5% to 40%. It is worth mentioning that the NCEP's ensemble intensity prediction results has enjoyed a more than 20% improvement from 48h to 120h.

### Priority Areas Addressed:

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

### Contact information:

Member: China

Name of contact for this item: Zeng Zhihua, Shanghai Typhoon Institute of CMA.

Telephone: +86-21-54896103

Email: zengzh@mail.typhoon.gov.cn

## **5. FY-4A's role in typhoon monitoring in 2017**

The FY-4A satellite is the first launched satellite of China's new generation geostationary meteorological satellites. It was launched in Xichang satellite launching center on 11 December 2016, and fixed on the space over the equator at 99.5 °E, officially named as FY-4A. On 5 March 2017, the FY-4A fixed on the 105 °E service observation position. The FY-4A satellite carried four types of remote sensing instrument, including multi-channel scanning radiometer (AGRI), atmospheric sounding interferometer (GIIRS), lightning imaging sensor (LMI) and space weather monitor (SEP). High temporal-spatial resolution image covering 14 channels could be provided by AGRI, it's including of near infrared bands, vapor bands and visible bands. The observation time of FY-4A is 15 minutes and the highest spatial resolution is 500 meters, which allowed to acquire cloud images with plentiful gradation. During the in-orbit test, FY-4A satellite data have been applied in the typhoon and depression monitoring covering northwest Pacific Ocean and the south China sea in 2017. The application results showed the FY-4A images could provide better result in distinguishing the detailed texture of cloud; gives better analysis result of the mesoscale and small-sized cloud structure inside the typhoon; and analysis the water vapor transportation in different levels. These traits made FY-4A could support the important decision making in the typhoon monitoring, analysis and forecast.

On 25 September 2017, the new generation of geostationary meteorological satellite FY-4A have been handover to China meteorological administration. The FY-4 satellite has international advanced comprehensive technique and performance, and its handover is the milestone of China's geostationary meteorological satellite observation system development. Moreover, the successful handover of FY-4A satellite is important significant to ensure the continuity, reliability, and stability of meteorological observation service in China, and revealed the international influence of our country's aerospace and meteorological industry.

### **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.

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

### **Contact information:**

Member: China

Name of contact for this item: Wang Xin, National Satellite Meteorological Center of CMA.

Telephone: +86-10-68407927

Email: xinwang@cma.gov.cn

## **6. Ocean observing system and experiment**

### **Main Text:**

#### **1) Observation and study of typhoon over South China Sea**

A parameterization scheme for shallow, medium and deep sea water vapor drag coefficients, based on the data released from the Maoming Bohe Marine Meteorological Experiment Center. A sequential analysis of the sea-air flux in the typhoon process over time shows that the atmosphere would feed heat to the ocean from the right front quadrant of typhoon, while the ocean would transport heat to the atmosphere from the right rear quadrant. An additional analysis of the observed results of sea and air temperature indicates that the flux difference is mainly caused by temperature differences within the different quadrants at the same height.

#### **2) Drifting buoy for typhoon observation**

Thanks to two-year's technical development, China has made a breakthrough in the development of marine drifting buoy observers. China has tested its prototype drifting buoy observers during June-August of 2016 in multiple sea areas. The test has obtained the observations of severe typhoon NIDA in 2016, and the observations of HATO and MAWAR in August of 2017. Thanks to the deepening of the experiment, China will have more means to acquire typhoon data, enhancing China's typhoon observing capability.

### **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.

### **Contact information:**

Member: China

Name of contact for this item: Chen Zitong, Guangzhou Tropical Institute of CMA.

Telephone: +86-20-39456551

Email: ztchen@grmc.gov.cn

Li Xiaoxia, Meteorological Observation Center of CMA.

Telephone: +86-10-58995861

Email: lxxaoc@cma.gov.cn

## **7. Advances in scientific research on typhoons**

### **Main Text:**

#### **1) Key typhoon research project**

The typhoon key research project of Natural Science Foundation of China, Theoretical study of tropical cyclone intensification theory based on Carnot heat engine, is approved. Based on the concept of a non-steady Carnot heat engine, this project attempts to develop a theoretical dynamical model system that can quantitatively estimate TC intensity change by introducing a dynamical-efficiency coefficient to the TC heat engine system. This coefficient is assumed to be a function of the TC inner- and outer-core inertial stability, the inner-core asymmetry, and environmental vertical wind shear (EVWS), and etc, and will be quantitatively determined by data analyses and ensemble numerical experiments.

#### **2) CRA verification of landfalling typhoon rainfall**

The CRA precipitation verification method, proposed by Dr. Beth Ebert in 2000, is different from the traditional precipitation verification method, as it is mainly designed to analyze the systematic errors of a precipitation prediction. The CRA verification method showed that China's typhoon precipitation prediction found its main errors in precipitation forms. The errors stemmed from precipitation forms would be reduced over the rise of precipitation levels, with a steadily increased position deviation from the precipitation center. This could be associated with the increased typhoon track errors in a long-term prediction. One may make a simple correction to offset the position deviation from the precipitation center as detected by the CRA method, and substantively improve the 48h and 72h precipitation prediction scoring.

#### **3) The statistical study of tropical cyclone unusual track**

Based on the best track dataset, the unusual track of tropical cyclone in the Vicinity of China's Coastal Waters During 1949-2013 are studied, including sharp westward turning, sharp eastward turning, sharp northward turning, sharp southward turning, looping, rotating, and zigzagging tracks. Their spiral and temporal distribution and associated circulations are investigated.

#### **4) Diurnal variation of tropical cyclone precipitation over land**

An analysis of the regular hourly rainfall data shows that there are significant diurnal variation signals in TC precipitation, with a peak in the morning and a bottom in the afternoon. TC's peripheral zone (400-900 km from the center) would have a diurnal variation larger than the main circulation zone (within 400 km from the center). As a consequence, a TC that makes landing during night would generate 30% more rainfall (combined precipitation within 12 hours after landing) compared with the one landing at noon or in the afternoon, due to the diurnal variation of precipitation signals.

#### **5) The tropical cyclone (TC) intensification rate (IR)**

The relationship curve between IR and TC intensity is a smoothing curve constructed by natural cubic splines for the univariate case. When TC intensity is stronger (weaker) than 36-41m/s, the IR and TC intensity change have positive (negative) correlation. The inner size of TC (radius of maximum wind) the outer-core wind skirt is anti-correlated with IR. Also, by introducing maximum

potential intensification rate (MPIR), a relationship between MPIR is found. MPIR increases as SST increasing, especially when SST is higher than 27°C.

**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.

**Contact information:**

Member: China

Name of contact for this item: Li Ying, the Chinese Academy of Meteorological Sciences.

Telephone: +86-10-68405830

Email: liying@camsma.cn

Zeng Zhihua, Shanghai Typhoon Institute of CMA.

Telephone: +86-21-54896103

Email: zengzh@mail.typhoon.gov.cn

## **8. Advancement on CMACast and WIS**

### **Main Text:**

1) CMACast is a satellite data broadcasting system built on the DVB-S2 standard. It is an important component of CMA's domestic and international communications system. It makes real-time weather data broadcasts to the Asia-Pacific region via ASIASAT-4's C-band transponders and the low-cost satellite receivers at a rate of 70Mbps. CMACast broadcasts an array of data products, including global ground/upper air observations, satellite remote sensing data and products, NWP products and radar products. OF them, the satellite data are mainly collected from FY-2E/F/G, FY-3B/C, Meteosat 7/10/11, Metop A/B, NOAA 19, GOES-13/15, Jason-2, and TERRA/AQUA. Meanwhile, CMACast is an Asian Regional Center of GEONETCast, and has a data exchange and re-broadcasting service with both EUMETSAT and EUMETCast. As of September 2017, CMACast has possessed 2,688 registered users in China, and 24 registered users in other Asia-Pacific countries. The combined used of CMACast and MICAPS can greatly enhance the applications of the data received from the CMACast.

2) CMA is an ardent participator and promoter of the WIS implementation. In 2017, 4 Beijing GISC and CMA product centers (DCPCs) have run smoothly, and provided a range of products, including FY satellite products, T639 global medium-scale NWP products, T213 ensemble prediction products, typhoon model ensemble prediction products, global/Asian regional climate monitoring products and other data discovery and access services, to North Korea, Mongolia, Nepal, Pakistan, China Hong Kong, China Macau and other WMO's members in the Asia-Pacific region. Beijing GISC has released 103,038 entries of metadata to 114 registered users, providing data services in a volume of 740GB/day. Beijing GISC released on September 5 the Beijing GISC online Version 2. In addition, the China Meteorological Administration has since September 2015 provided CMACast, MICAPS and WIS related training to some WMO Members, including Pakistan, North Korea, Myanmar and Laos, accommodating the needs of Beijing GISC members and WMO's members in Asia for WIS implementation, data access and applications. The effort has played a positive role in facilitating and promoting the implementation of WIS in the Asian region.

### **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.

### **Contact information:**

Member: China

Name of contact for this item: Wang Peng, National Meteorological Information Center OF CMA.

Telephone: +86-10-68406564

Email: wangp@cma.gov.cn

## **9. Ministry of Civil affairs strengthened typhoon disaster risk management and disaster response/relief**

### **Main Text:**

#### **1) Timely warning/loss assessment and effectively reduced disaster losses**

In 2017, the National Disaster Reduction Committee and the Ministry of Civil Affairs made their respective early warning response twice to fight typhoons HATO and MAWAR. The two government agencies issued emergency notices to the Central Relief Materials Reserve, guiding local civil affairs departments to get prepared for emergency relief. Meanwhile, they conducted 11 rounds of assessment of typhoon disaster early warning and losses, and 5 rounds of remote sensing based evaluations (Figure 2.5). They provided decision-making related reference to civil affairs authorities for personnel evacuation and emergency supplies scheduling.

#### **2) 24-hour disaster monitoring and real-time information release**

In 2017, the Ministry of Civil Affairs paid close attention to the disaster-affected areas before and after typhoon landing, and initiated 24-hour disaster watch. It uninterruptedly obtained disaster information and reports via 010-52829999 hotline, and from the national natural disaster management system. It received from provinces, cities and counties more than 2,800 pieces of information on 10 tropical cyclones affecting China, and released about 60 issues of information products to the State Council Administrative Office, the CPC Central Committee General Office, and the National Disaster Reduction Committee.

#### **3) Disaster reporting and information release**

In 2017, the national natural disaster management system upgraded and improved its functionalities with a refined management, mobile based remote management and an enhanced decision support capability. Up to date, all the provinces in the country have opened a township or community based disaster reporting network, with a steadily increased use of mobile disaster reporting APP across the provinces, cities, counties, townships and villages. The national disaster information database has completed the registration of 730,000 disaster informers and associated information updates. It pushes daily real-time disaster and disaster relief information to the public via its public WeChat number "China Disaster Reduction". The public number has more than 8,300 subscribers, and has released some thousand pieces of information to the public (Figure 2.6).

#### **4) Training of disaster informers**

In 2017, the Ministry of Civil Affairs staged four rounds of national training events for disaster informers. It has trained 445 trainees to be the disaster management personnel in provinces, prefectures and some disaster-prone counties. It assisted seven provinces, including Beijing, Jiangsu and Anhui, staging training events for the grassroots disaster informers. It has helped the training of some 3,000 disaster informers at the county and township levels (Figure 2.7). The administrative level oriented training has enhanced disaster informers' risk awareness, sense of responsibility, disaster management capability and disaster reporting instincts.

**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.

**Contact information:**

Member: China

Name of contact for this item: Sun Zhou, Disaster Reduction Center, the Ministry of Civil Affairs.

Telephone: +86-10-52811141

Email: sunzhou@ndrcc.gov.cn.

## **10. Big data based smart typhoon application system**

### **Main Text:**

Typhoon and associated meteorological, marine and disaster data creates a huge database containing massive multi-sourced observational data, numerical modeling data, and industry-wide data in diverse formats. Thanks to the hourly updates of satellite, radar and other observational data and the application of high-resolution numerical modeling products, the data volume has seen an accelerated growth. Statistics released by CMA show that the data storage volume increased by 6.54TB per day in 2015, and expect a ten-fold increase to 62.53TB in 2020. A meteorological big data era has arrived.

To address the frequent retrieval, use and handling of above mentioned data in real-time typhoon prediction operations and services, the National Meteorological Center launched in 2017 an R&D project to develop a big data based smart typhoon application system, and created a historical best typhoon track database with a statistical function that allows forecasters to search and review historical typhoons in a multi-dimensional, fast and accurate manner. It also made some observations and numerical modeling data part of the data pool, serving forecasters' daily activities. In the future, it will perfect the design of database, adding more data in the source pool, and exploring a smart typhoon application system that goes hand in hand with time.

### **Opportunities and challenges:**

An integrated application of massive multidisciplinary and multi-sourced data and data cloud storage and processing is the issue to be addressed in the future.

Typhoon forecast shall explore the possible use of numerical modeling based smart processing technique, taking advantage of the bonus of existing models, and realizing the driving effects of double engines: numerical modeling plus artificial intelligence.

### **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.

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

### **Contact information:**

Member: China

Name of contact for this item: Wang Qian, National Meteorological Center of CMA.

Telephone: +86-10-58995840

Email: qianwang@cma.gov.cn

## **11. CMA tropical cyclone training**

### **Main Text:**

In 2017, the China Meteorological Administration Training Center sponsored a training course on tropical cyclones, focusing on strengthening trainees' theoretical knowledge and promoting the application of new methods and data in typhoon prediction, enhancing trainees' operation and application capability and widening their horizon. Including:

1) Training Workshop on FY-4 Meteorological Satellite and the application of satellite data in weather analysis and forecast. In January 2017, 66 trainees participated in the workshop. The courses mainly include: basic principles of satellite meteorology, the development of FY-4, and the application of meteorological satellite products. In the typhoon monitoring section, it is exhibited that the application of domestic and foreign meteorological satellite in typhoon monitoring and the prospect of the application of FY-4 Meteorological Satellite products.

2) International Training Workshop on the Application of Meteorological Satellite Products. The tenth workshop was successfully held at the Training Center of CMA in Beijing from June 6 to June 16. 30 participants containing 21 international trainees and 9 Chinese trainees attended this workshop. The courses mainly include: introduction of FY meteorological satellite and satellite products, the application of satellite data in severe convective weather, the application of satellite data in tropical cyclone and satellite weather application platform (SWAP). Dr. Zhang Wenjian from WMO was invited to introduce WMO satellite program through video-conference system.

### **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.

### **Contact information:**

Member: China

Name of contact for this item: Wang Chen, the China Meteorological Administration Training Center.

Telephone: +86-10-68409220

Email: wangchen@cma.gov.cn

## Annexes



Fig. 2.1. Central Meteorological Observatory (NMC) Weibo won the Award of Top Ten Government Service Cases in 2017.

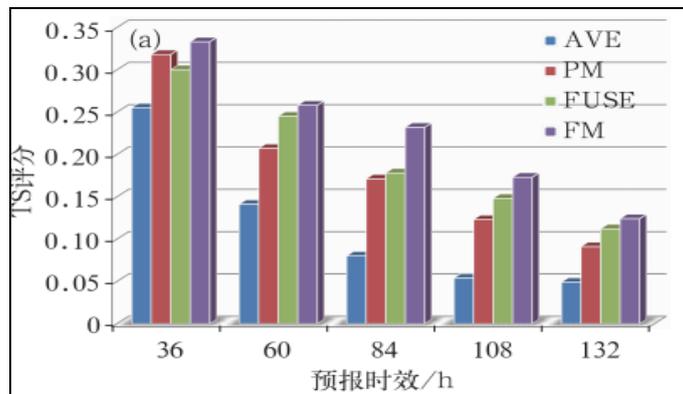


Fig. 2.2. TS scoring of 10 landing typhoon precipitation predictions based on improved PM, FUSE and FM algorithm products using AVE and member optimization, 2013-2015.

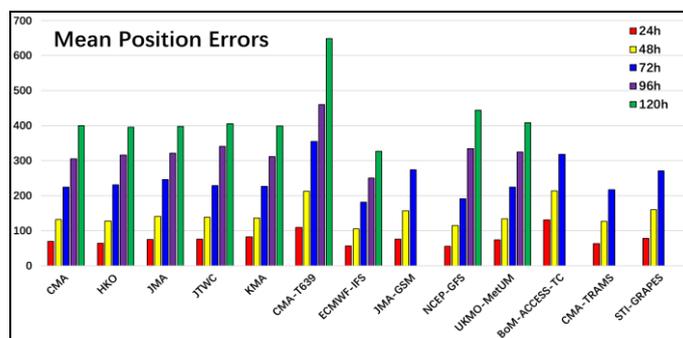


Fig. 2.3. Track prediction errors in 2016 from official subjective forecast, global modeling and regional modeling; 24h (red), 48h (yellow), 72h (blue), 96h (purple) and 120h (green).

Table 2.1. Averaged absolute wind speed errors for 24, 48, 72, 96 and 120h made by different forecasting systems in 2016 (Parentheses show the sample numbers in m/s)

Method		Lead times				
		24h	48h	72h	96h	120h
Official Guidance	CMA	5.10(363)	7.24(272)	7.13(196)	7.95(133)	9.07(85)
	HKO	5.12(214)	6.98(161)	8.42(112)	7.90(72)	10.16(44)
	JMA	5.30(358)	7.68(275)	8.96(200)	/	/
	JTWC	5.40(306)	6.11(221)	7.48(152)	8.02(84)	12.10(41)
	KMA	5.39(198)	8.33(144)	9.49(96)	8.22(56)	7.96(28)
Global NWP Models	ECMWF-IFS	9.22(141)	10.88(110)	11.28(83)	9.45(56)	7.24(34)
	JMA-GSM	6.92(336)	11.20(254)	13.64(184)	/	/
	NCEP-GFS	8.57(320)	10.81(205)	12.64(164)	15.29(98)	12.48(65)
	UKMO-MetUM	9.48(169)	10.67(126)	10.83(90)	10.45(58)	10.67(36)
Regional NWP Models	BoM-ACCESS-TC	8.19(52)	13.25(36)	14.38(21)	/	/
	CMA-TRAMS	8.60(158)	12.81(117)	13.13(85)	/	/
	STI-GRAPES	5.86(266)	7.35(212)	9.78(152)	/	/

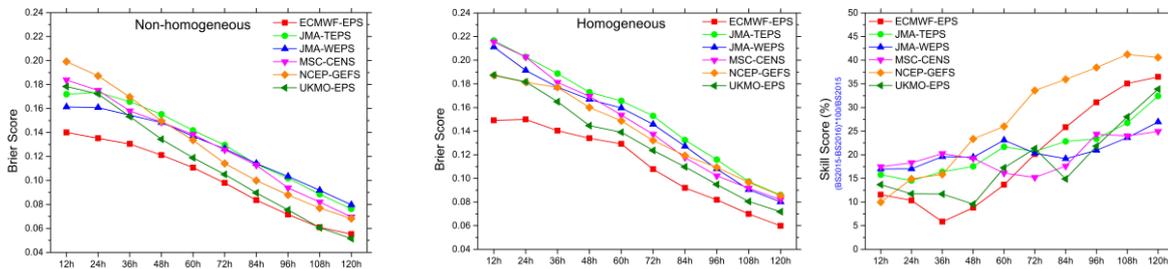


Fig. 2.4. BS scoring of ensemble intensity predictions in 2016. Left: different samples comparison; middle: same samples comparison; and right: scoring comparisons between 2016 and 2015.

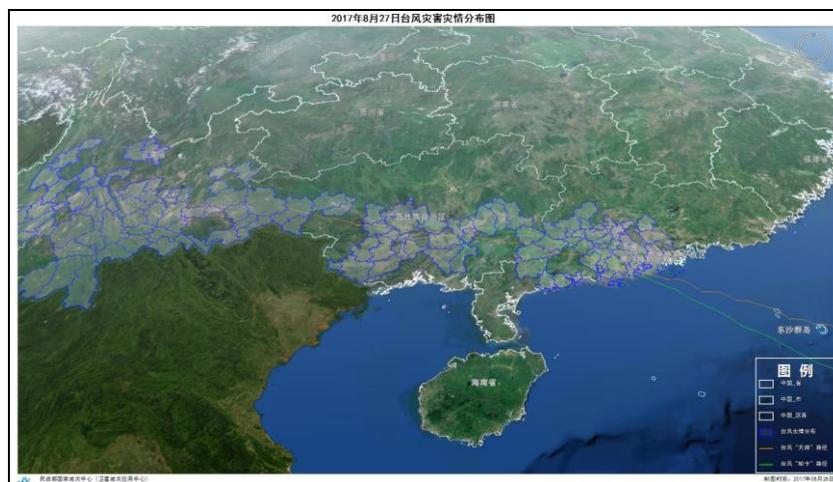


Fig. 2.5. A remote sensing image of the disasters caused by typhoon HATO.



Fig. 2.6. Typhoon HATO information released by the public WeChat number: China Disaster Reduction.

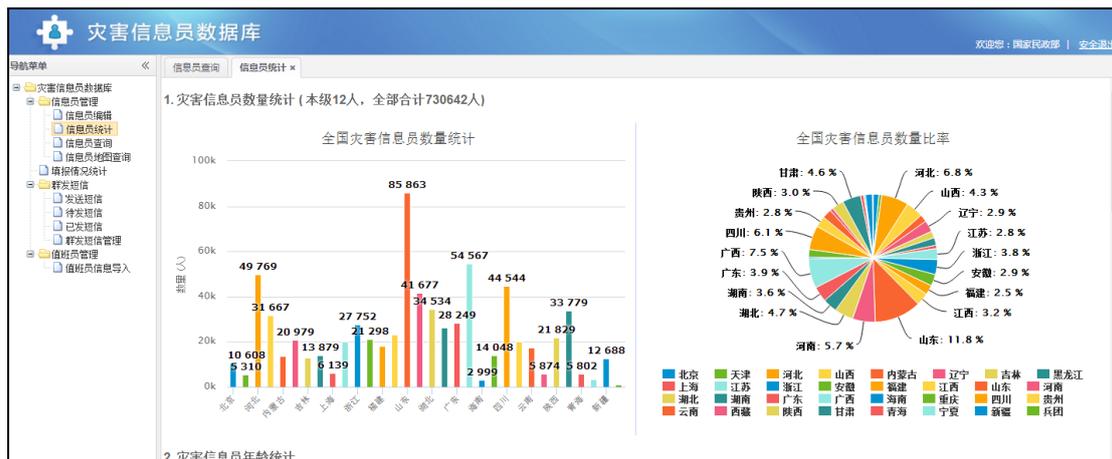


Fig.2.7. Disaster informers database by province.