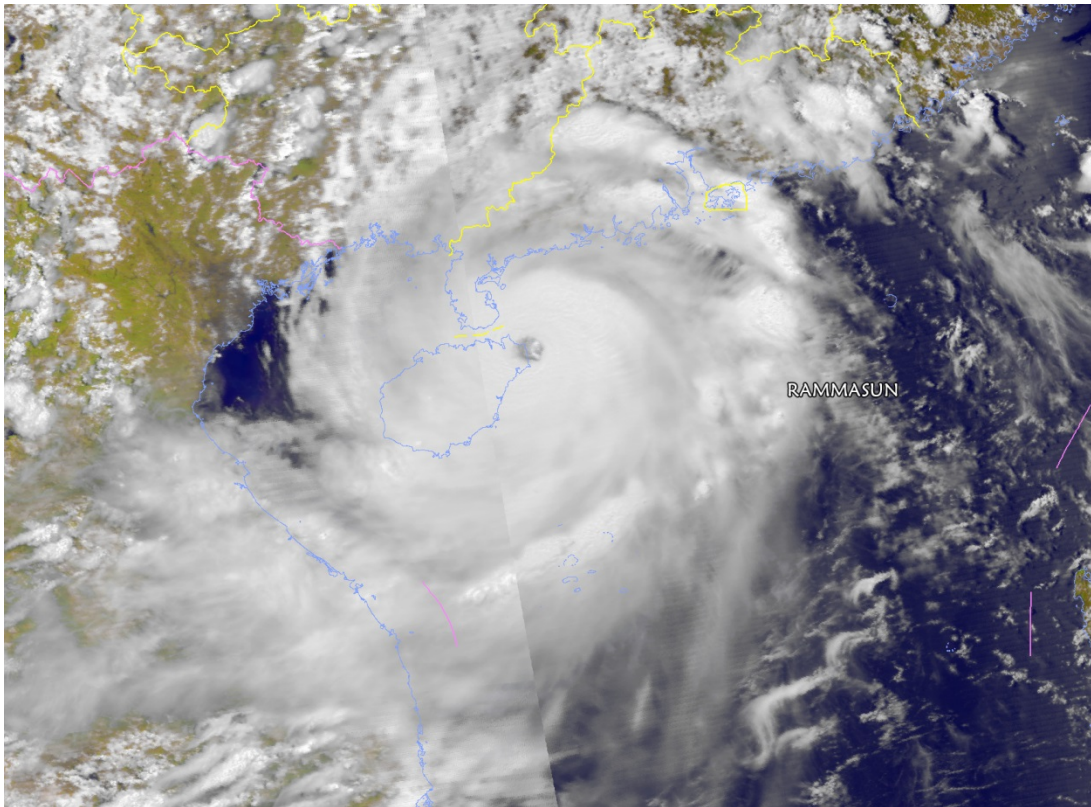


# **Member Report**

## **(2014)**

### **ESCAP/WMO Typhoon Committee**

#### **9<sup>th</sup> Integrated Workshop**



**China**

Thailand

20-24 October 2014

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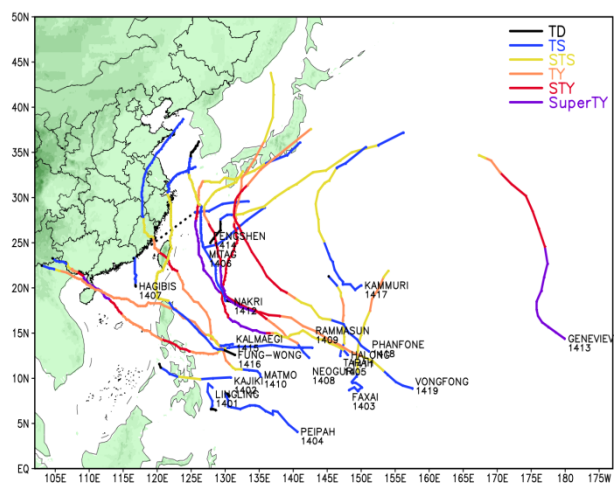


# I. Review of Tropical Cyclones Which Have Affected/Impacted Members Since the Previous Session

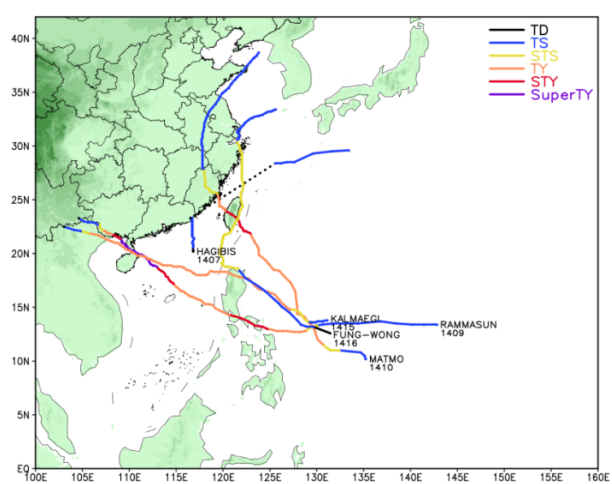
## 1.1 Meteorological and Hydrological Assessment

From January to April 2014, the surface sea temperature (SST) along equatorial Central and East Pacific was colder than normal in most time, while tropical West Pacific SST was warmer and the latitudinal Walker Circulation in Equatorial region was stronger. Such conditions were favorable to the genesis of tropical cyclones and obviously led to more typhoons generated than usual in the same period. Starting from May, SST in equatorial Central and East Pacific rose quickly, and the tropical atmosphere began to respond to warming SST. But a tropical subtropical high was also found in May, which was persistently stronger, larger and further southerly located than normal years. That explained the reason why there were fewer tropical cyclones generated from western North Pacific between May and August. Especially in August, due to sub-seasonal oscillation, a movement of weak eastward phase was found in tropical atmosphere, which depressed the convective activities in equatorial West Pacific. Accordingly, summer monsoon in the South China Sea was significantly weak and the monsoon trough was not easily formed. As a result, there was only one numbered typhoon, which hit the lowest record since 1951.

From 1 January to 14 October 2014, 19 tropical cyclones (including tropical storms, severe tropical storms, typhoons, severe typhoons and super typhoons) were formed over the western North Pacific or the South China Sea (Fig. 1.1). Out of 19, 5 tropical cyclones made landfall on the coasts of East China or South China (Fig. 1.2). More specifically, these landed tropical cyclones were tropical storm HIGIBIS (No.1407), super typhoon RAMMASUN (No.1409), severe typhoon MATMO (No.1410), typhoon KALMAEGI(No.1415), and severe tropical storm FUNG-WONG (No.1416).



**Fig. 1.1** Tracks of TCs over the western North Pacific and South China Sea from 1 Jan. to 14 Oct. 2014



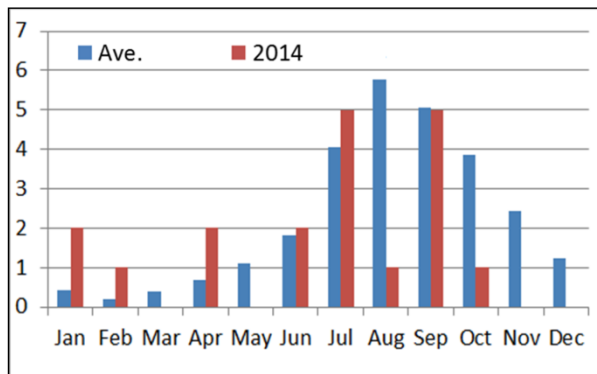
**Fig. 1.2** Tracks of TCs that made Landfall over China from 1 Jan. to 14 Oct. 2014

### 1.1.1 Characteristics of the tropical cyclones in 2014

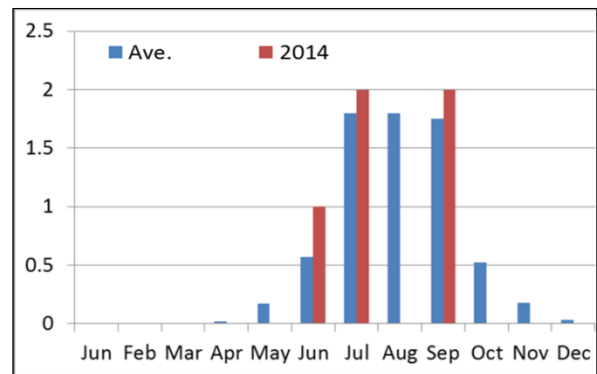
The characteristics of the tropical cyclones in 2014 were described as follows:

**1) The total number of tropical cyclones generated is fewer than usual, particularly in August.**

By 14 October 2014, totally 19 tropical cyclones over the western North Pacific and the South China Sea had been numbered, which were less than the historical average number (21.6) in the same periods. 5 of them landed on China's coasts, which were again less than the annual average number (6.4) of the landed TCs in the same historical periods. According to CMA's best track data, the average number of tropical cyclones generated in January over the past 65 years was only 0.4. However, the number of typhoons formed during this January was two, much higher than normal. In general, August witnessed 5.8 tropical storms generated over west North Pacific and the South China Sea, and it was a month with most tropical cyclones. The lowest record of TC genesis in August was two, which occurred in 1979. But there was only one in August of this year, which actually was the one moving from Central Pacific. This became an extreme and only case that no single tropical storm was generated in west North Pacific and South China Sea in August.



**Fig. 1.3** Normal monthly TC genesis compared with monthly TCs developed in 2014.



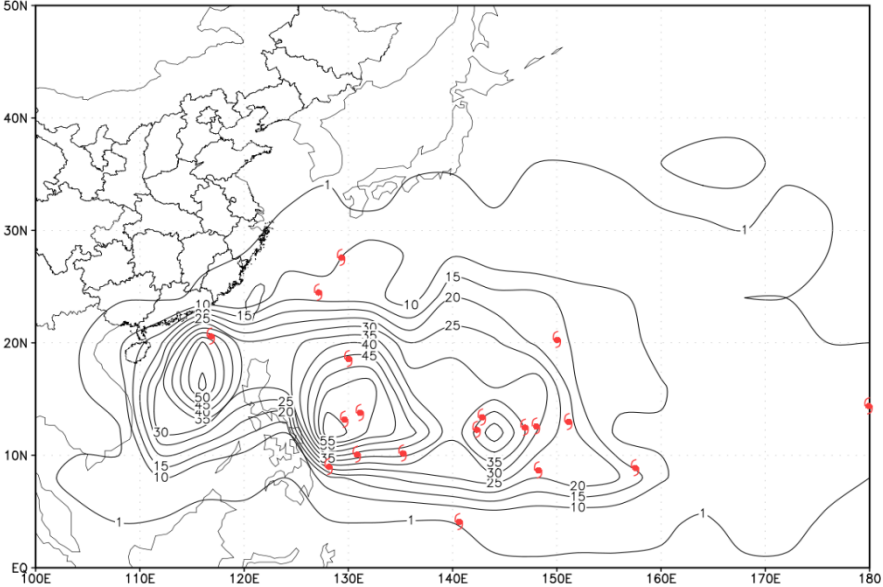
**Fig. 1.4** Normal monthly landfalling TCs compared with monthly TCs landed on China's coasts in 2014

**2) There were less landed typhoons but more typhoons made landfalls on more than 1 province**

As of 14 October, five (5) typhoons with tropical storm intensity or higher landed on China, which is 1.4 less than normal. But several typhoons made landfalls on three (3) provinces this year, which were rarely found in historical record. Tropical Storm HIGIBIS landed on Guangdong on 15 June, and Typhoon KALMAEGI landed on Hainan and Guangdong respectively. The other three typhoons made their landfalls on three provinces respectively: Super Typhoon RAMMASUN landed on Hainan, Guangdong and Guangxi; Severe Typhoon MATMO landed on Taiwan, Fujian and Shandong; Severe Tropical Storm FUNG-WONG landed on Taiwan, Zhejiang and Shanghai..

**3) Locations of genesis were almost the regions where tropical cyclones often formed, with less genesis over the South China Sea**

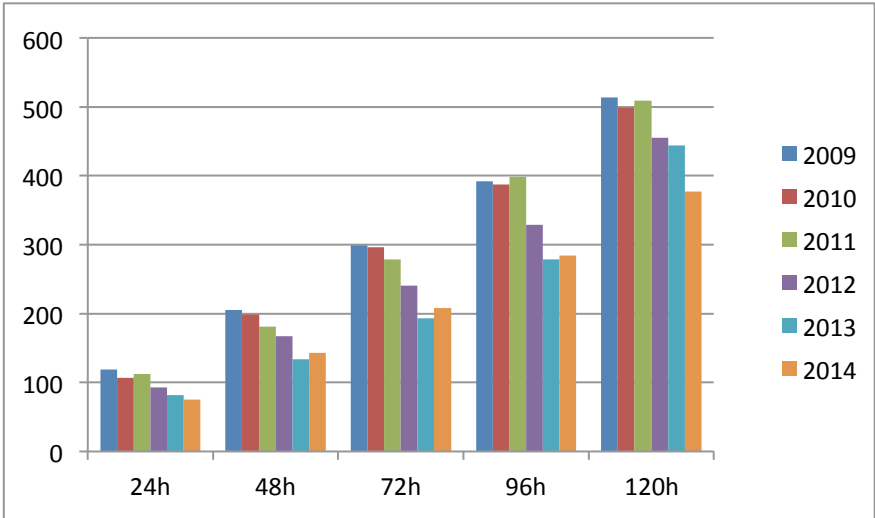
Within the western North Pacific and the South China Sea, there are mainly 3 regions where tropical cyclones were mostly generated: (1) northern part of the South China Sea; (2) ocean to the east of the Philippines; and (3) ocean near the Mariana Islands. In 2014, most tropical cyclones were formed in the latter 2 regions, and the number of tropical cyclones generated from northern South China Sea was significantly less than usual.



**Fig. 1.5** Distribution of TC-generating Source Density in NW Pacific and South China Sea in 1949-2012 (Unit: digit/ $\pi R^2$ ,  $R=250\text{km}$ ) Compared with TC genesis Locations in 1 Jan.- 14 Oct. 2014

**1.1.2 Advance in Operational Forecast**

During the past 5 years (2009-2013), the China Meteorological Administration (CMA) official TC track forecast errors showed a declining tendency. By 14 October 2014, the mean errors of TC track forecasts were 75km for 24 hours, 143km for 48 hours, 208km for 72 hours, 284km for 96 hours and 377km for 120 hours respectively, which were far below the normal mean.



**Fig. 1.6** CMA official TC track forecast errors between 2009 and 2014

### **1.1.3 Characteristics of major typhoon-induced rainfall that affected China in 2014**

In 2014, the major typhoon-associated heavy rain and floods that affected China could be characterized as follows:

1) Heavier rainfall and more suffered regions. Typhoon RAMMASUN, KALMAEGI and MATMO brought heavy rainfall in Hainan, Guangdong, Guangxi, Yunnan, Guizhou, Fujian, Jiangxi, Anhui, Zhejiang, Jiangsu, Shandong, Liaoning, Jilin and other places.

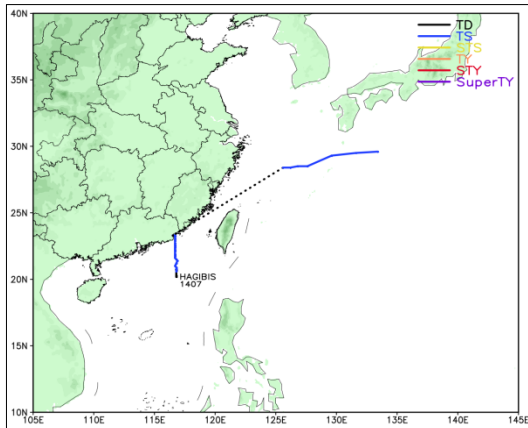
2) Flooding was widespread and floods in many rivers exceeded alerting water level. The flooding occurred in 13 provinces across South China, Southwest China, South of Yangtze River, Northeast China, and so on, and more than 60 rivers located in Hainan, Guangdong, Guangxi, Yunnan, Fujian, Zhejiang, Jiangxi, Jiangsu and Anhui witnessed the flood over alerting water level. More than 20 tide gauges reported high tides beyond the warning level, among which, the gauge in Haikou, Hainan recorded the highest tide since 1973 when it began to operate.

3) Some rivers in Hainan and Guangxi witnessed twice the large magnitude of flood beyond the alerting water level. Both Typhoon RAMMASUN and Typhoon KALMAEGI affected Hainan, Guangdong, Guangxi and others. The floods beyond alerting water levels, which were caused by the heavy rain from Typhoon RAMMASUN and KALMAEGI, occurred in Nandu River of Hainan, Yujiang River and its branch Zuojiang River of Guangxi, and some coastal rivers of Guangxi. In particular, the flood in Yujiang River of Guangxi exceeded alerting water level twice, Zuojiang River, branch of Yujiang River, witnessed 10-year-return-period flood, and the flood in the upper reaches of Nandu River of Hainan hit the record high, close to 100-year return period.

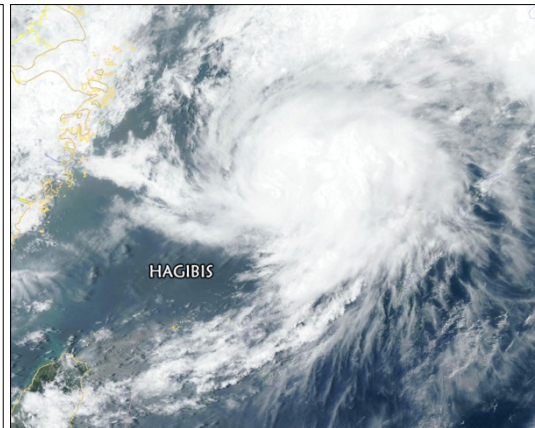
### **1.1.4 Tropical cyclones landed on China**

#### **1) Tropical storm HIGIBIS (No. 1407)**

At 00:00UTC on 14 June 2014, a tropical depression developed over northeastern South China Sea and moved north afterwards. At 06:00UTC 14 June, it developed into tropical storm HIGIBIS numbered 1407. It further moved north and approached the coast of Guangdong. It landed on Shantou, Guangdong at 08:50UTC on 15 June with maximum wind speed reaching Force 9 (23m/s) near its centre and central minimum pressure down to 986hPa at the landing time. After its landfall, it weakened rapidly and reduced to tropical depression in Guangdong at 12:00UTC on 15 June. The Central Meteorological Observatory (CMO) stopped the TC numbering at 15:00 UTC on the same day. Afterwards, the remaining circulation of HIGIBIS moved northeast and further into East China Sea. It re-developed into tropical storm over the central East China Sea at 06:00UTC on 17 June. It then moved speedily northeast with the speed of 50km/hour and later became an extra-tropical cyclone over the south of Japan. CMO stopped its TC numbering at 21:00UTC on 17 June.



**Fig. 1.7a** Track of tropical storm HIGIBIS



**Fig. 1.7b** FY-3B image at 05:25UTC 17 June 2014

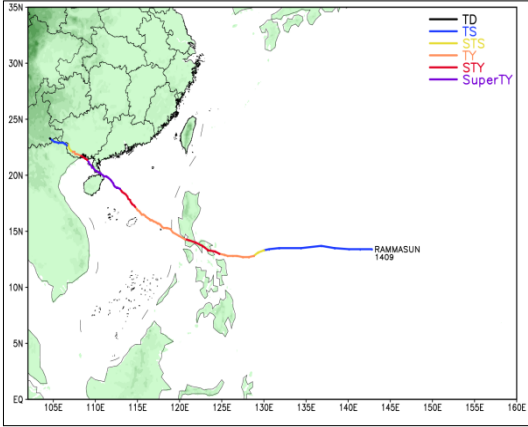
## 2) Super typhoon RAMMASUN (No. 1409)

Upon the genesis over west North Pacific at 06:00UTC on 12 July 2014, the tropical storm RAMMASUN was moving west with ever increasing intensity. It then landed on coast of central Philippines, swept across the entire central Philippines, and moved into South China Sea with decreased intensity. Afterwards, it turned to northwest and approached coast of northeastern Hainan. It strengthened once again and turned into a super typhoon in northern South China Sea at 21:00UTC on 17 July. It made a landfall on Wenchang, Hainan at 07:30UTC on 18 July with the maximum wind speed of Force 17 (60m/s) near its centre at the landing time and with its central minimum pressure of 910hPa. After its landing, it continued to move northwest and crossed Qiongzhou Strait. It made the second landfall on Xuwen, Guangdong at 11:30UTC on 18 July with the maximum wind speed reaching Force 17 (60m/s) near its centre at the landing time and with its central minimum pressure of 910hPa. Afterwards, RAMMASUN (1409) moved into Beibu Gulf and continued to move northwest. It landed the third time on Fangchenggang, Guangxi at 23:10UTC on 18 July with the maximum wind speed of Force 15 (48m/s) near its centre at the landing time and with its central minimum pressure of 950hPa. After its landfall, it turned to northwest and continued to weaken. It reduced into a tropical depression in Yunnan at 21:00UTC on 19 July. CMO stopped its numbering at 00:00UTC on 20 July.

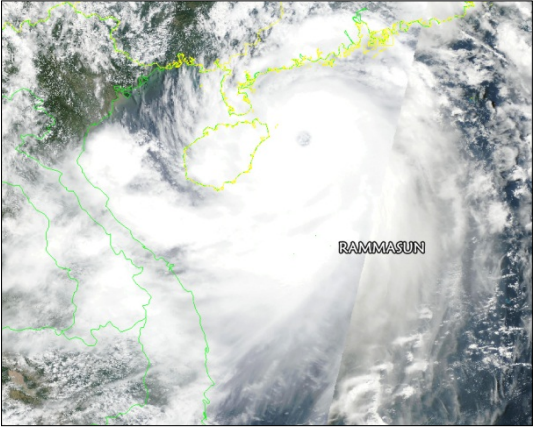
RAMMASUN (1409) had three features: a) the intensity at the time of landing was extremely high. Both the maximum speed close to the centre and central minimum pressure at the landing time reached or even exceeded the records in history. With the maximum wind speed of Force 17 (60m/s) near its centre when it landed on Wenchang, Hainan and Xuwen, Guangdong, it became the strongest typhoon landing on Guangdong and Guangxi since 1949. The central pressure of RAMMASUN was 910hPa, which was the lowest record for the typhoons landing China since 1949; b) RAMMASUN landed on three province/autonomous region in South China. It made landfall on Wenchang of Hainan, Xuwen of Guangdong, and Fangchenggang of Guangxi in a row, and; c) The associated wind speed was high and precipitation strong. Most regions in northeast Hainan, Leizhou Peninsula of Guangdong and coastal Guangxi experienced the strong wind with the average speed between Force 10-13 and gust with the Force 14-17. The buoy stations east to Hainan Island and Qizhou Archipelago within Wenchang recorded the maximum gust of 74.1 m/s



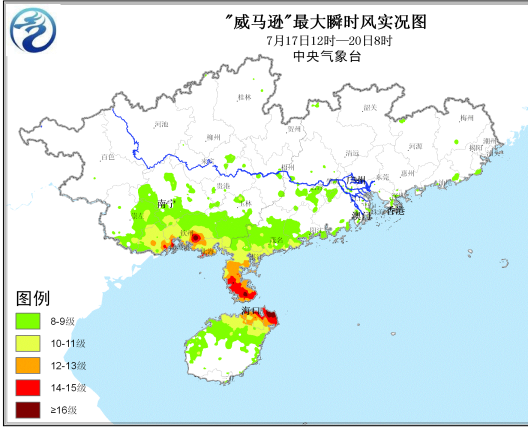
and 72.4 m/s respectively. In some regions of Haikou of Hainan, Leizhou Peninsula of Guangdong, and coastal Guangxi, the transient strong wind above Force 12 sustained 6-9 hours. From 17 to 21 July, the accumulated rainfall in coastal Hainan and Guangxi, and southern Yunnan reached 200-500 mm, and in Haikou, Changjiang, Baisha, and other places of Hainan reached 500-712mm. In particular on 18 July, the daily precipitation in Haikou, Qiongsan, Chengmai, Changjiang, Baisha, etc was above 400mm with 100-139mm/hour in many regions.



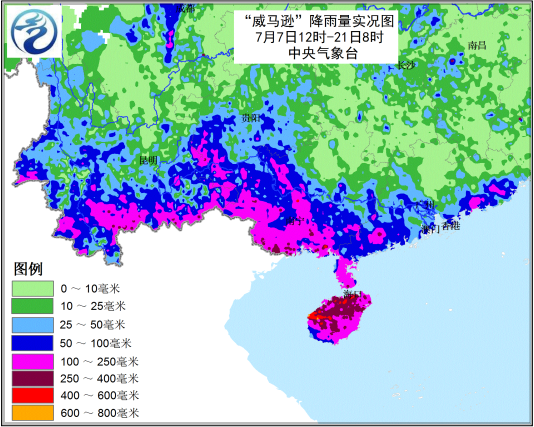
**Fig 1.8a** Track of super typhoon RAMMASUN



**Fig 1.8b** FY-3B image, 03:40UTC, 18 July 2014



**Fig 1.8c** Maximum Gust of Winds of RAMMASUN (04:00UTC, 17 July - 00:00UTC, 20 July)



**Fig 1.8d** RAMMASUN-induced Rainfall (04:00UTC, 17 July - 00:00UTC, 21 July)



**Fig 1.8e** Damages by RAMMASUN in Hainan



**Fig 1.8f** Disaster induced by RAMMASUN in Hainan

### **3) Severe Typhoon MATMO (No.1410)**

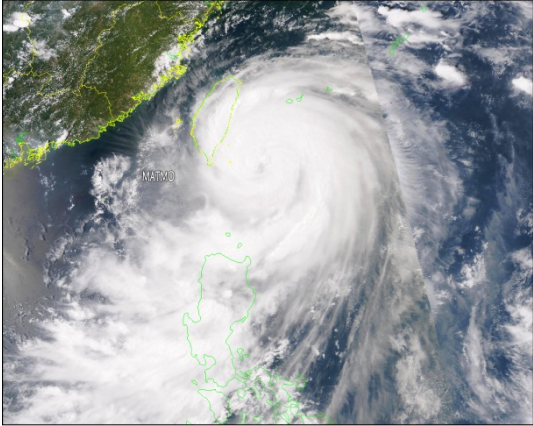
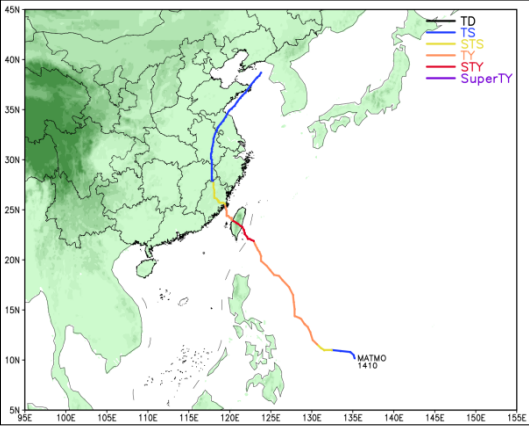
The tropical storm MATMO was generated over the west North Pacific at 18:00 UTC on 17 July. After its genesis, MATMO began to move in the west-northwest direction, and developed into a severe tropical storm at 18:00UTC on 18 July. Afterwards, it turned to northwest and approached the coast of eastern Taiwan with increasing intensity. MATMO further developed into a severe typhoon at 06:00UTC on 22 July, and landed on Taidong, Taiwan at 16:15UTC of the same day with the maximum wind speed close its centre reaching Force 14 (42m/s) and the minimum central pressure down to 955hPa at landing time. After landing, MATMO continued to move northwest, and entered into Taiwan Strait with declining intensity. It made the second landfall on Fuqing, Fujian with the maximum wind speed close its centre reaching Force 11 (30m/s) and the minimum central pressure of 980hPa. After landing, MATMO swept across Fujiang, Jiangxi, Anhui and Jiangsu with weakening intensity. It entered into Yellow Sea from northern Jiangsu and then moved northeast towards Shangdong Peninsula. MATMO made its third landfall on Rongcheng, Shangdong at 09:10UTC on 25 July with the maximum wind speed close its centre reaching Force 8 (20 m/s). Afterwards, it entered into northern Yellow Sea and turned into an extra-tropical cyclone. CMO stopped the TC numbering at 15:00 UTC on that day.

MATMO had the following features: a) it affected widespread regions when it was moving from south to north. The Taiwan Strait, East China Sea, Yellow Sea and southern Bohai Sea all were impacted. It brought about rainfall to 11 provinces, including Taiwan, Fujian, Guangdong, Zhejiang, Jiangxi, Hunan, Anhui, Jiangsu, Shandong, Liaoning and Jilin, and the total areas with heavy rainfall exceeding 100mm was 175000 km<sup>2</sup>; b) the intensity was weakening very slowly after landfall. The intensity reached level of the severe tropical storm (Force 11, 30 m/s) when MATMO landed on Fuqing, Fujian, but it reduced to the tropical storm (Force 9, 23 m/s) within Mount Wuyi till 16.5 hours later. It then swept across Jiangxi, Anhui and Jiangsu and made its third landfall on Hushan Township, Rongcheng of Shandong 33 hours later. The maximum speed of wind close to center even sustained at Force 8 (20 m/s); c) The duration of impact on eastern China was long. It took 43.5 hours for MATMO to make its third landfall in Rongcheng, Shandong after its second landing in Fujian. The impact of MATMO on Mainland China lasted as long as 4 days. During the said period, East China Sea saw Force 7-9 high wind in 3 consecutive days (between 23 and 25 July), and part of sea area even experienced Force 10-12 high wind. In the same period, Bohai Sea and Yellow Sea witnessed strong wind of Force 5-7 and gust of Force 8 in two consecutive days (24-25 July), and; d) Heavy rain and high wind occurred in some regions were strong. The rainfalls in some regions (including Ningde, Fuzhou, Qingdao and Yantai) from 12:00UTC on 22 July to 06:00UTC on 26 July reached 350-500mm. The rainfall in Zhongfang Township, Luoyuan of Fujian registered 577.8mm, and Gaotang Township, De'an of Jiangxi recorded 99.4mm rainfall in 1 hour and 296.8 rainfall in 3 hours. Parts of eastern Fujian, eastern Zhejiang, eastern Guangdong, central and northern Jiangxi, central Anhui, central and southern Jiangsu, eastern Shandong, eastern Liaoning and other places were affected by strong winds of Force 7-9, and Force 10-12 wind in some local regions. The extreme transient wind above Force

10 in Ningde, Fuzhou and Putian of Fujian occurred within 10 to 31 consecutive hours, and the transient wind exceeding Force 12 in Changle County took place up to 10 hours.

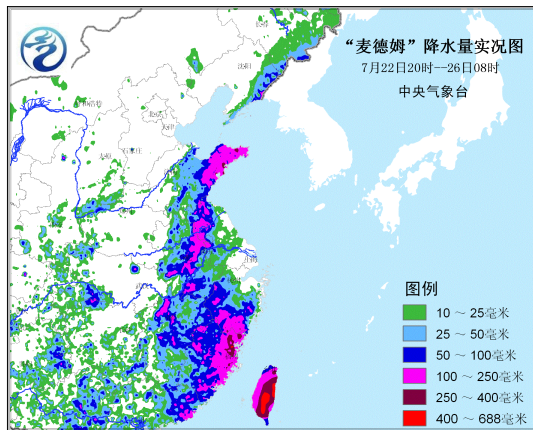
The MATMO-induced heavy rain caused floods with their water levels exceeding the warning lines in a range of 0.05-3.57m in 20 rivers, including Jiaoxi River, Aojiang River and Meixi River, a tributary of Minjiang River in Fujian, Nangang River, a branch of Aojiang River in Zhejiang, Boyang River within Boyang Lake region in Jiangxi, Chuhe River in Jiangsu, Qiupu River and Xihe River in Anhui. Among those rivers, a 20-year return period of flood occurred in Boyang River within Boyang Lake region in Jiangxi.

In addition, the drought and high temperature conditions in Huanghuai region were relieved. In mid-July, the meteorological drought was found in some regions of North China, Huanghuai, and Liaoning to a varying degree. Shandong, Henan and northern Jiangsu and Anhui suffered moderate drought and even severe drought. The water storage in drought-affected regions in Huanghuai and Liaoning increased by 20.8 billion m<sup>3</sup> after the MATMO-induced rainfall processes. Among others, the water storage in Shandong substantially increased (by 8.49 billion m<sup>3</sup>). The extent of area affected by severe drought in Shandong, northern Jiangsu and northern Anhui sharply contracted, while the meteorological drought conditions in Shandong Peninsula and southeastern Liaoning were totally relieved. In the meantime, the high temperature conditions across Huanghai, Jianghuai, South of Yangtze River and South China were mitigated as a result of the rainfall.



**Fig 1.9a** Track of Severe Typhoon MATMO

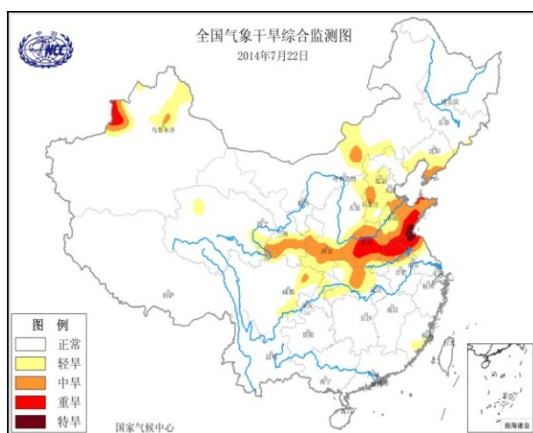
**Fig 1.9b** FY3B Satellite Image, 06:10UTC, 22 July 2014



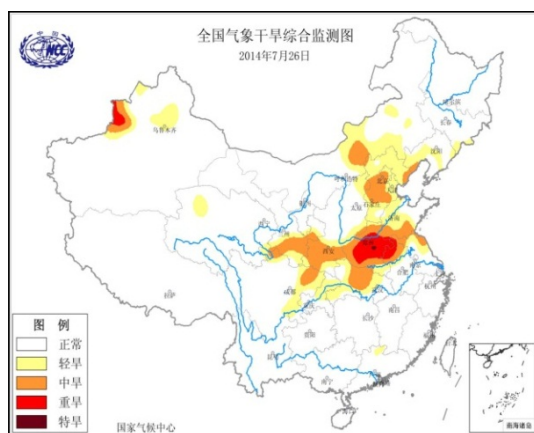
**Fig 1.9c** MATMO-induced Rainfall  
(12:00UTC, 22 July- 00:00UTC, 26 July)



**Fig 1.9d** Serious Impacts of MATMO on Agriculture  
in Taiwan



**Fig 1.9e** Met. Drought Conditions before MATMO-  
induced Rainfall (22 July 2014)



**Fig 1.9f** Met. Drought Conditions after MATMO-  
induced Rainfall (26 July 2014)

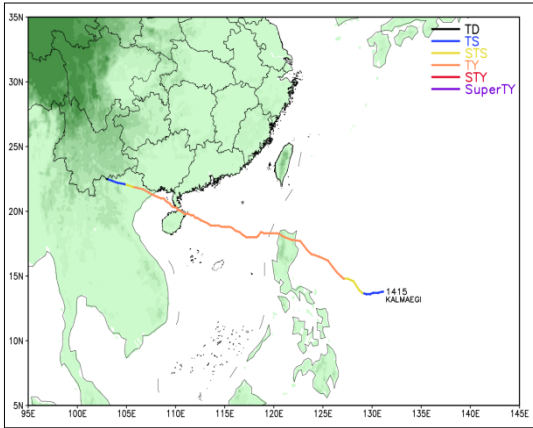
#### 4) Typhoon KALMAEGI (No. 1415)

The tropical storm KALMAEGI numbered 1415 was generated over the western North Pacific at 06:00UTC 12 September. After its genesis, it began to move west. At 21:00UTC on 12 September, it developed into severe tropical storm and then turned to northwest. KALMEAGI escalated into typhoon and approached the coast of northeastern Luzon Island, the Philippines at 09:00UTC on 13 September. It made its landfall on northeast of Luzon Island and then moved in west-northwest direction. KALMEAGI entered into South China Sea on 15 September and approached the northeast of Hainan. It made its second landfall on Wenchang, Hainan at 01:40UTC on 16 September with the maximum wind speed close its centre reaching Force 13 (40m/s) and the minimum central pressure down to 960hPa at landing time. Afterwards, KALMEAGI entered Qiongzhou Strait and then made its third landfall on Xuwen County, Guangdong at 04:45UTC on 16 September with the maximum wind speed close its centre reaching Force 13 (40m/s) and the minimum central pressure of 960hPa at landing time. Later on, it continued to move in west-northwest direction and entered Beibu Gulf. At 15:00UTC on 16 September, it made another landfall along the coast of northern Vietnam. After landing, its

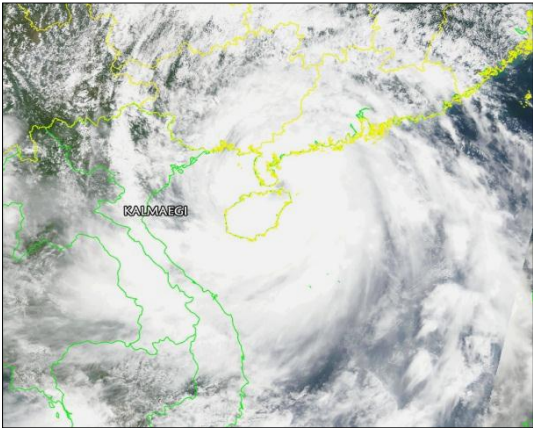
intensity rapidly receded and it reduced to tropical depression within Yunnan at 06:00UTC on 17 September. CMO stopped the TC numbering at 09:00UTC on the same day.

KALMEAGI had the following 4 features: a) Speed was fast. After entering South China Sea early morning on 15 September, KALMEAGI moved quickly in west-northwest direction at an average speed of 32 km/h. It only took 34 hours to make a movement of 1,100 km from entering South China Sea to landing on Xuwen, and the speed between afternoon and night of 15 September reached up to 40km/h; b) Wind and rainfall were widespread. The cloud system during the period when KALMEAGI stayed in South China Sea covered the entire Sea. Between 15 and 18 September, the total area with accumulated 100mm rainfall and with 250mm in Hainan, Guangdong, Guangxi, Yunnan, Guizhou and other provinces reached respectively 184,000km<sup>2</sup> and 8828.8 km<sup>2</sup>, and the water storage totaled 58.38 billion m<sup>3</sup>. The land area affected by above Force-8 high wind in South China amounted to 141,000 km<sup>2</sup>, and the area affected by Force-10 wind and beyond reached 41,000 km<sup>2</sup>; c) Storm surge was high. 10m and even higher waves were reported to the west of Guangdong and 2-meter-high storm surge along Leizhou Gulf. The highest tide level reported in Haikou, Hainan on 16 September was 4.37m, 1.47m higher than the alerting level and highest tide since 1948, and; d) Post impact was significant. After landing in Vietnam, KALMEAGI reduced to a depression circulation. Due to this circulation and outer cloud system, Guizhou, eastern and southern Yunnan, southeastern Sichuan experienced rainstorm or heavy rainstorm, and even extreme rainstorm in some localities. The accumulated rainfall in parts of western Guizhou and southeastern Yunnan reached in a range of 200mm-300mm, and the rainfall in parts of Liuzhi, Guizhou amounted to 387mm.

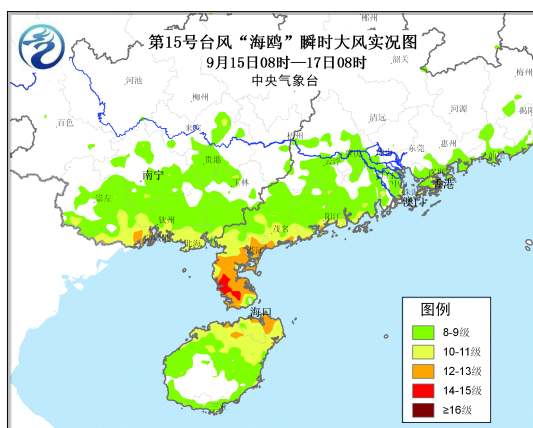
The KALMEAGI-induced heavy rain caused flood beyond the alerting water levels in a range of 0.07-5.93m in more than 10 rivers, including Nandu River of Hainan, Moyang River of Guangdong, Yujiang River of Guangxi, Panlong River, a branch of Lujiang River of Yunnan. Among other tide gauges, the one located in Haikou, Hainan reported the highest tide level ever since 1973 when it began to record.



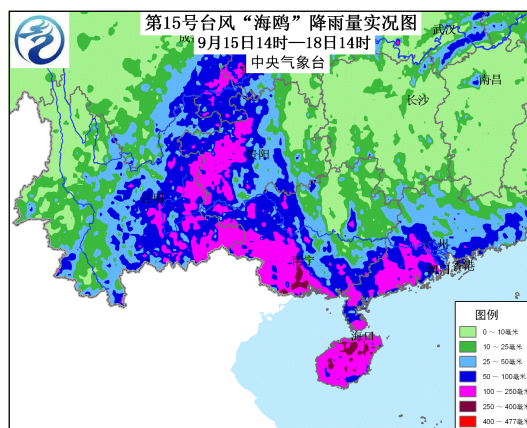
**Fig 1.10a** Track of Typhoon KALMEAGI



**Fig 1.10b** FY3C Satellite Image, 03:20UTC, 19 September 2014



**Fig 1.10c** Transient High Wind by KALMEAGI  
(00:00UTC 15 Sep - 00:00UTC, 17 Sep)



**Fig 1.10d** Rainfall by KALMEAGI  
(06:00UTC 15 Sep - 06:00UTC, 18 Sep)



**Fig 1.10e** Disaster by KALMEAGI in Hainan

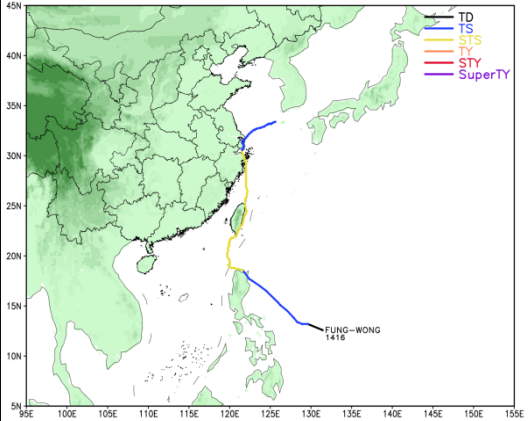


**Fig 1.10f** Disaster by KALMEAGI in Hainan

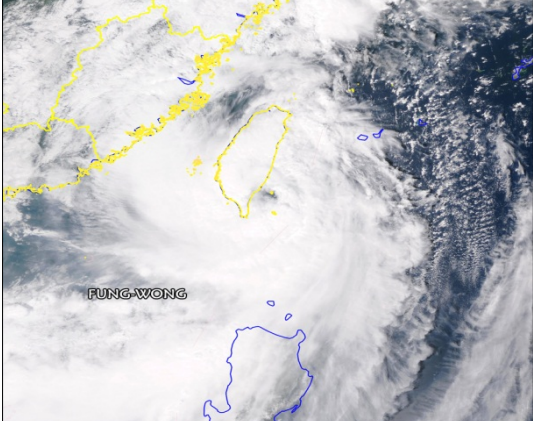
## 5) Severe Tropical Storm FUNG-WONG (No. 1416 )

A tropical depression was generated over the western North Pacific at 12:00UTC on 17 September. After its genesis, it began to move in west to northwest direction, and it developed into tropical storm FUNG-WONG numbered 1416 at 18:00UTC on the same day. Afterwards, it turned to northwest and approached northeastern coast of Luzon Island, the Philippines. Again, FUNG-WONG developed into severe tropical storm close to northeastern coast of Luzon Island and made its landfall there at 12:00UTC on 19 September. After landing, FUNG-WONG moved west northerly into Bashi Channel, where it turned to north towards southern coast of Taiwan. It made its second landfall on southern Hengchun Peninsula, Taiwan, with the maximum wind speed close its centre reaching Force 10 (28m/s) and the minimum central pressure down to 982hPa at landing time. It then moved north easterly along offshore of eastern Taiwan and made its third landfall on the junction between Yilan and Xinbei of Taiwan at 14:20UTC on 21 September with the maximum wind speed close its centre reaching Force 10 (28m/s) and the minimum central pressure down to 982hPa at landing time. After its landfall, FUNG-WONG moved north westerly into southern East China Sea and approached northern coast of Zhejiang. It made its fourth landfall on Xiangshan, Zhejiang at 11:35UTC on 22 September with the maximum wind speed close its centre reaching Force 10 (28m/s) and the minimum central pressure of

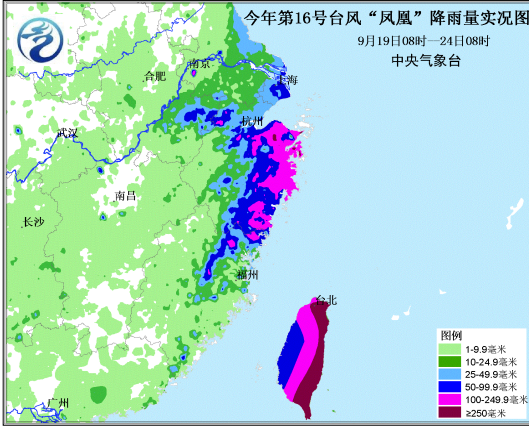
982hPa. After its landing, it continued to move north westerly into Hangzhou Bay and receded into a tropical storm at 01:00UTC on 23 September. It made its fifth landfall on Fengxian, Shanghai at 02:45UTC on the same day with the maximum wind speed close its centre reaching Force 9 (23m/s) and the minimum central pressure down to 990hPa at landing time. At 09:00UTC on 23 September, it entered into the junction of East China Sea and Yellow Sea and then moved east northerly. It ultimately turned into an extra-tropical cyclone over southeastern Yellow Sea. CMO stopped the TC numbering at 03:00UTC on 24 September.



**Fig 1.11a** Track of Severe Tropical Storm FUNG-WONG



**Fig 1.11b** FY3B Satellite Image, 05:30UTC, 21 Sep. 2014



**Fig 1.11c** Rainfall by FUNG-WONG (00:00UTC 19 Sep - 00:00UTC, 24 Sep)



**Fig 1.11d** Disaster by FUNG-WONG in Zhejiang

**1.2 Socio-Economic Assessment**

By 14 October 2014, altogether 5 tropical cyclones had made landfall in China, among which, Super Typhoon RAMMASUN (No. 1409) was the strongest one this year. It was also the strongest in South China ever since 1973. Out of the 5 landed typhoons, it killed people most, made people evacuated most and houses collapsed most, and caused most direct economic losses.

According to preliminary estimation, the typhoon-related hazards or disasters in 2014 had totally affected 25.603 million people in 13 provinces (municipalities or autonomous regions), including

Liaoning, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Guangdong, Guangxi, Hainan, Yunnan, Guizhou, and Taiwan, caused 116 people died or missing plus 1.572 million person-times being evacuated for safety in emergency responses. Due to these typhoons, the total area of affected crops was 3.1157 million hectares, among which 345,400 hectares of crops completely failed. Furthermore, 52,000 houses collapsed and 586000 houses were damaged to a varying degree. The total direct economic loss was 66.72 billion RMB in 2014. In comparison with others, Guangdong, Guangxi, Hainan and Yunnan suffered most from the typhoon-associated hazards or disasters.

**Table 1.1** Impacts and Disaster caused by Typhoons in 2014

TC Name & No.	Landing Site	Landing Date	Max. Wind Force Near TC Centre When Landing (unit: force)	Affected Province (municipality, AR)	Affected Population (1,000)	Death Tolls (person)	Direct Economic Loss (RMB 100 m)
HIGIBIS (1407)	Guangdong	6.15	9 (23m/s)	Fujian, Guangdong	468	/	12.3
RAMMASUN (1409)	Hainan	7.18	17 (60m/s)	Guangdong, Guangxi, Hainan, Yunnan	11,940	88	443.3
	Guangdong	7.18	17 (60m/s)				
	Guangxi	7.19	15 (48m/s)				
MATMO (1410)	Taiwan	7.23	14 (42m/s)	Liaoning, Jiangsu, Zhejiang, Anhui, Jiangxi, Taiwan, Shandong, Guangdong,	2,196	16	24.7
	Fujian	7.23	11 (30m/s)				
	Shandong	7.25	8 (20m/s)				
KALMAEGI (1415)	Hainan	9.16	13 (40m/s)	Guangdong, Guangxi, Hainan, Yunnan, Guizhou	9,585	11	177.4
	Guangdong	9.16	13 (40m/s)				
FUNG-WONG (1416)	Taiwan	9.21	10 (28m/s)	Zhejiang, Shanghai, Taiwan	1,414	1	9.5
	Zhejiang	9.22	10 (28m/s)				
	Shanghai	9.23	9 (23m/s)				
Total					25,603	116	667.2

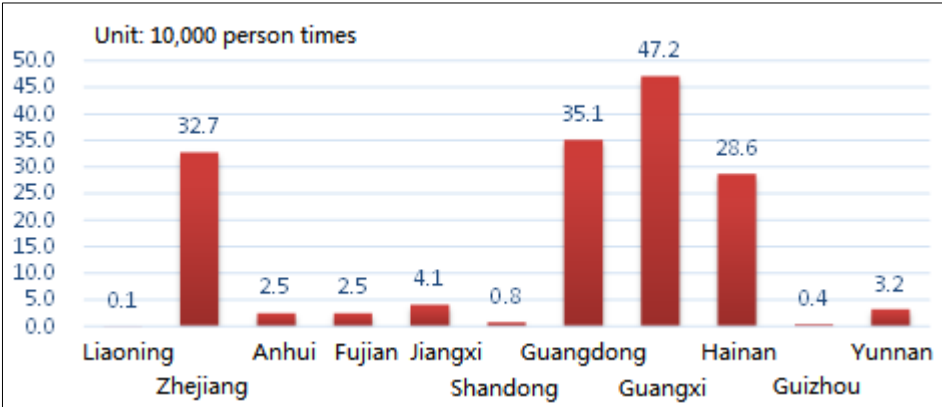


Fig.1.12 Statistics of evacuated people in emergency responses to potential typhoon-induced disasters in 2014



## 1.3 Regional Cooperation Assessment

### 1.3.1 Signed a Memorandum of Cooperation with the Australian Bureau of Meteorology

China National Key Laboratory of Severe Weather (LaSW) of Academy of Meteorological Sciences, China Meteorological Administration (CMA) signed a Memorandum of Cooperation with Weather and Climate Research Center of the Australian Bureau of Meteorology in 2014, intending to conduct the research on extreme rainfall/storm in weather and climate events for a better understanding and forecasting of extreme weather events. Areas to cooperate cover South China monsoon rainfall test; monsoons in China and Australia; and extreme rainfall event during tropical cyclones landing.

### 1.3.2 The 7th Korea-China Joint Workshop on Tropical Cyclones

The experts from Shanghai Typhoon Institute, Shanghai Central Observatory as well as Ocean and Typhoon Center of CMA attended the 7th Korea-China Joint Workshop on Tropical Cyclones hosted by National Typhoon Center of Korea Meteorological Agency on May 26-29 in Korea. The meeting has promoted the exchange of the latest developments in the field of tropical cyclones research and application between China and Korea, and also enhanced the bilateral cooperation in tropical cyclone forecasting techniques.



Fig. 1.13 The 7th Korea-China Joint Workshop on Tropical Cyclones

### 1.3.3 The delegation of Typhoon Committee Working Group on Hydrology visited China

As request by Typhoon Committee Secretariat, Hydrology Bureau of Ministry of Water Resources received the delegation of Typhoon Committee Working Group on Hydrology consisted by several experts from Royal Irrigation Department of Thailand, Irrigation Department of Malaysia and Typhoon Committee. The delegation visited the Guilin hydrological stations to learn the equipments for information collection and transmission of small river hydrological monitoring projects; visited Guilin mountain flood prevention stations to check rainfall monitoring and real-time early warning broadcasting of mountain flood disaster project; visited Bureau of Hydrology and Water Resources of Guangxi Zhuang Autonomous Region to discuss flood

forecasting models and systems, as well as public-oriented warning release mechanism and systems.

Mr. Olavo, Secretary-General of the Typhoon Committee, has highly praised and appreciated the successful completion of the visit, which has contributed to strengthen technological exchanges and capacity building in the aspects of the typhoon disaster prevention among members of the Typhoon Committee.



**Fig. 1.14** The delegation of Typhoon Committee Working Group on Hydrology visited China

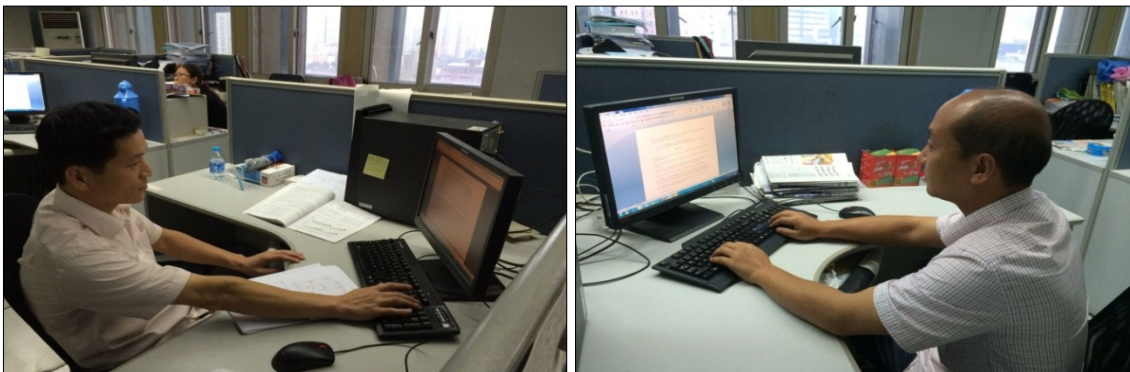
#### **1.3.4 Scholarship Programme of Typhoon Committee**

Dr. Bai Lina, who was selected to participate in the Scholarship Programme of Typhoon Committee from May 10 to July 13, 2014, was invited to visit the National Typhoon Center of Korea Meteorological Agency. The visit focused on: (1) optimization typhoon forecasting methods by using TAPS system; (2) study on the interactions of typhoon with mid-latitude systems; (3) study on typhoon steering and movement speed; (3) study on the relationship between typhoon central pressure and maximum sustained wind speed.

Also, the “tropical cyclone forecast verification” project under 2014 annual work plan of the Working Group on Meteorology provides a scholarship program within its mandate, with the theme of “tropical cyclone generation forecasting techniques”. The scholarship program which lasted for three months (from July to September, 2014) was jointly funded by Typhoon Committee Trust Fund and Shanghai Typhoon Institute. The Member States of the Typhoon Committee made applications. Mr. Boonthum Tanglumlead from Thailand and Song Yong Chol and Mr. Pak Sang Il from North Korea were invited to participate in the scholarship program.



**Fig. 1.15** Dr. Bai Lina visited Korea to participate in the Scholarship Programme of Typhoon Committee.



**Fig. 1.16** The experts were invited to participate in the scholarship program in China.

## II. Summary of Advances in Key Result Areas

### 2.1 Improvement of objective forecasting method for typhoon track

1) In 2014, the typhoon team of the National Meteorological Center continues to improve the forecast skills of the objective track forecasting method TYTEC (TYphoon Track Ensemble Correction), giving different weights on different ensemble models (ECMWF, NCEP, etc.), which further reduces the track forecast errors. Based on the experiment of 2013 ensemble forecasting data, it showed that the error of 24 hours track forecast by the new method reached 77 km, which was 5 km less than the original method, and the rest timing were also improved. The improved TYTEC was put into operational use in 2014 typhoon season. Up to October 14 of this year, the mean track forecast errors for 24-120 hours are 75、143、208、284 and 377 km respectively.

2) Making use of the combination of dynamics and statistics, National Climate Center picks up the optimal information of the model forecasting large-scale circulation patterns to conduct downscaling application tests. America's second-generation climate forecast system (CFSv2) is a relatively mature forecasting system that rolling updates monthly and seasonal forecast. The large-scale circulation field factors in the output results were rich, which can provide us with adequate ocean and atmospheric circulation information. Therefore, based on the averaged ocean-atmosphere forecast results from June to October which is based CFSv2 model, the annual typhoon downscaling objective typhoon downscaling typhoon forecast was developed; based on ocean-atmosphere forecast results from July to December, the second half scale typhoon downscaling objective typhoon forecast was developed; using monthly forecasts from May to September and the monthly average large-scale circulation factor from June to October, monthly typhoon downscaling objective typhoon downscaling typhoon forecast from June to October was developed.

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

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

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

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## 2.2 Advances in numerical models for typhoon Prediction and data assimilation

1) T639L60 global model typhoon numerical forecasting system which is based on BDA vortex initialization technology was operational running on the trial basis.

2) The systematic errors (South China Sea typhoon track forecast northward, and stronger typhoon intensity forecasts, etc. ) of regional model typhoon numerical forecasting (GRAPES\_TYM) has been improved, meanwhile the forecast period extended from three days to five days, forecast increased from every day two times to 4 times.

3) Based on the T639L60 global model, Typhoon Ensemble Prediction System was developed and being batch tested, with its forecast results better than T213L31 Typhoon Ensemble Prediction System.

4) GRAPES model dynamic framework has been improved. The rotating coordinates were added into GRAPES, to move the model area away from the polar regions, making the equatorial region through the model area, thereby obtain a relative uniform grid. Two-dimensional Coriolis force has been increased to three-dimensional Coriolis force, to meet the requirements of high resolution. The implicit Rayleigh attenuation with vertical speed was used as false reflection treatment option of vertical gravity waves (rigid) at the top of model. The three different heights terrain-following coordinate were unified in one version, leading to a new pressure gradient force calculation scheme, thereby effectively reducing the computational error of pressure gradient force in steep terrain.

5) Application of the new typhoon vortex initialization technique. Based on the new NCEP vortex initialization scheme, the new regional typhoon forecasting system was established under the improved GRAPES-TCM model framework. Compared to the old system, the new system reduces the impact of human factors on the typhoon vortex structures, makes minimization revision for the typhoon vortex, and generates three-dimensional spatial vortex which meets the dynamic and thermodynamic equilibrium, thereby maintaining the consistency of the model.

6) In earlier stage, CSI hybrid system has been used in WRF model, and has achieved good results in typhoon track forecasting. The research by the Shanghai Typhoon Institute has further transplanted this system into GRAPES model. After completion of establishment, the assimilation system has been tested by using a single point test and applied to the actual typhoon cases. The test results show that the performance of hybrid GSI assimilation was superior to GSI 3DVAR system, and its typhoon path and precipitation forecasts significantly better than 3DVAR system.

7) Since January 2014, South China Sea typhoon mode TRAMS has produced typhoon path, typhoon intensity of 120 hours. In 2014, the South China Sea typhoon mode technology programs have been further improved, especially nonlinear term computing model, marine boundary layer parameterization techniques, and dynamic process technology coupled with the physical process, which lead to the improvement of the model prediction capabilities. Meanwhile, based on TRAMS, mobile high-resolution South China Sea typhoon mode TRAMS-9km has been developed (Figure 2.1). TRAMS-9km model was embedded in the

TRAMS-36km mode. The forecasting grid can move according to the typhoon location, to determine the number of nested 9km model based on the number of typhoons. Forecast tests showed that the new generation of high-resolution typhoon model can significantly improve the forecasting level of typhoon path.

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

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

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

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### 2.3 Advances in scientific research on typhoons

1) A comparative study on asymmetric structure of TC temperature and humidity. By using CFSR 0.5° reanalysis data from NCEP and the typhoon best track dataset from the Tokyo Typhoon Center, the synthesis and comparative analysis have been made on asymmetric and heterogeneous vertical structure of TC temperature and humidity over Northwest Pacific and South China Sea from 1979-2010.

2) An observational study on turbulence energy cascade conversion in surface layer during typhoon process. Based on continuous high-resolution observation in surface layer for three of the typhoons landed in China in 2010, the Shanghai Typhoon Institute (STI) found that direct and inverse cascade processes coexisted in surface layer, but in its different regions respectively. The limits of cascade conversion may have direct linkage with the intensity and scale of typhoon, based on which a model on turbulence cascade distribution in TC boundary layer was developed.

3) Studies were conducted on mechanism of TC rain band structure; on application of Doppler data from both sides of the Taiwan Straits in forecasting heavy precipitation induced by Typhoon 'Morakot' (2009); and on atmospheric factors causing asymmetric precipitation distribution characteristics of Typhoon 'Haitang' (2005).

4) An observational study on asymmetric precipitation distribution of TCs landed in China. Based on the analysis of TRMM satellite-estimated precipitation data from 2001 to 2009, a study was made on asymmetric precipitation distribution of TCs landed in five provinces of mainland China. The results showed that: max asymmetric precipitation was located on the down shear side and left of the landed TCs, which was consistent with the results of the available ocean TCs studies.

5) Observational analysis based on data from the field experiment. The analysis was made on data from the devices installed on the 100m high wind towers along the coastline in Chihu town of Zhangpu county, Fujian Province, as shown in Figure 2.2. By using the wind profiling method, a study was made on on-shore wind drag coefficient changing with wind speed. 2003 hours data were available including that of three typhoons.

6) Advancements in typhoon dataset and its operational system. Collection and archive of data related to TC activities were finished in 2014, including the newly collected ASCAT ocean surface wind data, and applied in the Yearbook of Tropical Cyclone; charting and re-design of the Yearbook of Tropical Cyclone 2012-2013 has been completed; The Northwest Pacific Tropical Cyclone Retrieval System V3.3 has been published, with three new functions.

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



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

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

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2.4 Journal of Tropical Cyclone Research and Review

Up to now, the Tropical Cyclone Research and Review has been published for ten issues with a total of 75 papers. The authors mainly come from member states of the Typhoon Committee and other non-member states including Australia, India, Oman, Germany and Russia. More and more experts proactively contribute their papers to the journal.

According to the Journal's official website, readers are widespread covering more than 100 countries and territories, with the papers being downloaded about 36000 times (averaging 480 times for each paper). This indicates that the increasing number of experts around the world have interests in the Journal. Currently, the Journal is in the stage of application for being a SCI-listed Journal.

Mr. Maytee Mahayosananta from Thai Meteorological Department and Mr. Paul Icamina from the Philippine Atmospheric, Geophysical and Astronomical Services Administration were invited to be the guest editors of STI editorial office from 21-27 September 2014.

For more information, please see: <http://tcrr.typhoon.gov.cn>.

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

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

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

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## 2.5 Ocean observing system and outfield typhoon observation experiment

### 1) Ocean observing system

As of October 2014, the availability of the national ocean observing system includes: 290 island Automatic Weather Stations (AWSs), 200 strong wind stations, 39 ship AWSs, 25 moored buoys stations, 25 weather radars, 10 radiosonde stations, 17 wind profiling radars, 68 GNSS/MET stations, 30 thunder and lightning detection stations, 1 surface wave radar and 2 storm surge stations.

### 2) Outfield typhoon observation experiment

With the approval of the Monsoon Panel of WMO Working Group On Tropical Meteorological Research (WGTMR), the Chinese Academy of Meteorological Sciences was enabled to implement the WMO/WWRP South China Monsoon Rainfall Experiment (SCMREX) in July 2012. It is an international scientific experiment programme that the Chinese meteorologists proposed for addressing such scientific issues as South China monsoon heavy precipitation, and abrupt rainstorm hazards in particular. The outfield experiment in 2014 has successfully acquired heavy precipitation process data with high spatial- and temporal- resolutions.

In 2014, typhoon 'Fung-wong' that landed on the east China coast was observed by STI through the observing vehicle in Wenling city, Zhejiang Province from 8:00 am on 22 to 2:00 am on 23 September. The vehicle was equipped with such devices as ultrasonic anemometer, raindrop disdrometer, microwave radiometer, AWS, wind profiling radar and GPS radiosonde; the Guangzhou Institute of Tropical and Marine Meteorology made tracking observation of Typhoons 'Rammasun' and 'Kalmaegi'.

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

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

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

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## 2.6 Research and development of comprehensive typhoon analysis based on multi-source and multi-channel satellite data

FY-3C was put into operation in June 2014. In typhoon monitoring from June to September 2014, FY-3C replaced FY-3A that operated in the morning orbit for 5 years, as a main operational satellite, and it would maintain a morning- and afternoon-orbit constellation with FY-3B. Particularly, data from additional FY-3C devices and bands played a vital role in the 2014 typhoon monitoring.

Compared with FY-3A/B, FY-3C's technical performance has been improved that was fit for new devices and channels, and its microwave thermographs and microwave hygrometers have been upgraded to type II, with their channels being increased from 4 to 13 and from 5 to 15 respectively, which significantly improved the precision of observation from space. The microwave hygrometer onboard FY-3C has a new set of 118GHz adjacent channels which was used for the first time worldwide. These channels were used to monitor and analyze typhoon tracks in 2014, based on which the new experiences and research outcomes were gained: these channels are indicative in typhoon warm-ward movement, meanwhile, the warm area shown in 118GHz channels in the middle-upper troposphere was matched with the dark area of FY-2E water vapor channels, which laid the scientific basis for integrated use of polar-orbiting and geostationary satellites in developing methods of multi-source satellite data fusion to monitor typhoon tracks and intensity.

Therefore, preliminary advancement has been achieved in developing techniques for monitoring refined 3-dimensional structure of a typhoon by the experiment on comprehensive application of multi-source data in typhoon analysis proceeded with typhoon structure and intensity, based on data from FY-3C's newly added channels and FY-2E/F data.

In addition, the 250m resolution data from the medium resolution imager onboard FY-3B/C, data with high temporal resolution from FY-2F and data from other foreign satellites were used in typhoon monitoring and analysis in 2014 to reveal the detailed internal structures of typhoon cloud system, including those of typhoon eye and evolution from genesis to dissipation of its internal meso-scale systems. This could continuously enhance the comprehensive capability for detection of 3-dimensional typhoon structures with high spatial and temporal resolution data.

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

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

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

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## 2.7 Establishment of satellite product algorithm and featured models, and Improvement of Analysis Techniques

1) Establishment of an algorithm for typhoon-related quantitative products based on FY series satellites.

An inverse algorithm was established for such FY-3 based quantitative parameters as cloud water, cloud ice and precipitation in typhoon and water vapor, ocean temperature and ocean surface wind, and the relevant quantitative products were generated. In terms of products derived from precipitation estimates, a fusion algorithm was established for polar-orbiting microwave and geostationary orbiting infrared precipitation estimates. It effectively improved the precision of typhoon precipitation estimates, which is essential and useful for addressing the gaps of observations of typhoon precipitation over the ocean.

2) Pre-study on establishing a satellite-based characteristic model related to typhoon tracks and intensity.

Based on further enrichment of quantitative typhoon analysis product and advancements in typhoon diagnostic and analytical techniques, an individual cases dataset of satellite-based typhoon monitoring have been compiled for each year from 2008 to 2014, including relevant quantitative products of all the numbered typhoons in whole year. In addition, a pre-study was conducted on establishing an individual cases dataset of satellite-based typhoon characteristic analysis classified and retrieved by tracks and cloud types through comprehensively using satellite-base data and derived products, analyzing changes in water vapor transport and synoptic-scale circulation in the occurrence and evolvement of a typhoon and developing a conceptual model that contained conditions favorable to tropical cyclone recurvature and intensity development.

3) Improvement of the analysis techniques for typhoon cloud system characteristics.

Based on traditional subjective interpretation and analysis of typhoon tracks and intensity by using satellite images, combined with quantitative information extraction method, the analysis technique method for typhoon cloud system characteristics was improved, which was selected in comparative ways. The improved method could effectively identify supercooled water cloud, convective cloud and thin cirrus in typhoon cloud systems to enhance the quantitative classification of typhoon cloud systems.

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

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

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

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## 2.8 Improved CMACast and WIS systems

1) Currently, more than 2600 meteorological offices at provincial, prefectural and county levels receive in real-time the routine data and products provided by CMA via CMACast for weather forecasts, climate prediction and service delivery. Meanwhile, CMACast also provides data broadcasting services for 24 users from 20 WMO members in Asia-Pacific region, with daily data broadcast volume exceeding 210GB, including observational data from both China and overseas, CMA T639 NWP products, satellite data or products from FY-2D/E and FY-3A/B, EUMETSAT satellite products among others. In combination with the Meteorological Information Comprehensive Analysis and Processing System (MICAPS) - a data/product platform developed by CMA, the efficient and effective CMACast data and product applications can be capitalized to a largest extent.

2) CMA has actively participated in and promoted the implementation of the WMO Information System (WIS). In 2014, the GISC Beijing further released data from the 'Bai Long' buoys and from the tidal gauge stations at Xisha and Nansha islands, Shenzhen, Zhapo and Qinglan, China. CMA has achieved global exchange of its ocean data. So far, the GISC Beijing provides data discovery and access services for Mongolia, Nepal, Pakistan, Hong Kong China, Macao China and other Members within its responsible area, as well as for other WMO Members in the Asia and Pacific region via its portal. The GISC Beijing has released over 150,000 metadata (data volume over 500GB per day), and it has 92 registered users. In addition, to address the requirements of members within its responsible area as well as for other WMO members in the Asia and Pacific region for WIS implementation, data access and application, CMA has sent its experts since 2013 to Pakistan, Mongolia, Nepal, Tajikistan, Kazakhstan for providing technical training on CMACast, MICAPS system and WIS implementation, which played the active role in facilitating and promoting the regional WIS implementation in Asia.

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

Users of CMACast and WIS Beijing are requested to provide feedbacks in order for CMA to improve its service.

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

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

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## 2.9 Strategies and actions for typhoon preparedness of CMA

### 1) Timely launch of emergency response to trigger the “starting gun” of typhoon preparation.

During the influence of typhoon, the meteorological departments at all levels were ready for emergency responses by launching the effective typhoon preparation mechanism that has been improved in recent years and adjusting appropriate emergency response categories and levels, based on the actual circumstances, to deliver the monitoring and early warning services (table 2.1). China’s national and local flood control and drought relief offices launched appropriate emergency responses based on meteorological information.

### 2) Proactive understanding of service requirements to identify priorities.

Relevant Provincial Meteorological Services participated in the coordinating meetings held by their provincial governments every day to capture the key requirements for meteorological services and to present the typhoon evolution and its potential weather impacts. They also delivered the targeted meteorological support services. In addition, the meteorological departments at provincial, prefectural and county levels and the in site meteorological units provided special weather services for their relevant authorities respectively including the governmental emergency offices and the departments of local land, water resource and civil administration.

### 3) Taking advantage of the institutional management system to provide seamless meteorological services

CMA made its best efforts to deliver typhoon forecast and service by taking fully advantage of its vertical management system and the strength of its subordinate departments nationwide. During the influence of typhoon, CMA initiated the intensified region-specific observations by FY series satellites, with the frequency of once every 10 minutes, to timely produce, process and analyze the remote-sensing image products. CMA also sent its working groups to guide service delivery at the forecasting desks. The meteorological departments at national, provincial, prefectural and county levels achieved seamless services through interaction between higher and lower level departments and close cooperation with each other.

### 4) The widest possible dissemination of early warnings to the public for guiding their disaster preparedness.

The meteorological departments at all levels have transmitted the forecasts, early warnings and preparedness guidance to the public by such means as TVs, radios, websites, weibo (microblog), newspapers, electronic screens and loudspeakers, basically achieving full coverage of early warnings for key areas. In Guangdong Province, for example, the typhoon ‘Rammasun’ resulted in 2.55 million people reported affected and 13 billion RMB in economic loss, but no casualties reported. The damage that it caused had been minimized compared to the historically similar typhoon ‘Sally’ (resulting in 9.3 million people affected, 216 people reported killed, 17.57 billion RMB in economic loss).

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

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

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

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

### 1) Assessment and research on benefits from preparedness and reduction of typhoon-induced hazards

The National Climate Centre (NCC), together with meteorological services in three provinces, accomplished Assessment on Benefits of Actions to Prevent and Prepare for Typhoon-induced Disasters. During the assessment, a survey was made in Fujian Province into the impact of Typhoon Soulik by using the questionnaire developed in 2013 by the project group. The survey showed that during the typhoon preparedness, government departments took part in 95.8% of the activities, different departments took part in 90.2%, and the public took part in 78.2% (the number is the ratio of the total scores of different indicators in a category given by the investigated to the total scores of the category). The results reflect China's typhoon preparedness guidelines: "the government takes the lead, different departments make joint efforts and the public takes part in." A field survey on Super Typhoons Rammasun and Kalmaegi was made in Guangdong province, and the results show that the emergent evacuation lead by the government played an important role in reducing casualties of disasters.

### 2) Typhoon risk mapping

Under the project - Meteorological Support to Prevention and Preparedness for Flash Flood-induced Geological Disasters, as a first group of constructive actions in 2013, the mapping of heavy rain, floods, drought and typhoon-related disaster risks continued in 2014. One county in Fujian and one in Guangdong were selected for trial. As typhoons have three disaster-causing factors including strong winds, rainstorms and storm surges, which lead to heavy rain-related floods, wind hazards, geological disasters and storm surges. One county has been selected as a pilot target zone in Fujian and Guangdong province each. As the disaster-causing mechanism for the four kinds of hazards are different, a series of risk maps will be drawn based on study of the disaster-causing conditions and their occurrence probabilities, in combination with analyses of exposure and vulnerability curves of various disaster-bearing objects. Now this program is being studied.

### 3) Successful post-disaster reconstruction of observation system

On July 18, 2014, due to the Super Typhoon Rammasun, the temporary duty rooms at Haikou upper-air observatory, Haikou Meteorological Bureau, collapsed. Computers, printers, radiosonde and other equipment in the rooms were all damaged. At the automatic station in Hailanyefeng residential district, Lingshan, Haikou, the stem cells were broken, and wind direction and speed sensors, wind cable, wind lever cables, lightning rod brackets were all damaged. Because of rainfall, collectors and pressure sensors failed. Now those damages have been repaired, as shown in Figure 2.3 to 2.5.

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

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

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

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

### 1) Measures taken to reduce casualties and results

#### 1.1) Launching early-warning responses timely and evacuating people before disasters.

In 2014, The National Commission for Disaster Reduction of China and the Ministry of Civil Affairs launched three early-warning responses for Typhoons Rammasun, Matmo and Kalmaegi. According to the forecasts from the meteorological departments, the civil affair authorities at various levels launched their early-warning responses to remind masses in the potentially affected regions of making necessary preparations, to assist in doing such preventative work as replacing people operating at sea and exposing to potential risks to safety, and to call vessels at sea back to wind sheltering ports. Several working groups were sent out to inspect relief material reserves and emergency shelters.

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

The theme of the National Disaster Prevention and Reduction Day in 2014 was "Urbanization and Disaster Reduction". During the week, about 45 million public outreach handouts were disseminated, nearly 20000 training events were organized, over 30000 drills were carried out, and more than 10000 thematic outreach events were organized, with up to 63 million person-times were directly benefited from these activities.

2. In terms of measures taken to mitigate socio-economic impacts and results, compared with the same periods since 2000, the number of killed and missing and the number of ruined houses by typhoons decreased by 56.9% and 66.1% in 2014 respectively.

#### 2.1) Launch of emergency responses and effective disaster relief

For Typhoons Rammasun, the National Commission for Disaster Reduction of China and the Ministry of Civil Affairs launched national emergency responses for natural disaster relief (Figure 2.6), sent two working groups to the affected areas to assist and guide the local governments to carry out relief and arrange central government disaster relief funds and materials. Up to now, 4.4 billion RMB Yuan have been allocated as life subsidies targeted to typhoon disaster relief.

#### 2.2) Timely assessments on early warning of typhoon-induced disasters and losses to reduce disaster losses

In 2014, seven assessments have been made on early warning of typhoon-induced disasters and losses and one on remote sensing monitoring. During the assessments the real-time path of the typhoon forecast data were mainly used, combined with precipitation forecast, historical typhoon loss data, geological disaster point data, etc., to assess scope of impact, risk of loss, ruined and damaged houses, emergency replacement of people to safety among others, in order to identify typhoon-impacted areas and risk levels and predict the possible losses. The assessments informed decision makers in the civil affairs agencies for reference. The county civil affairs agencies evacuated masses and the property in the areas with high typhoon and flood risk in advance and reduced property damage.

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

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

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

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## 2.12 Improved capacities of Ministry of Civil Affairs on managing typhoon-induced disaster risks

### 1) Disaster reporting and information releasing.

In 2014, the National Natural Disaster Management System was upgraded (Figure 2.7). The system integrates disaster reporting management, statistical analysis, product development and space display. On a preliminary basis, the townships (or towns and sub-districts) of additional seven provinces (or municipalities and autonomous regions) can report their disasters. With 20,000 users, the coverage of the reporting function has been enlarged to all the provinces, prefectures and cities and counties as well as all the townships, towns and sub-districts of twelve provinces (or municipalities and autonomous regions). The disaster reports received by the system were doubled to 200,000 annually. The intelligent terminal-based disaster reporting system began running this year, which allows on-site users at county level to deliver disaster information and photos through smart phones or PAD in real time (see Fig. 2.8). This year through the system over 160,000 MMS have been sent to the central and provincial decision-making users; "China Disaster Relief", a Wechat platform was officially launched in late June, which delivers daily information on disasters and disasters relief to the national and provincial disaster management personnel. Now China Disaster Relief has nearly 2,000 government users.

### 2) Improving comprehensive disaster response capacity through satellite industrialization projects.

In 2014, the Ministry of Civil Affairs led the implementation of two satellite industrialization projects of NDRC, through which, the ability of disaster collecting and reporting, remote sensing monitoring and evaluation and providing integrated product services will be greatly enhanced through the development of systems and platforms. Among them, the "independent satellite-based disaster reporting and services integrated application demonstration" project will realize rapid collection of disaster information, comprehensive analysis of multi-source remote sensing data and operational data, intelligent processing of large-scale information and integrated, multi-terminal, multi-network and one-stop disaster information services to build a "state - province - city (prefecture) - county - township - village" comprehensive disaster reporting and services application demonstration system. The project "autonomously controlled high-resolution remote sensing satellites-based integrated disaster reduction and rapid service platform building and demonstration" will develop software systems for rapid disaster response scheduling, rapid development of disaster-related products, end to end service of disaster-related products, comprehensive disaster reduction services and applications of satellite remote sensing product. The project will also develop fast imaging products, standard imaging products and typical disaster basic customized information products targeted to rapid services for comprehensive disaster reduction.

### 3) Improving disaster reduction and relief standards.

In 2014, Statistical Indicators of Human Resources for Disaster Prevention and Reduction,

Specifications for Mapping Integrated Natural Disaster Risk (1: 10,000), Natural Disaster Shelter Management Specifications were officially implemented, which provide basis for scientific and standardized management of natural disasters.

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

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

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

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2.13 Improved warning and forecasting capacities of impacts of rainstorm and flood on small- and medium-sized reservoirs

With over 90 thousand reservoirs, China is one of the countries in the world with the largest number of reservoirs. Among the reservoirs, more than 90% are small- and medium-sized ones, and more than 30 thousand are dangerous ones. During the flood season, the safe operation of small- and medium-sized reservoirs is critical to the flood preparedness safety of 310 million people, 132 large and medium-sized cities and 4.8 million mu of farmland. However, most small and medium sized reservoirs are managed by corresponding administrative areas with insufficient professionals, information equipment and weak flood forecasting and early warning capacity. With small basins, this kind of reservoirs has short flooding convergence time, thus leading to short flood control response time. In addition, such reservoirs have small flood storage capacity and flood control ability. Therefore, in the situation of emergent rainstorm extremes, the reservoir water level rise quickly, and it is difficult to take effective measures to control flood, thus causing outburst of floods, which seriously affect people's lives and property safety downstream.

Based on 50 × 50 kilometers grid numerical rainfall forecast from CMA, Bureau of Hydrology, Ministry of Water Resources, use power ---- statistical downscaling method to study the coupling calculations between atmospheric numerical models and hydrological models, use distributed hydrological models to simulate inflow processes of reservoirs and calculate the amount of storm water reservoirs can afford while meeting the design water levels to optimize reservoir flood control programs and analyze the anti-storm ability of small- and medium-sized reservoirs, so that information can be provided to decision-making departments for scientific scheduling, and the early-warning and forecasting ability of such reservoirs in response to emergent rainstorms and floods can be improved.

During Typhoon "Rammasun" in 2014, Guangdong Province used the technology to carry out warnings and forecasts for small and medium-sized reservoirs in advance and ensure the safety of the reservoirs.

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

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

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

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2.14 CMA training courses on TC operational skills

In 2014, the Training Center of CMA held several operational training workshops related to tropical cyclones. Those workshops strengthened the theoretical knowledge of frontline forecasters and improved operational skills of forecasters to apply new technologies and methods related to typhoons and rainstorms, including:

- 1) Workshop on Processing of Meteorological Data and Mapping Technologies. 65 trainees participated in the workshop, the courses mainly include: application techniques of GrADS, interface of GrADS with 9210 data, NCEP, Grib, netCDF and other data formats, a variety of graphics display and data processing methods, the use of the data of observational stations, the display of irregular zone data, as well as matlab graphics and so on.
- 2) Advanced Training Workshop on Monitoring and Forecasting Technologies of Typhoons and Rainstorms (Figure 2.9). 33 trainees participated in the workshop, and the courses mainly include: understanding the mechanism of typhoons and rainstorms and their monitoring and forecasting technology. The lectures covered the main findings of the 973 program on typhoons "abnormal changes of landing typhoons", precipitation mechanisms and prediction theories of landing typhoons, including the mechanisms and forecasting of the growth and torrential rain, the formation and activity mechanism of stage squall line, nowcasting techniques based on radar, and technologies on the application of lightning data in typhoon monitoring and the application of satellite data in intensity analyses.
- 3) International Workshop on Thunderstorm Nowcasting Technologies, with 27 trainees attending.

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

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

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

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## 2.15 International Workshops on Tropical Cyclones

### 1) Workshop on Synergized Standard Operating Procedures (SSOP) for Coastal Multi-hazards Early Warning System

On June 9, 2014, the Training Workshop on Synergized Standard Operating Procedures (SSOP) for Coastal Multi-hazards Early Warning System of Typhoon Committee was held in Nanjing University of Information Science and Technology (NUIST). Mr. Olavo Rasquinho, Typhoon Committee Secretary-General, Mr. Imran Akram, ESCAP Panel on Tropical Cyclones expert, Mr. Samuel Muchemi, representative of WMO, and Professor Jiang Jianqing, President of NUIST, as well as more than 40 representatives from 13 countries and regions including China, Thailand, Philippines, India, Maldives, Malaysia, Vietnam, Pakistan, Laos, Bangladesh, Sri Lanka, Myanmar attended the opening ceremony of the workshop.

Mr. Olavo Rasquinho pointed out that this is the first program of WMO Typhoon Committee sponsored by ESCAP. He emphasized that only through comprehensive testing and latest tracking technology, can the early warning capacity of national meteorological and hydrological services be improved and the impact of disasters reduced. To fulfill these tasks, coordination and sharing of resources and communication networks among different sectors are needed.

### 2) The International Training Course on Tropical Cyclone Forecast

The International Training Course on Tropical Cyclone Forecast was organized on 15-26 May 2014 in Nanjing by WMO Regional Training Centre Nanjing, twelve meteorologists from China, Pakistan, UAE, Oman, Kenya, Thailand, the Solomon Islands and Kiribati attended the course (Fig.2.10). Zhou Guanbo and Wang Jing, forecasters of the Typhoon and Ocean Center, CMA, also participated in the course. They introduced operational forecasting of typhoon, observation and numerical assimilation of typhoon of CMA to other participants and learnt about the situation of relevant countries in the studies and forecasting of tropical cyclones. In doing so, international communication in typhoon forecasting was greatly promoted.

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

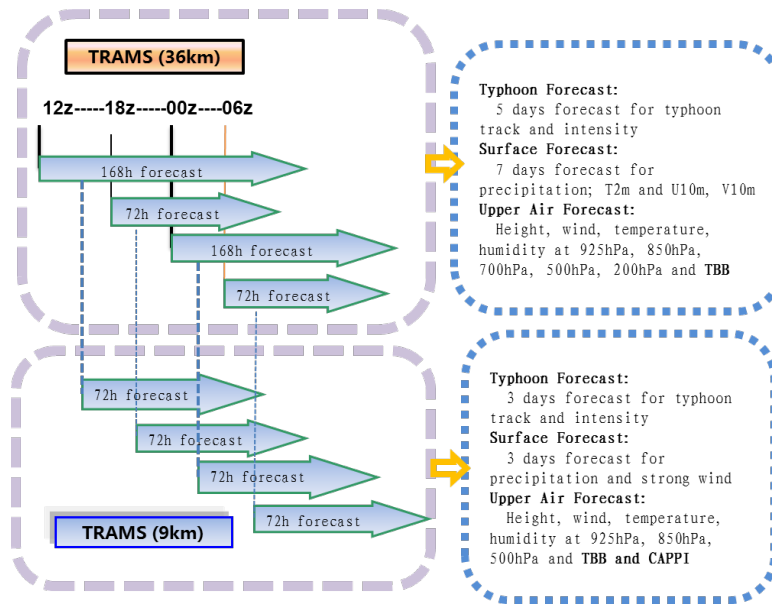
Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

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

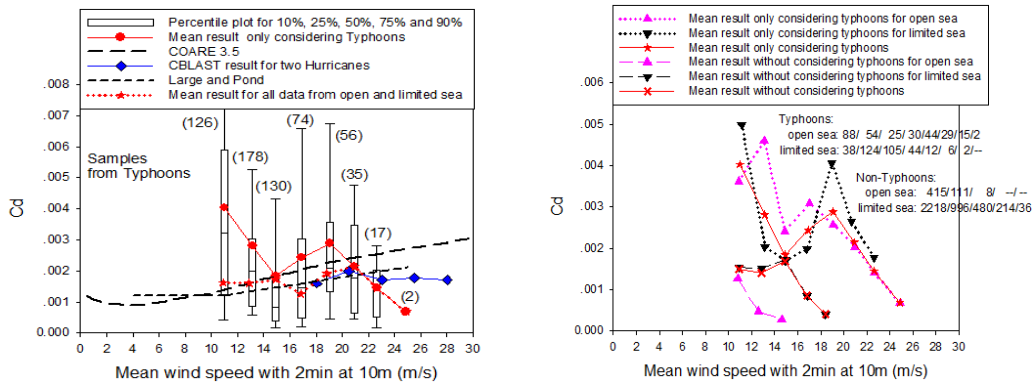
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# Appendix



**Fig. 2.1** Schematic diagram of South China Sea Typhoon Mode



**Fig. 2.2** Changes of the drag coefficient with changes of wind speed during typhoon and without typhoon



**Fig. 2.3** left) On July 18, 2014, due to the Super Typhoon Rammasun, the temporary duty rooms at Haikou upper-air observatory, Haikou Meteorological Bureau, collapsed. Right) On July 23, 2014, Haikou Meteorological Bureau rebuilt the rooms.



**Fig. 2.4** left) On July 18, 2014, due to the Super Typhoon Rammasun, the temporary duty rooms at Haikou upper-air observatory, Haikou Meteorological Bureau, collapsed. Computers, printers, radiosonde and other equipment in the rooms were all damaged. Right) On July 19, 2014, Haikou Meteorological Bureau equipped computers, printers, etc. for Haikou upper-air observatory.



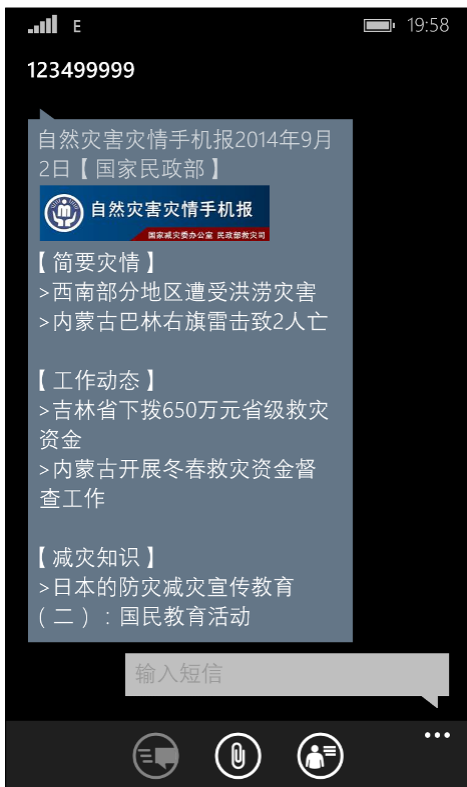
**Fig. 2.5** left) On July 18, 2014, due to the Super Typhoon Rammasun, at the automatic station in Hailanyefeng residential district, Lingshan, Haikou, the stem cells were broken, and wind direction and speed sensors, wind cable, wind lever cables, lightning rod brackets were all damaged. Because of rainfall, collectors and pressure sensors failed. Right) On July 25, 2014, the image of the automatic station in Hailanyefeng residential district, Lingshan, Haikou after repair.



**Fig. 2.6** Remote sensing analysis of house collapsing and damages in Wenchang City, Hainan due to Typhoon Rammsun



**Fig. 2.7** 2014 version of National Natural Disaster Management System



**Fig. 2.8** MMS (left) and Wechat (right) about natural disasters



**Fig. 2.9** Advanced Training Workshop on Monitoring and Forecasting Technologies of Typhoons and Rainstorms (Beijing, China)



**Fig. 2.10** The International Training Course on Tropical Cyclone Forecast (Nanjing, China)

**Table 2.1** Emergent responses and typhoon early-warning services of CMA in 2014

Typhoon No.	Typhoon name	Numbers of warnings released	Categories of emergency responses to major met. disasters (Typhoon) launched by CMA
1407	Hagibis	5	/
1409	Rammasun,	14	Category I
1410	Matmo	16	Category III
1415	Kalmaegi	13	Category II
1416	Fung-wong	15	Category IV