Study of High Impact Weather Events in China during Recent years

Sixiong Zhao and Jianhua Sun
Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, 100029, P.R. China
Email: zhaosx@mail.iap.ac.cn
Outline

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1. Introduction

Weather and climate systems are very complex in East Asia, especially in China.

Extreme Weather Systems occur very often in China during monsoon season, such as, heavy rainfalls, typhoons, strong storms, heat waves, dust storms and so on.
2. Heavy rainfall

The rainbands shift northward in China continent accompanying the onset and advance of summer monsoon. It can be found that there are three main rainbands:

- South China in May to mid-June,
- Yangtze River in mid-June—mid-July
- North China in mid-July—mid August
2. Heavy rainfall cases

In July, 1998, the very strong heavy rainfall occur in the Yangtze River (Zhao et al., 1998; Bei et al., 2002). The circulation is very favorable to the formation and development of heavy rainfalls.
Percentage Summer Rainfall Anomaly for June to August, 1998

- Positive Rainfall anomaly in Yangtze River
- Heavy rain in Northeast China

Map showing rainfall anomalies across China for June to August 1998.
Dongting lake
- 1998’s summer flood -
Flooding in Yangtze River in 1998
The local heavy rainfall in Beijing 10 July 2004

During 16~21 LST July, downtown area of Beijing occurred severe heavy rainfall.

The maximal hourly precipitation is 52 mm in Fengtai. The maximal total precipitation is 125 mm.
1998 Yangtze River Case: The accumulated precipitation of 12 UTC 19 – 12 UTC 22 July 1998 in Hubei province (mm)
Heavy rainfall forecast
The observational system includes: 15 radiosonde, 120 surface intensive observation stations, 9 weather Doppler radars, 8 GPS stations, 2 wind profilers, 1 boundary layer observation system and 114 automatic weather stations.
Multi-scale model of heavy rainfall in Meiyu front

Model of synoptic scale

High moisture area

Precipitable water

Precipitation
Multi-scale model of heavy rainfall in Meiyu front

Model of $M \alpha CS$ in Meiyu front

- $M \beta CS$: 20~200 km
- Meso-β convective line

$M \alpha CS$: 200~500 km
Multi-scale model of heavy rainfall in Meiyu front

**Model of meso-\(\beta\) convection line**

The first convergence line forms along the boundary convergence line.

The second boundary convergence line forms between the boundary outflow of the first convection line and southwesterly.

850hPa wind direction

East

South

Surface

Boundary convergence line

850hPa wind direction

Surface

Boundary convergence line

East

South
The physical model of meso-β vortex

HUBEX资料: 6小时间隔的风场

SCSMEX资料: 850hPa平均湿度场

低层里查逊数和流场的垂直剖面
3-D cubic chart of the precipitation field at 05:40 21st July by TRMM radar retrieval, the precipitation threshold value is 1.0mm/hr. The visual angle is 60°, the position of central point is 30.1°N, 115°E. (From: Minghu Chen)
3. Tropical cyclone

China is one of the countries influenced frequently by tropical cyclones (TC), including typhoons. The TC brings the very serious damages and economic loss to this area. Particularly, the landing TC is one kind of important disastrous weather systems.
3. Tropical cyclone cases

The very famous case is typhoon influencing Henan province in July 1975, which produced the severe flooding in this area (Ding et al., 1978). In this case, TC could moved northwards due to the meridional amplitude of Subtropical High to the east of TC and the continent subtropical high in North China maintained statically to keep the TC staying almost in the same area during three days, which is very favorable to the formation of heavy rainfall and flooding in Henan province.

The other important case of TC in recent years appeared in Shanghai at the beginning of August 2001 (Qi et al., 2003).
A long-lived, local record severe rainfall since 1949 occurring in Shanghai on 5-6 August 2001, which belongs to a typical urban meteorological disaster.
Track of the TD (thick solid line) and observed precipitation (shaded) from 0000UTC 4 to 0000UTC 6 August 2001 (units: mm)
The hourly precipitation showed that the heavy rainfall was mainly caused by *four mesoscale rainy clusters*. The horizontal scale of rainy clusters was about *ten kilometers* and the life cycle was about *1-3 hours*. 
The hourly precipitation of Shanghai's autostation (units:mm)
50002:(Changning); 50003:(Nanshi); 50004:(Xiaodongmen); 50008(Wujiaochang);
50010:(Jingan); 50011:(Middle school of Yucai); 50013:(Yangpu); 50018:(Xuhui)
The GMS5 images at (a) 1200 UTC 5, (b) 1400 UTC 5, and (c) 1800 UTC 5 Aug 2001.
the assembled reflectivity of radar at 1441UTC, 1614UTC, 2244UTC 5, 0000UTC 6
The record heavy rainfall occurring in Shanghai on 5-6 August 2001 was the most severe event in that area since 1949.

The maximum observed precipitation amount during 24h and 1h broke, respectively, the 50-year records in Shanghai.

By analyzing, it is found that the heavy rainfall was caused by a series of mesoscale convective cloud clusters developing in the landing tropical depression (TD), which moved very slowly and re-intensified in Shanghai.
4. Heat wave

In summer, temperature more than 35°C is defined as heat weather.

According to the statistics during the recent 60 years, the yearly frequency of heat weather in Beijing is around 81%, it appear very often, especially in 1940’ and 1990’.
4. Heat wave cases

For example, more than 42°C was reported in Beijing in June 1942 and July 1999.
The temperature difference between urban and suburb area in Beijing from 20 LST 23 July to 20 LST 24 1999
(a) Hourly temperature at Guanyuan station and (b) the temperature difference between Guanyuan and Pinggu stations
The averaged general circulation on 500 hPa of 23-29 July 1999
(sold line: geopotential height in gpm; dashed line: temperature in °C)
Cross section of simulated streamline along (a) 110°E and (b) 120°E at 00 UTC 24 July 1999
• Heat wave is also closely related with the general circulation. The important factor is that the continent subtropical high maintains in North China and downward motion warming is a main possible reason.

• It is found that the heat island effect could make air temperature go up more than 2°C than temperature in instrument shelter.
5. Dust storms

- Dust storm is one kind of the disastrous weathers. The occurrence of dust storms depends on two aspects: state of ground and strong wind.

- In recent years, the occurrence of dust storms in China is more frequent, especially during the period from 2000-2002. It is related to the formation and development of rapid developing cyclones in Mongolia and North China.
The averaged total dust-storms days in one year in China (1961-2000)

From Zhou et al.
The dust-storm in Beijing on 20 March 2002
Observed dust event phenomena on 19 March 2002.

1, 2, 3, and 4 represents dust-in-suspension, blowing dust, dust storm, and severe dust storm events, respectively. (Beijing Standard Time)
Observed dust event phenomena on 20 March 2002. 1, 2, 3, and 4 represents dust-in-suspension, blowing dust, dust storm, and severe dust storm events, respectively. (Beijing Standard Time)
Integrated dust-storm modeling system

- **TERRAIN**
  - Terrain and Landuse Data Process

- **REGRID**
  - First Guess Field

- **RAWINS/Little_r**
  - Surface and Rawinsonde Data Process

- **INTERPF**
  - Vertical Interpolation

- **GIS Data Base**
  - Soil Type, Vegetation Type, Vegetation Height, Vegetation Cover, LAI, Landuse

- **Pro-processor for Dust Emission Model**
  - Friction Velocity
  - Soil Moisture

- **Dust Emission Model**
  - Computing Dust Flux $F$
  - Computing Sand Flux $Q$

- **Dust Transport Model**
  - Computing Dust Concentration $C_i$

- **MM5**
Simulated dust flux on 19 March 2002
(Units: $10^{-3}$mg m$^{-2}$ s$^{-1}$ , LST)
Simulated dust flux on 20 March 2002
(Units: $10^{-3}$mg m$^{-2}$ s$^{-1}$, LST)
6. Conclusions and discussions

1. The high impact weathers occur very often in China in the different seasons, such as heavy rainfalls, tropical cyclones, heat waves, dust storms and so on in the favorable general circulation conditions.

2. The variation of important members of atmospheric general circulation, including the trough in westerlies, West Pacific Subtropical High, monsoon surge, and eastward moving short wave trough from Tibetan plateau could be associated with the extreme weathers.

3. The environment conditions influencing the extreme weather are very complex, including ocean, plateau terrain, snow cover, monsoon circulation, middle latitude westerlies systems, and even ENSO.

4. Study of the high impact weathers in China have been conducted and preliminary results have been obtained. For better understanding of their mechanism and improving of their prediction, more investigation should be made in future.