Statistical Characteristics of thunderstorm activity in the middle reaches of the Yangtze River Basin based on a lightning clustering method

Qian Wei[1,2], Jianhua Sun[1,2], Dongxia Liu[3], Zhuling Sun[3], Mingyuan Liu[3], Zheng Ma[1]

[1]Key Laboratory of Cloud-Precipitation Physics and Severe Storms (LACS), Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP/CAS), Beijing, China.
[2]University of Chinese Academy of Sciences, Beijing 100029, China.
[3]Key Laboratory for Middle Atmosphere and Global Environment Observation (LAGEO), Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, PR China

Corresponding author: Jianhua Sun (sjh@mail.iap.ac.cn)

1. Background

- Lightning can serve as a good tracer of the occurrence and development of thunderstorm systems. It is an affiliated phenomenon of thunderstorm systems and occurs more frequently in the intense development stage of thunderstorms.
- Lightning clustering methods have been used to **group the lightning strokes that are close in time and space to obtain a lightning cluster originating from the same thunderstorm**, so that the evolution of lightning strokes within the cluster can reflect the characteristics of thunderstorms.
- The middle reaches of the Yangtze River Basin (YRB) have a complex underlying surface (Figure 1). This region has a relatively well-developed radar and cloud-to-ground (CG) lightning detection network, which provide a basis for studying thunderstorm activity based on CG lightning data.

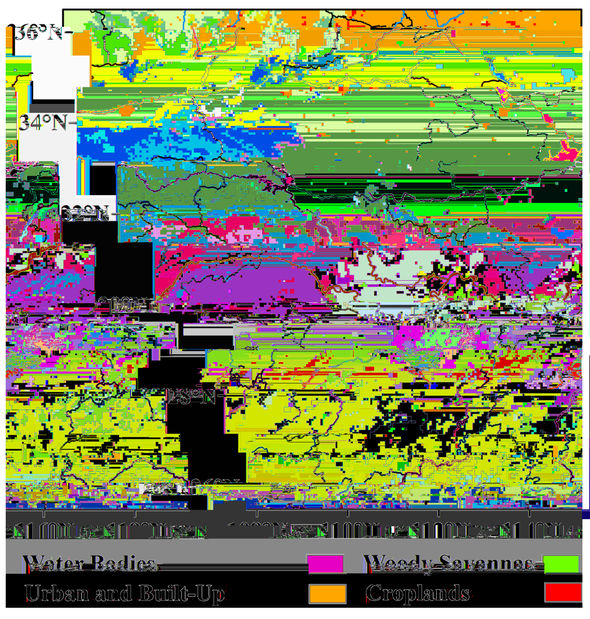


Figure 1. The type of land use in the middle reaches of the YRB.

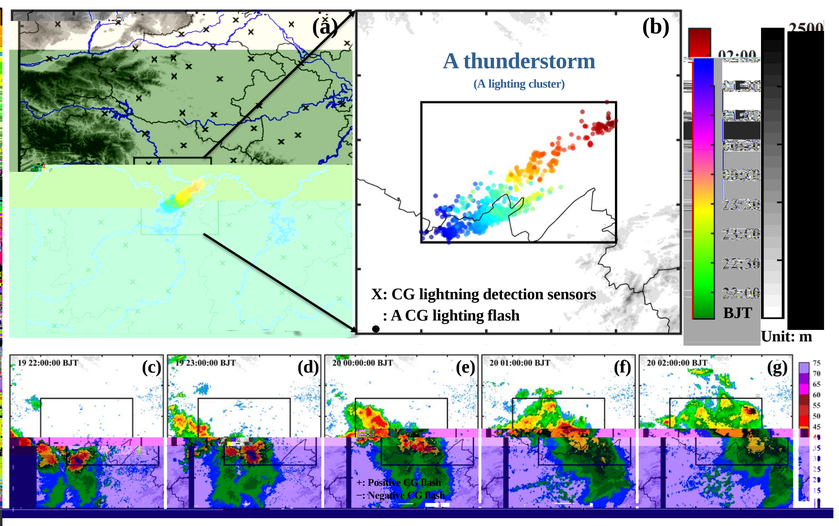


Figure 2. A nocturnal thunderstorm with a duration of 4.9 h and a CG flash frequency of 881 occurring on June 19, 2019 in the middle reaches of the YRB. In (a) and (b), a dot and its color denote a CG flash and its occurrence time (BJT), respectively. (c-g) spatial distribution of CR (dBZ, shadings) and the corresponding 6-min CG flashes (+ denotes positive CG, − denotes negative CG) at different times. Gray shadings denote elevation (unit: m).

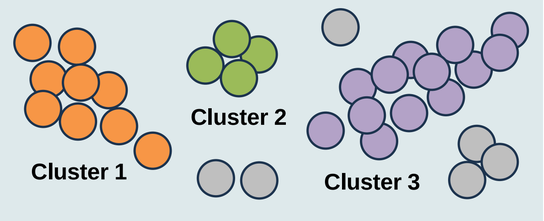
2. Data and the clustering method

- **Study period:** the warm seasons (May-September) of 2016-2020
- **Data 1:** The mosaics of composite reflectivity (CR) with a time interval of 6 min and a horizontal resolution of 0.01 0.01 from the network of Chinese next-generation weather radars.
- **Data 2:** The CG lightning data (the time, location, polarity, and peak current of the returning stroke) from the China Lightning Detection Network (Figure 2a, 81 sensors). In addition, a CR value is assigned to each CG flash.

The clustering method

A thunderstorm is considered as **a composite of lightning flashes occurring within a 16-minute time window and a spatial distance of 0.1 (10 km)**. An example is shown in Figure 2. Some parameters for a thunderstorm are defined as follows:

Start and end time: the occurrence time of the first and last CG flash, respectively
Duration: the time difference between the occurrences of the first and last CG flash.
Area: the minimum circumscribed convex polygon area of the lightning cluster.
Length: the distance between the two CG flashes that are furthest apart within the lightning cluster.
Displacement: the distance between the first and last CG flashes.
Moving direction: the angle between the direction of the displacement and the east direction.
Moving speed: the ratio of displacement to duration.



3. Results: thunderstorms are divided into 3 types based on duration

THS1 6min-3h
- Occurrence: 71714 times
- Percentage: 56.8% of total CG flashes

THS2 3 6 h
- Occurrence: 1094 times
- Percentage: 26.6% of total CG flashes

THS3 6 18 h
- Occurrence: 166 times
- Percentage: 16.6% of total CG flashes

3.1 Thunderstorms duration, area, speed, etc.

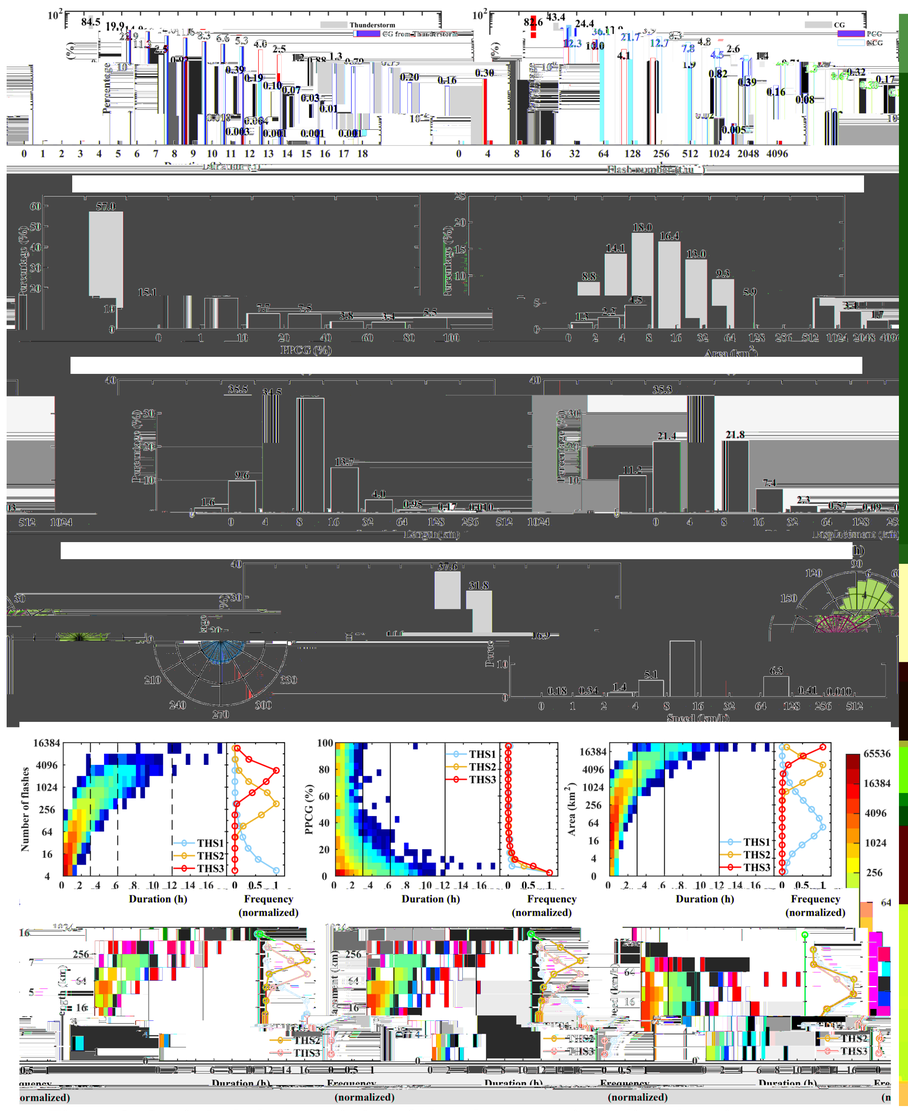


Figure 3. Statistical characteristics of thunderstorms including duration, percentage of positive CG flash, flash number, area, length, displacement, speed, direction.

3.2 Temporal and spatial distribution

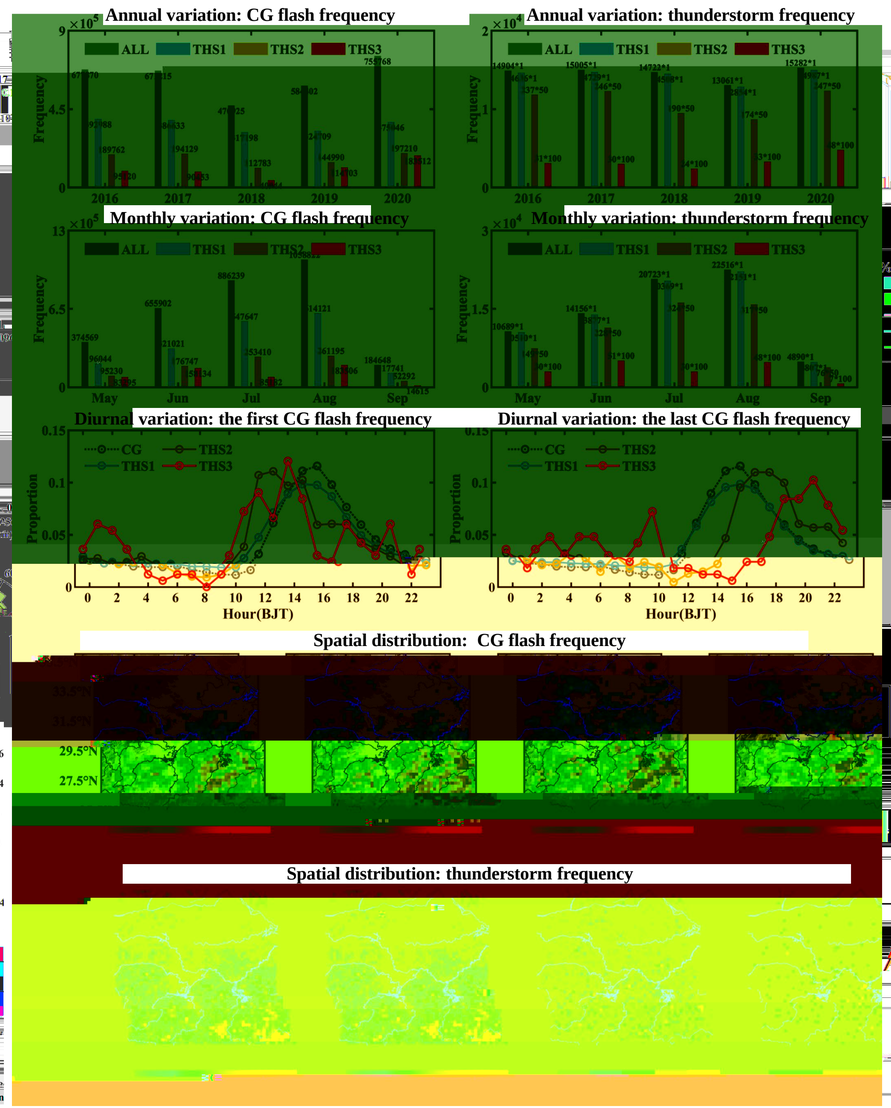


Figure 4. Temporal and spatial distribution of thunderstorm frequency and CG flash frequency for THS1, THS2 and THS3.

3.3 CG flash and its corresponding CR

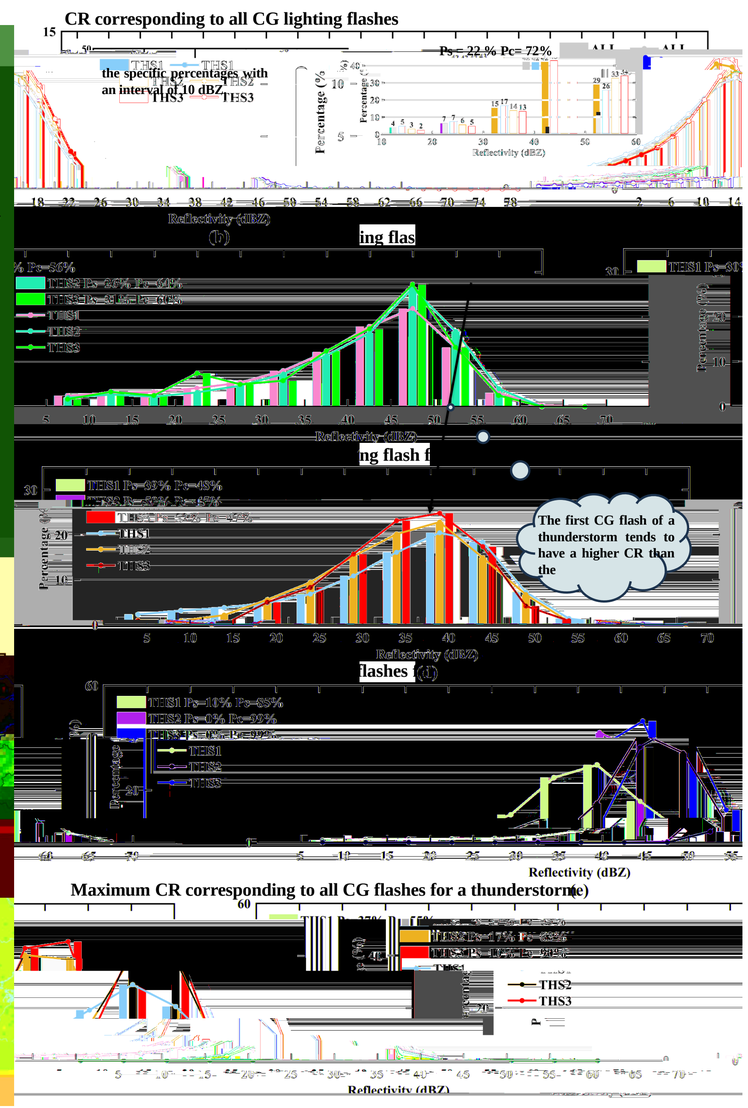


Figure 5. Probability distributions of CR corresponding to CG flashes for THS1, THS2 and THS3.

4. Conclusions:

- **The lighting frequency, area, displacement, etc. of thunderstorms derived from CG lightning data change with the increasing thunderstorm duration.**
- **The lightning activity of longer-duration thunderstorms, mostly triggered near the mountains, occurs (ends) earlier (later) in the afternoon (evening).**
- **Radar echo characteristics of CG flashes from thunderstorms with different durations show certain regularities.**

Qian Wei, Jianhua Sun, Dongxia Liu, Zhuling Sun, Mingyuan Liu, Zheng Ma. Statistical Characteristics of thunderstorm activity in the middle reaches of the Yangtze River Basin based on a lightning clustering method. 2023 In revision.

Contact:
Email: weiqian@mail.iap.ac.cn