

基于闪电聚类的长江中游地区雷暴活动特征

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

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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.

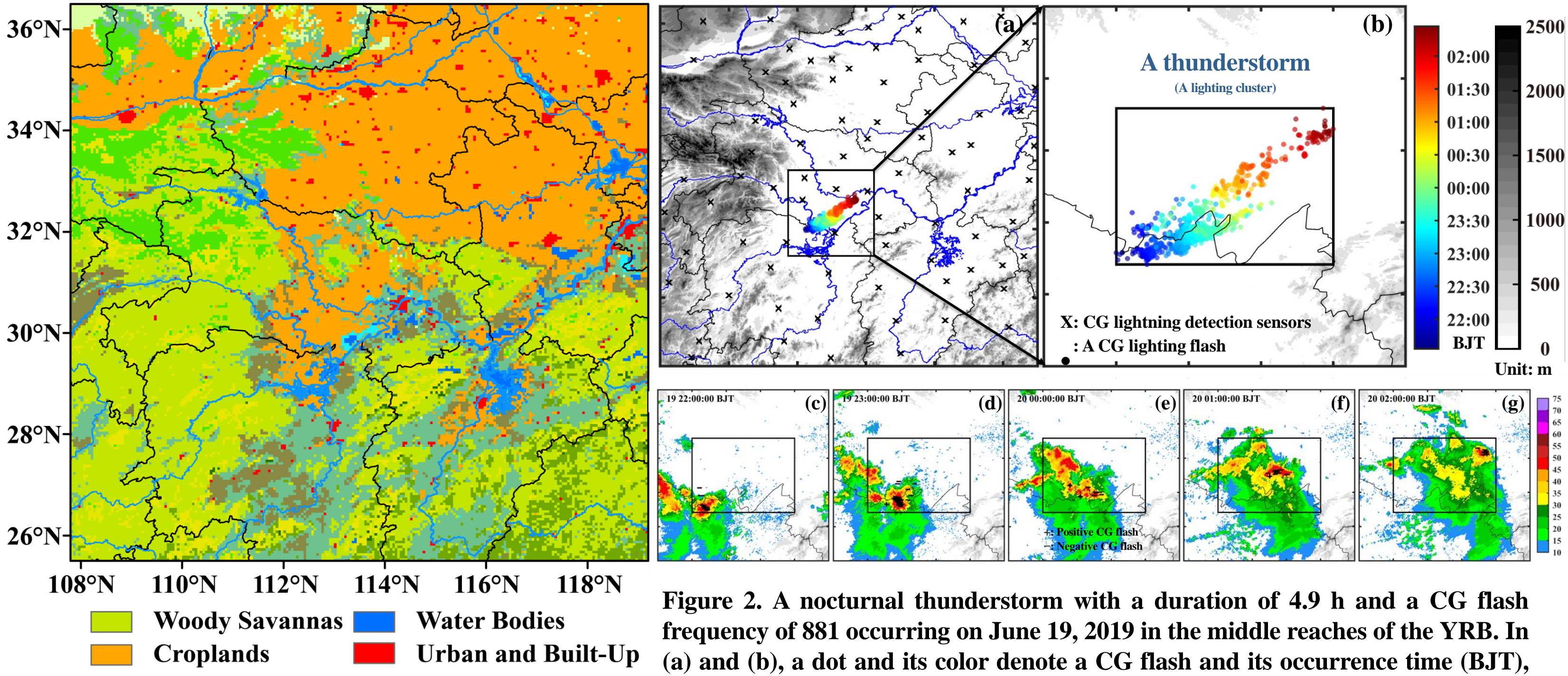


Figure 1. The type of land use in the middle reaches of the YRB.

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 $0.01^\circ \times 0.01^\circ$ 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.

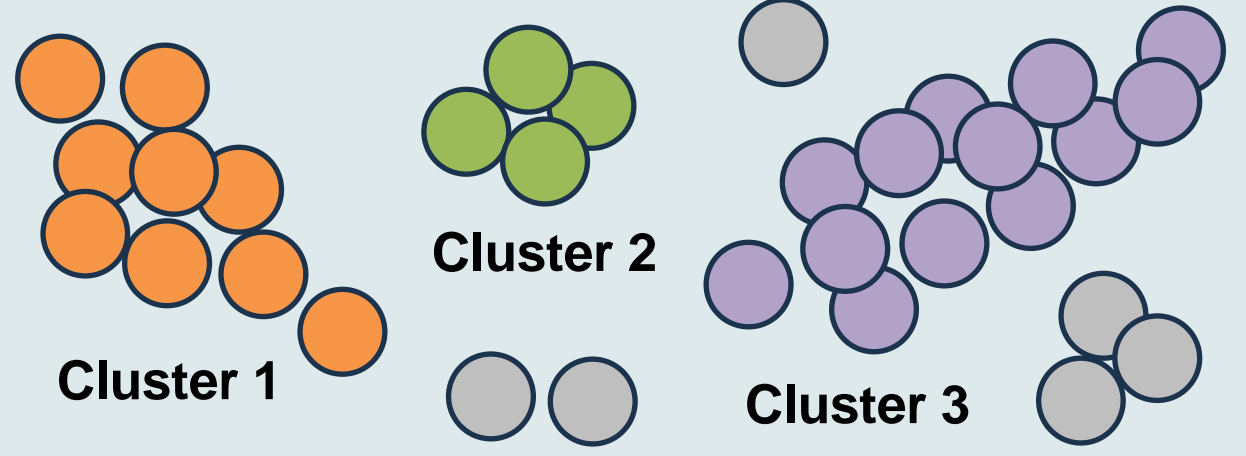
Area: the minimum circumscribed convex polygon area of the lightning cluster.

Length: the distance between the two CG flashes that are furthest apart within the lightning cluster.

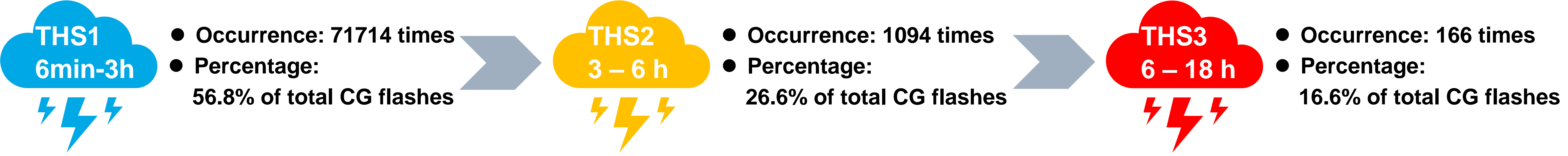
Displacement: the distance between the first and last CG flashes.

Moving direction: the angle between the direction of the displacement and the east direction.

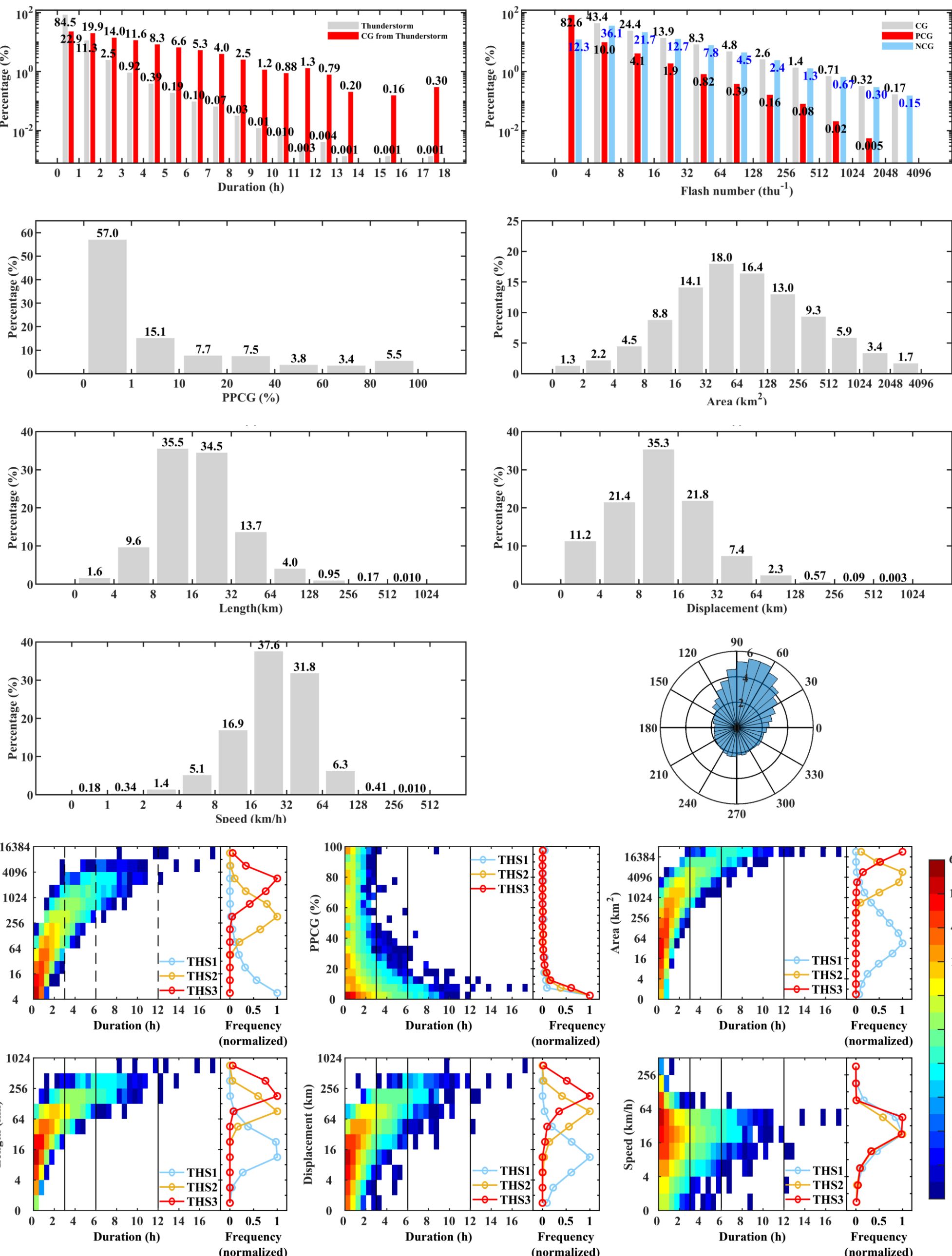
Moving speed: the ratio of displacement to duration.



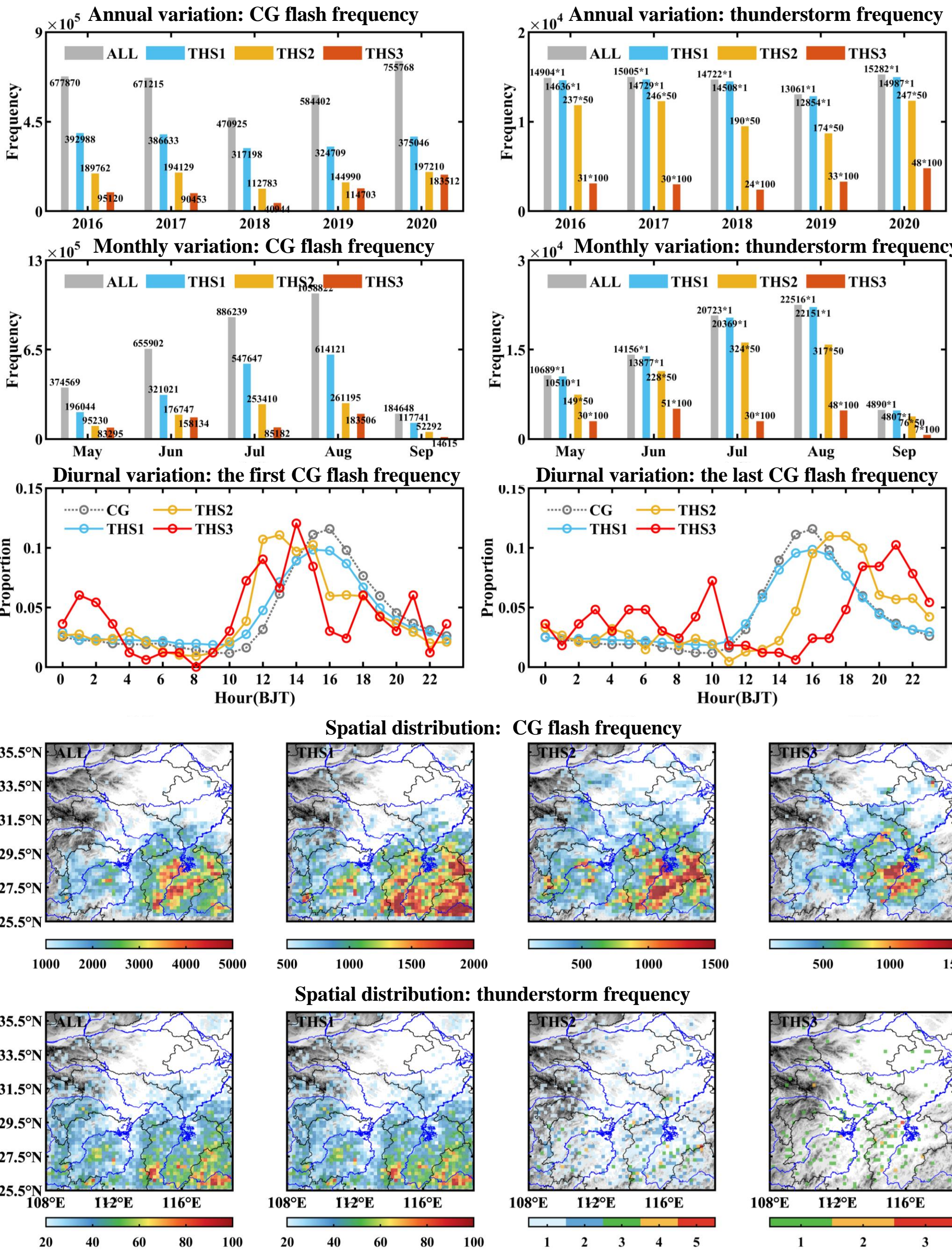
3. Results: thunderstorms are divided into 3 types based on duration



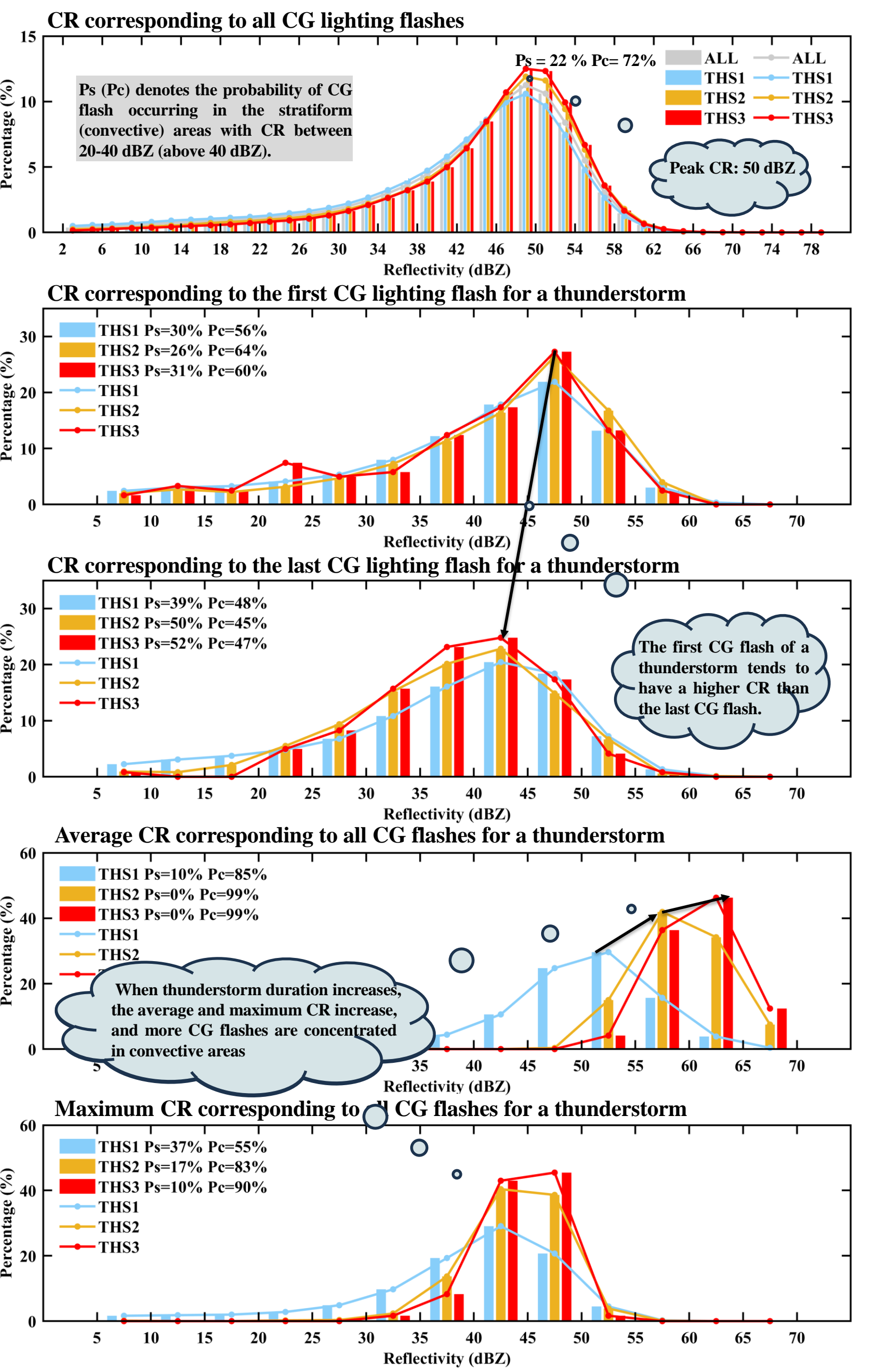
3.1 Thunderstorms duration, area, speed, etc.



3.2 Temporal and spatial distribution



3.3 CG flash and its corresponding CR



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.