The Observation of Three Dimensional Lightning activity Characteristics in ChongQing Area

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ABSTRACT: Since 2009 we set up a 3D lightning location system based on the arrival time difference. The 3D lightning location system has been used to observe three dimensional lightning discharge of Chongqing area in 2011. The percentage of the thunder intra-cloud flash, cloud-to-ground lightning and NBE is 66%, 31% and 3% respectively in Chongqing area, the positive and negative cloud flash ratio is 3.0 while the ratio of the intra-cloud flash to cloud-to-ground lightning is 2.2. Among the cloud-to-ground lightning, the negative ground lightning flash covers an area of 94% of the total. The height of about all the lightning is 20 km or less for the 80% is below 15 km. The negative intra-cloud flash lay mainly in 8 to 11 km while the positive ones mainly concentrated in 7 to 9 km and 11 to 14 km. In addition, the discharge height of negative NBE is 7 to 10 km and the discharge height of negative NBE is 12 to 16 km. the discharge height of negative NBE is obviously higher than the discharge height of negative NBE.

INTRODUCTION

Various countries have conducted the 3D detection technology research on thunders for clearer understanding of its occurrence and development mechanism. Currently the LMA and LASA systems are two quite representative location systems. LMA system, a 3D lightning radiation source location system developed by New Mexico Mining Technical College of the USA, is an arrival time difference location technology based on the GPS clock synchronization. The LASA lightning detection system was established in 1998 in New Mexico State to provide lighting demarcation in cooperation with satellite observation, and is a quick electric field change location network that works at VLF/LF frequency. Betz [2004]set up a lightning location system similar to LASA in Germany, and spread it to the entire Europe afterwards. This system is able to distinguish between intra-cloud lightning and cloud-to-ground lightning according to the heights of sources; the determination of source altitude is done with the quasi-3D technology of the sensor that’s closest to the lightning source. Since 2009 we set up a 3D lightning location system (named CTLLS) based on the arrival time difference in Chongqing area. This system not only can locate the cloud to ground lightning but also the intra-cloud lightning. In this paper, observation of three dimensional lightning activity characteristics in ChongQing area in 2011 was given .

INSTRUMENTATION AND DATA

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Location Network Arrangement

The Multi-Station Lightning Location Network contains 9 sub-networks, namely, XPF, YBZ, BSZ, BNZ, BBZ, TSP, SPB, NSZ and CJZ; their respective arrangement is marked in Fig 1, and distance between each station is generally 10 to 30 kilometers. This location system adopts VLF/LF frequency for detection, and provides absolute tune benchmark with high precision GPS system. It conducts lightning detection and location by using DTOA (Difference of Time of Arrival).

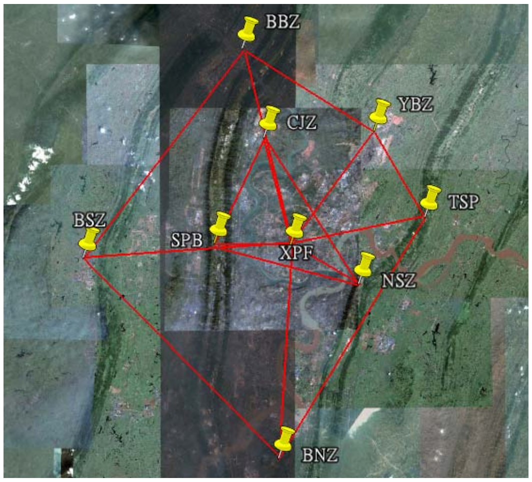

Figure 1. The distribution of ChonQing Network

Data

Table I shows the thunder positioning results of the CTLLS system in 2011. Specifically, over 1.2 million times of thunder occurrence were detected from June to August, 2011, among which 226,000 times of lightning were detected in June, taking up 18.6% of the total detected times that year. According to the previous cloud-to-ground lightning statistics, Chongqing Area stepped into its frequent thunder occurrence period gradually from April to June. In July 2011, over 820, 000 times of lightning were detected, accounting for 67.3% of the year's total and thus indicating that July is the month with most frequent thunder activities in Chongqing. August 2011 saw around 172,000 times of lightning altogether, taking up 14% of the total number for that year, and illustrating gradually weakened thunder activities in August of Chongqing, controlled by sub-polar high pressure system.

Table I 3D thunder positioning results of 2011

Year	June	July	August	Total
2011	226628 (times)	822727 (times)	171701 (times)	1221056 (times)

DATA ANALYSIS AND RESULTS

Distribution Features of CG and IC Lightning in Chongqing Area

CTLLS system could recognize cloud-to-ground and intra-cloud lightning, as well as the narrow bipolar events (NBE), a special type of discharge events in intra-cloud lightning. Thus here the lightning detected was divided into three categories, namely, cloud-to-ground lightning, intra-cloud lightning, and NBE, with each category subdivided into positive and negative polarity.

Fig 2 indicates the positive-to-negative-polarity ratios in different categories of lightning. Respectively, 3.0, 2.7 and 0.06 for intra-cloud lightning, NBEs and cloud-to-ground lightning respectively. According to the cloud-to-ground lightning positioning data statistics in Chongqing through many years, the negative cloud-to-ground lightning amounts to over 90% of the total, and that figure in the CTLLS system stands at 94%. Fig 3 indicates the distribution percentages of intra-cloud lightning, cloud-to-ground lightning and NBEs to be 66%, 31% and 3%, respectively.

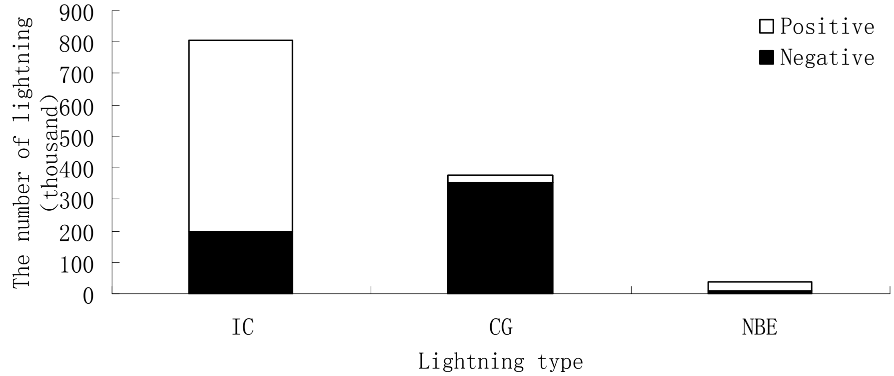

Figure 2. Positive and negative polarity distribution of CG and IC, as well as the NBE in 2011

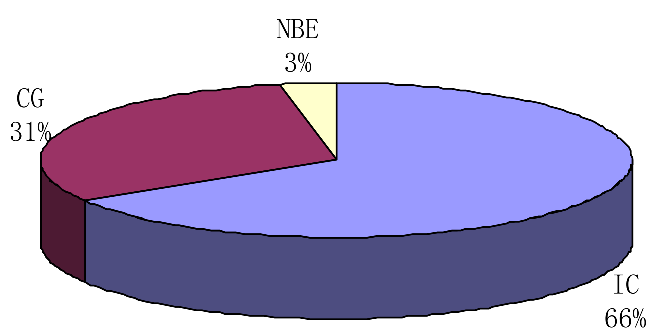

Figure 3. Percentages of different categories of lightning, 2011

Lightning Height distribution features in Chongqing Area

Fig 4 shows the discharge height distribution of positive and negative intra-cloud lightning.

Specifically, almost all lightning activities occur below 20km, among which 80% are mainly below 15km; at 8km-12km, the positive intra-cloud lightning sees a peak, while the peak for negative intra-cloud lightning occurs at 9km. Frequent thunderstorm activities are generally considered to occur at the height of 4-15km. No thunderstorm activities occur at the stratosphere above 20km. These coincide with the CTLLS observation results, thus proving that the CTLLS system is valid in getting height positioning results.

Fig 5 shows statistics on positive and negative NBE discharge heights. Specifically, positive NBEs have discharge heights of mainly 7-10km with the peak occurring at 8km, while negative NBEs have discharge heights of mainly 12-16km with the peak occurring at 13km. the general height of negative NBE discharges is higher than that of its positive counterpart. Smith, etc. [1999,2004] calculated the positive and negative NBE discharge heights through ionosphere reflection, and concluded that positive NBEs have discharge heights of mainly 7-15km with the peak at 13km, while negative NBEs have discharge heights of mainly 15-20km with the peak at 18km.

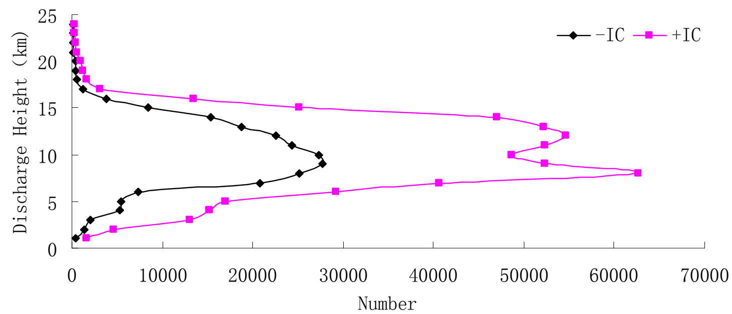

Figure 4. Statistics on intra-cloud lightning discharge heights

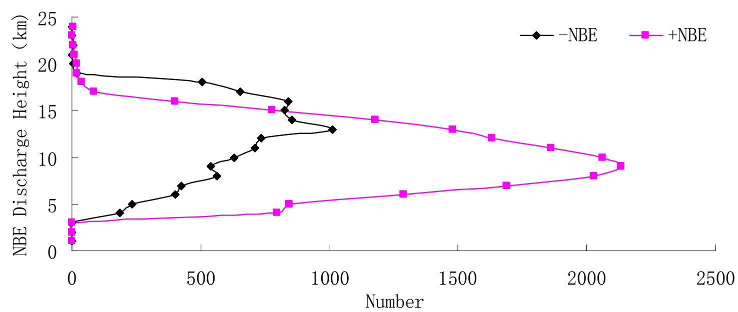

Figure 5. Statistics on NBE discharge heights

That statistics on positive and negative NBE discharge heights from this paper are of much narrower scope than those of Smith, etc. could probably be attributable to geographical differences.

CONCLUSIONS

The percentage of the thunder intra-cloud flash, cloud-to-ground lightning and NBE is 66%, 31% and 3% respectively in Chongqing area, the positive and negative cloud flash ratio is 3.0 while the ratio of the intra-cloud flash to cloud-to-ground lightning is 2.2. Among the cloud-to-ground lightning, the negative ground lightning flash covers an area of 94% of the total.

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