The Optical Characteristics of Cloud-to-ground Lightning Flashes in Pingliang of China

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ABSTRACT: For the large positive charge region under the thundercloud base, we conducted the experiments during the summer of 2012 and 2013 in Pingliang, Gansu province, China, to invest the characteristics of lightning processes. The characteristics of CG flash have been analyzed based on both the images from high-speed video camera and electric field changes from fast and slow antennas. The luminescence of the leader which contacted with the ground was weaker than that of flash in other region of China. In the CG lightning flashes, four out of them had more than one contact on the ground and the most was three. The luminescence time of leader lasted time were about 3-25 ms. And the most return stroke order was nine.

INTRODUCTION

Pingliang is inland plateau and located at Gansu province, northwest of China. There existed larger positive charge region near the cloud base than normal thunderstorm cloud. This document is to present a lightning with long IC process before the first stroke. The relationship between the IC process and the stroke process will be discussed using the optical images and the electric field changes.

DATA AND OBSERVATION EXPEIMENT

The observation experiment on thunderstorm and lightning was conducted in the summer of 2012 and 2013 in Guansu Province, China. The electric field changes caused by lightning flashes were recorded by slow and fast antenna systems. And, a few of them was captured by a high-speed digital camera system. The time constants of the slow antenna and fast antenna system are 6 s and 2 ms with a frequency bandwidth of 2 MHz and 5 MHz, respectively. All field measurements were digitized continuously for about 2.0 s at a sampling rate of 5 MHz by DL850. The sensor of the high-speed digital camera is a 256×240 CCD array in synchronous mode with 1 ms time resolution.

During seven thunderstorm systems, Total 17 CG flashes were recorded by the high speed video camera. Among them, seven flashes had two or more grounding-point. Four out of them had more than one contact on the ground and the most was three. The luminescence time of leader lasted time were about 3-25 ms. And the most return stroke order was nine. One CG lightning of them had long time IC process

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before the first return stroke. This lightning will be discussed in detail.

RESULTS

The lightning lasted about 500 ms and had four strokes. The time of downward leader from the optical images was 5 ms. The IC process before the first stroke was about 154 ms. The time intervals between the four strokes were about 36 ms, 84.8 ms and 27 ms. Figure 1 presents the slow and fast electric field changes and the relative luminescence. After the last return stroke, many M components happened and caused the luminescence of the grounding channel. For the condition limitation of observation, the distant of the lightning away from the station was absence.

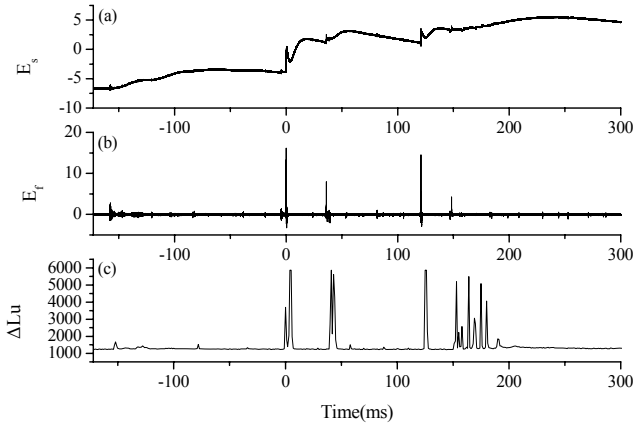

Figure 1 Electric field change waveforms and the relative luminance of the channel. Waveform of slow antenna (b) Fast antenna, and (c) Relative luminance of grounding branch

IC process

Figure 2 shows the optical images of the lightning. The electric field change began before the stroke about -158 ms. At the same time, the luminescence was captured by the high speed video camera system. Many branches crossed the cloud base at different region. The branches progressed near the cloud base or downward to ground. Zhang et al. (in 2014 ICAE conference) observed that the thunderstorm was triple in Pingliang using the sounding balloon. The lower positive charge region was about 2-4 km (a.s.l.), and the middle negative charge region was about 4.5-5.3 km(a.s.l.), and the upper positive charge region was about 5.3-6.3 km(a.s.l.). So, the lightning in the document should be happened in the lower positive charge region and the middle negative charge region. The lightning in Qinghai was also observed while it developed near the cloud base. Qie et al.(2005) reported that most of the intracloud (IC) flashes occurred in the lower part and only a few occurred in the upper part of the thunderstorm in Qinghai, and the charging activity in the lower part of the storm was more vigorous than in the upper part. But the luminescence of Pingliang was weaker than that of Qinghai.

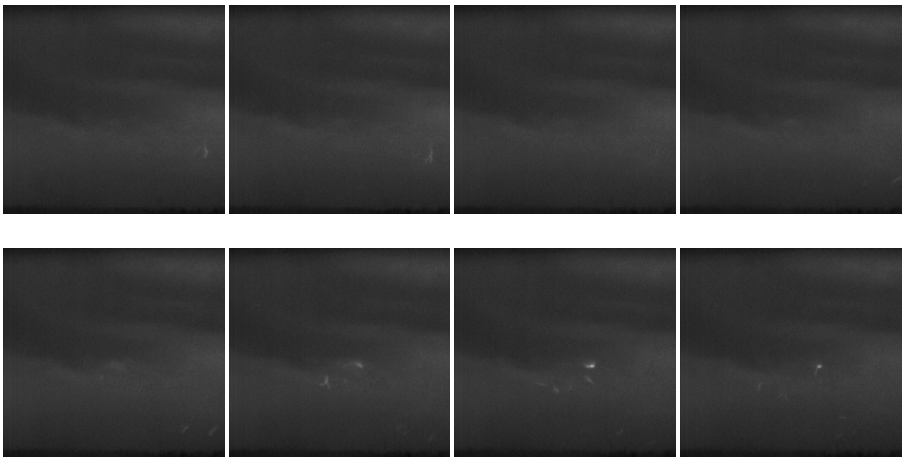

Figure 2 Optical images of IC process the lightning near the cloud base from -158 ms to 151 ms before the first stroke. The time interval between the adjacent frames is 1 ms.

The optical characteristics of the leader and the return stroke

Figure 3 shows the optical images of leader before the first stroke of lightning. This lightning had two grounding points, just like Kong et al. (2009) during very short time. Unfortunately, another grounding point was out of the view of the camera. The time interval between the two grounding points was about 190 μs based on the electric field change caused by the lightning. As shown in Figure 3, the one of the grounding channels was lighted at -4 ms. Then, the channel travelled to ground.

Figure 3 Optical images of leader and first return stroke processes the lightning from -4 ms to 1 ms. The time interval between the adjacent frames is 1 ms.

Ralationship between the IC process and the return stroke

Figure 4 shows the combination pictures of the optical images while developing under the cloud base. (a) is the channel of IC phase. (b) is the one of grounding channels superimposing on (a). Shown in figure 4b, part of the grounding channel had been formed during the IC phase (Fig.4a). This seemed to suggest

that a negative discharge to ground could be initiated by branch of a cloud discharge under suitable condition. Positive return strokes usually tended to be followed by a continuing current that lasted for tens to hundreds of milliseconds [Fuquay, 1982; Beasley et al., 1983; 1985; Saba et al., 2010]. This seemed to suggest a branch of a cloud discharge could initiate a positive discharge to ground [Rakov and Uman, 2003]. The IC flash could not only trigger the positive CG lightning flashes, but also trigger the negative CG flashes.

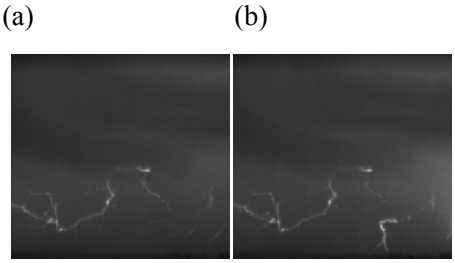

Figure 4 Combination pictures of (a) IC process and (b) grounding channel.

CONCLUSIONS

Using the high speed video camera and electric field changes systems, the CG lightning flash with long time IC process was discussed. The lightning happened in the lower positive charge region and the middle negative charge region. The IC flash could not only trigger the positive CG lightning flashes, but also trigger the negative CG flashes. The luminescence of the leader which contacted with the ground was weaker than that of flashes in other region of China.

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