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OBSERVATIONAL STUDY OF LIGHTNING CHARACTERISTICS IN HAIL-PRODUCING CLOUDS

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1 INTRODUCTION

Lightning is a phenomenon of atmospheric electricity with convective storms. Since the 1960's, its characteristics during weather processes of torrential rain, hails and tornadoes have been widely studied and a lot of attempts made to probe into the mechanisms responsible for the formation of lightning[1], giving rise to two theories explaining the lightning genesis, from the points of convection and ice-phase precipitation, respectively. In addition, some studies[2-9] show, from various aspects, that lightning indicates the occurrence of severe convective weather. There has been lack of concrete indices to identify lightning features and determine hail-producing clouds. Apart from diagnostic analysis based on conventional data[10], this work studies the evolution of lightning in 11 hails using relevant records and Doppler radar information and sums up a number of lightning features for hail weather in the sub-plateau area of Gansu province by taking as the criterion whether convective clouds cause hails in determining hail-producing clouds. In Gansu, hail-producing clouds usually originate from mountainous areas, follow fixed routes of movement and are often accompanied with heavy rainfall as they produce hails in more than a spot in the life cycle. To mitigate losses, it is essential to use scientific detectors to warn of hail weather in advance and conduct weather modification to check the growth of hails. The weather radar is an efficient tool to watch and forecast severe convective weather like hails, for it not only detects the structure but also tracks down the generation and evolution of hail-producing clouds to aid in isolating where the hail falls. It is, however, not realistic to perform real-time radar watch in Northwest China and existing radars are not capable of observing thunderstorms. Costing relatively low to purchase and maintain, the lightning locator has wide range of measurement and works non-stop without human attendance, making it easier to watch large-scale convective clouds in the region. With hails, heavy rains and tornadoes isolated and warned of based on features captured by the locator, operations of weather modification can be made more efficient with further identification from radar echoes and observed facts of electric mechanisms can be better understood for convective weather.

2 DATA AND METHODS

The lightning data are taken from a single-site M-LDARS locator of Type B in Zhongchuan. It was made in 1991, based on the relationship between phase difference and distance in the transportation of electromagnetic waves (Tao and Zhou[11]) and an improved technique of measuring the difference of arrival time of sky and ground waves. It measures the azimuth, distance, intensity and polarity of C-G lightning within areas on the 250-km radius, with the

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locating azimuth at ±1.0°. It is as reliable as three-site positioning system. The radar data are from a Doppler, CINRAD/CC (3830), and a Type 713, in Lanzhou. The hail record is extracted from surface weather telecommunications or local records.

A mesoscale severe thunderstorm has a typical horizontal scale between 25 and 250 km and brings about local-scale hails. The hail count in this work is done in terms of total lightning times taking place around the point of hailing, which is on a specific radius in east, west, north and south directions and within 2.5 min of a single strike. The radius is either 50 km or 75 km. The lightning density is the sum of all C-G lightnings within an area of 25 km × 25 km.

3 OBSERVATION AND CONCLUSIONS

A total of 11 hails that took place in Gansu in 2003 are studied. As shown in the analysis of the variation of lightning counts, hails may be pre-warned of for the region of Northwest China if peak values for which more than 20 lightning strikes occur within 5 min in convective weather are taken as the criterion to determine whether convective clouds will grow to produce hails. Analyzing ratios of positive lightning to negative one and intensity change indicates that the observed rates of positive C-G lightning are all above 15%, with the maximum at 40%. The large positive C-G lightning may be one of the electric characteristics of the regional hail-producing clouds in contrast to other weak convective weather. As shown in the analysis of lightning density, hails usually fall on the right, leeward side of the maximum core of lightning density, which does not have any hails itself. The maximum core of lightning is ahead of the hail area in location and there is more negative than negative C-G lightning in the early and decaying stages of hail-producing clouds but their number are both large and concentrated in location during the middle stage. Areas with the most negative C-G lightning are temporally lagging behind the density center, possibly due to the presence of multiple cells in all stages of evolution during the migration of hail-producing clouds.

4 DISCUSSIONS

(1) The 5-min counts of lightning regularly changes during the evolution and migration of hail-producing clouds and a peak of more than 20 times appear 4 to 97 minutes before the fall of hails. It can be used as a criterion to indicate if the target is a hail-producing cloud. During the hailstorm, the positive C-G lightning ranges between 24.7% and 40%.

(2) The maximum of lightning density appears in front of the area where hails fall. The path for which hail-producing clouds evolve and move is indicated by hourly distribution of lightning. Lightning distribution in the radar echo does not coincide with the most intense radar echoes. Lightning distribution on the migratory path of hail-producing clouds and temporal series distribution of lightning may be used to pre-warn up-coming hails.

(3) One of the key goals in the study of lightning with convective weather is to develop a pre-warning system for meteorological disasters in the next few hours to come. If hails and lightning can be observed through a 3-site lightning locator from a network combining satellites and surface monitors, information obtained by radars can be integrated to extract signals to accurately determine if the thunderstorm keeps intensifying, or to be used as criterion for severe precipitation or weak hails that are commonly seen.

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