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Cloud to Ground Lightning distribution over Tokyo metropolitan area observed by Lightning Location System (LLS)

Daiki Tsurushima (1), Kiyotaka Sakaida (1), Yukihiro Takahashi (2), and Noriyasu Honma (3)
(1) Tohoku University, Japan, (2) Hokkaido University, Japan, (3) Tohoku Electric Power co., Inc.

Much of resent research shows a significant enhancement in Cloud-to-Ground lightning over large urban areas (Stallins and Rose, 2008). One of the possible causes of this lightning anomaly is local wind convergence that is thermally induced by urban heat island (UHI). In short, UHI modifies local surface wind distribution to form strong convergence zones over highly urbanized area, leading to intensified upward air motion in thunderclouds. There are many studies concerning the above-mentioned heat island effect in regard to summertime convective rainfall in Tokyo (Fujibe, 2004). However, no study can be found discussing urban effects on lightning.
In this study the urban heat island effects on lightning activity in Tokyo metropolitan area are discussed in an analysis of summertime (Jul-Aug) CG flash data over the course of 9 years (2000-2008). The flash data was acquired by Lightning Location System (LLS) in Tohoku-Kanto district operated by Tohoku Electric Power co., Inc. (Honma et al., 1998). The relationship between CG flash distribution and local meteorological fields (wind, temperature and rainfall) was also discussed through the analysis of CG flash data and meteorological data obtained by AMeDAS (Automated Meteorological Data Acquisition System) operated by Japan Meteorological Agency (JMA).
An investigation of annual average flash distribution in Tokyo metropolitan area revealed a relatively higher flash density from the city center to the southern part of Saitama prefecture. However, it must be observed that flash distribution in Tokyo is highly affected by several natural causes such as elevation, topography and complex coastline of the study area.In order to estimate the urban effects on lightning, 98 cases of thunderstorms observed in urban areas were selected and classified according to their areas of formation. 57 cases were formed over plain areas (plain-type), 26 cases over mountain areas (mountain-type) and the remaining 15 cases were a combination of plain-type and mountain-type.
Wind and temperature distributions preceding the occurrence of the aforementioned plain-type and mountain-type thunderstorms were examined separately based on observational data by AMeDAS. In agreement with earlier studies, the results indicate that wind distributions preceding plain-type thunderstorms are characterized by the "E-S type" pattern, in which easterly winds from the east coast of the Kanto plain and southerly winds from the southwestern coast converge over urban areas, thus favoring thundercloud formation. In case of mountain-type thunderstorms, the heat lows developed in mountain areas affect the sea breeze from the Pacific Ocean, causing the formation of convergence zones along the mountain foot.
Wind divergence (divU) and temperature gradient (gradT) were in each case calculated and compared with flash density. The plain-type cases showed a significant negative correlation between divU and flash density($R=-0.43$) and a significant positive correlation($R=0.55$) between gradT and flash density. These results suggest that the alteration of surface wind and temperature distribution in consequence of the urban heat island may potentially influence thundercloud formation and its lightning production.