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Displacement between Winter Sprites and Parent Could-to-Ground Lightning

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A various investigation of sprites, one of frequent observable transient luminous events (TLEs), has been reported. Sprites are induced from mesosphere to lower ionosphere by a strong electric field attributed to the neutralization of a large amount of positive charges at the upper part of thunderstorm when cloud-to-ground (CG) lightning occurs. Many papers have implied that the complex physics of sprite-induced CG lightning, namely parent CG lightning, causes various morphologies and lifetime of sprites and the time delay of sprite occurrence, which have been some of unsolved issues in the TLEs studies. In addition, the major issue might be the large horizontal displacement between the center of sprites and the observed parent CG lightning, which often reaches 50 km. On the other hand, sprites occur just above the luminous center of parent CG lightning from satellite observations. It is expected that the luminous center of parent CG lightning over the thunderstorm is equivalent to the horizontal position of positive charges at the upper part of thunderstorm. Few study, however, discusses the horizontal discrepancies among the center of sprites, the luminous center of parent CG lightning over the thunderstorm, and the observed strike point of the parent CG lightning. Thus, we investigate the discrepancies among them through an optical measurement, assuming that the position of positive charges at the upper part of thunderstorm is the luminous center of parent CG lightning over the thunderstorm.

We conducted sprite observation campaign from December, 2012 to February, 2013. Low light CCD cameras were deployed at Tokyo and Shizuoka prefecture to observe the sprites above the Sea of Japan near the west coast of Japan. During the campaign, more than 50 events were captured. We analyzed the horizontal difference between sprite and lightning flash from CCD cameras records. Parent thunderstorm and CG positions are investigated by radar echo and several lightning location system, respectively. In particular, six sprite events were observed simultaneously in Tokyo and Shizuoka, which gave the location of sprites. From the observations, we found that the most of lightning flash center was located under the center of sprites but the reported CG location differed from them. In the presentation, we propose a plausible model to explain such discrepancy.

Keywords: Sprite, Lightning, TLEs