Study of oscillations of atmospheric electric field during snowfall at Chiba, Japan, using W- and X-band cloud radars

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It is known that cloud-to-ground lightning and precipitations generated from thunderclouds are a generator of global electric circuit (e.g., Williams, 2009). In the fair weather, the atmospheric electric field at the ground is generally 100 V/m and downward (positive). The atmospheric electric field varies during not only lightning/thunderstorms, but also snowfall/blizzard (e.g., Minamoto and Kadokura, 2011). Wave pattern of the atmospheric electric field with the periods of several tens of minutes during snowfall was first observed in England (Simpson, 1948). The wave pattern of the atmospheric electric field occurred, when the snow clouds were nimbostratus (Kawamura, 1961). The oscillations with the period of 20 minutes during snowfall were observed in Hokkaido, Japan, on 16 January, 1978 (Kikuchi and Inatsu, 1979). When the polarity of the snow particles at the ground was positive (negative), the atmospheric electric field was negative (positive), which was called as "mirror image relation". Based on balloon observations, the mirror image relation became weak with increasing height (Asuma et al., 1988). As the cause of the oscillations, the polarity of snow particles arrived at the ground became opposite to that in the bottom of snow clouds due to corona discharges at the ground (Asuma et al., 1988). However, the mechanism of the oscillations has not been revealed yet. In this study, we investigate the oscillations of the atmospheric electric field during snowfall of 23-24 November, 2016, using a field mill, the 95 GHz cloud radar, FALCON (FMCW Radar for Cloud Observations)-I that was originally developed by our group, Chiba University, and a X-band radar (9.4 GHz). We have observed the atmospheric electric field with a Boltek field mill, and cloud reflectivity and the Doppler velocity with the FALCON-I in Chiba University, Japan, (CHB, 35.63N, 140.10E). At 16.2 km southeast from the CHB, a phased array X-band radar operated by Japan Radio Co., Ltd. observed precipitations/cloud. During the snowfall of 23-24 November, 2016, periodic oscillations in the atmospheric electric field with periods of 70-90 minutes were observed at four observation sites; CHB, Kakioka (KAK, 36.23N, 140.19E), Tokyo Gakugei University (KGN, Kokubunji, Tokyo, 35.71N, 139.49E), and Seikei High School (MSN, Musashino, Tokyo, 35.72N, 139.57E). The distances of CHB-KAK, CHB-TGU, and CHB-SHS are 64.8 km, 55.9 km, and 49.0 km, respectively. This is the first observations of similar oscillations in the atmospheric electric field with the periods of 70-100 minutes at different observation sites separated by a long distance of 50-65 km. The coherence between the atmospheric electric field and FALCON-I reflectivity was highest (0.98) at 0-1 km height with the same periods (39.0, 54.6, and 78.0 min.) of the oscillations. The FALCON-I reflectivity preceded the oscillations at 0.8 km height by 40 min. The phase difference decreased with decreasing the height. At the same time, various snow crystals (with/without cloud particles and hail) were observed in Kanto region, which means conductive snow clouds (Araki, 2018). We consider that the oscillations with the period of 78 minutes were caused by that positive/negative snow particles fell down from the bottom of the snow clouds to the ground alternately. The origin was internal vertical cells in the snow clouds. In the presentation, we will discuss the cause of the oscillations in the atmospheric electric field.