

## Dual frequency observation of subionospheric perturbations associated with Hokuriku winter lightning

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Intense electromagnetic pulses (EMP) radiated from lightning discharge could cause heating and ionization and alter the conductivity in the ionospheric D-region. The purpose of this study is to reveal influence of the lightning on the lower ionosphere and its dependence on properties of lightning discharges. For this purpose, two LF radio observation systems were installed in Takine (Fukushima) and Sasaguri (Fukuoka). Radio signals from two JJY transmitters at Haganeyama (Fukuoka, 60kHz) and Otakadoyayama (Fukushima, 40kHz) are simultaneously measured at Takine and Sasaguri, respectively. Radio propagation paths of both transmitter ? receiver pairs are almost overlapped and the midpoints of both paths are located over the coast of Hokuriku area. These enable us to investigate the lightning effect on the lower ionosphere at different height because it is expected that reflection height of radio wave depends on radio frequency.

The LF signature of subionospheric perturbations associated with winter lightning in the Sea of Japan (around Hokuriku) has been observed from December 13, 2014. Signatures of subionospheric perturbation (early event) which occur immediately after the causative lightning were detected. While modeling studies (E. D. Schmitter. 2014) show that change of ionization state in the lower ionosphere depends on intensity of EMP, there is no clear observation evidence that shows quantitative relationship between them. We analyze the data derived from these observations using peak current of causative lightning and difference in frequency of two JJY.

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