

Interrelation between ELF Transients and Ionospheric Disturbances in Association with Sprites and Elves

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ABSTRACT

In this paper we present results of our winter lightning campaign especially focused our attention on the phenomena in association with optical emissions (sprites and elves) over Japan sea as a case study. Our measurement consists of ELF Transients observation in Moshiri Hokkaido, VLF perturbation at Kasugai station and lightning information from Japanese lightning Detection Network (JLDN). Observed parameters together with information of optical measurements operated by Tohoku University indicate significant atmosphere-mesosphere-ionosphere coupling.

INTRODUCTION

Recent findings of the optical emissions in the mesosphere in the various places over the world attract a lot of interests about the electrodynamic coupling between the lightning in the troposphere, mesosphere and lower ionosphere. Red sprites and elves were observed in Japan during the winter of 1998/99 in Hokuriku region by the group of Tohoku Univ.[1]. So far various phenomena in association with these optical events were observed, e.g. (1)ELF transients, (2)VLF scattering and (3)Gamma-ray and individual characteristics of those were published. However, in order to have the comprehensive understanding on the coupling between the mesospheric optical phenomena and tropospheric lightning, and the ionosphere, coordinated measurement with quantitative information is extremely important.

OBSERVATION

We have the optical measurement (consisting of CCD camera and Spectrometer installed by Tohoku University) to detect the sprite and elves, ELF transient measurement is used to extract the charge moment of the parent lightning strokes, VLF scattering measurement is a sensitive tool to obtain the ionospheric disturbances (electron temperature and density perturbations), and the data from Japanese Lightning Detection Network recently covered all over Japan allow us to locate the event, time and its peak current.

RESULTS

We analyze quantitatively the results from coordinated measurement and find the clear straightforward relationship between charge transfer of the parent discharge calculated from ELF ($f < 15$ Hz) and the ionospheric disturbances regardless of the types of optical events indicating significant atmosphere-mesosphere-ionosphere coupling. Sprites tend to associate with a large ionospheric disturbance (-13~+4.6 dB) with a large charge moment change (250~875 Ckm), whereas a large lightning peak current (+223~+470 kA) (or slow-tail amplitude) leading to the strong EMP is necessary to initiate elves, but with rather small ionospheric disturbances. Furthermore, the different characteristics between sprite and/or elve producing lightning and other conventional lightning will be discussed.

REFERENCE

[1]Fukunishi et al., EOS, 80(46), F217, 1999