

Sferic and optical observation of TLEs and lightning discharges using a balloon

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Transient optical phenomena in the mesosphere and in the lower thermosphere / ionosphere called TLEs (Transient Luminous Events) have been investigated extensively since the first discovery in 1989. Most TLEs are induced by cloud-to-ground (CG) discharges. However, some observations have recently indicated that also intra-cloud (IC) horizontal discharges would affect the generation of TLEs and their shapes. Since these observations were carried out on the earth, simultaneous measurements for horizontal component of electric field of sferics in VLF/ELF range and optical imaging of lightning flashes have not been carried out in TLE studies. Therefore, the contributions of horizontal discharges to TLEs are still unknown.

Horizontal component of electric field of sferics cannot be received on the earth due to the high conductivity of the ground, but can be detected at altitudes over ten kilometers. Then we carried out the simultaneous measurements with optical and VLF equipments for TLE events and lightning discharges, using a balloon on the night of August 25 / 26. The optical measurement was carried out with CCD cameras and two photometers fixed on the gondola. One of the two photometers has a red filter and the other has a blue one. VLF sferics waveform measurement was carried out with three dipole antennas; one received vertical VLF sferics and the others received two horizontal components. The balloon equipped with these instruments was launched at Sanriku Balloon Center (SBC) of JAXA, and flew to about 140 km east from SBC before it U-turned. It rose up to 26 km altitude and returned to the east coast, keeping the same altitude. In the period of this observation, there were two regions where lightning activity was high; one was Suwa district in Nagano prefecture from 18:30 LT to 20:00 LT, the other was off the Izu peninsula of Shizuoka prefecture from 21:30 LT to 00:00 LT. The ranges from the balloon to these active regions were ~550 and ~600 km, respectively.

As a result of this flight experiment, we succeeded in observing these two thundercloud regions for five hours and thirty minutes with optical and VLF radio wave instruments. We can investigate temporal occurrence variation of lightning discharges for each thundercloud region, using information about coming directions of sferics determined from image data. Therefore, we can infer the required and necessary conditions of thunderclouds to induce TLEs. Also stroke multiplicity of a flash and the temporal variation of the ratio of vertical to horizontal components in electric field can be investigated through out thundercloud lifetime. Furthermore we succeeded in getting the first optical and sferic data for four TLE events in the same period from 20:55 LT to 00:10 LT, when the balloon was at 26 km altitude. These are considered to be elves because of those shapes, horizontal scales and altitude ranges of luminous region. One of these elves shows symmetric form with a hole in the center, while others show asymmetric form, which may reflect the role of horizontal component of electromagnetic pulse in producing elves. We will report the relationships between the shapes of elves and the intensities of horizontal and vertical components of VLF electric field. We will also discuss the difference between causative lightning discharges for elves and other lightning discharges, which cause no TLEs.

This work is supported by Sanriku Balloon Center, Japan Aerospace Exploration Agency. Especially, we would express our appreciation to Professor Yamagami, who is the chief of this flight experiment, Drs Yoshida, Ihzima and Ohta, who are in charge of the optical instruments.