Characteristics of VLF atmospherics associating wintertime sprites observed in 2003-2004, in Japan

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Sprites are transient luminous events induced by cloud-to-ground discharges (CGs) in the mesosphere, which are considered to be generated by quasi-electrostatic (QE) fields caused by CGs. There are several types of sprites exhibiting different features of evolution. However, the factors producing different features are still unknown. Spherics have the highest power spectral density in VLF range and VLF sferics can propagate in long distance with extremely low attenuation. Consequently, from the waveform data, we can obtain information not only on the locations of lightning but also on the types of lightning discharge such as CG or intracloud discharges (ICs). The purpose of this research is to investigate the characteristics of the lightning discharges that generate sprites using VLF atmospherics, and to find the factors that determine temporal development of sprites. We have carried out sprite observations from December 15, 2003 to the middle of February at Tohoku University Iitate observatory (37.7oN, 140.7oE), Fukushima. We employed an II-CCD camera and two sets of multi-anode array photometers (MAPs) for optical observations, and a VLF receiver one with vertical electric field dipole antenna and two horizontal crossed loop magnetic field antennas for measurement of VLF atmospherics. The size of dipole antenna is 2 m and the shape of the loop antenna is a one-side equilateral triangle of 1.7m. The frequency range of the receiver is 1 to 40 kHz for all antennas. The atmospherics data are recorded in an A/D board by event trigger mode. The sampling frequency is 100 kHz and one event recording time is 2.56 sec. Further, we operated another VLF receiver with the same two horizontal loop antenna and the same recording systems at Yamanashi Prefectural Science Center (35.40ºN, 138.40ºE), Yamanashi form December 2003, for more accurate determination of the CG locations. On December 15, 2003, image data of 21 sprite events were acquired and concurrent VLF sferics data were acquired for 17 of these events. From spectral analysis of these waveform data, it is found that enhancements occur in the range of 10 - 40 kHz within 50 ms from the onset of sferics for all events. Further we identified 3 sprite events with MAP measurements. Two of 3 events showed a time delay of 30 - 40 ms from the onset CG to the initiation of sprite, and the enhancements on the range of 10 - 40 kHz occurred between CGs and sprites. Moreover faint cloud flash emissions were accompanied by these VLF enhancements. We will discuss the origins of these enhancements and their relationship to lightning discharge processes. Further we will consider the role of these enhancements in the generation of sprites.