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Simultaneous observations of VHF waves and optical emissions for lightning from the International Space Station

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Since Novenber 2012, Global Lightning and sprIte MeaSurements (GLIMS) mission has been conducted on Exposed Facility of Japanese Experiment Module (JEM-EF) of the international space station (ISS) which is orbiting the earth at an altitude 400 km. The VHF broadband digital interferometer (VITF) attached on JEM-EF is designed to estimate the direction of arrival of electromagnetic waves. The VITF has th bandwidth from 70 MHz to 100 MHz. The VITF consists of two antennas, band-pass filters, amplifiers, and 2-channel-AD-converter. The electromagnetic radiations from lighting discharges received by the antennas are digitized by the AD converter synchronizing with another channel through the filters and the amplifiers. The band-pass filter and the amplifier of the VITF are exactly the same as the ones of the VHF sensor on Maido-1 satellite. The basic specification and most of devices in the AD converter of VITF.

In previous study, the Array of Low Energy X-ray Imaging Sensors (ALEXIS) satellite (1993) had a high-speed VHF receiver/digitizer (Blackbeard) for studying the effect of lightning and electromagnetic impulse from lightning and other man-made noise, which means TV and FM carrier interference. Furthermore, the Blackbeard reported the unique characteristics of VHF waves radiated from lightning known as transionospheric pulse pairs (TIPP). In 1997, the Fast On-orbit Rapid Recording of Transient Events (FORTE) satellite recorded many VHF pulses associated with lightning discharges.

The observation results of the VITF of the JEM-GLIMS mission were described. As a case study, the lightning event captured by the two optical sensors (photometers and CMOS sensor) was analyzed. In these events, the waveform data of VITF were used to estimate the arrival direction of EM waves. There are two methodologies which are the interferometry technic and the group delay characteristic of EM waves. We compared the results of direction of arrival estimation with CMOS sensor data. The results agreed with the position of the lightning emission captured by the CMOS sensor. We also compared the results of VITF with that of the photometers in order to find the temporal relationship. The results indicated that the frequency of the VHF radiations recorded with the VITF had a positive relationship with optical waveform captured with the photometers.

Keywords: lightning, radio wave propagation, VHF waves