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VHF and optical lightning observations by JEM-GLIMS

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Global Lightning and sprIte Measurements (GLIMS) mission is now ongoing on Exposed Facility of Japanese Experiment Module (JEM-EF) of the International Space Station (ISS). JEM-GLIMS mission is designed to conduct comprehensive observations with both the EM and the optical payloads for lightning activities and related transient luminous events (TLEs) expecting to give us many scientific impacts to the field. The integrated 4 sensors installed into Multi Mission Consolidated Equipment (MCE), which is the bus system, and is mounted at JEM-EF as GLIMS mission. The 4 sensors consist of very high frequency (VHF) broadband digital InTerFerometer (VITF), very low frequency (VLF) receiver, CMOS cameras at two different wavelengths, and photometers at six channels.

VITF consists of two sets of antennas, band-pass filters, amplifiers, and 2-channel-AD-converter. Impulsive EM radiations received by the antennas are digitized by the AD converter synchronizing with another channel through the filters and the amplifiers. A patch type antenna is developed within the size of 200$*$200 mm. It is mounted on the antenna base made of aluminum alloy and Teflon block with the total height of 100 mm to gain its bandwidth and to reduce the interference from other structural objects. The same two units of antennas are installed with the separation of 1.6 m. Their bandwidths with the less return loss than 3 dB are from 70 to 100 MHz. The signals received by the antenna are transmitted along cables with the same lengths to the electronics. The AD converter records 130 waveforms as maximum of one dataset with the duration of 2.5 μs with 200 MS/s. The developments of VITF are based on the heritage of VHF sensor on Maido-1 satellite.

JEM-GIMS mission payload was successfully launched at the end of July 2012, and transported and installed to the ISS. After the initial checkout and maintenance, its nominal operation is continued from December 2012. Through the operation period, VITF corrects numerous VHF EM data synchronized with optical signals. About 2,900 VITF datasets were obtained in 20 months. The timing of data acquisition is controlled by a photometer through this period. Namely, the EM and optical data are recorded being triggered by a photometer. 65 - 80% of optical observations are accompanied with VHF radiations. Though the discrimination is in progress, most optical signals are from lightning.

The estimations of the EM direction-of-arrival (DOA) are attempted using the broadband digital interferometry. Some results agree with the optical observations, even though DOA estimation has difficulties caused by its very short baseline of the antennas and multiple pulses in short time, namely burst-type EM waveforms. VITF is designed expecting to estimate the DOA with about 10 km resolution that is equivalent to the scale of a thundercloud. This paper makes comparative discussion about the observations by VITF and optical payloads, CMOS camera and photometer. It is found that the brighter lightning makes the denser VHF radiations.

Keywords: Lightning discharge, International Space Station, Transient luminous event