

Wideband VHF Radio Observations for Lightning by Maido-1 satellite

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Maido-1 satellite, a small satellite manufactured by factory members in Higashi-Osaka, Japan, was launched on 23 January 2009 and has been operating since then. The satellite is a spin-stabilized microsatellite of JAXA (Japan Aerospace Exploration Agency)'s MicroLabSat heritage. It is in sun-synchronous polar orbit at an altitude of 660 kilometers. The satellite carries the radio-frequency payload, Broadband Measurement of Waveform for VHF Lightning Impulses (VHF sensor), for research on lightning. The aim of the sensor is to examine the feasibility of the space-borne Broadband Digital Interferometer (DITF), which is an equipment to locate sources of impulsive VHF radiation based on the digital interferometric technique. In other words, DITF is a system to visualize lightning channel by VHF radio observations. The feature of DITF is its ultra-wide bandwidth (from 25 MHz to 100 MHz) and implicit redundancy for the direction-of-arrival (DOA) estimation. Its fairly high resolution and the compactness of the system are great advantages to be the space-borne system. Maido-1 started the VHF sensor operation in February 2009 and its correct performance is verified. As a previous work for the satellite observations associated with lightning, Optical Transient Detector (OTD) on Microlab-1 satellite launched in 1995 and Lightning Imaging Sensor (LIS) on the Tropical Rainfall Measuring Mission (TRMM) satellite in 1997 revealed the global distribution of lightning with optical observations. The Array of Low-Energy X-Ray Imaging Sensors (ALEXIS) satellite launched in 1993 and Fast On-orbit Recording of Transient Events (FORTE) satellite in 1997 for the RF observations recorded many transionospheric pulse pairs (TIPP) waveforms.

The VHF sensor was designed and developed by Lightning Research Group of Osaka University (LRG-OU), Osaka, Japan. It is proposed to examine the feasibility of space-borne DITF by receiving VHF lightning impulses from the orbit. The sensor comprises a single pair of an antenna, a band-pass filter with a pass band of 30-100MHz, an amplifier with a gain of 45dB and an analog-to-digital converter with a sampling rate of 200MS/s and 8-bit resolution to record broadband VHF signals. The 100 waveforms of VHF impulses from a lightning flash with the duration of 2.5 usec can be recorded.

Maido-1 has conducted 153 sets of the VHF sensor observations around the world and over 10,000 pulses were recorded. The observation results indicate the lightning activity is more frequently on shore than over the sea. In previous study, OTD and LIS have brought the global frequency and distribution of lightning activity. The results using the VHF sensor on Maido-1 satellite agrees with past investigations using optical observations. Though the sensor received the lightning signals above the Atlantic Ocean, these results mean that it received the propagated signals through the ocean from the radiation source above African or American continent.

The VHF sensor on Maido-1 satellite has conducted 153 lightning observations around the world and proved its function in space. The results indicate the frequency of the lightning activity was higher on shore than at sea. We confirmed that it is possible to observe lightning activities using radio wave from orbit. There are regional characteristics for waveform because the observed

waveform of the lightning varied with observation areas.

Keywords: Lightning observations, Satellite observations, VHF EM wave