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## Broadband VHF lightning impulses observed by a small satellite "Maido-1"

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Lightning Research Group of Osaka University (LRG-OU) has been developing VHF Broadband Digital Interferometer (DITF) to image precise lightning channels and monitor lightning activity widely. The feature of broadband DITF is its ultrawide bandwidth (from 25MHz to 100MHz) and implicit redundancy for estimating VHF source location. LRG-OU considers an application of the broadband DITF to the spaceborne measurement system and joins the SOHLA (Space Oriented Higashi-Osaka Leading Associate) satellite project.

The SOHLA satellite project represents a technology transfer program to expand the range of the space development community in Japan. The objective is to get SMEs (Small and Medium sized manufacturing Enterprises) involved in small space projects and new space technologies. Under the cooperative agreement, JAXA (Japan Aerospace Exploration Agency) intends to contribute to socio-economic development by returning its R&D results to society, and SOHLA tries to revitalize the local economy through the commercialization of versatile small satellites. According to the agreement, JAXA provides SOHLA its technical information on small satellites and other technical assistance for the development of the small satellites, SOHLA-1. The prime objective of the SOHLA-1 program is to realize low-cost and short term development of a microsatellite which utilizes the components and bus technologies of JAXA's MicroLabSat. SOHLA-1 is a spin-stabilized microsatellite of MicroLabSat heritage (about 50 kg). The spin axis is fixed to inertial reference frame. The spin axis (z-axis) lies in the plane containing the solar direction and the normal to the orbital plane.

LRG-OU takes responsibility for a science mission of SOHLA-1. To examine the feasibility of the DITF receiving VHF lightning impulses in space, LRG-OU proposes the BMW (Broadband Measurement of Waveform for VHF Lightning Impulses).

BMW consists of a single pair of an antenna, a band-pass filter, an amplifier, and an analog-to-digital converter (ADC) to record broadband VHF pulses in orbit. The waveforms of 100 EM pulses in VHF band emitted from a lightning flash are obtained. Three pairs of BMW with accurate synchronized 3-channel-ADC are needed to realize DITF. From the successful satellite observation like TRMM/LIS, the effectiveness and impact of satellite observations for lightning are obvious. The combination of optical and VHF lightning observations are complimentary each other. ISS/JEM is a candidate platform to realize the simplest DITF and synchronous observations with optical sensors.

SOHLA-1 was launched by a HII-A rocket at January 23, 2009 and named Maido-1. BMW on Maido-1 satellite has conducted 153 lightning observations around the world. BMW has recorded VHF EM waveforms well and verified the feasibility for the space-born DITF. Observation results show the clear distinction between over land and ocean as well as the regional dependency in the features of obtained VHF signals. The numerical study on the VHF EM wave propagation through

the ionosphere represents the effects of dispersion.

Keywords: Lightning discharge, Satellite observations, VHF EM wave, The ionosphere