Basic development of direction finding system for lightning discharge at small balloon

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1. Introduction
As for the observation of the upper atmosphere, new observation technique has been born with a technological change in history. Balloon observation is lower-cost than other upper atmospheric observation technique like rockets, and in the recent years various experiment is performed with large balloons of JAXA. In addition, in the recent years when the downsizing of microcontrollers and the sensors has been realized rapidly, the observing experiment using small weather balloons is currently becoming feasible for the university laboratory level [1,2].
In this study, we developed the basics of balloon borne type small thunder direction-finding payload system. At present, the Meteorological Agency thunder reporting are leading the thunder observation in Japan. General technique of the thunder observation includes ground station as well as satellites for weather observation. However, most of the observation via the altitude area that a thundercloud developed (approximately within 5km-10km) has not yet been performed. For that reason, here, we introduce a thunder observation system to be equipped on high-altitude small balloons for weather observation use, and it is thought that provided data by making in-site measurements might be useful scientifically. In this paper, we report a design and the experiment of the small discharge direction-finding system and a future view [3].
2. System development
We adopted an electromagnetic wave detection type system by using a small loop antenna with a simple structure for balloon deployment with the direction-finding technique aboard. The developed system consists of a SD memory card and a GPS receiver for the precise data acquisition, a pair of orthogonal loop antenna, pre-amplifier for signal amplification with bias circuit, and 2-channel A/D converters.
3. System evaluation experiment
We performed an experiment for confirming the electric discharge detectabilities by using a discharging tube as a microscopic thunder generator. Confirming if a small loop antenna of φ100 mm× 90 turns could detect the change of the magnetic field. The purpose of experiment was checking distance-dependency and declination-dependency of the loop antenna when changing the distance direction of the discharging tube as a electromagnetic wave source. The distances of 0.5 m, 0.7 m, 1.0 m and 1.2 m were used for confirming each electromagnetic wave strength.
In addition, for confirming declination-dependency of the crossed loop antennas, chopping angle of the loop antenna was charged from right to left to realize 0-90 degrees changes in the direction relations artificially.4. Experimental results and discussion
In the distance-dependency experiment, it was confirmed that a second multinomial relation between signal strength A and distance d. The reception signal was weak but it canbe said that we can detectthe electromagnetic waves from the discharging tube quantitatively. On the other hand, the direction finding was impossible due to the low characteristics of accepted sampling rate on the used micro-controller, signal delay between the both channels growing at a time of the A/D conversion with the mbed microcontroller.
5. Summary
The developed system perferms continuous data collection without any significant problems. Microscopic discharge experiment was used for simulating a thunderbolt in laboratory. However, we have never tried the outdoor setting of this system, thus the electro-magnetic wave detection

coming from nature a lightning was not yet confirmed. Downsizing of the system and performance experiment under the simulated environment of the upper atmosphere is necessary when we consider the real balloon deployment. There exist two kinds of electric discharge phenomena that the polarity of discharge is anode-related lightning and cathode-related one. Thus, it is necessary to build an additional dipole antenna for the real direction-finding.

Keywords: Thunder, Electromagnetic wave, Balloon

