Observations of Volcanic Eruption Columns with Different Types of Weather Radars

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The present paper describes the results of observational studies of volcanic ash columns using different types of weather radars: X-band marine radar, bi-static Ku-band radar, Ka-band Doppler radar, and operational X-band polarimetric radar. In order to observe eruption columns with extremely fine temporal resolution, an X-band marine radar was set up during three months in 2018 at the Kurokami observatory of Kyoto University located about 4km from the vent of Sakurajima volcano. The marine radar has a slot antenna that has the PPI scanning speed of 48 rpm, with a vertical beam width of 22° and a horizontal beam width of 1.2°, and a range resolution of 8m. We carried out observations by physically changing the rotational axis of the slot antenna from vertical (PPI) to horizontal (RHI) to achieve an elevation angle resolution of 1.2°. The MRI Ku-band radar and Kagoshima University Ku- band radar set up in 2017 in Sakurajima have Luneberg antenna with a horizontal and vertical beam width of 3°. The antenna rotates spirally from an elevation angle of 0° to 90° to obtain hemispherical volume data in one minute. The Ka-band Doppler radar of NIED was operating at the Kurokami observatory during 3 months in 2015 to investigate the inner structure with the RHI antenna scanning. The MLIT operational X-band polarimetric radar located approximately 11km from the vent of the Sakurajima volcano can measure volcanic ash columns three-dimensionally at 5-minute intervals, even though it is an operational radar aiming to measure heavy rainfalls in Sakurajima.

Utilizing these different types of radar data, we perform detailed analysis of eruption columns. The marine radar succeeded in detecting eruptions and at the same time detecting falling pyroclastic particles (Fig. 1). The radar also reveals the fine structure of an ascending eruption column at 1.25-second intervals. While the marine radar observes volcanic ash columns with the wider azimuth angel resolution 22° due to its fan beam antenna, Ka-band Doppler radar can observe the targets with finer azimuthal resolution using RHI scanning of the parabolic antenna. The Ka-band radar RHI observations also reveal the upward speed of the ash echo top at 2-minute intervals. While both the marine radar and the Ku-band Doppler radar measure eruption column vertically at a fixed azimuthal direction, the Ku-band Doppler radar measures all azimuth and elevation angles every 1 minute. Using this scanning strategy, we can clarify the temporal change of the eruption column during its downwind movement: the radar reflectivity factor of the upper part of the eruption column becomes high 5-minute after the eruption, which is probably due to the aggregation process in water clouds (Fig. 2). The operational X-band MP radar collects 20 tilts PPI scan data at 5-minute interval. We can construct three-dimensional data of ash clouds with time and spatial interpolation method. Then we can obtain the wide-area ash fall distributions.

In conclusion, as mentioned above, different types of weather radars are now available for studying volcanic eruption columns and their applications to disaster prevention are promising.

Keywords: X-band marine radar, Ku-band rapid scanning Doppler radar, X-band polarimetric radar

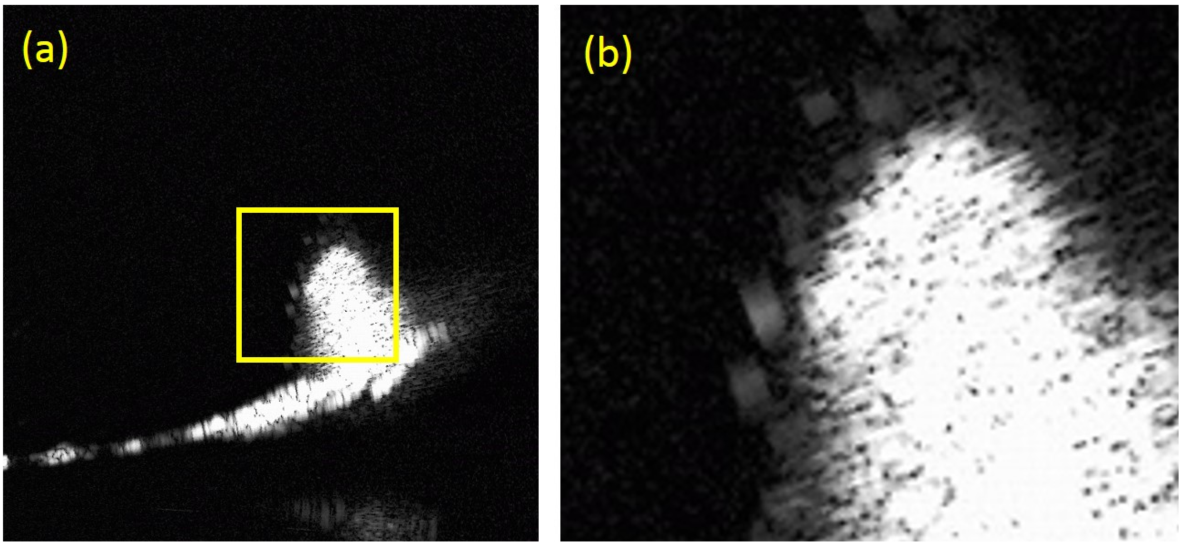

Fig. 1 Volcanic eruption column 2 minute after eruption observed by X-band marine radar. 22:11 LST, May 4, 2018.

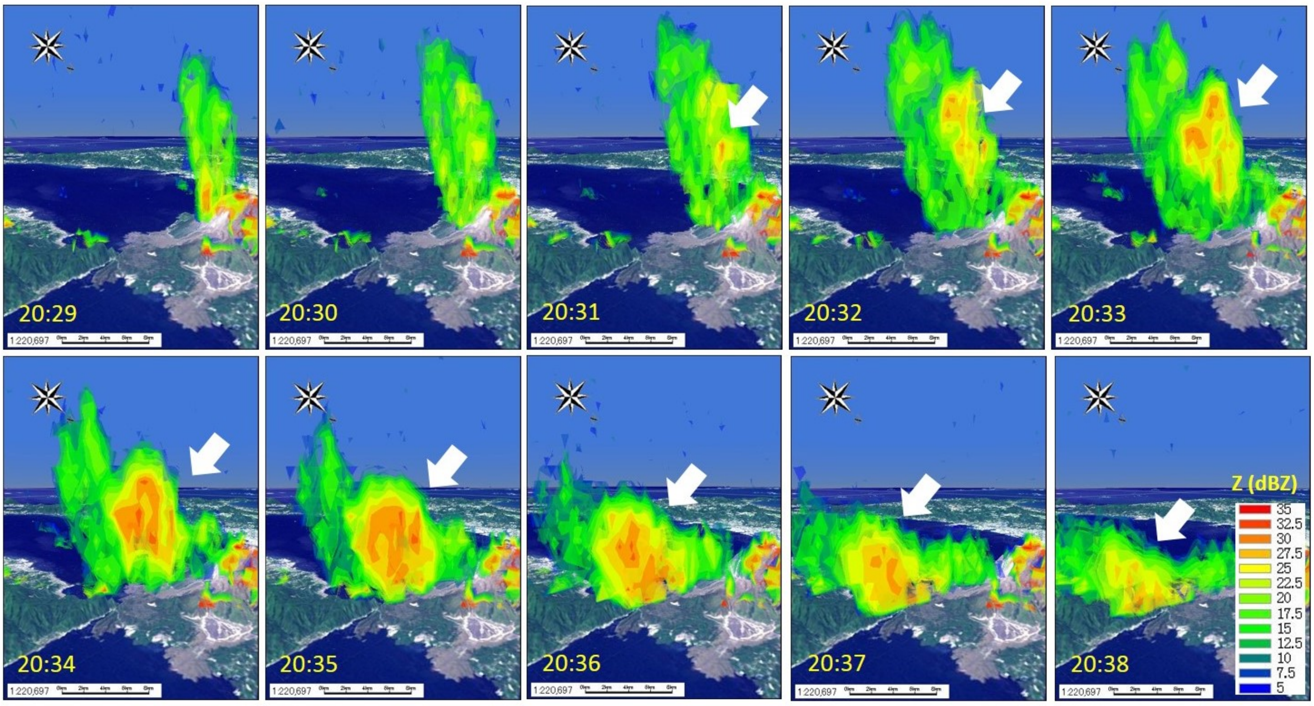

Fig. 2 Temporal change of inner structures of volcanic eruption clouds observed by KuRAD. 20:29-20:38 LST, March 5, 2018.