Polarimetric radar observations of volcanic eruptions

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There have been several reports of 'conventional' radar succeeded in detecting volcanic eruptions and estimating ash amount distributions. In addition to this information, 'polarimetric' radar has the potential to deduce the microphysical properties of volcanic ash particles such as ash particle size distribution, particle shape and postural. From analogy of past studies of hydrometeor classification in radar meteorology, polarimetric radar parameters may be used to discriminate ash particles from hydrometeors, which is a difficult task for non-polarimetric radar. The present study examines the potential use of polarimetric weather radar in the detection of volcanic eruptions, quantitative ash fall estimations (QAE), and the microphysical retrieval of ash particles.

The radar data analyzed in the present study are from the eruptions of the Mt. Shinmoedake volcano (1,421 m ASL) in the Kirishima Mountan Range and the Mt. Minamidake volcano (1,040 m ASL) in Sakura-jima, Kagoshima prefecture, both of which are located in southern Kyushu, Japan. The data selected for analysis are based on the Japan Meteorological Agency (JMA) monthly report on volcano activity, collected from 27 explosive eruptions of the Mt Shinmoedake volcano during the period January to March 2011, and 12 explosive eruptions of the Mt. Minamidake volcano during the period July to October 2012. The radar data from the Mt. Shinmoedake eruptions were collected by Kunimiyama C-band polarimetric radar, which was located 67.8 km south of the Mt. Shinmoedake volcano. The radar data from the Mt. Minamidake eruptions were collected by Tarumizu X-band polarimetric radar, which was located approximately 11 km south-southeast of the volcano.

Based on analysis of the eruption time period, the maximum and accumulated reflectivity factor, and the differential reflectivity of the volcanic ash, we reach the following conclusions:

1) Operational polarimetric weather radar has the potential ability to quantitatively estimate the amount of volcanic ash expelled during volcanic eruptions.

2) The *Z*-*A* relationship, where *Z* is reflectivity and *A* is the ash amount, can be derived if ground measurements of the ash amounts are available.

3) The coefficient and exponent of the power low function of the *Z*-*A* relationship is dependent on each volcanic eruption, which may be due to the difference in ash particle size distribution.

4) Differential reflectivity over a volcano crater fluctuates in space and time, while showing significant spatiotemporal patterning in the downwind regions, which suggests the presence of an ash particle aggregation and sorting mechanism.

5) The radar cannot detect weak ash echoes due to the minimum detectable reflectivity, which depends on the range from the radar and the receiver noise level of the radar system.

6) In-situ measurements of ash particles are necessary for more detailed analyses of polarimetric radar parameters.