Microphysical Studies of Volcanic Ash Clouds by X-band Polarimetric Weather Radar Observation

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It has been recognized since the 1970’s that weather radars can detect volcanic ash clouds. However, it is only since the 1990's that weather radars have been used in studies of quantitative ash cloud estimation. The present paper investigates the microphysical properties of volcanic ash clouds, the knowledge of which is necessary for quantitative ash cloud studies. Two volcanic eruptions at the Showa crater in Sakurajima, Kagoshima, Japan are analyzed. Both eruptions were observed by X-band operational polarimetric radar, which is installed by the Ministry of Land, Infrastructure, Transportation and Tourism approximately 11 km from the crater.
In the first eruption, which occurred on August 18, 2013, the ash column rose to a height of 5500 m above the crater. In the second eruption, which occurred on August 29, 2013, the ash echo and the precipitation echo coexisted. Analysis was performed on polarimetric radar parameters that were obtained by PPI scan at an elevation angle of 6 degrees. Radiating echo patterns, which extended from the north-northwest direction to the south-southeast direction through the crater, are found in the reflectivity factor (ZH) and the differential reflectivity (ZDR) immediately following the eruption. The direction of the radiating echo corresponds to that of a line connecting the radar and the crater. The radiating echo is probably due to the effect of the range side lob of the transmitted pulses. A similar radiating pattern was also found in the correlation coefficient of the horizontal and vertical polarization (RHOHV) immediately after the eruption. The radiating echo patterns had almost disappeared by 6 minutes after the eruption. Interesting time changes of ZH and ZDR were found during the period from 6 minutes to 24 minutes after the eruption: While the ZH decreased with time, ZDR increased with time. The RHOHV values were 0.8-0.9 until 24 minute after the eruption. This value decreased to 0.7-0.8 at the central region of the echo and to less than 0.5 at the outer edge of the echo. On the other hand, the time change of the specific differential phase (KDP) of the ash smoke was quite different from those of the other polarimetric radar parameters: it was too small to be detected immediately after the eruption, while it was 0.5deg/km at 14 minutes after the eruption before increasing to about 1deg/kmk. The present paper explains these polarimetric radar parameter time changes by time changes of the microphysical properties of ash particles.
While the first eruption studied occurred in dry environmental conditions, the second occurred in wet conditions. Before the eruptions, precipitation echoes were generated to the west of Sakurajima and passed over Sakurajima immediately after the eruptions. The subject radar could detect the precipitation echoes and the eruption echoes independently. However, it was difficult to distinguish between the ash smoke and the precipitation because both ZH patterns were quite similar. We attempted to discriminate them using polarimetric radar parameters.

Keywords: radar, volcanic smoke, volcanic eruption, three dimensional

