Characteristics of particle size distribution of falling ash particles from Sakurajima obtained from laser-optical particle size velocity disdrometer observation data

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The particle size distribution (PSD) of falling ash particles is important for the remote sensing of ash clouds, volcano disaster countermeasures, and elucidation of the internal structure of ash clouds. One of the common methods of measuring the PSD of volcanic ash particles is manual ground sampling after an eruption. Ground sampling, conducted from the viewpoint of volcanic geology, aims to understand the internal conditions of the volcano and the eruptive phenomena by measuring the size, shape, quantity and composition of the resulting ash particles. In contrast, information on the PSD of falling ash particles is essential for the development of a quantitative method for estimating the amount of falling ash with meteorological radar, and the investigation of the internal structures of ash clouds. In recent years, attempts have been made to observe ash falls by means of high temporal resolution, laser-optical particle size velocity (Parsivel^2) disdrometer developed by OTT. Parsivel^2, one such device, detects a drop in light quantity, as a voltage change, as the falling particles pass through the measurement area of the laser, and determines the PSD of the falling particles every minute.
In this study, we analyzed a total of 106 PSD samples of seven eruptions of Sakurajima, Japan, collected during May and June 2018 by Parsivel^2 installed in Sakurajima by the Disaster Prevention Research Institute of Kyoto University and the National Research Institute for Earth Science and Disaster Prevention.
We obtained the following results. The PSD of volcanic ash $N(D)[m^{-3}mm^{-1}]$ can be expressed by an exponential distribution $N(D) = N_0\exp(-\Lambda D)$, where D[mm] is the particle diameter, $N_0[m^{-3}mm^{-1}]$ is the intercept parameter and $\Lambda[mm^{-1}]$ is the slope parameter. The values of N_0 and Λ were calculated using the perfect moment method. We found that N_0 is from $10^{3.9}$ through $10^{4.5}$ (the modal value is 1.39×10^4). The shape parameter Λ decreased with an increase in the ash fall rate $R_A[kgm^{-2}h^{-1}]$: we found a relationship of $\Lambda = 4.64R_A^{-0.143}$. The results of this study are useful for establishing radar quantitative falling ash estimation formulae, improving the accuracy of falling ash forecast models, and elucidating the internal structures of cloud ash. In the future, it will be necessary to clarify temporal and spatial variations of particle size distribution.

Keywords: PSD, ash particle

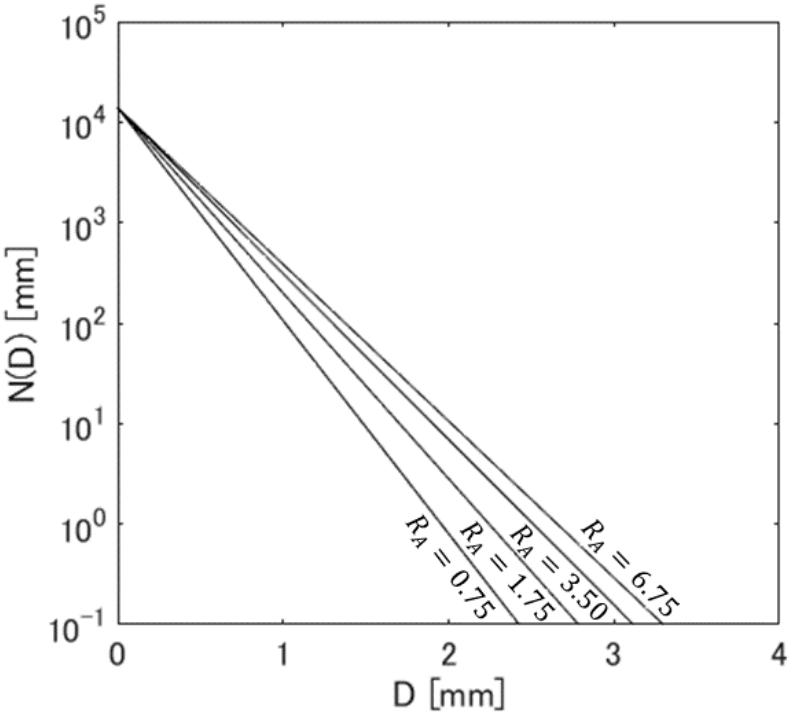

Fig. 1. The ash particle size distribution obtained from a total of 106 samples measured by Parsivel[2]. Samples were extracted from a total of 7 eruptions in Sakurajima volcano, Japan. PSD data were divided into four categories based on the ash fall rate R_A: 0.5-1.0 [$kgm^{-2}h^{-1}$], 1.0-2.5 [$kgm^{-2}h^{-1}$], 2.5-4.5 [$kgm^{-2}h^{-1}$], and 4.5-9.0 [$kgm^{-2}h^{-1}$]. Note that the classification criteria of R_A were determined to make the number of data samples uniform.