Segregation height and size distribution of volcanic ash of Sakurajima eruptions inferred by observed settling velocity

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1. Introduction

The most important input values of a volcanic ash dispersion model are mass eruption rate and wind. Aiming more precise estimation, ash segregation pattern from plumes is also important. Mannen [2014] estimated the segregation height of ash particles of 1986B sub-Plinian eruption of Izu-Oshima volcano, with a column of 10km high, using Tephra2, an advection-diffusion model. Using a method similar to Mannen [2014], we investigate features of particle segregation height and size distribution (PSD), based on the observation of the settling velocity of ash particles released by many Vulcanian eruptions of Sakurajima Volcano.

2. Observation method and Data

We install Parsivel^2, a laser-optical rain gauge (OTT Co.) at 13 sites in Sakurajima. The instrument classifies particles into 32 diameters (0.2-24.5mm) and 32 settling velocities (0.2-20.8m/s), and records particle count every minute. We analyze the data from May to December in 2018. Ash particles were detected at a total of 261 sites from 156 eruptions among 346 events. The size ranges from 0.25mm to 20mm, and the volume-based mode diameter is 0.625mm - 0.75mm. The settling velocity is less than 12.8m/s and slower than the terminal velocity of sphere in each diameter [Wilson and Huang, 1973].

3. Analysis method

Ash particles from a plume reach the ground through combination process of advection, diffusion, and dropping. We estimate back trajectory of ash particles from the ground to the plume based on wind data measured by JMA, in order to determine the nearest point to the plume as the segregation height. Horizontal wind field is obtained at the time of eruptions by the interpolation in time and altitude, and vertical wind is neglected. We assume the 2D Gaussian distribution [Suzuki, 1983] for diffusion, a constant settling velocity determined by observation for dropping, and a vertical line source for plume.

4. Particle segregation and PSD

Segregation mass and PSD are obtained for 17 eruptions using the data of ash particles estimated to have segregated within 10 minutes from the eruption. The plume height ranges from 400 to 4700m, and the mass and PSD are estimated at heights interval of 150m - 990m. The largest height interval is obtained at 1260m –2250m above sea level (asl) for the eruption which occurred at 15:09, June 9th in 2018. Its plume height was 1400m above the crater (2400m asl), and 4.4×10^3 tons of ash is estimated to be released from the range. Here we define α as the logarithm of the segregation density [t/m]. In the eruption, α ranges from -1 to 0 and there was no correlation between α and height. As for PSD, there was a strong inverse correlation (R=-0.94) between height and volume fraction of particles smaller than 0.75mm.

The plume of the eruption on July 16th in 2018 reached an elevation of 4600m above the crater. Segregation mass is 3.6×10^3 tons at the altitude range of 1290m –1710m and 2070m –2570m asl. α ranges from -2 to 0, and there is no correlation with α and height. As for PSD, there is no strong correlation (R=-0.39) between height and volume fraction of particles smaller than 0.75mm.

While most of eruptions don’t have correlation between height and PSD, some have strong inverse correlation (R<-0.9; 4 events) and another has strong positive correlation (R>0.9; 1 event). Mannen [2014] also showed similar inverse correlation.

5. Examination of the method

The mean α during the same period is obtained, 0.46, from the total mass of volcanic ash sampled continuously at wider area in Kagoshima pref. The mean α in this study, -0.18, is smaller than this because we treat the data for 10 minutes from the beginning.
Some segregation heights were obtained below the crater (1000m asl). This may be due to negligence of downward wind. Vertical wind will be taken into account later.

Keywords: segregation from a volcanic plume, Sakurajima volcano, tephra fall, Parsivel

