Tephra segregation profiles from Vulcanian eruptions on Sakurajima volcano, Japan, based on settling velocity observations

*Kosei Takishita[1], Masato Iguchi[2], Alexandros Panagiotis Poulidis[2], Tadaomi Sonoda[2]

1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2. Sakurajima Volcano Research Center, DPRI, Kyoto Univ.

Ashfall from volcanic eruptions has been predicted by studies using advection-diffusion models based on the wind velocity field and terminal velocity estimated from the particle size of volcanic ash particles. Models calculate the ash fallout distribution considering the advection, diffusion, and descent processes from the plume to the surface. Among the input parameters, plume height, total weight of volcanic ash, wind field, particle size, etc. are given based on observations, and the deposition pattern of ashfall can be faithfully reproduced at distances of tens to hundreds of kilometers, but not at distances of a few kilometers proximal to the crater.

The profile of tephra concentration along a volcanic column is decided by the complex interplay of eruption dynamics and the atmospheric state. Despite its importance in tephra transport and dispersal modelling, large uncertainties remain, mainly due to the lack of direct observations. Here, we investigate tephra segregation profiles (TSPs) from Vulcanian eruptions on Sakurajima volcano, Japan, using a combination of in-situ observations and high-resolution atmospheric and tephra transport modelling.

A total of 17 optical disdrometers (OTT Parsivel2) were installed on the flanks of Sakurajima for the in-situ measurement of tephra fall, allowing for the detailed observation of particles with sizes between 0.25-20 mm and settling velocities under 12.8m/s. Deposit loads for each disdrometer were estimated using an empirical formula that accounts for different densities in the observations. For the reproduction of the observed tephra deposits, we coupled the WRF numerical weather prediction model with a modified version of Tephra2, an advection-diffusion model that estimates the trajectories of the center of particle groups. Improvements made include: the replacement of the diameter distribution with observed terminal velocity distribution, the ability to solve the equations over temporally-evolving three-dimensional meteorological fields (three wind components and air density), and the ability to apply arbitrary TSPs.

A total of 6 Vulcanian eruptions were used for the study, with the plume heights ranging between 1400m and 4700m above the vent. The estimated TSPs were bimodal distributions. The higher peak corresponds to the top of a mushroom-shaped plume, which is made just when an eruption occurs, and the lower one indicates the dominance of segregation from the lower part of plume, which follows the mushroom-shaped plume. The results suggest that TSPs reflect temporal changes of discharge rate of volcanic ash.

Keywords: Tephra segregation profile, disdrometer, Vulcanian eruption, Sakurajima, Parsivel

