Simulating tephra fall deposit from a bending eruption plume: development of a new code and its validation using inversion

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Most of the existing tephra fall simulations, such as Tephra2, assume a vertical plume as the particle source. However, such a source may not be applicable in many cases, because atmospheric wind easily bend the uprising plume and paricle fallout can take place from horizontally drifting plume far downwind from the source vent. In this study, we developed a new code named WT (= windy Tephra2). The prototype of this code is Tephra2 (Connor et al 2001; Bonadonna et al 2005) and include the trajectory and the diameter of the source, which are predicted by a recently developed 1D plume model in windy condition (Woodhouse et al 2013). To validate WT, we reconstructed tephra dispersal of the 2011 Shinmoe-dake eruption, in which extensive particle fallout from a horizontally drifting plume was observed.

This eruption was recorded in detail using various instrumental and fluctuation of plume height was observed. However, since the tephra fall simulation is in very primitive stage, such a time-dependent height change cannot be included in the simulation and only a single set of wind profile and plume height should be assigned to run a simulation. Also, particle segregation pattern along the plume is unknown but essential to reconstruct the tephra dispersal. We thus gave possible sets of wind profile and plume height that were observed during the eruption and calculated inversely the particle segregation pattern and misfit between observed and calculated mass loadings on the ground. Then, the set of wind profile and plume height that shows the lowest misfit was compared with observed time (=wind profile) and plume height.

The result shows misfit lowered at the timings of three main explosions during the eruption and the optimum plume height is calculated to be 4 km, which is slightly lower than horizontally drifting plume observed by a meteorological satellite (MTSAT). The particle segregation showed logarithimic decay of particle fallout as a function of distance from the source vent and this implies well mixed nature of the plume.

Keywords: tephra, eruption plume, particle segregation

