Which part of the eruption cloud does volcanic ash fall from? An inversion analysis of the 1986B Izu-Oshima eruption

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Eruption clouds are the source of volcanic ash. Although several physical models of eruption clouds have been developed during the last three decades, and many reconstructions of ancient eruption clouds based on tephra dispersal have been attempted, the mode of particle release from eruption clouds remains unclear. Current tephra fall simulations assume a simple model, such as uniform release from entire span of an eruption column. Since wind direction and the downwind flow differ depending on altitude, the mode of particle release as a function of height greatly changes ash dispersal. The accuracy of tephra fall simulation thus significantly depends on mode of particle release from the column.

The 1986B Izu-Oshima eruption was sub-plinian and formed a vertical eruption column up to 13km high. Based on data of ash mass loading in tens of localities in downwind area and calculation using Tephra2, an advection-diffusion tephra fall simulation code, we obtained quantitative change of particle release as a function of height.

We calculated particle contribution of every 1-km height interval of the eruption column (i) to each locality (j) using Tephra2. Wind data at the eruption time was based on a re-analysis data, JRA-25. The contribution is calculated using Tephra2 for each size class (phi) and expressed as cij(phi). The mass loading at the locality sci(phi) is calculated cij(phi)ri(phi), where ri(phi) is released particle mass from height interval i. The ri(phi) is obtained by grid-search to minimize evaluation function E changing ri(phi) in appropriate range. The evaluation function adopted here is expressed as E = log(sci/ soi), where soi is ash mass loading measured in the field.

Our result indicates bimodal particle release as a function of height. All available particle sizes (2 to -5phi) show that the most significant particle release took place at around 2 to 3 km above the vent and up to 90% of detected erupted mass left in this lower part of the column. The -2 and -3phi particles also have significant particle release at around 6 to 7 km above vent and approximately 20% of these fractions are released in this higher part of the column. The release of larger particles (<-3phi) in the higher part is limited to up to several percent. Particle release in the middle part of the column seems to have been limited. Smaller particles (>-2phi) have no resolution in the higher part because these particles are assumed to fall beyond the island's coast.

These results support the conventional theory that predicts particle release took place from uppermost part of the column, where an eruption cloud spread laterally. The results also indicate substantial particle release from the lower part of the column, confirming the importance of fallout from this region in estimating total eruption volume and in understanding column dynamics.