Relationship between eruption plume heights and seismic source amplitudes estimated of eruption tremors and explosion events

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It is important to analyze and interpret tremors and volcanic earthquakes for estimating eruption size and for understanding eruption phenomena. In this study, we focus on eruption tremors and explosion events to understand physical processes of eruptions and to contribute to realtime estimation of eruption size.
Previous studies investigated the relation between eruption tremor and eruption size. McNutt (2004) studied the relation between the reduced displacement (DR) of tremor and the volcano explosivity index (VEI). However, there is a wide range of DR values for each VEI, so that VEI could be overestimated or underestimated from DR. Furthermore, there are the following problems in DR: (1) The estimated DR depends on tremor's frequency, and (2) the duration of tremor is not taken into account.
Kumagai et al. (2015) estimated the source amplitudes (As) and cumulative source amplitudes (Is) for eruption tremors and explosion events at Tungurahua, Ecuador, using the amplitude source location (ASL) method based on the assumption of isotropic S-wave radiation in a high-frequency band (5-10 Hz). Their results indicated that (1) Is linearly increased with increasing As for explosion events, and (2) the log of Is was proportional to As for eruption tremors. However, the universality of these scaling relations is not confirmed yet, and the physical meanings of As and Is are also not clear.
In this study, we analyzed eruption tremors and explosion events observed at Japanese volcanoes to investigate the relations between As and Is. We used continuous seismic waveform data of Japan Meteorological Agency's volcano observation networks, which are available through the V-net website of the National Research Institute for Earth Science and Disaster Prevention (NIED). We analyzed eruption tremors and explosion events at Sakurajima (Aug. 2013-Sep.2015), Kuchinoerabu (May. 29, 2015), and Ontake (Sep. 27, 2014), for which we applied a band-pass filter of 5-10 Hz to obtain envelope waveforms. We assumed sources at vents and estimated As and Is using the ASL method. Then, we examined the relation between As and Is as well as As and the maximum heights of eruption plumes.
We obtained the linear relationship between As and Is for explosion events at the Japanese volcanoes, and these values were similar to those estimated at Tungurahua by Kumagai et al. (2015). This suggests that the linear relationship between As and Is for explosion events is universally held. Our comparison between As and maximum plume heights indicated that there is a linear relationship between them, suggesting that the plume height may be estimated from As. Is may be related to eruption volume, but it was not confirmed due to the lack of eruption volume data. Assuming the linear relationships between Is and eruption volume and between As and plume height and using the relation that the log of Is is proportional to As, we obtained the relationship that the log of eruption volume is proportional to the plume height. We compared this relation with that estimated by Mastine et al. (2009) for various eruptions in the world. We found that the proportionality coefficient between As and plume height estimated from this comparison and that estimated from the above analysis were very similar. This supports that the proportional relationship between As and plume height is widely held. However, the differences in eruption styles (vulcanian and plinian) must be taken into account in our interpretations of As and Is and their relations with the plume height and eruption volume, which are open to future studies.

