Behaviors of volcanic ash, SO2 and sulfate aerosol: A perspective from research results on academic journals

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Articles for the studies on volcanic eruption clouds (ECs) using satellite-borne instruments are selected from 3 academic journals to clarify various behaviors of volcanic ash, SO2 and aerosol and to know the influence of volcanic aerosol on ash and SO2 measurements. Journals (J) are the following 3: J of Geophysical Research (JGR-B: Solid Earth and JGR-D: Atmospheres), Bulletin of Volcanology (BV) and J of Volcanology and Geothermal Research (JVGR). The periods investigated are from 1965 to 2012 for JGR-B, JGR-D and BV and from 1976 to 2012 for JVGR, respectively. Number of the papers selected is 355, and 297 of them discussing satellite data analyses and models are investigated here. They are classified into 6 categories; EC detection / discrimination (number of papers; 19), ash extent and mass measurements (81), SO2 extent and mass measurements (59), aerosol extent and mass measurements (71), EC development models (30) and EC trajectory models (37).

At early stage of the studies, detection and tracking of ECs are actively conducted. Then, the techniques of ash discrimination from meteorological clouds, SO2 extent detection at ultraviolet wavelength region (WR) and estimation of ash particle size and mass loading are developed. Ash and SO2 tracking and estimation of their mass loadings are introduced using infrared WR, and retrievals of volcanic sulfate aerosol generated from SO2 are successively proposed. Volcanic sulfate aerosols are monitored by space-borne lidars. Measurements of SO2 clouds at the upper troposphere and the lower stratosphere (UTLS) and the boundary layer (BL) are successfully conducted. EC models and trajectory models are actively developed.

Research results show that ash and SO2 collocate together for several hours to three days after eruption onsets. ECs injected at high altitudes are affected mainly by wind shear and show complicated extents, and separation of ash and SO2 clouds in different directions are confirmed. Usually, SO2 gases in ECs change to sulfate aerosols at early stage after eruption onsets, and cover widely dispersed areas of ash and SO2.

When the measurements of ash and SO2 mass loadings are conducted one to two days after eruption onsets, the increased volcanic aerosol may cause masking of ash and SO2 extents, and may bring misunderstanding for detection of ash and SO2 distributions, and for estimation of their mass loadings. To prevent false analyses, plural satellite data are necessary for the validation of measurements. Recent satellites are equipped with high-resolution, multi-spectral and hyper-spectral detectors and space-borne lidars. Using those data, further developments of the techniques of data processing are required. In addition, ash detections in thick and opaque ECs and in ice rich ECs generated soon after eruption onsets are essential for urgent issues of VAAs (Volcanic Ash Advisories) and ash trajectory models. They are vital to mitigate the aerial volcanic hazards.