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Refractive index of volcanic ash material estimated from the data of satellite infrared sounder

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From the data of volcanic ash measurement by satellite infrared sounder and radiative transfer calculations, refractive indices of ash material for some volcanic clouds were estimated. For the past volcanic events of high eruption activities, a dataset of volcanic ash clouds over ocean which detected by the Atmospheric Infrared Sounder (AIRS) on board Aqua satellite was prepared. Appling the atmospheric profiles from global analysis and ash cloud parameters in radiative transfer calculations, a least square analysis for the observed and calculated brightness temperatures was carried out using 836 AIRS channels in wavenumber range between 700 cm^{-1} and 1100 cm^{-1}. A mixture of andesite and rhyolite for the ash material was considered, and a fraction of andesite was used as a retrieval parameter as well as ash optical depth, effective radius, and ash cloud height. Using the estimated cloud parameters as the fixed values, imaginary part of the ash refractive index was then estimated by iterative calculations for each AIRS channel. Final results of the spectral refractive indices were determined from the cross retrieval calculations for other measurement footprints of the same ash clouds.

Results of the imaginary part of the ash refractive indices for nine volcanos at the time of large explosions are proposed. For wavenumber range 850-1100 cm^{-1}, refractive indices of a mixture of previously proposed andesite model and the rhyolite model well represented the observed brightness temperatures. On the other hand, weak absorptions which cannot be produced by the mixture of the two refractive index models, were derived from our analysis at wavenumber around 700-850 cm^{-1}. These weak absorptions are likely due to Si-O and/or Al-O antisymmetric vibrations which have been confirmed in laboratory experiments for some silicate glass samples. Our results suggest that the detailed refractive index of volcanic ash can be estimated from the analysis of satellite infrared sounder data.

In the current IR volcanic ash algorithms of geostationary meteorological satellites and earth observing satellites, two or three infrared window channels are used for the detection and evaluation of the ash clouds and the andesite model of refractive index is assumed for the absorption property of ash material. It is expected that the refractive index of ash clouds for specific volcano estimated from the satellite infrared sounder data can improve the ash retrieval algorithms. Furthermore, the retrieved refractive index may give information regarding the diagnosis of volcanic activity by comparing the ash refractive index for the past eruption events.

Keywords: volcanic ash, satellite infrared sounder, refractive index