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# Determining the altitude of tropospheric volcanic ash clouds using the $CO_2$ slicing technique

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The $CO_2$ slicing technique has been widely used to obtain the heights of meteorological clouds from satellite data. Research has shown that it has the capability to obtain the heights of volcanic ash clouds in the troposphere; an important variable used to minimise the risk posed by volcanic ash clouds to aviation and used as an input into models of ash cloud propagation. The technique has only been applied to ash for measurements by the Moderate Resolution Imaging Spectroradiometer. This study adapted the $CO_2$ slicing technique for the Infrared Atmospheric Sounding Interferometer (IASI), a hyperspectral sensor with hundreds of channels within the $CO_2$ absorption band. Simulated ash spectra were first used to select a subset of the most appropriate channels. It was then demonstrated that the subset of channels was capable of successfully retrieving the ash cloud pressure using simulated spectra. The results indicated a strong match between the simulated and retrieved pressures except for ash clouds close to the surface or with low optical depths, The technique was applied to IASI spectra obtained during the Eyjafjallajökull and Grimsvötn eruptions in Iceland in 2010 and 2011 respectively. Both eruptions emitted ash plumes into the troposphere, and were widely studied with other instruments, making them appropriate choices for this application. The $CO_2$ slicing results were compared against those from an optimal estimation (OE) scheme developed for IASI which also retrieves the ash optical depth and effective radius. In general, the $CO_2$ slicing results were slightly higher than those from the OE method. The Cloud-Aerosol Lidar with Orthogonal Polarization satellite instrument was used for validation. In some cases, the $CO_2$ slicing and OE techniques both produce results which resemble the backscatter plots from the LiDAR, but there are clear cases where one method outperforms the other. Overall the $CO_2$ slicing technique is shown to perform better. Despite this technique being widely used for meteorological cloud, this is the first application to volcanic ash with IASI. This tool could be used to get a first approximation of the ash height, potentially for use for hazard mitigation, and which could also be used as an input for other retrieval techniques.