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Imaging trace gases in volcanic plumes with Fabry Perot Interferometers

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Within the last decades, progress in remote sensing of atmospheric trace gases revealed many important insights into physical and chemical processes in volcanic plumes. In particular, their evolution could be studied in more detail than by traditional in-situ techniques.
A major limitation of standard techniques for volcanic trace gas remote sensing (e.g. Differential Optical Absorption Spectroscopy, DOAS) is the constraint of the measurement to a single viewing direction since they use dispersive spectroscopy with a high spectral resolution. Imaging DOAS-type approaches can overcome this limitation, but become very time consuming (of the order of minutes to record a single image) and often cannot match the timescales of the processes of interest for volcanic gas measurements (occurring at the order of seconds).
Spatially resolved imaging observations with high time resolution for volcanic sulfur dioxide (SO_2) emissions became possible with the introduction of the SO_2-Camera. Reducing the spectral resolution to two spectral channels (using interference filters) that are matched to the SO_2 absorption spectrum, the SO_2-Camera is able to record full frame SO_2 slant column density distributions at a temporal resolution on the order of < 1s. This for instance allows for studying variations in SO_2 fluxes on very short time scales and applying them in magma dynamics models. However, the currently employed SO_2-Camera technique is limited to SO_2 detection and, due to its coarse spectral resolution, has a limited spectral selectivity. This limits its application to very specific, infrequently found measurement conditions.
Here we present a new approach, based on matching the transmission profile of Fabry Perot Interferometers (FPIs) to periodic spectral absorption features of trace gases. The FPI's transmission spectrum is chosen to achieve a high correlation with the spectral absorption of the trace gas, allowing a high selectivity and sensitivity with still using only a few spectral channels. This would not only improve SO_2 imaging, but also allow for the application of the technique to further gases of interest in volcanology (and other areas of atmospheric research).
Imaging halogen species would be particularly interesting for volcanic trace gas studies. Bromine monoxide (BrO) and chlorine dioxide (OClO) both yield absorption features that allow their detection with the FPI correlation technique. From BrO and OClO data, ClO levels in the plume could be calculated.
We present an outline of applications of the FPI technique to imaging a series of trace gases in volcanic plumes. Sample calculations on the sensitivity and selectivity of the technique, first proof of concept studies and proposals for technical implementations are presented.