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A novel technique for studying volcanic gas chemistry and dispersion on short time scales

Christopher Fuchs[1], Jonas Kuhn[1,2], Nicole Bobrowski[1,2], and Ulrich Platt[1,2]
[1]Institute of Environmental Physics, University of Heidelberg, Germany, (cfuchs@iup.uni-heidelberg.de)
[2]Max Planck Institute for Chemistry, Mainz, Germany

Volcanic gas emissions, in particular, of sulphur and halogen species, play an important role in atmospheric chemistry. Due to the complex reaction kinetics of halogen radicals inside the volcanic plume, many properties like e.g. chemistry limiting factors and timescales of reactions, are still not well understood.
Imaging techniques based on optical remote sensing can get valuable insights into the study of both volcanic degassing fluxes and chemical conversions within the plume that continuously mixes with the atmosphere. However, state-of-the-art techniques are either too slow to resolve plume chemistry processes on its intrinsic time scales (e.g. DOAS) or show many cross sensitivities and hence are limited to rather high trace gas concentrations (e.g. SO_2 cameras).

We introduce a novel technique for volcanic trace gas imaging, which, by employing a Fabry-Perot interferometer (FPI), uses detailed spectral information for the detection of the target trace gas. Cross sensitivities are thereby drastically reduced, allowing for the detection of much lower SO_2 concentrations and imaging of other trace gas species like, e.g., BrO, OClO. Furthermore, the inherent calibration of the new techniques avoids the requirement of additional DOAS measurements or gas cells for calibration.

We present the first measurements of volcanic SO_2 with an imaging Fabry-Perot interferometer correlation spectroscopy (IFPICS) prototype. The sensitivity of ≈ 10^{19} cm^2 $molec^{-1}$ is comparable to filter based SO_2 cameras, whereas the selectivity is much higher (e.g. no ozone interference). This will largely increase the accuracy of SO_2 emission rates, which are routinely used to approximate fluxes of other volcanic gas emissions into the atmosphere.

Additionally, sensitivity studies for further trace gases combining laboratory measurements and radiation transfer modelling show promising prospected BrO detection limits of < 10^{14} molec cm^{-2}, corresponding to mixing ratios of 10 to 100 ppt in volcanic plumes. The direct visualisation of BrO within the volcanic plume mixing with the ambient atmosphere will give important insights into the plume's halogen chemistry and, thereby, its impact on the atmosphere.