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Quantifying gas, ash and aerosols in volcanic plumes using emission OP-FTIR measurements

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Monitoring of volcanic emissions (gas, ash and aerosols) is crucial to our understanding of eruption mechanisms, as well as to developing mitigation strategies during volcanic eruptions. Ultraviolet (UV) spectrometers and cameras are now ubiquitous monitoring tools at most volcano observatories for quantifying sulphur dioxide (SO2) emissions. However, because they rely on scattered UV light as a source of radiation, their use is limited to daytime only, and measurement windows are often further restricted by unfavourable weather conditions. On the other end of the spectrum, Open Path Fourier Transform Infrared (OP-FTIR) instruments can be used to measure the concentrations of a series of volcanic gases, and they allow for night-time operation. However, the retrieval methods rely on the presence of a strong source of IR radiation in the background - either natural (lava flow, crater rim, the sun) or artificial – restricting their use to very specific observation geometries and a narrow range of eruptive conditions. Here we present a new approach to derive quantities of SO2, ash and aerosols from measurements of a drifting volcanic plume. Using the atmosphere as a background, we measured self-emitted IR radiation from plumes at Stromboli volcano (Italy) capturing both passive degassing and ash-rich explosive plumes. We use an iterative approach with a forward radiative transfer model (the Reference Forward Model – RFM) to quantify concentrations of sulphur dioxide (SO2), aerosols and ash in the line of sight of the spectrometer. This new method could significantly enhance the scientific return from OP-FTIR instruments at volcano observatories, ultimately expanding their deployment as part of permanent scanning networks (an alternative to DOAS instruments) to provide continuous data on the emissions of gas, ash and aerosols.