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Recent advances in ground-based and airborne remote sensing of volcanic degassing

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Since the advent of correlation spectrometers (COSPEC) in the mid-1970s, volcanologists have been measuring volcanic degassing using remote sensing techniques. It was quickly realized that upward-looking remote sensing instruments, be they located on ground-based or airborne platforms, allow accurate determination of the volcanic sulfur dioxide (SO_2) emission rate. In first order, this parameter is directly linked to the supply of magma to shallow depths in volcanic systems. Therefore, its determination represented a new independent measure of volcanic activity with significant potential for forecasting future activity.

Forty years later, SO_2 emission rates have become a standard parameter commonly measured at volcanoes all over the world. Miniature ultraviolet differential optical absorption spectrometers (DOAS) have taken the place of large COSPEC instruments, and SO_2 cameras now allow 2D imaging of plumes at high temporal resolution. However, challenges remain. Aerosol scattering can affect radiative transfer in and around volcanic plumes, thus potentially skewing measured SO_2 column densities and emission rates significantly, and determining reliable plume speeds is still of key importance to obtaining accurate SO_2 fluxes from plume scans or imagery.

Also, it has become increasingly clear that interpretation of SO_2 output alone can be very ambiguous. Sulfur is efficiently scrubbed in volcanic systems when gases interact with hydrothermal systems or groundwater, a process that often suppresses SO_2 emissions during the early stages of unrest. Determining the relative chemical and isotopic composition of emitted gases is helpful in solving this complex puzzle, but operational measurements of plume speciation are mostly performed using in-situ instrumentation because only a handful of gas species are currently accessible to standard operational remote sensing techniques.

In this presentation, we will give an overview of recent advances in volcanic gas remote sensing technology and methodology that show promise in advancing our understanding of volcanic systems. We will focus on applications that can deliver real time data and help inform operational eruption forecasts. We will highlight new approaches to dealing with common measurement errors such as radiative transfer/scattering corrections for DOAS retrievals and new algorithms for evaluating SO_2 plume imagery. We will also discuss novel techniques that might be used to remotely measure additional gas species in volcanic plumes in the future, e.g. summarizing recent DOAS water vapor measurements, the utilization of unmanned aerial platforms for gas measurements, and the benefits of solar occultation measurement geometries.