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Observing the plume of Popocatépetl and Colima with a novel SO2-Camera

Peter Lübcke (1), Nicole Bobrowski (1), Sebastian Illing (1), Christoph Kern (2), Leif Vogel (1), Johannes Zielcke (1), and Ulrich Platt (1)

(1) Institute of Environmental Physics, University Heidelberg, Germany (pluebcke@iup.uni-heidelberg.de), (2) now at: U.S. Geological Survey, Vancouver WA, USA

Sulfur dioxide (SO_2) emissions are related to the volume of magma degassing beneath the Earth's surface. SO_2 emission flux measurements can therefore be an important tool for monitoring volcanoes and eruption risk assessment. For instance, changes in the SO_2 flux have been recorded together with an increased seismic tremor prior to volcanic eruptions at Santa Ana volcano (El Salvador). The SO_2 camera is a technique for remote sensing of volcanic sulfur dioxide emissions based on measuring the ultra-violet absorption of SO_2 in a narrow wavelength window around 310 nm by employing band-pass interference filters and a 2-D UV-sensitive CCD detector. Solar radiation scattered in the atmosphere is used as a light source for the measurements. The effect of aerosol scattering can be eliminated by additionally measuring the incident radiation around 325 nm where the absorption of SO_2 is no longer significant, thus rendering the method applicable to plumes containing aerosols. The ability to deliver spatially resolved images of volcanic SO_2 distributions at a frame rate on the order of 1 Hz makes the SO_2 camera a very promising technique for volcanic monitoring. The high time resolution allows the calculation of the wind-speed directly from the measurements, thus largely eliminating this error source in the flux measurements. Another advantage of the high time resolution is the possibility to correlate the gas flux with other data sets, i.e. seismic data, on shorter timescales than previously possible. Here we present results of measurement campaigns conducted at Popocatépetl and Colima, Mexico in April 2010 and February 2011, which were performed with a new prototype of a SO_2 camera incorporating an additional Differential Optical Absorption Spectroscopy (DOAS) system. The DOAS system was used to apply a new calibration method, besides making the correction for radiative transfer effects possible. The built in DOAS system carried out point measurements of the volcanic plume in a region that corresponds to the center of the SO_2 camera images. This yields column density / apparent absorption pairs that can be used to determine the calibration curve for the SO_2 camera images. In order to test and validate this approach, simultaneous measurements with an imaging-DOAS (IDOAS) were conducted. The IDOAS measures two dimensional trace gas distributions using the DOAS technique. A two dimensional detector is used. The incident radiation is spectrally dispersed along one dimension, while the other dimension corresponds to a dimension in space. The second image dimension is obtained by using a scanning mirror. Despite the lower measurement time resolution (about 30 minutes for one image), the inherent calibration of the IDOAS allows verification of the camera calibration. For this, each column of the IDOAS image has is compared to the respective column of the contemporaneously taken SO_2 camera image.