Geophysical Research Abstracts,
Vol. 11, EGU2009-8141, 2009
EGU General Assembly 2009

Radiative transfer corrections for precise spectroscopic measurements of volcanic emissions

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Passive remote sensing techniques are increasingly being applied to quantitatively measure volcanic emissions. Well established techniques such as COSPEC, mobile DOAS, scanning DOAS, imaging DOAS, and the SO_2-camera all use sunlight scattered in the atmosphere as a light source. Therefore, they measure the integrated column density of plume components along the average optical path from the sun to the instrument. To obtain gas concentrations or emission fluxes, however, the average optical path through the volcanic plume must be known. Radiation scattered towards the instrument without having passed through the plume can cause measurement errors. Also, aerosols in volcanic plumes can cause an extension of the optical path, thereby causing an overestimation of emissions. Recent model studies have shown that radiative transfer in and around volcanic plumes can be highly variable and that optical paths depend strongly on distance between plume and instrument, plume SO_2 concentration, plume aerosol load, as well as aerosol conditions in the ambient atmosphere.

Inaccurate knowledge of radiative transfer can result in significant measurement errors. However, a method for retrieving optical path lengths in volcanic plumes was recently developed and now allows the correction of these errors. The magnitude of radiative transfer induced errors will be demonstrated using exemplary field measurements conducted with both DOAS and SO_2-camera techniques. By combining different measurement techniques and applying the novel radiative transfer retrievals, volcanic emissions of SO_2 (and other trace gases) can be measured in real time, at a high temporal and spatial resolution, and at high precision.