Geophysical Research Abstracts,
Vol. 10, EGU2008-A-07562, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-07562
EGU General Assembly 2008
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Radiative transfer in volcanic plumes

C. Kern, T. Deutschmann, L. Vogel, T. Sommer, M. Fickel and U. Platt

Institut fuer Umweltphysik, University of Heidelberg, Heidelberg, Germany
(ckern@iup.uni-heidelberg.de / Fax: +49 6221 546405 / Phone: +49 6221 546315)

Differential Optical Absorption Spectroscopy (DOAS) is becoming an increasingly popular technique for measuring trace gases such as sulphur dioxide (SO_2) and halogen oxides (e.g. BrO, ClO, OClO) in volcanic plumes. Passive DOAS instruments use scattered sunlight as a light source to measure the characteristic absorption structures of the individual trace gases. The advantages of this remote sensing technique include its contact-free nature, high sensitivity, the ability to simultaneously measure several species at a distance from the volcano's crater, and the high accuracy of the trace gas column density measurements.

In order to calculate emission fluxes or plume concentrations from the measured column densities, it is however necessary to determine the light path of the measured photons through the plume. While direct measurement is not possible, several approaches can be made: For one, the known atmospheric concentration of the oxygen dimer O_4 allows its absorption to be used as a tracer for atmospheric photon path lengths. Also, broadband analysis of the measured spectra can give insight into Raleigh and Mie scattering processes while the magnitude of the Ring effect can be used as a measure for inelastic Raman scattering. In this study, 3 dimensional radiative transfer modelling was used to gain a quantitative understanding of these effects. The model results of several case studies are discussed. Also the implementation of retrieval algorithms for photon path lengths in and around volcanic plumes is presented.