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Retrieval of volcanic plume aerosol properties from UV-spectroscopic DOAS measurements

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Passive differential optical absorption spectroscopy (DOAS) has become a standard tool for the quantification of SO_2 emission fluxes from volcanoes. However, this measurement technique has the potential to measure not only trace gas absorption but also some aerosol properties of volcanic plumes. In fact, recent model studies have shown that knowledge of the plume's aerosol optical depth is important for the retrieval of accurate SO_2 column densities, as multiple scattering of radiation on aerosol particles in a plume can lead to a significant enhancement of the measured SO_2 absorption signal. In this presentation, a retrieval scheme is presented that combines radiative transfer modelling with spectral analysis of DOAS measurements in the ultra-violet spectral region to simultaneously retrieve accurate SO_2 column densities and aerosol optical depths. A three-dimensional backward Monte Carlo radiative transfer model is used to simulate measurement spectra that would be obtained for a certain physical state of the atmosphere and volcanic plume. Thus, a solution to the forward problem is obtained. By varying the state vector until the simulations match the remote sensing observations, this problem can be inverted using a standard Levenberg-Marquardt algorithm. We show here that the information content of the measurement is sufficient to allow an unambiguous inversion of both, the aerosol optical depth and SO_2 column. The method is then tested on a number of different scenarios and the potential and limitations of the algorithms are explored. By applying this novel retrieval technique to DOAS measurements from ground-based and satellite platforms, the accuracy of UV-spectroscopic measurements of SO_2 in volcanic plumes can be greatly enhanced while at the same time allowing an accurate retrieval of aerosol conditions.