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Retrieval of absolute SO_2 column amounts from scattered-light spectra - Implications for the evaluation of data from automated DOAS Networks

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Remote sensing of gas emissions is an important tool for monitoring volcanoes. The Network for Observation of Volcanic and Atmospheric Chance (NOVAC) comprises approximately 80 scanning Differential Optical Absorption Spectroscopy (DOAS) instruments installed at 30 volcanoes world-wide. The DOAS evaluation requires a Fraunhofer Reference Spectrum (FRS) that is free of the trace-gas of interest, however, for scanning DOAS instruments at volcanoes this requirement can be formulated in a weaker form. The spectra from one scan (e.g. from horizon to horizon) are evaluated using the DOAS approach employing one spectrum of the respective scan as FRS (for example a zenith-looking spectrum). Possible SO_2 contamination of the FRS is corrected for by calculating an SO_2 offset value for each scan that is then subtracted from the results of all encompassing. The SO_2 offset can, for example, be defined as the average SO_2 column density (CD) of the 20% of spectra with lowest SO_2 content in one scan (the standard NOVAC method) or simply as the lowest SO_2 CD that can be found in each scan. This approach is based on the assumption that at least one spectrum is recorded at a viewing direction with negligible absorption signature of volcanic SO_2.
We investigated an alternative approach for the DOAS evaluation using a modelled FRS which is based on a high-resolution Solar Atlas spectrum. We analyzed spectra from two volcanoes that are part of NOVAC - Nevado del Ruiz (Colombia) and Tungurahua (Ecuador) during January 2010-June 2012 and during January 2009-December 2011, respectively. Instrumental effects were identified with help of a Principal Component Analysis (PCA) of the residual structures of the DOAS evaluation. The major advantage of a retrieval based on a modelled FRS is that it yields absolute CDs of SO_2 and other molecules included in the spectral retrieval. We investigated how frequently all viewing directions of each scan are contaminated with SO_2. The results are compared to an evaluation that is similar to the standard NOVAC approach. The investigation at these two strongly degassing volcanoes showed that 21.4% of the scans (containing significant amounts of SO_2) at Nevado del Ruiz and 7% of the scans at Tungurahua had a large difference between the two methods (more than a factor of 2). The retrieval with a modelled FRS can be used to identify cases where contamination of all spectra in a scan leads to an underestimation of the SO_2 CD and thus influence the derivation of SO_2 emission rates. We will present the method, the results and discuss the possible reasons for contamination of all spectra and when this can lead to an underestimation of the SO_2 emission rate.
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