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DOAS evaluation of volcanic SO_2 using a modeled background spectrum: Examples from the NOVAC stations at Nevado del Ruiz (Colombia) and Tungurahua (Ecuador)

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SO_2 emission rates are monitored using Differential Optical Absorption Spectroscopy (DOAS) in the UV at an increasing number of volcano observatories. The Network for Observation of Volcanic and Atmospheric Change (NOVAC) has currently installed 80 scanning DOAS instruments at 30 volcanoes world-wide. One important question for the evaluation of spectra using DOAS is the availability of background spectra that are not influenced by volcanic gas emissions. An SO_2 contaminated background spectrum would lead to a negative offset of the retrieved SO_2 column densities, and thus to an underestimation of the volcanic SO_2 emission rate. In NOVAC this problem is approached by performing a scan, e.g. through a plane from one horizon to the other horizon, and defining the average of the 20% spectra with the lowest SO_2 content as the zero-baseline value, which is assumed to be gas free. To verify this assumption we revisit the idea of evaluating spectra using the DOAS method with a modeled background spectrum based on a high-resolution solar atlas. One challenge when evaluating spectra with a modeled background spectrum is properly accounting for instrumental effects that are usually removed when calculating the measured optical density relative to a measured background spectrum. We present our approach to handle these instrumental effects, showing that we gain a similar fit quality to the method using a measured reference spectrum. For example, wavelength dependent structures in the spectrum due to the spectrometer (e.g., quantum efficiency of the detector and grating efficiency) were identified with help of a principal component analysis of an SO_2 free subset of the residual spectra. These structures were included in a second iteration of the fit in order to improve the evaluation. We further discuss influences like strong ozone absorption and the instrument temperature on the quality of the SO_2 fit using a modeled background spectrum. The new evaluation scheme was applied to data from Nevado del Ruiz (Colombia) and Tungurahua (Ecuador). We investigated how often and under which circumstances SO_2 contaminated background spectra occur and how big the effect on the SO_2 emission rates is. At Nevado del Ruiz, although characterized currently by a large emission and therefore broad plume the NOVAC stations are installed at a distance of only 2-5 km from the volcano. At this volcano up to 30% of the scans underestimate the SO_2 emission rate, with stronger underestimation occurring at low wind speeds (below 5 m/s). At Tungurahua, where the stations are installed at more than 5 km distance from the volcano preliminary results indicate that fewer scans are influenced by contaminated background spectra.