Answer to an Interactive comment on "Retrieval of absolute SO_2 column amounts from scattered-light spectra – Implications for the evaluation of data from automated DOAS Networks" by Peter Lübcke et al.

Dear Editor,

We like to thank our colleague for the comments and suggestions. We implemented his suggestions into the revised version of our manuscript. With these changes (and those in response to the other reviewers') we are confident that the revised manuscript has improved considerably. Please find the comments (in normal face) and our answers (in bold face) below:

Thank you for the opportunity to review for AMT. I am recommending minor revisions here.

We like to thank Dr. Andrew McGonigle for his review.

This article concerns an important area of interest in terms of scanning DOAS measurements of volcanic sulphur dioxide emissions. These data are now routinely collected at a number of volcanoes worldwide, in particular via the NOVAC project, which this article pertains to. The data are a significant component of the work of volcano observatories in terms of monitoring and this article describes an important contribution to ensuring data integrity in respect of spectral processing methodologies. In particular the paper details an approach concerning use of modelled rather than measured Fraunhofer spectra in the retrievals.

In my opinion the paper is very well written with excellent structure throughout, strong demonstration of the key points and scientific integrity.

We appreciate the positive evaluation of our manuscript.

The only point which I would recommend that the authors consider, is regarding the operational utility of this approach. There is no doubt that could be a useful refinement of currently adopted protocols in terms of scanning DOAS measurements. However, the transference of this approach into routine application in volcano observatories internationally, in particular by staff who are not necessarily expert in remote sensing, could be another matter. Perhaps the authors could comment on how transferable this approach could be into operational utilisation e.g., would it require spectroscopic knowledge from the user community, or could user-friendly programs be written to enable non-experts to benefit from these developments. Some more text anticipating how this approach could be transitioned into operational usage could really help with uptake from the end user community.

We thank the referee for this excellent suggestions. As he correctly points out, the approach encompasses some tasks which require an end-user with a certain level of knowledge in the evaluation of spectroscopic data, however our approach was developed from the beginning with the aim to ultimately implement it into operational spectroscopic networks. We, therefore, will add the following discussion to the conclusions:

“The approach presented was developed with the aim to implement it into the operational monitoring of spectroscopic networks. Its great advantage is reduction of manual labour (field measurements and calibration) at the expense of a more elaborate statistical evaluation. The main challenge for the implementation is the availability of a ’training set’ of field-spectra, which is guaranteed to be gas free (the importance of such a data set was also suggested in Burton and Sawyer, 2016). Additionally, the end-user has to set a number of instrument specific parameters, which can potentially influence the performance of the retrieval. These parameters are mainly connected to the PCA and include the cut-off value determining which spectra are excluded from PCA, accounting for hot-pixels of the detector (which leave a dominant structure in the residual) and a well chosen number of principal components to include in the DOAS retrieval.
At present, the algorithm can easily be applied to any other volcano of the NOVAC network off-line, but it is not part of the standard software used by the observatories in the network. The main advantage of implementing this method in the future will be the possibility to identify plume scans not having an SO_2-free spectrum that gives the baseline zero SO_2 level. Currently lack of a SO_2-free reference spectrum will result in the standard NOVAC software not calculating the correct SO_2 emission rate for such measurements. In these cases, applying our new method yields the important information that the SO_2 emission rate from the volcano is non-zero if one of the following conditions prevails: 1) The plume is extending at low altitude towards the spectrometer site, and/or 2) The plume is elevated but sufficiently extended to fill the entire range of scan angles. Even if those cases may only occur rarely at some volcanoes, it is highly advantageous to obtain information on gas emissions in these cases to complement monitored time series. Last but not least, the presented method confirms SO_2 emission rate measurements with low or no degassing present because it eliminates the chance that those are resulting from contaminated FRS.“