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Atmospheric Measurement Techniques Discussions

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Interactive comment on "Remote sensing of volcanic CO_2, HF, HCl, SO_2, and BrO in the downwind plume of Mt. Etna" *by* André Butz et al.

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General comments:

The paper presents results of a measurement survey, sensing volcanic gas concentrations (CO2 , HF, HCl, SO2 and BrO) a couple of km downwind Mt. Etna, Sicily (Italy), using passive remote sensing apparatus. In particular, a fourier transform spectrometer operating in the SWIR, and a DOAS operating in the UV were employed.

I have not come across ground based passive remote sensing of volcanic gas from this long distance from the volcano mouth. While the methods used are established the data are new and an important result for climate related science and environmental monitoring in general. The paper is well written in a concise and straightforward manner.

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Discussion paper

I like the fact that the authors measured other volcanic species (HCL, HF etc.) in parallel as this allows a rather precise distinction of the volcanic CO2 in space.

The measurement precision, particularly that of CO2 VCD is impressive, given that the observatory was moving on a road (even though CO2 absorption spectra were recorded when the car stopped). How sensitive is the setup to shocks and vibrations? Is there an influence on the vibrations and have you quantified them or at least have a semi-quantitative measure?

The retrieval algorithm used remains mysterious, as well as the impact of model and fitting errors on the VCDs (see specific comments).

In my opinion the paper could be further improved by comparing the measured enhancements with plume dispersion models (e.g. Burton et al., 2013, p. 325), which are in line with your result. But this might be out of scope for an AMT paper.

Specific comments:

P2, l 22 and 23: Lidar BILLY measures range resolved CO2 concentrations. Whether or not it has to be close to the source depends on various parameters, including instrumental parameters such as the pulse energy, excess CO2 concentration, aerosol density etc.. There is no fundamental reason why the LIDAR has to be close to the plume. The CO2 plume of big cities is visible in airborne LIDAR signals from several km flight altitude.

P4, l31: How sensitive is the measurement precision of the gases, particularly CO2 (i.e. the 3.7×1018 molec/cm2) to errors of your atmospheric model. Do the assumptions of your model (e.g. horizontally homogeneous layers) cause a bias? Are you actually able to quantify that bias since you do not know the “true” atmospheric composition (e.g. transmittance at a given wavelength etc.).

P5, l9: I do not understand the phrase, seems like the subject is missing

P5, l27: It would be interesting to know how high the fitting error is and how and if it propagates into VCD.

P6, l8: It is clear that the measured VCD vary with observer altitude, but it is not very clear why this is a challenge to obtain the volcanic enhancement. Isn't the VCD looking through the plume larger than when looking outside of the plume (at constant observer altitude)?

P7: Section 5 is largely a discussion rather than pure result section and as such it might be better placed in the discussion section.

P9, l17: How did you estimate the measurement precision? P7, l29 does not really make it clear.

P9, l23: "The O 2 column was used to compensate CO 2 variations due to changes in observer altitude." What means "CO2 variations"? Variation in VCD?

P10, l10: Have you thought about measuring closer to the crater of Mt. Etna? Being $\sim$1 km away the enhancement would be greater. Being off-roads, you would not be constrained to roads. This might allow assessing some of your sources of uncertainty (negative enhancements, minimum integration time etc.).

Technical comments:

P4, l8: direct or directed?

P13, l17, space before comma: FTIR measurements , J.

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