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Atmospheric Measurement Techniques Discussions

Interactive comment on "The AOTF-based NO_2 camera" *by* Emmanuel Dekemper et al.

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Dear Dr Smekens,
Thank you for the positive recommendation and the time taken to perform the in-depth review of our manuscript. Your comments and questions have contributed to improving the quality of our paper. Please find below our answers to your questions and comments.

- p.2,L10: Relative importance of SO2 cameras in volcanic plumes remote sensing.
Point taken, the sentence starting on p.2,L10 will be changed to: "In volcanology for instance, the so-called SO2 cameras are now complementing the measurements performed with classical dispersive techniques (grating spectrometers). Their concept ..."

- p.8: Data averaging, exposure time and SNR.

Section 3.3 on p.8 is devoted to detail how, mathematically-speaking, multiple images taken at the same wavelength can be combined; and how a retrieval can also be attempted based on multiple image pairs. This chapter is really about mathematical formalism only.
The timing of the acquisitions reported in this manuscript are given in the first paragraph of section 4.1. It is stated that the exposure times for all wavelengths was 0.5 second, and a dwell time of 1.3 second must be accounted for between each image. In total, 13 seconds were needed to complete the series of 8 spectral images. Eventually, it turned out that the four shortest wavelengths were delivering too noisy images (because of the weaker natural radiance and the instrument sensitivity droping towards the blue), whereas the four longest ones gave decent measurements. As explained in the second paragraph of section 4.1, the essential reason why we had to average the images is because of the plume dynamics. From successive trials, we found that starting from 10 loops averaged (i.e. 10 times the same 4 wavelengths reduced to 4 images), plume mismatches between successive snapshots had essentially vanished. The sentence on p.10,L13 will be extended: "The dwell time between the closing of the shutter and its re-opening was 1.3 s, yielding a total acquisition sequence duration of 13.1 s for the 8 spectral images."

- p.9,L25: Optical thickness of the plume.
During the measurement campaign, the content of the exhaust plume often changed, sometimes within a few seconds. Actually, most of the time, the smokes were white and opaque, possibly caused by some smoke washing process. In this paper, we are only showing results applicable to optically thin smokes. The results samples illustrating the paper (fig.5) have been taken in this situation. The smokes were slightly brownish while clouds could also be observed passing behind. By comparing the background signal with the plume signal, it appears that the plume optical thickness at the measurement wavelengths was around 0.06-0.08 above the 2nd stack, and 0.04-0.06 above the 3rd stack.
This point will be added in the text with a new sentence at the end of p.10,L4: "In partic-

ular, the smokes were optically thin, with the blue sky clearly visible in the background. This ensures that absorption is the dominant process over scattering for the extinction of light rays crossing the plumes (Beer-Lambert regime). The optical thickness of the smokes was always smaller than 0.1 at our measurement wavelengths."

- p.12: Time series of NO2 fluxes.

Indeed, we could plot the evolution of the NO2 flux at some reference altitude above the stacks. To do so, we have planned to use the moving average technique as you suggest. These kinds of results will be exploited in another paper belonging to the AROMAT campaigns special issue (in AMT as well). In that paper, we hope to go a little bit deeper into the plume chemistry. Our feeling was that the NO2 SCD maps, plus a preview of what can be extracted from them (the NO2 flux profile), is sufficient in a paper whose scope is to present a new instrument. . .

- p.11: Potential capability of correcting SO2 camera data.

We suppose that you are actually referring to the first paragraph on p.13.

You are correct to point out that this first NO2 camera suffers from a poorer temporal resolution compared to that achieved by SO2 cameras. If we hadn't wasted time with taking images at the 4 shorter wavelengths, we would have been capable of providing NO2 SCD maps every 1.5 minutes or so. We are currently working on vastly improving this aspect, and we have good hopes to end up with a system capable of delivering SCD maps every 10 seconds in the same illumination conditions. However, we will probably never reach 1Hz because the throughput of the instrument is smaller than for a SO2 camera.

We will add the following sentence on p.13,L10: "On the temporal resolution side though, the NO2 camera is, at the moment, not capable of following the pace of SO2 cameras (1 Hz typical), such that the correction maps would have to be applied to temporally-averaged SO2 data."

- Limitations of data averaging.

We are not sure we understand the point here. . . As you write it, plume transient fea-

tures make the NO2 field unsteady. This is why we were forced to average our acquisitions over time in order to work on a "mean" plume, rather than on the instantaneous plume which turned out to be impractical with our sequential acquisitions. To come back to the numbers presented in section 4.1: the 12 sequences of 4 wavelengths constitute 48 samples of the scene over 3 minutes. To put it differently, the plumes were observed every 3.75 seconds at each wavelength during 3 minutes. We first combined the samples wavelength-wise. This gave a "mean" scene observed at 4 wavelengths. Two doublets were created from these 4 "mean" images and finally, the NO2 SCD map was retrieved. If the "mean" image wouldn't have been consistent from one wavelength to another, then artefacts like negative SCDs would have appeared in the final result. This is precisely based on the absence of false negative SCDs that we found that at least 10 sequences had to be averaged.

Maybe the point of misunderstanding is that we are not calculating NO2 SCDs based on single pairs of images, but on the "mean" images... By comparison, we suspect that much more doubts can be raised with the SCD maps obtained with scanning DOAS instruments.

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