Author comment to Referee comment #1 “Excellent application of a novel method” on «Characterising vertical turbulent dispersion by observing artificially released SO2 puffs with UV cameras”

We thank Jean-François Smekens for his thorough review and helpful suggestions. Please find our answers in blue underneath each point raised by the reviewers. Resulting manuscript changes are stated below our answers with changed passages marked in red.

This manuscript describes the results of a large scale experiment of to sample the three-dimensional (3D) concentration distribution of an atmospheric tracer (sulfur dioxide – SO_2) in the atmospheric boundary layer at high spatial and temporal resolution, using a network of UV cameras. UV cameras are increasingly used in volcanology research to quantify SO2 emissions from a variety of eruptions. This application however, represents an innovative use for the instrument, and further demonstrates its advantages for atmospheric research in general. The uniqueness of the experiment makes their findings extremely valuable to the community, and the authors detail those findings with very clear phrasing and comprehensive figures. I strongly recommend the publication of this manuscript and have only a few general comments and recommendations that could improve the general discussion.

General comments

Continuous release experiment. The authors mention experiments with continuous release of SO2 (both in the text Px,Lxx and in the abstract P1,L7). Yet no results are shown or even discussed from that set of experiments. Given the added value that such a dataset would represent, especially to members of the volcanology community, I would suggest the authors either include some results (even if they are not entirely conclusive) in their manuscript, or explicitly state why they will not be discussed.

> The data from the continuous releases are not yet fully analysed, partly because the plume meteorological conditions during these experiments were unfavourable or, on 20 July, the plume measurements were carried out early in the morning, when UV light levels were still low. However, in principle, the results that can be obtained from the plume data set are of relevance for both the volcanology community (e.g. validation of SO_2 flux retrieval, radiative transport effects) and the turbulence community (e.g. plume dispersion studies). We have conducted a new campaign this summer under more favourable conditions and will also analyse plume experiments. However, this will take time, and is out of scope of the present paper. We have added an explanation that plume experiments are not studied in the present paper.

> P4 L20: "In this paper, however, only analyses of the puff experiments will be presented."

On the use of tomography. The authors correctly state that to this day, no successful tomography has been reported with UV camera imagery. The presented study, though very compelling and entirely justified, still does not present tomography results. The imagery is used to project trajectories for the center of mass of each puff, and calculate spread and dispersion factors. The full inverse problem yielding a 3-D concentration map of a puff remains unsolved. Perhaps a clarification to this point could be added in the discussion?

> We agree with the referee and we will clarify this point in the manuscript. Although a tomographic setup which in principle allows for a full tomography was used, no full tomography results are actually presented in this study. First tests of a full tomographic reconstruction have shown that during this campaign the camera positions and especially the time synchronisation of the cameras, were not accurate enough for a 3D reconstruction. These issues have been solved in the meantime, so we expect full tomography studies to be possible in the future.

> P3 L30: "However, note that a fully resolved tomographic reconstruction is not necessary for this retrieval and is not presented in this paper."

Specific comments

P3, L15 – Just a small note. Although clear sky conditions will provide a higher UV signal, this signal remains non-uniform. Excellent acquisition conditions can be obtained on cloudy days if the cloud cover is uniform at a sufficiently high ceiling. Problems arise when the cloud cover is either very low or non-uniform (i.e. scattered clouds).

> We agree with the referee. Unfortunately, during our experiments the clouds were always either inhomogeneous or quite low, or both.

> P3 L15: "Non-uniform cloud cover in the image background can cause inhomogeneous illumination of the sky, which complicates the SO_2 column concentration retrieval of SO_2 camera images. "

P9, L27 – What specific techniques were used for noise reduction of the images? This could be added to the Appendix.

> The specific techniques are described in Appendix B2. The images are smoothed with a Gaussian filter, and separately subsampled in order to reduce the noise.
> The Gaussian filter was performed using the function cv.GaussianBlur() from the OpenCV library. The kernel size was 5 and the sigma was 1.

The subsampling is internally performed using Laplacian image pyramids which allow to switch between different compression levels of the image. Explicitly, each compression step consist of a Gaussian Filter (5x5 kernel size) and subsampling by rejecting even rows and columns. Each such step reduces the pixel number by a factor of 4. To reach a resolution of 87x65 pixel, four compression steps were subsequently performed on the images by applying the OpenCV function cv.pyrDown() four times.

> Appendix B2: “The algorithm is based on three copies of the original image (see Fig. A2): (1) the original high-resolution image, (2) an image which was blurred with a 2D Gaussian function (mean: 1, sigma: 5) and (3) a low-resolution image which was sub-sampled to (87x65 pixel) using image pyramids. The images are increasingly noise-reduced and have consequently lower detection limits for SO_2 The average standard deviations for the three image types are (1) 2.4e16 molec cm^{-2}, (2) 1.75e16 molec cm^{-2}, and (3) 5.0e15 molec cm^{-2}”