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Atmospheric Measurement Techniques Discussions

Interactive comment on "Quantitative imaging of volcanic SO_2 plumes with Fabry Pérot Interferometer Correlation Spectroscopy" *by* Christopher Fuchs et al.

Toshiya MORI (Referee)

mori@eqchem.s.u-tokyo.ac.jp

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This manuscript presents a sophisticated imaging technique using an interferometer (FPI) for volcanic SO_2. A developed prototype instrument, IFPICS solves several issues of the conventional SO_2 cameras which use broad interference filters. The technical background of the newly developed instruments is well described and the results of the field observation using the prototype IFPCS seems very promising for the future application in volcano monitoring. I have several comments on the manuscript as shown below.

Specific comments:

"2.2 The IFPICS prototype"

From Figure 2, it seems that the tilt angles of FPI is controlled by a stepping motor. However, there seems to be no description on how the tilt angles for the two settings A and B are controlled in the manuscript. Although the optics of the IFPICS are explained in detail, the mechanical part of the IFPICS is poorly explained. The mechanical part of the IFPICS prototype especially about the changing of the tilt angle should also be described in the manuscript. How long does it take to change the tilt angle? This may partly explain rather low frame rate of 0.2 Hz for the pair of images.

"Table 1 and Equation 6"

Direct use of the parameter values in Table 1 into equation 6 seems inappropriate. Either the values in Table1 or the equation 6 needed to be modified. The sine in eq. 6 is in radiance and the cosine is in degree. They should be matched. d and λ in eq. 6 needed to be in the same unit or conversion factor should be included in eq 6.

"Figure 6"

In Fig.6(b), CD S_{SO2} value between Row 400 and 415 (most part is hidden behind the "crater flank" label) seems to be shifted to positive side unlike those of other Row s (distributed around zero). As stated in the end of the figure caption of Fig. 5, I_A is basically equal to I_B for both background sky and flank. Is there any possibility of SO_2 on the flank or is there any other reason to explain for the positive shift? According to a Global Volcanism Program report in "Global Volcanism Program, 2019. Report on Etna (Italy) (Crafford, A.E., and Venzke, E., eds.). Bulletin of the Global Volcanism Network, 44:10. Smithsonian Institution. https://doi.org/10.5479/si.GVP.BGVN201910-211060." There was a lava flow event between 19-21 July, 2019 (until a day before the observation) on the eastern flank of SEC.

Probably part of the flow may have been in the view of the IFPICS at the time of the observation on 22 July, 2019. Is there any possibility detecting volcanic fume with SO_2 from the lava flow?

Lines 194-200:" The SZA during the time of the measurement is (78±3) (NOAA) with a $VCDO_3$ retrieved calibration function ...with x0 = 1.0×10^{13}, x1 = 1.1×10^{19}, x2 = 9.3×10^{18}, x3 = 7.9×10^{18}, and x4 = 1.6×10^{19} in units of molec cm^{-2} respectively."

Reading here and the figure caption of Fig. 6, x0-x4 parameters is supposed to correspond to SZA=78 degrees. As I plotted Eq. 8 with x0-x4 values, it seems the conversion function correspond to SZA 25 degrees. Please give the parameters for SZA=78 degrees corresponding to the observation. If the conversion function with x0-x4 given in the manuscript are used for calculation of SO_2 CD distributions in Fig. 6, SO_2 CD need to be recalculated using appropriate conversion function.

"Equation 8"

According to equation 1, AA is zero, if SO_2 CD (S) is zero. Considering this, 0th order parameter x0 may not be needed or may be set to zero in the 4th order polynomial fitting.

Line 203:" The atmospheric background is $S_{SO2,bg}$ = 4.3×10^{16} molec cm^{-2}"

Definition of atmospheric background S_{SO2} is not clear. Does this value correspond to the difference of S_{SO2} between plume direction and flat-field image direction or to the absolute atmospheric background value for observation direction?

Lines 230-231: "Furthermore, the small interference to broadband effects extends the range of meteorological conditions acceptable for field measurement."

I agree that one of the major advantages of the IFPICS is extension of acceptable meteorological ranges in the field measurements such as minimal influence of background clouds. I suppose the author need to explain more specific on this. Personally, I feel slightly pity because the authors did not show clear example images corresponding to outcome of "the small interference to broadband effects" in this manuscript, which would definitely convince the readers of the clear advantages of the new IFPICS compared to the conventional SO_2 cameras.

Minor comments:

Line 190: "The circular shape of the retrieved image arises from the FPI's circular clear aperture limiting the imaging FOV." And, line 216:" a high spatial and temporal resolution (400×400 pixel, 1 s integration time)"

The 2D UV-sensitive CMOS sensor (SCM2020-UV) is originally a 2000x2000 pixels

sensor. It seems 4x4 pixel binning is applied to the images. If so, please indicate in the manuscript.

Lines 205-207:" The similar plume free area (white square, 100 × 100 pixel, in Fig. 6, (a)) is further used to give an estimation for the SO_2 detection limit of the IFPICS prototype by calculating the 1-σ pixel-pixel standard deviation. The obtained detection limit is 5.5×10^{17} molec cm^{-2} s$^{-\frac{1}{2}}$ given by the noise equivalent signal."

Please explain how the detection limit was calculated more in detail. 1-sigma pixel-pixel standard deviation does not seem to give the detection limit unit indicated here.

Figure caption of Fig. A1:" acquired with the IFPICS prototype on 22. July 2019, 08:50 - 09:10 CET"

Delete "." after "on 22"

Other comment:

It would be helpful, especially for non-volcanological readers, to show visual image of the plume from the observation site if available.

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