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Atmospheric Measurement Techniques Discussions

Interactive comment on "Theoretical description of functionality, applications, and limitations of SO_2 cameras for the remote sensing of volcanic plumes" *by* C. Kern et al.

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General

This is a very nice and timely paper describing a relatively new technology that the authors believe may become a standard tool for volcanic SO2 gas monitoring. The paper is very thorough and provides the research community with a wealth of information and ideas on how to use these novel cameras. The authors are also careful to describe the limitations and potential problems, including a good analysis of how to calibrate the cameras. They also include some results from a prototype camera they have used and suggest several set-ups and analysis techniques that will be useful for

other researchers to explore.

The only major item that I would like to see in this paper is a summary Table showing the errors arising from the different effects described in the paper (e.g. optics, choice of filters, interference from other absorbers, calibration, radiative transfer). This should be followed by an error analysis from the results obtained with the prototype camera in comparison to the DOAS measurements. This would give readers a succinct way to evaluate the potential usefulness of an SO2 camera for their applications.

I have no major problems with this paper; indeed I think it is very good. In the spirit of constructive criticism I list a few minor points that the authors may like to consider for a revision.

Minor points

1. Abstract, P532, L1. Change "technique" to "device".
2. Abstract, P532, L8. I suppose if the plume were really optically opaque then it would be difficult to determine SO2 accurately. So there must be an optical thickness were the retrieval becomes difficult.
3. Abstract, P532, L10. What is so significant about sampling at 1 Hz? Is this a volcanological requirement or something to do with plume dynamics or perhaps a fundamental sampling limit for these UV CCDs? Would 10 Hz sampling be better?
4. Abstract, P532, L17. Delete "thus" after "The".
5. Abstract, P532, L21. Change "In addition" to "Thirdly".
6. Abstract, P533, L1. Change "chosen setup" to "setup chosen".
7. Abstract, P533, L2. Change "the instrument" to "an instrument".

8. Introduction, P533, L16. Delete comma after “both”.

9. Introduction, P533, L25. Delete “e.g.”.

10. Introduction, P534, L5. Change from “. . . allow to determine the . . . ” to “. . . allow determination of the. . . ”

11. Introduction, P534, L19. So if the time-scale is order of seconds, why do we need 1 Hz sampling?

12. Introduction, P534, L29. Change “discussed methods” to “methods discussed”.

13. P535, L17. I think the correct name for this law is “Beer-Lambert-Bouguer”. Bouguer was first to describe this *law* in a paper published in 1729 “*Essai d’optique sur la gradation de la lumiere*”, which predates both Beer’s and Lambert’s expositions, but somehow it is often quoted as the Beer-Lambert law or often just “Beer’s Law”.

14. P536, L8-L9. I don’t really see any fundamental difference between the spectroscopic measurement principle and that of the SO2 camera, at least in a theoretical sense. The SO_2 camera could, in principle, be an imaging spectrometer.

15. P537, L16. I don’t think the reason for there not being an analytical solution is because these aren’t analytic functions, although this is obviously true. More important, I think, is that any errors in the Is(I) will ensure that there is no unique solution and maybe not even a stable solution.

16. P537, L24. Change “to analyze where” to “analysis of where the”.

17. P538, L28. Delete “radiation”.

18. P545, L28, L29. Need spaces in the words in the braces.

19. P548, L1. Change “not linear” to “non-linear”?

20. P547, L7. Stating that the zenith angle is time dependent is not really the important point. The zenith angle is also location dependent. In the Arctic circle, for example, during summer, the Sun is always above the horizon. Likewise, it is possible to have the same SZA at different times of day depending on where you are making the measurements. I understand the point but I think it could be better explained.

21. P549, L14. Change “exchanges” to “exchange”.

22. P550, L17 onwards. Maybe consideration of the integration time and sample averaging are also important here.

23. P550, L18 onwards. Does this also depend on the SO2 amount? For example might one choose different filter combinations if only interested in low concentrations, for example, from ships or boundary layer industrial pollution sources. Likewise, is it possible that different combinations may be better suited for industrial power plant emissions with highly concentrated SO_2 emissions.

24. P554, L20 onwards. Can the effects of ash be corrected by including more filters? For example, OMI and TOMS (previously) have an absorbing index that is sensitive to ash (apparently).

25. P554, L26. “. . . radiative transfer can effectively be retrieved . . . ”. This does not make sense. Radiative transfer is a process. I assume the authors mean that RT ca be used to retrieve something. Please re-word.

26. P555, L22. Delete “with” after “cells”.

27. P556, L14. Change “co-located” to “collocated” (Latin root).

28. P556, L19. Delete “the” before “perhaps”.

29. P557, L6. Use of the expression “For one, . . . ” suggest some follow-on, e.g. secondly, thirdly . . . I suggest this be re-worded.

30. P558, Limitations of SO_2 cameras. I’m not sure that the inability of the camera to measure other trace gases is a “limitation”. The camera is presumably designed to measure SO_2 and not other trace gases. I suppose it might be possible to add more filters to measure different gases that absorb through the UV.

31. Limitations of SO_2 cameras. I suggest that a Table be included here (or perhaps before) showing the magnitudes of the main error sources. This could be corroborated by listing the differences between the prototype camera measurements and the DOAS data (e.g. calculate the bias and rms error from Figure 14).

32. P560, Future work. I think the cost specified (€0,000) is a factor 2 too low.

33. Figures. I suggest replacing the “commas” with “decimal points” in the ordinates of all relevant Figures (e.g. Figs. 1, 3, 4, 5(a), 6, 8, and 9).

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