Interactive comment on "A Fabry–Perot interferometer based camera for two-dimensional mapping of SO_2 distributions" by J. Kuhn et al.

Response to the comments of Anonymous Referee #1
Received and published: 29 July 2014

We like to thank the reviewer for the valuable comments, which definitely helped to improve our manuscript. In the following we repeat the comments of Anonymous Referee #1 and add our comments in italic face.

The paper by Kuhn et al, outlines a proposed new remote sensing method for SO2 detection in the atmosphere using a Fabry-Perot Interferometer (FPI). Up to the present the most common methods use either correlation spectroscopy or the DOAS technique, derivatives if these (scanning schemes), and SO2 2D cameras using broad-band filters. This paper introduces the idea of using an FPI, not a new technique in itself, but the novel idea of designing a system for the UV and applying this to volcanic monitoring (for example, but it could also be equally applied to a range of atmospheric monitoring applications).
The authors give a brief overview of the basics of FPI theory, how this would be applied to the particular problem of SO2 in the UV, and compares the performance of the theoretical instrument with current broad-band filter SO2 cameras and DOAS systems. Finally the authors describe 3 potential optical configurations for FPI SO2 systems, with their respective advantages/disadvantages. This makes a very good case for this instrument. It appears to have a number of advantages over currently employed technologies used in remote sensing of SO2 from volcanoes. If the instrument performs as well as stated it will be a significant advance for this field of measurement.
The paper is well written, clear and concise. The figures are easy to read. The paper outlines a new and novel method for UV SO2 remote sensing measurements and is therefore recommended for publication in AMT subject to a few minor comments list below, and a small list of minor typographical errors.

1) It is clear that a filter instrument when subtracting or differencing filter A and B, figure 1, obtains the SO2 signal without bias. That is, the filter B signal has no SO2 contribution at all. For the FPI though the SO2 band has a continuum associated with it. How is this potential bias dealt with in the FPI analysis when the differencing is between the maximum and minimum SO2 features, but the minimum SO2 signal is non-zero? Is this achieved through a calibration procedure or could this continuum be accounted for in the forward model?

The FPI method examines the differential SO2 absorption. This means that the SO2 signal is solely derived from differences in the optical density spectrum (in our case the optical density differences between two wavelength ranges, or 'wavelength combs'). The reviewer is correct in pointing out that light passing the FPI in setting B (offline) also contains broad band absorption features. However, these broad band absorption features are also present in light passing through the FPI in setting A (online). They cancel to the greatest part (ideally completely) when taking the ratio of the filter's signal and therefore only reduce the sensitivity of the FPI. We also note that in the case of the conventional SO2 camera the signal of filter B may have a (small) contribution of SO2 absorption which cancels in the same way) We might further add that non-linearities occurring at very high SO2 absorptions are accounted for by calibrating the measured apparent absorption, and are also accounted for in the forward model (it wouldn't work if a high pass filtered absorption cross section is used as

in some DOAS applications). Please see also our answer to comment 2) from the review of R. Campion and our corresponding addition to the manuscript.
We acknowledge that issues raised by the reviewer may potentially lead to misunderstandings and therefore added the following statement to section 2:

"By comparing the transmitted radiances recorded with FPI setting A and B the SO2 column density can be derived by calibration, similarly to the SO2 camera and COSPEC."

2) It would be instructive to add to figure 1, if possible, the contribution of other terms in the spectra, that is, aerosol scattering and ozone. This could be a fourth panel. What about solar Fraunhofer and ring effects, are these significant and have any structure that might coincide with the FPI fringes?

Changes in the Ring effect and depth of Fraunhofer lines are negligible and cancel out if background measurements are taken.
We added panel (d) to Fig. 1, showing the optical densities of ozone and plume aerosol for the amounts used in our simulation.

Minor edits:

3) Page 1, line 19: suggest replacing ": : :become a more and more common : : : " with " : : : become an increasingly more common : : :"

We changed the sentence according to the reviewer's suggestion.

4) Page 2, line 46: densities

We corrected this typo.

5) Page 5, line143: structure

We corrected this typo.

6) Page 5, lines 144-147: This sentence seems to mean the opposite to what is intended. The intention here is to make the point that FPI measurements should take place at wavelengths shorter than lambda max and avoid regions where the SO2 absorptions are weak and therefore subject to interference from scattering effects.

We restructured the sentence to prevent future misunderstandings to:

"For FPI SO2 measurements in the regarded spectral range it is therefore sufficient to prevent measuring at longer wavelengths, where SO2 absorption structure is weak. "

7) Page 5 line 161: add a comma after "above".

We added the comma.

8) Page 5 line 162: suggest replacing "Similar as for the: : :" with "Similarly for the : : :"

We replaced the expression "Similar as for the…" by "Similarly to…".

9) Page 7 lie 208: ppm

ppm times meter=ppmm column averaged mixing ratio (SO2 column density per 1 meter of STP air column)

10) Page 7 line 221 signal

We corrected this typo.

11) Page 8 line 254: an OP FPI

We corrected this typo.

12) Page 8 line 259: shifted

We corrected this typo.

13) Page 9 line 307-308. This sentence is not very clear. Suggest replacing ": : :saturation at wavelength of strong SO2 absorption bands and therefore flattening of the calibration curve occurs earlier." With ": : :saturation at the wavelengths of strong SO2 absorption bands, and therefore flattening of the calibration curve, occurs earlier."

We changed the sentence according to the reviewer's suggestion.

14) Page 11, line 358: suggest replacing "Even for the by a factor of: : :" with "Even for the factor of : : :", and then later in this sentence add a comma after "camera" on line 359.

The sentence was restructured for readability

15) Page 11 line 377: increasing

We corrected this typo.

16) Page 19 fig4 caption line 4: remove comma after "shows"

We corrected this typo.

17) Page 20 fig 5 caption line 5: separates

We corrected this typo.

18) Page 22 fig 7 caption line 6: increasing

We corrected this typo.