Reply to: Anonymous Referee #4
On the manuscript: “Characterisation of the magmatic signature in gas emissions from Turrialba volcano, Costa Rica”

Reply to General comments:

(1) Geometrical factors:
Scans were made at a distance of 2.1 km from the plume, with an inclination angle of 20 degrees above horizontal. The scanning stage was in motion continuously, with spectra being recorded such that each spectrum is the average over 0.1 degrees of scan. This uncertainty is included in the error bars in figure 3.

The plume conditions varied slightly over the period of measurement, however, it was typically 5-8 degrees in width as viewed from the scan site (183-293 m). Each scan therefore contained between 50-80 in-plume measurements – see additional figure (attached in this reply and new Fig. S1c in the revised manuscript) showing a representative scan from 23 March. As shown in the figure the scans covered the entire plume and included clear-sky backgrounds on each side.

ADDED: “Scans were made at a distance of 2.1 km from the plume, with an inclination angle of 20 degrees above horizontal. The scanning stage was in motion continuously, with spectra being recorded such that each spectrum is the average over 0.1 degrees of scan. The plume conditions varied slightly over the period of measurement, however, it was typically 5-8 degrees in width as viewed from the scan site (183-293 m). Each scan therefore contained between 50-80 in-plume measurements. Fig S1c show a representative scan from 23 March. As shown in Fig. S1c, the scans covered the entire plume and included clear-sky backgrounds on each side.”

(2) Aerosol transmission:
The plume transparency, estimated as the ratio of signals at about 360 nm registered inside and outside the plume typically varied between 1.1 and 1.2. This is shown in the attached figure, new Fig. S1d in the revised manuscript.

ADDED: “The plume transparency, estimated as the ratio of signals at about 360 nm registered inside and outside the plume typically varied between 1.1 and 1.2 (Fig S1d).”

(3) Mean and max of SO2 amount within the plume:
These values are averaged from ~20 scans from each day.
22nd March: Mean = 2012, Std. Dev. = 615, Max = 3553
23rd March: Mean = 1885, Std. Dev. = 621, Max = 3687
25th March: Mean = 1200, Std. Dev. = 586, Max = 2548

All values are in ppm.m

ADDED: “The mean and maximum values of SO_2 column amount within the plume where (all values in ppm.m) on 22 March: Mean = 2012, Std. Dev. = 615, Max = 3553; on 23 March: Mean = 1885, Std. Dev. = 621, Max = 3687 and on 25 March: Mean = 1200, Std. Dev. = 586, Max = 2548.”

(4) Fitting window used:
Following comments from reviewer 3, all retrievals have been rerun using a fitting window of 315 – 325 nm. Ten different fitting windows were trialled with lower limits ranging from 303 to 320 and 315 was found to give the smallest residual.

ADDED: "…using a fitting window of 315 – 325 nm"

(5) SO_2 column amount error:
These values are averaged from ~20 scans from each day and consider the backgrounds on each side of the plume:
22nd: Mean = 43, Std. Dev. = 59
23rd: Mean = -65, Std. Dev. = 61
25th: Mean = 38, Std. Dev. = 71

ADDED: "Column amount measurements were associated with an error (based on standard deviation of retrieved column amount outside the plume) of ± 59 on 22 March, ± 61 on 23 March and ± 71 on 25 March."

(6) Scattering Effects:
We were unable to use Kern et al., (2010) like a look-up table as none of the setup in that study looked much like ours and they all cover widely varying conditions. Given the transparency of the plume and the new fitting window used we can safely assume that scattering effects are minimal.

Reply to specific comments:

(1) Provide detailed description of the used gas sensors in MultiGas instrument and their accuracy.

ADDED: "The NDIR CO_2 sensor (model Gascard II) is calibrated for 0–3000 ppmv with an accuracy ±2% and a resolution of 0.8 ppmv. The electrochemical sensor for SO_2 (City Technology, sensor type 3ST/F) has a calibration range of 0–200 ppmv, an accuracy of ±2%, a repeatability of 1% and a resolution of 0.5 ppmv. The electrochemical sensor for H_2 (City Technology, sensor type 3HYT) has a calibration range of 0–500 ppmv, an accuracy of ±5% a repeatability of 2% and a resolution of 2 ppmv. In addition to the gas sensors, temperature and relative humidity sensors (Galltec) are mounted in the instrument, providing a measuring range of 0–100 % Rh and an accuracy of ± 2%. All sensors were housed inside a weatherproof box, with the ambient air sampled via Teflon tubing connected to a HEPA filter fed through an inlet in the box. The sampled gas was dispersed via an outlet similarly fed through a hole in the case. An on-board data-logger card in the "MultiGas" instrument captured measurements at a rate of 0.5 Hz"

(2) Comment the usage of Figure 3. It proves that reported SO2 flux confident intervals reflect the error of measurements but not the natural variability of the volcanic emission during the experimental period. Improve axes captions.

ADDED: "Fig. 3 shows that significant (greater than three standard deviations) variation in SO_2 flux occur at a timescale of hours to days."

Please note that Fig.3 has been changed after rerun of the retrieval routine using a fitting window of 315 – 325 nm, the new Fig. 3 is attached to this reply.

(3) In scatter plots CO2 vs SO2 (Figure 4) use only CO2 concentration of volcanic origin. The intercepts there correspond to atmospheric CO2 content and probably the systematic errors of your measurements but they do not influence the correlation analysis.

Fig. 4 has now been changed accordingly, the new figure is attached in this reply.