Reply to: Referee #3
On the manuscript: "Characterisation of the magmatic signature in gas emissions from Turrialba volcano, Costa Rica"

Reply to specific comments:

(1) Gonzalez et al (2014) is not in the reference list:

ADDED: "González, G., Mora-Amador, R., Ramírez, C., Rouwet, D., Picado, C., Mora, R. In press. Actividad Histórica y Análisis de la Amenaza del Volcán Turrialba, Costa Rica. Revista Geologica de America Central."

(2) DOAS retrievals The DOAS retrieval is not described with enough precision. The least should be to describe the wavelength window for the DOAS fit. This is important since it can have important implications on how the radiative transfer issues may affect the retrievals.

ADDED: "…using a fitting window of 315 – 325 nm" and new Fig S1.

(3) SO2 flux results: … You should try to perform DOAS retrievals at longer wavelength (315-330 nm) or 370-380 nm, as suggested by Bobrowski et al., (2010) for very concentrated plume?

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.

Using this fitting window we obtain a mean flux for all days of 5.2 kgs-1 (std dev of 1.9). The text and tables have all been modified accordingly.

(4) Gas composition discussion: I agree that the most likely cause of the discrepancy between the C/S ratio of the 2010 and 2012 vent is the high retrieval error on the FTIR measurements of the latter. The intercept concentration of CO2 is rather low compared to the 400ppm of a standard atmosphere. What are the results if you force both regression lines to pass through this value?

Forcing the regression through 400 ppm would result in a CO2/SO2 ration of 1.69 (R^2:0.4) for the mix plume and of 2.0 (R^2:0.1) for the 2012 vent but note that at the elevation measurements were taken (2900 m a.s.l) given the lower atmospheric pressure, background CO_2 levels are expected to be around 300 ppm. Our FTIR intercepts concentrations are slightly above this value which is not unexpected given the summit degassing.

(5) Discussion-Current stage of degassing: What are the factors that may cause the reduction of permeability in a high temperature volcano-hydrothermal system? Self-sealing of the fractures by hydrothermal deposits? My intuition is that it should be a slow process. So I would consider the possibility that the apparent decrease of SO2 flux in the 1 week time lapse between the measurements of (Conde et al., 2014) and yours may be an retrievals issue (see my previous comments)

Several processes can contribute to a reduction of permeability in the conduit; the deposition of minerals is indeed the slowest and self-collapse has also been proposed for dome-like configurations, the most likely process however is thermal healing of the fractures. Thermal healing can operate at short time scales and is likely to be effective in the Turrialba case given that the measured surface temperature (>800°C) is already likely higher than the glass transition

temperature of the melt.

After reprocessing all spectra using a fitting window of 315 – 325 nm, our calculated SO2 flux are still lower than that of Conde et al., (2014), do note however that (1) NOVAC typically uses a 310 - 330 nm fitting window and for other reasons highlighted by reviewer #4, comparison is not straightforward. (2) The important point in the discussion is that the measured SO_2 fluxes are low and comparable to the one measured just prior to the 2010 eruption.

(6) Table 1: some species (H2O, CO2 and CO) appear several times (once in the "target species" list and twice in the "other species included"). Is this a typo or does it mean you fit them both in the "volcanic gas" layer and in the "atmospheric" layer? to take into account the change in shape of their absorption spectra with temperature?

That's right.

(7) Figure 2d is too dark to be readable

But it's a night picture showing the incandescence from the 2012 vent so yes the rest of the crater is black.

(8) Please specify in the legend of Figure 4 that these are Multigas measurements (it is not so obvious)

FIXED

(9) Fig 6: How can you report values of C/S ratio prior to the date of first detection of SO2 in fumaroles? Please revise the literature and be consistent.

Prior to the detection of SO_2, sulphur was measured as H_2S and S, there is no inconsistency.

(10) I would include an additional synthetic figure showing the set-up conditions of the DOAS, a scan through the plume and a correlogram used to derive the wind speed.

A new figure (Fig. S1) has been added showing all this information in addition to information demanded by reviewer #4. The new figure is attached to this reply.

Caption:
Figure S1: **A**. Satellite image showing the location of the scanning DOAS instrument relative to the summit of Turrialba volcano. **B**. Picture of Turrialba summit taken from the scanning cite on 25 March 2013 and representative of the clear sky and transparent plume conditions prevailing during the field period. **C**. Typical horizontal scan across the plume, acquired on 23 March, showing the high scan resolution, typical SO_2 column amounts and that the scan covered the entire plume and included clear-sky backgrounds on each side. **D**. Intensity at 360 nm as a function of scan angle showing that the plume transparency (estimated as the ratio of signals at about 360 nm registered inside and outside the plume) typically varies between 0.91 and 0.83 (0 representing an entirely opaque plume and 1 a totally transparent plume). Corresponding SO_2 column amount are also shown, note the speed at which a typical scan is acquired. **E**. Upper panel: SO_2 column amount from the upper and lower telescope of a dual wide field of view (DW-FOV) spectrometer system showing the high correlation between the two units. Lower panel: rise speed determined by cross correlation of data shown in the upper panel.