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Atmospheric Measurement Techniques Discussions

Interactive comment on "Opportunistic validation of sulfur dioxide in the Sarychev Peak volcanic eruption cloud" *by* S. A. Carn and T. M. Lopez

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We thank the referee for a constructive review of the manuscript and some excellent suggestions for improving the analysis. Please find below our response to the referee's specific comments.

General Comments

- The authors' discussion, together with the FLYSPEC data plotted in Figure 3 and 4, indicate that the SO2 distribution was variable in both time and space. The south-bound FLYSPEC survey (Figs. 3b and 4a) suggests that P1 was the best characterized of the OMI pixels because the FLYSPEC results are fairly constant over the time and

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distance required to traverse this pixel (I'm not sure why the average of the FLYSPEC measurements over P1 is greater than any of individual measurements, however).

Response: The FLYSPEC average for pixel P1 (this is the spatial average across the OMI pixel is greater than any of the individual measurements due to the spatial averaging technique we used. The FLYSPEC traverse only covered the northern half of this pixel (Fig. 3), but when the FLYSPEC data are extrapolated, some higher SO2 concentrations appear in the southern half of the pixel (Fig. 3d). Hence the spatial average of the extrapolated data is larger than the average of the raw FLYSPEC measurements. We have added a note in the text in the revised manuscript to clarify this.

- The north- bound survey results (Figs. 3c and 4b) indicate that P1 and P2 were well-characterized by FLYSPEC, but this apparent uniformity may be the result of saturation of the instrument more that uniformity in the SO2 cloud. Assuming that the north-bound measurements were not saturated, we have good characterizations of the cloud at the spatial scale of P1 acquired approximately :50 before and 1:30 after the OMI overpass. The temporal change between the south- and north-bound results appears to be uniform over the survey stations (Fig. 3b vs. 3c). We can calculate the gradient of SO2 abundance vs. time and predict the abundance at the time of the overpass. Given the time symmetry of the P1 surveys, relative to the overpass time, the average of the south- and north-bound results is a good prediction of the OMI result (8.2 and 3.5 DU, respectively, giving a relative difference of 134%).

Response: We can confirm that the FLYSPEC measurements were not saturated at any point during data acquisition. Although the SO2 column amounts appear to be quite homogeneous in pixel P1, the FLYSPEC survey only covered the northern half of this pixel (see also our response to the previous comment above). Consideration of the spatial distribution of SO2 in P1 suggests that there was a significant ∼N-S gradient in SO2, and so we do not believe that the pixel was well characterized by FLYSPEC. Furthermore, as we point out in the paper, P1 also suffers from a large cloud fraction, which may have impacted the OMI and FLYSPEC measurements. On the other hand,

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the reviewers suggestion to calculate the gradient of SO2 abundance vs. time is an excellent one and we have now done this for each pixel (Table 1). Consideration of this gradient improves the comparison between the OMI and FLYSPEC data for pixel P5.

- The average abundance over the south-bound survey of P2 was closest to the corresponding OMI result, but the steep slope of the FLYSPEC plot in Fig. 4a tells us that cloud was poorly-characterized at the scale of P2. We should, therefore, view the FLYSPEC/OMI comparison with caution. As noted above, P1 is the best characterized by the FLYSPEC data provided that the instrument did not saturate on the north-bound survey. Please verify that the FLYSPEC measurements were NOT saturated!

Response: As stated above, the FLYSPEC measurements were not saturated at any point during data acquisition. We still believe that P2 was best characterized by the FLYSPEC data as the measurement geometry provided constraints on the SO2 distribution both along- and across-rack with respect to the OMI pixels (i.e., along both their long and short axes).

- I think that this paper will have great value as a discussion of the difficulties of comparing ground- and satellite-based retrievals of SO2 abundance. I also think that further analysis can be done to the FLYSPEC data to better characterize spatial and temporal changes. For example, Figure 4 shows the combined changes in FLYSPEC with location (relative to pixel boundary) and time. A 2-D plot with location and time on different axes would be interesting as we could determine if the change was dominated by the spatial or temporal gradient. Another approach might be to plot histograms of the FLYSPEC results within pixel boundary to determine how well that pixel is described by the mean of the histogram (i.e. compare the mean to the mode). This analysis could exonerate the south-bound results for P2!

Response: We thank the reviewer for providing some excellent suggestions for further analysis of the data. As mentioned above we now include calculations of the gradient of SO2 abundance with time to assess the relative magnitude of the spatial and temporal

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gradients in SO2 column. We have also added a figure showing distance traveled against time (new Figure 4) to demonstrate that the speed of the FLYSPEC SO2 survey was almost constant throughout. We have also produced histograms of FLYSPEC SOÂň2 column for each pixel (new Figure 6) as suggested. We believe that this further analysis provides additional support for P2 and P5 as the best-characterized pixels in the spatial and temporal domains, respectively.

Technical Issues

- Figure 1 This figure is difficult to interpret. At the very least you should add arrows pointing out the various data sets. With the current perspective (point of view), it is not readily apparent that the CALIPSO data are show in profile – and it is difficult to distinguish the CALIPSO data from the OMI data. Given that Figure 2 is a nice display of the CALIOP results, and the MODIS data do not play a large role in your analysis, Figure 1 could be deleted.

Response: We have labeled the datasets shown on this figure to improve interpretation. In response to a suggestion by referee #1, we will also provide the original Google Earth KMZ files as supplementary material so that interested readers can visualize and explore the datasets themselves.

- Figure 3 The pixel boundaries in Figure 3d are very hard to see. This figure (3d) does not add much to the discussion, so you might delete it if this means that Figs 3a-c could be made larger.

Response: We have improved the visibility of the pixel boundaries in the revised Figure 3d. We believe this part of the figure is important since it shows the extrapolated FLYSPEC data used to calculate the spatial averages for each OMI pixel.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 3861, 2011.