

Interactive comment on “A laser-induced fluorescence instrument for aircraft measurements of sulfur dioxide in the upper troposphere and lower stratosphere” by Andrew W. Rollins et al.

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We would like to thank the Referee for reviewing our paper, and for a number of suggestions that we believe have led to improvements in the manuscript. In the following, we quote the Referee's individual points in bold, followed by our responses in plain text.

The description of the measurement procedure to distinguish between fluorescence and background measurements is somewhat late in the paper. I would suggest to mention this earlier and to refer to the procedure more often (for example: p4 l13-16: mention how much the laser is tuned for offline measurements;

C1

p9 l32/33: mention how the zero is derived).

We have added text in a number of locations to address this suggestion 1) A sentence is added as suggested at P4 L16 2) We added a comment about zero air (P10 L16) 3) P13 L19 now specifies that zeros are measured with zero air during test flights.

p8 l9: I would suggest to state the correction factor for the maximum SO₂ mixing ratio that was measured to give an expression of the impact of the correction factor. Does this correction add uncertainty in the measurement?

As was stated in the text, the count correction is theoretically exact, and from the calibrations we have no evidence otherwise (e.g. Fig. 6 (previously Fig. 7)). Another way of seeing this issue is that Equation (1) is an exact form of the instrument response function and instead of linearizing the signal and fitting to a line, one could directly fit the calibration data to Equation (1). Therefore, only additional uncertainty due to precision must be considered and at high count rates, the uncertainty due to precision starts to increase. We have added text to this section to expand on this issue. We state explicitly that no additional uncertainty is incurred by using this correction to the count rate (P8 L5, P8 l16). We also added text to discuss at what count rates the precision would be degraded and that we only use data much below this limit (P8, l18-23). At 3.1 ppb, the adjustment to the count rate is 33

p10 l27/28: The authors mention that they assume no water vapor dependence, because this was not observed in an other instrument. Why was this not tested in laboratory experiments? This would be an essential and feasible test of the instrument performance. Is there no quenching by water vapor expected from the quenching constant of water?

Due to the comments of both reviewers we now report the results of a precise test of the sensitivity of the fluorescence quantum yield due to quenching by water vapor. We can detect no significant reduction in signal at increased water vapor mixing ratios. Text has been added on p11 L13-15 to reflect this.

C2

I would suggest to move the paragraph p11 I23-33 after p11 I10, because this is exactly what the reader wants to know after having read the first paragraph on that page.

We agree and have moved this paragraph as suggested (now P11 L18-17).

p12 I23: Was the change in sensitivity observed in a random way between two consecutive calibration measurement, or was there a trend during the flight? If this was random, how do the authors know that the sensitivity did not change randomly on a shorter time scale between two calibration measurements, so that a linear interpolation may not be justified? How does this variation for flight measurements compare to variations in laboratory measurements?

The change in the measured sensitivity was observed in both laboratory and flight conditions and typically resulted in slow, monotonic drift and therefore linear interpolation is justified. It is now believed that this was due to an alignment issue with the photodiodes that monitor the laser power. Text has been added (P13 L9-16) to describe this in more detail.

Figure 10: What do the error bars include? If they only give the precision of measurements, why are they larger than the variability seen in the measurements?

We believe that the reviewer confused the 5 Hz data points for error bars. Therefore, we have changed the 5 Hz datapoints from lines to markers to clarify this figure.

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