

We thank both the reviewers for their helpful comments and suggestions. In the following detailed response to all reviewer comments, the Reviewer Comment is first copied using regular text in black, followed by our response using italic font in blue. A copy of the text that we have changed in the manuscript is also added (green italic font) to facilitate a simultaneous consideration of the reviewer's comments and our replies to those comments where appropriate.

## **Reviewer #1.**

### **General comments**

The authors successfully describe the rationale behind the development of their new mobile tracker. The construction and algorithm is well documented, as is the overall performance. Indeed the performance seems to be very good, and the authors should be congratulated on their success in integrating the various modern modules that comprise the bulk of the hardware.

The use of centre to limb darkening (CLD) as a method of evaluating tracker precision was demonstrated but I would have appreciated seeing a single clear plot of pointing error (in degrees) as determined from CLD vs. the error (in degrees) detected directly using the fit from camera pixels.

*We have updated Figure 5 to include CLD results in the plots. The CLD results confirm the data from the camera. The shape of the CLD results in Figure 5 reflect the fact that only at the edges of the solar disk CLD signals are significant; CLD is not a sensitive indicator across the solar disk, as we had shown in the original Fig. S4.*

The final section (3.3: Comparison with MAX-DOAS), provides some further validation of overall system performance but is probably not needed.

*Section 3.3: Comparison with MAX-DOAS serves multiple purposes in the paper. In addition to providing validation of the overall system performance, it also shows the capability of the system i.e. (i) high time resolution and (ii) low noise of the data. Hence we prefer to keep the section 3.3 Comparison with MAX-DOAS.*

### **Specific comments**

(1) In section 2.1, when discussing the motion compensation system, it was initially unclear whether the two motors referred to in line 104 are in fact the same two stepper motors referred to earlier when discussing the tracker. Perhaps replace “the two motors” with “the two stepper motors of the tracker” or similar.

*We have changed “the two motors” to “the two stepper motors of the tracker” as suggested.*

(2) In section 2.2 there is no need to define optical resolution or explain how it is determined using the Krypton emission line. Consider deleting “(full width. . .FWHM)” in line 221 and part of 212 - 213.

*We have removed the details as suggested.*

(3) In section 3.1 “Evaluation”, I can understand why pointing precision becomes worse at increased vehicular speed, and with higher SZA, but I would be keen to see the author comment on the slight loss of precision seen at 10km/h and at 20 - 30 deg. SZA (figure 6).

*The apparent slight loss of precision seen at 10 km/hr and at 20-30 deg SZA is not statistically different from the mean. Also this behavior is not observed during other drives. This has been added in the revised manuscript.*

(4) A larger size picture of the complete system is well justified. Consider replacing figure 2A with something showing more detail.

*We have added a new figure that shows the top and side view inside the mobile laboratory.*

(5) The caption for figure 4 has a description with an order of 0, 25 and 50 pixel offsets, yet the figure has an order of (top to bottom) 50, 25 and 0. I suggest the figure order is reversed for clarity.

*The figure has been updated. The new figure has 0 pixel offset at the top and 50 pixels at the bottom.*

### **Technical corrections**

For reasons of clarity I also make the following suggestions:

The use of “a.u.” in S5 and S6 should be changed to “arb. Unit” to avoid any (somewhat unlikely I admit) confusion with astronomical unit.

*We have changed the figure axis labels accordingly.*

Line 105: I don’t think it is necessary to explain the acronym “GPS” as it is now in general uses. Conversely there is no need to introduce the acronym “INS” in the same sentence as it doesn’t appear again.

*Changes have been made as suggested by the reviewer.*

Eliminate unnecessary use of detailed make and model numbers (e.g. lines 114, 201, 202 and elsewhere). I also recommend removing reference to PC speed (line 115). Such details can be added to an appendix if needed.

*We have consolidated the details in the sentence.*

Line 129: Consider adding a hyphen “Camera-based”.

*We have changed it to “Camera-based” as suggested.*

Line 165: Change “. . .lead indeed to measurable improvements of the tracking...” to: “. . .lead to measurable improvements in the tracking precision. . .”.

*The sentence has been formatted as suggested.*

Line 271: This URL could go in an appendix.

*We have left the URL in its current place as there is currently no appendix section and we prefer to not add an appendix section for just the URL.*

Line 310: Grammar: change “has” to “have”.

*The suggested grammatical change has been made.*

## Reviewer #2.

### General comments

This manuscript describes the development of an impressive mobile solar tracker that should enable the authors to successfully characterize outflow from urban regions and discrete sources. The increase in signal strength via direct solar observations is well worth the effort expended to develop this system. I am impressed by the improvement achieved by their method of accounting for the platform motion during the control loop interval.

I agree with all of the corrections suggested by reviewer number one, and I propose a few additional changes.

Section 3.1: I believe the authors need to further address the percentage of time that the signal is completely lost from the camera-based feedback system. How quickly can the system reacquire a signal after loss? How do you filter the data to account for this loss of signal? If a measurement takes 2 seconds (11409 L 26) and you are losing signal every 3 to 4 seconds (11413 L 6) then I believe that this needs to be addressed more fully in the text.

*This text has been added to the manuscript:*

*“The solar disk was in the FOV of the camera 88% of the time that the mobile laboratory was in motion. Of the ~12% that the system needs to reacquire the solar disk, the sun is back in the FOV within 0.5 seconds for 90% of the instances that it was lost. Our system is largely unaffected by these short losses because of the fast scan acquisition time (8 ms), which enables filtering of good data with 8ms time resolution. A 2 second spectrum accumulates many 8 ms scans, and scans that do not meet a minimum threshold signal criteria are automatically eliminated. Thus the 2 sec spectra contain useful data that can be evaluated for NO<sub>2</sub> VCDs with a duty cycle of ~91% of the drive time under clear sky conditions.”*

Figure 7C: There are missing MAX-DOAS points during what appears to be a fairly significant change in signal as measured by the direct sun measurements. Why is this? I believe this warrants a comment in either the figure caption or text.

*MAX-DOAS instrument takes a zenith spectrum to be used as reference spectrum in DOAS analysis for 60 seconds at periodic intervals. The time period between 3:48 and 3:49 PM just happened to be one such zenith spectrum and hence the reason for the missing MAX-DOAS data points. The MAX-DOAS data at 3:51 PM did not pass the quality control based on the RMS of the DOAS retrieval. We have added those points in the Figure 7C as open circles for comparison. We have added the following text to the figure caption.*

*“Note that the MAX-DOAS instrument was acquiring a zenith reference spectrum at 3:49 PM for 60 seconds. The open red circles in Figure 7C represent MAX-DOAS data point which did not pass the RMS based quality control but included for comparison purposes.”*

### Technical Comments:

Mostly minor grammar suggestions.

Page 11403 L16: change EA to EAs.

*We have changed it to EAs.*

Page 11405 L5: rewrite "2 in f/4" to avoid confusion.

*We had included it as "2 inch f/4" in the manuscript. All inch and inches were converted to in during typesetting. We will make sure it remains "2 inch f/4" in the final AMT typesetting.*

Page 11406 L23: change "in the FOV" to "into the FOV"

*Changes made as suggested.*

Section 2.1.1: you state that the choice of using a circle of ellipse fitting routine is based on the location of the solar disc – but it is unclear how you originally determine the location of the solar disc without first performing a fitting routine.

*The program performs an ellipse fitting the very first time. The following sentences have been added to the manuscript.*

*"Next, an ellipse fitting algorithm is applied to the binary image contours. For subsequent images, depending on the distance of the solar disk to the aperture, either a circle or an ellipse fitting algorithm is applied".*

Page 11413 L21: "requiring" to "require"

*Changed to "require" as suggested.*

Page 11415 L19: "direction" to "directions"

*We have changed it to "directions".*

Figure 4: Please carefully confirm order of panels in the figure / caption.

*We have updated the figure order to match the figure caption.*

Figure S1: Little is gained by extending this figure out to 200 pixels.

*The x-axis of the figure is limited to 120 pixels in the updated figure.*

Figure S3: Consider adding the 1 sigma deviation from the text directly to this figure.

*We have added 1 sigma deviation to the figure.*