Second review of An et al.

July 7, 2020

The authors did a fair job responsing to my individual comments in the author response; however, I did not find most of those clarifications incorporated into the paper. I would like to see the clarifications made in the author response incorportated in some form into the paper. This is true even for my previous comments where I gave my interpretation of what was being said in the paper and my interpretation was correct; the fact that I had to ask whether my understanding was correct meant that I found it unclear.

I will list here my previous comments that were not addressed in the paper and indicate whether the comment in the author response was sufficient.

I also strongly recommend that the authors deposit supporting code and data in a public, persistent repository as recommended in the AMT data policy.

If the authors can revise the manuscript to address these remaining points of confusing and meet AMTs standards for reproducibility, then publication is warranted. However, at this time, major revisions are still required.

- Concerning Sect. 2.2, I previously said: "...it seems the authors are exploring different observing strategies and rejecting ones that will not accomplish their goals. It is not clear that this is what they are doing, and it is not clear how they determined whether a particular strategy met their requirements, or even what those requirements are...." This was not addressed in the revision; for example, it is still unclear to me whether the two T2 points are merely hypothetical and one will be chosen for the operational algorithm, or whether both will be used in the operational algorithm. To reiterate my previous suggestion; I strongly recommend the authors revise the section to answer three questions clearly. One, what criteria must an observing strategy meet to be considered successful? Two, how were different strategies evaluated to determine if they met those criteria? Three, which strategies were considered? Fourth, which strategy was selected? The distinction between which strategies are merely being considered and which one was selected must be **extremely** clear. Please reevaluate the structure of this section very carefully; the lack clarity is due to how this section is organized, not only grammatical errors.

- "The description of the two sensors as scanning along and across the satellite's orbit implies, to me at least, that the main axes of the telescopes are pointing parallel to the satellite's direction of flight, but Fig. 3 looks like the sensors are pointing to the right of the direction of flight." I saw no edit to the paper that made this clearer.

- "How long will the spectrometers record at T1 and T2? Is it very briefly, or is the spectrometer recording as it sweeps across the target zone?" I saw no edit to the paper to make this clearer.

- "Perhaps more generally, what is happening between T1 and T2? Is the satellite reorienting to get the appropriate pointing vector for the measurement at T2? Are the spectrometers on during this time?" I saw no edit to the paper making this clearer. I should also expand by question: the authors indicate that the spectrometers are on between T1 and T2. Is that data recorded used for anything—is it for example recording the T1 spectra for a bunch of other target areas?

- Two comments together: "Do I understand right that the point of Fig. 3b is that one cannot use data collected at only one time to retrieve the target area? If so, why not? That is not explained." Also: "It's not obvious to me why the strategy shown in Fig. 3c of using SHS1 at T1 and SHS2 at T2 is better than using both SHS1 and SHS2 at both T1 and T2. Surely having SHS1-T1 + SHS2-T1 + SHS1-T2 + SHS2-T2 would provide a better constraint on the OH fields?"

  - I did not see an edit to the paper that made these clearer.
  - I'm still not clear on why two times and two spectrometers are necessary. Based on other parts of the response, I'm assuming that the two spectrometers are both pointing along the satellite's direction of flight but measuring in orthogonal planes. That is, if we define the direction of flight as the x-axis, the vector 90° to that but still parallel to the Earth's surface as the y-axis, and the vector pointing away from the Earth as the z-axis, then one spectrometer measures in the xy-plane and the other in the xz-plane.
  - In the response, the authors say that, for measurements at one time, there is no intersection between the spectrometers' fields of view. Why not? If they are orthogonal, their planes of view will intersect. I finally found the field of view (2°) listed in the introduction, instead of the instrument design section. That is important information, which I would expect to be included in the same section as the instrument design (Sect 2.2). How far away from the satellite is the target area? Is it close enough that a 2° FoV is too small for any overlap? If so, why is the FoV so small? Or why could the telescopes not be angled to allow for overlap between the spectrometers' FoV in the target area during a single time of measurement?
  - I don't follow the argument made in the reply that having data from both spectrometers at both T1 and T2 would reduce the signal to noise ratio. Why would considering 4 observations with random noise lead to more noise than only 2 observations? Why wouldn't the noise reduce with $\sqrt{n}$?
  - I'm also not convinced by the assertion in the same reply that combining all four observations (both spectrometers at both times) would provide only redundant data. I understand in principle that *if* the data were redundant it would slow down the lookup since it requires interpolating more coordinates. However, if the data

is truly redundant, then that implies that SHS1 at T1 and SHS2 at T2 provides the same data as SHS1 and SHS2 at T1, which the authors claim is insufficient for the tomographic retrieval. Please provide experimental or theoretical evidence in the paper that SHS1 and SHS2 at T1 only provides insufficient data for the inversion, but that SHS1 and SHS2 at both T1 and T2 provides redudant data. Simply asserting this to be the case is not sufficient.

- For section 4.2, thank for for answering my questions. However I need to follow up on several:

  - Since the authors indicated that all wavelengths from both SHS1 and SHS2 are inputs to the look up table, I'm curious how this lookup is handled. Later in the paper, the look up is referred to as a 6-dimensional spline interpolation. But, from Table 5, the 6 dimensions would seem to be latitude, longitude, altitude, SZA, azimuth angle, and season. How are the OH concentrations that correspond to given radiances looked up?

    I'm confused because the only way I can see is if the coordinates for the table included the radiance intensity at each wavelength measured. If even 10 wavelengths are measured, then the table would have 20 spectral dimensions (10 per spectrometer) plus the 6 dimensions mentioned above. If there's just five points in each dimension (which seems quite sparse) and each table OH concentration is stored in 4 bytes, then this means the table would be $5^{26} \times 4$ bytes which is impossibly large. Please elaborate on how exactly the radiance values from SHS1 and SHS2 are included as dimensions in the table, or more generally in the look up process (and please include this in the paper).

- In Sect. 5.2.1, regarding the 30% uncertainty in ozone, please include the details or reference that supports the 30% uncertainty that were mentioned in the response to the paper itself. Additional details or citations that support the assertion that ozone is the only relevant source of uncertainty (and thus the only parameter of the atmospheric model that needs be discussed) should be included.

- In Sect. 5.2.3, thank you for adding the brief description "We give a certain disturbance to different parameters to calculate the effect of the interpolation algorithm on the OH concentrations". Two comments:

  1. A bit more detail would help, i.e. how much you perturbed the different parameters (and why that magnitude perturbation was chosen), how many parameters were perturbed at once, etc. I assume "parameters" here are the coordinates of the look up table, so you tested how much the spline fit changed if e.g. all the SZA were increased by 1°?
  2. A separate concern to how dependent the spline interpolation is on the coordinates is how well the spline reproduces known points. So a better experiment might be to remove a set of points from the data the spline is fit to (e.g. remove all points of a specific SZA value), fit the spline to the limited dataset, and test how close it

comes to those known points (similar in concept to withholding test data during machine learning training).

- Sect 3: Regarding the HITRAN database, I am still uncertain what is meant. Do you mean (a) you *completely* removed HITRAN 2012 and use HITRAN 2014 for *all* spectroscopy or (b) you retain HITRAN 2012 but added OH UV absorption lines *only* from HITRAN 2014?

- Sect 5.2.4: Please add a proper citation for the MLS data description document when it is mentioned.