

First review of “Simultaneous retrievals of biomass-burning aerosols and trace gases from the ultraviolet to near-infrared over northern Thailand during the 2019 pre-monsoon season” by Jeong et al.

April 11, 2022

### Reviewer Recommendation:

Requires major revisions before publication

### Summary:

The submitted manuscript discusses measurements from the SMART-s instrument. The SMART-s instrument is a ground-based spectrometer mated to a scanning head with imbedded filter wheels used to measure direct sun and diffuse sky radiances. The instrument is described in fairly sparse detail, but the calibration procedure and data preparation are described in much more detail. From the spectra measured, retrievals of aerosol optical properties are performed. Those retrieved values are compared to ancillary instrumentation including an AERONET instrument. In general, the data presented seem reasonable and show good correlation with previously described instrumentation. This is perhaps not surprising as the instruments chosen for comparison are all passive remote sensing instruments with spectrally resolved data streams.

In general, the results seem reasonable and the methodology sound, but the presentation of those results is quite confusing in my opinion. The citations are simultaneously very clear and maddeningly unhelpful. The major issues of the manuscript, in my opinion, relate to the way the data are organized, presented, and described. In general, the clarity of data presentation is, in my opinion, poor and is an area of substantial concern. My comments below outline the issues I see in more detail.

I would suggest that the information contained within the article is novel and publishable, if not somewhat incremental, but that major revisions are required to the manuscript to make the data presentation clear and precise.

### Major Comments:

1. The scope of this paper seems to be somewhat confusing in my opinion. Specifically, I have 2 major comments:
  - a. It seems that the novel element of this manuscript is combined aerosol and gas retrievals and the hardware that facilitates that. However, the text focuses at times on other elements that seem to be reported elsewhere.
    - i. Trace gases are frequently mentioned, but never really addressed in any great detail. It seems, based on lines 228-230 that this is intended to be a second manuscript or companion paper. To me, it seems that a large part of the novelty of this work is the combined retrieval of aerosol properties and trace gases, leaving a feeling that the presentation of information is incomplete. Simply stated, I don't believe that the trace gas retrievals can be omitted and be called self-contained.

- ii. Lines 199-217: The scanning head, which is stated as being reused from the Pandora network, is described in more detail than the spectrometer, which is novel.
  - iii. Section 2.3: The radiometric calibration procedure of the hardware is exceptionally well described. That said, it appears to me to not be novel. If that is true, the section could be substantially shortened or moved to an Appendix to focus on the truly novel.
  - iv. Lines 414 and the following paragraph: This seems to serve partially as motivation and partially as a data comparison. In my opinion, the motivation should be split out and described before the measurements.
- b. The organization seems somewhat illogical and there is spurious information given that detracts from the overall data flow.
  - i. Lines 163-167: Several comments here:
    - 1. Is lidar data ever used or important?
    - 2. Why describe the DRAGON approach if it is not possible?
    - 3. Are the multiple chemistry samplers named/used?
    - 4. What satellites are you planning to use?
  - ii. Lines 168-186: This paragraph seems out of place and unnecessary. Why describe the measurement of dust in the “Experimental Design” section?
  - iii. Lines 382-397, Line 412: background on AERONET seems out of place in the Results section
  - iv. Lines 414-436: Literature review on n and k within Results section seem out of place. This is the first time it becomes clear how measurements of these parameters can inform the source of aerosol.
  - v. I would suggest a more logical outline for this paper to be:
    - 1. Introduction
    - 2. Measurements
      - a. Experimental Design
      - b. Instrument Calibration
      - c. Ancillary Instrumentation
        - i. AERONET
        - ii. ...
    - 3. Results
      - a. Relationships between aerosols and trace gases
      - b. Comparisons with AERONET
      - c. Satellite Algorithms
    - 4. Summary
    - 5. Appendix
      - a. Inversion Algorithm
      - b. Calibration
      - c. SMART-s vs AERONET
- 2. Lines 190-192: That your measurements are unaffected by local emissions seems critical, otherwise you have an uncontrolled bias source of unknown

- spatial/temporal magnitude causing unknown biases. This sentence therefore needs to be rock solid. I see very little evidence to substantiate this claim that local emissions are negligible, i.e. this sentence doesn't suffice to make that point. Furthermore, it seems to use circular logic that we are seeing mostly biomass burning aerosol, therefore local emissions are negligible, therefore we are ignoring local emissions, therefore we are only seeing biomass burning aerosols.
3. Line 322-323: I would assume, based on my own past experience not related to the SMART-s sensor, that the SMART-s measurements would be fairly sensitive to intensity of light incident on the sensor, with more light facilitating more precise measurements (up until sensor non-linearity and other non-idealities occur). The information presented in the calibration section seem to support this. I can't help but wonder, therefore, what the difference between thin cirrus and more optically thick plumes would be. Line 633 suggests aerosol optical thicknesses frequently exceeds 2.0. I don't see too much discussion or analysis given to plume optical thickness causing any retrieval issues of any kind. I believe this should be addressed in detail.
  4. There are significant English language errors, mostly in the Introduction and Experimental Design section that need to be addressed. I have noted several persistent comments in the "Typos" section below, but this should not be considered an exhaustive list. More accurately, this list is a somewhat halfhearted attempt on my part to highlight this comment but is definitely not all the errors. Given the pervasive nature of the mistakes, it makes the paper difficult to read.
  5. The referencing in this paper is often good, especially when comparing data from this manuscript to former studies. However, I see 3 major issues that need to be addressed:
    - a. I count at least 21 instances where the phrase "*and references therein*" is used in lieu of specific referencing. There are two major issues with this in my opinion. First it lacks precision and does not help the reader understand where they should direct their attention to verify or further explore the information presented. Second, this style tends to fail to give credit to those authors whose original findings are cited.
    - b. There are a number of websites included for important information: Line 203: AvaSpec spectrometer, Line 204: Pandonia Global Network, Line 257: Pandonia calibrations, Line 264 for Grande calibration reports, Line 395 for SMARTLabs sensor, Lines 756-757 for data. In general, in my opinion, this is inadequate as websites are very easy to change/remove or simply not update. I believe you need permanent citations, academic literature, or DOIs for this information?
    - c. SMART-s data link (Line 756) redirects to <https://earth.gsfc.nasa.gov/climate/instruments/smartlabs/> , which gives an overview over SMARTLabs instruments. I could not find data.

As a reviewer, I can not ignore any of these points as they cause a general lack of precision with referencing. To put a very fine point on this comment: the referencing is often inadequate and must be improved.

Minor Comments:

1. In general there are a number of places where redundant information can be omitted for brevity:
  - a. Lines 127-128: “and section 2.2 below” is probably not needed as this is the introduction. I would omit this line.
  - b. Lines 751-753: This sentence should be removed. It is given verbatim in the Code/Data Availability Section below and is not an Acknowledgement.
  - c. Figure 1: The latitude, longitude, and altitude of the site are given in the text main body. I would remove it from the figure caption to avoid redundancy.
  - d. I would remove color / lineshape information from the text, as that is included within the Figure and captions:
    - i. Line 343
    - ii. Line 347
    - iii. Line 368
    - iv. Line 405
    - v. Line 407-408
    - vi. Line 471f
    - vii. Line 528
    - viii. Line 532f
    - ix. Line 547
    - x. Line 585f
    - xi. Line 589f
    - xii. Line 602
    - xiii. Line 604
  - e. Redundant information that contains typos and does not agree in the text and Figures:
    - i. Figure 11: caption states AE calculations use e.g. 440 and 555 nm for blue, but in panel (d) it says 440 – 555 nm which suggest the entire range
    - ii. Line 602: values differ from values in Figure
    - iii. Line 604: values differ from values in Figure
    - iv. Line 610: value does not reflect value in Figure
2. In general, I believe you are well served to always include units after giving numeric values, even if the units are [unitless], it is best to note. I note this in at least the following locations (but please consider this a general pervasive comment that needs to be addressed everywhere):
  - a. Line 122: “up to 0.07 at ...”
  - b. Line 212: “dynamic range of  $10^7$ ” (is this photon counts, radiance units, or other?)
  - c. Line 225: “FWHM  $\sim 1.0$ ”
  - d. Line 401: “RMSE less than 0.02”
3. Line 18: Have you omitted the word “resolution” in the phrase “measuring high-spectral \_\_\_\_\_ ultraviolet”.
4. Line 27: “high spectral resolution” is relative. Please simply provide the resolution here for context.

5. Line 82: What is meant by location vs emission source? Location seems irrelevant in comparison to the source (i.e. biome) type. Additionally, I can believe that  $w_0$  evolves as the plume ages, but don't the others here simply cause  $w_0$  to be different since emission?
6. Line 93: "acceptable agreement" lacks clarity and precision. Suggest modifying this to be quantitative.
7. Line 131-132: "which are yet lack of sufficient reliable measurements" makes no sense. Perhaps change to "for which reliable measurements remain sparse".
8. Line 154: In my opinion, this sentence is more of an "Experimental Setup" than "Experimental Design". Suggest changing the title.
6. Lines 155-157: This sentence seems to be an attempt to be general but needs serious revision, or deletion. In general, I believe it is saying that the best match to spaceborne spectrometer data is ground based spectrometer data. This is fairly obvious. However, that spaceborne or ground based spectrometer data are the best representation of the state of the atmosphere is highly dependent on the properties of the atmosphere. My suggestion is to simply delete this sentence. At the very least, the words temporal, spectral, angular, and spatial describe observed dimensions with passive remote sensing equipment and not "fundamental elements".
9. Lines 157-159: This sentence is almost unintelligible.
  - a. What are collocated satellites?
  - b. "in-situ representation of measurements" seems backwards. In-situ measurements should be improved to better represent the state of the atmosphere.
  - c. Are you just trying to say you are more broadly deploying sensors in the DRAGON network?
10. Line 160: suggest changing "northern Thailand of Chiang" to "northern Thailand, specifically the Chiang".
11. Line 196f: Are measurements and data analysis restricted to the daytime?
12. Lines 213-215: Is this a mistake that inserting the diffuser alters the instrument field of view? Does the diffuser have optical power (i.e. does it have a focal length smaller than infinity)? I am assuming the field stop is the optical fiber that transfers light from the scanning head to the spectrometer, which I am also assuming doesn't change with or without the diffuser. I could easily believe that the diffuser acts as an aperture stop but that seems weird that it would alter the field of view.
13. Line 215: suggest changing "secure more photons reaching" to "allow more photons to reach".
14. Line 216: "fiber-optic cable in" should be "fiber-optic cable with a".
15. Line 217: What temperature is it cooled to? Is the temperature monitored?
16. Line 240: "for whole wavelengths" should probably be "for all wavelengths".
17. Line 243: SMART-s uncertainty should be cited. If that citation is intended to be the Jeong et al. 2018 paper, it should be moved forward in the sentence as the sentence really puts forth 2 ideas: uncertainty and the source of the uncertainty.
18. Line 247: Below 50 degree in terms of zenith or elevation?

19. Line 268: “levels of light output” sounds odd and lacks precision. Are you describing increased intensity, irradiance, radiance, fluence, or something else entirely?
20. Line 268-270: This sentence describing the reduced calibration uncertainty with increasing intensity makes sense to me. It does not explain the most noticeable feature of the plot, at least in my opinion, which seems to be the significant increase in uncertainty around 330 nm. There is only a small figure caption footnote here to explain, which I think should be expanded. As this wavelength is used somewhat often, I believe you should describe the mechanism causing this uncertainty more clearly in your main text.
21. Line 274-275: “wired the cable differently” lacks precision. Are you simply reseating the cable in its mount or inserting elements or rerouting the cable or something else?
22. Line 296: Unclear whether it is a second detector or the identical detector used to measure the solar irradiance.
23. Line 339f: This is unclear to me. The UV region remains susceptible to stray light influences despite the OOB stray light correction?
24. Line 364: Is this the first place where RMSE and MBE (Root Mean Square Error and Mean Bias Error) are used? If so, the acronyms should be defined here in the main text (not on line 401) and not in the Figure caption
25. Lines 366-67: the phrase “—utilization of individually own measurements with different instrumental characteristics” makes no sense to me. My suggestion is simply to omit it as the sentence stands alone without the additional clarification.
26. Line 368f: Mention of non-negligible portions of the aerosols being from e.g. desert dust. How exactly is that determined which aerosol makes up which source quantities? What percentage is desert dust to be claimed as non-negligible in comparison to other sources?
27. Line 371: “which is in general consistency” should be “which is generally consistent”.
28. Line 371: “agreements” should be “agreement” as it is referencing the plural “V(r)s”.
29. Lines 414-436: This information is summarized in Table 1. However, it is not mentioned until the paragraph below. Suggest mentioning Table 1 up front for your readers’ reference.
30. Line 512f: Are you trying to say  $w_0$  from 330nm correlates better with H<sub>2</sub>O than  $w_0$  from 550nm with H<sub>2</sub>O? This sentence is unclear as it starts with “ $w_0$  and H<sub>2</sub>O are correlated” but then speaks of “temporal trends for  $w_0$ ”.
31. Figure 11-12: The in-figure text sometimes overlaps your data. I would suggest putting the blue and red text next to each other instead of stacking it. I would also put the letters defining the panel in a consistent spot.
32. Figure A1: What is the difference between the data shown in black (in the foreground of the image) and red (a few points in the background of the image)? Do the statistics only account for the black data?

#### Typos:

1. In general, the addition of an article is needed in a number of places:
  - a. Line 50: “Dominant fraction” should be “The dominant fraction”

- b. Line 58: “sphere” should be “a spherical”
- c. Line 94: “Over Southeast Asia series of” should be “Over Southeast Asia a series of”
- d. Line 102: “Majority” should be “A majority”
- e. Line 112: “a wavelength-independent”
- f. Line 113: “Krotkov et al. used aerosol” should be “Krotkov et al. used the aerosol” or “Krotkov et al. used an aerosol”
- g. Line 117: “ SKYNET instrument” should be “A SKYNET instrument”
- h. Line 189: “Population of” should be “The population of”
- i. Line 202: “is made by same” should be “is made by the same”
- j. Line 203: “but covers wider” should be “but covers a wider”
- k. Line 212-213: “sky-scans using single” should be “sky-scans using a single”
- l. Line 236: “operate global network” should be “operate a global network”
- m. Line 244: “temperature sensitivity of detector” should be “temperature sensitivity of the detector”
- n. Line 245: “Current AERONET” should be “The current AERONET...”
- o. Line 246: “it can add 380” should be “it can add a 380” or “it can add the 380”
- p. Line 301: “derives conversion factor” should be “derives a conversion factor”, and “based on solid-view-angle estimation algorithm” should be “based on the solid-view-angle estimation algorithm”
- q. Line 302: “combination of” should be “a combination of”
- r. Line 310: “sky-measurement” should be “a sky-scan measurement”, and “detector to radiance” should be “the detector to the radiance”
- s. Line 311: “instrument’s” should be “the instrument’s”
- t. Line 315: “direct-Sun measurement” should be “the direct-Sun measurement”
- u. Line 333: “spectral mean” should be “the spectral mean”, and “traditional method” should be “the traditional method”, and “high-resolution” should be “a high-resolution”
- v. Line 334: “instrument’s” should be “the instrument’s”
- w. Line 335: “is final solar irradiance for SMART-s algorithm” should be “is the final solar irradiance for the SMART-s algorithm”
- x. Line 336: “near to middle” should be “near to the middle”
- y. Line 338: “spectral shape” should be “the spectral shape”
- z. Line 345: “wavelength node” should be “the wavelength node”
- aa. Line 353: “total error” should be “the total error”
- bb. Line 355: “solar spectrum” should be “the solar spectrum”
- cc. Line 361: “optically effective range” should be “the optically effective range”
- dd. Line 362: “assumes bi-modal” should be “assumes a bi-modal”
- ee. Line 387: “at higher” should be “at a higher”
- ff. Line 423-424: “based on optical trapping method” should be “based on the optical trapping method”

- gg. Line 518: “did not show meaningful” should be “did not show a meaningful”
  - hh. Line 530: “show relationship” should be “show the relationship”
  - ii. Line 533: “proportional relationship” should be “a proportional relationship”
  - jj. Line 535: “following equations” should be “the following equations” and “radius” should be “radii”
  - kk. Line 550: “information on degree” should be “information on the degree”
  - ll. Line 556, 557: “showed negative correlation” should be “showed a negative correlation” and “positive correlation” should be “a positive correlation”
  - mm. Line 563: “suggest potential benefit” should be “suggest the potential benefit”, and “measure” should be “measurements”
  - nn. Line 578: “ASHE algorithm” should be “the ASHE algorithm”
  - oo. Line 650: “during limited” should be “during a limited”
2. A number of simple phrases seem odd to me. To read more naturally, I would suggest:
- a. Line 74: “complement their limitations” should perhaps be “expand upon their limitations”?
  - b. Lines 90-91: “15 years of period” should be “a 15-year period”
  - c. Line 103: “as discrete” should be “in discrete” or “within discrete”
  - d. Line 104: “at each” should be “per”
  - e. Line 110: “To take account for” should just be “To account for”
  - f. Line 117: “with the AERONET” should be “within the AERONET”
  - g. Line 131f: Suggest “which yet lack sufficient reliable measurements”, i.e. remove “are” and “of”
  - h. Line 162: “in rotary-/fixed-wing of ~130 flights” should be “in a rotary-/fixed wing configuration for ~130 flights”
  - i. Line 193: “started since 8 March 2019” should be “started on 8 March 2019”
  - j. Line 206: “we refer this modified” should be “we refer to this modified”
  - k. Line 212: “it can measure radiances” (plural)
  - l. Line 216: “fiber-optic cable with 400 um diameter” or “fiber-optic cable 400 um in diameter”
  - m. Line 234: Suggest “are in the study, key characteristics are included here in Appendix B.”
  - n. Line 248: Suggest either “adopts monthly climatologies” or “adopts a monthly climatology”
  - o. Line 268: changing “UV than in the” to “UV compared to the”
  - p. Line 298: change “solar light after passed” to “solar light after it passed”
  - q. Line 452: “is yet challenging” should be “remains challenging”
  - r. Line 453: “for the Figure 5” should just be “for Figure 5”
  - s. Line 515: the insertion of “rather” into “to more smoldering rather than flaming” would make this sentence read more smoothly
  - t. Line 633: changing “significantly large” to “frequently large” or something similar



- u. Line 648: “which supposed to” should be “which is supposed to”
- 3. Line 79: I believe the comma after “Particularly,” should be omitted
- 4. Line 97: I believe “aerosols are analyzed” should be “aerosols were analyzed” as all the references are at least 6 years old
- 5. Line 107: “Collocated AERONET” should be “Collocated AERONET instruments”
- 6. Line 107: “Peters” should be “Petters”
- 7. Line 111: Should there be a subscript “ $\tau$ ” for tau?
- 8. Line 114: Suggest removing “the” prior to “n at 440 nm”
- 9. Line 118: “SKYNET instrument is” should be “SKYNET instruments are”
- 10. Line 131f: Suggest “which yet lack sufficient reliable measurements”, i.e. remove “are” and “of”
- 11. Line 161: “Systems” should be “system” or “a” should be something like “several”
- 12. Line 161: I believe your parenthetical ends after System, i.e. “sUAS (small Unmanned Aerial System)”
- 13. Line 163-164: “one SMART-s instruments” should be “one SMART-s instrument”
- 14. Line 187: AERONET is not an instrument but a collection of them. Therefore, “and AERONET are” should be “and AERONET instrument are”
- 15. Line 192: Omit the “at” in the phrase “Chotana road shown at behind”
- 16. Line 195: “AERONET is installed at the” should be “AERONET instrument is installed on the”
- 17. Line 214: “Sky observations does” should be “Sky observations do”
- 18. Line 311: “radiometer” should be “radiometer’s”
- 19. Line 339: “undergo” should be “undergoing”
- 20. Line 340: “Fcomb supposed” should be “Fcomb is supposed”
- 21. Line 346: should be plural, “absorption bands”
- 22. Line 354: Usually Vis was all capital letters
- 23. Line 361: Should “radius nodes” be “radiance nodes”?
- 24. Line 371: “consistency” should be “consistent”
- 25. Line 447: remove “(subscript f for fine-mode and c for coarse-mode)”, already clear from Line 437
- 26. Line 496: Should “adsorption” be “absorption”?
- 27. Line 511f: Should e.g. “decreased” be added to this sentence to read: “H<sub>2</sub>O gradually increased as biomass-burning activities decreased approaching toward the monsoon season”
- 28. Line 571: “from observations by the CALIOP” should probably be “from observations by CALIOP” to match the treatment above by the other satellite sensors.
- 29. Line 745: “Authors of Jeong/Tsay” should be “Authors Jeong/Tsay”
- 30. Figure 8: Should there be a label for panel (b)?