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Atmospheric Measurement Techniques Discussions

# *Interactive comment on* "Aerosol Optical Depth comparison between GAW-PFR and AERONET-Cimel radiometers from long term (2005–2015) 1-minute synchronous measurements" *by* Emilio Cuevas et al.

**Anonymous Referee #3**

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Three major data interpretation issues discourage publication. They are about natural variability, sampling bias and instrument field of view (FOV).

First, the paper compares AOD observations between 60s averages and less-than-1s averages (Page 8, line 1-2). The true AOD in the atmosphere generally changes over the 59s differentials. Yet the paper neglects the natural changes when making inferences on calibration.

For example, the paper shows that Cimel observes generally wider AOD differences



between daily minimum and maximum than does PFR (page 15, line 21-24; Figure 3). This must be at least partly because Cimel samples with 30s intervals and captures natural changes while PFR sleeps. Yet the paper interprets the wide diurnal ranges as a sign of "an imperfect calibration" of Cimel (page 15, line 24-25). The comparison is fairer if PFR data are paired up over 61s and, better still, if the second of the three consecutive Cimel samples is excluded.

Misinterpretation is evident on a multi-year basis too. The paper attributes poor AOD agreements at 380 nm under pristine conditions to "insufficiently accurate calibration of AERONET-Cimel" (page 15, line 33-34). This is unsubstantiated. Because AOD is generally higher at shorter wavelengths, so is its natural variability in the absolute term. This would make the AOD discrepancies greatest at the shortest wavelength, even if calibration were perfect for both instruments.

Second, the paper finds "a bias with positive large outliers (higher Cimel AOD)" (page 15, line 5; Figure 2). This results from the intentional exclusion of high PFR values, an attempt to assess "pristine conditions (AOD500nm <= 0.03)" (page 13, line 26, 28). It is misleading to use this assessment to suggest contaminations on Cimel (page 15, line 6, 7). It is only fair to explicitly state that many negative outliers (higher PFR AOD) exist for PFR AOD just above 0.03 (shown in Figure 7).

Third, FOV is not adequately appreciated as a significant source of AOD uncertainty under dust. The forward scattering by aerosols into FOV is definitely the primary cause for the poor agreement at 380 nm away from pristine conditions, not just "might be" (page 33, line 30). A support for this statement partly comes from the theory that the forward scattering is greater at shorter wavelengths.

A more definitive support is given in Figure 7. It shows that the observed AOD differences is about 3% of AOD at 380 nm. Russell et al. [2004] explain why the FOV effect increases with AOD. And their calculation predicts a $\sim$4% error for 1.25 degree half FOV and a $\sim$1% error for 0.60 degree half FOV, both at 380 nm (their Figure 3). The

difference, ∼3%, is similar to Figure 7. It is incorrect to assign "an insufficient[ly] accurate calibration of AERONET-Cimel in this channel" as "the most likely cause" (page 32, line 9) of the observed differences (page 32, line 9). Such errors would not increase with AOD.

FOV will remain as a source of uncertainty even if the adjustments are made for it. Because the FOV is much wider, the adjustments are greater for PFR than for Cimel. So is the uncertainty in them. Thus, other things being equal, the PFR is destined to be more erroneous than Cimel. It is incorrect to hold both instruments equally responsible for the resulting AOD discrepancies (page 34, line 8-9).

Also, the FOV-related uncertainty leads to a question as to why "WMO defines the PFR FOV as the recommended one for sun radiometers" (page 33, line 24-25). The quoted statement is not explained. Forward scattering into the FOV constitutes a deviation from the condition to which Beer's law pertains – a deviation that should be minimized, not recommended. Nor is the statement supported by a citation. To be sure, WMO (2007) recommends that the WORCC be designated the primary WMO Reference Centre for OD measurements, as referenced in page 2, line 24-26. But the WMO report does not mention a specific instrument, let alone support the PFR-specific statement.

Meanwhile, there are a few reasons to encourage resubmission. The topic is important, given how widely ground-based sunphotometers are used in climate science and satellite validation. The data are abundant. Careful and useful pieces of discussion are provided regarding the impact of unattended operations (page 3, line 18-21) and the implications for other measurement sites (page 24, line 4).

Authors are encouraged to consider the following suggestions and comments, in addition to the major issues raised above, prior to resubmission.

Page 2, line 16. Skynet with PREDE instruments is worth mentioning as another ground-based sunphotometer/sky-radiometer network. [Takamura, T., and T. Nakajima, Overview of SKYNET and its activities, Opt. Pura Apl. 37, 3303-3308, 2004.,



http://atmos3.cr.chiba-u.jp/skynet/index.html]. Skynet has about as many stations as GAW-PFR does.

Page 4, line 32. Separate vice from versa.

Page 5, line 1. Insert something like "Dust provides a good test on the treatment of the forward scattering into the field of view."

Page 5, line 14. The precise sun-tracking enabled by a quad detector should be mentioned somewhere in this paragraph for Cimel. Sun tracker is only described for PFR (page 6, line 1).

Page 5, line 27. Is there a reference on the instrument response over the field of view, especially over the 0.7 degree "slope" (Table1)?

Page 5, line 28. Replace significant with significantly.

Page 6, line 1. Replace the second comma with a period.

Page 6, line 4-7. The air mass dependence of uncertainty is worth mentioning here, since radiometric calibration is the primary concern of this paper.

Page 6, line17. Make 0 subscript, as in line 16.

Table 1. What does "No specific Sun tracker" mean? What does "Sun tracker robot" refer to? Replace "long-term" with 6 months, as described in page 6, line 18. Replace "2-3 months" with 3-4 months as described in page 6, line 16.

Page 6, line 21. Provide references that detail the data processing protocol, preferably including Langley plots, for each instrument.

Page 6, line 24. Break down the second word.

Page 7, line 8. Drop "s" from corresponds, since the word data is used as plural in the preceding sentence.

Page 7, line 5. Replace criterium with criterion or criteria. Note that the plural, if

chosen, requires changes in the rest of the sentence.

Page 9, line 3. Revise this sentence, as it contradicts with the fact that the agreement is achieved for less than 95% at 380 nm.

Page 9, line 5. Table 4 is expected to appear after Table 3. Revise numbering.

Page 9, line 6. Is the first period “2005-2010”? Table 2 has “2005-2009”, as in page 12, line 1 and page 34, line 14.

Page 9, line 11. Explain how it is determined that problems in sun pointing were “the main cause” of AOD discrepancies between PFR and Cimel. Table 4 indicates that the fail rate decreased merely by one third - from 4.2% to 2.8% - at 500 nm upon the tracker update.

Page 9, line 11. This sentence implies that a sun tracker is not considered a part of the PFR instrument. That is surprising to those who perceive the tracker as an essential, fully-integrated component of a sun radiometer. It is like saying the steering wheel is not part of a car. Consider dropping the comma and the subsequent eight words.

Page 11, line 9. Replace “can be one of the main causes of part of” with “is the main cause of”.

Page 11, line 10. Replace 5.4 with 5.3.

Page 11, line 16. Bring Kazadzis et al. before the first parenthesis, and drop the comma.

Page 12, line 3. Again it is not clear what supports the notion “the most important cause [. . .], which were associated with a poor pointing of GAW-PFR”.

Page 12, line 5. Replace “of both periods” with “between the two periods”.

Page 12, line 21. Elaborate on “MB values to be within 0.01 bias”.

Page 12, line 23. Drop the first “and”.



Page 13, line 2. This paragraph feels misplaced. It deserves to be a stand-alone subsection under Section 5.2. Combine it with the sixth paragraph of section 5.1.

Page 15, line 3. Remove the comma.

Page 15, line 19. “maximum value minus minimum value of AOD in one day” is less logical a metric for evaluating the calibration than the difference between the measurements at minimum and maximum air mass factor of the day.

Page 15, line 28. Insert a comma after “causes”.

Page 15, line 29. Replace “worst” with worse.

Page 15, line 30. Replace the comma.

Page 17, line 10. Replace “a” with an.

Page 24, line 17. Explain what exactly is “more clearly” shown at 500 nm.

Figure 7. If this figure is to remain on the paper, note in the caption that an identical data set, PFR AOD, appears in both x and y axes, a practice generally discouraged. Also state that the numbers in the legend are rounded to the significant digits. This is to forestall questions as to why the black lines do not reach exactly (x,y)=(0,0).

Page 26, line 7. “first” is misleading. Refer to previous studies such as Russell et al. [2004]. Replace “might play” with plays.

Table 9. “(14.9)” for 500 nm, AOD>0.1 is not consistent with the “AOD>0.10” row of Table 4.

Figure 8. Revise the caption, yaxis labels and legends to better clarify what are plotted.

Page 28, line 13. Replace “could lead” with leads.

Table 10. Complete the right-most vertical line.

Page 31, line 8. Explain in what way GAW-PFR is “the AOD reference globally” and

“directly linked to WMO/CIMO”.

Page 31, line 14, remove the first comma and “which”.

Page 31, line 28. Does the judgment made here with the word “excellent” hold even while the 95% criteria are not met at 380 nm?

Page 31, line 30. Remove the last five words.

Page 32, line 5. Provide more details or references regarding the Langley plots so that their quality can be verified.

Page 32, line 29. Replace “in” with on.

Page 32, line 33. Remove “Even so,”.

Page 33, line 13. Explain why the traceability metric should be redefined based on actual performance.

Page 33, line 14. Replace “shouted”.

Page 33, line 15. The purpose of this paragraph is unclear. If it is a disclosure that low AOD cases are removed from the present analysis, it should be noted much earlier. If this paragraph is a suggestion to exclude negative AOD values from future data analyses, it is misguided. While such values are not physical, their exclusion would artificially bias the remaining data high.

Page 33, line 16. Replace “absolute” with relative.

Page 34, line 7 says “both [PFR and Cimel] are representative of the same AOD population” over the 11 years, except for 380 nm. Similarly, page 12, line 7 says “[The agreement in AOD] proves the consistency and homogeneity of the long AERONET-Cimel AOD data series”. These conclusions imply that Cimel’s stability is adequate and that PFR’s features for greater stability (page 5, line 27-31) are, while remarkable, not a significant advantage. It is, then, logical to favor Cimel for its much narrower FOV,



a clear advantage over PFR. Arguments like this, or ones against it if any, would be a good addition.

Page 34, line 15. Revise the sentence. The paper does not directly address calibration transfer. Rather, the paper reveals that special attention should be paid to natural variability, sampling bias and PFR’s wide FOV.

References

Russell, P. B., Livingston, J. M., Dubovik, O., Ramirez, S. A., Wang, J., Redemann, J., Schmid, B., Box, M., and Holben, B. N.: Sunlight transmission through desert dust and marine aerosols: Diffuse light corrections to Sun photometry and pyrheliometry, J. Geophys. Res., 109, D08207, 10.1029/2003JD004292, 2004.

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