Atmos. Meas. Tech. Discuss., 8, C2578–C2583, 2015
www.atmos-meas-tech-discuss.net/8/C2578/2015/

Atmospheric Measurement Techniques
Discussions

Interactive comment on "Can AERONET data be used to accurately model the monochromatic beam and circumsolar irradiances under cloud-free conditions in desert environment?" *by* Y. Eissa et al.

Anonymous Referee #1

Received and published: 13 August 2015

The paper is a detailed and careful analysis of radiative transfer calculations of direct beam and circumsolar irradiances, where aerosol optical properties are characterised by AERONET sunphotometer measurements and inversions. Results show that AERONET characterisation of aerosols allows for an excellent simulation of direct beam irradiances, and for a poorer simulation of circumsolar irradiances, which is still encouraging given the complexity of the measurements in such narrow solid angles.

The paper also presents an interesting comparison of AERONET measurements of

aerosol optical depths to similar Sun and Aureole Measurement (SAM) measurements. This suggests that AERONET optical depth may be systematically biased because of its instrument's relatively wide aperture angle – an important result which deserves more discussion in the paper, as I argue below.

The paper is well-written and should be of interest to *Atmos. Meas. Tech.* readers. Figures and Tables illustrate the results well. In the discussion, the authors are not able to identify all the causes for biases between radiative transfer calculations and measurements, but they make a good effort considering the many simplifying assumptions that need to be made both on the observational and radiative transfer side. I recommend publication, after minor revisions have been made to address the comments below.

1 Main comments

- Section 5: When comparing τ_a from SAM and CIMEL, the authors choose to remove measurements where the two instruments disagree by more than ± 0.03 (page 7709, line 28), which is the stated accuracy of the SAM. This choice surprises me for two reasons. First, SAM measurements that agree with AERONET could very well be as inaccurate as those that disagree – agreement could very well be coincidental in some cases. Second, the points showing large disagreements are arguably the more interesting to explore. When comparing radiances, the authors justify a similar screening by invoking different cloud shading experienced by the two instruments. Is that also the reason why the two instruments disagree in τ_a 27% of the time? That would seem like a high frequency of occurrence.

  It is important to do the comparison in a transparent way, because the result that AERONET AOD may be biased high by 5% is an important one, given that AERONET AOD is taken as ground truth by so many applications, from satellite remote-sensing to global aerosol modelling. This is the first time I hear about such a bias in AERONET, and the authors explanation of the bias being due to the CIMEL instrument's larger aperture angle makes sense. Is that aperture effect not considered in the AERONET retrieval algorithm at all? Does the authors' result imply that the stated AERONET AOD uncertainty is 0.01 to 0.02 at 0.44 μm should be revised upwards?

- The authors clearly focus their paper on desert areas, but it would be interesting to discuss in the conclusions whether the method can be reasonably expected to work elsewhere. In many ways, the method does not depend on the origin of the extinction, so it should work for any aerosol type, or even for thin cirrus. As long as the single-scattering albedo and phase function at small scattering angles can be derived, the method would work. Is that correct, or am I overlooking other aspects?

2 Other comments

- Page 7702, line 12: the uncertainty in $E_{0,n,\lambda)}$ must also be a large contributor to total uncertainty in computed radiance, doesn't it?
- Page 7704, line 16: I am not sure I understand the "statistically significant" here. Is that in terms of sampling of the temporal variations in aerosol properties?
- Page 7704, line 23: It would be helpful to give basic statistics on the observed τ_a (min, max, standard deviation). I expect that it varies strongly, since there are clear and dusty days in the region.
- Page 7705, lines 8–9: In the context, it should be the other way around: L is proportional to ϖ_a.

- Page 7705, line 14: it is a bit of a nitpick, but "not valid" is slightly inexact. A better word would be "not useable", because the uncertainty in the retrieval of ϖ_a becomes large at low optical depths, affecting the usefulness of the retrieved value. In fact, it is rather unfortunate that AERONET does not give the uncertainty in ϖ_a in their products, even in low aerosol optical depth conditions.
- Page 7705, line 21: Here again, it would help to give an idea of variability in the phase function by giving basic statistics of the dataset.
- Page 7706, lines 15–17: Does that mean that CSNI derived from SAM is underestimated? Is it possible to quantify that underestimation?
- Page 7706, line 26: Does that mean that τ_a is also retrieved from SAM measurements? We would need more details on that procedure, as it would help to better understand point (i) of the quality control described page 7707, line 5.
- Page 7708, line 23: It would be useful to state here that the actual number of AERONET samples is 10757. That helps the reader determine that the 253 measurements filtered out due to possibly different cloud shading experienced by the two instruments (page 7709, line 1) represent about only 2% of the total, which sounds reasonable if the two instruments are not located too far apart.
- Page 7709, lines 13–16: Those details should be given in the Figure caption instead.
- Page 7709, line 26: Another nitpick, but surely AERONET's accuracy is the one that is greater than SAM, not the other way around.
- Page 7710, line 6: "exceed" -> "sometimes exceed"
- Page 7711, lines 16 and 21: "abbreviated in" -> "abbreviated as"

    - Page 7713, lines 14–16: Supplying hundreds of Legendre moments does not sound so terrible with current computers. Is the reader supposed to understand that it is in fact impractical?
    - Page 7714, lines 3–4: A more common method to deal with phase functions with sharp forward scattering peaks is the delta-Eddington approximation, where the peak is truncated and SSA and g scaled accordingly (Joseph, Wiscombe, and Weinman, J. Atmos. Sci., 33, 2452–2459, 1976). The truncated phase function is easily represented with a few 10s of Legendre coefficients. Did the authors consider that method, but found it unsatisfactory?
    - Page 7715, line 5 and page 7716, line 6: How is the vertical profile of aerosols specified?
    - Page 7715, line 20 and page 7716, line 12: What are the characteristics of the OPAC desert type and DESERT$_{M}AXaerosolmodels?$
- Page 7716: It is unnecessary to give the variable names and state which output option was selected. Scientific details are important for reproducibility but at the same time the paper is not supposed to be a user manual for SMARTS.
- Page 7718, lines 1–3: How would that kind of errors affect the comparison of SMARTS to SAM?
- Page 7719, lines 3–11: It would be informative to identify which of the characteristics of the aerosol models is responsible for the poor fit. For example, the OPAC desert aerosol model has a single-scattering albedo of 0.89, which is outside the range observed by AERONET in this study. That could account for some of the errors in radiative transfer calculations of the CSNI.
- Figure 7: Circles are not a very accurate way to represent data on a graph. Could we have crosses instead?

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Interactive comment on Atmos. Meas. Tech. Discuss., 8, 7697, 2015.