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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Diurnal variations of aerosol optical properties in the North China Plain and their influences on the estimates of direct aerosol radiative forcing" *by* Y. Kuang et al.

Anonymous Referee #2

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Review of "Diurnal variations of aerosol optical properties in the North China Plain and their influences on the estimates of direct aerosol radiative forcing" by Kuang *et al.*, submitted to *Atmos. Chem. Phys.*

In this study, the authors use in-situ aerosol measurements combined with Mie and radiative transfer calculations to quantify the impact of the diurnal cycle of aerosol optical properties on the direct radiative effect. They find that although diurnal variations can be sizable, their impact is generally more modest. This result has positive implications for studies based on satellite or AERONET retrievals, which are limited to one measurement per day or to a narrow range of solar zenith angles.

The paper is interesting and well written. The demonstration of cancellations of the effects of single-scattering albedo and asymmetry factor is of particular interest. I recommend publication after the following comments are addressed. Because comments involve additional analyses, they may amount to major revisions. In particular, the authors should clearly specify the implications of their work, and clarify their assumptions on the refractive indices used in their calculations. I am also concerned that the authors focus on diurnal variability without saying that day-to-day variability is much larger. Finally, the authors should make a better case on the applicability of their findings to other regions.

1 Main comments

- In the introduction, the authors motivate their study by saying that satellites only provide one or two measurements per day, and AERONET inversions are limited to a narrow range of solar zenith angles (page 341, lines 8 to 24). The authors should be fair, and their abstract and conclusion (after line 27 on page 355) should clearly state that according to their findings, observing an incomplete diurnal cycle has only second-order consequences on direct radiative effect estimates.
- The authors use a fixed refractive index for the core and shell of their aerosol particles (page 346, lines 10 and 19). To what chemical compositions do those refractive indices correspond? Are refractive indices constant with wavelength? If so, wouldn't that be a larger source of error than diurnal variations in optical properties?
- Throughout the paper, day-to-day variability of aerosol optical properties appears to be a major factor, but it is never quantified. According to Figures 1 and 2, day-to-day variability is much larger than diurnal variability. It would be useful to

compare the two in terms of direct radiative effect. In addition, when discussing variability in direct radiative effect (from page 353, line 22), variability for case 1 (compared to its 17-day average) should be shown, and the high variability of cases 5 and 8 deserves to be discussed (especially since the authors mention it on page 354, line 16).

- The authors claim that their findings can be applied beyond the North China Plain (page 354, lines 16–19), but this is not obvious and needs a more specific discussion. Which regions share the same diurnal pattern of relative humidity? In which seasons? Are aerosols in those regions similarly hygroscopic? I believe that the results are not as universal as claimed by the authors.

2 Other comments

- Page 340, line 6 and page 355, line 2: Saying that diurnal variations are "evident" is not useful. It would be better to say what they are.
- Throughout the paper, I recommend the use of direct radiative *effect* rather than *forcing*. The latter term is nowadays commonly used for the radiative effects of anthropogenic aerosols only (see IPCC 2013 chapter 7, or Myhre et al., 2013).
- Page 341, lines 4 and 20: constant in time? They also vary with wavelength.
- Page 341, lines 5–7: The authors seem to give the conclusion of the study a little early.
- Page 341, near line 17: The study by Kaufmann *et al.* (2000) is relevant here.
- Page 342, line 3: "rather small" Be more quantitative: how small?

- Page 343, lines 21-22: The current sentence makes it sound like the temporal resolution depends on relative humidity. Please rephrase.
- Page 344, line 13: Rigorously speaking, g is an approximation of the phase function. Using that approximation introduces errors, see Boucher (1998).
- Page 344, line 13: Say here that the AERONET site is not located in the same place as the HaChi measurements.
- Page 345, equation 3: This assumes that $r_{\mathrm{ext-LAC}}$ does not depend on D_p. Is that assumption reasonable?
- Page 345, equation 4 and page 347, equation 11: I recommend to place brackets to clearly indicate what terms are under the summation signs.
- Page 345, line 11: A reference is required for the assumed density.
- Page 345, line 18: Again, a supporting reference is needed for that assumption. Is it a strong assumption?
- Page 345, equation 6: Is it really RH on the left-hand side of the equation?
- Page 346, line 1: Please give the value of $\sigma_{s/a}$.
- Page 346, line 4: Please give a short summary of the size-resolved κ method, so the paper stands on its own.
- Page 346, line 5: Note that using Mie theory assumes that particles are spherical.
- Page 348, line 4: Are calculations for the shortwave spectrum only? Are diurnal variations in solar zenith angle fully accounted for?
- Page 348, line 16: Please give a typical value for surface albedo at the measurement site.

- Page 348, line 19: Say here that those hours are approximately those of sunrise and sunset (according to page 350, lines 6–8).
- Page 348, line 22: Most studies report the 24-hour average, but here it seems to be the daytime average. Any good reason why?
- Page 348, line 23 and Table 1: “ambient” is not a great choice of word, because that case in fact refers to accounting for the full temporal variation of optical properties. I suggest “full temporal” for the name of case 1.
- Page 348, line 26 and page 349, line 1: Can you give approximate hours in the day for those two values of solar zenith angle?
- Page 349, line 3: Technically, case 2 should be the reference for cases 3 to 11, but thankfully, results for case 2 are similar to those for case 1.
- Page 349, line 10: “variations of aerosol optical properties” -> “of selected aerosol optical properties”
- Page 350, line 1: Note that the two peaks in AOD are not shown on Figure 1.
- Page 350, lines 9–11, page 351, lines 8–10, page 352 line 24 to page 353 line 6: There is no need to motivate the study again, the introduction has done that. Delete those sentences.
- Page 351, line 3–4: It is true that the single-scattering albedo of the dry aerosol varies in time. Is that due to a change in composition?
- Page 351, lines 5–7: This correlation is in fact built-in the Mie calculations as done by the authors.
- Page 351, line 20: I am not sure that it is so easy to understand, because it implies that diurnal changes in size distribution are small. It is not obvious that it should be the case.

- Page 351, line 25: Please give the values of direct radiative effect in case 1, for the sake of completeness.
- Figures 4 and 5 can be merged into one.
- Page 352, line 1: “The results of case 2” -> “the small differences in case 2”
- Page 352, line 5: Why is case 4 not discussed?
- Page 352, lines 12 and 17: “hit onto the ground” does not read well. Rephrase to “reaches the surface”.
- Figure 2: Please re-label the panels so that they are listed in alphabetical order in the caption.

3 Technical comments

- Page 341, line 12: “limited for” -> “limited to”
- Page 342, line 15: “are therefore important” -> “is therefore important”
- Page 347, line 7: “according to the definition” -> “its definition”.
- Page 353, line 20, also captions of Figures 4, 5 and 6: typo: compare -> compared
- Page 353, line 27: exactly -> exact

4 References

Kaufman, Y.J., B.N. Holben, D. Tanré, I. Slutsker, A. Smirnov, T.F. Eck. Will aerosol measurements from Terra and Aqua polar orbiting satellites represent the daily aerosol abundance and properties? *Geophys. Res. Lett.*, **27**, 23, 3861–3864, 2000.

Boucher, O. On aerosol direct shortwave forcing and the Henyey-Greenstein phase function. *J. Atmos. Sci.*, **55**, 128-134, 1998.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 339, 2015.