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Interactive comment on “A study of the impact of synoptic weather conditions and water vapor on aerosol-cloud relationships over major urban clusters of China” by K. Kourtidis et al.

Anonymous Referee #1

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General comments

Kourtidis et al. investigate how water vapor, large-scale synoptic conditions, and seasonal trends may contribute to aerosol-cloud relationships over parts of China. Their analysis has the potential to make a valuable contribution to this important field of research. I recommend publication after the authors have considered the comments below.

Major comment: interpretation and communication of results

Some of the main features I observe in Figs. 2-4 and Tables S3-S5 are as follows:

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1. For small bins of AOD, there is a positive WV-CC relationship for both SLP regimes across all three regions.
2. For small bins of WV, the AOD-CC relationships generally tend to be small yet often still positive and significant for both SLP regimes across all three regions. These AOD-CC relationships are much weaker than those in Tables S1 and S2, when WV has not been taken into account.
3. For small bins of AOD, there is a positive WV-CTP relationship for the SLP<1008hPa regime across all three regions.
4. For small bins of WV, there appears to be no consistent WV-CTP relationships across all three regions.
5. Positive WV-AOD relationships often exist (e.g. in Fig. 2b, the WV=8cm line only starts at AOD=0.7). This is consistent with the second observation above.

These results do indeed imply that “studies of AOD-CC relationships based on satellite data that do not take into account WV might greatly overestimate the AOD impact on CC” (p14013.21), although I am not convinced that the results support the second half of the sentence about underestimating the AOD-CC relationships when AOD and WV have opposite seasonal trends (also at p14015.27) - I suggest deleting this. Similarly, in the Abstract, I suggest deleting “or underestimate” and “or opposite” in the sentence at p14008.9-10, as the results do not show this. (If I have misunderstood the results, and one of the three chosen regions does exhibit the proposed underestimation effect due to opposite seasonal trends, please do correct me.)

It is misleading to imply that “AOD does have an impact on CC even if synoptic and WV are accounted for” (p14014.3) because not all synoptic variability has been accounted for and remaining positive AOD-CC relationships do not imply a causal relationship. It would be more accurate to say something along the lines of: “Even after accounting for SLP and WV, weakened positive relationships between AOD and CC do often remain.”

Figure 5 does suggest that for small bins of CC, there is no large increase in WV as AOD increases. However, it does not show that “there is no large systematic AOD retrieval bias due to aerosol swelling at increased WV” (p14014.15, also p14016.15). In order to address the dependence of AOD of WV (rather than WV on AOD), a more helpful figure would be to plot a line of AOD vs WV for different WV bins. Furthermore, any AOD dependence on WV (a proxy for humidity) would not be a “bias” per se due to the fact that increasing WV may lead to higher AOD in reality (unlike the situation with cloud contamination of AOD, which is a retrieval error).

In the conclusions, I found the following sentence at p14015.12 somewhat misleading the first couple of times that I read it: “Over all urban clusters, and for all SLP regimes, CC is found to increase with AOD, thus pointing out that the CC dependence on AOD is not driven by synoptic co-variability.” I suggest re-writing the second half of the sentence along the following lines: “thus suggesting that the relationship between AOD and CC cannot be explained by consideration of SLP alone.” Alternatively, the second half of the sentence could be deleted. Similarly, the second half of the sentence in the Abstract at p14008.5, “thus pointing out that the CC dependence on AOD is not solely due to meteorological covariability”, is misleading and should be amended.

I suggest that the authors spend some more time thinking though what the main results are that they would like to communicate, and how best to communicate these results (especially in the Conclusions).

Specific comments

Title. One of the interesting aspects that the authors consider in the manuscript is the effect of seasonal trends. The authors may want to make reference to this in the title, e.g. “A study of the impact of synoptic weather conditions, water vapor, and seasonal cycles on aerosol-cloud relationships over major urban clusters of China”.

Abstract. (a) It could be good to mention CTP in the first sentence at p14008.2, ie “Aerosol Optical Depth (AOD), Cloud Cover (CC), and Cloud Top Pressure (CTP)”. (b)

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Consider re-writing second half of sentence at p14008.5 (see major comment above). (c) Consider deleting “or underestimate” and “or opposite” (p14008.9-10) (see major comment above). Also consider deleting “Hence” at start of sentence (p14008.8).

Data and methods. (a) It would good to include more discussion of possible retrieval errors. How may cloud and aerosol retrieval errors (e.g. cloud contamination, Huang et al, 2011, doi:10.1029/2010JD014910; 3D effects, Varnai and Marshak, 2009, doi:10.1029/2008GL037089 etc) affect the results? What about the WV retrieval? (b) How do these region sizes relate to the recommendations of Grandey and Stier (2010, doi:10.5194/acp-10-11459-2010)?

Results and discussion. (a) At p14012.8, consider changing “to exclude” to “to partially exclude”, as synoptically induced co-variance has only partly been accounted for (via SLP). (b) Consider showing some of the Terra results (mentioned at p14012.28) in the Supplementary Material. (c) What happens if the data is analysed season by season, in an attempt to account for the seasonal trends? It could be interesting to include a version of e.g. Fig. 2, or Table S3, using data from just one season. (d) Consider deleting end of sentence at p14013.23, “while they might greatly underestimate...” (see major comment above). (e) Consider re-writing sentence at p14014.3 (see major comment above). (f) I am not convinced that Fig. 5 supports the claim that “there is no large systematic AOD retrieval bias due to aerosol swelling at increased WV” (p14014.15; see major comment above). (g) Meskidze et al (2009, doi:10.5194/acp-9-3461-2009) may be of interest when discussing differences between Aqua and Terra (p14015.3).

Conclusions. (a) The sentence starting at p14015.12 is potentially misleading (see major comment above). (b) Consider deleting second half of the sentence at p14015.27 (see major comment above). (c) When discussing how the hydrological cycle may interfere with aerosol–cloud relationships (p14016.5), Grandey et al (2014, doi:10.1002/2014GL060958) and Gryspeerd et al (2015, doi:10.5194/acpd-15-6851-2015) may be of interest. (d) I am not convinced by the final statement (p14016.15;

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see major comment above).

Additional references. The following two recent papers may be of interest: Rosenfeld et al (2014, doi:10.1002/2013RG000441), a review paper; and Gryspeerd et al (2014, doi:10.1002/2014GL059524), which discusses how AOD-CC and AOD-CTP relationships may be related.

Figure 1. (a) Apply label to colourbar (e.g. “Ratio of local AOD to global mean AOD”). (b) State global area-weighted mean AOD for reference in figure or caption. (Am I correct in assuming that you use the area-weighted mean?). (c) Add y-axis label (“Population”) to embedded population graphs. (d) Explain acronyms (BTH, YRD, and PRD) in figure caption, not just in main manuscript text.

Figures 2-4. (a) Consider adding name of region as title above the figure (e.g. “Beijing-Tianjin-Hebei (BTH)” above Fig. 2). (b) Consider adding SLP labels (e.g. “SLP < 1008hPa” as a row title to the left of Figs (a) and (c)). (c) Flip CTP axes so that increasing height is upwards.

Figure 5. Consider adding row titles to figure (ie “BTH” to the left of (a) etc).

Figures S1 and S2. Are these monthly averaged data? Please clarify in caption.

Tables S1-S5. Does “ $a=0.05$ ” mean the same as “ $p=0.05$ ”?

Technical corrections/suggestions

- p14008.3 - “3” to “three”.

- p14008.4 - “MODIS observations” to “MODIS satellite-retrieved data”.

- p14008.22 - “solar and terrestrial radiation” to “solar and terrestrial short-wave radiation” (to avoid confusion with terrestrial long-wave radiation). Also, consider mentioning that absorption *in the atmosphere* may impact the vertical temperature structure and clouds (ie semi-direct effect; Ackerman et al, 2000, Science)

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- p14009.10 - “growth the” to “growth over the”.

- p14013.12 - “that the” to “than the”.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 14007, 2015.

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15, C3188–C3193, 2015

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