Atmos. Chem. Phys. Discuss., 15, C4860–C4869, 2015
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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

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.

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Received and published: 14 July 2015

Response to Referee #1

General comments We thank the referee for his positive comments.

Major comment: Interpretation and communication of results

The referee agrees with our statement 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 in regions where AOD and WV have similar seasonal variations" but is not convinced that the results show that "studies of AOD-CC relationships based on

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satellite data that do not take into account WV [. . .] might greatly underestimate the AOD impact on CC in regions where AOD and WV have opposite seasonal variations". The reason is that none of the studied regions exhibit the proposed underestimation effect. However, we believe that although our study was limited to regions of similar AOD and WV seasonal variations, it nevertheless shows (as the referee agrees) that in regions of similar AOD and WV seasonal variations AOD-CC relationships become much weaker when WV is taken into account. The above is a consequence, as the figures 2-4 show, of the water vapor impact on CC and the fact that if WV is not accounted for, its impact appears as AOD impact due to the common AOD-WV seasonal cycle in the three regions of the present study. We believe that as a logical consequence it follows that, CC in regions where AOD and WV have opposite seasonal variations, AOD-CC relationships based on satellite data that do not take into account WV, will underestimate the AOD impact on CC (or, if you prefer, "will most probably underestimate the AOD impact on CC". Hence, we opt not to delete the respective part of the sentence, but rephrase it slightly as follows:

p14008.9-10, from "Hence, studies of AOD-CC relationships based on satellite data, might greatly overestimate or underestimate the AOD impact on CC in regions where AOD and WV have similar or opposite seasonal variations, respectively" to "Hence, studies of AOD-CC relationships based on satellite data, will greatly overestimate the AOD impact on CC in regions where AOD and WV have similar seasonal variations, while they will probably underestimate the AOD impact in regions where AOD and WV have opposite seasonal variations".

p14013.21, from "Hence, studies of AOD-CC relationships based on satellite data that do not take into account WV, might greatly overestimate the AOD impact on CC in regions where AOD and WV have similar seasonal variations, while they might greatly underestimate the AOD impact on CC in regions where AOD and WV have opposite seasonal variations" to "Hence, studies of AOD-CC relationships based on satellite data that do not take into account WV, will greatly overestimate the AOD impact on CC

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in regions where AOD and WV have similar seasonal variations. Keeping in mind the reasons for the observed overestimations in the three regions studied here, it is logical to infer that, in regions where AOD and WV have opposite seasonal variations the AOD impact on CC may most likely be underestimated if WV is not taken into account".

p14015.27, from "Namely, studies of AOD-CC relationships based on satellite data, might greatly overestimate the AOD impact on CC in regions where AOD and WV have similar seasonal variations, while they might greatly underestimate the AOD impact on CC in regions where AOD and WV have opposite seasonal variations" to "Namely, studies of AOD-CC relationships based on satellite data, will greatly overestimate the AOD impact on CC in regions where AOD and WV have similar seasonal variations, while they may propably greatly underestimate the AOD impact on CC in regions where AOD and WV have opposite seasonal variations".

The referee considers it misleading to imply in p14014.3 that "AOD does have an impact on CC even if synoptic and WV variability are accounted for" because "not all synoptic variability has been accounted for and the remaining positive AOD-CC relationships do not imply a causal relationship". Along these lines, the referee suggests rephrasing to "even after accounting for SLP and WV, weakened positive relationships between AOD and CC often remain". Along the referee line of thought, but taking also into account our argumentation about using SLP as a synoptic conditions proxy in p14012.7-21, we rephrase to "even after accounting for WV and synoptic variability as manifested by SLP, weakened positive relationships between AOD and CC often remain". The referee makes a comment for the interpretation of Fig. 5, stating that "Fig. 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'". The ref suggests that "to address the dependence of AOD on WV (rather than WV on AOD)" it would be helpful "to plot a line of AOD vs WV for different WV bins". We fail to see how such a line figure of AOD vs WV would be helpful if WV is already in bins. We wonder if this is a typos, and instead

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of “different WV bins” the referee meant “different CC bins”. Further, if Fig. 5 does suggest that for small bins of CC, there is no large increase in WV as AOD increases, it does also suggest, viewed from a different perspective, that for small bins of CC, there is no large increase in AOD as WV increases. The referee also points out that any AOD dependence on WV would not be a bias per se. We agree with this latter point, so we rephrased the relevant parts of the text from “there is no large systematic AOD retrieval bias due to aerosol swelling at increased WV” to “there is no large systematic AOD increase at increased WV”.

Referee comment on conclusions p14015.12 and Abstract p14008.5: Taking into account the referee comment, and also our considerations (mentioned also above) about using SLP as a synoptic conditions proxy, we rephrased the respective passages to “Over all urban clusters, for all SLP regimes, CC is found to increase with AOD, thus pointing out that the CC dependence on AOD cannot be explained by synoptic covariability, as approximated by SLP, alone”.

Specific comments

Title: We think that at this point it would not be very appropriate to include “seasonal cycles” in the title, as this would require substantial more results on seasonal cycles than what is currently presented in the manuscript or what could be included in the manuscript within its current focus, so we opt not to. We do indeed have an on-going analysis of seasonal cycles, but the results are so extensive that cannot be included here and will be presented in a future manuscript.

Abstract: a) done as suggested, b) rewritten (see above), c) rephrased (see above).

Data and methods: a) The literature is so extensive on this matter, being a research subject on its own, and it is outside the scope of the present paper to review it. The proposed references might also not be the most appropriate ones for the present paper, e.g., Varnai and Marshak (2009) examine the 3-D cloud effects on MODIS observations of clear sky reflectance, and they are not very appropriate at this point, while

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Huang et al. (2011) examine the effects of this cirrus on AOD, and, while interesting, we also think we should not enter into this discussion here. The two papers referenced in our work present results regarding the quality of both AOD (Remer et al., 2005) and WV retrievals (King et al., 2003). We added also a more recent paper by Remer et al. (2008). b) Indeed Grandey and Stier (2010) identified a scale problem in aerosol-cloud-interaction (ACI) studies, but as they note, "Analysing satellite datasets over large regions may introduce spurious relationships between aerosol and cloud properties due to spatial variations in aerosol type, cloud regime and synoptic regime climatologies". Also (Figs. 6 and 7 of Grandey and Stier), this problem is much less pronounced over land (where our study was conducted, being smaller than 5% for the scale sensitivity of Ne to τa up to 80×80 regions and also being smaller than 5% for the scale sensitivity of re to τa up to 80×80 regions. As our three studied regions range from 20×30 (PRD) to 40×50 (BTH), no significant scale problems are expected according to the Grandey and Stier results on the issue.

Results and discussion: a) "to exclude" changed to "to exclude, at least partially". b) we will also add all the relevant Terra results in the Supplementary material as Figs. S4 to S6., see below at Annex I of this response. c) this would indeed be an interesting exercise, but see our response to the Specific Comment on the manuscript title above. d) sentence amended (see above in our response to the refs major comment). e) rewritten, see our response to major comment, above. f) see above in our response to the refs major comment. g) Reference to Meskidze et al. added.

Conclusions: a) See our response to major comments, above. b) Sentence rephrased, see our response to major comments, above. c) Indeed. We added the following sentence to the relevant discussion section part (not the conclusions section), p14014.12: "Also, the results suggest a profound interference of the hydrological cycle with the aerosol climatic impact, that needs further investigation. Recent studies also point out to different aspects of the aforementioned interference (Grandey et al., 2014, Gryspeerdt et al., 2015, Rosenfeld et al., 2014)". d) Statement revised, see our re-

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sponse to major comments, above. Additional references: Rosenfeld et al. (2014) ref. added (see response on conclusions c) above. Ref. to Gryspeerdt et al., GRL, (2014) added also, as Gryspeerdt et al., 2014b, and included in the Discussion section part that deals with CTP ("Recently, Gryspeerdt et al. (2014b), using satellite data, reported that apart from AOD, CTP is also strongly correlated to CTP and argue that influences such as aerosol humidification and meteorology play an important role and should be considered in studies of aerosol-cloud interactions.").

Figures: Figure 1. a) Label applied in revised version of the figure. b) The MODIS TERRA AOD550 global average is estimated at ~0.1523 for the period 2003-2013. This value is given now in the caption. c) Y-axis label applied in embedded figure in revised version of the figure. d) Acronyms explained in caption. Figures 2-4a), b), c): We considered making the proposed adjustments to the figures, but prefer not to implement them as we think this will deteriorate slightly the clarity of the figures (the figs. will have to get smaller). Figure 5: Again, we considered making the proposed adjustment to the figure, but prefer not to implement it as we think this will deteriorate slightly the clarity of the figure (the fig. will have to get smaller). Figures S1 and S2: No, these are daily data, smoothed with a 20-day moving average. This will be clarified in the caption in the revised version.

Tables S1-S5: Yes, a=0.05 means the same as p=0.05. a will be changed to p in the revised version, to avoid misunderstandings.

Technical corrections/suggestions All corrected as suggested by the referee.

Annex I: Figs S4 to S6 to be added to the Supplementary Material:

Captions of Figs. S4 to S6.

Figure S4. MODIS TERRA, Beijing-Tianjin-Hebei (BTH) urban cluster, 2003-2013, AOD-WV-CC (a-b), AOD-WV-CTP (c-d) for SLP <1008 hPa, and AOD-WV-CC (e-f), AOD-WV-CTP (g-h) for SLP>1017 hPa. NaN at the cloud data color bar denote no

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values or less than 6 values in this bin. Figures on the left present average CC and CTP values in 1 cm WV and 0.1 AOD bins, while figures on the right present results as line graphs. The line graph CC-AOD and CTP-AOD relations were calculated by averaging CC and CTP within 0.1 AOD bins for several 1cm WV classes.

Figure S5. As in Fig. S4, but for the Yangtze River Delta (YRD) urban cluster.

Figure S6. As in Fig. S4, but for the Pearl River Delta (PRD) urban cluster.

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

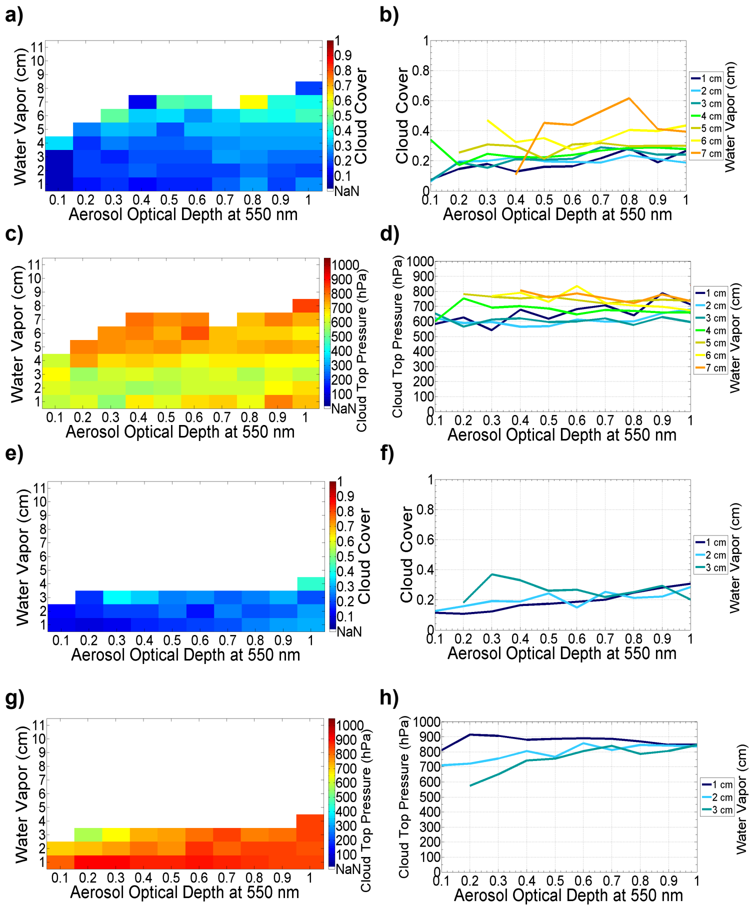

Fig. 1. Figure S4

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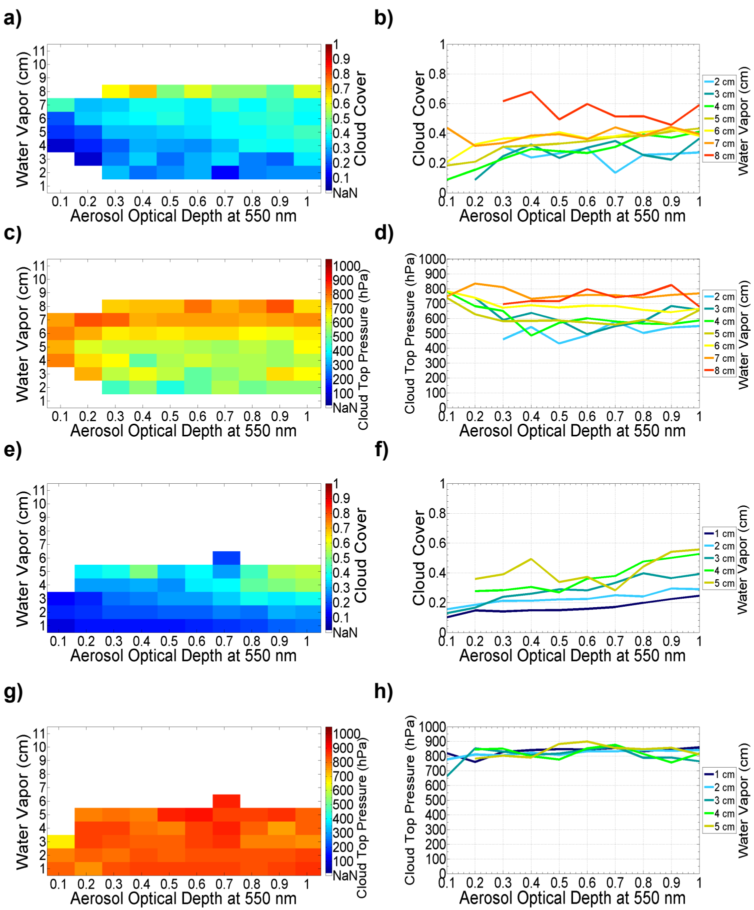

Fig. 2. Figure S5

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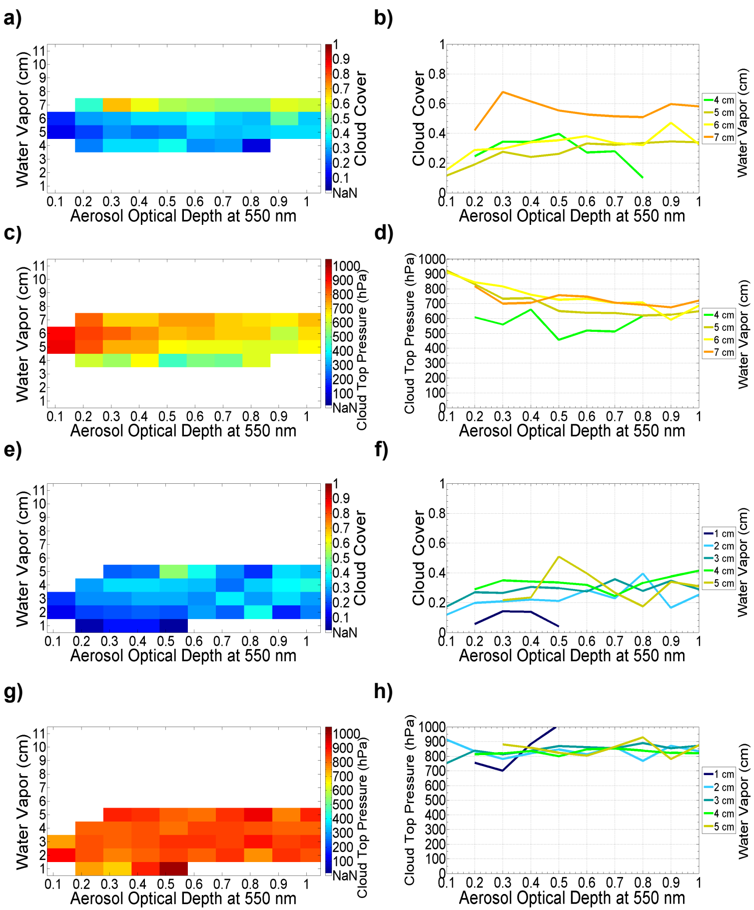

Fig. 3. Figure S6

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