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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol-cloud interaction inferred from MODIS satellite data and global aerosol models" *by* G. Myhre et al.

G. Myhre et al.

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We thank for the useful comments from the Reviewer.

Minor comments 'MODIS' rather than 'Modis' Response: Taken into account

9352: Line 10: why the split at AOD >0.2? Response: In the summary we have added the following: 'We have split the results at AOD=0.2 since the results differ for AOD above and below this number'

Line 10: be more specific on what you mean with 'aerosol-cloud interactions' Response: We have added in the first paragraph in the introduction after the sentence with 'aerosol-cloud interactions': 'In particular how aerosols influence clouds and its microphysics.'

Line 11: was do you mean with 'meteorology' (synotics?, weather-systems?, frontal

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passage?) Response: ‘meteorology’ is replaced with ‘large and mesoscale weather systems

Line 12: aerosol without water uptake (not very realistic): ALWAYS aot decrease with more cloud cover? Response: Added ‘Sensitivity simulations show that’ and added ‘mostly’ before ‘decreases with AOD’

Line 21: I do not see the low cloud-fraction is an reason to dismiss cloud contamination Response: We have added in the abstract ‘we argue that’ and we refer to response on comment on page 9366 and line 25 with references to existing literature.

9353: Line 14: add “ ˇ Eand increased reflectivity of solar insolation. This cloud ˇ E. Response: The suggested text is included

Line 15: delete ‘for’ Response: Taken into account

Line 18: can inhibit precip, can ˇE (it not necessarily does) Response: Taken into account

9354:

Line 2: Kaufman algorithm makes many asumptions and is only produced over oceans! Response: We have noted that this algorithm is only over ocean

Line 6: are these all observation or are these model results? Response: These are all observational studies

Line 15: ‘due to aerosol’ how do you know? give a reference for this statement. Response: The sentence is somewhat rewritten in order to show that this finding is from the Rosenfeld et al. (2006) study

Line 16: Lohmann’s results are based on a model, which may be wrong (my analysis shows that MODIS aot data correlations with cloud cover are often stronger than those for cloud LWC and that correlation are not necessarily positive, as negative correlations are expected over land, especially in regions/seasons of pollution and biomass

ACPD

6, S7223–S7229, 2007

burn- ing - probably from s semi-indirect effect) (when introducing results for indirect effect signatures do not always switch between obs and simulations) Response: In the description of the Lohmann paper it is noted twice that this is a model study. We thank the reviewer for his views on this issue. We still want to refer to this paper to underline the large uncertainty in this field and have added the following sentence: 'Although it must be noted that LWP and cloud cover in GCMs are treated in relatively simplified way'

9355: Line 11: mention that you talk about WATER clouds Response: We have studied the total cloud cover

Line 15-20: Do we care about water vapor or ambient relative humidity. Anyway I am not certain in which way the water vapor (especially on larger scales) would change, given any of the mentioned indirect effects (also it is better to have references when making statements that are not quite clear) Response: We have changed the wording so that it is not so clear in which directions changes in ambient water vapour will be

Line 24: what do you mean that there are no aerosol cloud-interactions in models. There certainly is aerosol processing (e.g. removal) and an aerosol aod dependence on relative humidity considered in modeling. Response: We have added 'aerosol impact on cloud cover and cloud properties'

9356: Line 2/3: I assume you mean the analysis of satellite data (as the previous sentence was about modeling) Response: It is added 'of satellite data'

Line 8/9: meteorological conditions ? meteorology? Response: Changed to 'large and mesoscale weather systems'

9357: Line 14: you use year 2000 ECWMF data ˇE., yet you use MODIS 2001 data. Why couldn't it be the same year. This would be much more meaningful. Response: Unfortunately we do not have aerosol distributions from the Oslo CTM2 for the year 2001. As shown in Figure 6b the difference in the AOD and cloud cover relation-

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6, S7223–S7229, 2007

ship varies little for different years (10 month available for 2000). This is the case also for relationships of AOD vs water vapour and AOD vs LWP

9359: Line 10: we know there are snow contamination problems at NH high latitude. Also the high aots in the SH esterlies are likely from contamination with clouds (I suggest to use the new collection 5 to verify that) Response: Collection 5 is not ready yet for the full period we have studied

Line 14: not surprising as MODIS (coll. 4) data over land have severe accuracy issues if available Response: Since collection 5 is not available for the period included in this study we have not been able to investigate this issue

Line 12: Figure3: Are the PDFs based on daily data? I suggest to use MODIS equivalent sub-samples from modeling otherwise it could be apples and oranges (e.g. for Africa). Also note that PDF are contaminated by seasonal cycles (e.g. trop. Biomass burning) Response: It is added the following: 'The analysis is based on daily data.'

Line 18: say so: marine aerosol (30_S-20_S), smoke (20_S-5_N), mineral dust (5_N-25_N), and pollution aerosols (30_N- 60_N) do not refer to another paper for definitions Response: The four regions are included in the manuscript.

Line 19: the increase in cloud cover with high aots involving hydrophobic dust is a bit surprising as dust loads are higher at dry conditions. This is expected near sources but these regions are far away in off-flow regions where sources of sea-salt are more relevant: so no surprise (e.g. more convection  mode windspeed  more sea-salt spray) , ditto for biomass. Response: We agree that the increased cloud cover in areas with dust is somewhat surprising. We have slightly reworded the sentence to show this

9360: Line 4: what, if MODIS dust is interpreted as cloud? This cannot be ruled out. Response: We have add these 2 sentences:' However, it cannot be ruled out that MODIS interpret dust as clouds. Although this is less likely for AOD lower than 0.6 as

ACPD

6, S7223–S7229, 2007

considered here.'

Line 6: I would expect the leveling off as in the model and anti-correlations between aot and cloud cover at high aot events, because these are usually dry conditions (with few clouds). Could this be a retrieval issue? Response: See response to comment above

9361: Line 6: Is the MODIS tendency a reflection of met. conditions (e.g. dry clear conditions after precip) ? Response: We have included the following sentence: 'If the MODIS results are a reflection of the meteorological conditions (e.g. dry clear conditions after precipitation) this would imply that the models have too weak aerosol washout.'

Line 20: for the Indian Ocean we would expect Monsoon seasonality (polluted +less cloud in dry season as compared to Monsoon time: anticorrelation expect ˇE thus it might be better to investigate in terms of seasonality) Response: We have added the following paragraph: 'The seasonality in AOD is significant in some regions such as in the Indian Ocean. In this region the strong increase in cloud cover with AOD for low AODs in the MODIS data and the modeled decreased cloud cover with increasing AOD for the dry case are very similar for the four seasons.'

9362: Line 9: when you use the MODIS liquid water path product, did you filter for warm ($>$273K) cloud top T ? Response: No, we did not apply such a filter but the MODIS retrieval distinguishes between liquid water path and ice water path.

Line 11: these are very general statements. If you look at correlation fields there are differences with respect to aerosol type: over oceans dust-outflow is usually show anti-correlations, while pollution and biomass outflow regions usually are positive correlated. At high latitude storm-tracks there are also anti-correlations but I am worried there about incorrect interpretations from sub-pixel cloud contamination Response: We have added the following sentence: 'It is worth noticing that sub-pixel cloud contamination may influence these relationships'

ACPD
6, S7223–S7229, 2007

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9363: General: relative humidity would be much more interesting ˇE but this is a 3D field and altitude dependent Response: Relative humidity would be more interesting for investigating the importance of swelling of the aerosols and to understand the cloud cover increase. Whether aerosols impact the speed of the hydrological cycle the column water vapour is more important.

9364: General: if we would only have small particles then the Angstrom parameter would decrease with swelling. However, if the ratio of accumulation/coarse aot gets larger then the Angstrom increases. In many cases the second effect in case of pollution can partially or more than partially offset the the swelling effect Response: The following sentence is added: 'The Ångstrøm exponent may also change if the ratio of the small and large mode particles changes.'

Line 20: the increase in cloud-height should be more thoroughly investigated. Most interesting in terms of The indirect is the altitude of water clouds (and I believe there is hardly any correlation with low level cloud top, which by the way has severe retrieval issues) The idea of invigorated clouds (the Rosenfeld idea) only works if clouds are already present, as pollution arrived, yet if there are no clouds to start with there won't be any invigoration rather a suppression to create clouds (semi-indirect). Response: We thank for this comment but we regard this as beyond the scope of this paper.

9366 Line 14: low aot retrievals are strongest impacted by sub-pixel contamination. Small cloud cover does not say anything about the spatial distribution of this cloud cover (many small sub-pixels cannot be ruled out) - so I do not buy the argument attributed to Kaufman and Zhang. I think to advance our understanding on the humidity effect near cloud we need information about the proximity of aerosol near a cloud pixel. Response: We find this comment quite interesting, but still we find it appropriate to refer to existing literature.

9367: Line1: I find relatively fewer positive than negative correlations between aot and Angstrom parameter for MODIS data. There is a lot of variations spatially, which make

ACPD

6, S7223–S7229, 2007

global generalities quite difficult. Also given the problems with AOD land retrievals of MODIS, only the ocean correlations should be considered: Based on outflow regions MODIS data show for biomass/pollution usually positive correlations and for dust dominated regions usually negative correlations Response: We have added: Also over ocean where the MODIS aerosol retrieval has smaller uncertainty than over land there are more regions with increase than decrease in the Ångstrøm exponent with AOD.

Line 10: these are (I think too) strong statements regarding the semi-direct effect. Again I think it depends, if clouds were there to begin with. Response: In our opinion the statements are phrased taking this uncertainty into account.

9367: There are other issues with r,eff derivations from MODIS data. Generally there is an overestimation in cloud-droplet size in particular in case of broken cloud fields. The expected anti-correlation is actually seen between aod and low level cloud eff. Radius in the MODIS data ˇE but manily over oceans. If taking the effective radius of all clouds correlations are more frequent, which tells me that relationship of the general sense (without filtering for low level clouds, where most aerosol are expected) are even more difficult to interpret. Response: We have added the following: Marshak et al. (2006) discuss the possibility that the cloud effective radius is overestimated.

9368: Line 10-15: the conclusion are not very satisfying. Why doing all that work with concluding that everything may be 'fictious'? Response: The paragraph is modified and 'fictitious' is removed

Line 18+ : it would be nice to discriminate by aerosol type rather than making a global statement ˇ E. and I fully agree with the last sentence of the paper Response: We agree this would be nice followup of our work, but we regard this beyond the scope of this paper.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 9351, 2006.

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6, S7223–S7229, 2007

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