

Interactive comment on “Impacts of water vapor/aerosol loading trends and land cover on aerosol microphysical and radiative effects on clouds during the Amazon biomass burning season” by J. E. Ten Hoeve et al.

Anonymous Referee #1

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This manuscript reports an analysis of the impacts of biomass burning smoke on warm clouds during the dry-to-wet transition season using MODIS observations of aerosol, cloud, water vapor, temperature, and land cover. The analysis consists of two parts. The first part examines the day-to-day variation of column water vapor (CWV) and weak dependence of CWV on aerosol optical depth (AOD), and then uses CWV to stratify data for examining aerosol-cloud interactions. The second part examines possible role of land cover in regulating aerosol-cloud interactions. Results from this original research will add significant value to the ongoing discussion of complex aerosol-cloud

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interactions. In particular the paper makes a strong case that it is important to remove meteorological interferences when extracting aerosol-cloud interactions from observations. The paper is generally very well written, though some efforts could be made to tight up the paper a little bit. I recommend the paper be published in ACP after minor revision.

Specific comments: 1. The paper deserves a better title. In particular, “trends” should be avoided here and THROUGHOUT the paper. People usually use “trend” to describe variation over long time spans e.g., 20+ years. You are discussing day-to-day variations of water vapor and AOD over the dry-to-wet transition season only. Does a title like “Aerosol microphysical and radiative effects on warm clouds during the Amazon biomass burning season as observed by MODIS: roles of water vapor and land cover” better describe what you are presenting?

Abstract 2. p.24920, line 2: better remove “high resolution” because MODIS has “Moderate” resolution just as its name suggests.

3. p.24920, L9: change “Previous studies” to “Many previous studies”.

4. p.24920, L22-24: “. . .then a linear relationship between the indirect effect and increasing AOD, assumed in a majority of global climate models. . .”. First, “the indirect effect” is ambiguous here. What are you referring to? Second, I am not sure if a majority of global climate models just simply assume “a linear relationship” between something and AOD.

Introduction 5. p.24921, L7: change “large uncertainties in our climate system” to “large uncertainties in the understanding of Earth’s climate system”.

6. p.24921, L13: there is a modeling study that discusses possible roles of aerosol absorption on the South America dry-to-wet circulation transition: Zhang et al. (2009): Impact of biomass burning aerosol on the monsoon circulation transition over Amazonia. *Geophys. Res. Lett.*, 36, L10814, doi:10.1029/2009GL037180.

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7. p.24921, L24: Andreae et al. (2004) argue that smoke aerosol slows the hydrology cycle through aerosol microphysical effects. I don't think the paper provides any direct evidence that "smoke cools the surface, increases the static stability. . . ., suppresses surface heat and moisture fluxes". So this is not an appropriate reference for here.

8. p.24923, L22-27: The atmospheric boundary layer height in the region is generally 1-2 km (lower over forest and high over pasture). It is reasonable to say "the majority of biomass burning smoke exists at or below the cloud layer at an approximate altitude of 3 km", as Davidi's case studies are corroborated by some CALIOP and GLAS analyses over longer periods. So you should not say the smoke is "generally mixed with the boundary layer".

9. p. 24924, L1-3: I would suggest to change the sentence to: "In some studies of aerosol-cloud interactions, variations of cloud properties are assumed to be weakly dependent on meteorology due to the stationary high pressure systems during the biomass burning season".

10. p.24924, L13: "longer timescales", longer than what?

11. p.24925, L1-3, "smaller" and "finer" than what?

12. p.24925, L4-7 and L17: you describe the lower branch of mesoscale circulations (a flow from forest to pasture) introduced by heterogeneity of land cover properties as "land breeze". But I think the otherwise. This kind of flow is analogous to the sea breeze and people call it "inland sea breeze".

14. p.24925, L16-17: I don't believe Koren et al. (2004) show evidence that "cloud fields generally form by noon and dissipate overnight throughout the Amazon Basin". There should be more appropriate references, such as Silva Dias, M. A., Rutledge, S., Kabat, P., Silva Dias, P. L., Nobre, C., Fisch, G., et al. (2002): Clouds and rain processes in a biosphere-atmosphere interaction context in the Amazon Region. Journal of Geophysical Research, 107, 8072. doi:10.1029/2001JD000335 and references

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therein.

15. I think some efforts can be made to tight up the Introduction.

Data and methods 16. This section can be tighten up too by simplifying description of the data.

17. p.24926, L7-10: You already stated why you choose Aqua over Terra. So you may not need to say why you choose MODIS over MISR (because MISR doesn't fly on Aqua). Also you don't mention MODIS's much better coverage.

18. p.24926, L11, "Data from these products, which are provided at resolutions between 1-km and 5-km..." "these" is a little ambiguous. It appears in the context that "these products" include aerosol, cloud, water vapor, and temperature. But MODIS aerosol product is at a resolution of 10 km, not 1km or 5km.

19. p.24926, L20-22: "yield" should be "yields". It is better to cite the most recent MODIS over-land aerosol validation paper: Levy et al., Global evaluation of the Collection 5 MODIS dark-target aerosol products over land. Atmos. Chem. Phys., Vol 10, pp 10399-10420, doi:10.5194/acp-10-10399-2010, 2010.

20. p.24928, L19: "...increases with time....", at what time scale?

21. p.24929, L7: Are 700 hpa wind vectors representative of weather pattern? Need a reference here.

22. p.24929, L29: change "between MODIS and AERONET retrievals" to "between MODIS retrievals and AERONET measurements".

Results 23. It may be better to change 3.1 title to "Effect of water vapor variability on aerosol-cloud interactions".

24. p.24930, L21-24: It may be not that straightforward to extend the conclusions over the tropical Atlantic to Amazon basin.

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25. p.24931, L9-14: I don't quite understand these statements. It appears to me that these statements contradict with those in line 26-29. Or maybe I missed something here.

26. p.24932, L15: what do you mean "source variations"?

27. p.24932, L27-29: "...because CWV should not be affected by a warming atmospheric column". Can the warmer atmosphere promote more evapotranspiration and hence CWV?

28. p.p.24933, L26: "five percentile groupings". Is it enough to just say "five groupings"?

29. p.24934, L4-7: It is not surprising to me that "CWV only varies marginally between AOD bins" because you have grouped CWV into 5 bins. I think you may not need to show Figure 5a anyway.

30. p.24934, L8 to p.24935, L6: It is interesting that you show difference in the cloud fraction-AOD relationship between this study and Koren et al. (2004, 2008). Later on you attribute part of reasons for the difference to the North-South gradient of aerosol absorption. Do you think the variation of CWV may have "contaminated" those previous analyses?

31. p.24935, L7-8: "If the aerosol is affecting cloud microphysics, the signal should be apparent in the cloud optical depth (COD) as well in the cloud fraction". I am not quite sure about this assertion or hypothesis. There may be some processes (e.g., entrainment, aerosol absorption, etc) that compete with aerosol microphysical effect and the observations may not show signals that are consistent with the Twomey effect.

32. p.24937, L2: what do you mean by saying "non-polluted values of COD"?

Section 3.2 33. How about changing title to "Effect of land-cover on aerosol-cloud interactions"?

34. p.24938, L5-6: You should also mention albedo change that modifies the net

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surface solar radiation.

35. p.24938, L11: you should consider moving the last sentence of this paragraph (p.24939, L3-4) to here, immediately before “Warm cloud...”. You did a good job in explaining the forest-pasture contrasts and citing literature. Because this is not your main focus, probably you could consider to tight it up by rephrasing.

36. p.24940, Figure 8b and corresponding text: It is interesting that CWV difference between forest and pasture doesn't seem to change with increasing AOD. This observation evidence seems to corroborate with results of several model simulations, such as Matsui et al., 2008; Zhang et al., 2008, and Yu et al., 2002. These modeling studies show that absorbing aerosol reduces sensible heat flux much more than evapotranspiration over land. So the local source of CWV would not differ significantly between forest and pasture. Although Zhang et al. (2009) suggest that absorbing aerosol can change the monsoon circulations that would influence large-scale moisture transport and CWV, it is not expected that the resulting CWV change would depend on land cover.

Matsui et al. (2008), Aerosol light scattering effect on terrestrial plant productivity and energy fluxes over the eastern United States. *J. Geophys. Res.*, 113, D14S14, doi:10.1029/2007JD009658.

Zhang, Y., et al. (2009), Impact of biomass burning aerosol on the monsoon circulation transition over Amazonia, *Geophys. Res. Lett.*, 36, L10814, doi:10.1029/2009GL037180.

37. p.24942, L20: what is NE, WE?

38. p.24953, Fig.1: What is the white dashed line across the map? “Yellow pixels represent...” it doesn't appear “yellow” in my screen.

39. p.24955, Fig3: Because (a) and (c) look so much alike (so are (b) and (d)) in terms of variations, probably you only need (c) and (d) and say something in text about (a)

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and (b).

40. p.24959, Fig.7 caption: What do you mean “Clouds that extend throughout the column may be misclassified as heavy aerosol plumes”? Some aerosol features are actually clouds? 5th percentile and 50th percentile are not clear to me. Did you sort the cloud top pressure from low to high or from high to low?

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