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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Meridional distribution of aerosol optical thickness over the tropical Atlantic Ocean" *by* P. Kishcha et al.

Anonymous Referee #1

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This paper analyzes satellite products and assimilated data sets over the tropical Atlantic to explore the meridional distribution of aerosol, cloud and rainfall products. The paper is well-written. Previous literature is well-referenced.

By using MERRAero data for their aerosol, which is satellite-assisted model results, the authors can distinguish between different aerosol types, including dust and OC/BC that is associated with biomass burning smoke in their area of study. This is a nice capability not directly available from satellite products. The MERRAero total aerosol optical depth is compared with MISR products and looks really, really good. The cloud fraction data are taken directly from MODIS aerosol products, as are the rainfall products taken directly from TRMM.

The authors use their data set to identify both temporal and spatial associations between total aerosol, aerosol types, cloud fraction and precipitation. They show that some of the asymmetry in cloud fraction between northern and southern hemispheres is linked to the migration of the ITCZ and its hemispherical asymmetry. However, they note a spatial association between the location of the dust and maximums in the cloud fraction.

The authors imply, but do not state in their conclusions, that increasing cloud fraction is due, in part, to increased aerosol loading.

From my perspective, these results are interesting without being important. Without a conclusion that discusses the possible reason(s) for these observed associations, the paper adds little value for the community.

Discussing possible reasons for these associations is not easy. My first thought is that the MODIS Cloud Fraction is contaminated by heavy aerosol loading and that is why the associations are so strong. There are several different cloud fraction products available from MODIS. I believe the authors are using the cloud fraction that is derived from the standard cloud mask (MOD35). The purpose of this mask is to identify clouds, but to err on the side of preventing "leakage". It may very well call heavy aerosol "cloudy".

There are other possible reasons for the observed associations, including some that are physical mechanisms. However, it would surprise me if cloud fraction is increasing through the Albrecht (1989) mechanism. Here in this study the authors find the strongest relationship between aerosol and cloud fraction when the aerosol is very thick. We know to expect the strongest relationships when clouds are starved for CCN, when aerosol goes from pristine to moderately loaded (Koren et al., 2008, 2014). A physical possibility may be a pathway that involves ice nuclei and ice processes. All we see here is cloud fraction, so we don't know if the association between aerosol and clouds affects water clouds, ice clouds or both.

When the aerosol is very thick it should create a temperature signal in the vertical temperature profiles because both dust and OC/BC are absorbing aerosols that absorb sunlight and heat the column (Alpert et al., 1998; Ackerman et al., 2000; Koren et al., 2008). The more aerosol, the greater the amount of heating. Most studies associate this heating with a suppression of cloudiness, so that there should be a negative correlation between aerosol loading and cloud fraction. I know of one paper by Johnson et al., (2004) that finds a physical mechanism that can explain increased cloudiness, due to the heating, in this region. There may be others.

Anyway there are several possible reasons why we see these associations, some because of artifacts or co-varying meteorology, and some perhaps because aerosols are influencing the clouds through microphysics or by changing the environment in which the clouds evolve. Simply discussing all the possibilities, as I have done here, still only lifts the paper to the mediocre level. Some attempt should be made to PROVE which possibility is the most likely.

There is nothing WRONG with the analysis presented in this paper, but I question whether simply presenting the results of the analysis with no conclusion is worth publication. I do not recommend publishing this paper in this form.

Minor comments:

My comments are linked to the web-based (non printer friendly) version of the paper.

p. 23312 lines 17-23. Why does the meriodional distribution of aerosol and cloud fraction matter? No where in the introduction do the authors explain their motivation for doing this study.

P23313 line22 and throughout the manuscript. The authors use ten yr to denote ten-year or 10-year without explaining what yr stands for. The journal style book may disagree with me, but I feel that ten-year or 10-year is better.

P23314 lines 23-25. Reference Frey et al. (2008) or Ackerman et al. (1998) so that we know that this is derived from MOD35.

P23316 line 15. Here we have 10yr, which I really prefer to be 10-year.

P23316 line 16. “much more” should be “many more”

P23321 lines 15-16. Do the authors know for sure that it is gravitational settling? Could it not be wet deposition? All that implied aerosol-cloud interaction and I would expect that a lot of aerosol is leaving the atmosphere because of washing out in the rain.

Figures 9 and 10, and associated discussion in the text. You lose the inversion as you travel from zone 1 to zone 6. Meanwhile the convection intensifies. The authors see this as cause and effect, which I’m willing to accept. However, the cloudiness decreases. More convection, but less cloud cover. Earlier in the paper the authors noted that in the north-south direction the peak in cloudiness corresponded to the peak in convection, but here in the east-west direction the opposite is true. This only points out that the full story is still hidden. How are cloud types and morphology changing? How do these changes associate with the different types of aerosol? Is there a possibility that the aerosol absorption is contributing to the strength of the inversion? Lots and lots of questions that should be answered or at least partly answered.

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