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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Increasing manmade air pollution likely to reduce rainfall in southern West Africa" *by* Gregor Pante et al.

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Comments "Increasing manmade air pollution likely to reduce rainfall in southern West Africa", by Pante et al.

I commend the authors for taking up an important problem that is understudied.

I recommend minor revision, but I expect authors to address concerns below.

I would suggest up front that the paper should go through critical review to improve grammar and direct "usage" at places. For example, ". . . not inconsistent . . . (Line 424)" can be re-written using a direct expression ". . . consistent . . .". Indirect explanation may lead to misunderstanding. Also, I suggest authors should be careful on some "throw away" phrases such as "traditionally ... (Line 47) and " ... hardly organized convection

. . . (Line 44)". I encourage authors to re-write sentences framed in such way at few places.

Abstract The abstract, in this reviewer's opinion, should incorporate the overarching objective of the work, most important data and methods, and major conclusions. The first few sentences of the abstract are vague and would require either reference or additional explanation. These broad summaries may be removed. Below are examples.

L1-2: "Southern West Africa has one of the fastest growing populations worldwide. This has led to a higher water demand and lower air quality." No evidence and no clear reference. Fast population growth→ more energy demand→ more pollution can be discussed in the body of the paper. This reviewer did not find investigation on population increase and implication of this in the body of the paper.

L3: "little" dry season. What does that mean? Is there "large" dry season? This is mainly a terminology issue. I encourage the authors to consider changing to an appropriate phrase. I am not sure if "short" could substitute "little". Terms "Short rain season, longer rain season, etc." are widely used in African monsoon literature.

L5-7: "Increased pollution"→ "dimming solar radiation"→ "suppressing rainfall" – For a "linear" reader this would be hard to understand. I would encourage more clarity.

L10-12: " . . . decreases in horizontal visibility and incoming surface solar radiation are consistent with the hypothesized pollution impact . . ." . I would defer this to later sections. Or, authors may consider adding clarity.

Sections 1-3: Line 19-25: I encourage authors to consider to significantly reduce or improve the introduction. Most of the statements are not relevant. Just a couple of sentences to indicate the relationship between increasing population and energy demand and what that means to vulnerability. The overarching objective of the paper is explain rainfall trend and variability and the role of pollution resulting from this.

L27: "Generally, the climate of SWA is strongly controlled by the seasonal evolution

of the West African monsoon. Given the proximity to the equator, ...". This is vague. SWA is part of W. African monsoon (note: "Generally" is used). There are several examples that can show bi-modal, tri-modal rainfall away from the equator (about 10o away from Equator). As the authors know very well, the reason low-latitude regions exhibit bimodal or multimodal rainfall pattern are associated with north-south swing of the convective zone (ITCZ in the earlier literature). For example, L28 – dry season Dec-Feb. is related to the convective zone far to the south. I think the month-to-month variability should be described in that context and as described in along lines 31-34.

L44: I recommend extra care in the use of adjectives or modifiers. What does "hardly organized convection" mean? Weakly organized? Also see comments above. Considering proximity of SWA to sea, and given the description in lines 35-45, what is the role of land-sea breeze?

Overall: the first few paragraphs of the Introduction may refocus on trend and mechanisms that potentially explain the trend and setting the stage for "pollution effect".

L47: Again, I suggest remove "traditionally" and rephrase the sentence. Something like . . . " In the literature, marked SWA rainfall variability on interannual to decadal timescale is linked to . . .."

L50" ". . .undergone a mild recovery of rainfall since then . . ..". Can you be more specific? In the 1990? 2000s?

L54-56: "While SST changes appear to have played a role in creating this trend, the seasonality and magnitude of changes remains poorly understood ..." Any reference? This inference is drawn after discussion of "interannual and decadal" variability and trend. It is unclear how is "seasonality" can be discussed in the same line(s).

In the data and methods section, various techniques of trend analysis are discussed. Various parameters that have influence on rainfall have been explored. One way of investigating a quick and simple method to identify most important impact on a predic-

tand is to run a partial correlation analysis. I'm not suggesting to redo the results, but I would like to know if this was considered. The reason I suggest this is that often times two predictors can have strong relationship and can affect one another and analysis based on linear relationship can give biased results.

Association between AOD and rainfall: I would expect a timeseries plot that shows how radiation, cloud cover and horizontal visibility including relative humidity (RH) > 95% vary over time. Before discussing trends, a reader would have a chance to form an idea about how these parameters change over time. I believe this could be justified. This could be shown in section 3.1.

Lines 275: Discussion can be made clearer if you refer to Fig. 3.

Yes, The RH >95% is in LDS deeper compared with other seasons. Deeper RH may be associated with stronger meridional winds (winds are also stronger at lower levels of the troposphere). So, more moist air is brought into (or circulating) the region from ocean. But, this may not be translating into rainfall. Would a local dynamic factor lacking? As shown, LDS is characterized by weak convective organization. Climatologically the convective zone is far to the north. Please explain.

Line 280: Is 06UTC closer to cloud maximum? Since the solar time for the study area is almost the same as the Greenwich time, 06UTC is 6AM local solar time. If my assumption is true, cloudiness over SWA is more like the oceanic condition. Does information for cloud cover is more from more stratified clouds? I thought convective cloud coverage is later in the day for coastal areas (solar noon).

Lines 335-340: Question mark after a reference. Indicates something is missing.

In the Introduction section, there is a discussion related to aerosol transport from out of the study area. Although qualitative descriptions are provided, Aerosol transported from out of the region is not quantified or shown. In lines along line 340-350, since the trend can not be fully explained by the parameters, the conclusion was "anthro-

pogenic aerosols play a role". This is unclear. How do we know whether anthropogenic aerosols play the main role in the rainfall trend? There could be multitude of factors that could explain the patterns. I guess the problem is the relationship between variables identified and aerosols not firmly established ("indirectly" to borrow authors words). I recommend adding a sentence or two explanation to help readers. Explain how "inland transport" might occur (in absence of data, literature might help).

Lines 378-382: This paragraph is interesting. The authors stated that MODIS AOD data is either "not useful" or very limited. Given this justification, I'm wondering why authors decide to continue using it? I suggest the rational for continuing the investigation is unclear. I encourage authors to re-write this.

Section 3.3.2: Visibility and cloud cover As described in the text, the source of visibility measurements are observers. That means this data is prone to biases. One person's visibility estimation could be different form another person's estimate (different people taking observations over time). I am curious if authors consider a different way of looking at the same data. That is, (1) categorize visibility estimates into ranges, e.g., low, medium and high, then (2) workout the frequencies of each category. For example, what is the frequency of low visibility? Then, this can be used to describe the objective of the research. Higher frequency of low visibility can be related to high frequency of fog or bad weather, or pollution. Trend analysis can be performed on frequencies. The advantage of this approach is reducing biases because high and low visibility are categories and do not directly point to a measurement. Interpretation would also be easier. I thought about this because of the following!

I have hard time understanding a 200m/yr reduction in visibility (Line 420). What is the difference between an average 1km low visibility and average 0.8km visibility? How do this be a proxy for aerosols?

Figures: Captions are well explained but can be shortened at places. For example, in Fig. 3 2.0 and ERA5 can be used while omitting their full description. Meridional

wind depiction is confusing. By plotting it as a vector, you are assuming zero zonal wind. Since you are considering one component of the wind field, you may consider using a line plot (with solid for positive and dashed for negative). Describe or give context to symbols just below season captions (e.g., ++ higher convection, O less, and + moderate)

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