Review of "A satellite-based analysis of semi-direct effects of biomass burning aerosols on fog and low cloud dissipation in the Namib Desert" by Alexandre Mass et al.

This manuscript assesses the impact of seasonally emitted biomass burning aerosol (BBA) on the fog and low cloud (FLC) dissipation in the Namib Desert, using long-term geostationary satellite observations, reanalysis data, and a statistical model tasked to disentangle the role of BBA from that of the co-varying synoptic-scale meteorological pattern. They find that the FLC dissipation time is significantly later on high BBA days, which is mainly attributed to the longwave radiative effect of the co-transported moisture and subsequent changes in the regional circulation pattern and atmospheric heating profiles. Although the ridge regression model they trained is able to reproduce the statistical mean difference in the FLC dissipation time between high and low BBA days, it fails to provide definitive conclusions about BBA effects, due to the underfitting issue.

The manuscript is well written and enjoyable to read. I find this work appears of sound methodology and is of great interest to the community, with particular implications for the climate and the hydrological cycle of the Namib Desert.

I do have a few minor points/comments on the paper that I would like the authors to consider and address, in order to improve the manuscript's clarity and the soundness of the conclusions.

Comments:

- Attribution to BBA semi-direct effect. To me, the evidence that the authors demonstrated for a dominant role of the changing meteorological patterns (circulation, heating profile, moisture LW effect) in delaying FLC dissipation time is convincing and robust, but there are two subtleties to this that I think the authors could address/discuss in the paper
    - The definition of 'semi-direct' effect of BBA, one thing I think this paper wasn't very clear about is the definition of the 'semi-direct' effect (appears in the title) or BBA effect, one could argue it's the local effect of BBA on FLC, *all else equal*, or, one could define it as the net, integrated impact of the presence of BBA on FLC (accounting for large-scale circulation adjustments). For example, Diamond et al. (2022) discusses both the "large-scale" and "local" semi-direct effects of BBA on low clouds in the SE Atlantic.
    - Changes in meteorological conditions and coastal circulation that the authors focus on discussing in the paper, to me, is part of this "large-scale" BBA/moisture semi-direct effect. However, there could be potential contributions simply from the spatiotemporally correlated synoptic patterns and regional BBA transport, which has nothing to do with the moisture LW effect or the BBA absorption, one such example is the mid-latitude intrusion events (more frequent in Sept.) that can constrain the smoke plume closer to the continent (e.g., Zhang & Zuidema, 2021, ACP). I wonder if the method used in this study can indicate/control such correlations?

- Clarity on the methodology.
    - It wasn't clear to me whether only June-October are used in the analyses or the whole year was used? (L82 says 15 years of data are used while L344 says only months June-October are used)

- L83 ‘some of the analyses’ and L128 ‘For some analyses,’ are not clear, please clarify and be specific.
- L103, please briefly summarize how does this work, such that one doesn’t need to go to Pauli et al. (2022) to grasp the idea of this method (one can of course read it if more details are sought).
- What are the predictors used in the ridge regression? It says broadly “the predictors are the spatial fields of ERA5 meteorology and BCAOD from CAMS” I assume all the variables mentioned in section 2.3 are included in the training?
- What exactly are the thresholds for BCAOD (25^{th} and 75^{th} percentile)? (a histogram as a supplementary figure would be nice)
    - How good is this column-integrated BCAOD reanalysis, since there are aircraft measurements from the field campaigns in the region, I wonder if this product can be validated against observations?
    - I wonder if the authors have considered using the above-cloud AOD (ACAOD, by Kerry Meyer at NASA) product to indicate BBA loading, given it’s more observationally-based.
    - L120, assuming 15 years of Jun-Oct days are used, a 25^{th} percentile will yield ~562 days for each ‘high BBA’ and ‘low BBA’ group, is there additional screening involved? or missing data?
    - L194, why only 200 days? instead of 300 days (L120)
- In section 2.4, CALIPSO is introduced, but I don’t see how it is used. I couldn’t find anywhere in Section 2 or 3 where CALIPSO data is used/discussed. L279 states the lack of skill of the statistical model could be due to the lack of vertical information of BBA (it confuses me as I thought you used CALIPSO to get the vertical dimension).

- Statistical model
    - In general, I wonder what’s the rationale to stick to this ridge regression *linear* model (given the low R^2 values), over other *non-linear* models, such as CNN or random forest?
    - What’s the ensemble spread in terms of member skill and the prediction of the mean delay in dissipation time?
    - Could you show the scatter plot between truths and predictions for this model?
    - As mentioned in L279, have the authors tried other predictors to try to improve the skill of the model?

Editorial:

- L103, what is ‘logistic regression’? a typo?
- L133, do we know which direction?
- Figure 2, cross and star labels on the map is reversed?
- Figure 3, caption, please define IQR at first use.
- L230-235, what’s the reason for such a strong land-sea contrast (reversed in the sign) in terms of T2M difference between high and low BBA days?
- L349, as mentioned in my first comment, BBA effects can include these large-scale circulation adjustments, depending how one defines it.

- L366, perhaps, given the primary role of BBA - modulating the large-scale synoptic pattern/circulation, the use of this regression model is not suited?
- L375, one possible way of doing this could be the "synoptic matching (or locking)" method used in Quaas et al. (2021, ERL), where, given a location and time, they search in their climatological database for a day with the synoptic pattern that matches the current one the best, but with different aerosol states.
- L375-377, given that CALIPSO is used (?) already in this study and that the key issue is the covariation between meteorology and BBA, I struggle to see how can EarthCARE offer better ways to disentangle aerosol effects.

References

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