“Pollution slightly enhances atmospheric cooling by low-level clouds in tropical West Africa”, submitted to ACP by Valerian Hahn et al., 2022

We thank Referee #2 for his valuable comments and the effort that has been put reviewing the submitted manuscript on the pollution effects on atmospheric cooling by low-level clouds in tropical West Africa.

Response to the General Comment:

We thank the Referee for the suggestion and completely agree to add a conclusion section to the manuscript, which outlines the impact and implications of this study.

This includes the discussion of the representativity of the results concerning season and location.

This analysis comprises a data set from the DACCIWA aircraft campaign segment in June and July 2016. In light of a predicted tripling of anthropogenic emissions in tropical West Africa between 2000 and 2030 alongside an increasing urbanization and demographic growth, the overarching goal of the DACCIWA aircraft campaign, as part of a multidisciplinary project, was to quantify the consequences for the local climate. The underlying motivation was to better understand interactions between emissions, clouds, radiation, precipitation, and regional circulations, with an emphasis on a better understanding of the two-way cloud and aerosol impacts on the radiation and energy budgets from the cloud scale to the scale of the West African monsoon circulation with a certain attention to low-level clouds (Knippertz et al., 2013).

With our study we directly address one essential campaign objective by analysing the radiative impact of polluted versus less polluted low-level clouds, which before the campaign were suspected of being highly susceptible towards local emissions (Knippertz et al., 2015).

Knippertz et al. (2017) describe the meteorology and chemistry corresponding to this monsoon onset season, for which the data set at hand is representative.

Closely correlated to this study is the ubiquitous background aerosol, transported from central and south Africa into the measurement region. This is correlated to agricultural land use in southern and central Africa where each year slash-and-burn methods are used for land cultivation. Outside this period (including a certain transport delay) background biomass burning aerosol from these sources vanish.

Nevertheless, this instance allows us to draw conclusions for similar cases, where additional urban emissions are released into an already polluted background environment. Take cities in South America for instance, here, slash-and-burn methods are used in the Amazon Rainforest. A blending with urban emissions from densely populated conurbations likely has comparable implications. The same holds for regions in south east Asia, either in terms of biomass burning from agriculture or in the agglomeration regions of megacities, where there is no seasonality. These Implications will be added as a in a conclusion section to bolster the significance of our study.

Comment 1:
Line 25: is accumulation aerosol on a number concentration basis?
Answer 1:
Accumulation aerosol has been used in terms of ambient particle number concentrations. The new draft has been modified accordingly.

Comment 2:
Line 31: Add close parenthesis
Answer 2:
A parenthesis has been included at this spot in the revised version.

Comment 3:
Line 36: I don't understand what is being said in the sentence: "Thus, polluted low-level clouds add only a relatively small contribution on top of the already exerted cooling by low-level clouds in view of a background atmosphere with elevated aerosol loading". Are the authors making the case that the indirect cooling from polluted clouds is similar to the direct cooling from pollution aerosols in the absence of clouds? Please clarify.
Answer 3:
The phrasing of this sentence might be inconclusive. We have changed it in the revised version to:
"Thus, the exerted atmospheric cooling by low-level clouds only increases ever so slightly in light of their formation in an environment with a substantial increase of accumulation mode aerosol on top of an already elevated aerosol background."

Comment 4:
Line 234: Should this be $\alpha\Delta\lambda$?
Answer 4:
This has been accounted for in the revised version.

Comment 5:
Line 266: Were the OPC size distributions fitted (say to a lognormal function) in order to account for the accumulation mode contribution below 250 nm?
Answer 5:
The particle number concentration described as accumulation mode aerosol used in this study comes entirely from the OPC Instruments with a cut off at 250 nm. No subsequent fitting to a density function has been performed. Although this lower measurement cut off does not consider the entire accumulation mode, this estimate was regarded as sufficient to be correlated to CO as a pollution tracer.

Comment 6:
Lines 270-272: Were aerosol measurements made within the vicinity of the cloud? Is the accumulation mode aerosol just below cloud well correlated with the CO-correlation-based estimate?
Answer 6:
The aerosol measurements were entirely outside, but (below 1800 m) constantly in the vicinity of clouds. The flight strategy, in order to accommodate all campaign goals, included only few instances where we probed along a prescribed flight track on various altitudes. Unfortunately,

a precise analysis of accumulation mode aerosol measurements just below individual clouds is not possible.
We would like to draw the Referee's attention to the inflight images in figure 1a-c for a better depiction of the cloud situation of low-level clouds land inwards. A typical phenomenon during the campaign was a break-up of the shallow stratiform cloud deck during the late morning and noon, that has formed during the night. Convection either shallow or with a certain vertical extent formed during the afternoon.
Thus, flying below 1800 m altitude necessarily brought us close to clouds (and somewhat below clouds, when flying below).

Comment 7:
Figure 5: what is the lowest droplet diameter shown on the x-axis?
Answer 7:
We thank the Referee #2 for this hint. The x-axis was readjusted according to the low droplet size threshold of 3 µm.

Knippertz, Peter: Dynamics-aerosol-chemistry-cloud interactions in West Africa- DACCIWA Fact Sheet, https://www.imk-tro.kit.edu/download/Dacciwa-FactSheet-eng.pdf, 2013.

Knippertz, P., Coe, H., Chiu, J. C., Evans, M. J., Fink, A. H., Kalthoff, N., Liousse, C., Mari, C., Allan, R. P., Brooks, B., Danour, S., Flamant, C., Jegede, O. O., Lohou, F., and Marsham, J. H.: The DACCIWA project: Dynamics-aerosol-chemistry-cloud interactions in West Africa, B. Am. Meteorol. Soc., 96, 1451–1460, https://doi.org/10.1175/BAMS-D-14-00108.1, 2015.

Knippertz, P., Fink, A. H., Deroubaix, A., Morris, E., Tocquer, F., Evans, M. J., Flamant, C., Gaetani, M., Lavaysse, C., Mari, C., Marsham, J. H., Meynadier, R., Affo-Dogo, A., Bahaga, T., Brosse, F., Deetz, K., Guebsi, R., Latifou, I., Maranan, M., Rosenberg, P. D., and Schlueter, A.: A meteorological and chemical overview of the DACCIWA field campaign in West Africa in June-July 2016, Atmospheric Chemistry and Physics, 17, 10 893–10 918, https://doi.org/10.5194/acp-17-10893-2017,https://www.atmos-chem-phys.net/17/10893/2017/, 2017.


a)
b)

Figure 1 a), b), c): Inflight images from the Falcon research aircraft during DACCIWA campaign from different days.