Response to Reviewer #3

We appreciate your time for carefully reviewing our manuscript. We would like to thank you for the constructive comments and suggestions, which encourage and help us to improve the manuscript. The manuscript has been revised accordingly. In the response below, your comments are provided in black text and our responses are provided in blue text.

Response:

The authors analyze the impact of the environment on the aerosol-cloud interactions (ACI) from ground observations over the eastern north Atlantic. They find that both lower-trosospheric stability and turbulent kinetic energy influence the connection between water vapor, cloud-microphysics, and subsiquently ACI. For instance, they find that higher lower-tropospheric stability leads to higher cloud drop concentrations and ACI.

Overall, I think this paper is both well thoughout and written. However, I do have a number of issues that I would appreciate clarification on. Note that, even though I split my comments between major and minor, this is more of just a distinction between general and technical comments. Therefore, I recommend publication once these comments are addressed.

Major:

Line 147: Is LTS the most appropriate variable to use over the northeast Atlantic, considering the much larger influence of midlatitude cyclones compared to subtropical regions?

We agree with your comment and the other reviewer's comment that the LTS might not be a feasible variable to use over ENA site, and thus we have added the relative discussion in section 3.5.2 of the revised manuscript:

Combining LTS and PWV_{BL} as sorting variables, the ACI_r values for four regimes are shown in Fig. S4. The ACI_r differences between low and high PWV_{BL} regimes are still retained. In the low PWV_{BL} regime, the ACI_r values are limited to 0.016 and 0.056 for low and high LTS regimes, respectively. In the high PWV_{BL} regime, the ACI_r values are 0.150 and 0.171 for low and high LTS regimes, respectively, which is about 3-5 times greater than those in low PWV_{BL} regime. However, the ACI_r in different LTS regimes cannot be distinctly differentiated (ACI_r differences between LTS regimes are ~0.02 and ~0.04), and the main difference in ACI_r are still induced by the PWV_{BL}. Owing to the location of the ENA site where it locates near the

boundary of mid-latitude and subtropical climate regimes, the MBL clouds over the ENA are found to be often under the influences of cold fronts associated with mid-latitude cyclones, where the cloud evolutions are subject to the combine effects of post-frontal and large-scale subsidence (Wood et al., 2015; Zheng et al., 2020; Wang et al., 2021). Therefore, over the ENA, although the spatial gradient of LTS is studied to be associated with the production of MBL turbulence and the change in wind direction (Wu et al., 2017), the LTS value itself is examined to has a weak impact on the aerosol-cloud interaction from this study.

Line 171: How many potential non-precipitating cloud cases were there, and do your results suggest that most MBL clouds produce precip over the northeast Atlantic?

During the study period we found 20 valid non-precipitating single-layer low cloud case that fit in our criteria and also lasting at least longer than 2 hours. And yes, our results support the previous study that over the ENA site, the annual mean drizzle frequency is 55%, with 70% in winter and 45% in summer (Wu et al., 2020).

Line 193: You could highlight that the median LTS of 19.1 K is close to the value (18.55 K) used by prior studies to separate stratocumulus from shallow cumulus.

The result from prior study is highlighted as follows:

Note that the median LTS of 19.1 K in this study is close to the separation threshold of 18.55K suggested by prior studies to distinguish the marine stratocumulus from a global assessment of marine shallow cumulus clouds (Smalley and Rapp, 2020).

Line 226: You compare the logarithmic ratio that you find to other studies, but I don't understand what it actually means.

The ratio reflects the relative conversion efficiency of cloud droplets from the CCN, regardless of the water vapor availabilities. Theoretically it has the boundaries of 0 - 1, where the lower bound means no change of N_c with N_{CCN}, and the upper bound indicates a linear relationship that every CCN would result in one cloud droplet. Our result is comparable with the previous studies that also targeting the MBL stratiform clouds, indicates a certain similarity of the bulk

cloud microphysical responses with respect to aerosol intrusion in those type of cloud and over different marine environments, further support that the assessment in this study is valid.

The discussion above is added in section 3.2 in the revised manuscript.

Figures 5 - 7: There doesn't appear to be much of a trend in the scatter plots, so what is the R^2 value for these regressions? Maybe this could be fixed by constraining your axes to closer to the limits of your datapoints?

In the revise manuscript, we changed to use the sub-cloud PWV_{BL} in sorting the data, as suggested by reviewer #2. We have constrained the plotting axes to be closer to the data points. Since the values of ACI_r have a theoretical upper bound of 0.33 (McComiskey et al., 2009), so even the largest ACI_r will probably not showing a steep trend in the scatterplot. However, the slopes of regression can be distinguished, all linear regressions for those groups of data have been tested by two-tailed T statistic and pass the 95% significant level.

Minor:

Line 77: "relatively shallower" should be "relatively shallow"

The word is changed to ‘shallow’.

Line 78: I think "and is prone to" should be and "are prone to"

It is changed to ‘are prone to’.

Line 80: "marine boundary layer maintained by" should be "marine boundary layer which is maintained by"

The ‘which is’ is added to the sentence.

line 85: "regime of active coalescence process" should either be "regime of the active coalescence process" or "regime of active coalescence"

It is changed to ‘regime of active coalescence’.

line 106: "particularly disentangling" should be "particularly by disentangling"

It is changed to ‘particularly by disentangling’.

line 121: "operates at 910 nm laser beam" doesn't make sense, and maybe could be "operates at 910nm"

It is changed to ‘operates at 910 nm’.

line 159: "from Doppler lidar" should either be "from a Dopplar lidar" or "from the Dopplar lidar"

It is changed to ‘from the Doppler lidar’.

line 183: "lay" should be "lie"

It is changed to ‘lie’.

line 388: Unless I missed something why is Figure 5b discussed before Figure 5a, could you just flip those subpanels?

The figure subpanel is flipped.

Figure 1: This may just be my printout, but the median dashed lines are difficult to see. Could you use a thicker line or a different color?

The median value is now displayed directly on each subpanel in Figure 1.

Reference:

McComiskey, A, Feingold, G., Frisch, A. S., Turner, D. D., Miller, M., Chiu, J. C., Min, Q. and Ogren, J.: An assessment of aerosol-cloud interactions in marine stratus clouds based on surface remote sensing, J. Geophys. Res., 114, D09203, doi:10.1029/2008JD011006, 2009.

Smalley, K. M. and Rapp, A. D.: The role of cloud size and environmental moisture in shallow cumulus precipitation, J. Appl. Meteorol. Climatol., doi:10.1175/JAMC-D-19-0145.1, 2020.

Wu, P., Dong, X. and Xi, B.: A climatology of marine boundary layer cloud and drizzle properties derived from ground-based observations over the azores, J. Clim., doi:10.1175/JCLI-D-20-0272.1, 2020.