Response to Reviewer #1

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:

Using a total of 20 non-precipitating single-layer marine boundary layer (MBL) stratus and stratocumulus cloud cases over the eastern north Atlantic (ENA) ocean, this study investigates the impacts of the environmental variables on the aerosol-cloud interaction (ACIr). Interesting results have been found with valuable discussions. For example, it shows that the ACIr values vary from -0.004 to 0.207 with increasing precipitable water vapor (PWV) conditions, indicating that re is more sensitive to the CCN loading under sufficient water vapor supply, owing to the combined effect of enhanced condensational growth and coalescence processes associated with higher cloud droplets and PWV. The paper is also well written. I would recommend its acceptance for publication after necessary minor revisions.

Detailed comments;

Line 41-44, two "verbs" exist for this sentence, which should be rephrased. Also, a few more studies are recommended here, particularly the longwave radiative property change of clouds by aerosols, such as Garrett and Zhao (2006, Doi:10.1038/nature04636).

The sentence is rephrased, and the citation is added.

Line 48-52, a few similar studies have also been carried out over the western pacific regions, which might be worthy to mention, such as Zhao et al. (2019, Doi:10.3390/atmos10010019), and Yang et al. (2019 , Doi:10.1016/j.atmosres.2019.01.027).

The citations are added.

Line 66-69, Qiu et al. (2017, Doi:10.1016/j.atmosenv.2017.06.002) showed negative relationship between cloud re and aerosol amount for low precipitable water vapor condition in spring, fall and winter at southern great plain site, but positive relationship between cloud re and aerosol amount for high precipitable water vapor condition, which could be also cited

here. Similar findings have also been found over other locations, such as western pacific region near Hebei province, China.

The citation is added.

Line 281-283, similar height normalization method has been proposed and used by Zhao et al. (2018, Doi:10.1002/2017EA000346), which is worthy to mention here. Also, Similar findings (Line 283-287) have been found earlier in several studies, including the study mentioned here.

The citation is added, in section 3.5.1 of the revised manuscript.

Line 319, Eq. (2). Earlier studies often define this for fixed LWC. How could the different definition affect the results?

The LWC/LWP describes the liquid water (i.e., existing cloud droplets), so physically linked to the r_e and N_c. Mathematically, they have interdependent relationship in the cloud retrieval procedures, and hence to a certain extent, share the co-variabilities with the cloud microphysical properties (Dong et al., 1998; Wu et al., 2020a). In this study, by using the PWV as a sorting variable, we are trying to capture the role of ambient available water vapor in the cloud droplet growth process (especially the water vapor diffusional growth), using measurement independent to the cloud retrievals.

The discussion above is added, in section 3.3 of the revised manuscript.

Line 332-343, These are interesting findings and explainations. I wonder if this is related to the supersaturation adoped for CCN observed, or related to the true supersaturation status within clouds.

In order to investigate the theoretical implication of supersaturation conditions on the aerosol-cloud interaction observed here in the MBL stratiform clouds, the ACI_r values are calculated with respect to the surface N_{CCN} theoretically at two additional high supersaturation levels (0.5% and 1.2%), under all PWV_{BL} conditions. The results in Table 3 show that the ACI_r signals are both weak and do not have significant changes under relatively

lower PWV_{BL} conditions, while the ACI_r signals tend to strengthen with the increase of supersaturation under the relatively higher PWV_{BL}. Base on the Köhler theory, if the supersaturation exceeds the critical point for the given droplet, the droplet will thus experience continued growth, so theoretically the ACI should increase with the supersaturation under same aerosol number concentration. However, the observed limited water vapor cannot support this ideal droplet growth, results in weak responses of cloud droplets to aerosol intrusion. With the increase of observed water vapor, the continued growth of cloud droplets becomes more plausible, hence the high supersaturation yields larger droplets with low number of aerosols, more efficient droplet activation with a large number of aerosols, and in turns, larger ACI_r (even out of the theoretical bounds). However, considering these high supersaturation environments are unphysical in the observed MBL cloud layers, and estimating the real supersaturation conditions using ground-based remote-sensing is beyond the scope of this study, we chose the supersaturation level of 0.2% because it represents the most typical supersaturation conditions of MBL stratiform clouds.

Table 3. ACI_r calculated with respect to N_{CCN} theoretically at different supersaturation levels, under all PWV_{BL} conditions

PWV_{BL} (cm)	0.4-0.6	0.6-0.8	0.8-1.0	1.0-1.2	1.2-1.4	1.4-1.6	1.6-1.8	1.8-2.0	2.0-2.2	2.2-2.4
ACI_r (N_{CCN}@0.2%SS)	0.020	0.057	0.002	-0.014	0.108	0.076	0.145	0.151	0.221	0.175
(N_{CCN}@0.5%SS)	0.023	0.057	0.0002	0.024	0.129	0.121	0.309	0.136	0.293	0.159
(N_{CCN}@1.2%SS)	0.023	0.045	0.002	0.072	0.125	0.123	0.323	0.175	0.347	0.186

The discussion above is added, in the last paragraph of section 3.3 of the revised manuscript.

Line 358-376, The mechanism proposed here is valuable. If possible, I would suggest the authors illustrate the mechanism proposed here with a diagram.

The diagram is added as Figure 8 in the revised manuscript as follows:

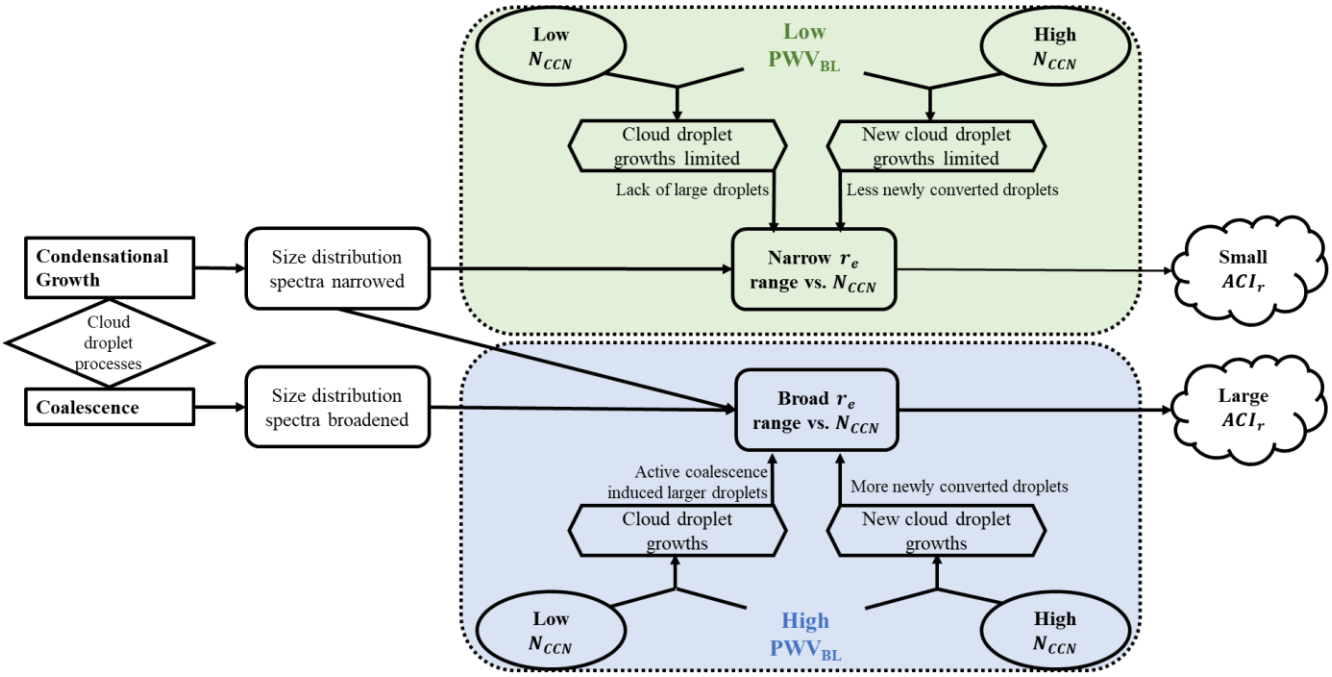

Figure 8. Theoretical mechanism of the responses of cloud droplet size distributions to different CCN intrusion, under relative insufficient (low PWV_{BL}) versus sufficient (high PWV_{BL}) water vapor availabilities.

Line 390, “that more close to adiabatic” shuold be “that are more close to adiabatic”

This sentence is removed in the revised manuscript.

Line 432, “to narrows the DSD” should be “to narrow the DSD”

The word ‘narrows’ is changed to ‘narrow’.