



Supplement of

Investigating the sign of stratocumulus adjustments to aerosols in the ICON global storm-resolving model

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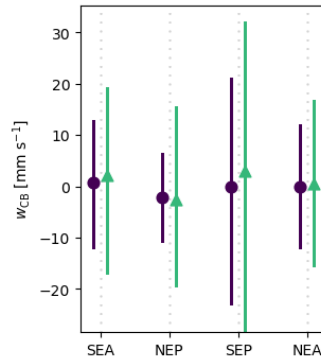


Figure S1. Same as Fig. 2g but showing the variance of cloud-base vertical velocity in the original 5-km ICON data instead of the coarser $0.5^\circ \times 0.5^\circ$ resolution.

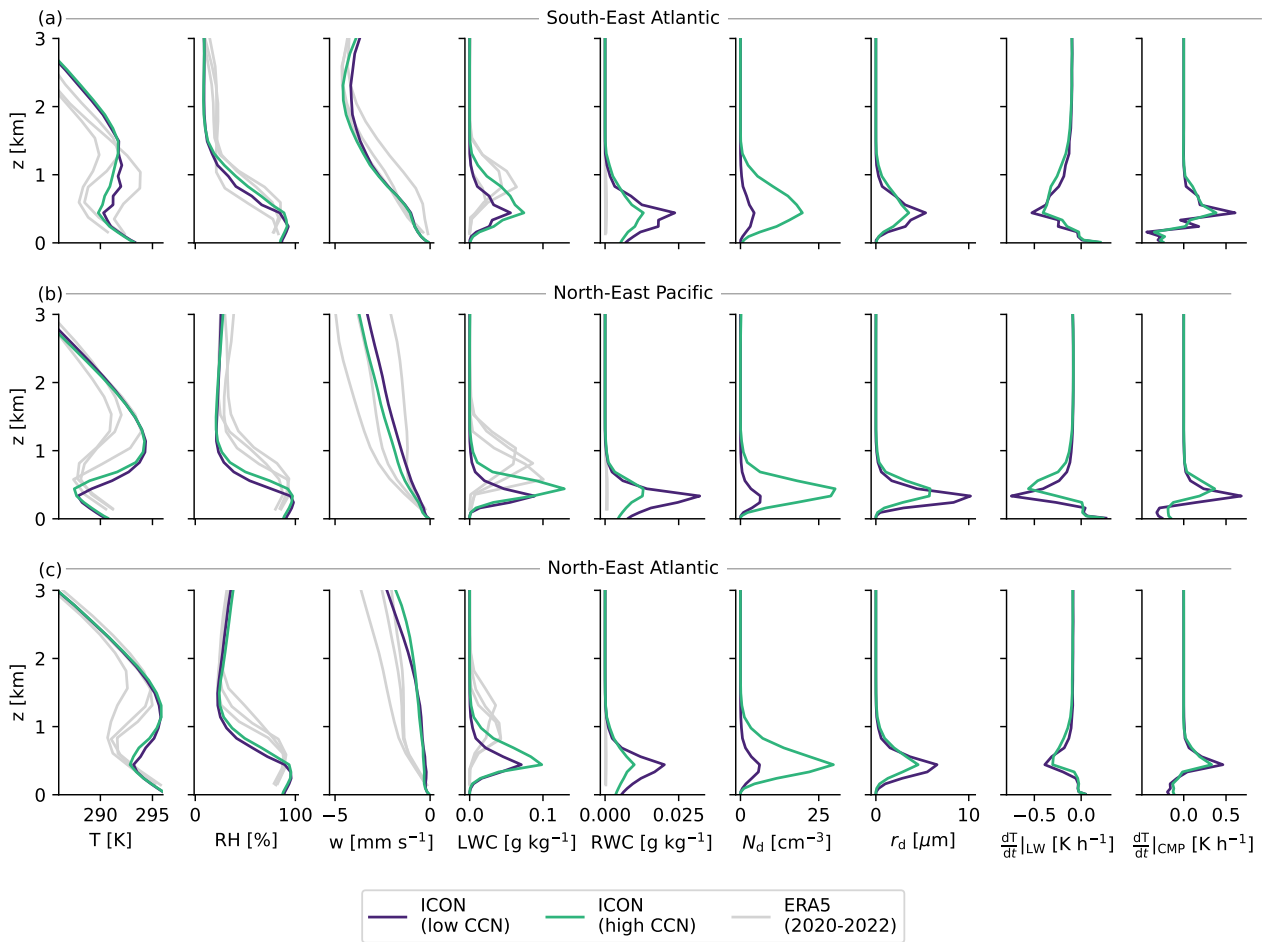


Figure S2. Same vertical profiles as Fig. 4 and 6 but for the SEA (a), NEP (b) and NEA (c) regions.

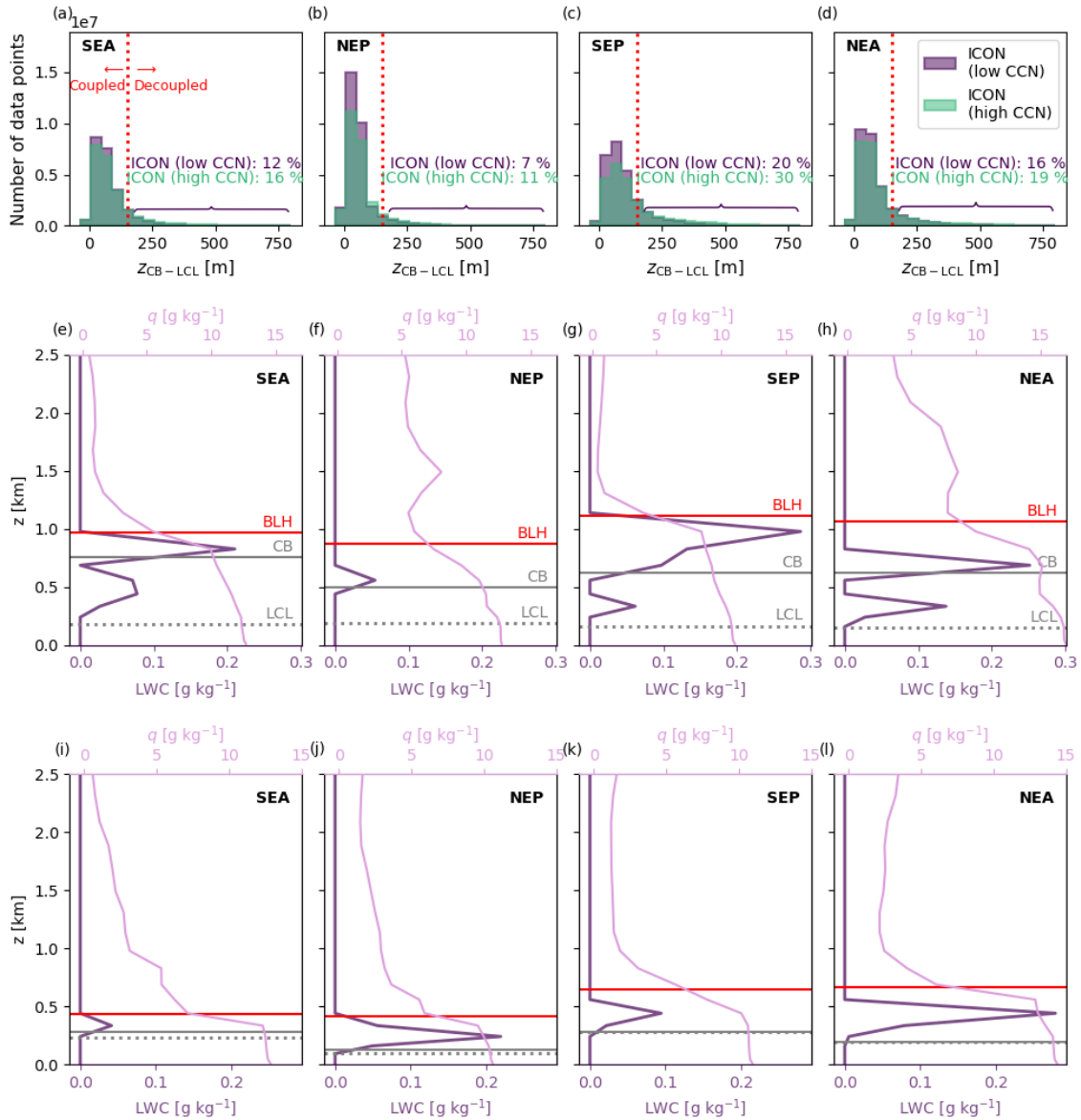


Figure S3. Occurrence of boundary layer decoupling in the ICON simulations. The first row shows histograms of z_{CB-LCL} , a decoupling metric, for the (a) SEA, (b) NEP, (c) SEP and (d) NEA regions. z_{CB-LCL} is the height difference between the lifting condensation level (LCL) and the stratocumulus cloud base (CB). $z_{CB-LCL} > 150$ m identifies decoupled boundary layer (Jones et al., 2011). Percentages of decoupled boundary layers are displayed on each figure panel above the horizontal curly bracket. The second row (e-h) show randomly picked LWC and specific humidity (q) profiles exhibiting decoupling in the ICON (low CCN) simulation for each region. On each profile, the boundary layer height (BLH), CB and LCL are labeled. Similarly, (i-l) show randomly picked profiles for well-mixed boundary layers.

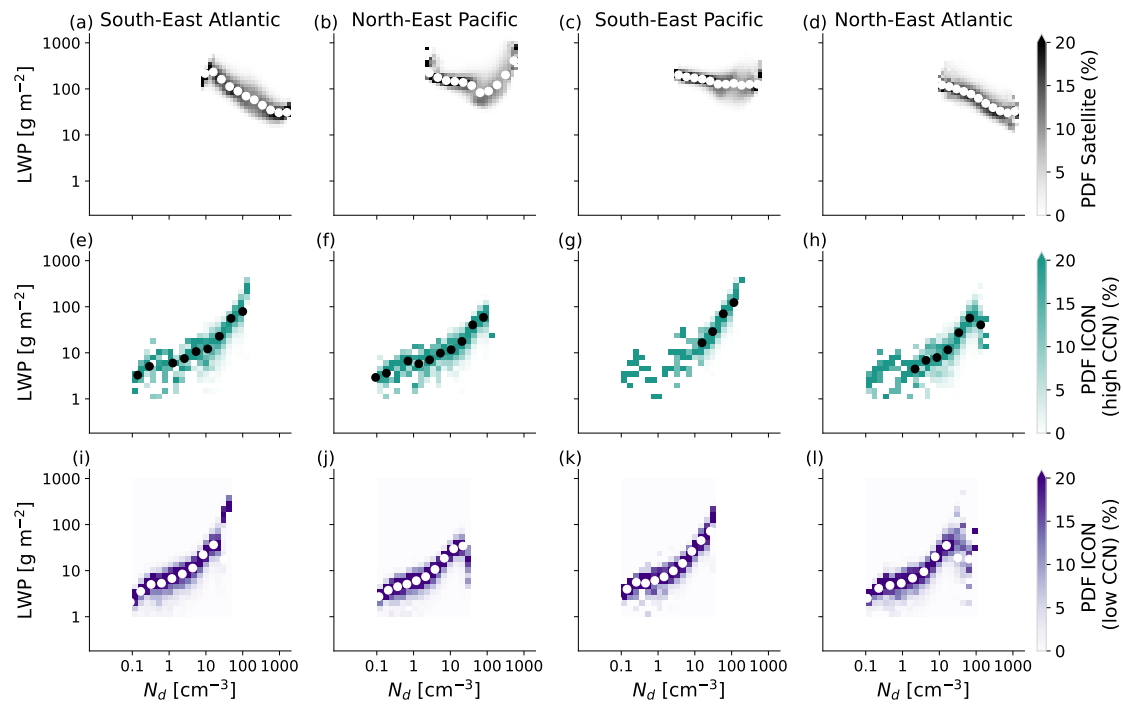


Figure S4. Same 2D LWP vs. N_d histograms as Fig. 5, but disaggregated by region. Subplots show the regional relationships, in the satellite data (a-d), the high CCN ICON experiment (e-h) and the low CCN ICON experiment (i-l).

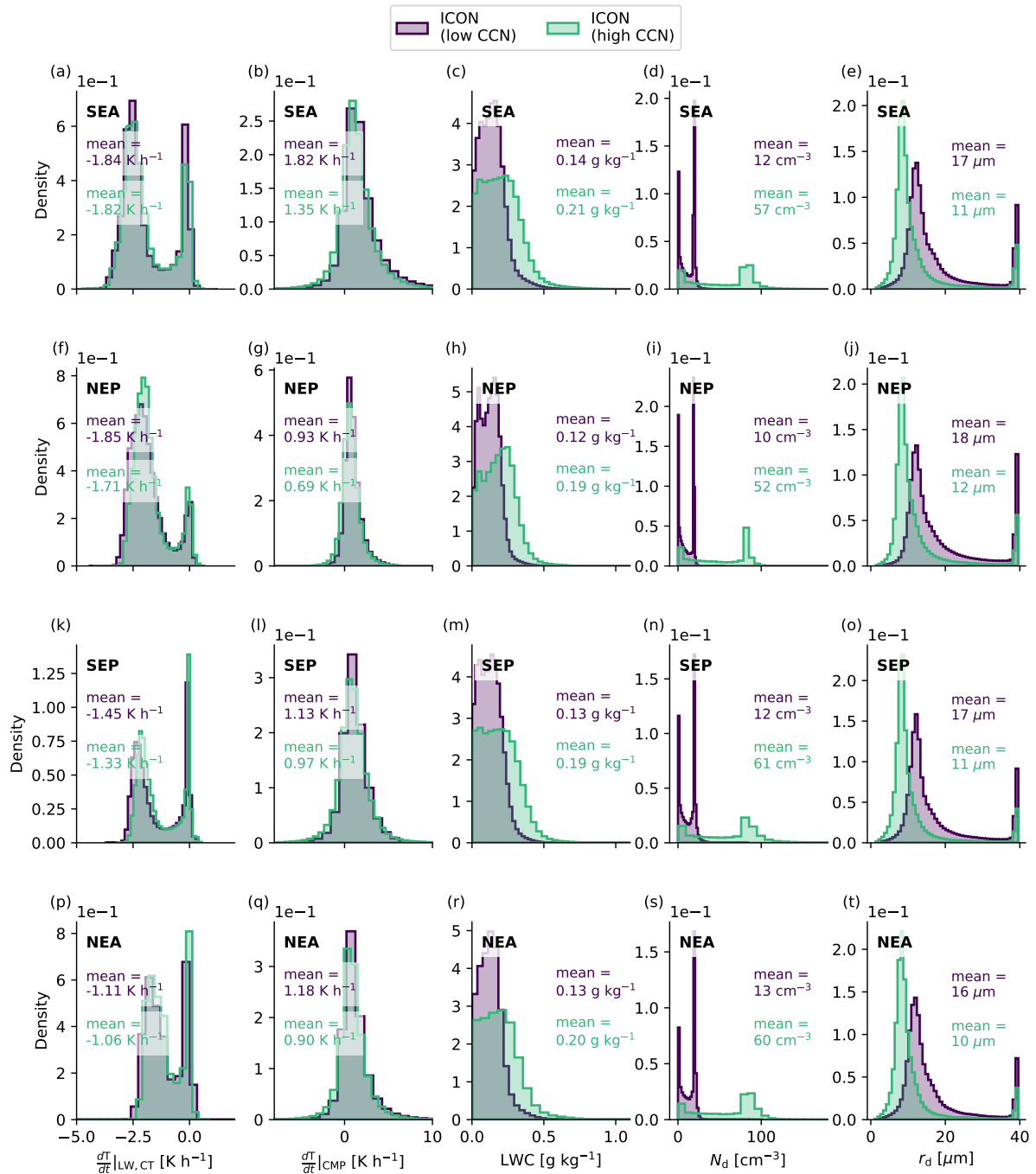


Figure S5. Histograms of instantaneous cloud properties for the low and high CCN ICON experiments: (a) temperature tendencies due to longwave radiation for grid cells at cloud top; (b) temperature tendencies due to the cloud microphysics scheme; (c) liquid water content averaged over the cloud depth; (d) cloud droplet number concentration averaged over the cloud depth; (e) cloud droplet radius averaged over the cloud depth. (a-e) show the five variables for the SEA region, (f-j) for the NEP region, (k-o) for the SEP region, and (p-t) for the NEA region.

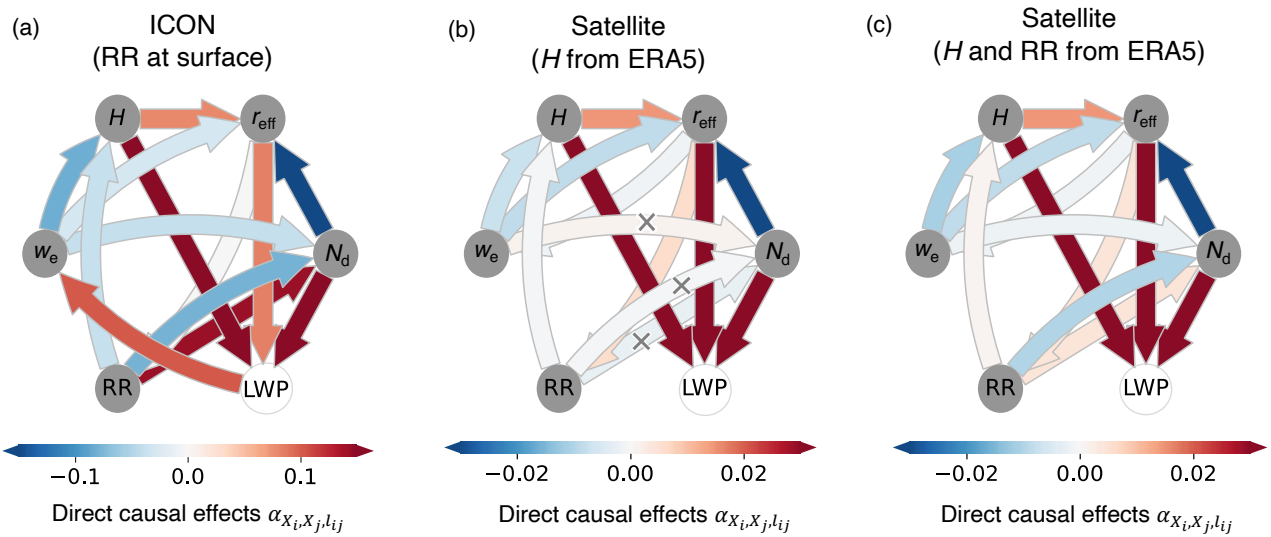


Figure S6. Same as Fig. 7b with different proxies for H and RR . (a) H is estimated from the satellite data, (b) H is estimated from ERA5, (c) both H and RR are taken from ERA5.

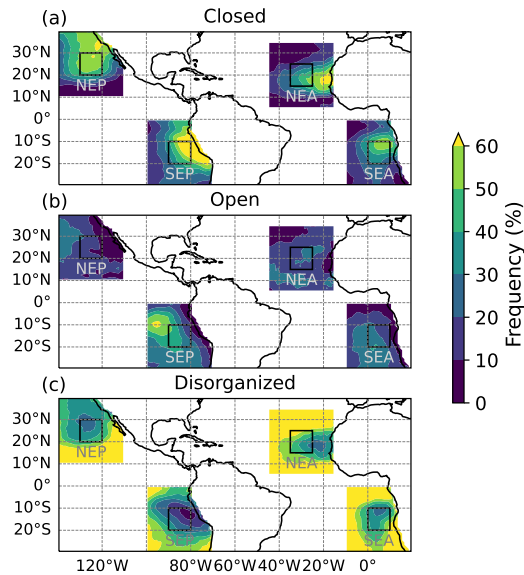


Figure S7. Frequencies of stratocumulus morphologies, computed using the MIDAS satellite product from McCoy et al. (2023); Eastman et al. (2023). (a) shows the frequency of the closed-cell morphology, (b) shows the frequency of the open-cell morphology and (c) shows the frequency of the disorganized morphology. Frequencies are calculated with respect to the total number of pixels identified as one of the three morphologies in a given pixel over the time period of the data set (2003 to 2018). For each year, only the 1th of July to the 9th of August are selected to match the time period of this study. Maps from cartopy (Met Office, 2010 - 2015)

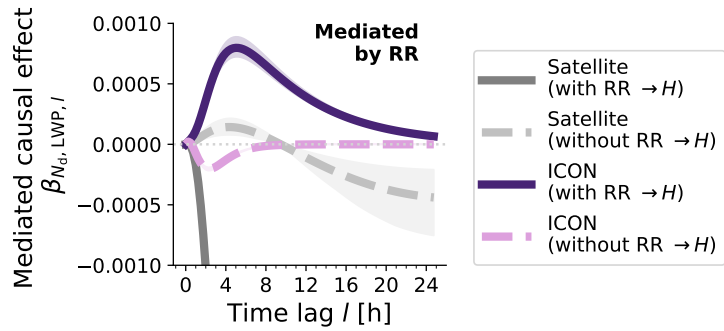


Figure S8. Same as Fig. 8c but comparing the graph with the arrow from RR to H to the graph without this link

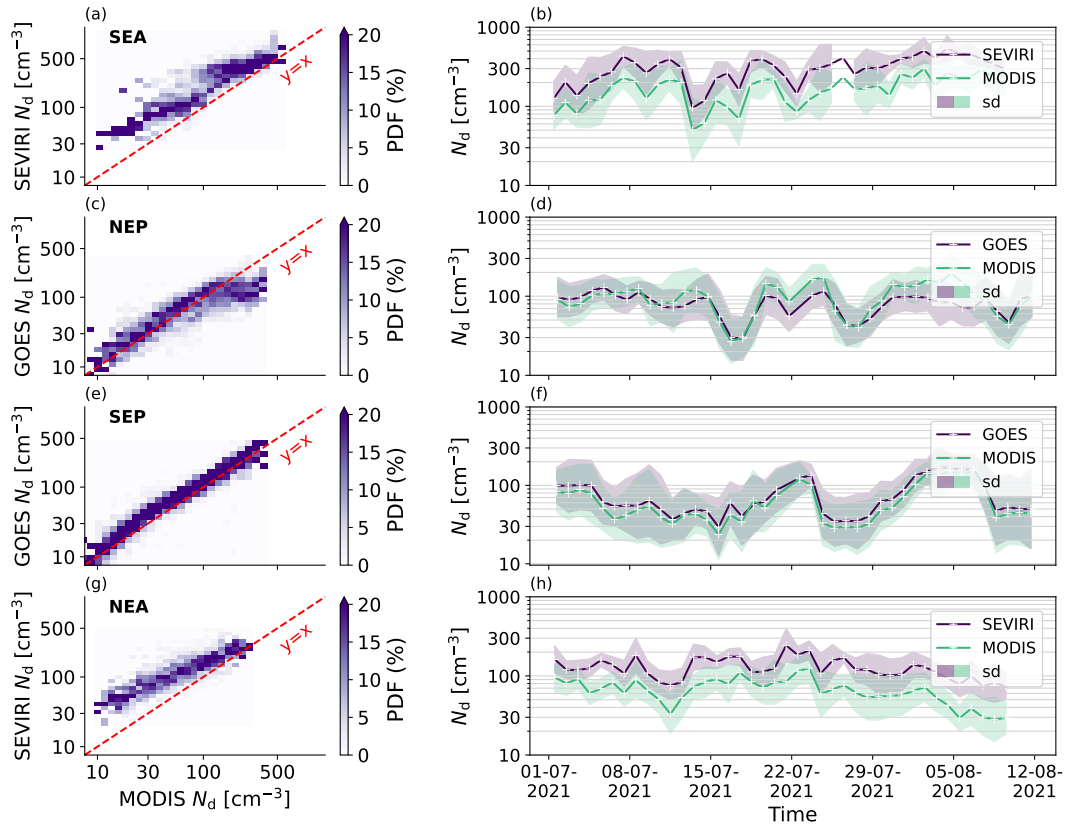


Figure S9. N_d retrievals for MODIS Terra vs. geostationary satellites. (a), (c), (e), (g) show 2D histograms of N_d from geostationary satellites as a function of N_d from MODIS for the four study regions. (b), (d), (f), (h) show the same comparison, but as time series, averaged over the four regions.

References

- Eastman, R., McCoy, I. L., Schulz, H., and Wood, R.: A Survey of Radiative and Physical Properties of North Atlantic Mesoscale Cloud Morphologies from Multiple Identification Methodologies, *EGUsphere*, pp. 1–33, <https://doi.org/10.5194/egusphere-2023-2118>, 2023.
- Jones, C. R., Bretherton, C. S., and Leon, D.: Coupled vs. Decoupled Boundary Layers in VOCALS-REx, *Atmospheric Chemistry and Physics*, 11, 7143–7153, <https://doi.org/10.5194/acp-11-7143-2011>, 2011.
- McCoy, I. L., McCoy, D. T., Wood, R., Zuidema, P., and Bender, F. A.-M.: The Role of Mesoscale Cloud Morphology in the Shortwave Cloud Feedback, *Geophysical Research Letters*, 50, e2022GL101 042, <https://doi.org/10.1029/2022GL101042>, 2023.
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