Supplement of Atmos. Chem. Phys., 23, 13523–13553, 2023
https://doi.org/10.5194/acp-23-13523-2023-supplement

Atmospheric Chemistry and Physics
Open Access
EGU

Supplement of

Evaluation of liquid cloud albedo susceptibility in E3SM using coupled eastern North Atlantic surface and satellite retrievals

Adam C. Varble et al.

Correspondence to: Adam C. Varble (adam.varble@pnnl.gov)

Supplement

Supplemental Figures

Dataset	% Time > 0.001 mm h^{-1}	% Time > 0.01 mm h^{-1}	% Time > 0.1 mm h^{-1}	% Time > 1 mm h^{-1}	Average (mm h^{-1})
60-min Parsivel2 Disdrometer	15	9.2	3.4	0.1	0.014
60-min Optical Rain Gauge	18	10	2.9	0	0.010
E3SM	62	49	8.5	0	0.033
E3SM (only stratiform)	21	7.1	1.0	0	0.005

Table S1: Probabilities of surface hourly rain rate exceeding several threshold values and average surface hourly rain rates across all times including those with < 0.001 mm h^{-1} set to 0.

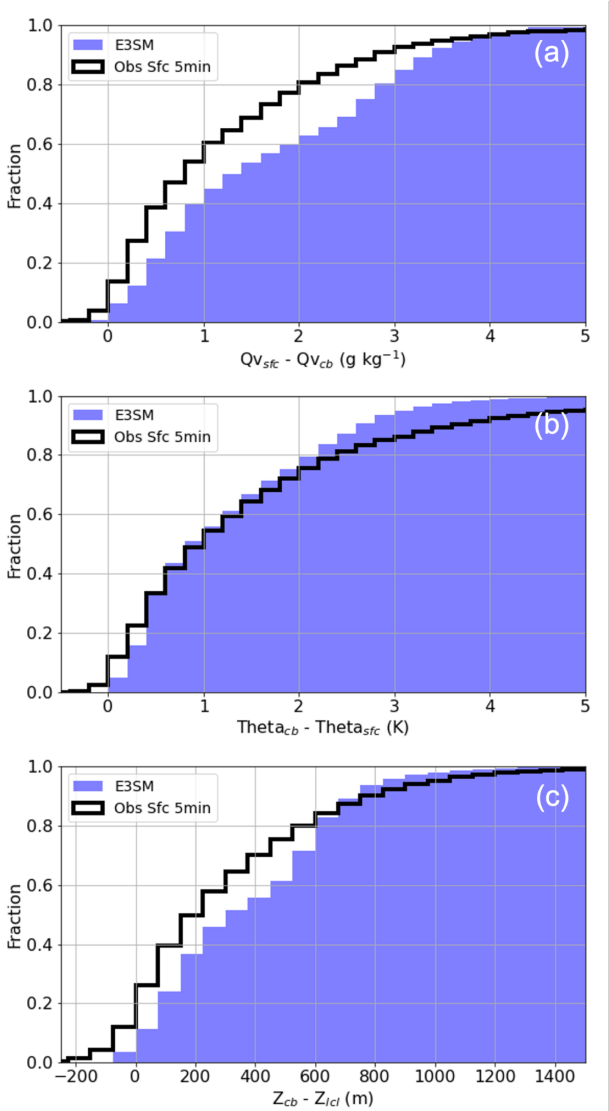

Figure S1: Cumulative distributions of boundary layer coupling indices including (a) water vapor mixing ratio difference between the surface and cloud base, (b) potential temperature difference between the surface and cloud base, and (c) the difference between cloud base height and the surface-based lifted condensation level. All are derived from interpolated sounding observations and E3SM output. The greater the value, the more decoupled the cloud is from the surface.

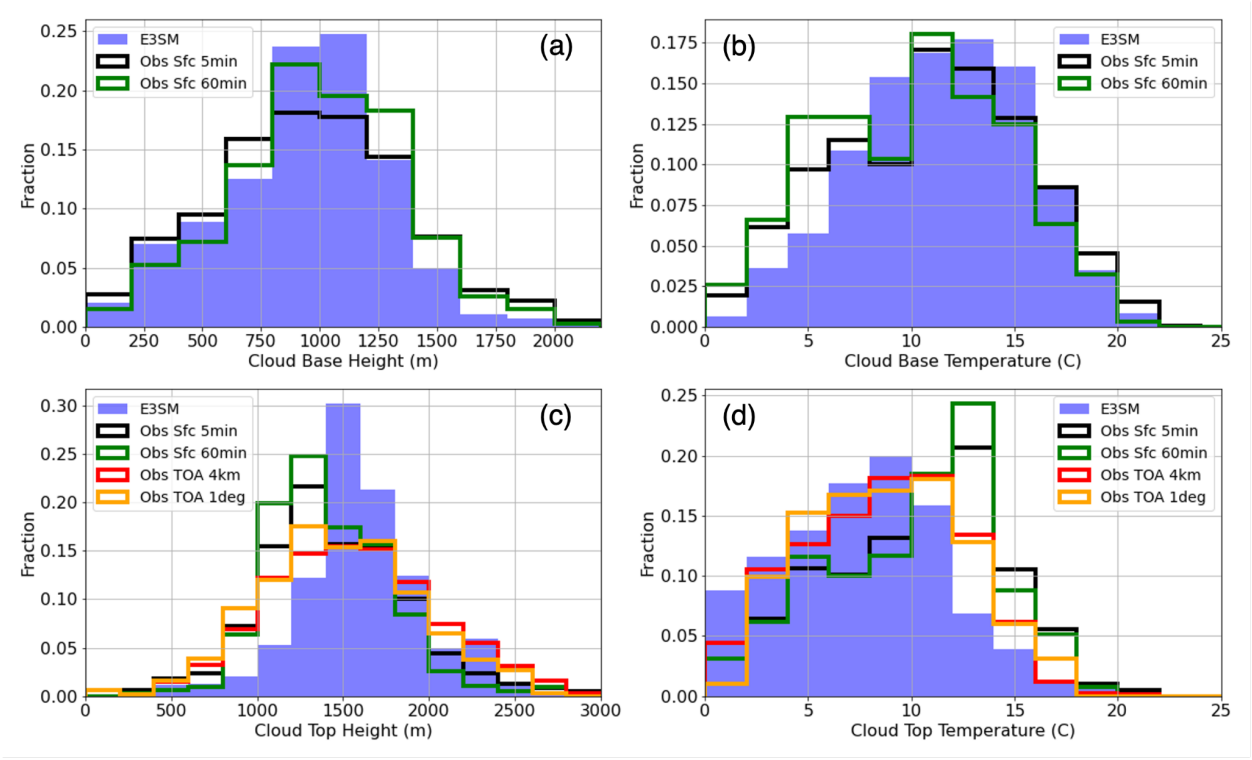

Figure S2: Cloud base (a) height and (b) temperature, along with cloud top (c) height and (d) temperature probability distributions. TOA estimated cloud base values are not shown due to being poorly estimated. Datasets are excluded when they are similar to another already shown due to being derived from the shown dataset.

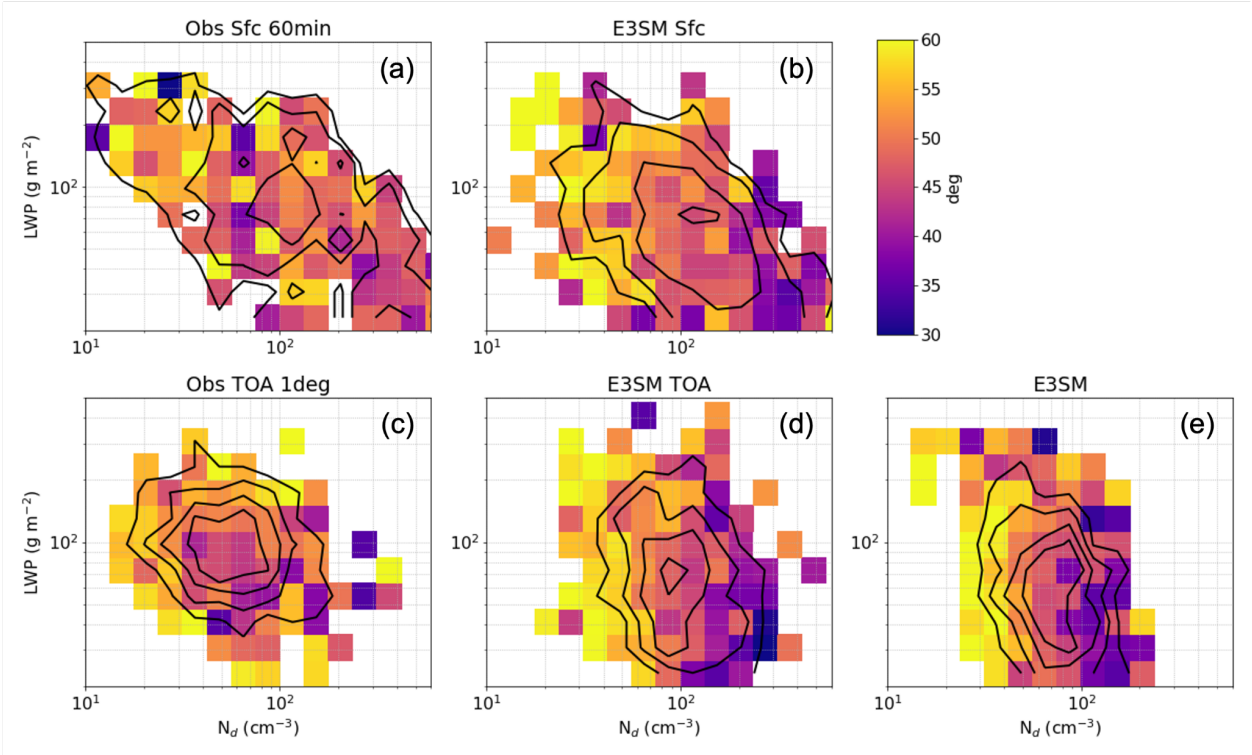

Figure S3: Median SZA as a function of N_d and LWP for (a) Obs Sfc 60min, (b) E3SM Sfc, (c) Obs TOA 1deg, (d) E3SM TOA, and (e) E3SM. Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.

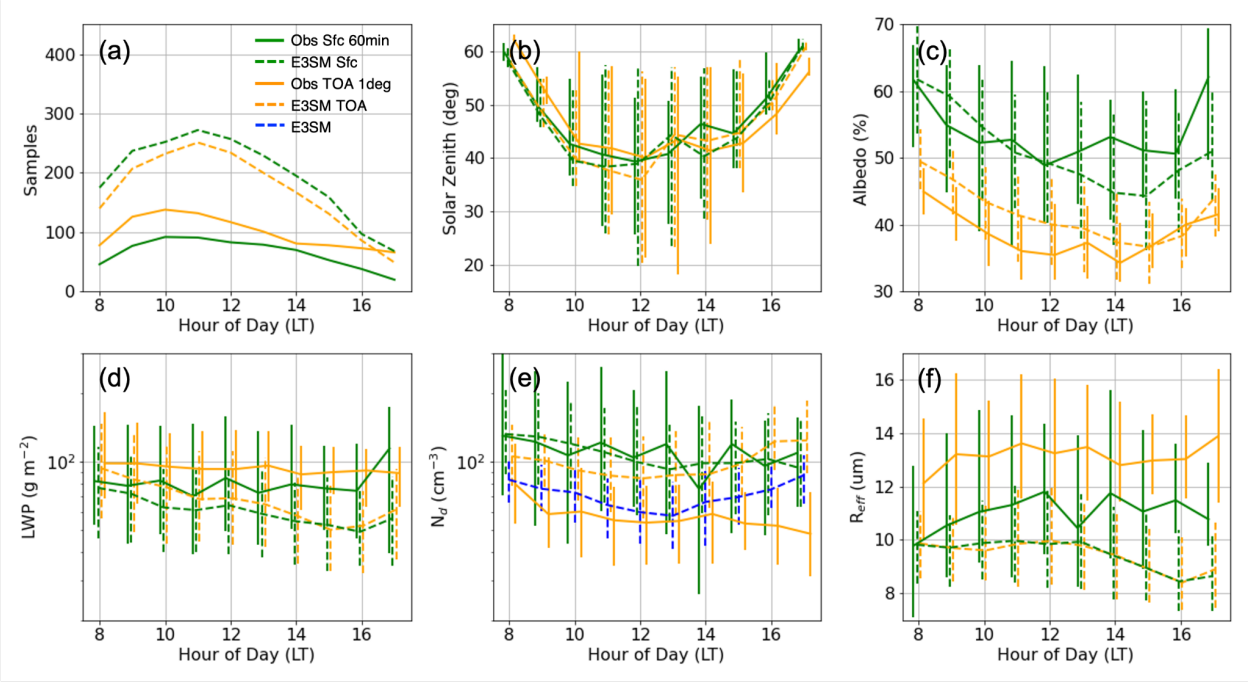

Figure S4: Diurnal cycles of (a) the samples and interquartile ranges connected by medians for (b) SZA < 65°, (c) TOA or cloud effective albedo, (d) cloud LWP, (e) layer-mean N_d, and (f) R_{eff}.

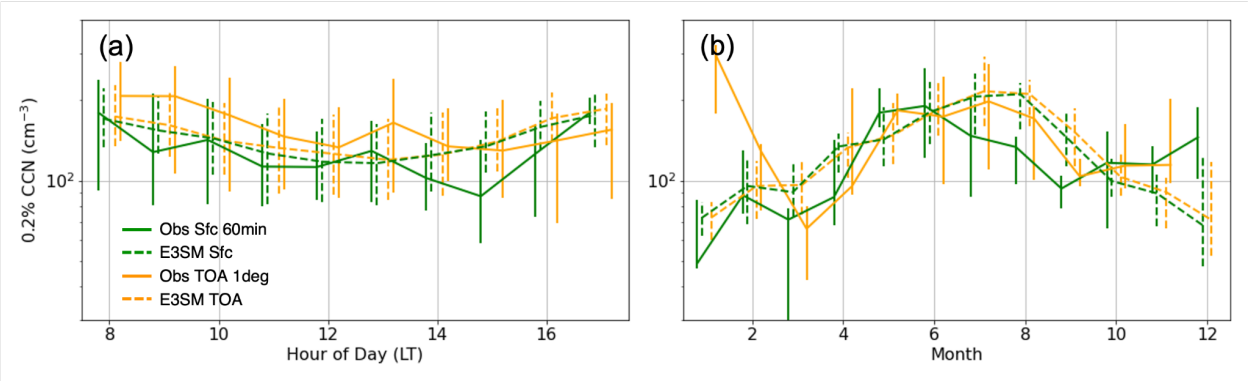

Figure S5: (a) Diurnal and (b) seasonal cycles of the 0.2% CCN concentration in observed and E3SM surface and TOA datasets for situations in which overcast, single layer liquid clouds are more likely to be coupled with the surface.

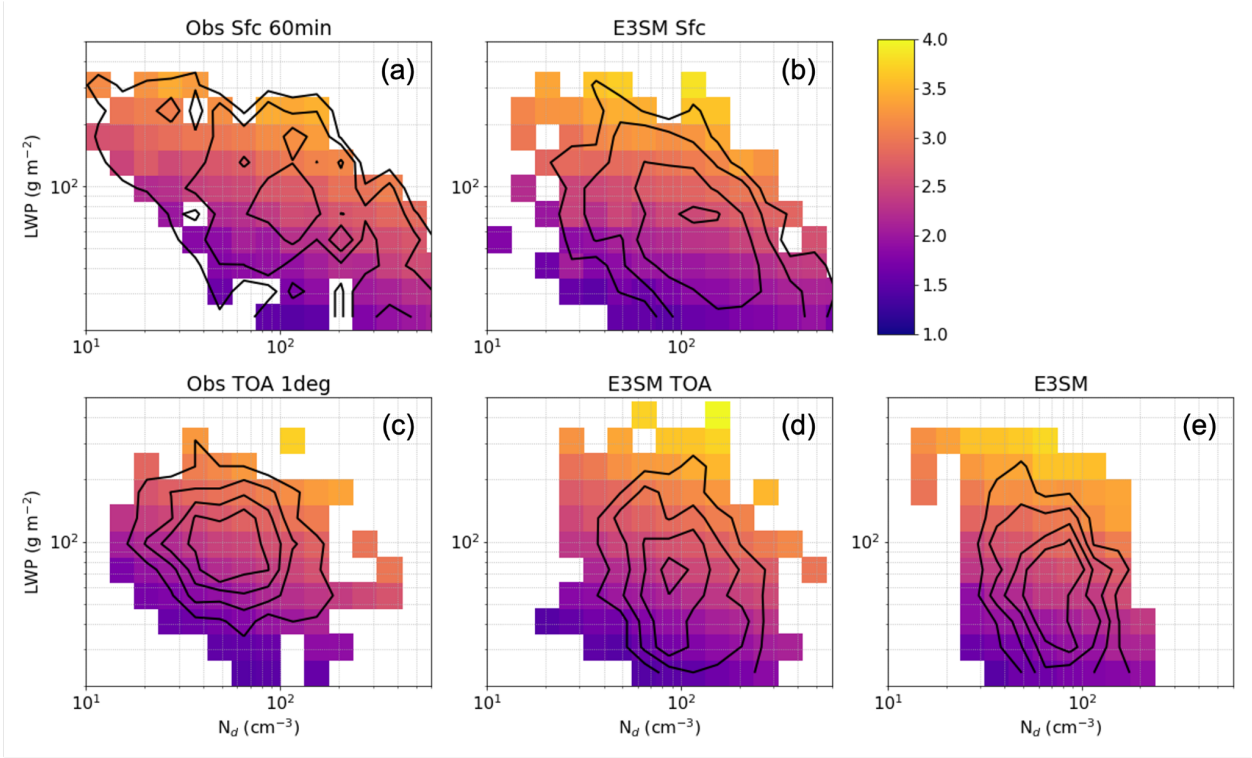

Figure S6: Median lnCOD as a function of N_d and LWP for (a) Obs Sfc 60min, (b) E3SM Sfc, (c) Obs TOA 1deg, (d) E3SM TOA, and (e) E3SM. Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.

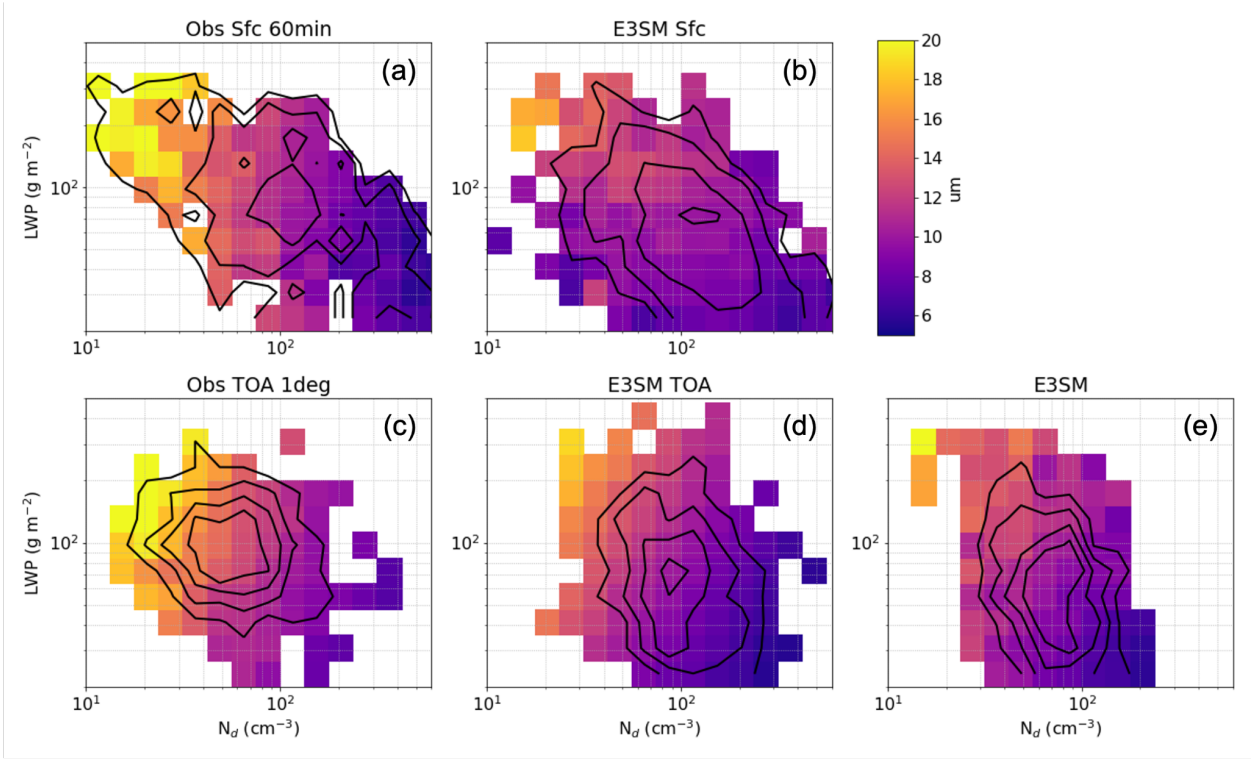

Figure S7: Median R_{eff} as a function of N_d and LWP for (a) Obs Sfc 60min, (b) E3SM Sfc, (c) Obs TOA 1deg, (d) E3SM TOA, and (e) E3SM. Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.

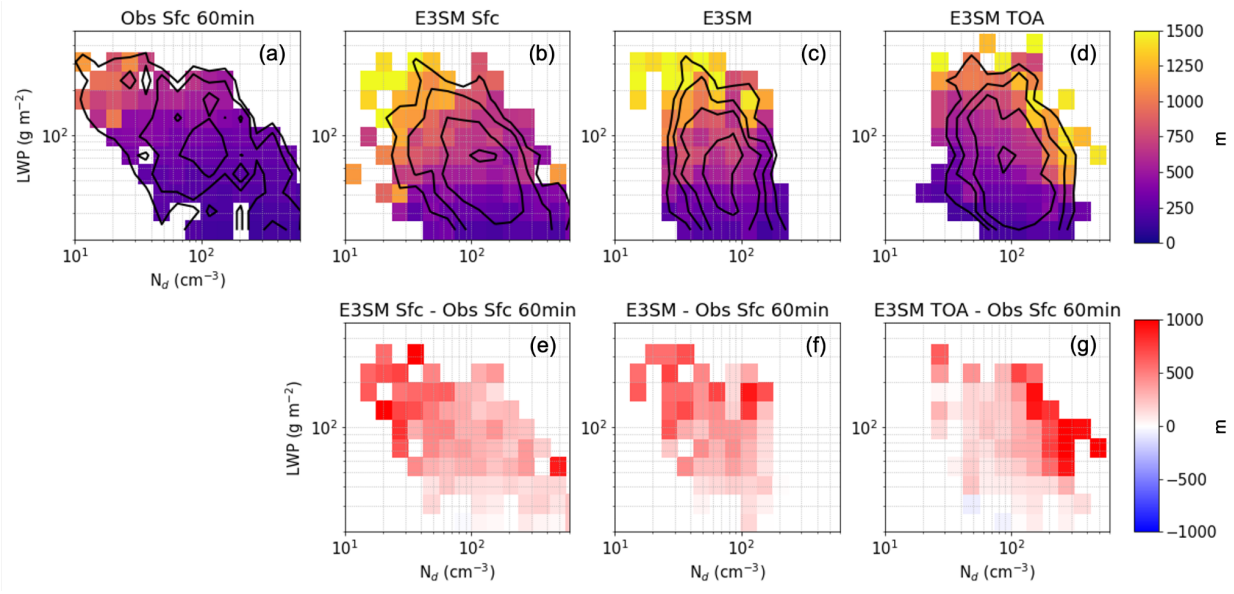

Figure S8: Median cloud depth in (a) Obs Sfc 60min, (b) E3SM Sfc, (c) E3SM, and (d) E3SM TOA. For E3SM TOA, the cloud depth from E3SM direct output is shown rather than that retrieved assuming a constant adiabaticity of 80% in Figure 5. Absolute differences between the 3 E3SM datasets and observations are shown in (e-g). Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.

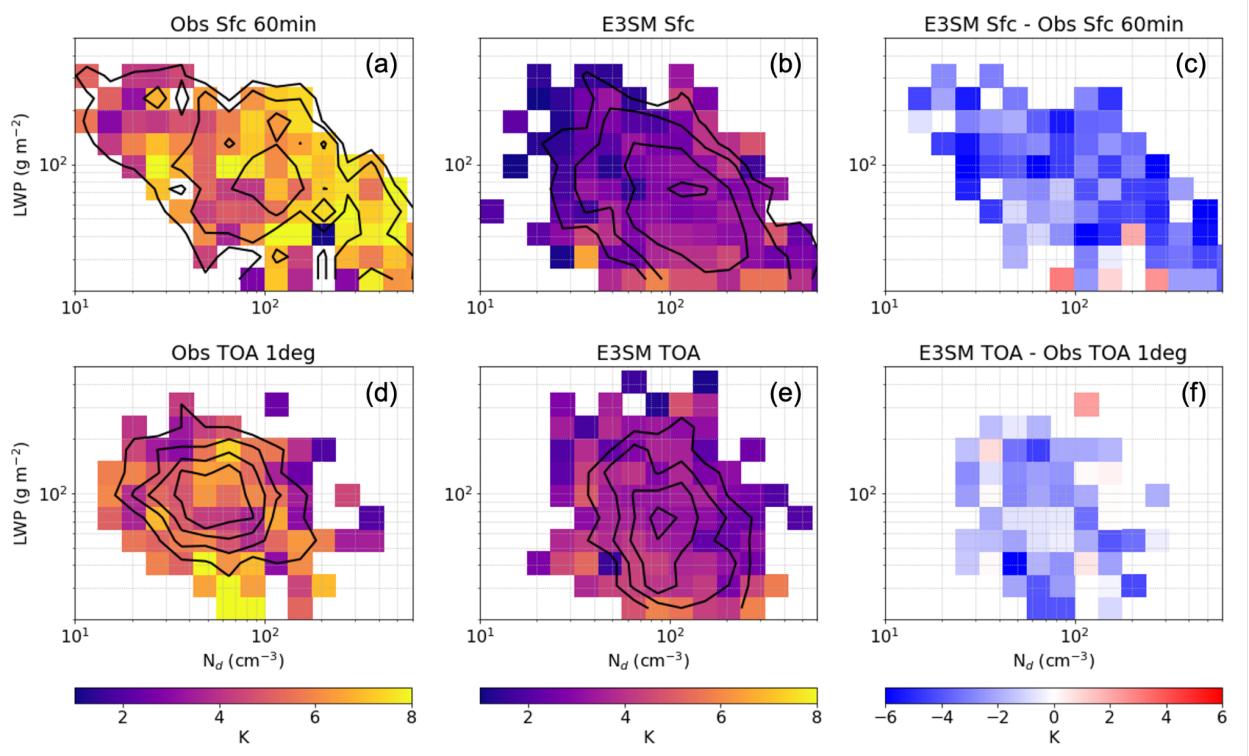

Figure S9: Median EIS as a function of LWP and N_d for (a) Obs Sfc 60min and (b) E3SM Sfc with their absolute difference shown in (c). Median EIS for Obs TOA 1deg, E3SM TOA, and their difference are shown in (d-f). Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.

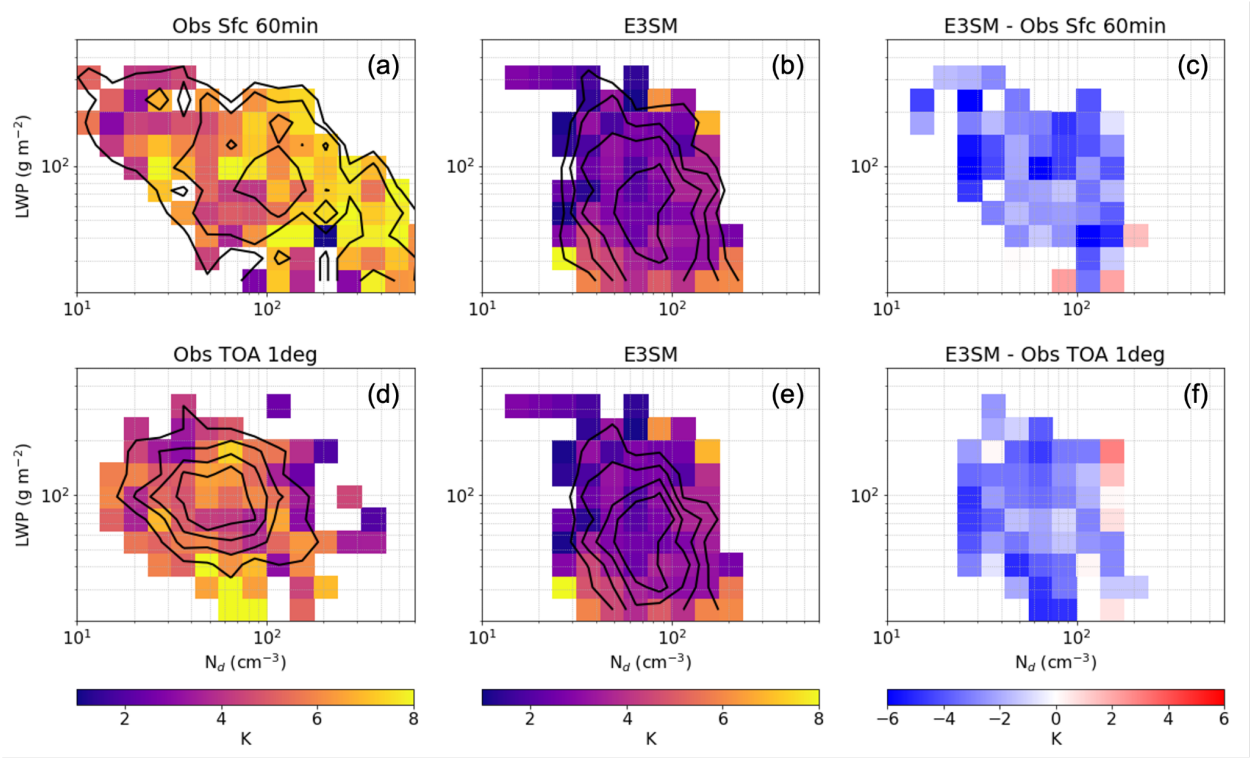

Figure S10: Median EIS as a function of LWP and N_d for (a) Obs Sfc 60min and (b) E3SM with their absolute difference shown in (c). Median EIS for Obs TOA 1deg, E3SM, and their difference are shown in (d-f). Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.

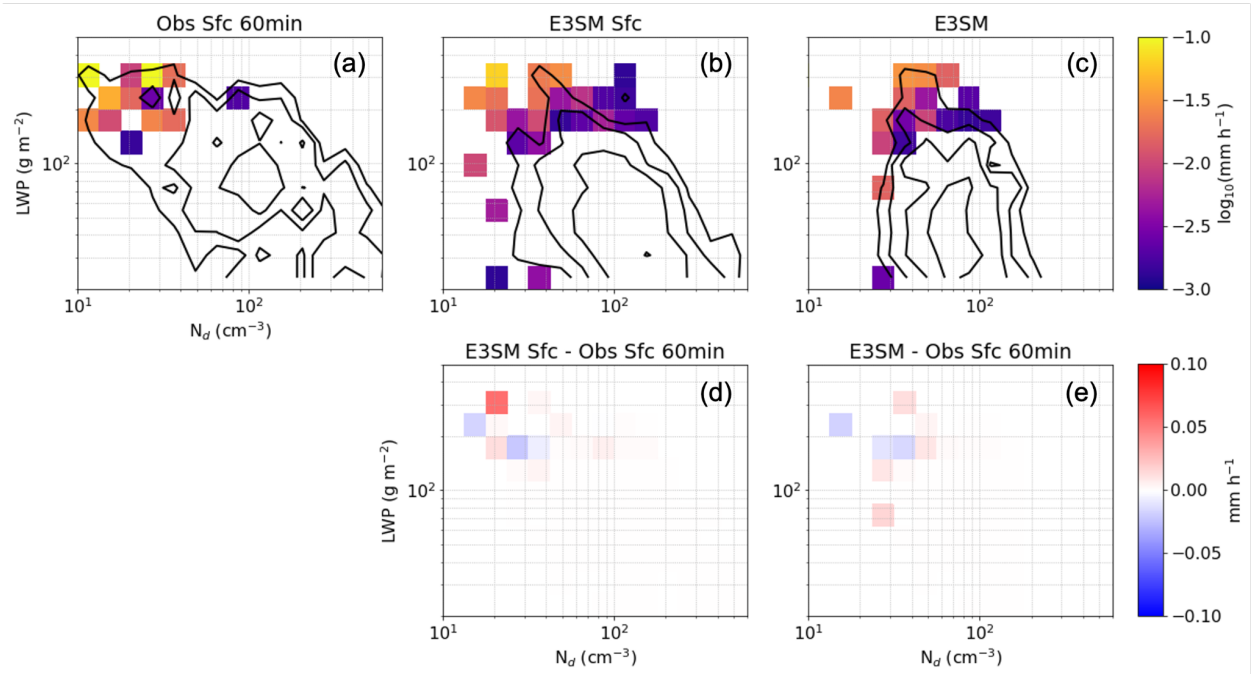

Figure S11: Median surface hourly rain rate as a function of LWP and N_d for (a) Obs Sfc 60min disdrometer retrievals, (b) E3SM Sfc, and (c) E3SM, but including only stratiform rates for E3SM and E3SM Sfc. (d) Absolute differences between E3SM Sfc stratiform and Obs Sfc 60min disdrometer rain rates. (e) Absolute differences between E3SM stratiform and Obs Sfc 60min disdrometer rain rates. Only rain rates exceeding 0.001 mm h^{-1} are included in statistics due to observational sensitivity limitations. Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.

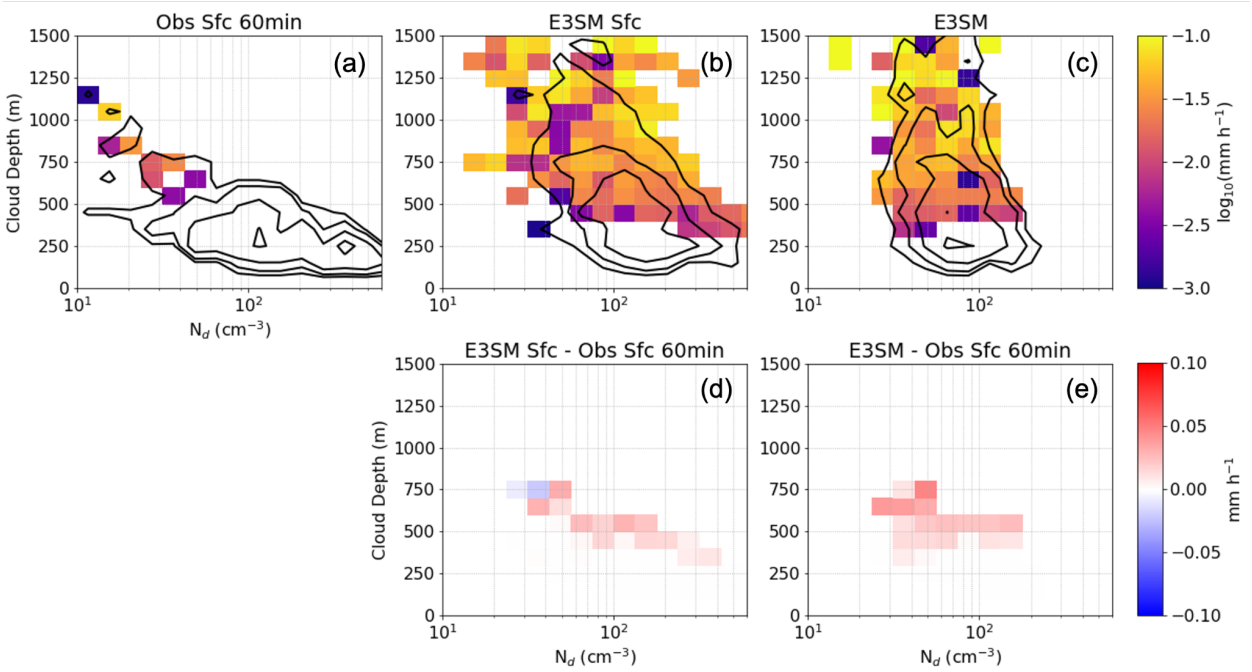

Figure S12: Median surface hourly rain rate as a function of cloud depth and N_d for (a) Obs Sfc 60min disdrometer retrievals, (b) E3SM Sfc, and (c) E3SM. (d) Absolute differences between E3SM Sfc and Obs Sfc 60min. (e) Absolute differences between E3SM and Obs Sfc 60min. Only rain rates exceeding 0.001 mm h^{-1} are included in statistics due to observational sensitivity limitations. Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.

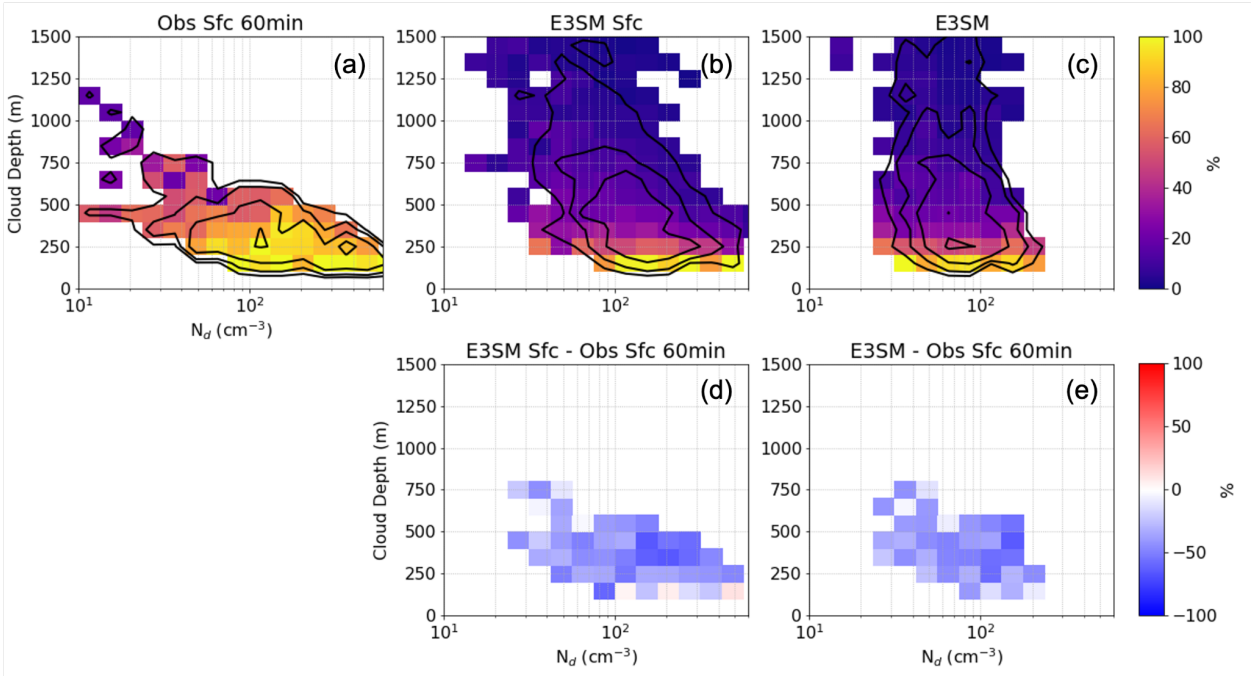

Figure S13: Median cloud adiabaticity as a function of cloud depth and N_d for (a) Obs Sfc 60min, (b) E3SM Sfc, and (c) E3SM. (d) Absolute differences between E3SM Sfc and Obs Sfc 60min. (e) Absolute differences between E3SM and Obs Sfc 60min. Black contours indicate sample size thresholds of 0.4, 0.8, 1.6, and 3.2%.