Peeking Beneath Clouds: An Investigation of Aerosol-Cloud Interactions over the Southeast Atlantic

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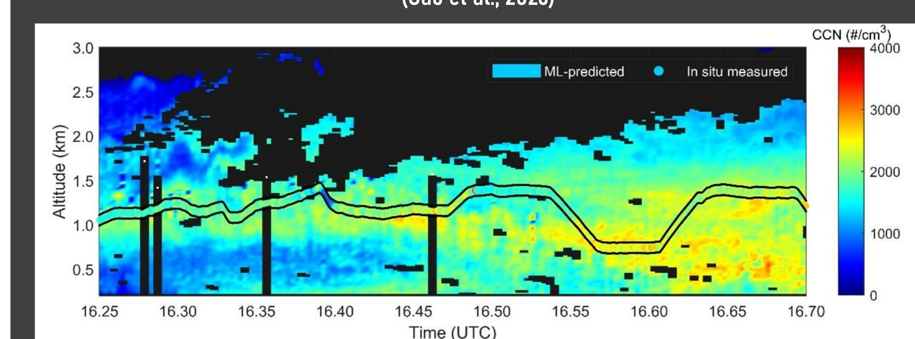
1. Introduction

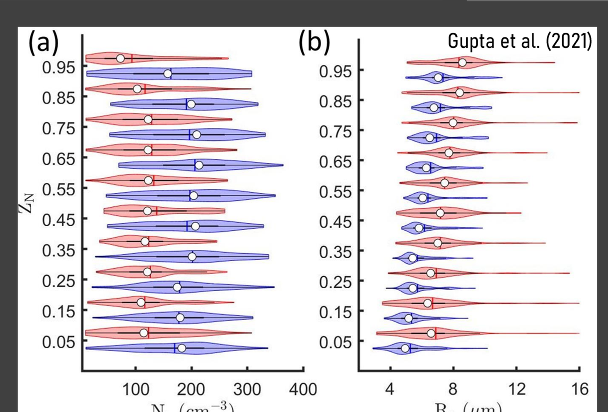
The **vertical distribution of cloud condensation nuclei** concentrations (N_{CCN}) is necessary to better understand **aerosol-cloud interactions (ACI).**

Previous Work:

- Columnar products like aerosol optical depth (AOD) cannot **distinguish CCN layers** relative to cloud height.
- In situ observations help with vertical placement of CCN but are limited in **spatiotemporal availability.**

Machine Learning (ML) model trained using High Spectral Resolution Lidar 2 (HSRL-2) observables and in situ N_{CCN} (Gao et al., 2026)





In situ ORACLES observations have shown an above-cloud aerosol effect on cloud microphysical properties

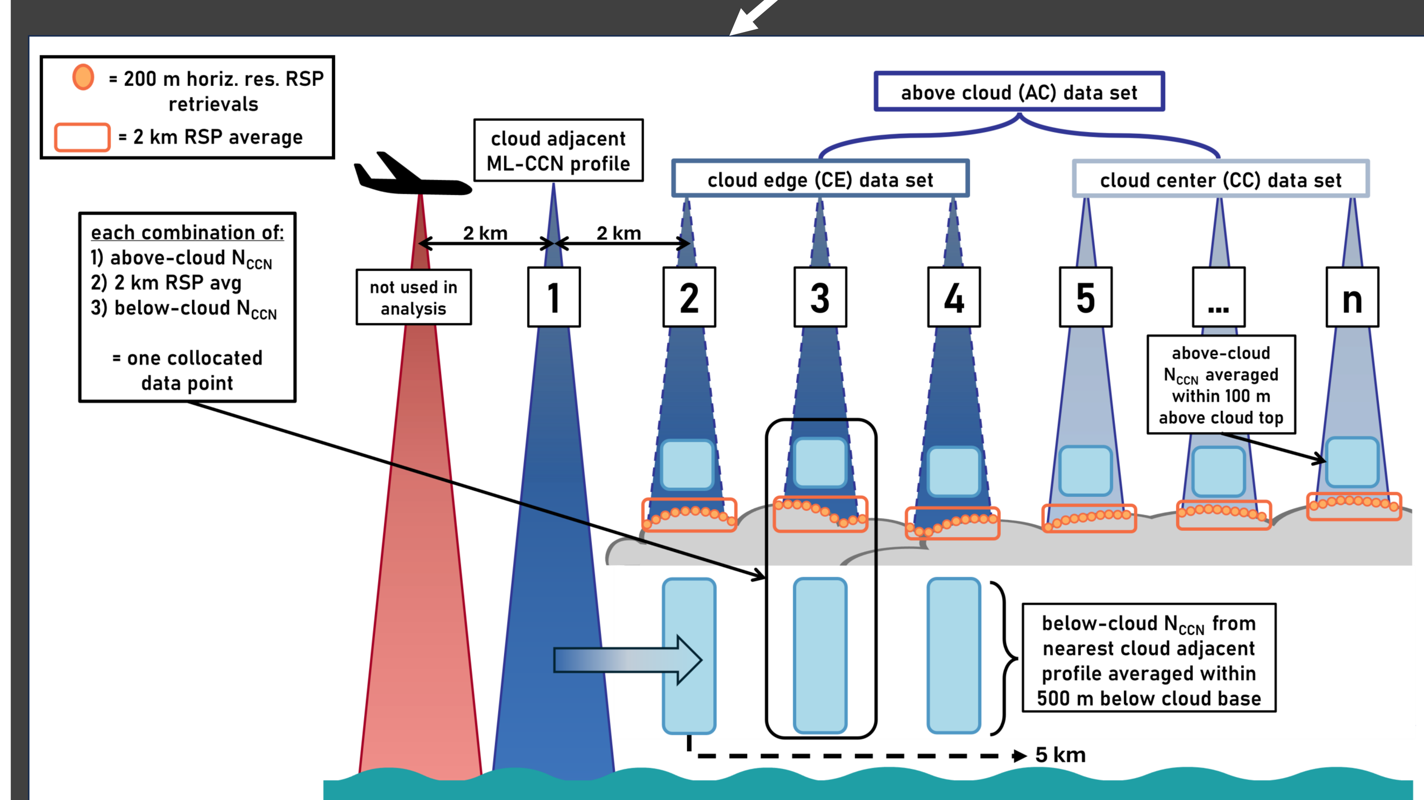
Red = cloud **separated** from smoke plume
Blue = cloud in **contact** with smoke plume

Goal: Use **remote sensing** observations to investigate **above-cloud aerosol impacts** on stratocumulus cloud properties

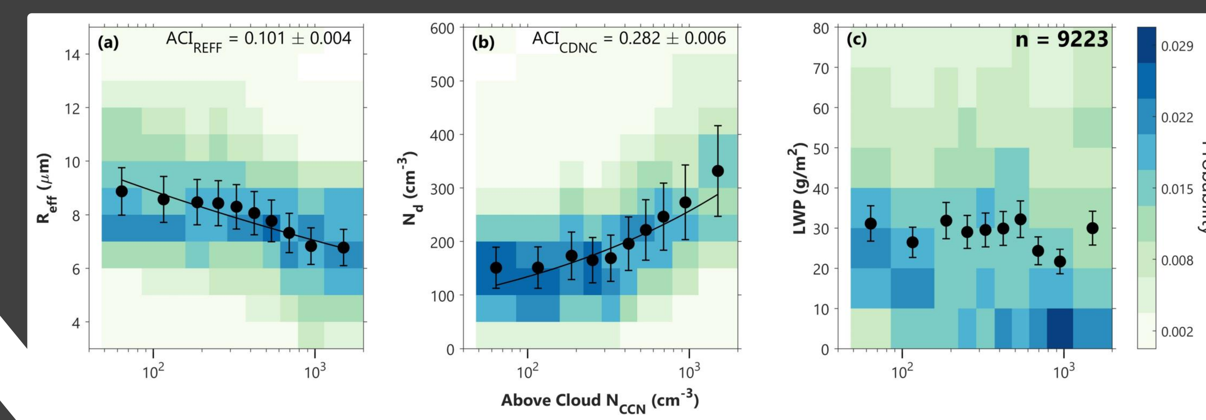
2. Data and Methods

Instrument	Variables
High Spectral Resolution Lidar 2 (HSRL-2)	• Machine learning (ML) retrieved CCN profiles (**ML-CCN**) at supersaturation (S) = 0.4% • Cloud top height
Research Scanning Polarimeter (RSP)	• Retrieved: cloud droplet effective radius (**R_{eff}**) and optical thickness (**COT**) • Calculated: liquid water path (**LWP**) and droplet number concentration (**N_d**)

- ML-CCN profiles are collocated with RSP retrievals, and cases are categorized as cloud edge (CE), cloud center (CC), and above cloud (AC).
- The impacts of below-cloud N_{CCN} are only investigated in CE cases.
- Below-cloud N_{CCN} are assumed to be constant over horizontal distance of 5 km as a result of in situ autocorrelation analysis



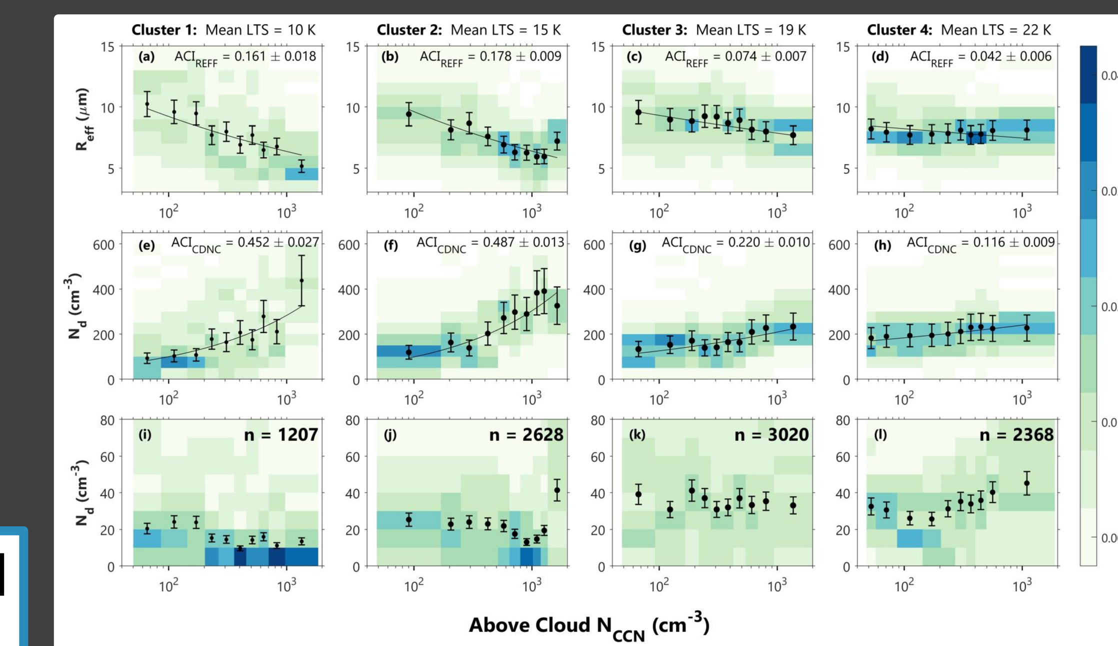
3. Results: Above-Cloud N_{CCN}

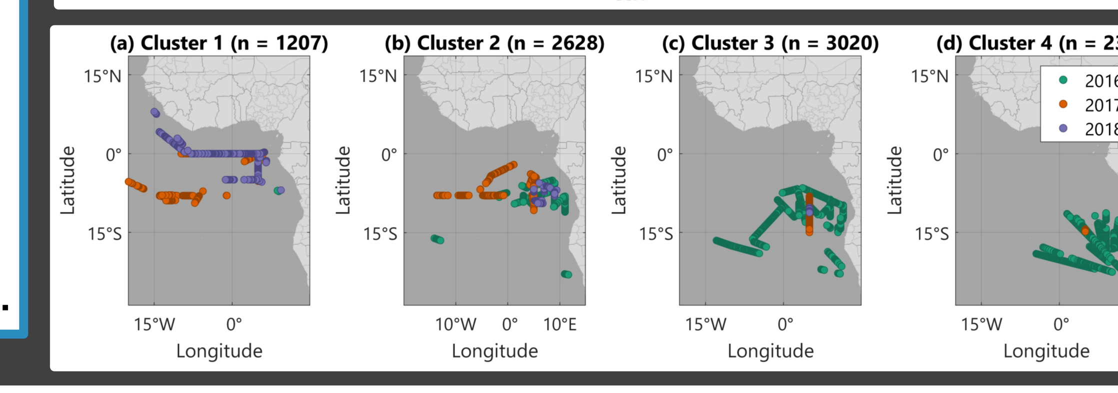


For observations from all three ORACLES deployments, **increases in above-cloud N_{CCN}** are associated with **decreases in R_{eff} and increases in N_d.**

Remote sensing observations reveal aerosol-cloud interactions at stratocumulus **cloud tops** that depend on **environmental stability.**

4. Results: Environmental Stability

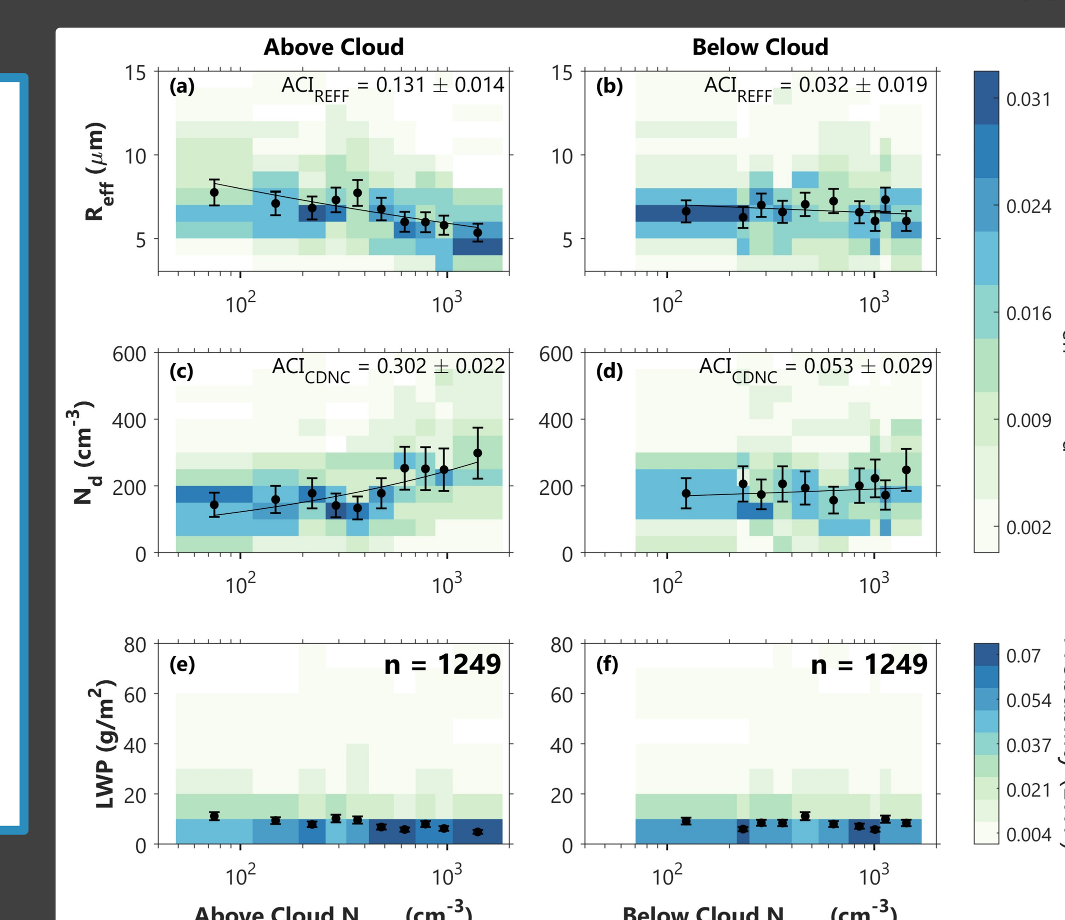


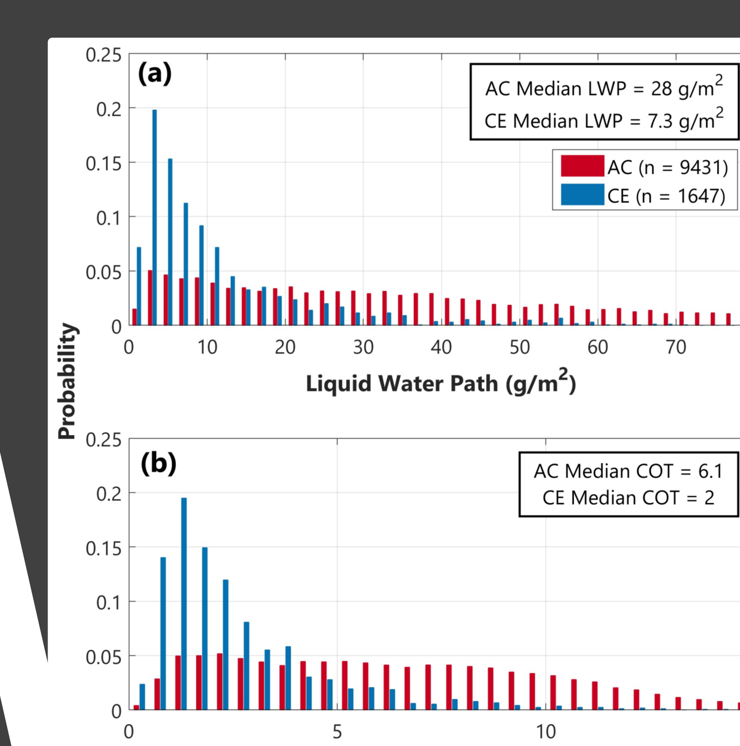


As **LTS** increases and SST decreases (NW to SE), **cloud sensitivity** to increasing above-cloud N_{CCN} **decreases.**

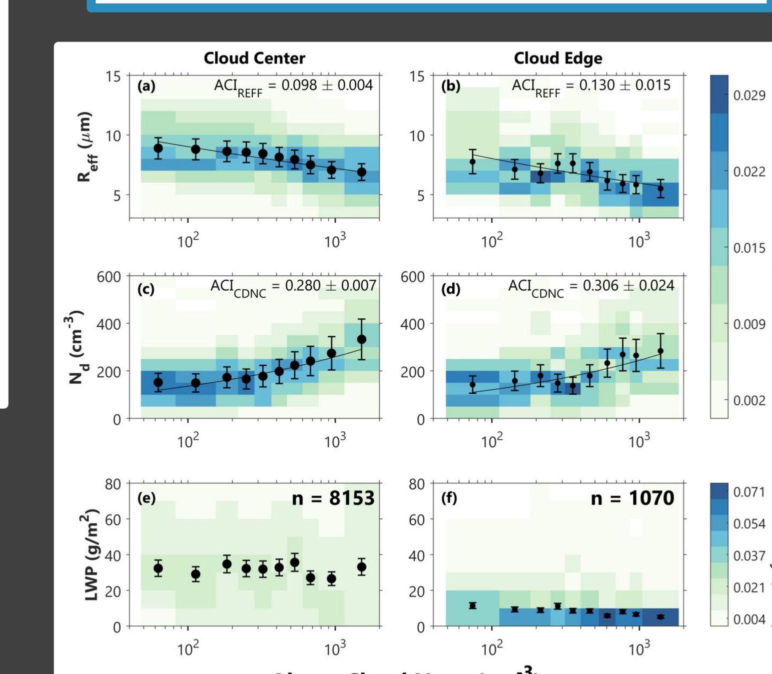
5. Results: Above- vs. Below-Cloud N_{CCN}

Though **not physically expected,** this dataset shows a **stronger relationship** between **above-cloud N_{CCN}** and cloud properties than with below-cloud N_{CCN}.





ACI metrics are **similar at cloud edge and cloud center** despite expected differences in LWP and COT.



6. Conclusions

- As **LTS increases, cloud sensitivity** to increasing above-cloud N_{CCN} **decreases.**
- Cloud edge HSRL-2 profiles allow us to assess **above- and below-cloud N_{CCN}** impacts on cloud properties.
- Remote sensing-based results align well with in situ results: **ACI are observed at cloud top** with overlying smoke plume.

Special thanks to:

- Funding from NASA FINESST (80NSSC24K0008)
- More about ORACLES analysis in our ACP pre-print via the QR code on the right:
- Contact: emily.lenhardt@ou.edu