Using LASSO-ENA Simulations to Fill Data Voids

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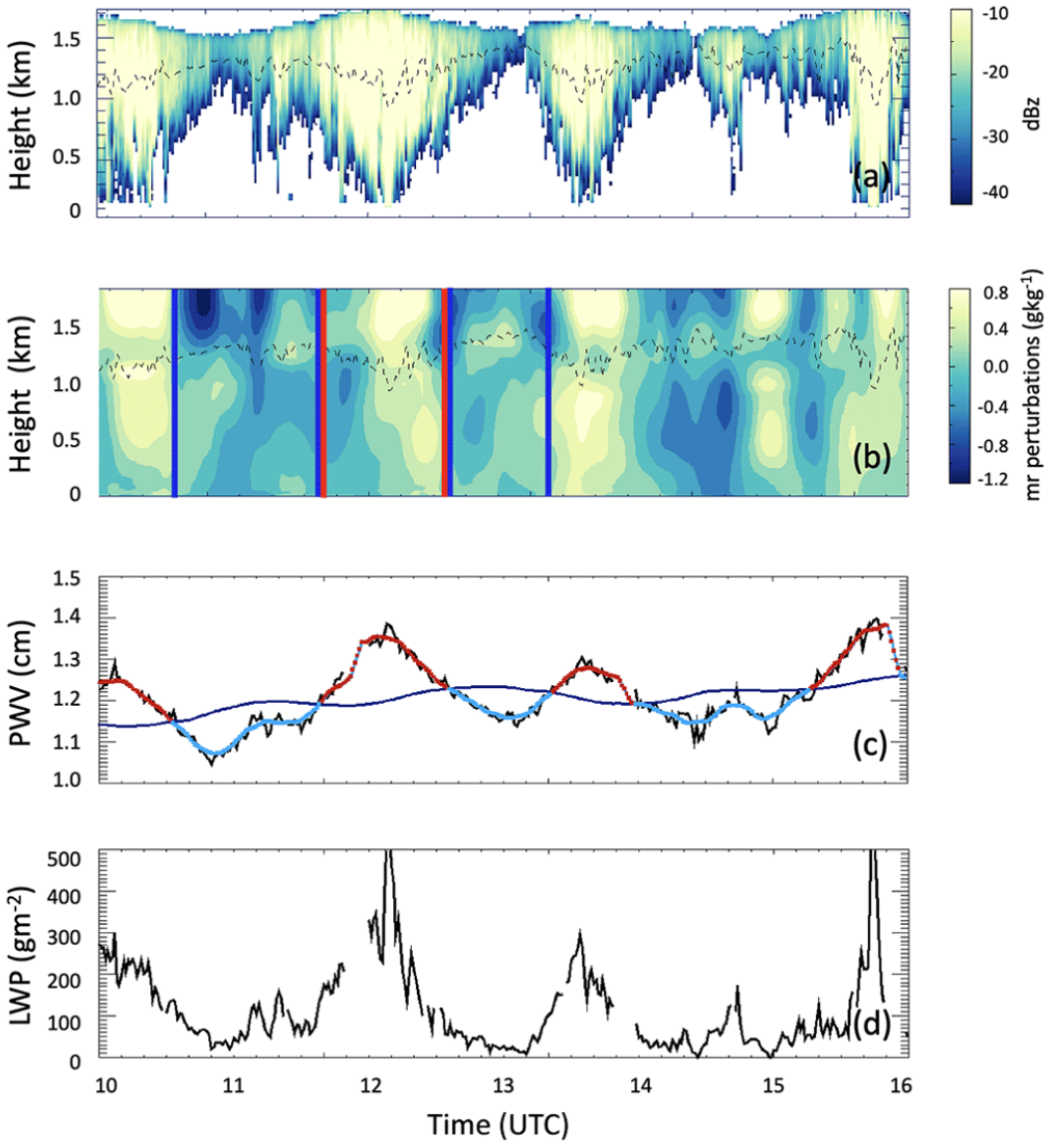
ASR Atmospheric System Research

Mesoscale Variability



- Water vapor, cloud, and precipitation is known to exhibit mesoscale variability in stratocumulus topped boundary layers.
- ENA site data shows higher LWP, and drizzle in moist patches, as compared to dry patches. Turbulence results have been mixed.
- LASSO output can be used to quantify the mesoscale circulations near cloud top that lead to these moist/dry patches.

Cadeddu et al. 2023 ACP; Zhou and Bretherton 2019 JGR etc.

Cumulus-Coupled Stratocumulus and Marine Boundary Layer Convective Complexes (MBLCC)

Qiuxuan Zheng and Mark A. Miller

- ~ 30% of the summertime MBL clouds are **cumulus-coupled stratocumulus and MBLCC.**

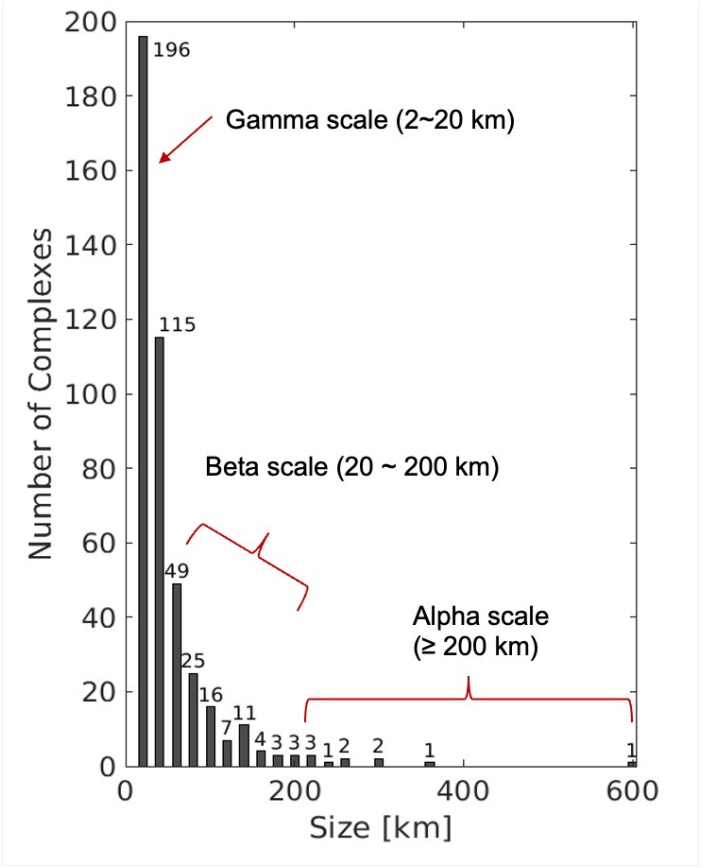
As horizontal scale increases:

- Larger average KAZR reflectivity (drizzle), Lower cloud base, Smaller drizzle depth, lower wind speed.

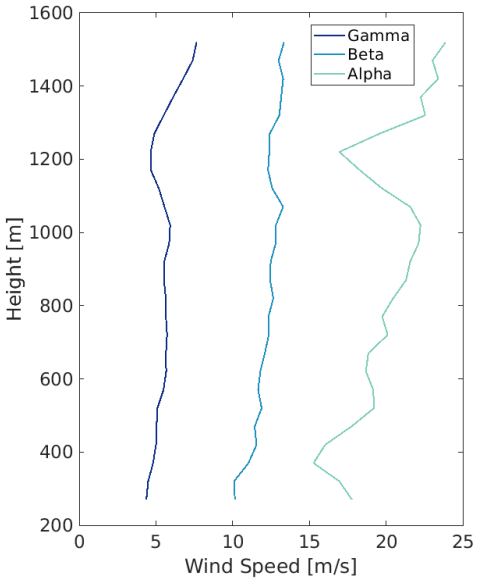
MBLCC LASSO Science Questions

- How does drizzle evaporation and-low level wind shear impact the life cycle of MBLCC?
- How does turbulent entrainment impact the strength of decoupling

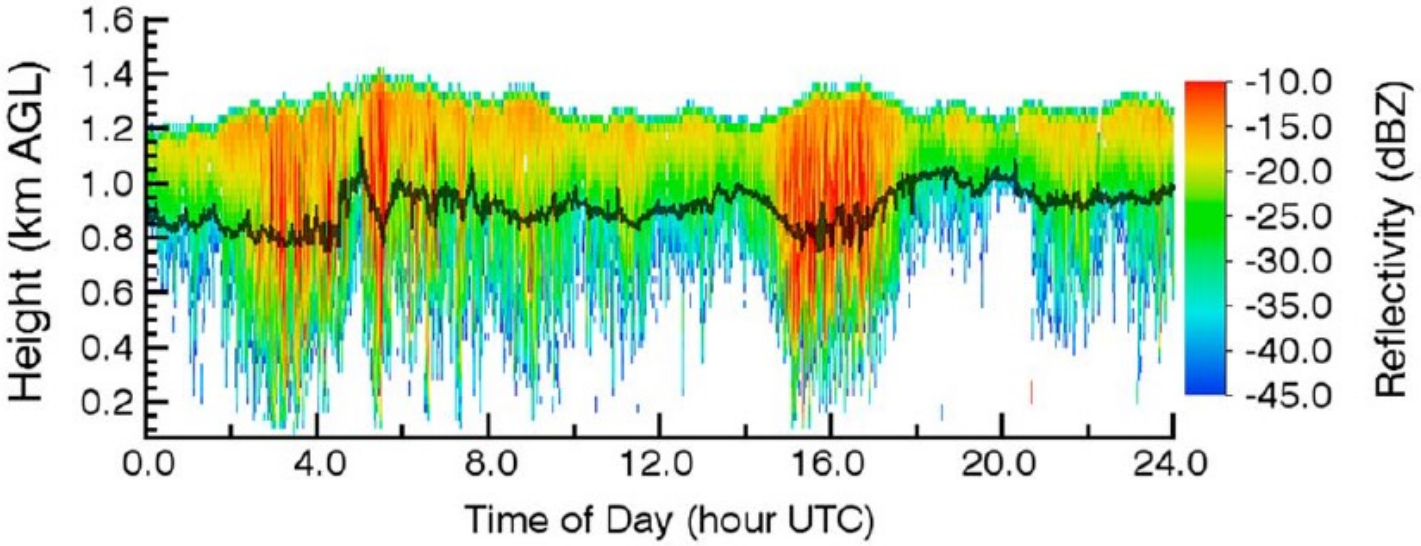
MBLCC Summertime Scales



Windspeed and Scale



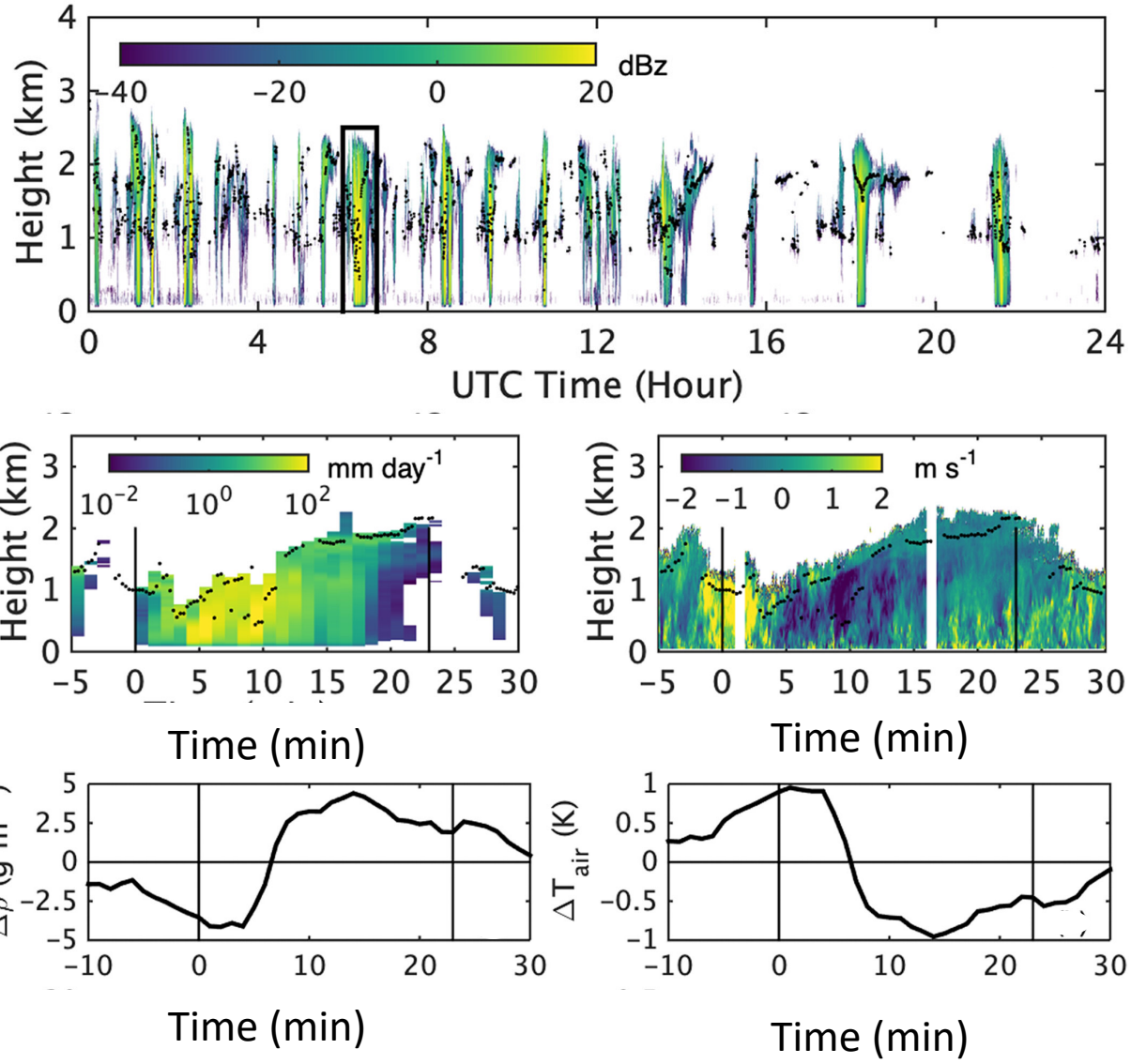
Drizzle Virga Variation and Impact on Sub-cloud Layers (Fan Yang and Zeen Zhu, BNL)



Yang et at. 2018, GRL

- 83% of marine stratocumulus clouds generate drizzle virga, although only 31% reach surface based on ENA observations.
- Analytical model predicts that, $H_{virga} \propto H_{cloud}^{3}$, which shows good agreement with long-term observational data.
- LASSO output can be used to investigate the fluctuation of drizzle virga depths and its impact on sub-cloud layers.

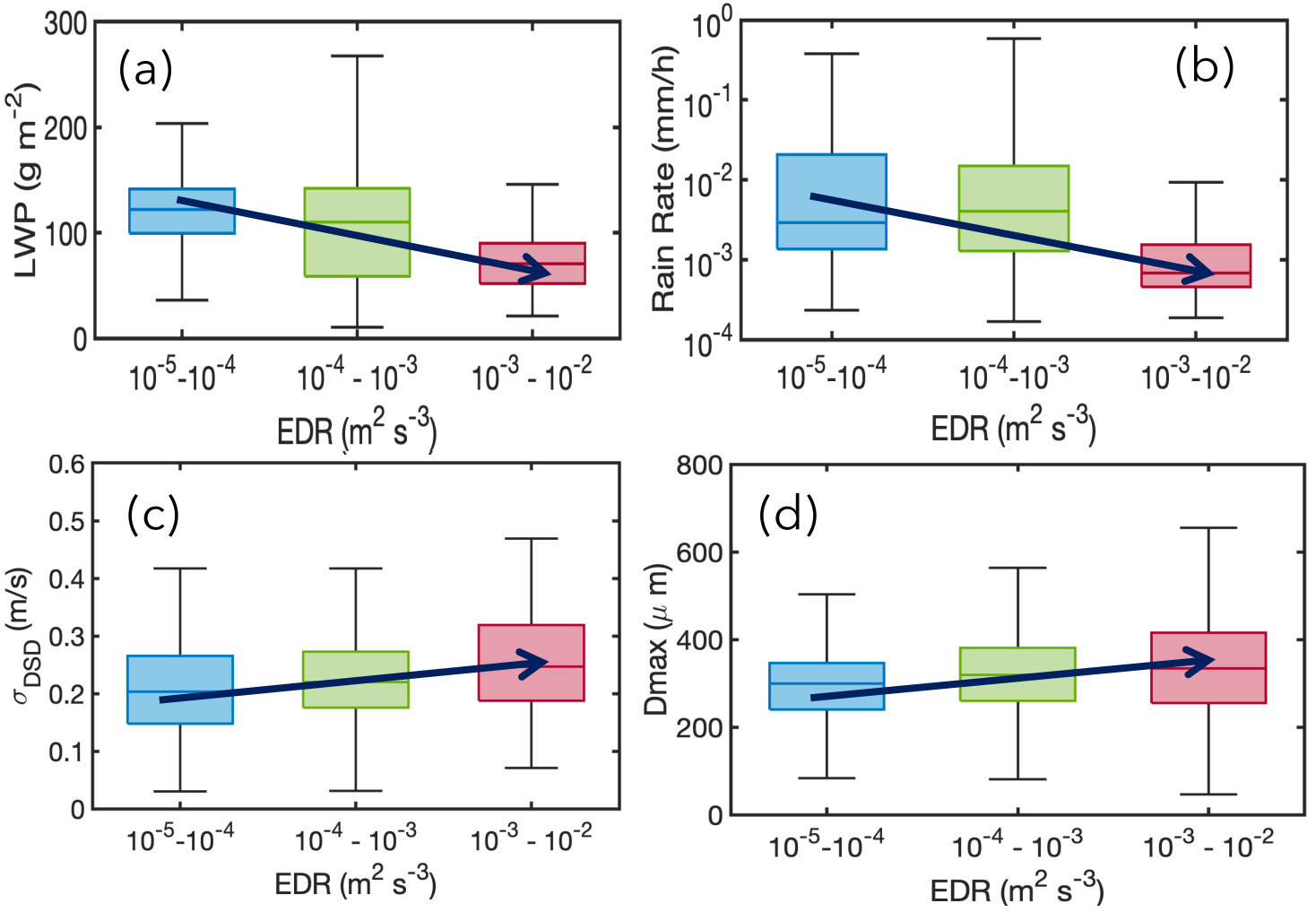
Drizzle-turbulence-cold pool Interactions



- Open cellular heavily precipitating marine stratocumulus with cumulus below them are routinely observed during winter months.
- Observations show them to exhibit a strong drizzle-turbulence-surface coupling.
- LASSO output can help quantify cold pool characteristics, impact of drizzle evaporation on downdrafts, etc.

Ghate et al. 2020 JGR-Atmos

Effect of Turbulence on Precipitation and Cloud Microphysics (Zeen Zhu and Fan Yang, BNL)

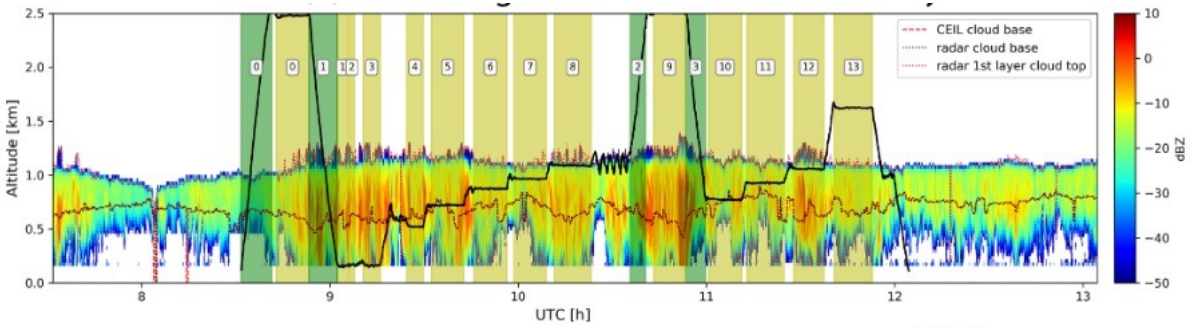


EDR = Eddy Dissipation Rate

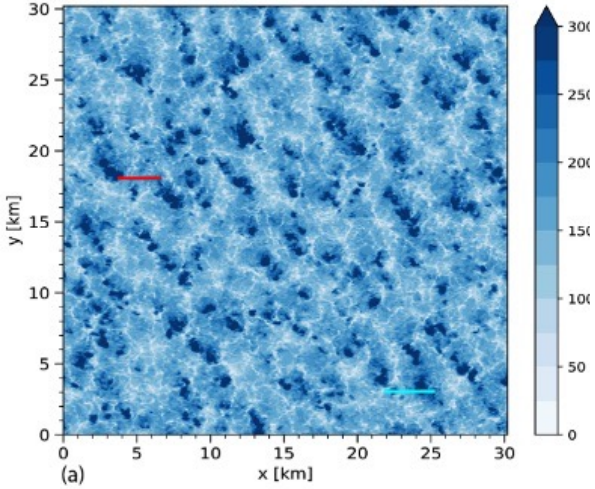
Zhu et at. 2023 GRL

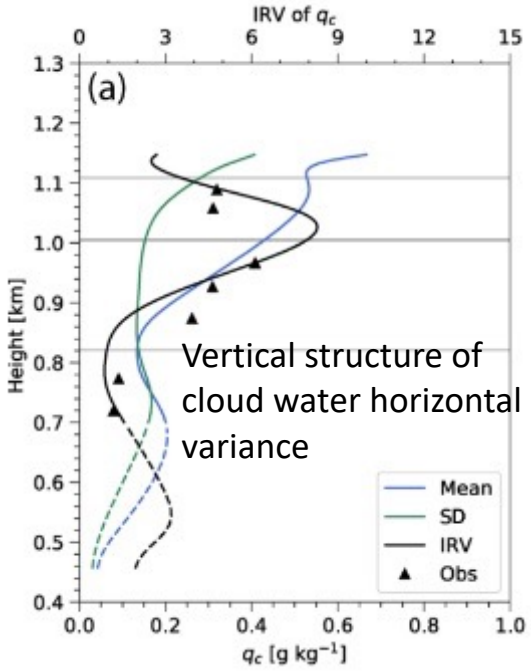
- Turbulence plays a great role in precipitation and cloud microphysics in marine boundary layer clouds.
- Observations show strong turbulence environment corresponds to weak precipitation and favors large droplets formation.
- LASSO output can help to investigate the mechanism leading to the inverse relationship between turbulence and precipitation.

Understanding Subgrid Cloud Variations (David Mechem and Zhibo Zhang)



LES (Full 3-D structure)

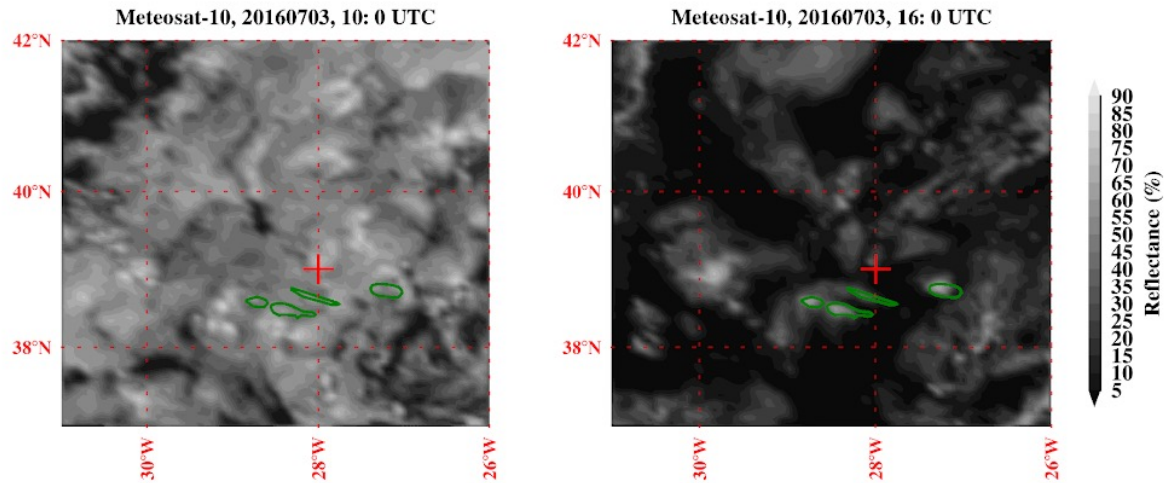


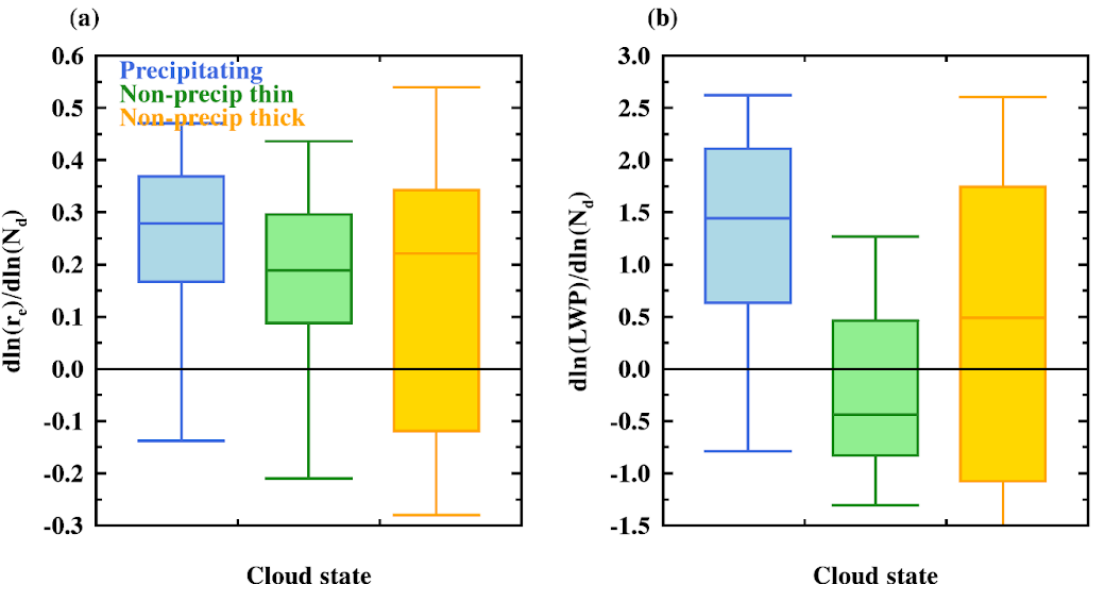


- Subgrid variations (both horizontally and vertically) of clouds are a significant source of uncertainty in ESM cloud parameterization.
- It is extremely difficult to obtain the full 3-D structure of clouds from observations.
- LASSO output can be used to evaluate and improve the subgrid parametrization schemes, from turbulence to warm rain and radiative transfer, for ESMs.

Zhang et al. 2021 ACP; Covert et al. 2021/2023 ACP; Ademakinwa et al. (in preparation); etc.

Cloud susceptibility to N_d (Xue Zheng and Shaoyue Qiu, LLNL)





- *Statistical results using the 5-min cloud retrievals within each two-hourly period from 242 ENA summertime warm boundary layer cloud cases*
- ENA observations indicate that cloud LWP susceptibility to cloud droplet number concentration (Nd) tends to be positive for precipitating clouds while negative for non-precipitating thick clouds.
- LASSO output can help understand how cloud LWP and Nd interact in warm boundary layer clouds with and without precipitation.

See Shaoyue Qiu's Poster 3-103

Summary – Use* of LASSO-ENA

- Mesoscale Variability Focus
  - Mesoscale water vapor, cloud and precipitation variability.
  - Maintenance of marine boundary layer convective complexes (MBLCC)
- Cloud Macro-physics Focus
  - Drizzle-turbulence-cold pool interactions
  - Virga depth variability with cloud and boundary layer properties.
- Cloud Microphysics Focus
  - Effect of turbulence on precipitation and cloud microphysics
  - Cloud susceptibility to Nd
  - Sub-grid scale variability of cloud water and Nd
  - CCN number and size during closed/open cellular stratocumuli.

*Not a comprehensive list