Potential modeling studies with EPCAPE stratocumulus cloud cases

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Motivation

- **Process-oriented** diagnosis and improvement of E3SM/SCREAM simulated cloud processes using ARM data

- Better understand the **aerosol indirect effect** on warm boundary layer clouds with ARM observations and LES simulations
- Reduce the related uncertainty in E3SM models

THREAD: Tying in High Resolution E3SM with ARM Data

E3SM: DOE Energy Exascale Earth System Model

SCREAM: the Simple Cloud-Resolving E3SM Atmosphere Model

Previous studies with ARM field campaign cases

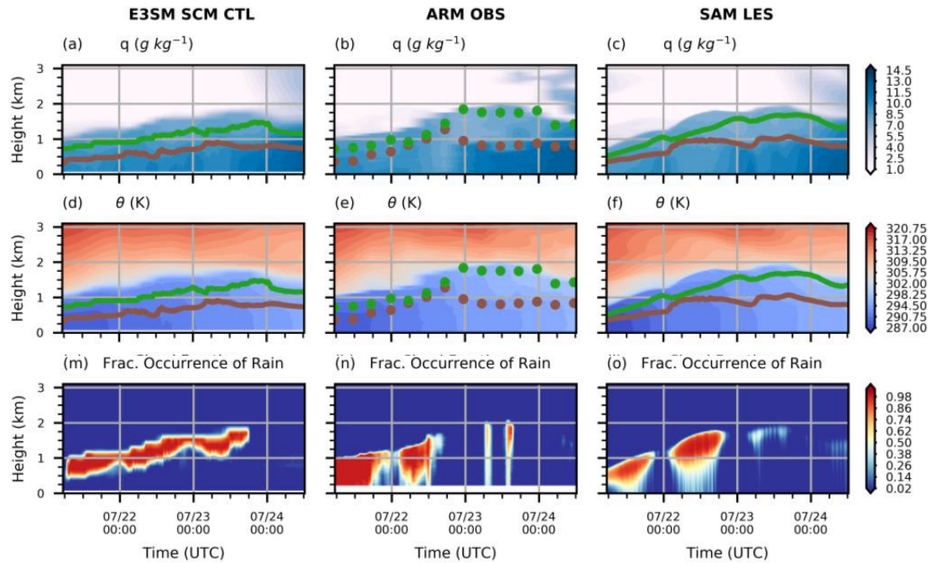
Findings

- The MAGIC case study evaluate the stratocumulus-to-cumulus transition in E3SMv1.
- An overly long microphysics timestep and an unrealistic parameterization of precipitation fraction in E3SMv1 cause unrealistic sub-cloud precipitation profiles.
- The CAP-MBL case study helps uncover issues with coupling between parameterizations in atmospheric model simulations

Zheng, X., S.A. Klein, V.P. Ghate, S. Santos, J. McGibbon, P. Caldwell, P. Bogenschutz, W. Lin, and M.P. Cadeddu, 2020: Assessment of Precipitating Marine Stratocumulus Clouds in the E3SMv1 Atmosphere Model: A Case Study from the ARM MAGIC Field Campaign. *Mon. Wea. Rev.,* **148**(8), 3341-3359, https://doi.org/10.1175/MWR-D-19-0349.1

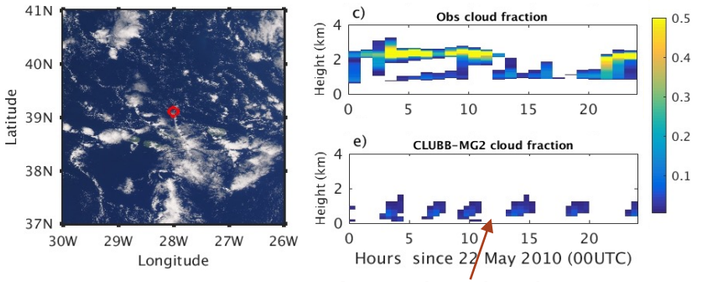
Zheng, X., Klein, S. A., Ma, H.-Y., Caldwell, P., Larson, V. E., Gettelman, A. and Bogenschutz, P. (2017), A cloudy planetary boundary layer oscillation arising from the coupling of turbulence with precipitation in climate simulations. *J. Adv. Model. Earth Syst.*, **9**, doi:10.1002/2017MS000993

MAGIC



CAP-MBL

Azores

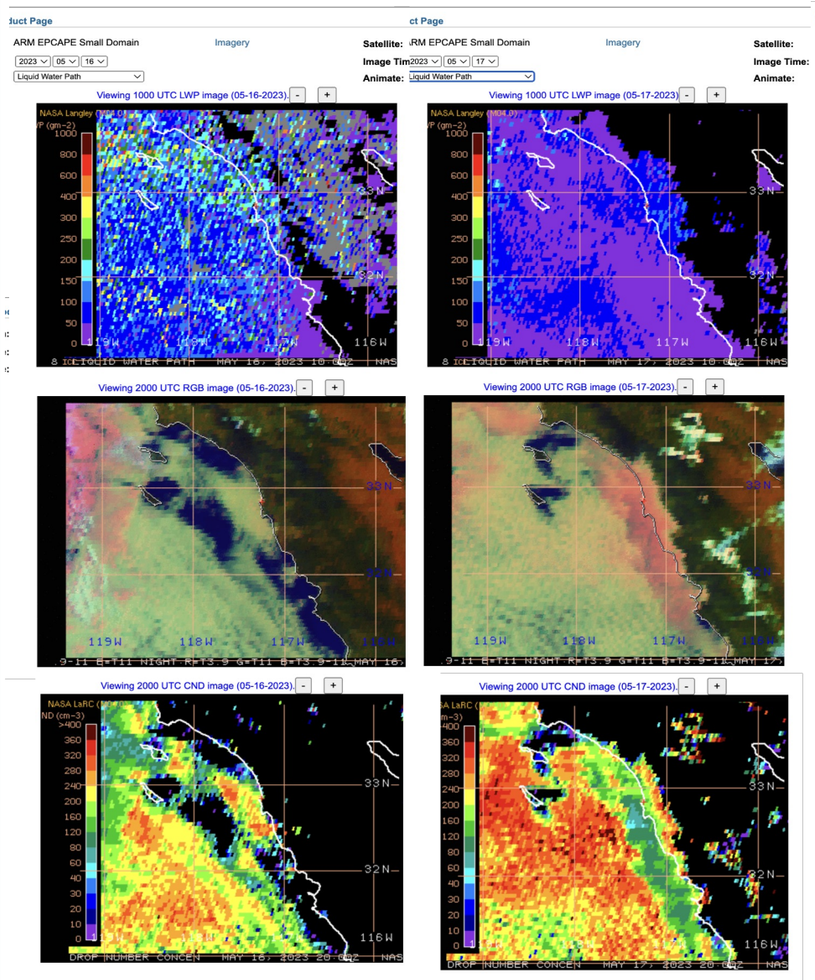


A regular cloud oscillation

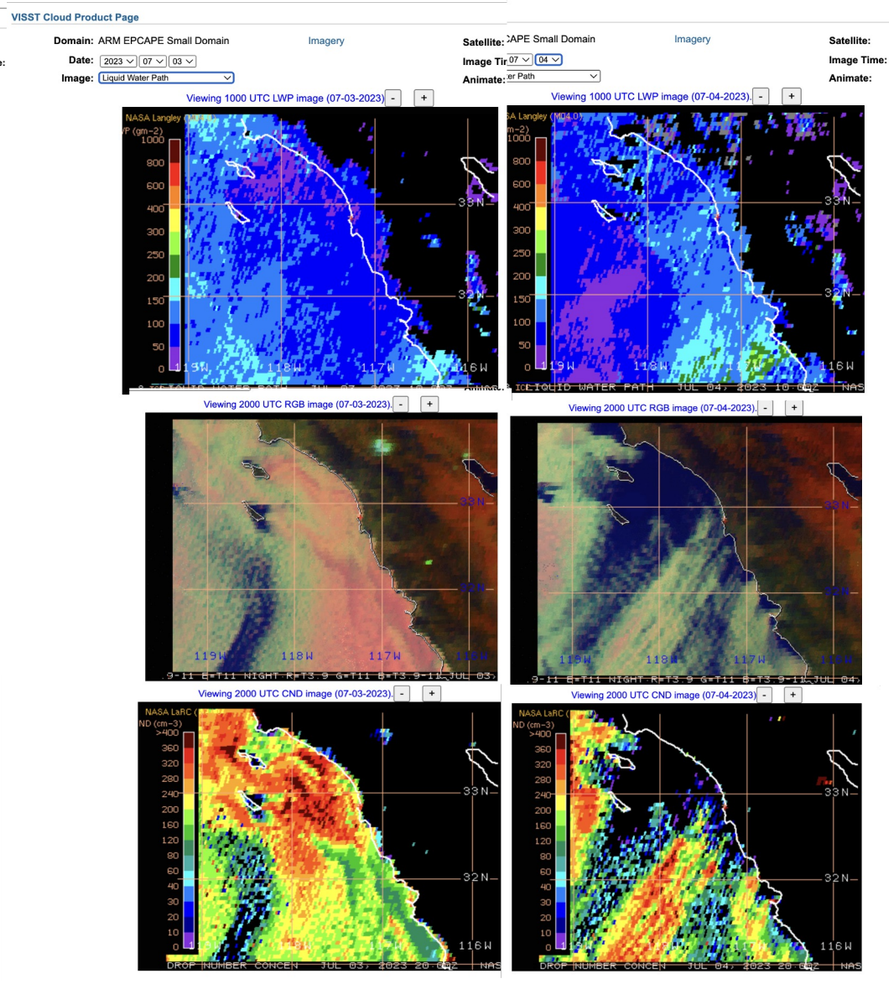
Objectives

- Spring time and early summer EPCAPE Cases (two illustrative cases).
- With EPCAPE observation, we are interested in:
  - Diurnal variability of the Planetary Boundary Layer (PBL), Stratocumulus Clouds, and Precipitation.
  - Cloud microphysical variations responding to different CN/CCN conditions.
  - Aerosol concentration and local aerosol transport under different synoptic conditions.
- The potential EPCAPE modeling study will emphasize coastal conditions.

EPCAPE Cases



May 16-17

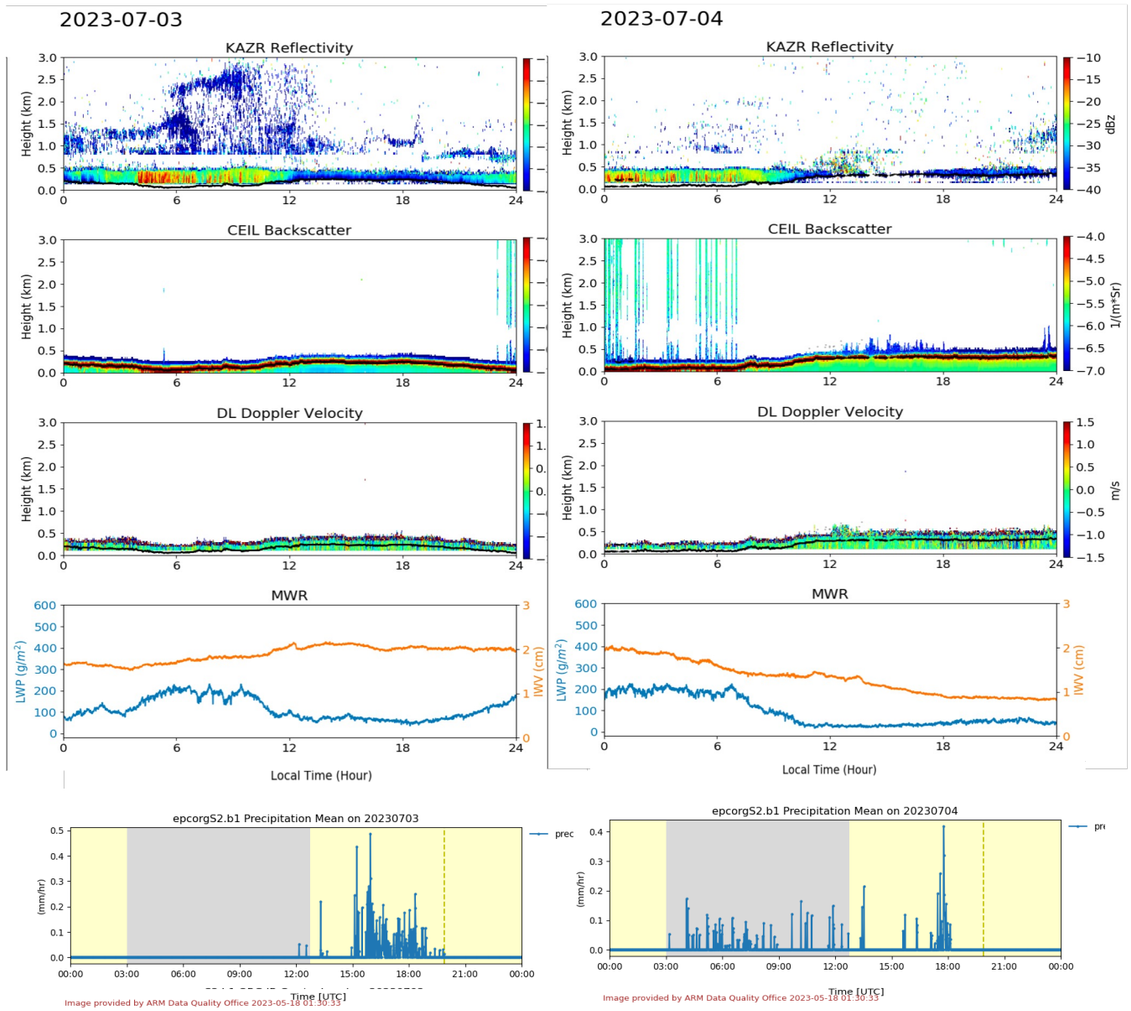


July 3-4

Long-term double-site ground based EPCAPE observations consist of a set of multi-day cases under different synoptic(or mesoscale) conditions with observed coastal cloud patterns and evolutions from satellite retrievals

(Simon, 1977; Koračin and Dorman, 2001; Koračin et al., 2005)

Diurnal Variability of PBL, Cloud and Precipitation

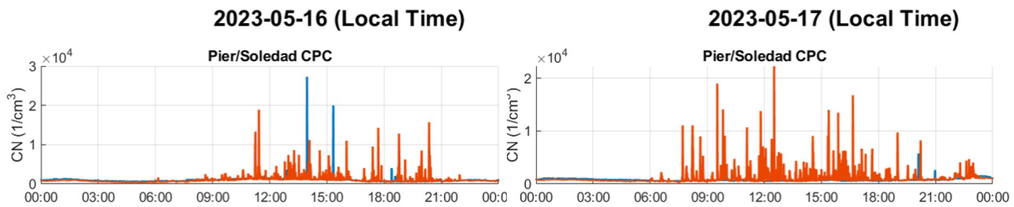


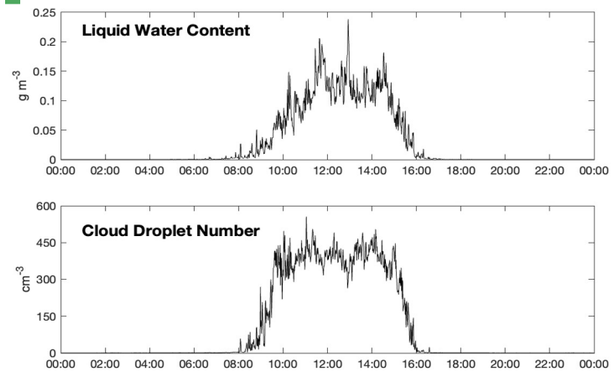
- Cases showing a clear diurnal cycle of PBL, cloud and precipitations
- Continuous PBL, cloud and precipitation observations from KAZR, Ceil backscatter, DL and surface met measurements.
- Additional observations covering spatial evolutions.

Chlond *et al.,* 2004; McMichael *et al.,* 2019; Considine, 1997

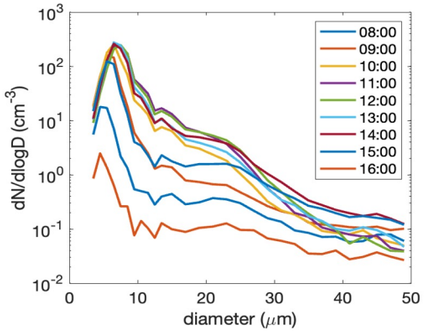
https://adc.arm.gov/afcd/#/epcape/overview

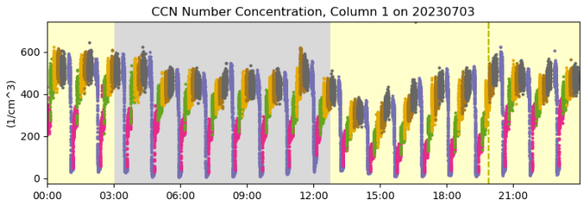
Cloud microphysics





May 16





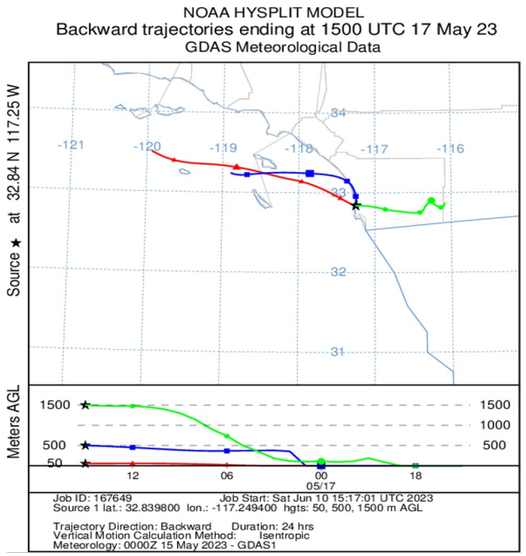
(UTC Time)

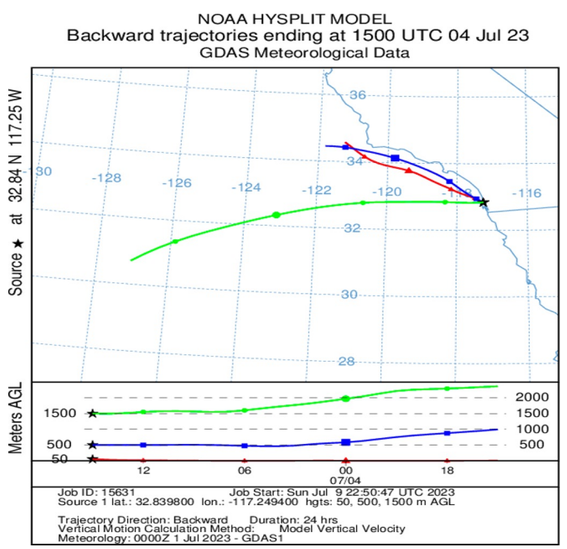
Fog Monitor

Rachel Chang, Dalhousie

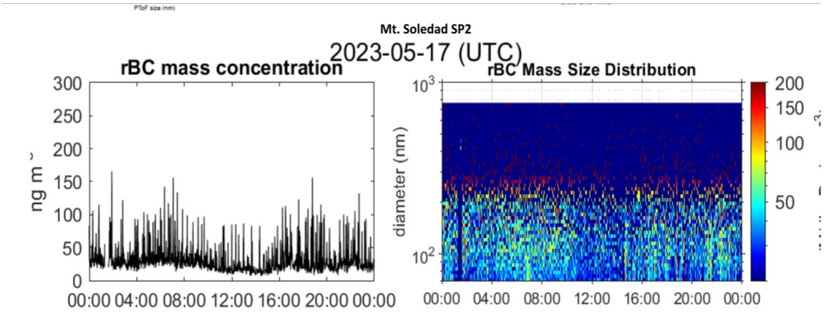
- EPCAPE PBL, cloud, and precipitation observations.
- Cases with continuous measurement (or retrievals) of cloud water content, drizzle water content, cloud droplet concentration, and cloud effective radius that respond to changes in CN/CCN conditions.
- Additional observations of in-cloud microphysical properties are ideal.

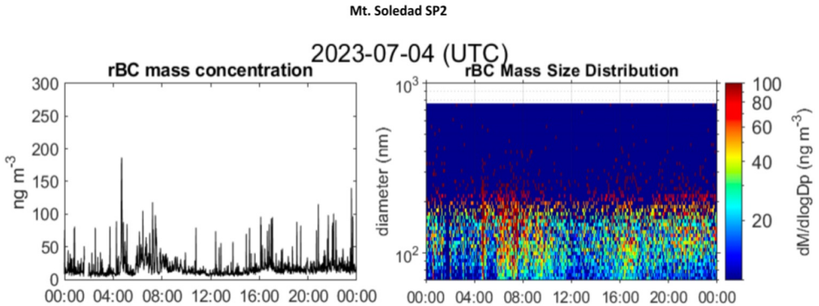
Aerosol concentration and local aerosol transport





- Multi-day cases showing significate aerosol concentration variability and synoptical changes in the local circulation.

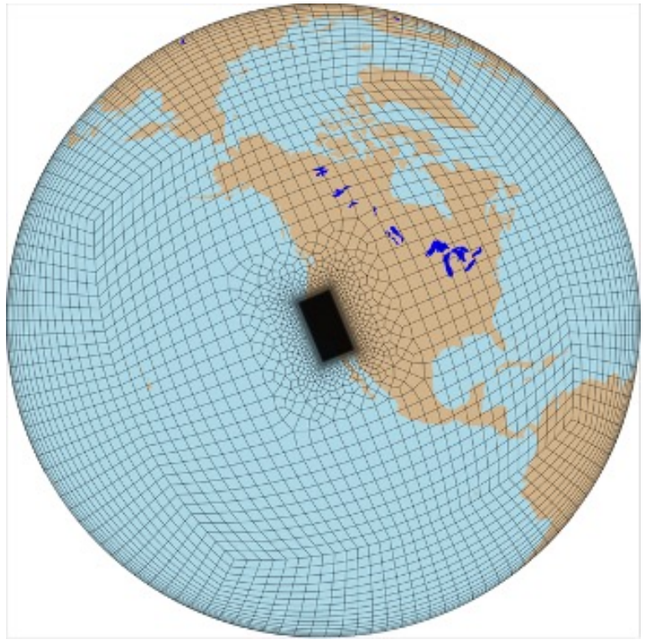


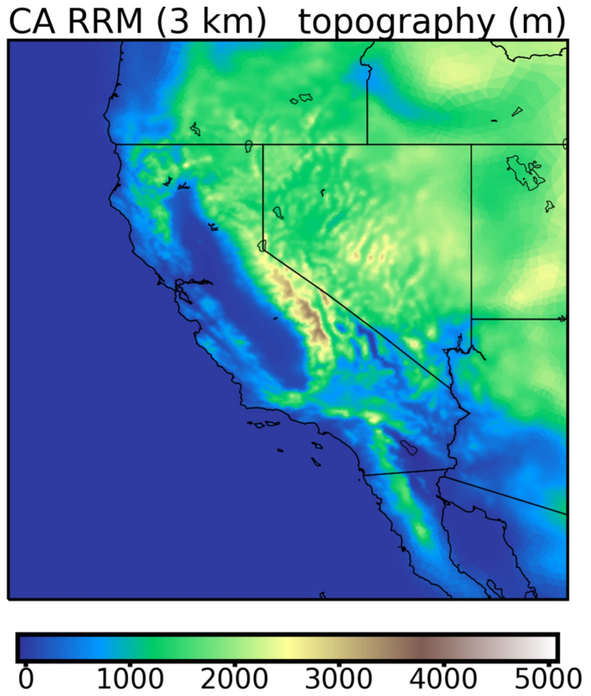


Potential modeling studies

E3SM/SCREAM RRM Simulations

- Diurnal cycle of PBL, cloud and precipitation.
- Coastal vs. offshore cloud variability
- Aerosol transport (using passive tracers)





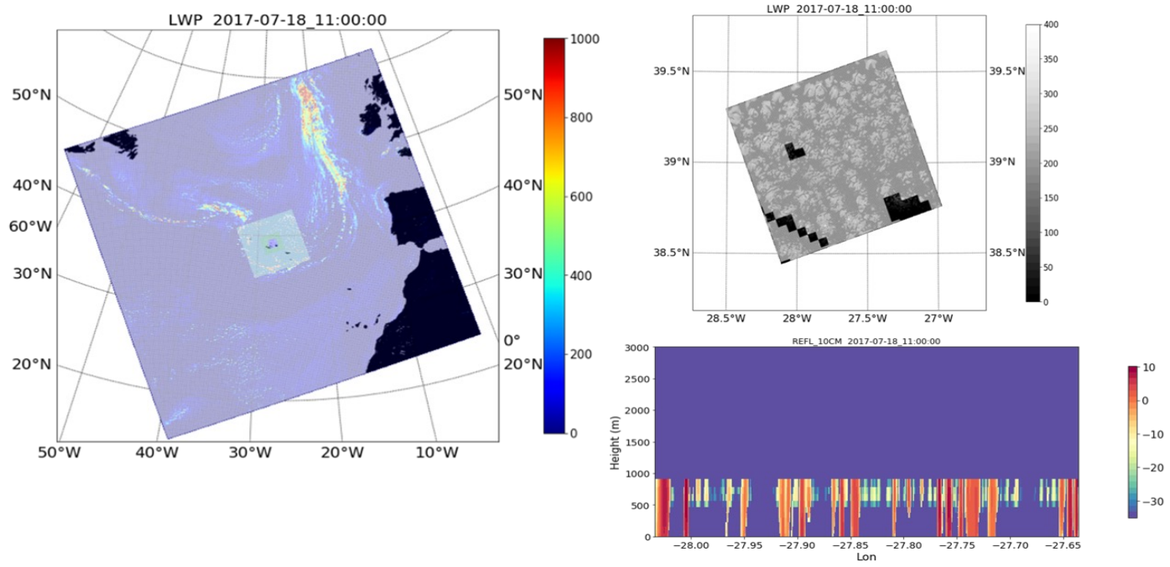
RRM: Regionally Refined Meshes

A RRM domain developed for a LLNL LDRD effort by Qi Tang and Peter Bogenschutz. Figures courtesy of Qi Tang, Jishi Zhang, and Peter Bogenschutz

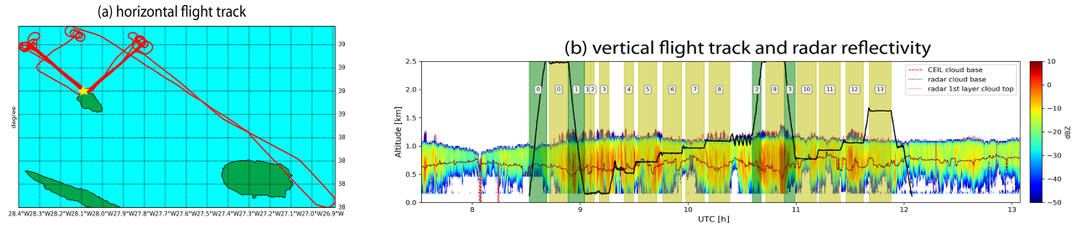
WRF Nested-domain Simulations

- Cloud microphysical responses to changes in CN/CCN conditions.
- Aerosol-cloud interactions in coastal stratocumulus clouds.

ACE-ENA simulation as an example



ACE-ENA IOP Case July 18, 2017



(Zhang *et al.*, 2021ACP)

Postdoc position at LLNL

https://www.llnl.gov/join-our-team/careers/find-your-job/all/all/3743990002299566

Summary and discussion

- Compared to previous field campaigns and modeling studies, we aim to use EPCAPE cases to
  - Assess the E3SM km-scale model, SCREAM's performance on the coastal stratocumulus cloud macro/microphysical variabilities related to the complex interplay between near coastal synoptic evolution, local circulations and boundary layer processes.
  - Understand the cloud responses to changes in aerosol conditions with WRF nested-domain simulations
- How can different EPCAPE modeling studies better collaborate with each other?
  - Case selection, model forcing and initial conditions, observational reference, modeling results

Thank you!