RACORO-FASTER Case Studies for Continental Boundary Layer Clouds

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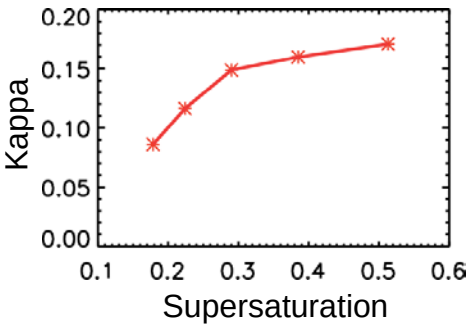
Goals:

- Assess and improve models of continental boundary layer cloud processes using RACORO aircraft and SGP observations
- Develop case studies for use by the modeling community

RACORO-FASTER Multi-Scale Analysis of Coupled Processes

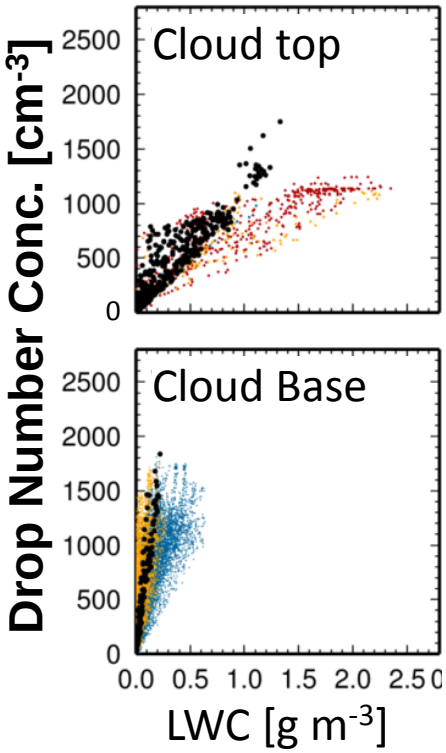
Provides an end-to-end analysis of boundary layer cloud processes

Observations

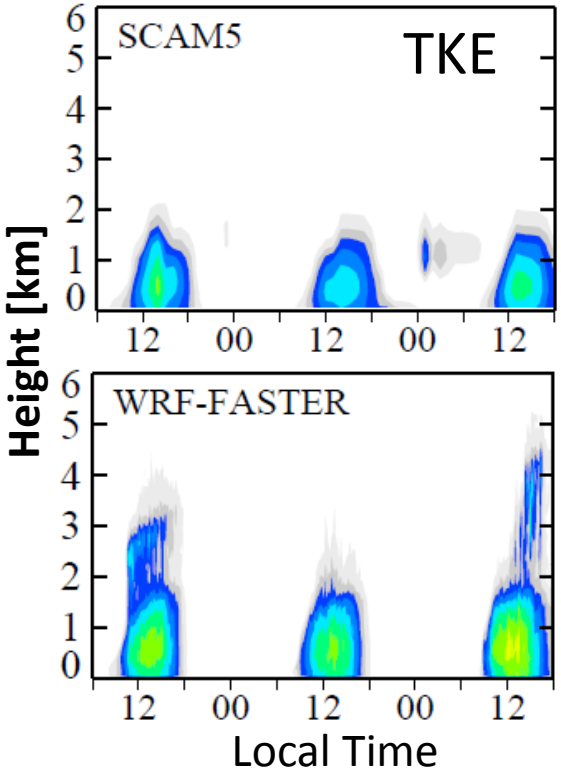


Plus ensemble Large-scale forcings

Large-Eddy Simulations



Single-Column Models



Part I: Vogelmann et al. (submitted)

Part II: Endo et al. (submitted)

Part III: Lin et al. (submitted)

Three 3-Day Case Study Periods Selected from RACORO

Continental vs. maritime

Capture diverse states:

- Time variation & transitions
- Cloud type (Cu, St, driz. St)

Comprehensive obs

Aircraft

- Aerosol size & CCN
- Cloud microphysics
- Atmospheric state
- Radiation

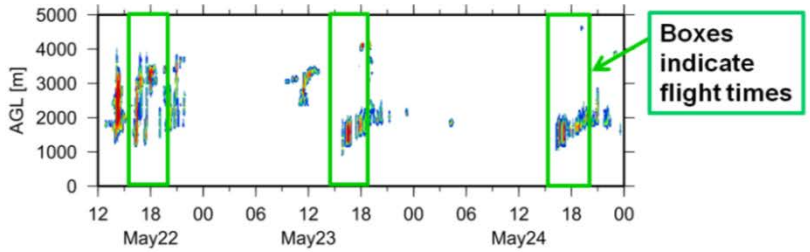
SGP surface observations

3 large-scale forcing datasets

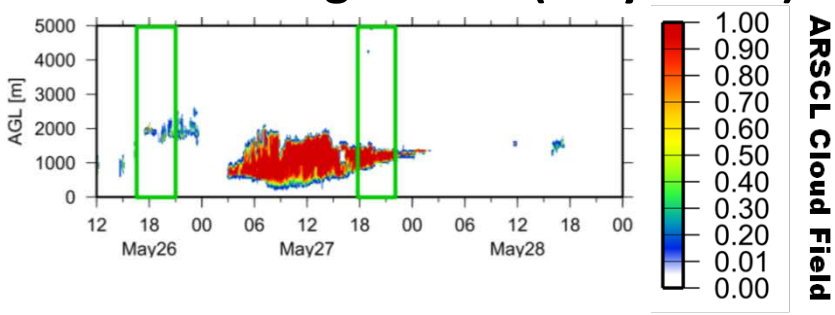
2 domains 300 km, 150 km

1. ARM Variational Analysis
2. ECMWF (12-36 hr forecasts)
3. Multi-Scale Data Assimilation

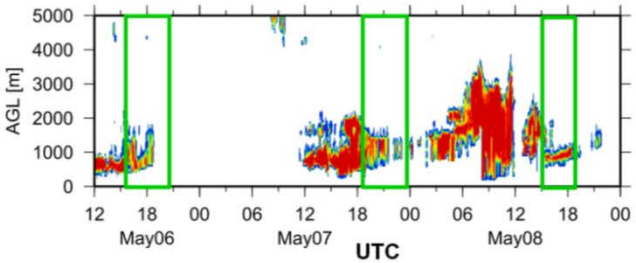
Case 1: Cumulus with Variable Aerosol (May 22-24)



Case 2: Cumulus and Drizzling Stratus (May 26-28)



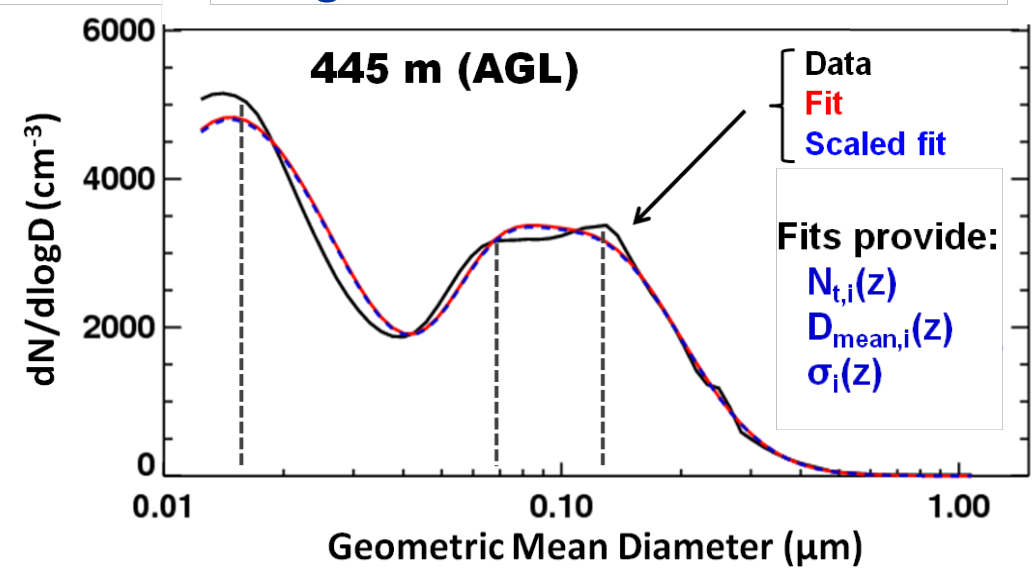
Case 3: Variable Cloud Types (May 6-8)



Aerosol Size Distribution and Hygroscopicity

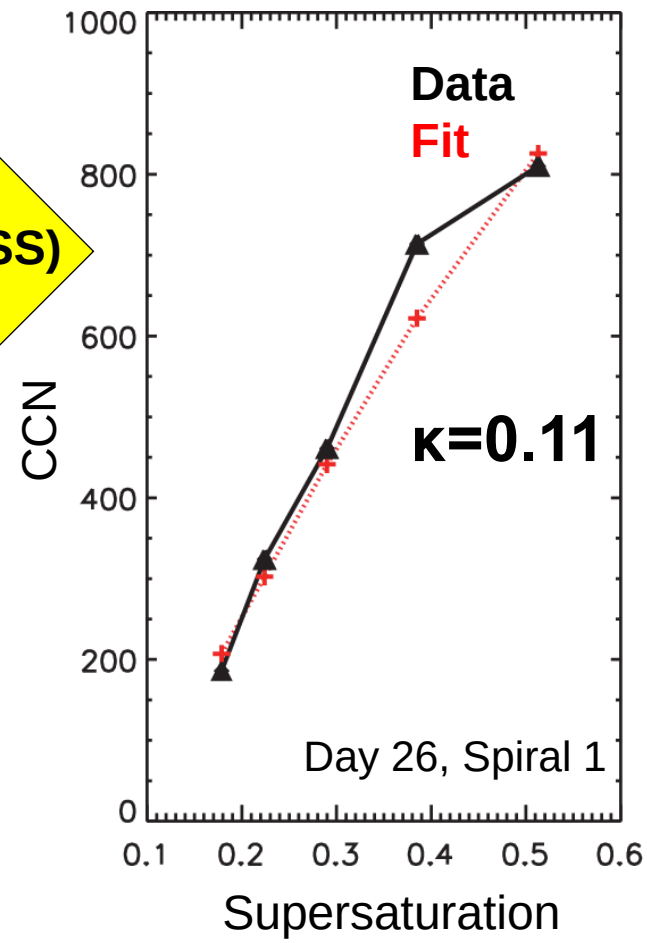
Aerosol profile observations of CCN (multiple SS) and size distributions

3 Lognormal Mode Aerosol Fits



+ CCN(SS)

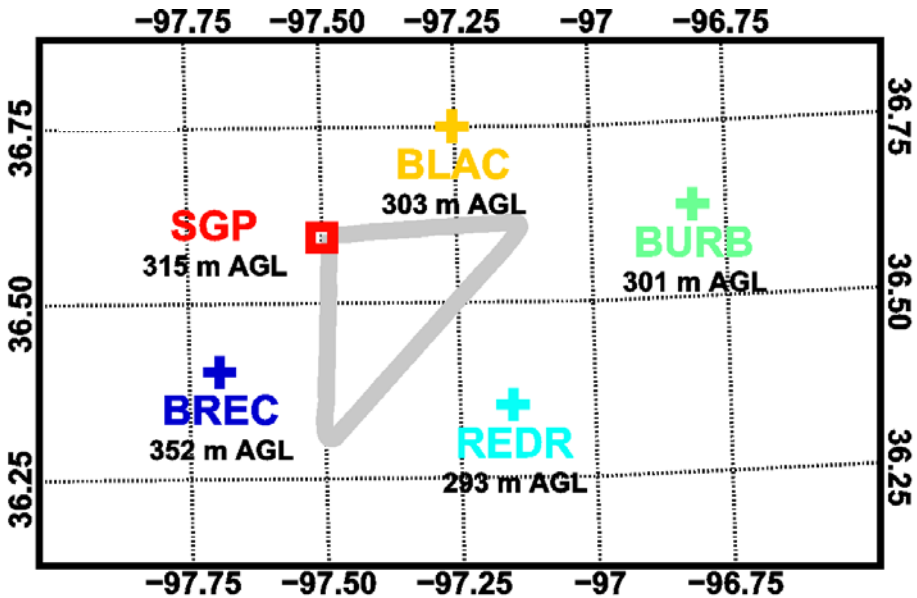
Kappa Fit

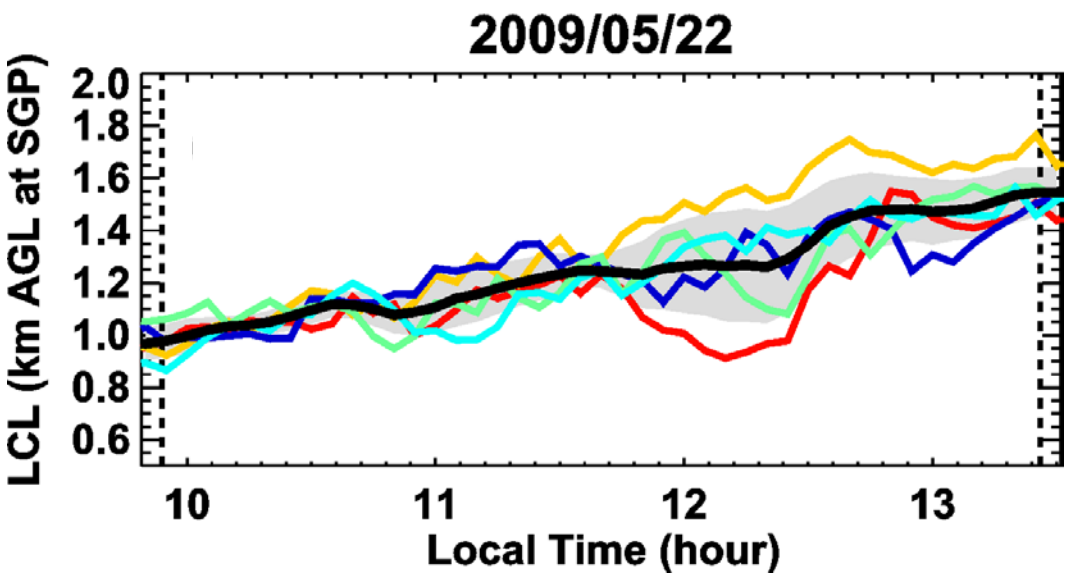


3 Flavors of Size Distribution

- Raw data
- 3-Mode Fits
- Fixed D,σ (variable $N_t(z)$)

Cloud-Base Height Characterization from LCL





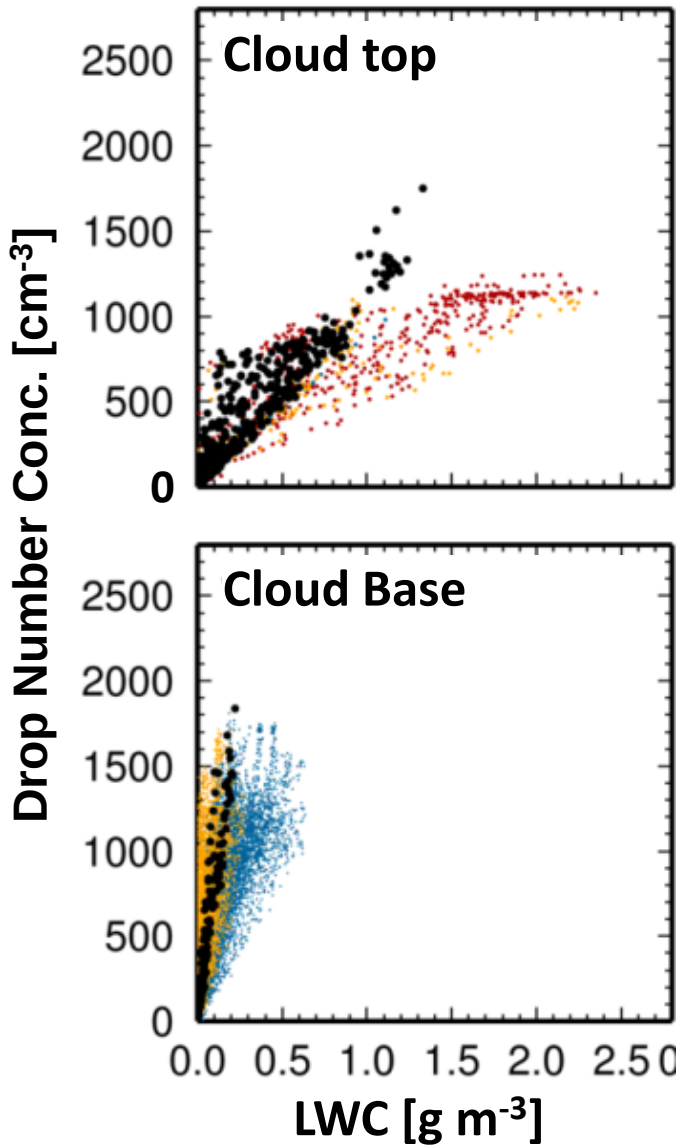
Endo et al. (submitted)

WRF Case 1 Cumulus Microphysics Analysis

- **Aircraft**

Model

- **Mean+σ**
- **Mean**
- **Mean-σ**



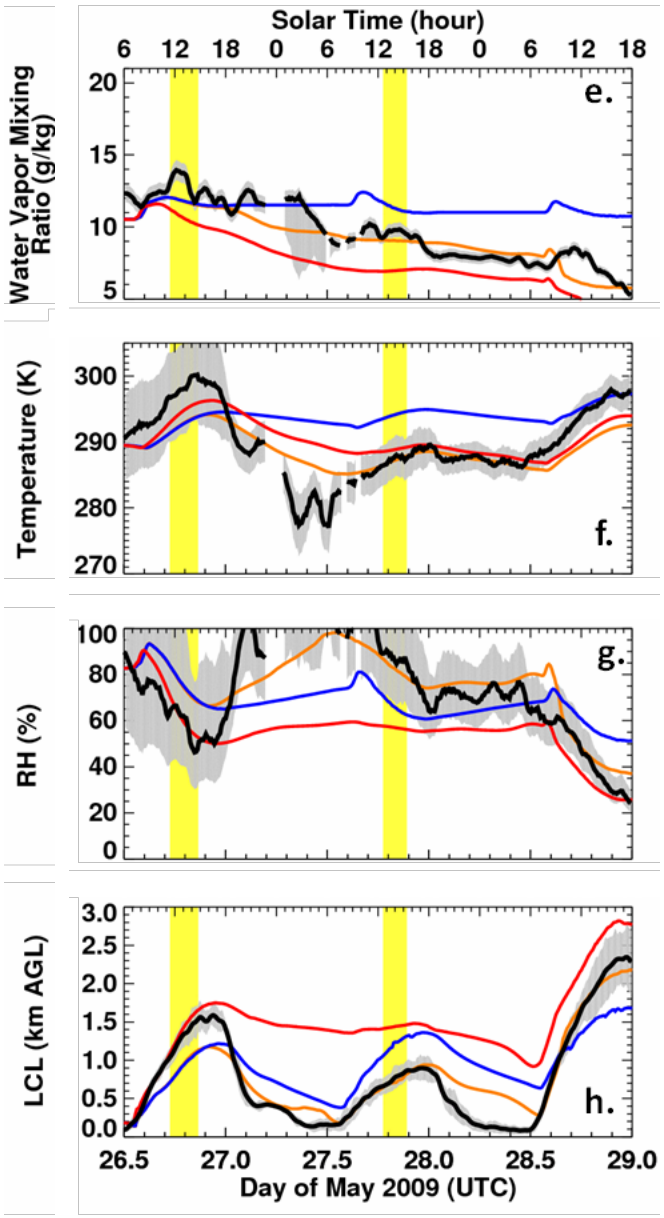
- Same pattern in DHARMA
- Entrainment mixing weak in model or
- Observed sampling missing maximum core values in cloud field

Endo et al. (submitted)

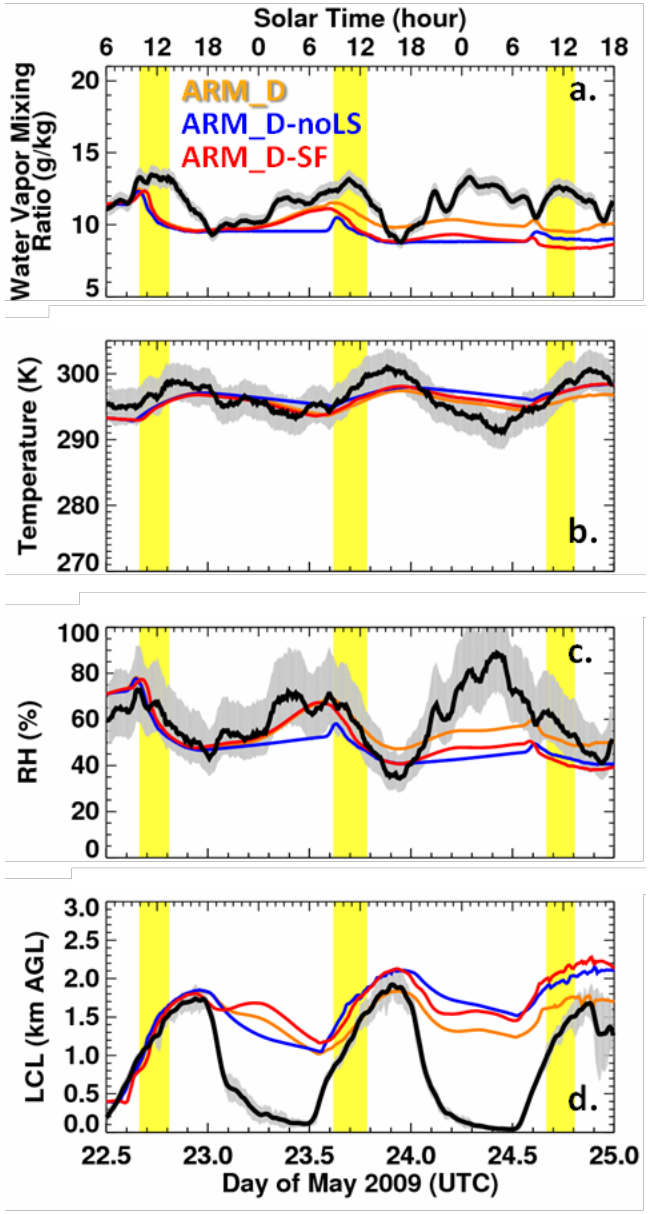
Importance of Large-Scale Forcing

Obs
ARM VA
No LS
~~Surf Flux~~

(2) Cu & Drizzling Status

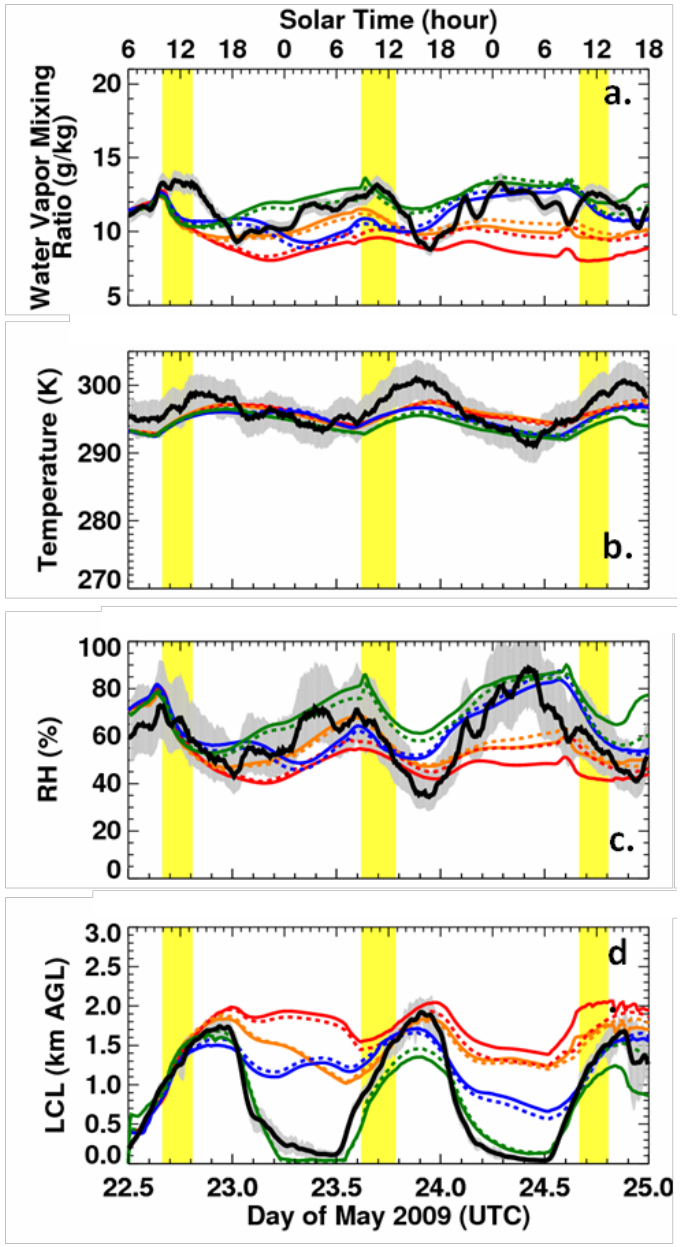


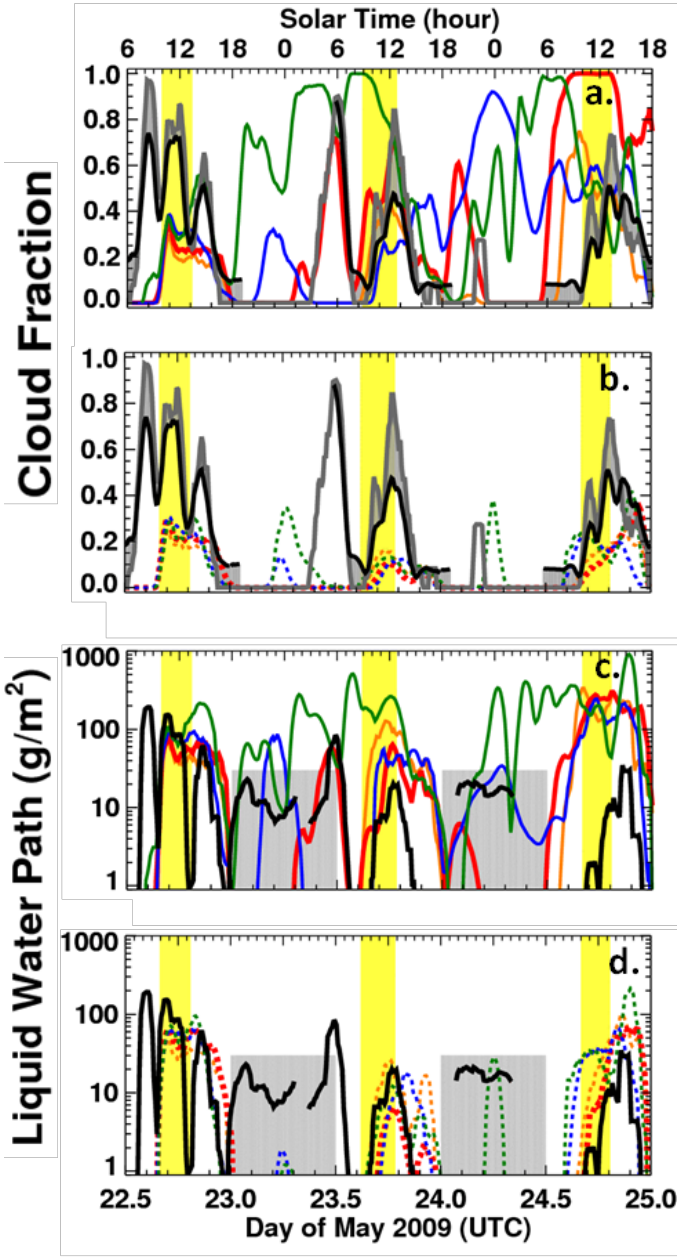
(1) Cumulus Case



(1) Cumulus Case: Ensemble Large-Scale Forcing Differences

ARM_D
ARM_d
ECMWF_d
MS-DA_d





Summary

RACORO cases developed for community use

- Diverse low-cloud types
- Three sources of large-scale forcing (ARM, ECMWF, MSDA), 2 domains @
- Standardized representation for easy use (LES, CRM, SCM)

Detailed aerosol description

- 3-mode fits
- Kappa determined to be ~0.1
  - Characteristic of a large organic fraction

Provides an important constraint for LES microphysics simulations

- Entrainment mixing weak in model or
- Sampling missing maximum core values in cloud field

Ensemble Large-Scale Forcings

- Small but important in locally forced cumulus case
- Significant differences between state-of-the-art forcings
- Relaxation/nudging can yield mixed results (improve one, degrade another)