1. RACORO*-FASTER: Case Study Generation for Continental Boundary Layer Clouds

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RACORO=Routine Atmospheric Radiation Measurement (ARM) Aerial Facility (AAF) Clouds with Low Optical Water Depths (CLOWD) Optical Radiative Observations

Summary

- Case studies are constructed to assess and improve models of continental boundary layer clouds and their fast-physics processes, as part of the FAst-physics System TEstbed and Research (FASTER) project.
- Cases are a synthesis of data from the RACORO aircraft campaign (Vogelmann et al., 2012) and the ARM SGP site, which were selected to capture diverse physical states:
  - Boundary layer cloud types (Cu, St, drizzling St)
  - Time variation/transitions (multiple days/timing)
- These cases are a physical contrast to the Global Atmospheric System Studies (GASS, previously GCSS) that primarily focus on steady-state, marine boundary layer clouds.
- We use the FASTER integrated observation-LES-SCM evaluation framework to address the inherent multi-scale nature of the problem.

1. FASTER Case Study Selection/Development

Data-model integration takes a team

Observation-LES-SCM Approach

1. **Observations and initial conditions (This poster)**
   Selects multi-day periods with aircraft flights that sampled different cloud types
   Generates aerosol size distributions and hygroscopicity data
   Assesses large-scale forcing datasets

2. **High-resolution modeling (Lead: Ann Fridlind and Satoshi Endo)**
   Examines simulated cloud properties for study periods
   See Satoshi Endo's poster →

3. **Single-Column Model (SCM) diagnostics (Lead: Wuyin Lin)**
   Examines SCM biases for low-level clouds
   Examines reason for over triggering in the CAM5 SCM
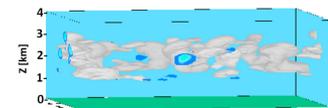   **See Wuyin Lin's poster →**

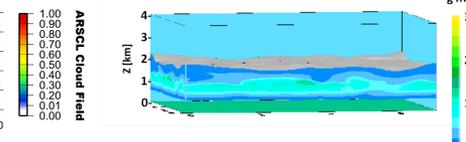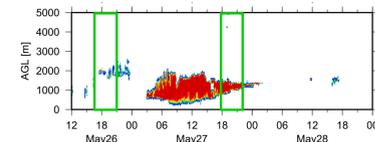## 2. Three 3-day Case Study Periods Selected

Case 1: Cumulus with Variable Aerosol (May 22-24)
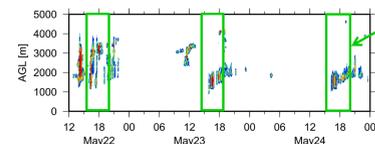
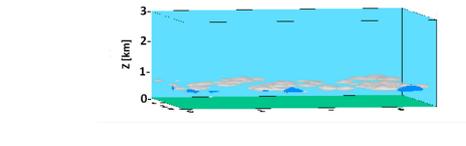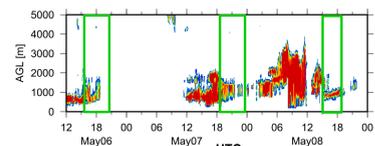Liquid water content field in DHARMA

Boxes indicate flight times

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

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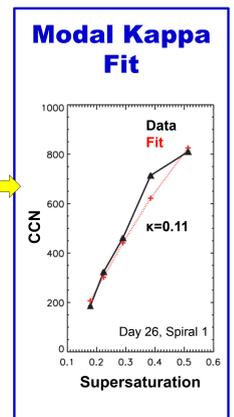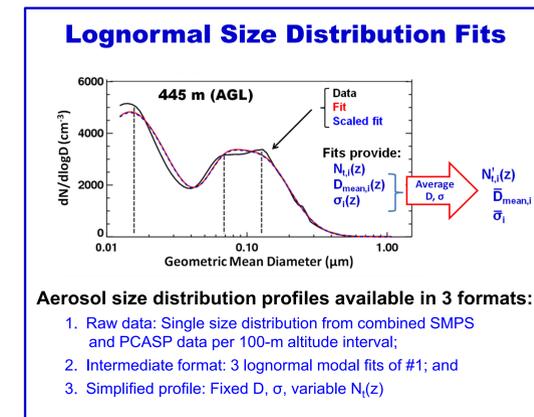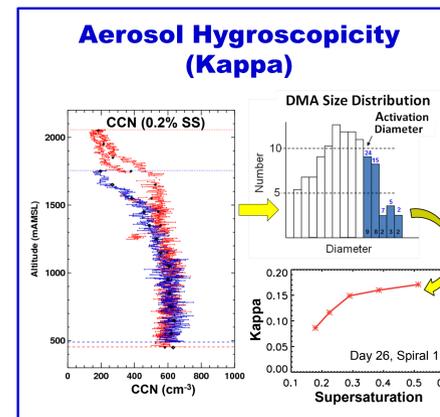
Case 3: Variable Cloud Types (May 6-8)

The Plan:
- Generate integrated, realistic cases for FASTER, ASR and broader communities
- Later, simplify to observationally constrained "idealized/hybrid" cases (for ease of use)

3. Aerosol Size Distributions and Hygroscopicity

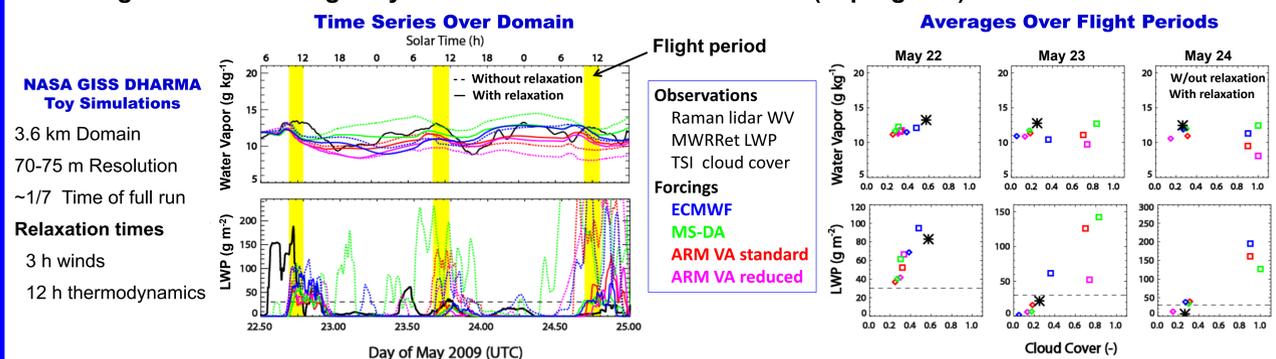RACORO aerosol profile observations of CCN (multiple supersaturations) and size distributions

Aerosol Hygroscopicity (Kappa)

CCN (0.2% SS)

DMA Size Distribution
Activation Diameter

Day 26, Spiral 1

Lognormal Size Distribution Fits

445 m (AGL)

Data
Fit
Scaled fit

Fits provide:
$N_i(z)$
$D_{mean,i}(z)$
$\sigma_i(z)$

Average D, σ

$N'_i(z)$
$\bar{D}_{mean,i}$
$\bar{\sigma}_i$

Aerosol size distribution profiles available in 3 formats:
1. Raw data: Single size distribution from combined SMPS and PCASP data per 100-m altitude interval;
2. Intermediate format: 3 lognormal modal fits of #1; and
3. Simplified profile: Fixed D, σ, variable $N_i(z)$

Modal Kappa Fit

Data
Fit

$\kappa=0.11$

Day 26, Spiral 1

The low kappa values observed (0.05-0.20) suggest a large organic aerosol fraction

4. Large-Scale Forcing Datasets

Large-scale forcings are obtained:
- From the ARM variational analysis (ARM VA) for a standard domain (300 km, 25 mb) & reduced domain (150 km, 10 mb)
- Derived from ECMWF for a standard domain (300 km) and a reduced domain (150 km), both with 3-25 mb vertical resolution
- Derived from a Multi-Scale Data Assimilation (MS-DA) System (300 km, 25 mb) (see **Sha Feng's poster →**)

Forcings assessed using "Toy" LES runs and bulk observations (in progress)

Time Series Over Domain

Flight period

NASA GISS DHARMA Toy Simulations

3.6 km Domain

70-75 m Resolution

~1/7 Time of full run

Relaxation times

3 h winds

12 h thermodynamics

Without relaxation
With relaxation

Observations
Raman lidar WV
MWRRet LWP
TSI cloud cover

Forcings
ECMWF
MS-DA
ARM VA standard
ARM VA reduced

Averages Over Flight Periods

May 22
May 23
May 24

W/out relaxation
With relaxation

Acknowledgements & References

Contact: Andy Vogelmann, vogelmann@bnl.gov, 631-344-4421

For more information on RACORO:

RACORO ACRF Website: http://acrf-campaign.arm.gov/racoro/
Vogelmann, A. M., 2012: RACORO Data Guide Version 2: http://www.arm.gov/publications/programdocs/doe-sc-arm-10-031.pdf?id=13
Vogelmann, A. M., G. M. McFarquhar, J. A. Ogren, D. D. Turner, J. M. Comstock, G. Feingold, C. N. Long, and 19 co-authors, 2012: RACORO Extended-Term, Aircraft Observations of Boundary Layer Clouds, *BAMS*, 93, 861–878.

Papers in preparation/submitted:

Endo, S. et al., RACORO-FASTER Large Eddy Simulations of Continental Boundary Layer Cumulus Clouds (*JGR*, in prep)
Lin, W. et al., RACORO-FASTER Single-column model simulations and parameterization improvement in the SCAM5 (*JGR*, in prep)
Vogelmann, A. M. et al., RACORO-FASTER Case Studies of Continental Boundary Layer Clouds (*JGR*, in prep)
Development and Analysis of Large-Scale Forcing Using a Multi-Scale Data Assimilation System.
    Part I: Methodology and Evaluations (Li, Z. et al., *JGR*, submitted)
    Part II: Scale-Aware Forcing and Single-Column Model Experiments (Feng, S. et al., *JGR*, in prep)
    Part III: Hydrometeor Forcing and Single-Column Model Experiments (Feng, S. et al., *JGR*, in prep)