The RACORO-FASTER Project

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Poster #s

106 Yangang Liu et al.:
Development of Integrative LES-CRM-SCM-NWP Evaluation Framework and Demonstration with RACORO Case

107 Andy Vogelmann et al.:
1. RACORO-FASTER: Case Study Generation

108 Satoshi Endo et al.:
2. RACORO-FASTER: Large Eddy Simulations

109 Wuyin Lin et al.:
3. RACORO-FASTER: Climate Significance and SCM Simulations

110 Zhijin Li et al.:
Aerosol Reanalysis Using a Multiscale Aerosol Data Assimilation System for the FASTER Project
FASTER RACORO: Selection and Observational Constraints

A multi-pronged observation-LES-SCM approach selected three 3-day periods:
Case 1: Cumulus with Variable Aerosol
Case 2: Cumulus and Drizzling Stratus
Case 3: Variable Cloud Types

Observational Constraints:
- LW & Aerosol Profiles

**Longwave Flux Calculations**

**Aerosol Accumulation Mode Fits**

**Aerosol Hygroscopicity (Kappa)**

CCN (0.2% SS)

DMA Size Distribution

Kappa: 0.11-0.17
A new set of “realistic” runs by DHARMA and WRF-FASTER are under examination.

**New Since Telecon**
- 3-h relaxation for temperature/water vapor
- Using the **same grid spacing** in low levels
- **Radiation ON**
- Aerosol effect in DHARMA (to be included in WRF)

**No Change**
- Three 60-h runs initialized by sounding just after sunrise
- Driven by surface and large-scale forcings from the ARM VARANAL product
- 1-h relaxation for horizontal wind components

We plan more examination in model configuration (e.g., relaxation time scale), comparison with observation, and idealization for target processes/periods.
FASTER RACORO LES update

Test of aerosol representation in DHARMA with Morrison two-moment microphysics.

**Aerosol-Cloud Interactions**
- Idealized, observation-based, *time-varying aerosol number size distribution profile*
- Observation-based composition ($\kappa=0.12$)
- *Aerosol loss* via local coll-coal
- *Relax to background* (advection/sources)

**Next Steps**
- Use RACORO in situ cloud obs to evaluate DHARMA, WRF-FASTER, SAM results
- Document case studies: description, intercomparison of LES/SCM/obs, and climatological/radiative context

CASE 1: Background aerosol and predicted cloud droplet number concentrations varying on consecutive days of cumulus
FASTER-assisted ModelE development

Implementation of Morrison and Gettelman (2008) two-moment microphysics in ModelE.

**RACORO/CAP-MBL GISS Posters**
- 56—DHARMA/ModelE SCM—Ackerman
- 57—CAP-MBL/ISCCP/ModelE—Tselioudis
- 58—CAP-MBL cloud/drizzle obs—Rémillard
- **Suite of continental and oceanic shallow cloud case studies** (observationally rich)

**Other FASTER/RACORO Posters**
- 106—FASTER methodology overview—Liu
- 107—RACORO obs to cases—Vogelmann
- 108—RACORO LES comparison—Endo
- 109—RACORO SCM/climatology—Lin
- 110—RACORO WRF-Chem—Li
FASTER-RACORO SCM/Climatology update

Larger-scale cloud environment of the three cases

1: Cu. w/ variable aerosols

- May 23
- May 24
- Short lived
- Locally developed
- Scattered cumulus

2: Cu & Drizzling stratus

- May 27
- May 28
- 1st daytime Cu, locally developed;
- 2nd day, cloud structures (N & S) merged, evolved then moved out

3: Variable cloud types

- May 7
- May 8
- Migrating cloud fields, daytime clouds mostly locally developed then moved out

Source: NASA Langley
Overview of the simulated clouds by GFDL AM3, GISS modelE, and CAM5 SCMs

1: Cu. w/ variable aerosols
2: Cu & Drizzling st.
3: Variable cloud types

ARSCL  GFDL  GISS  CAM5

GFDL: very few clouds
GISS: well simulated. scattered, recurrence, vertical extent
CAM5: penetrate too high not dissipated night time

2nd day St: all well reproduce clouds, esp. temporal evolution.
1st day cumulus: GFDL: missed GISS and CAM5: OK

GISS and CAM5: some thin stratus, day 1 & day 2.
GFDL: very few clouds (all 3 cases missed locally driven clouds)
Do the convection schemes rule concerning cloud production?

**Overall Cloud Fraction**

- **Height (km)**
- **Standard CAM5**

**Convective Cloud Fraction**

- **Both unfavorable to the problem**

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**Turn off Deep convection**

- **CAM5_nodc**

**Confined w/i lower-troposphere. Insufficient vert. extent. Not dissipated night time.**

**Good timing of Cu occurrence But Cu clouds under-produced**
FASTER-RACORO SCM/Climatology update

Cloud production by shallow cumulus in SCMs:

- Very little direct cloud production by (shallow) cumulus scheme!
- Shallow Cu., more physically based
- Stratiform RH-dep.
What can LES simulations inform us about the working of UW shallow Cu. scheme?

Shallow Cu scheme tends to underestimate cloud amount at cloud base?

\[ w > w_c = \sqrt{2CIN}, \text{ convect} \]

\[ P(w) = \frac{1}{\sigma_w \cdot \sqrt{2 \cdot \pi}} \cdot \exp \left( -\frac{w^2}{2 \cdot \sigma_w^2} \right) \]

PDF-width: TKE

*AM3 vs CAM5

\( w_c \): updraft properties launching level sounding
Screening criteria: presence of low-level clouds with very little overlying clouds.

Multi-year statistics of low-level clouds over the SGP site (poster # 109 by Lin et al.)
Low-level cloud regimes over the SGP site

1. Scattered shallow cumulus
2. Stratocumulus
3. Thick Stratus
   (weather influence)
4. Thin Stratus
What do long-term SCM simulations get?

More often than not, SCMs fail to respond correctly to ENV in producing low-level clouds!
Data Assimilation for Improved Hydrometeor Forcing

\[ - \vec{v} \cdot \nabla q_w = - \vec{v} \cdot \nabla \bar{q}_w - \vec{v}' \cdot \nabla q'_w \]

(Advection of liquid water)

(Average over 300x300 km²)
Large-Scale and Multi-Scale Forcing

\[- \mathbf{v} \cdot \nabla q = - \mathbf{v} \cdot \nabla q - \mathbf{v}' \cdot \nabla q' \]

- The subgrid component of moisture forcing is significant with a grid-size of 200 km.

- The significance of the subgrid component of moisture forcing increases with a smaller grid size.

• The subgrid component of moisture forcing is significant with a grid-size of 200 km.

• The significance of the subgrid component of moisture forcing increases with a smaller grid size.
High concentrations and complex spatial and temporal changes suggest a requirement on aerosol initialization and forcing.
Impact of Hydrometeor Advection on CAM5-SCMs

With

Without

Difference