Large-Eddy Simulation of the VOCALS RF06 Pocket of Open Cells:
Dynamics, Maintenance Timescale for Microphysical Gradients, and Entrainment

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Modeling Objectives

- Effects of $N_c$ treatment
  - Evaluate the sensitivity of the simulation to the choice of fixed or advected $N_c$ distribution

- Comparison to Observations
  - See if LES can capture the character of the observed boundary layer when initialized from observations

- Entrainment
  - Investigate differences in entrainment between the overcast (OVC), open-cellular (POC), and transition (TRANS) regions
Model and Simulation Configuration

- **SAM v6.7 LES**
  - Anelastic dynamical formulation
  - Morrison 2005 microphysics
    - Advecated or fixed $N_c$
  - CAM3 radiation

- **Simulation**
  - Bowling alley domain, 192 km x 24km in horizontal, x direction oriented perpendicular to mean PBL wind
  - 125m $\Delta x$ and $\Delta y$, varying $\Delta z$ of 30m near surface, 5m near inversion, stretched to grid top at 30km for radiation
  - Total of 192x192x1536 gridpoints
Initialization

- Thermodynamic and Wind Profiles
  - Basic profile assembled from RF06 legs P2d, P4u, and NCEP reanalysis
  - Wind profile tweaked such that mean boundary layer wind spins up with geostrophic forcing to profile similar to obs
Initialization (2)

- Microphysics
  - Varying $N_c$ specified across x direction
    - $N_c$ of 60 cm$^{-3}$ in overcast region (88 km)
    - $N_c$ of 10 cm$^{-3}$ in POC region (88 km)
    - 8 km half sine wave transitions between regions
Cloud Field Evolution

- Pseudo-albedo snapshots
Effects of $N_c$ Advection
Time Series

- LHF [W m\(^{-2}\)]
- SHF [W m\(^{-2}\)]
- LWP [mm]
- Surface Precip [mm day\(^{-1}\)]
- Cloud Fraction

Legend:
- NCFIXED OVC
- NCFIXED POC
- NCFIXED TRANS
- NCADVECT_OVC
- NCADVECT_POC
- NCADVECT_TRANS
- SEP_OVC
- SEP_POC

Local Solar Time

0000  0200  0400  0600  0800  1000  1200  1400
Profiles: 02-04 LST

Profiles:

\[ \theta_l \quad q_t \quad q_i \quad \text{Cloud Fraction} \]

\[ 0 \leq z \leq 2000 \text{ m} \]

\[ 285 \leq \theta_l \leq 305 \text{ K} \]

\[ 0 \leq q_t \leq 10 \text{ g kg}^{-1} \]

\[ 0 \leq q_i \leq 0.75 \text{ g kg}^{-1} \]

\[ 0 \leq \text{Cloud Fraction} \leq 1 \]

Drizzle Flux

\[ 0 \leq z \leq 2000 \text{ m} \]

\[ 2000 \leq \text{Drizzle Flux} \leq 6 \text{ mm day}^{-1} \]

Vertical Velocity Variance

\[ W_{e, OVC} = 7 \text{ mm s}^{-1} \]

\[ W_{e, POC} = 4 \text{ mm s}^{-1} \]

Buoyancy Flux

\[ 0 \leq z \leq 20 \text{ m} \]

\[ 0 \leq \text{Buoyancy Flux} \leq 2 \times 10^{-4} \text{ m}^2 \text{ sec}^{-3} \]
Cold Pooling

00 LST

02 LST

04 LST

06 LST

Surface Temperature [°K]

x [km]

y [km]
Mesoscale Circulation

Two-hour mean streamfunction $\Psi''$

00-02 LST

02-04 LST

04-06 LST

(contours of $\Psi/10$ [kg m$^{-2}$ s$^{-1}$])

$z$ [km]

$x$ [km]
Entrainment

- Analysis of streamfunction at level of inversion suggests diminished effective subsidence over POC

Two-hour mean $\Psi'$ at $z_i$

$W_{OVC} = -3.2$ mm s$^{-1}$

$W_{POC} = -0.2$ mm s$^{-1}$
Conclusions

- LES initialized from observations captures the basic behavior of the boundary layer fairly well.
- Too much cloud in the POC; less simplistic microphysical scheme necessary?
- Entrainment differential across between POC and surrounding overcast compensated by mesoscale circulation in order to keep the inversion level.
Thanks for listening!
Questions?
Entrainment Time Series