On the new CCSM boundary layer physics interactions & the subtropical South Atlantic

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Low cloud climatology
## CCSM-CESM/CAM Evolution

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<tr>
<td>Atmosphere</td>
<td>CAM3 (L26)</td>
<td>CAM3.5 (L26)</td>
<td>CAM4 (L26)</td>
<td>CAM5 (L30)</td>
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<tr>
<td>Boundary Layer</td>
<td>Holtslag and Boville (93)</td>
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<td>UW Diagnostic TKE Park et al. (09)</td>
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<td>Shallow Convection</td>
<td>Hack (94)</td>
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<td>Zhang and McFarlane Neale et al., Richter and Rasch (08) mods.</td>
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<td>Radiation</td>
<td>CAMRT (01)</td>
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<td>RRTMG Iacono et al. (2008)</td>
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<td>Aerosols</td>
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<td>Dynamics</td>
<td>Spectral</td>
<td>Finite Volume (96,04)</td>
<td>Finite Volume HOMME</td>
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<tr>
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<td>POP2 (L40)</td>
<td>POP2.1 (L60)</td>
<td>POP2.2</td>
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<td>CLM4 – CN</td>
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<td>Sea Ice</td>
<td>CSIM4</td>
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<td>CICE</td>
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</table>
CAM4 v. CAM5 Physics

*Vertical Diffusion*

1. Turbulent Mountain Stress
2. Eddy Diffusivity
   A. compute_eddy_diff (CAM5, store TKE for shcu)
   B. compute_hb_diff (CAM4)
3. Diffusion solver (compute_vdiff)
Moist turbulence & low clouds

- Entrainment
- Turbulent Mixing
- "Convective Layer"
- Cloud-top Cooling
- TKE
- Surface fluxes
- "Penetrative Entrainment"
- Updraft Mass Flux
- "Convective Layer"
- Turbulent Mixing
- TKE

Saturday, April 9, 2011
CAPT Forecasts

CAM4 Surface Pressure at 85W, 20S

Forecast Initialization

Finite Volume dynamics
Δx = 2.5°
Δy = 1.9°
Δt = 30 minutes

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What controls the cloud water come from?

\[
\frac{\partial q_\ell}{\partial t} = -\mathbf{V} \cdot \nabla q_\ell + P(q_\ell)
\]

\[
P(q_\ell) = T_{PBL} + C_{\text{Trans}} + C_{\text{Det}} + M
\]
Decoupling

-OR-

Thin stratus
decoupled layers

Deep, well-mixed stratocumulus
SE Pacific sensitivity experiments

CAM4, RHMINL = 85, 80

CAM4, RHMINL = 95

CAM5, RPEN = 2.5, 5

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Forecasts of the south Atlantic

CAM5
Finite Volume dynamics
Δx = 2.5°
Δy = 1.9°
Δt = 30 minutes

October 2006

Low-level cloud
Low level wind
Prescribed SST

CAUTION: Dangerously Preliminary
Selecting south Atlantic Sc
South Atlantic mean forecast

Center of cloud layer lower & drier than SEPac
Decoupling in the Atlantic?

Thin stratus
-OR-
decoupled layers

Deep, well-mixed stratocumulus

seatl_cam5_rel02

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Concluding thoughts?

UW Moist Turbulence scheme improves cloud-topped boundary layers.

- Improved physics interactions.

Pros/Cons seen in Sc forecasts:

- CAM5 able to maintain well mixed PBL, driven by cloud-top cooling.
- Tight coupling of moist physics plays into daily breakup of cloud deck.

Understanding these interactions, e.g., decoupling, can shed light on climate errors.

Southeast Atlantic vs. Southeast Pacific