A Comparison of Parameterization Tendencies Between CAM6 and CAM5

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Community Earth System Model

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Tendency differences in CAM6

- CAM6 parameterization schemes changed significantly
- MG2 upgraded from MG1, deep ZM more sensitive
- CLUBB changes the paradigm
- CAM5: Shallow convection, vertical diffusion and large-scale/stratiform/resolved-scale cloud
- CAM6: All processes rolled into CLUBB

How do we interpret in similar detail the balance of these processes in CLUBB?

Is CLUBB doing the same things as the ‘familiar’ processes in CAM5?
Initial CAM Tendency Study

- AMIP (1979-2005)
- Tendencies->increments to the model state by parameterized processes
- Depth averaged temperature and humidity tendencies. Climatological (ANN, DJF, JJA) values

- Global distributions, regional vertical profiles, PDFs
- CAM6 ‘revert’ parameterization simulations
Tendency differences (dT/dt, dq/dt)

**CAM5**

"Total": Moist + vert. diffusion
- Deep Convection
- Microphysics (MG1)
- LW Radiation
- SW Radiation
- Shallow Convection
- Large-Scale Cloud
- Vertical Diffusion

**CAM6**

"Total": Moist + vert. diffusion
- Deep Convection
- Microphysics (MG2)
- LW Radiation
- SW Radiation
- CLUBB

*Does not include surface fluxes or dynamical tendencies. But it will!*
Global Distributions
Near Surface “Total” Tendencies (ANN)

CAM6

Ave. = 1.88  Min. = -2.95  Max. = 15.42

Temperature

CAM5

Ave. = 2.02  Min. = -3.01  Max. = 18.05

Temperature

Ave. = 0.48  Min. = -7.41  Max. = 5.34

Humidity

Ave. = 0.46  Min. = -8.12  Max. = 4.52

Humidity
Most of PBL parameterization temperature tendency comes from CLUBB.
PBL Temperature Tendencies (CAM5)

- CLUBB-like similar to CLUBB (a bit larger)
- But large compensation of ShCU and LS cloud over most of sub-tropical ocean

- Critical regions for cloud feedbacks
PBL Humidity Tendencies (CAM6)

(a) Moist Processes
Ave. = 0.48  Min. = -7.41  Max. = 5.34

(b) Deep Convection
Ave. = -0.74  Min. = -4.40  Max. = 0.00

(c) Microphysics (MG2)
Ave. = 0.15  Min. = -0.14  Max. = 0.47

(d) CLUBB
Ave. = 0.99  Min. = -6.00  Max. = 5.45

The color scale represents g/kg/day.
• CLUBB-like similar to CLUBB (a bit weaker)
• But large compensation of ShCu and vertical diffusion over most of tropical
• MG2 has much larger influence than MG1 in mid-latitudes
Free-troposphere (800-200 mb) Humidity Tendencies

(a) Moist Processes

CAM5

Average = -0.12, Minimum = -3.40, Maximum = 0.51

(b) Deep Convection

Average = -0.16, Minimum = -2.48, Maximum = 0.03

CAM6

Average = -0.13, Minimum = -2.71, Maximum = 0.67

Average = -0.09, Minimum = -1.83, Maximum = 0.24
Boundary layer (~900mb) PDF of tendencies

- CLUBB-like and LW radiation approx. balance
- Compensation of ShCu and LS cloud
- They can have very large magnitudes

**CAM5**

45S-45N

dT/dt: Ocean
Boundary layer (~900mb) PDF of tendencies

**dT/dt: Ocean (45N-45S)**

- **CAM5**
  - CLUBB-like skews more +ve
  - LW radiation skews more -ve
  - Greater role for MG1 than MG1

- **CAM6**
Boundary layer (~900mb) PDF of tendencies

**dT/dt: Land (45N-45S)**

**CAM5**

- Deep Convection
- Microphysics (MG1)
- LW Radiation
- SW Radiation
- Shallow Convection
- Large-Scale Cloud
- Vertical Diffusion
- CLU BB-like

**CAM6**

- Deep Convection
- Microphysics (MG2)
- LW Radiation
- SW Radiation

- Closer match than for ocean
- But, vertical diffusion dominates
Regional Profiles
East Pacific

Temperature

Ave. = 1.88  Min. = -2.95  Max. = 15.42

Humidity

Ave. = 0.48  Min. = -7.41  Max. = 5.34
• CLUBB has small tendencies where CAM5 has multiple (ShCu/LSC)
• Cloud depth lower in CAM5
• Near surface tendencies differ the most
• Some microp (MG2) compensation with large CLUBB warming
• CAM5 has different process balance to temperature (ShCu/Vdiff)
• Cloud depth lower in CAM5
• Deep convection largely balances CLUBB below 800 mb
Tibetan Hot Spot

**CAM5**
- Total
- Deep

**CAM6**
- Total
- Deep
- CLUBB
- CLUBB-like

- MG2 and MG1: Largest cooling tendencies on planet in JJA!
• CLUBB/CLUBB-like tendencies are very similar
• CAM5 has strong contributions from ShCu and Vertical Diffusion
• Can we diagnose whether CLUBB is doing the ‘same’, given the response is the same?
AMIP ‘Revert’ Experiments (Cecile)
Southern Ocean (JJA)

Temperature:
Ave. = 1.88  Min. = -2.95  Max. = 15.42

Humidity:
Ave. = 0.48  Min. = -7.41  Max. = 5.34
Humidity Sensitivity: CLUBB->UW/park

Southern Ocean (JJA)

Humidity tendencies

- CAM5 process ordering recovered
- Cloud fraction tuning only sig. difference
West Pacific (Ocean, DJF)

Temperature

Ave. = 1.88  Min. = -2.95  Max. = 15.42

Humidity

Ave. = 0.48  Min. = -7.41  Max. = 5.34
Deep Convection Sensitivity: capeten

- Revert to CAM5 deepens deep convection
- CLUBB compensates in CAM6
Summary and Next

• Initial parameterization tendency analysis (T,q)
• CLUBB combines shallow convection, diffusion, LS cloud
• CLUBB-like and CLUBB are often similar
• CAM5: Process are often strongly opposed
• Greater differences over the ocean
• Near-surface differences are largest
• MG2 more active than MG1; deep less active
• Revert experiments can tease out role of CAM5/6 changes

• Condensed species, momentum tendencies, dynamics
• Exploit CLUBB higher order information to infer, “shallow convection”, “large-scale” and “diffusion” contributions
• Climate change response through tendencies
Boundary layer (~900 mb) PDF of tendencies

$dq/dt$: Ocean (45N-45S)

- Compensating processes with large tendencies
- Balanced by convective drying