Preliminary Results on the Coupling of CAM with CLUBB

Peter Bogenschutz\textsuperscript{1}, Andrew Gettelman\textsuperscript{1}, Hugh Morrison\textsuperscript{1}, Vincent Larson\textsuperscript{2}, David Shannen\textsuperscript{2}, Nate Meyer\textsuperscript{2}, Cheryl Craig\textsuperscript{1}

\textsuperscript{1}National Center for Atmospheric Research, Boulder, CO
\textsuperscript{2}University of Wisconsin, Milwaukee, WI

AMWG February 2, 2012
Current CAM5 Physics

- Boundary Layer (Bretherton)
- Deep Convection (ZM)
- Shallow Convection (Park)
- Cloud Macrophysics (Park)
- Microphysics (MG)
- Radiation (RRTM)
- Aerosols (Modal)
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• CLUBB = Cloud Layers Unified By Binormals

• First developed by Golaz et al. (2002), maintained by University of Wisconsin Milwaukee (Vincent Larson’s group)

• “Incomplete” Third-order turbulence closure centered around an assumed PDF

• Cloud fraction, liquid mixing ratio, and higher-order turbulent moments are closed via a triple joint (temperature, moisture, and vertical velocity) assumed double gaussian PDF.

• Should provide a unified treatment of PBL and shallow moist convection
CAM-CLUBB

- UW PBL (Bretherton and Park), UW Shallow convection (Park and Bretherton), and Cloud macrophysics (Park) are all turned off
- CLUBB is warm cloud parameterization, therefore still strip out a subroutine from Park macrophysics to compute ice cloud fraction
- Detrainment of liquid water into environment still computed per Park macrophysics for deep convection
- CLUBB called after deep convection & before MG, currently with a 5 minute sub-timestep
- Predicted vertical velocity variance passed from CLUBB to MG for SGS vertical velocity needed for aerosol activation
- CLUBB drives the MG microphysics scheme (for both stratified and shallow convective cloud)
CAM-CLUBB Status

- Alive... but premature
- Runs stably in SCAM and globally
- Climate and low clouds resembles planet Earth
- Computational increase is 4% over CAM5*
- CAM-CLUBB code close to being on trunk (code review next couple weeks)
- Lots of science questions, uncertainty, testing, and work remain!
Single Column Testing

- SCAM-CLUBB tested on many boundary layer & deep convective regimes
  - Cumulus: RICO, BOMEX, ARM_CC
  - Stratocumulus: DYCOMS-RF01, DYCOMS-RF02, ATEX
  - Deep convection: GATE, TOGA, ARM97
  - Mixed phase: Storm tracks IOP
DYCOMS2-RF02 - Marine Sc
Current Issues/Questions We Are Facing Globally

- Trade-Wind Cumulus do not precipitate enough via MG, leading to “anvils” at cumulus top and SWCF distributions that are not ideal

- Work at UWM provides strong evidence that prognostic precipitation microphysics (i.e. Morrison microphysics) ameliorates this issue

- Temporary kludge: Increase precipitation efficiency by tuning accretion rates

- Long term solution (~6 months): Implementation of MG2 (prognostic precip)

- Storm track regions (especially SH), look wildly different than CAM-BASE

- Seasonal simulation of marine Sc is a persistent problem in CAM-CLUBB
Low Cloud Amounts

CAM5

CAM-CLUBB

ANN
Shortwave Cloud Forcing

CAM5

cam5_1_17 (yrs 0001)

TOA SW cloud forcing

mean = -52.09 W/m²

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CAM-CLUBB
camclubb_newcore2 (yrs 0001)

TOA SW cloud forcing

mean = -50.88 W/m²

ANN

CERES

TOA SW cloud forcing

mean = -48.59 W/m²

ANN

CERES

TOA SW cloud forcing

mean = -48.59 W/m²

ANN

Cam5_1_17 - CERES

mean = -3.50 W/m²

ANN

Camclubb_newcore2 - CERES

mean = -2.29 W/m²

Thursday, February 2, 12
Problem: Seasonal Simulation of Sc
Problem: Seasonal Simulation of Sc
Ice Water Path

**CAM-CLUBB**
camclubb_accre6 (yrs 0001)

**CAM5**
cam5_1_17 (yrs 0001)

**camclubb_accre6 - cam5_1_17**

Thursday, February 2, 12
Ice Water Path

CAM-CLUBB camclubb_accre6 (yrs 0001)
Total grd-box cloud IWP mean = 12.56 g/m²

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Min = 0.02 Max = 95.12

CAM5 cam5_1_17 (yrs 0001)
Total grd-box cloud IWP mean = 17.95 g/m²

Min = 0.04 Max = 99.37

Ice Mixing Ratio at 60°S and 180°W

Pressure (hPa)

CAM–BASE CAM–CLUBB

Ice Path

(g/m²)

latitute

60S 30S 0 30N 60N

0

200

400

600

800

1000

200

400

600

800

1000

(g/kg)

x 10⁻³

0 2 6 8
Summary & Future Plans

• CAM-CLUBB is alive but premature

• Within striking distance of CAM5 for many scoring metrics... but not quite there yet.

• Still several issues to address, can utilize SCAM (i.e. seasonal Sc, storm tracks)

• Future work will involve moving to sub-columns

• More astute examination with observations (i.e. COSP)

• Investigate aerosol indirect effects and climate sensitivity