Update on CAM development.
Recent activities and near-term priorities.

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Mark Taylor, Peter Lauritzen, Sungsu Park,
Julio Bacmeister, Joe Tribbia, Rich Neale,
and many others.
## The CAM family

<table>
<thead>
<tr>
<th>Model</th>
<th>CAM3 CCSM3</th>
<th>CAM4 CCSM4</th>
<th>CAM5 (CAM5.1) CESM1.0 (CESM1.0.3)</th>
<th>CAM5.2 CESM1.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamics</td>
<td>Spectral</td>
<td>Finite Volume</td>
<td>Finite Volume</td>
<td>Spectral element</td>
</tr>
</tbody>
</table>

= New parameterization/dynamics
What’s in CAM5.2?

- **New dynamical core:** Spectral Element (CAM-SE)
  - Improves scalability of CAM (no polar filter)

- **New topography** for CAM-SE

- **6 bug fixes**
  - Fix for the land scaling of dust
  - Fix to wet radius calculation in the modal_aero_wateruptake module.
  - Fix for the value for the Obukhov length used in dry deposition calculations.
  - Fix in zm_conv to fix some inconsistency in the initialization of moist static energy.
  - Fix in uw_shallow for the unreasonable concentration of some species in WACCM.
  - Mods in MAM to generalize the method for calculating pH value of cloud water.

- **Tuning** for CAM-SE (dust and stratocumulus)
Coupled simulations with CAM5.2 (CESM1.1)

CAM5.2-FV 1 degree: 50 years

CAM5.2-FV 2 degree: 70 years

CAM5.2-SE ne30 (~1 deg): 25 years

Similar to CESM1.0
=> bugfixes have small impact

Competitive with FV
except for stratocumulus

Diagnostics:
http://www.cesm.ucar.edu/experiments/cesm1.1
Stratocumulus are degraded in CAM-SE

**SWCF (W/m²)**
- CERES-EBAF
  - mean = -47.1 W/m²
- FV 1 deg
  - mean = -48.9 W/m²
- SE ne30
  - mean = -47.7 W/m²
Vertical transport in CAM-SE

Vertical advection of tracers \((q, \ldots)\)  
(Lagrangian method)

Vertical advection of \(T\)  
(Eulerian method)

(Lagrangian method)
Lagrangian code improves stratocumulus deck

SWCF (W/m²)
CERES-EBAF
mean = -47.1 W/m²

FV 1 deg
mean = -48.9 W/m²

SE ne30 + Lagrangian code
mean = -48.1 W/m²
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- CAM5.2-FV 1 degree: 50 years
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- CAM5.2-SE ne30 (~1 deg): 50 years + Lagrangian code

similar to CESM1.0
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Competitive with FV
except for stratocumulus
Temperature biases (Model – HadISST)

FV 1deg
mean = -0.13 K
RMSE = 0.97 K

SE ne30 + Lagrangian code
mean = -0.21 K
RMSE = 0.92 K
Precipitation

FV 1 deg
mean = 3.06 mm/day

GPCP
mean = 2.67 mm/day

SE ne30 + Lagrangian code
mean = 3.07 mm/day
Taylor diagram

<table>
<thead>
<tr>
<th>Model</th>
<th>RMSE</th>
<th>Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCSM4 (FV 1 deg)</td>
<td>0.883</td>
<td>0.78</td>
</tr>
<tr>
<td>CESM1.1 (FV 1 deg)</td>
<td>0.791</td>
<td>1.58</td>
</tr>
<tr>
<td>CESM1.1 (SE ne30)</td>
<td>0.735</td>
<td>1.34</td>
</tr>
<tr>
<td>+ Lagrangian code</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- CCSM3.5
- CESM1.1 (FV 1 deg)
- CESM1.1 (SE ne30)
In summary (so far)

• **CAM5.2** was released in November 2012
  
  Spectral Element (SE) dycore (improves scalability of CAM)
  
  Includes 6 bugfixes (minor impact)
  
  CAM-SE competitive with CAM-FV except for **stratocumulus**

• Implementation of **Lagrangian vertical transport** for all variables
  
  Fixes **stratocumulus**
  
  **Taylor score** is better than CAM-FV

**CAM5.2 + Lagrangian code** => **This will become CAM5.3**

  Code will be released in **May 2013**

  Earlier for **developers**

**CAM5.3** will also include

  **Prescribed aerosol**

  **Reduced size** history files (namelist flags for extra output)
Too many versions of CAM… What should I use?

<table>
<thead>
<tr>
<th>Release Date</th>
<th>FV Dycore</th>
<th>SE Dycore</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAM 5.1 (in CESM1.0)</td>
<td>June 2011</td>
<td>Don’t use (6 known bugs)</td>
</tr>
<tr>
<td>CAM 5.2 (in CESM1.1.1)</td>
<td>Nov 2012</td>
<td><strong>YES</strong> (bugfixes)</td>
</tr>
<tr>
<td>CAM 5.3 (in next release)</td>
<td>May 2013</td>
<td><strong>YES</strong> (FV 2 deg only)</td>
</tr>
</tbody>
</table>
Near-term model development

- **Unified Convection (UNICON)**
  - unifies treatment deep + shallow

- **Cloud Layers Unified By Binormals (CLUBB)**
  - third-order turbulence closure centered around an assumed double Gaussian PDF
  - treatment for shallow+PBL+macrophysics

- **PDF-based macrophysics**

- **SP-CAM**: super-parameterization on branch

- **Next generation MG microphysics**
  - prognostic precipitation, mixed phase ice nucleation and convective microphysics

- **Aerosol scheme**
  - Prescribed Aerosol (BAM /MAM)
  - MAM4 (“aging” black carbon)

- **Sub-columns infrastructure**
  - all schemes see the same sub-columns: consistency among processes
Physics framework in CAM5+

Single grid-column state

Convection
Macrophysics
Microphysics

Sub-Column Generator

Radiation

\[ d(q_v, q_l, q_i)/dt \]

Sub-Column Generator

Cloud Mass = \[ \int s \cdot PDF(s) ds \]

Cloud Fraction = \[ \int PDF(s) ds \]

a) PDF
Gaussian

b) CLUDBB

Deep conv. Microphysics

c) CAM-SP

Radiation

\[ d(q_v, q_l, q_i)/dt \]

Slide courtesy: Rich Neale
Near-term model development

• Dynamics
  - Conservative Semi-Lagrangian Multi-tracer (CSLAM) advection
  - MPAS dycore and regional mesh refinement in CAM-SE

• Address systematic precipitation biases
  - double ITCZ, Asian monsoon, summertime US rainfall
  - CAPT framework, high-resolution, UNICON, …

• Resolution
  - High resolution runs (0.25 and finer). Horizontal resolution dependence (climate change response).
  - Vertical resolution dependence (L30 -> L31, L60)

• Diagnostics (http://www.cgd.ucar.edu/amp/amwg/diagnostics)
  - Refactored diagnostics package (compatible with CAM-SE history files)
  - New diagnostics sets for aerosol, chemistry, WACCM
  - COSP cloud phase diagnostics

• Documentation
  - Moving from latex file to web-based documentation
  - Guidelines for developers (http://www.cesm.ucar.edu/working_groups/Atmosphere/)
Thanks