Simulating Deep Convection Using CLUBB and Subcolumns in CAM

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Outline

• What are subcolumns?
• Current status of subcolumn framework in CAM
• CAM-CLUBB-SILHS configurations
• CLUBB as a Deep Convection Scheme
  • ARM, TWP-ICE, and TOGA-COARE
• CAM-CLUBB-SILHS in global simulations
What are Subcolumns?

• A second dimension for grid columns in CAM
• A data structure that represents the model state within a GCM grid column
• Subcolumns have the same vertical resolution as the larger grid
Subcolumn Framework Status

- Added to the CAM development trunk in tag cam5_3_28, updated in tag cam5_3_36
- Subcolumn interface now available on the development trunk.
- See `subcol_tscp.F90` for an example sub column generator. See `subcol.F90` and `subcol_utils.F90` for the interface functions.
- Microphysics (MG 1.0 and 1.5) is currently the only parameterization currently on subcolumns.
Subcolumn Generators

- To create and populate the subcolumn ecosystem, a **SubColumn Generator** is needed.

- Only test generators are currently on the trunk as examples.

- The SILHS generator is still under development. Contact katec@ucar.edu if interested in the code.
Subgrid Importance Latin-Hypercube Sampler (SILHS)

- Created at UWM and implemented in their local single-column model.

- Subcolumns are generated by sampling the PDF produced by the Cloud Layers Unified by Binormals (CLUBB) shallow cloud and macrophysics parameterization.

See [http://clubb.larson-group.com](http://clubb.larson-group.com) and Larson and Schanen, 2013 (Geoscientific Model Development)
CAM 5

Deep Conv:
Zhang and McFarlane (1995)
Local Single Moment Microphysics

Shallow Conv:
Park and Bretherton (2009)
Local Single Moment Microphysics

Macrophysics: Park
Morrison and Gettelman (2008)

PBL: Bretherton and Park (2009)
CAM-CLUBB-SILHS

Deep Conv:
Zhang and McFarlane (1995)
Local Single Moment Microphysics

Shallow Conv:
CLUBB-SILHS
Morrison and Gettelman (2008)

Macrophysics:
CLUBB-SILHS
Morrison and Gettelman (2008)

PBL: CLUBB
CAM-CLUBB-SILHS No Deep

Deep Conv:
CLUBB-SILHS
Microphysics:
Morrison and Gettelman (2008)

Shallow Conv:
CLUBB-SILHS
Microphysics:
Morrison and Gettelman (2008)

Macrophysics:
CLUBB-SILHS
Morrison and Gettelman (2008)

PBL: CLUBB
<table>
<thead>
<tr>
<th>Configuration</th>
<th>Tested SCAM</th>
<th>Tested Global</th>
</tr>
</thead>
<tbody>
<tr>
<td>SILHS Mean Cloud (ZM)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Only Qv, T, and W vary in subcol. Mean Qc/Qi/Nc/ Ni used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SILHS Mean Nc (ZM)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Same as above, but Qc &amp; Qi vary in subcol.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SILHS CLUBB ZM</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Same as above, but Nc &amp; Ni vary in subcol.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SILHS CLUBB No Deep</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Same as row 2, but without ZM deep convection scheme.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Single Column Model Tests

- Single Column version (SCAM) of CAM 5.3
- Eulerian Dycore, 10 minute timestep between SILHS sampling, 30 vertical levels, 16 subcolumns, forcing from ARM, TWP-ICE, and TOGA-COARE IOPs
- Using CLUBB as the “shallow” cumulus and stratiform (macrophysics) parameterization, and MG 1.5 for microphysics.
- ZM deep convection OFF (No Deep)
ARM97

Total Precipitation

Time (days)

Prec (mm/day)

CAM5
No Deep SC
LES

Total Precipitable Water

Time (days)

PW (mm)

CAM5
No Deep SC
LES

Cloud Water Path

Time (days)

CWP (kg/m2)

CAM5
No Deep SC
LES

Outgoing LW Radiation

Time (days)

OLR (W/m2)

CAM5
No Deep SC
LES
TOGA-CORE

Temperature

Relative Humidity

Cloud Fraction

Cloud Liquid Amount
Global SILHS

- Running with ZM deep convection
- 2 degree, 1200 sec, AMIP style
- 4 subcolumns => 50% increase in runtime
- 14 months
Future Work

• More global simulations - No Deep Global
• Integrate MG2.0 (prognostic precipitation on subcolumns)
• Impact of more subcolumns, vertical resolution
Thank you for your time!

References


http://larson-group.com

Acknowledgements

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