CESM1-CAM5 Coupled Experiments

Rich Neale + AWMG Development Team
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<th>CAM Evolution</th>
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**Model**

- **CCSM3** *(2004)*
- **CCSM3.5** *(2007)*
- **CCSM4 (Apr 2010)*
- **CESM1 (Jun 2010)*

**Atmosphere**

- CAM3 (L26)
- CAM3.5 (L26)
- CAM4 (L26)
- CAM5 (L30)

**Boundary Layer**

- Holtslag and Boville (93)
- Holtslag and Boville
- Holtslag and Boville
- UW Diagnostic TKE
  - Park et al. (09)

**Shallow Convection**

- Hack (94)
- Hack
- Hack
- UW TKE/CIN
  - Park et al. (09)

**Deep Convection**

- Zhang and McFarlane (95)
- Zhang and McFarlane
  - Neale et al. (08), Richter and Rasch (08) mods.
- Zhang and McFarlane
  - Neale et al., Richter and Rasch mods.

**Stratiform Cloud**

- Rasch and Kristjansson (98) *Single Moment*
- Rasch and K. *Single Moment*
- Rasch and K. *Single Moment*
- Morrison and Gettelman (08) *Double Moment*
  - Park Macrophysics
  - Park et al. (10)

**Radiation**

- CAMRT (01)
- CAMRT
- CAMRT
- RRTMG Iacono et al. (2008)

**Aerosols**

- Bulk Aerosol Model (BAM)
- BAM
- BAM
- Modal Aerosol Model (MAM)
  - Ghan et al. (2010)

**Dynamics**

- Spectral
- Finite Volume (96,04)
- Finite Volume
  - HOMME
- Finite Volume
  - HOMME

**Ocean**

- POP2 (L40)
- POP2.1 (L60)
- POP2.2
- POP2.2

**Land**

- CLM3
- CLM3.5
- CLM4 – CN
- CLM4

**Sea Ice**

- CSIM4
- CSIM4
- CICE
- CICE
Climate Performance Summary
Relative to CCSM3.5 (2 deg)

<table>
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<tr>
<th>Metric</th>
<th>CESM1-CAM5 1850</th>
<th>CESM1-CAM5 Late 20th</th>
<th>CCSM4-CAM4 1850</th>
<th>CCSM4-CAM4 Late 20th</th>
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<tr>
<td>Bias</td>
<td>1.082</td>
<td>1.025</td>
<td>0.759</td>
<td>0.812</td>
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<tr>
<td>RMSE</td>
<td>0.848</td>
<td>0.857</td>
<td>1.025</td>
<td>1.074</td>
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</table>
Mean Precipitation Biases

Observed (CMAP, average 1979-1998)
Mean SST Biases

**CESM1-CAM5 (2 deg)**

SST error (1970-1999) Compared to HadISST

**CCSM4 (1 deg)**

mean = 0.31  
rmse = 1.06  

**CCSM4 (2 deg)**

mean = 0.58  
rmse = 1.34
Polar Sea Ice

JAS Mean  Years 1985-2004

ice area (aggregate) %

JFM Mean  Years 1985-2004

ice area (aggregate) %

Turbulent Mountain Stress
ENSO Variability

20th Century El Nino
- Lag-zero nino3 SSTA correlation
- nino3 SSTA power spectrum
✓ Teleconection patterns maintained from CCSM4
✓ Amplitude is very strong
✓ Changed low-cloud feedbacks in East Pacific?

CCSM4 (1 deg)
CESM1-CAM5 (2 deg)
Surface temperature anomalies relative to (1961-1990) – 11-year smoothing
20th Century Temperature Change

Surface Temperature Change (1970-1999) minus 1850 control

- Marginal Nhem ocean and south-east Asia warming consistent with obs.
20th Century Cloud Forcing

Grid-Mean Liquid Water Path (1970-1999) minus 1850 control

- Increases in LWP dominate over cloud low-cloud fraction
- Increased droplet activation/condensation due to aerosols
Short wave cloud forcing over the 20th Century (1970-1999 minus 1850)

- CCSM3 and CCSM4: low-cloud feedbacks are positive (warming)
- CESM1-CAM5: low-cloud feedbacks+indirect forcing are net negative (cooling)
Summary of CESM1-CAM5 runs

✓ Mean coupled climate improved over CCSM3 (T85)/CCSM4 (2 deg)
✓ Competitive with CCSM4 (1 deg)
✓ Maintains many positive features from CCSM4 climate (e.g., ENSO period)
✓ 20th Century simulations
  ✓ Final warming less than CCSM4; less than observed
  ✓ Regional features better captured (NH ocean/SE Asia cooling)
  ✓ Consistent with local increases in liquid-water water path
  ✓ Increased cloud droplet number at PBL top; increased activation
  ✓ Net low-cloud feedbacks becomes negative CCSM4 positive
✓ Final 20th Century runs to be analyzed
✓ ENSO amplitude excessive (and very sensitive)
✓ Indirect affects a little strong