CESM1-CAM5
1 degree coupled simulation

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What’s new since Breckenridge?

CESM1-CAM5 simulations include:

• CAM5.1: includes some bugfixes + retunings

• 1-degree resolution

• Use CLM4CN (prognostic carbon and nitrogen cycle in the land model)
What’s in CAM5.1

• CAM5.1 = CAM5 + several bug fixes

• Changes: small effect except ...
  bug fix for size of snow particles used in radiation
  snow particles smaller -> more reflective -> large impact

SWCF, ANN

LWCF, ANN

Mean = -3.52 W/m²

Mean = 2.30 W/m²

• Change required retuning
Model versions and simulations

Models versions

- CCSM4: CAM4 – 1deg (released in April 2010)
- CESM1: CAM5 – 2deg (released in June 2010)
- CESM1: CAM5.1 – 1deg (will be released soon)

Simulations

- 1850 control
- 20th century
- Climate sensitivity simulation (SOM)
- Aerosol indirect effect
Model versions and simulations

Models versions

• CCSM4: CAM4 – 1deg => CAM4 (1deg)
• CESM1: CAM5 – 2deg => CAM5 (2deg)
• CESM1: CAM5.1 – 1deg => CAM5.1 (1deg)

Simulations

• 1850 control
• 20th century
• Climate sensitivity simulation (SOM)
• Aerosol indirect effect
1850 controls: SSTs versus Hurrell 2008

- Temperature errors: Model versus Hurrell 2008
- RMSE reduced in CAM5.1, 1 deg
- Error in key regions (Eastern ocean, Pacific cold tongue)

CAM4 – 1deg
Mean = 0.18
RMSE = 1.07

CAM5 – 2deg
Mean = 0.42
RMSE = 1.17

CAM5.1 – 1deg
Mean = -0.10
RMSE = 0.94
20th century: Surface temperature

Observations: HADCRU
CAM4 – 1deg
CAM5 – 2deg
CAM5.1 – 1deg
Late 20th century: SSTs versus Hurrell 2008

• Temperature errors:
  Model versus Hurrell 2008

CAM4: too much warming
CAM5.1: 20th century ends up a bit too cold
Late 20th century: 2-meter Temperature

- Temperature errors:
  Model versus CRU

- CAM4: warming too much at mid-latitudes (no indirect effect)

- CAM5.1: not enough polar amplification

CAM4 – 1deg
Mean = 0.02
RMSE = 2.13

CAM5 – 2deg
Mean = -0.29
RMSE = 2.36

CAM5.1 – 1deg
Mean = -0.81
RMSE = 2.05
Late 20th century: precipitation versus CMAP

• Temperature errors:
  Model versus CMAP (Xie-Arkin)

• Local improvements but globally, no significant improvement with CAM5 (twin ITCZ still present)
Late 20th century: SLP versus NCEP
Late 20th century: Taylor diagrams

**CAM3.5 – 2deg**

Bias = 1.0  
RMSE = 1.0

**CAM4 – 1deg**

Bias = 0.88  
RMSE = 0.88

**CAM5 – 2deg**

Bias = 1.09  
RMSE = 0.86

**CAM5.1 – 1deg**

Bias = 1.14  
RMSE = 0.77
ENSO: nino3.4 over 20th century

- CAM4: good simulation of nino3.4
- CAM5: amplitude too large
- CAM5.1: amplitude somewhat reduced
Climate sensitivity

- Change in SST at equilibrium due to a doubling of CO2
- Sensitivity is obtained from SOM simulations
- Qflux is obtained from a 50-year period of a well-balanced 1850 fully coupled simulation

\[
\begin{align*}
\text{CAM4 (1deg)} &= 3.17 \text{ K} \\
\text{CAM5 (2deg)} &= 3.95 \text{ K} \\
\text{CAM5.1 (1deg)} &= 4.08 \text{ K}
\end{align*}
\]
Aerosol: direct and indirect effect

Direct effect
- aerosols **scatter** and **absorb** solar and infrared radiation

Indirect effect
- If aerosols **increase** => number of cloud droplets increase
  => droplet size decrease
  => for same LWP, **clouds are brighter**

<table>
<thead>
<tr>
<th></th>
<th>Direct effect</th>
<th>Indirect effect</th>
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<tbody>
<tr>
<td></td>
<td>W/m² (SW only)</td>
<td>W/m² (SW+LW)</td>
</tr>
<tr>
<td>CAM5 – 2 degree</td>
<td>-0.59</td>
<td>-1.22</td>
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<tr>
<td>CAM5.1 – 1 degree</td>
<td>-0.21</td>
<td>-1.01</td>
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<tr>
<td>IPCC values</td>
<td>-0.5 [-0.9 to -0.1]</td>
<td>-0.7 [-1.8 to -0.3]</td>
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Sea-ice thickness: Loss over 20th century

CAM4-1deg  CAM5-2deg  CAM5.1-1deg

1850

Late 20th century
Summary

• Latest CESM simulations include: CAM5.1 at 1-degree resolution using CLM4CN (prognostic carbon and nitrogen cycle in the land)

• Overall, CAM5 produces better simulation than CAM4:
  \[ \text{CAM5-2deg} \leftrightarrow \text{CAM4-1deg}; \text{CAM5-1deg} \leftrightarrow \text{CAM4-0.5deg} \]
  More realistic surface temperatures, better scores (Taylor diagrams)
  But some biases remain (precipitation, double ITCZ)

• Climate variability: CAM4 reproduced nino3.4 fairly well, CAM5-2deg: amplitude too large
  CAM5.1-1deg: amplitude reduced.

• Aerosol direct and indirect effect are reduced in CAM5.1
  AIE: -1.01 W/m2 and ADE: 0.21 W/m2

• Climate sensitivity is larger in CAM5 (~4K) than in CAM4 (~3.2K). CAM5 and CAM5.1 have similar climate sensitivity