State of CESM

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CESM Chief Scientist
The Community Earth System Model: A Framework for Collaborative Research


Normalized distance to obs. of temperature and precip. Knutti et al., GRL, 2013
CESM Low Emission Ensemble

The graph shows the change in global mean temperature (K) above the pre-industrial levels, with a focus on emissions scenarios leading to 1.5°C and 2°C warming targets. The graph includes uncertainty ranges for different scenarios and historical temperature changes.

**Key Points:****
- **1.5°C (mean):** Green line
- **1.5°C (10-90):** Green shaded area
- **2°C (mean):** Blue line
- **2°C (10-90):** Blue shaded area
- **1.5°C O/S (mean):** Orange line
- **1.5°C O/S (10-90):** Orange shaded area
- **Historical:** Black line

**Time Periods:**
- 1850 to 2100

**Note:**
Slide from B. Sanderson

CESM WG Meeting 3/1/17
Temperature record exceedance

(a) World

- Obs
- 2.0degNE
- 1.5degNE
- 1.5degOS

(c) USA

Land fraction warmer than historical record [%]

Time [Years]

1980 2000 2020 2040 2060 2080 2100

0 20 40 60 80 100

Slide from B. Sanderson
CESM2
Many many thanks to the whole CESM community for the hard work in building CESM2!!
Changes beyond simulation #125

• Results from CESM2 simulation #125 released to community February 9. Results shown here come mostly from that configuration.

• Changes for final version:
  – Subgrid topography representation around Greenland (different scale due to very strong winds)
  – Caspian sea: from ocean model to land model (lake)
  – Update to land vegetation parameters (little climate impact, mostly for carbon-cycle improvements)
  – CMIP6 emissions
CESM2: update from June 2016

• Major issue #1: sea-ice over Labrador

Identified June 2016

• **Major issue #2: un-physical climate sensitivity**

4x CO2, coupled

Identified Nov. 2016
CESM2: update from June 2016

• **Major issue #2: un-physical climate sensitivity**
  4x CO2, coupled

  **Identified Nov. 2016**

  **Solved Dec. 2016**
CESM2: update from June 2016

• Minor focus: Greenland surface mass balance

Analysis started in Oct. 2016

Improved Jan. 2017
But impact on SSWs?

Slice from M. Lofverstrom (NCAR)

CESM WG Meeting 3/1/17
Phase errors (a)
Conditional bias (b)
Unconditional bias (c)
Scaled variance ratio

NMSE = (a)+(b)+(c)

• General monotonic improvement from CESM1 (DJF/ANN)
• Large initial degradation in JJA mostly recovered
• Removing super-saturation -> improved skill, but slightly higher climate sensitivity
• Land model strongly impacts JJA score (new land at 118).
CESM2: Comparison to CESM1 LENS

<table>
<thead>
<tr>
<th></th>
<th>CESM2</th>
<th>CESM1 (LENS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.18</td>
<td>0.37</td>
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<tr>
<td>RMSE</td>
<td>0.91</td>
<td>1.13</td>
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<tr>
<td>Bias w.r.t. GPCP</td>
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<tr>
<td>(annual precip.)</td>
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</table>

Slice from R. Neale

CESM WG Meeting 3/1/17
CESM2: Comparison to CESM1 LENS

Improved precip over land and river discharge
ENSO in CESM2

Slide from R. Neale

CESM WG Meeting 3/1/17
Madden-Julian Oscillation

- Lag correlation with Indian-Ocean precip
- 20-100day band pass filter, 10S-10N
- 9 years, DJFMAM

Slice from R. Neale

CESM WG Meeting 3/1/17
Summary

• Metric mean improved bias and RMSE
• Largest improvements in tropical precipitation (3,4), SWCF (1) and Pacific surface stress (6)
• Surface pressure field (0) degrading slightly (mostly variance)
CESM2: 20\textsuperscript{th} century smoke test

TS normalized 1961-1990
CESM2: Timeline for release

• Final configuration: done Friday Feb 24!
• Start PI run with final configuration this week
• Testing/documentation/clean up
  – > needs approximately 3 months
• Release of 1° version (including portion of CMIP6 PI control) May-June 2017
• Papers will be submitted to JAMES
• Out-of-the-box CESM configurations for idealized setups (Held-Suarez, moist baroclinic wave with Kessler physics, terminator chemistry, ...) for CAM-FV and CAM-SE
• Work underway for high-resolution testing (but will not be scientifically released as part of the CESM2.0)
• Isotope-enabled version of CESM will also be released later (2.1, probably by end of the 2017)
CESM2: Final configuration

- **Biogeochemistry** (Carbon-Nitrogen Cycles)
- **Land** (CLM5)
- **River runoff** (MOSART)
- **Surface Waves** (WaveWatch3)
- **Coupler** (CIME2)
- **Atmosphere** (CAM6)
  - High-Top (WACCM6)
  - Chemistry (CAM6-Chem)
- **Sea Ice** (CICE5)
- **Ocean** (POP2 + Estuary)
- **Biogeochemistry** (Marine ecosystems)

CESM WG Meeting 3/1/17
• Precipitation over land areas (esp. Amazon and Central US), incl. Greenland

• Cold climate in 1850

→ those are the known ones!
CMIP6
As part of the CSL 2016-2018 proposal, 250M core-hours were requested (and approved) for Yellowstone usage.

Provides sufficient computing time for the DECK and all requested Tier 1 experiments.

Additional simulations (Tier 2) part of the standard (i.e. WG-driven) CSL pool.
CMIP6: simulation breakdown DECK + Tier 1

• CESM2-CAM6-1\textdegree: \approx 17,000 \text{ years}
• CESM2-WACCM6-1\textdegree: \approx 5,000 \text{ years}
• CESM-CAM6-1/4\textdegree: \approx 200 \text{ years}
• Several PB of generated data
  \rightarrow working extensively with CISL on data management and overall throughput
CMIP6: timeline and workflow

• Approx. 10 months to perform all DECK and TIER1 simulations on Yellowstone

• 4 months needed before branching from PI control!
CMIP6: timeline and workflow

**Task 1**
- **WACCM (fixed SSTs)**

**Task 2A**
- **CAM (coupled)**

**Task 2B**
- **WACCM (fixed SSTs)**

**Task 2C**
- **CAM (coupled)**

**Task 3A**
- **Ocean only**

**Task 3B**
- **Land only**

**Task 4A**
- **500 years**

**Task 4B**
- **200 years**

**CAM:** 20+ sypd (1°, 32L)
**WACCM:** 6 sypd (1°, 70L, 228 sp.)
CMIP6: core team

- Assembled a team of experienced CESM users
  - Cécile Hannay
  - Bob Tomas
  - 1-2 TBD
  - CISL members (S. Mickelson/D. Hart/E. Nienhouse)
<table>
<thead>
<tr>
<th>MIP acronym</th>
<th>MIP name</th>
<th>Name of primary sponsor(s)</th>
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<tbody>
<tr>
<td>AerChemMIP</td>
<td>Aerosols and Chemistry Model Intercomparison Project</td>
<td>Lamarque/Emmons</td>
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<td>C4MIP</td>
<td>Coupled Climate Carbon Cycle Model Intercomparison Project</td>
<td>Lindsay</td>
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<td>Cloud Feedback Model Intercomparison Project</td>
<td>Medeiros/Kay (CU)/Klein (LLNL)</td>
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<td>Detection and Attribution Model Intercomparison Project</td>
<td>Tebaldi/Arblaster</td>
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<td>Decadal Climate Prediction Project</td>
<td>Danabasoglu/Meehl</td>
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<td>Global Monsoons Model Intercomparison Project</td>
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<td>VIAAB</td>
<td>VIA Advisory Board for CMIP6</td>
<td>Mearns/O'Neill</td>
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• CESM2 configuration is finalized and final check is on-going
• Strong improvements in many aspects of the model!
• Release will occur in May-June 2017
• Multi-step process to provide a traceable pre-industrial control; will take approx. 3-4 months
• Strong ramp-up in CMIP6 will occur starting in June; expecting to perform all 1-degree simulations DECK/Tier1 by end of 2017
High-resolution (25 km atmosphere, 0.1° ocean) coupled simulation captures short-term variability (hurricanes) and seasonal variations (sea-ice)

Movie from J. Small and T. Scheitlin