Overview of the CESM1.5 simulation

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David Bailey, Pete Bogenschutz, Gokhan Danabasoglu, Jim Edwards, Andrew Gettelman, Marika Holland, Jean-Francois Lamarque, David Lawrence, Keith Lindsay, Rich Neale, Keith Oleson, Bill Sacks, John Truesdale, Mariana Vertenstein and gazillions of others
CESM1.5: Many new babies!

- Atmosphere: CAM5.5
- Land: CLM5
- Sea-ice: CICE5
- Land Ice: CISM2
- Ocean: POP2 + BGC
- River Model: MOSART
CESM1.5: Building individual components

- Atmosphere: CAM5.5
- Land: CLM5
- Land Ice: CISM2
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- Sea-ice: CICE5
CESM1.5: Coupling individual components

- Atmosphere: CAM5.5
- Land: CLM5
- Land Ice: CISM2
- Ocean: POP2 + BGC
- Sea-ice: CICE5
- River Model: MOSART
What could happen at coupling?
CESM1.5: Development simulations

http://www.cesm.ucar.edu/working_groups/Atmosphere/development/cesm1.5/

At a glance

- Huge team effort started in Mid November 2015
- 2 co-chair meetings/week
- 34 experiments (“cases”)
- 1300+ years of simulations + diagnostics

Where are we?

- a lot of progress made
- a lot more needs to be done
Our best configuration so far: “28”

Coupled simulations
• 1850 Control (100 years)
• 20th century (1850-2005)

Additional simulations
• AMIP simulation (1979-2005)
• High frequency runs
• Indirect effect (pre-industrial versus present aerosol)
• Climate sensitivity (2xCO₂ with Slab Ocean Model) – in progress

How to reproduce “28”
• Experimental tag + namelist modifications
• Details will be available next week at:

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Sea Surface Temperature (SST) bias

**LENSS versus obs**
- Bias = -0.24K
- RMSE = 0.91

**CESM1.5 versus obs**
- Bias = -0.62K
- RMSE = 1.12

**SST climatologies**
- HadISST/OL.v2 (1870-1900)
- LENS (yrs 402-421)
- CESM1.5 (yrs 75-99)

Now who do we blame?

→ CESM1.5 significantly colder than observations (-0.62K)
Sea Surface Temperature (SST) bias

- LENS
  - Bias = -0.24K
  - RMSE = 0.91

- LENS + CAM5.5
  - Bias = -0.32K
  - RMSE = 1.03

- CESM1.5
  - Bias = -0.62K
  - RMSE = 1.12

Intermediate version

- Add CAM5.5
- Add CLM5, CICE5, MOSART, CSIM2

→ Jump in SST bias when adding all new components but CAM
Sea Surface Temperature (SST) bias

- **LENS**
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- **LENS + CAM5.5**
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- **CESM1.5**
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  - RMSE = 1.12

**Jump in SST bias when adding all new components but CAM**

**Colder North Atlantic was in CAM5.5 (indeed started with CAM5.4)**
20th Century Global Surface Temperature

Temperature anomalies from 1850-1899 average

- CESM1.5
- LENS (ensemble 1)
- LENS (spread)

→ CESM1.5 is more or less in the spread of LENS
→ LENS is warming a bit less than the HadCRUT3
20th Century Global Surface Temperature

Temperature anomalies from 1850-1899 average

- HadCRUT3
- CESM1.5
- LENS (ensemble 1)
- LENS (spread)

Global dimming period
Aerosol indirect effect is strong in CESM1.5
Currently exploring ways to reduce it (new autoconversion)
Arctic Surface Temperature (ANN)

Intermediate simulations show that

- Arctic TS is warmer in CESM1.5 than in LENS
- Arctic TS is very sensitive to CLM albedo and evaporation
- CAM also contributes to Arctic warming

Now who do we blame?
Taylor scores in LENS and CESM1.5

<table>
<thead>
<tr>
<th></th>
<th>RMSE</th>
<th>Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>CESM1.5</td>
<td>0.84</td>
<td>1.19</td>
</tr>
<tr>
<td>LENS</td>
<td>0.80</td>
<td>1.37</td>
</tr>
</tbody>
</table>

Degraded RMSE in CESM1.5 mainly comes from degradation in rainfall (especially over land) and sea-level pressure.

Now who do we blame?
Evolution of the Taylor scores since LENS

Improvement in Taylor bias starting with CAM5.4

Degradation in Taylor RMSE starting with CAM5.5
Sea-ice thickness

LENSS
grid cell mean ice thickness m

CESM1/CAM5.4
grid cell mean ice thickness m

CESM1.5
grid cell mean ice thickness m

CESM1/CAM5.5
grid cell mean ice thickness m

➡️ Sea-ice is thinner in CESM1.5 than LENS (despite colder North Atlantic)

➡️ It started with the introduction of CAM5.4
Sea-ice thickness at the end of the 20th century

Obs: Ice Sat 2001-2005

LENSS 2001-2005

CESM1.5 2001-2005

→ Sea-ice might be too thin in CESM1.5
   (while LENS sea-ice is likely to thick)

→ Tuning of sea-ice albedo can be done if needed
Ocean Temperature Bias in the Arctic

- **Sub-surface warming in Arctic ocean**
- **This might be a concern (or not)**

- **Already was in CAM5.5 but amplified when adding other components**

**Now who do we blame?**
Summary and next steps

• We provide a first simulation of CESM1.5

• Evolution of biases in CESM1.5 since LENS includes:
  – SSTs too cold ➔ everybody but CAM?
  – Precipitation bias over land increases ➔ CAM
  – Indirect effect likely too large ➔ CAM
  – Sea-ice is thinner in CESM1.5 ➔ CAM?
  – Arctic ocean 1-km warm layer ➔ everybody?
  – Arctic TS is warmer in CESM1.5 than in LENS ➔ CLM and CAM?

• Some of the next steps involve:
  – New set of tuning parameters to improve SSTs and precipitation biases
  – New autoconversion parameterization to reduce aerosol indirect effect
  – Tuning sea-ice albedo to increase ice thickness (if needed)
  – And many more … (More details in mini-Breck talks)
Who are the predecessors?

Large-ensemble (LENS)
CESM1/CAM5.1

Add MG2, ice microphysics, MAM4, dust

CESM1/CAM5.4

Add CLUBB

CESM1/CAM5.5

Add CLM5, CICE5, MOSART, CSIM

This is “28” alias “CESM.1.5”
Evolution of the SST bias since LENS

Jump in SST bias when introducing other components

Steady increase in RMSE since LENS
Sea-ice thickness at the end of the 20th century

- Sea-ice might be too thin in CESM1.5 (while LENS sea-ice is likely to thick)
- Tuning of sea-ice albedo can be done if needed