CESM2 Update (Ocean)

Outline

• Primary new features in the ocean model,
• Progress since the Breckenridge Workshop (Frozen Labrador Sea),
• An assessment of pre-industrial control and 20th century simulations with CESM2.0-,
• Final configuration for CESM2

• CESM2.0- solutions are compared to those of CCSM4 and Large Ensemble (LE) simulations
• A few fields of climatic interest, focusing on the 20th century simulations
• Means for the last 20-years and only one ensemble member are used
• Brief summary of trends in the pre-industrial control simulations
Primary New Features of the CESM2 Ocean Component

✓ Community ocean Vertical Mixing (CVMix) framework
✓ NOAA WaveWatch III as a new CESM component model
✓ “Langmuir mixing” parameterization
✓ Enhanced mesoscale eddy diffusivities at depth
✓ Prognostic chlorophyll for short-wave absorption
✓ Salinity-dependent freezing point temperature (also in CICE5)
✓ One-hour coupling frequency with Robert – Asselin time filter
✓ Estuary parameterization – Estuary Box Model (EBM)
✓ Caspian Sea transferred to the land model
Primary New Features of the CESM2 Ocean Component

- Community ocean Vertical Mixing (CVMix) framework
- NOAA WaveWatch III as a new CESM component model
- “Langmuir mixing” parameterization
- Enhanced mesoscale eddy diffusivities at depth
- Prognostic chlorophyll for short-wave absorption
- Salinity-dependent freezing point temperature (also in CICE5)

- One-hour coupling frequency with Robert – Asselin time filter → Two-hour coupling with default time stepping
- Estuary parameterization – Estuary Box Model (EBM)
- Caspian Sea transferred to the land model
Keith Lindsay
Labrador Sea Horizontal-Mean Temperature and Salinity Time Series (#79)
Sea Surface Temperature Differences from Observations

CCSM4

- Mean: -0.0184
- RMS: 1.014

LE

- Mean: -0.4819
- RMS: 1.024

#36

- Mean: -0.84
- RMS: 1.246

#79

- Mean: -0.7923
- RMS: 1.351
Sea Surface Salinity Differences from Observations

CCSM4

mean = -0.246
rms = 0.7847

LE

mean = -0.196
rms = 0.7722

#36

mean = -0.33
rms = 0.8739

#79

mean = -0.1745
rms = 0.8048
EBM to the rescue!

Sea surface salinity

EBM – CONTROL (COUPLED)

Sea surface temperature
However, there have been several bugs found since then ...

CLUBB mpi broadcast error for turning on liquid super saturation ......order of cloud formation
## Simulations

<table>
<thead>
<tr>
<th>Pre-Industrial Control</th>
<th>Ocean Initial Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CESM2.0</strong> (#125): 125 yrs</td>
<td>MP.3* @ year 97</td>
</tr>
<tr>
<td><strong>CCSM4</strong>: 1300 yrs</td>
<td>PHC2 + 130 years</td>
</tr>
<tr>
<td><strong>Large Ensemble (LE)</strong>: 2200 yrs</td>
<td>PHC2</td>
</tr>
</tbody>
</table>

### 20th Century Integrations Start from PI Controls at year(s)

| #125: 82                                |                          |
| CCSM4: 863 – 1031                       |                          |
| **LE**: 402                              |                          |

MP.3: yr 41 of #25 + yr 16 of #18 + yr 34 of #14 + 150 yrs of coupled simulation w/ CLUBB + unknown
Global-Mean Temperature Time Series (Pre-Industrial)

CCSM4

LE

1-500: +0.065 W m$^{-2}$
1500-2000: -0.004 W m$^{-2}$

+0.02 W m$^{-2}$

-0.11 W m$^{-2}$
AMOC Maximum Transport Time Series (Pre-Industrial)
Nino 3.4

Averaged over years 1 to 125:

- Power Spectrum
- Autocorrelation
- Variance ($K^2$)

Averaged over years 1850 to 2005:

- Power Spectrum
- Autocorrelation
- Variance ($K^2$/unit freq.)

Period (years)

$K^2$

GWS
Surface Temperature Anomaly Time Series (#125)
Sea Surface Temperature (SST) Differences from Observations

CCSM4

LE

#125
Equatorial Pacific Mean SST and its Seasonal Cycle

(a) EQUATORIAL PACIFIC MEAN SST

- OBSERVED
- CCSM4
- CCSM3

(b) OBSERVED

(c) CCSM4

(d) CCSM3

MONTH

J F M A M J J A S O N D

EQ SST MEAN

R&S CLIM (1.5°S - 1.5°N)

b.e20.BHIST.109_g16.20thC.125.02 [1.5°S - 1.5°N MEAN] [1986-2005]
Sea Surface Salinity Differences from Observations

CCSM4

(mean = -0.37, rms = 0.88)

LE

(mean = -0.3532, rms = 0.8337)

#125
Precipitation Differences from Observations*

**CCSM4**
- MODEL - OBS (a.b27.03.mean.1984-2006.nc)
- mean = 0.080
- rms = 1.279

**LE**
- MODEL - OBS (a.b27.03.mean.1984-2006.nc)
- mean = 0.3102
- rms = 1.175

* CORE-II: Blending primarily of GPCP and CMAP

---

#125

MODEL - OBS (a.b27.03.mean.1984-2006.nc)
- mean = 0.03848
- rms = 1.109

x $10^{-5}$
Global (top) and Atlantic (bottom) Meridional Overturning Circulations (Sv)

CCSM4

LE

#125
Atlantic Northward Heat Transport
Winter-Mean Mixed Layer Depth (Model – Observations)

CCSM4

LE

#125

Delta rho = 0.125 kg m$^{-3}$
Global- and Zonal-Mean pCFC12 Differences from Observations

Matthew Long
Changes Beyond Simulation #125

Results from simulation #125 released to community on 09 February 2017

Changes for final version:

• Subgrid-scale 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

• Hourly ocean coupling with Robert Filter

• Ocean initial conditions from LENS

• Dust tuning

• Ocean biogeochemistry