Status of CMIP6 and OMIP simulations at GFDL

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CESM Ocean Model Working Group Meeting
January 11-12, 2018
Rationalizing GFDL’s CMIP5 generation models

5-10 year Strategic Science Plan (2011) goal:
high resolution Earth System Model combining strengths of GFDL’s multiple AR5 modeling streams
### GFDL’s CMIP6 generation models: CM4 and ESM4

<table>
<thead>
<tr>
<th></th>
<th>CM4 (frozen, DECK re-started)</th>
<th>ESM4 (in final development)</th>
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</thead>
<tbody>
<tr>
<td><strong>Atmosphere: AM4</strong></td>
<td>100 km, 33 levels</td>
<td>100 km, 49 levels</td>
</tr>
<tr>
<td><strong>Atmos. Chem</strong></td>
<td>for aerosol (21 tracers)</td>
<td>aerosol+ozone (103 tracers)</td>
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<tr>
<td><strong>Ocean: MOM6</strong></td>
<td>1/4°, 75 levels</td>
<td>1/2°, 75 levels</td>
</tr>
<tr>
<td><strong>Ocean BGC</strong></td>
<td>BLINGv2 (6 tracers)</td>
<td>COBALTv2 (30 tracers)</td>
</tr>
<tr>
<td><strong>Land</strong></td>
<td>LM4.0</td>
<td>LM4.1 - PPA</td>
</tr>
<tr>
<td><strong>Sea Ice</strong></td>
<td>SIS2</td>
<td>SIS2</td>
</tr>
</tbody>
</table>

- All OM4 development was made in context of CM4 (i.e. we never ran CORE IAF until the end)

Note: All CM4 results shown are **preliminary** (based on potential vegetation historical, 1850- and 2010-forced experiments).
CM4’s climatology is a distinct improvement over previous GFDL models
CM4 temp., precip., OLR and reflected SW are the best in this CMIP5 ensemble
Wind fields are good but not the best
CM4 SST errors

- CM4’s SST errors are similar to CM2.6 (GFDL’s previous best simulation)
- We expect these can be improved further with higher ocean resolution as was seen going from CM2.5 to CM2.6 or with an eddy parameterization
• Strong, stable AMOC
• Deep flow is too shallow and warm
• Heat transport less than observed
Variability: Improved ENSO

- ENSO magnitude is more realistic than previous GFDL models which tended to be too large

- ENSO teleconnection pattern is well simulated
Variability: PDO / AMO patterns are well-simulated
- Heat uptake is less than CM2.5 (also using 1/4° ocean)
- Heat uptake is less than the difference in heat uptake between CM2.6 and CM2.5 (eddy-permitting res. effect)
- Warming of deep water points to inadequacy of deep water formation representation (in both hemispheres)
Historical Simulation: NH Sea Ice Extent

- Historical warming roughly consistent with observed with possible exception of post-Pinatubo period.
- Good simulation of NH extent and its satellite era trend.
- SH sea ice low biased in summer, high biased in winter; recent observed increase is not simulated.
CM3 thermosteric sea level rise problems:

- Excessive response to volcanoes (common to all CMIP5 models) due to lack of volcanic forcing in control experiment
- Lack of rise due to excessive aerosol forcing

CM4 has reduced aerosol forcing and improved simulation of OHU / thermosteric SLR
• Polynyas developed after the spin-up during the control
  – First in Weddell Sea
  – Third and largest in Ross Sea
• Lack of AABW found to be connected to a snow-on-glacier albedo being too dark
• Trying an alternative spin-up in January
• JRA-55do was planned to start in November
  – Postponed due to JRA updates
• 5-cycles of OMIP CORE-II IAF
  – First time we ran OM4 IAF
  – All development made in coupled mode
• SST biases in OM4 only loosely related to CM4 biases

• Similar Arctic SSS biases in OM4 and CM4
OM4 mixed layer

"Summer" mixed layer depth

"Winter" mixed layer depth
Summary

• CM4/ESM4 combine strengths of GFDL’s CMIP5 generation of models into two, related models based on the same code with differing emphases on resolution and complexity.

• Expected CM4 strengths:
  – Surface climatology; ENSO variability; ENSO, AMO and PDO teleconnection patterns;
  – Reasonable historical climate change simulation;
  – Reduced drift compared to previous eddy-permitting GFDL model.

• Expected CM4 weaknesses:
  – NADW too shallow and warm as in previous models.

• OM4 (CORE-II IAF) looks respectable but still have to do full analysis.

• CM4 spin-up re-started on January 5th in attempt to fix polynya problem.