COWCLIP: Coordinated Ocean Wave Climate Project

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Surface Waves are...

Fast, small, approx. irrotational solutions of the Boussinesq Equations

Have a Stokes drift depending on sea state (wave age, winds)


We’ve been busy on wave-current dynamics & Langmuir mixing:
3 Postdocs, 3.8 PhDs, 2 MAs, >18 papers.

With a few exceptions, not too much about the waves themselves.


In CESM2, though... waves are routine.
<table>
<thead>
<tr>
<th>Case</th>
<th>Summer Global</th>
<th>Summer South of 30°S</th>
<th>Summer 30°S-30°N</th>
<th>Winter Global</th>
<th>Winter South of 30°S</th>
<th>Winter 30°S-30°N</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTRL</td>
<td>10.62±0.27</td>
<td>17.24±0.48</td>
<td>5.38±0.14</td>
<td>43.85±0.38</td>
<td>57.19±0.76</td>
<td>12.57±0.28</td>
</tr>
<tr>
<td></td>
<td>(13.40±0.19)b</td>
<td>(21.73±0.32)</td>
<td>(6.71±0.09)</td>
<td>(45.50±0.40)</td>
<td>(56.53±0.59)</td>
<td>(16.16±0.29)</td>
</tr>
<tr>
<td>MS2K</td>
<td>15.37</td>
<td>15.47</td>
<td>17.03</td>
<td>119.91</td>
<td>171.92</td>
<td>40.31</td>
</tr>
<tr>
<td>SS02</td>
<td>36.79</td>
<td>63.83</td>
<td>7.54</td>
<td>99.32</td>
<td>164.34</td>
<td>17.39</td>
</tr>
<tr>
<td>VR12-AL</td>
<td>9.06</td>
<td>13.47</td>
<td>6.49</td>
<td>40.45</td>
<td>50.33</td>
<td>14.52</td>
</tr>
<tr>
<td>VR12-MA</td>
<td>8.73±0.30</td>
<td>12.65±0.47</td>
<td>6.61±0.22</td>
<td>40.99±0.37</td>
<td>51.78±0.65</td>
<td>14.23±0.30</td>
</tr>
<tr>
<td></td>
<td>(11.83±0.29)</td>
<td>(18.13±0.62)</td>
<td>(7.52±0.16)</td>
<td>(42.02±0.39)</td>
<td>(50.78±0.67)</td>
<td>(15.67±0.35)</td>
</tr>
<tr>
<td>VR12-EN</td>
<td>8.95</td>
<td>10.52</td>
<td>8.91</td>
<td>41.94</td>
<td>52.98</td>
<td>19.58</td>
</tr>
</tbody>
</table>

*Numbers with ± sign give the 90% confidence interval, estimated from the RMSEs of n = 1000 bootstrap estimates of the 48-year (for Wave-Ocean only experiments) and 20-year (for fully coupled experiments) mean mixed layer depth.

*Numbers shown in the parentheses are for the fully coupled experiments.


COWCLIP

- COWCLIP aspires to understand climate change in global wave statistics
- IPCC has sought this info since AR4.
- Wave models have been run offline, with CMIP saved winds, &tc.
- We will do projection with waves coupled online in CESM2


### CMIP5 List of Models

<table>
<thead>
<tr>
<th>ID</th>
<th>Full Model Name</th>
<th>Model</th>
<th>CMIP Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Australian Community Climate and Earth System Simulator 1.0</td>
<td>ACCESS1.0</td>
<td>5</td>
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<tr>
<td>2</td>
<td>Beijing Climate Centre, Climate System Model, 1-1</td>
<td>BCC-CSM1.1</td>
<td>5</td>
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<tr>
<td>3</td>
<td>Centre National de Recherches Meteorologiques Coupled Global Climate Model, version 5</td>
<td>CNRM-CM5</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Geophysical Fluid Dynamics Laboratory Earth System Model 2M</td>
<td>GFDL-ESM2M</td>
<td>5</td>
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<tr>
<td>5</td>
<td>Hadley Centre Global Environmental Model 2, Earth System</td>
<td>HadGEM2-ES</td>
<td>5</td>
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<tr>
<td>6</td>
<td>Institute of Numerical Mathematics Coupled Model, version 4.0</td>
<td>INMCM4</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Model for Interdisciplinary Research on Climate, version 5</td>
<td>MIROC5</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Meteorological Research Institute Coupled atmosphere-ocean general circulation model, version 3</td>
<td>MRI-CGCM3</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>ECMWF Hamburg climate model, version 5, dynamically downscaled using CCAM</td>
<td>CMIP3-CCAM-ECHAM5</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>CSIRO Mk3.5 general circulation, version 3.5, dynamically downscaled using CCAM</td>
<td>CMIP3-CCAM-CSIROMk3.5</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>Ensemble mean of CMIP-5 simulations (models 1–8)</td>
<td>CMIP5-EM</td>
<td>–</td>
</tr>
<tr>
<td>12</td>
<td>Ensemble mean of CMIP3-CCAM simulations (models 9–10)</td>
<td>CMIP3-CCAM-EM</td>
<td>–</td>
</tr>
<tr>
<td>13</td>
<td>Ensemble mean of all simulations (models 1–10)</td>
<td>EM</td>
<td>–</td>
</tr>
</tbody>
</table>

Waves are new diagnostic—constrained by Obs!
Wave extremes are important

The `getStat.f` is for calculating the following 7 statistics from an input wave data chosen by the user:

- `avg` - the mean
- `p10` - the 10th Percentile
- `p50` - the 50th Percentile
- `p90` - the 90th Percentile
- `p95` - the 95th Percentile
- `p99` - the 99th Percentile
- `max` - the maximum

In order to calculate these statistics for the COWCLIP-required 17 time-frames [12 monthly, 4 seasonal (DJF, MAM, JJA and SON), and an annual value], users need to run the program three times, one for each of the following 3 target time-frame resolutions:

- `MLY` - for monthly statistics
- `SNL` - for seasonal statistics
- `ANL` - for annual statistics
Future waves are interesting—societal value through inundation, erosion, etc.

Figure 2 | Projected future changes in multi-model averaged significant wave height. 

- **a**: Averaged multi-model annual significant wave height ($H_s$, m) for the time-slice representing present climate (~1979–2009).
- **b-d**: Averaged multi-model projected changes in annual (b), JFM (c) and JAS (d) mean $H_s$ for the future time-slice (~2070–2100) relative to the present climate time-slice (~1979–2009) (% change). Stippling denotes areas where the magnitude of changes is statistically significant.
Conclusions

- CESM2 is in a position to be the first model to submit a coupled ESM-wave model to COWCLIP.

- The data is already output in “standard” WaveWatch configuration. We will collect & condense from DECK sims, etc., as required to match other centers.

- COWCLIP is not a MIP formally, as it doesn’t normally required coupled sims. Does have IPCC & WMO support.

- We hope to receive beneficial cross-comparison stats about our wave modeling system (resolution, etc.). Will also identify relative wind errors.

- CIME, NUOOPC will make upgrading WaveWatch from NCEP easier, as in-house wave expertise is limited.