Regional model simulations around Hawaii: Open BC and evaluation with local data

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Outline

1. Status Report
   a) 2001 simulations at 0.08° and 0.04° resolutions
   b) experiments with open BC

2. Evaluation with local data: HYCOM vs other GCMs
   a) tidal stations
   b) TOPEX/POSEIDON altimetry
   c) CTD/XBT

3. Conclusions

4. Vision for 05/06

5. Technical issues
Hawaiian Islands configuration

Pacific Basin experiment 1979-2003:

Resolution 0.08°
Forcing: ECMWF 6-hour winds modified near Hawaii ('00-'03); bulk heat flux, E-P + relaxation to climatological SSS
Indonesian throughflow, Bering Strait closed
3° sponge layers at the open boundaries with relaxation to monthly T/S

Hawaiian regional experiments 2001-2002:

164°W – 152°W; 16°N – 26°N
Resolutions: 0.08°, 0.04°, … , 0.01°?
Open boundaries:
width of the nudging zone: 10-20dx
Relaxation times: 0.1-50 d
Experiments with open BC

1. 12-18 months: (01.01.2001-30.06.2002)
2. Relaxation to reference T,S,p,U,V, linearily interpolated in time and space, $\tau_1 = 1...50d$; $\tau_2 = 0.1...5d$.

<table>
<thead>
<tr>
<th>SGI/3000</th>
<th>Resolution</th>
<th>walltime/month</th>
<th>memory (16CPUs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.08^\circ$</td>
<td>2 hours</td>
<td>0.5Gb</td>
<td></td>
</tr>
<tr>
<td>$0.04^\circ$</td>
<td>15 hours</td>
<td>2.0Gb</td>
<td></td>
</tr>
<tr>
<td>$0.02^\circ$</td>
<td>5 days</td>
<td>8.0Gb</td>
<td></td>
</tr>
<tr>
<td>$0.01^\circ-0.04^\circ$</td>
<td>10-15 days</td>
<td>10-12Gb</td>
<td></td>
</tr>
</tbody>
</table>

Altix? (:3); LINUX cluster? (:5)

<table>
<thead>
<tr>
<th>$\tau_1$ (days)</th>
<th>1</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_2$ (days)</td>
<td>0.1</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>dx</td>
<td>$0.04^\circ$</td>
<td>$0.04^\circ$</td>
<td>$0.04^\circ$</td>
<td>$0.04^\circ$</td>
<td>$0.04^\circ$</td>
<td>$0.04^\circ$</td>
</tr>
</tbody>
</table>

2001 simulations

\[ dx=0.08^\circ \quad h=10dx \]
\[ \tau_1 = 1d \quad \tau_2 = 1d \]
\[ Corr=+0.28 \]

\[ dx=0.04^\circ \quad h=10dx \]
\[ \tau_1 = 1d \quad \tau_2 = 1d \]
\[ Corr=+0.26 \]

\[ dx=0.04^\circ \quad h=10dx \]
\[ \tau_1 = 1d \quad \tau_2 = 10d \]
\[ Corr=+0.35 \]
Difference between two open BC configurations

\[ h=10dx \]
\[ \tau_1 = 1d \quad \tau_2 = 10d \]

WNSE boundaries

\[ h=20dx \]
\[ \tau_1 = 0.75d \quad \tau_2 = 15d \]

E-boundary

\[ h=10dx \]
\[ \tau_1 = 1.5d \quad \tau_2 = 15d \]

WNS-boundaries
Comparison with tidal data

- **HYCOM**
  - dx = 0.08°

- **HYCOM**
  - dx = 0.04°

- **OfES (ECMWF)**
  - dx = 0.10°

- **OfES (Qscat)**
  - dx = 0.10°

- **NLOM**
  - dx = 0.06°
Comparison with T/P data

**HYCOM**
- $dx = 0.08^\circ$
- RMS SSH variance ($2^\circ$ horizontal smoothing)

**OfES (ECMWF)**
- $dx = 0.10^\circ$

**OfES (Qscat)**
- $dx = 0.10^\circ$

**T/P data**

**HYCOM.04**

**rms SSH variance**
- ($2^\circ$ horizontal smoothing)
Cross-validation of the models using SSH

Model-data correlations

<table>
<thead>
<tr>
<th>Station</th>
<th>HY.08</th>
<th>HY.04-0</th>
<th>HY.04-1</th>
<th>OfES(EC)</th>
<th>OfES(QS)</th>
<th>NLOM</th>
<th>SODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hilo</td>
<td>.33</td>
<td>.19</td>
<td>.15</td>
<td>-.17</td>
<td>.23</td>
<td>.06</td>
<td>-.07</td>
</tr>
<tr>
<td>Honolulu</td>
<td>.16</td>
<td>.32</td>
<td>.17</td>
<td>-.23</td>
<td>.18</td>
<td>.12</td>
<td>.08</td>
</tr>
<tr>
<td>Kahului</td>
<td>.07</td>
<td>.27</td>
<td>.25</td>
<td>-.15</td>
<td>.13</td>
<td>.22</td>
<td>-.30</td>
</tr>
<tr>
<td>Kawaiole</td>
<td>.53</td>
<td>.66</td>
<td>.51</td>
<td>-.37</td>
<td>.41</td>
<td>.21</td>
<td>.14</td>
</tr>
<tr>
<td>Mokuoloe</td>
<td>.33</td>
<td>.29</td>
<td>.08</td>
<td>-.22</td>
<td>.19</td>
<td>.20</td>
<td>-.01</td>
</tr>
<tr>
<td>Nawiliwilli</td>
<td>.26</td>
<td>.36</td>
<td>.43</td>
<td>.15</td>
<td>.36</td>
<td>.11</td>
<td>.15</td>
</tr>
<tr>
<td>mean</td>
<td>.28</td>
<td>.35</td>
<td>.26</td>
<td>-.16</td>
<td>.25</td>
<td>.16</td>
<td>-.03</td>
</tr>
</tbody>
</table>

| P1        | -.51  | .01     | -.43    | .38      | .24      | .08  | .15  |
| P2        | .48   | .34     | .46     | .17      | -.43     | -.15 | .53  |
| P3        | .37   | -.02    | .33     | -.32     | -.32     | .54  | .38  |
| P4        | -.00  | -.52    | -.08    | .41      | -.03     | -.01 | .51  |
| P5        | -.52  | -.53    | -.38    | .19      | .30      | .00  | .57  |
| mean      | -.03  | -.14    | -.02    | .17      | -.05     | .09  | .44  |

MIT GCM, ‘93-’97, [Lee et al., 2002]
Qscat vs ECMWF
Comparison with CTD data (HOT2 station)

<table>
<thead>
<tr>
<th>depth (m)</th>
<th>$T_\text{obs}$</th>
<th>$T_\text{HYCOM}$</th>
<th>$S_\text{obs}$</th>
<th>$S_\text{HYCOM}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>24.87±1.23</td>
<td>24.99±1.15</td>
<td>35.039±0.218</td>
<td>34.980±0.093</td>
</tr>
<tr>
<td>5</td>
<td>24.86±1.22</td>
<td>24.98±1.15</td>
<td>35.040±0.216</td>
<td>34.980±0.093</td>
</tr>
<tr>
<td>10</td>
<td>24.84±1.22</td>
<td>24.97±1.15</td>
<td>35.041±0.215</td>
<td>34.980±0.094</td>
</tr>
<tr>
<td>20</td>
<td>24.80±1.23</td>
<td>24.95±1.15</td>
<td>35.044±0.214</td>
<td>34.981±0.095</td>
</tr>
<tr>
<td>75</td>
<td>23.50±0.90</td>
<td>24.42±0.83</td>
<td>35.162±0.150</td>
<td>35.007±0.090</td>
</tr>
<tr>
<td>150</td>
<td>20.56±0.93</td>
<td>22.37±0.86</td>
<td>35.164±0.094</td>
<td>35.030±0.038</td>
</tr>
<tr>
<td>200</td>
<td>18.33±1.15</td>
<td>19.64±0.80</td>
<td>34.954±0.152</td>
<td>34.878±0.065</td>
</tr>
<tr>
<td>300</td>
<td>13.00±0.93</td>
<td>15.62±0.50</td>
<td>34.342±0.095</td>
<td>34.492±0.069</td>
</tr>
<tr>
<td>400</td>
<td>9.50±0.55</td>
<td>12.57±0.56</td>
<td>34.129±0.053</td>
<td>34.184±0.065</td>
</tr>
<tr>
<td>500</td>
<td>7.26±0.38</td>
<td>9.41±0.57</td>
<td>34.064±0.037</td>
<td>34.047±0.018</td>
</tr>
<tr>
<td>625</td>
<td>5.55±0.25</td>
<td>6.57±0.28</td>
<td>34.154±0.040</td>
<td>34.125±0.018</td>
</tr>
<tr>
<td>725</td>
<td>4.91±0.19</td>
<td>5.20±0.24</td>
<td>34.279±0.033</td>
<td>34.218±0.018</td>
</tr>
<tr>
<td>875</td>
<td>4.36±0.15</td>
<td>4.30±0.16</td>
<td>34.418±0.018</td>
<td>34.331±0.013</td>
</tr>
</tbody>
</table>
Data assimilation

Low-resolution data (2° - .25° resolution)

Global:
1. SSH altimetry (track, gridded (. 33°), 7 days)
2. SST (gridded, 0.16°, every 5-7 days)
3. SSS (gridded 0.16°, every 5-7 days?)

Local:
4. Tidal stations (continuous)
5. In situ soundings, ADCP profiles
   (HOT cruises, 0.1°, every 2-4 weeks)
6. Surface & ARGO drifters (1-3°, 1-10 days)

Hi-resolution data for nested configurations
(0.04°-0.01° resolution, Local):
1. Coastal HFR radars (0.01°, 10-20 min)
2. Gliders (T/S, 0.01°, 10-20 min)

Method:
MVOI, PMOA, ROIF/ROAF, SEEK filter?…
Conclusions

0. Experiments with open BC seem to show better performance with the relaxation time scale of 1-10 days
1. Higher resolution seems to provide better agreement with tidal data (regHYCOM-0.08 vs regHYCOM -0.04)
2. Pacific HYCOM 0.04 is in better agreement with tidal data than global OfES (0.10), NLOM, and SODA/POP1.4
3. All GCMs considered (HYCOM, NLOM, OfES) are doing bad with regard to T/P data [without assimilation].
4. QuikScat winds definitely improve model performance in reproducing tidal station records (OfES-ECMWF vs OfES-QScat)
5. Data assimilation improves performance with regard to T/P data but has no effect on performance with regard to tidal station data (SODA/POP1.4)

1. Comparison with local data, other models (global OfES, MIT Hawaiian regional ROMS) - ongoing, and data assimilation products (MIT, SODA, Pacific/global HYCOM?)

2. Experiments with higher resolution wind forcing (Qscat, 0.25°; local NOAA product, 0.02°) and bottom topography (up to 0.01° in area h < 2000m around Hawaii)

3. Nesting up to 0.01°

4. Start implementing sequential data assimilation
Technical issues

1. HYCOM data assimilation products/software
2. Module for tracers (ongoing project with local fisheries)
3. Tidal module (important for higher-resolution nested configurations)
4. Configuring HYCOM for Altix3000, Linux cluster?