Estimates of rapid variability in surface salinity and potential for aliasing in Aquarius measurements*

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Ocean Surface Salinity Science Team Meeting
7th Aquarius/SAC-D Science Meeting
April 2012, Buenos Aires

• **Rapid SSS variability**
  – How much variance expected at high frequency end of the spectrum at ~100 km scales?
  – How does rapid variability map into monthly Aquarius estimates?
  – What are contributions of temporal aliasing to overall error budget?

• **SSS estimates**
  – HYCOM global fields (daily, average over top 3 m, May09-April10, expt_90.8 with data assimilation, 1/12° grid)
  – TAO, PIRATA and RAMA moorings (hourly, 1 m depth, 2 to 10 years long)
Rapid variability (HYCOM)*

Total variability (all periods)

Rapid variability (<14d periods)

Ratio rapid/total

- Average ratio ≈0.2 but quite variable in space
- Ratios > 0.5 are seen in many regions

*HYCOM fields averaged over Aquarius L3 1° grids to match spatial resolution
Rapid variability (moorings)*

- Annual cycle (thin black) quite variable and not a dominant component in many sites
- Rapid variability (< 14-day, red) is substantial
- Same order of magnitude in data and HYCOM estimates, but data tends to show larger rapid variability

*Based on daily averages
Aquarius monthly sampling (1°)

- # samples highly variable in both latitude and longitude (from 4/mo in tropics to 28/mo in high latitudes)
- Irregular sampling interval in time (from few hours to few days)
Defining aliasing error

Ability to represent true monthly* means:

\[ \Delta = \hat{S} - S \]

\( \hat{S} \): estimated monthly mean based on Aquarius sampling
\( S \): true monthly mean based on daily sampling

\[ \alpha = \text{rms}(\Delta) \]

* Defined as 28 days for purposes of Aquarius analysis here
Spatial mean $\alpha \approx 0.02$ psu but considerably larger in tropical and coastal regions, and near strong surface currents.
Estimated aliasing (moorings)

- Not much aliasing effects at annual period
- HYCOM values weaker

<table>
<thead>
<tr>
<th>$\sigma_D$</th>
<th>$\sigma_H$</th>
<th>$\alpha_D$</th>
<th>$\alpha_H$</th>
<th>$r_{2mo}$</th>
<th>$r_{4mo}$</th>
<th>$r_{12mo}$</th>
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<tbody>
<tr>
<td>0.10</td>
<td>0.05 (0.07)</td>
<td>0.04</td>
<td>0.02</td>
<td>21</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>0.03</td>
<td>0.04 (0.06)</td>
<td>0.02</td>
<td>0.01</td>
<td>6</td>
<td>1</td>
<td>0.4</td>
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<tr>
<td>0.04</td>
<td>0.03 (0.04)</td>
<td>0.03</td>
<td>0.03</td>
<td>23</td>
<td>10</td>
<td>0.7</td>
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<td>0.08</td>
<td>0.08 (0.09)</td>
<td>0.02</td>
<td>0.02</td>
<td>16</td>
<td>3</td>
<td>0.06</td>
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<tr>
<td>0.05</td>
<td>0.04 (0.05)</td>
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<td>0.03</td>
<td>13</td>
<td>15</td>
<td>3</td>
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<td>0.08</td>
<td>0.09 (0.13)</td>
<td>0.03</td>
<td>0.03</td>
<td>25</td>
<td>9</td>
<td>0.6</td>
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<td>0.02</td>
<td>13</td>
<td>16</td>
<td>0.04</td>
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<tr>
<td>0.26</td>
<td>0.23 (0.24)</td>
<td>0.11</td>
<td>0.08</td>
<td>38</td>
<td>2</td>
<td>0.9</td>
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<td>0.05</td>
<td>0.02</td>
<td>22</td>
<td>1</td>
<td>0.5</td>
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Aquarius error budget

<table>
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<tr>
<th>Latitude range</th>
<th>Number of samples</th>
<th>α</th>
<th>CBE*</th>
<th>$\sqrt{\alpha^2 + CBE^2}$</th>
<th>Allocation*</th>
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<tbody>
<tr>
<td>0–10</td>
<td>8.0</td>
<td>0.04</td>
<td>0.11</td>
<td>0.120</td>
<td>0.150</td>
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<td>11–20</td>
<td>7.9</td>
<td>0.03</td>
<td>0.11</td>
<td>0.113</td>
<td>0.16</td>
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<tr>
<td>21–30</td>
<td>7.8</td>
<td>0.02</td>
<td>0.12</td>
<td>0.121</td>
<td>0.16</td>
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<tr>
<td>31–40</td>
<td>8.2</td>
<td>0.02</td>
<td>0.13</td>
<td>0.131</td>
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<tr>
<td>41–50</td>
<td>8.6</td>
<td>0.01</td>
<td>0.15</td>
<td>0.151</td>
<td>0.21</td>
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<td>51–60</td>
<td>8.4</td>
<td>0.01</td>
<td>0.17</td>
<td>0.171</td>
<td>0.24</td>
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<td>61–70</td>
<td>9.1</td>
<td>0.02</td>
<td>0.18</td>
<td>0.181</td>
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<td>Global RMS</td>
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<td>0.02</td>
<td>0.14</td>
<td>0.141</td>
<td>0.20</td>
</tr>
</tbody>
</table>

- Estimated aliasing error is small compared to other error components
- Largest possible effects at low latitudes

* From Lagerloef et al. (2008) Oceanography
Summary

• Rapid SSS variability can be a significant part of the total variability (20% on average, >50% in some tropical and coastal regions)
• Aliasing impacts are also dependent on sampling characteristics, including irregular sampling times
• Aliasing errors are small compared to other Aquarius errors on average but can be more important locally
• Effects typically larger at subseasonal periods diminishing towards longer periods, suggesting seasonal cycle not strongly affected
• Results from HYCOM and moorings comparable although HYCOM tends to underestimate aliasing impacts
• Estimates based on hourly (instead of daily) values also suggest our results might be biased low, particularly in places of strong precipitation