Using the Saildrone Unmanned Surface Vehicle for Validation of Satellite Derived Sea Surface Salinity from SMAP: The California/Baja Coast Deployment

Salinity Science Team
Santa Rosa, California
04/28/2019

Jorge Vazquez (JPL)¹, Jose Gomez-Valdes², Marouan Bouali³, Chelle Gentemann⁴, Wenqing Tang¹

¹ Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA 91109, USA
² Physical Oceanography Department, Center for Scientific Research and Higher Education at Ensenada, Ensenada, Mexico; jgomez@cicese.mx
³ University of Sao Paulo, Sao Paulo, Brazil; marouanbouali@gmail.com
⁴ Earth and Space research, Seattle, Washington
Methodology

1. Comparisons done directly between Saildrone derived Salinity and three satellite derived products:
   1. Remote Sensing 70km Version 3.0
   2. Remote Sensing 40km Version 3.0
   3. JPL SMAP version 4.2
   4. SST products for purpose of comparison

2. Products used were Level 3 8-day running means.
3. Co-location used was a simple nearest neighbor approach.
4. Biases, Root Mean Square Differences (RMSD), Correlations, and Signal to Noise Ratios were calculated
5. Spectra were calculated to compare spectral slopes with known slopes indicating mesoscale-submesoscale variability
6. Future studies will start to examine gradients and differences based on the products.
Saildrone

Saildrone is a wind and solar powered unmanned surface vehicle (USV) capable of long distance deployments lasting up to 12 months and providing high quality, near real-time, multivariate surface ocean and atmospheric observations while transiting at typical speeds of 3-5 knots. Data used in this work focused on the California/Baja deployment in April-June of 2018 at one minute sampling with approximately 0.1 spatial sampling. Although Saildrone measures several parameters, including air pressure, wind speed, oxygen, chlorophyll-a, humidity, air temperature, the focus of this work was to validate the salinity and temperature measurements. The salinity and temperature measurements were both derived from the on-board conductivity, temperature, depth (CTD) instrument.
Salinity Products Along the Saildrone Track

Clear differences observed among the 4 products.

SSS along the Saildrone track for the 4 products.
Time Series Along the Saildrone Track

Time Series of the four products along the Saildrone track. Visible are biases between the products.
Differences Along the Saildrone Track

Differences between JPLSMAP-Saildrone, RSS40km-Saildrone and RSS70km-Saildrone. Salty biases exist for the JPLSMAP, while fresh biases exist for RSS70km.
## Statistics using Saildrone SSS (SST shown for comparison)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Bias (PSU)</th>
<th>RMSD (PSU)</th>
<th>Correlation</th>
<th>Signal to Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPL SMAP</td>
<td>0.15</td>
<td>0.37</td>
<td>0.57</td>
<td>1.3</td>
</tr>
<tr>
<td>RSS40km</td>
<td>-0.17</td>
<td>0.45</td>
<td>0.49</td>
<td>1.1</td>
</tr>
<tr>
<td>RSS70km</td>
<td>-0.37</td>
<td>0.23</td>
<td>0.57</td>
<td>1.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Bias (°C)</th>
<th>RMSD (°C)</th>
<th>Correlation</th>
<th>Signal to Noise Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMC</td>
<td>-0.03</td>
<td>0.44</td>
<td>0.97</td>
<td>4.5</td>
</tr>
<tr>
<td>OSTIA</td>
<td>0.04</td>
<td>0.39</td>
<td>0.98</td>
<td>6.2</td>
</tr>
<tr>
<td>MUR</td>
<td>0.32</td>
<td>0.46</td>
<td>0.97</td>
<td>5.1</td>
</tr>
<tr>
<td>REMSS</td>
<td>0.11</td>
<td>0.43</td>
<td>0.97</td>
<td>4.4</td>
</tr>
<tr>
<td>K10</td>
<td>0.16</td>
<td>0.49</td>
<td>0.96</td>
<td>4.0</td>
</tr>
<tr>
<td>DMI</td>
<td>0.04</td>
<td>0.5</td>
<td>0.96</td>
<td>4.2</td>
</tr>
</tbody>
</table>
Spectra for the four different SSS products. Spectra clearly line up with a spectral slope of -2, consistent with mesoscale-submesoscale variability.
Coherence of JPLSMAP, RSS40km, RSS70km with Saildrone. Significant peak at 100 km consistent with upwelling scales.
### Spectral Slopes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>(k⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sail SST</td>
<td>-2.22</td>
</tr>
<tr>
<td>MUR SST</td>
<td>-2.11</td>
</tr>
<tr>
<td>OSTIA SST</td>
<td>-2.12</td>
</tr>
<tr>
<td>CMC SST</td>
<td>-2.12</td>
</tr>
<tr>
<td>REMSS SST</td>
<td>-1.92</td>
</tr>
<tr>
<td>DMI SST</td>
<td>-2.02</td>
</tr>
<tr>
<td>K10 SST</td>
<td>-2.03</td>
</tr>
<tr>
<td>Sail SSS</td>
<td>-1.81</td>
</tr>
<tr>
<td>JPLSMAP SSS</td>
<td>-1.69</td>
</tr>
<tr>
<td>RSS40km SSS</td>
<td>-1.96</td>
</tr>
<tr>
<td>RSS70km SSS</td>
<td>-1.91</td>
</tr>
</tbody>
</table>
Conclusions

- Observed Biases between the Saildrone Sea Surface Salinity (SSS) and the three satellite products are consistent with previous results. The JPLSMAP product showed overall positive biases while the RSS40km and RSS70km products showed negative biases.

- Compared with SST, correlations for the SSS products were significantly reduced. Two possible explanations are the lower inherent resolution of the SSS data, and issues with land contamination. For example the daily variability of the Saildrone SST is $0.4^\circ$K. Overall the RMSD of the different products with respect to Saildrone SST was $0.4^\circ$K or less. Thus the differences between the SST products could be explained by the inherent daily variability not resolved by the satellite derived SST. For SSS, the daily variability was 0.1 PSU, significantly lower than the RMSD differences of 0.3 PSU. Overall, other factors, besides the inherent daily variability resolved by the Saildrone USV, must be contributing to the SSS differences.

- Coherences show a peak at 100kilometers, consistent with known upwelling scales off the California Coast.

- Spectral Slopes are consistent with known scales of mesoscale to submesoscale variability.
Future Work (Examination of Gradients, SMAP and OSTIA SST)
## Gradient Statistics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Statistic (PSU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPL bias</td>
<td>-0.0227180</td>
</tr>
<tr>
<td>RSS40 bias</td>
<td>-0.00966065</td>
</tr>
<tr>
<td>RSS70 bias</td>
<td>-0.0164596</td>
</tr>
<tr>
<td>JPL RMSD</td>
<td>0.0372098</td>
</tr>
<tr>
<td>RSS40 RMSD</td>
<td>0.0255087</td>
</tr>
<tr>
<td>RSS70 RMSD</td>
<td>0.0272101</td>
</tr>
<tr>
<td>correlation jpl/sail</td>
<td>0.74</td>
</tr>
<tr>
<td>correlation rss40/sail</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Thank you! Questions?