Quantifying the Spatial Uncertainty of SST Data Products

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Seattle
Sea Surface Temperate Science Team Meeting

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Outline

1. Background

2. Differences Between Accurate and Precise
Outline

1 Background

2 Differences Between Accurate and Precise
Satellite-derived Earth science data sets are rich both
- Temporally, and
- Spatially.

However, we rarely evaluate the quality of spatial information in our data products.

Primary focus of the quality of most satellite-derived products is on ‘point’ accuracy.
- The mean and RMS difference of $SST_{satellite} - SST_{in situ}$
- The mean and RMS difference of co-located $SST_{satellite} - SST_{other product}$

For a number of the applications identified at the SST workshop, the point-to-point accuracy of SST tended to be more stringent than previous requirements.

In these cases the point-to-point accuracy is more important than absolute accuracy.
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## SST Requirements

<table>
<thead>
<tr>
<th>Application</th>
<th>Source</th>
<th>Spatial resolution (km)</th>
<th>Temporal resolution (hrs)</th>
<th>Geolocation accuracy (km)</th>
<th>Absolute accuracy (K)</th>
<th>Relative accuracy</th>
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<tr>
<td>CDR</td>
<td>Ohring et al., 2005</td>
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<td>Strictest</td>
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<td>0.1</td>
<td>0.1</td>
<td>0.05°K 0.04°K/decade</td>
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</table>
Feature versus Climate Studies

- SST Fields
  - Group 1
    - Cruise Support
    - Process Oriented Studies
    - Feature Analyses
  - Group 2
    - Climate Studies
    - Model BC
New requirements point to the need for a measure of the spatial fidelity of SST products.
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Accurate and Precise

\[ \text{SST}_{\text{Satellite}} - \text{SST}_{\text{in situ}} \]

Small scatter, no bias
Accurate and Imprecise

\[ \text{SST}_{\text{Satellite}} - \text{SST}_{\text{in situ}} \]

**Probability Density**

**Reference Temperature**

**SST**

Large scatter, no bias
Inaccurate and Precise

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Probability Density

Reference Temperature  SST

Large scatter, large bias
That was cool.

Now let’s look at these distributions in the context of the point-to-point (spatial) difference in an SST field.
Accurate and Precise; Small Point-to-Point

\[
\begin{align*}
SST_{\text{Satellite}} & - SST_{\text{in situ}} \\
SST(i, j)_{\text{Satellite}} & - SST(i+1, j)_{\text{Satellite}}
\end{align*}
\]

Small scatter, no bias when compared with in situ observations and small point-to-point variability.
Accurate and Imprecise; Small Point-to-Point

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Large scatter, large bias when compared with in situ observations and large point-to-point variability
All Together Now

Accurate

Precise

Imprecise

Inaccurate

Precise

Precise

Imprecise
Accurate

Precise

Imprecise

Inaccurate

Precise

Precise

Imprecise

Probability Density

Reference Temperature

SST
Let’s look at a couple of simple statistics for two different cases.

**Comparison 1: For the western North Atlantic**

- **The data sets**
  - MODIS - 4km global for 2008
  - AVHRR Pathfinder v5 - 4km global for 2008

- **The statistic**
  - The standard deviation for each 3x3 pixel tile in each image.
Examples: Case 1

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Standard Deviation on 3x3 Tiles

MODIS

Pathfinder

Latitude

Longitude

Longitude
Standard Deviation on 3x3 Tiles

Frequency of SST 3x3 Spatial Variance

- **Pathfinder**
- **MODIS**

Variance in Degrees C Over 3x3 Spatial Squares

MODIS
Pathfinder

Latitude
Longitude

-70 -60 -50 -40
-70 -60 -50 -40
And

- **Comparison 2: For the world ocean**
  - The data sets
    - Level 2 AMSR-E from RSS oversampled to 10km resolution (middle 160 pixels on each scan line).
    - Level 3 AMSR-E from RSS obtained from L2 and reprojected to a 25km resolution map.
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Examples: Case 2

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Seems reasonable:

- The L2 product is 10km resolution so allows for larger gradients than 25km L3
- But wait, the L2 product is oversampled from a nominal resolution of 25km.
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Sobel Gradient Magnitude for L2 versus L3 AMSR-E

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So, I’ve shown that:

- Two similar sensors with similar processing (MODIS/AVHRR)
- Yield quite different results for a statistic related to the spatial variability of the fields.
- Two data sets from the same sensor but in different projections (L2/L3)
- Yield quite different results for a slightly different statistic.
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Consideration needs to be given to metrics related to the fidelity with which a product reproduces the spatial characteristics of the underlying field.
The End