A comparative study of ocean thermal gradients from GHRSSST Level 4 SST products

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Outline

- Importance of fronts
- Statistics vs Geometry
- SST gradients from Level 4 products
  - Feature resolution
  - Temporal variability
- Conclusion
Fronts in oceanography

Marine ecosystem boundaries

Ocean 2D / 3D dynamics

Fisheries

Ocean-Atmosphere interaction

https://oceancolor.gsfc.nasa.gov/gallery/
Product selection for SST gradients
“What's the “best” Level 4 product for SST gradients?”

Temporal Coverage

- Daily
- >10 Years

Fronts in synoptic maps
  - Fishing spots
  - Submarine acoustic communication

Seasonal variability
  - Coastal Upwelling
  - Ocean models

Long term change
  - Impact of climate on ocean frontal activity
“What's the “best” Level 4 product for SST gradients?”

Can we use *in situ* measurements to evaluate the quality of a dataset with respect to SST gradients?

Long term change
Impact of climate on ocean frontal activity
Statistics vs Geometry

Bias = 0.16°C
Stdev = 0.5°C
Statistics vs Geometry

Matchup

In situ

Satellite

Bias = 0.16°C
Stdev = 0.5°C
Statistics vs Geometry

**Matchup**

*In situ*  
17.50 17.50 17.50  
17.50 17.50 17.50  
17.50 17.50 17.50  

*Satellite*  
17 17 17  
17 17 17  
17 17 17  

Bias = 0.16°C  
Stdev = 0.5°C
Statistics vs Geometry

**In situ**

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**Satellite**

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**Matchup**

*Same statistics*
*Different geometries...*

**Same statistics**

**Different geometries...**
How consistent are SST gradients from GHRsst Level 4 datasets?
Datasets

6 GHRSSST Level 4 SST (2016-2018)

- Canadian Meteorological Center **CMC**
- Naval Oceanographic Office **K10**
- Remote Sensing Systems **REMSS_MW_IR**
- UK MetOffice **OSTIA**
- Danish Meteorological Institute **DMI**
- NASA/JPL Multiscale Ultrahigh Resolution **MUR**

All data downloaded from PODAAC and reprojected to a 0.1°Lat/Lon grid
Datasets

Comparison over 5 regions

- Brazil-Malvinas confluence region
- California Current System
- Agulhas current and retroflection zone
- Gulf Stream
- Peruvian Upwelling System
# Datasets

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<thead>
<tr>
<th>In situ</th>
<th>MODIS</th>
<th>AVHRR</th>
<th>VIIRS</th>
<th>ABI</th>
<th>GOES</th>
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Feature resolution

Aqua MODIS
Dec 31 2018, Brazil-Malvinas (Level 2P, 1 km)
Feature resolution

Level 3U (0.1° grid)

Level 4 (0.1° grid)
# Feature resolution

<table>
<thead>
<tr>
<th>Feature</th>
<th>Bias</th>
<th>Stdv</th>
<th>MSE</th>
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\[
\text{Mean Squared Error} = \frac{(err_1^2 + err_2^2 + \ldots)^2}{N}
\]
### Feature resolution

<table>
<thead>
<tr>
<th>Feature</th>
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<th>MSE</th>
<th>SSIM*</th>
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*Structural similarity (SSIM) index*


Citations May 2019 > 21400
Interannual variability: SST
Interannual variability: $|\nabla SST|$
Histogram of $|\nabla \text{SST}|$

Histogram of SST gradient magnitudes from Level 4 (Daily, Global)
Annual Cycle: $|\nabla \text{SST}|$
Peruvian Upwelling System (2018)
Annual Maps: | ▽SST |

Peruvian Upwelling System (2018)
Annual Maps: \(\nabla \text{SST}\)

Brazil-Malvinas (2018)

CMC  K10  REMSS

OSTIA  DMI  MUR

\[\text{m}^\circ\text{C/km}\]
Annual Maps: \[\nabla\text{SST}\n\]

Brazil-Malvinas (2018)

CMC
Conclusion

- The magnitude of SST gradients from Level 4 products shows major differences in space and time despite consistency of SST.
- Differences originate from the SST analysis AND the Level 2 data ingested.
- Statistical metrics (Bias, Stdv, MSE) do not quantify the “geometrical quality” of SST fields (i.e., Statistical validation ≠ Geometrical validation).
- Validation of SST gradients requires new methods and metrics.
Conclusion

Differences in SST gradients

Level 4
SST analysis method

Level 2/3U

- Stripe noise
- Gaussian noise
- SST retrieval algorithm
- Undetected clouds
- Misclassified fronts
- Merging artifacts

...
Case study
SST gradients from Level 2 MODIS
California Current System
Case study
SST gradients from Level 2 MODIS
California Current System

Increasing trend of SST gradients on Terra MODIS due to continuous degradation of detectors in channels used for SST
Thank you! Questions?