Exploring and Quantifying Uncertainties for Extended Reconstructed Sea Surface Temperature (ERSST) Version 4

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Outline

- What is ERSST
- What is SST uncertainty
- Globally averaged uncertainty of local SST versus uncertainty of globally averaged SST
- Impacts of uncertainty to trends of globally averaged SST
- Intercomparisons of SST uncertainty among products
- Summary
What is ERSST

- ERSST – Extended Reconstruced SST
- Monthly global 2-deg from 1875 to present month
- Using in situ SST observations only
- SST bias adjustment using NMAT
- Low-frequency SST reconstruction: 15-yr running mean
- High-frequency reconstruction: Empirical Orthogonal Teleconnections (EOTs), localized EOFs
What is uncertainty and why it is important

wikipedia.org:
Uncertainty is the situation which involves imperfect and or unknown information.

Factors resulting uncertainty:
- Random errors
- Systematic instrumental biases
- Sparse (missing) observations
- Reconstruction methodology and parameter selections.

There are a total of 24 internal parameters
Uncertainties in ERSST analysis system

Total uncertainty: \( U_t^2 = U_r^2 + U_p^2 \)

Reconstruction uncertainty: \( U_r^2(x, y, t) = [A_f(x, y, t) - D(x, y, t)]^2 \)

Parametric uncertainty: \( U_p^2(x, y, t) = \frac{1}{M} \sum_{m=1}^{M} [A_m(x, y, t) - \bar{A}(x, y, t)]^2 \)

Ensemble average: \( \bar{A} = \frac{1}{M} \sum_{m=1}^{M} A_m(x, y, t) \)

Sampling uncertainty: \( U_s^2(x, y, t) = [A_f(x, y, t) - A_s(x, y, t)]^2 \)

D: Data or truth
A_f: Fully sampled (model data etc) analysis
A_m: Sub-sampled (observed data) analysis members, M=1000
A_s: Sub-sampled (model data with observed mask) analysis
## Data sets in uncertainty estimation

<table>
<thead>
<tr>
<th>SST products</th>
<th>Spatial resolution</th>
<th>Temporal resolution</th>
<th>Data ingest</th>
<th>Analysis method</th>
<th>External forcing</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFDL-ESM2G</td>
<td>1°×0.9°</td>
<td>Daily 1861-2005</td>
<td>N/A</td>
<td>Coupled model simulation</td>
<td>Greenhouse gases, Trace gases, Aerosols, Ozone, Land use</td>
</tr>
<tr>
<td>HadGEM2-AO</td>
<td>1°×0.8°</td>
<td>Monthly 1860-2006</td>
<td>N/A</td>
<td>Coupled model simulation</td>
<td>Greenhouse gases, Aerosols</td>
</tr>
<tr>
<td>HadISST</td>
<td>1°×1°</td>
<td>Monthly 1871-2013</td>
<td>In situ SST Satellite SST</td>
<td>EOF based reduced space optimal interpolation</td>
<td>N/A</td>
</tr>
<tr>
<td>MOISST</td>
<td>1°×1°</td>
<td>Monthly 1982-2013</td>
<td>In situ SST Satellite SST</td>
<td>Optimum interpolation</td>
<td>N/A</td>
</tr>
<tr>
<td>DOISST</td>
<td>0.25°×0.25°</td>
<td>Daily 1982-2013</td>
<td>In situ SST Satellite SST</td>
<td>Optimum interpolation</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Reconstruction uncertainty: GFDL-ESM2G, HadGEM2-AO, HadISST, MOISST

Parametric uncertainty: Ship and buoy observations

Sampling uncertainty: DOISST
Reconstruction Uncertainty averaged from 1871 to 2005
Reconstruction Uncertainty time series

Global averaged Ur of Local SST

Percentile

Ur of global averaged SST
Parametric Uncertainty

1871-2005 averaged Up

Up time series and its percentiles of local SST

Up of global averaged SST
Parametric Uncertainty and ensemble number

(a) Parametric Up of local SST

(b) Parametric Up of globally ave SST

Up of local SST

Up of global averaged SST
Histograms of SST trend and ensemble number

1901-2014 SST trend

1951-2012 SST trend

2000-2014 SST trend
Dominant factors affecting trend of globally averaged SST

1901-2014 SST trend
P3=Min SST STD, P1=First-guess

1951-2012 SST trend
P9=ship-buoy adjustment

2000-2014 SST trend
P12=NMAT
Comparison of total uncertainty of local SST

ERSSTv4

HadSST3

COBE-SST2
Comparison of globally averaged total uncertainty of local SST

Sampling error/uncertainty is ignored in the total uncertainty.
Comparison of total uncertainty of globally averaged SST

Sampling error/uncertainty is ignored in the total uncertainty.
Structure uncertainty of globally and annually averaged SST

Structural uncertainty is estimate by the STD of SSTs from ERSST.v4, ERSST.v3b, HadSST3, HadISST, Kaplan SST, and COBE-SST2
Summary

- ERSST uncertainty contains reconstruction and parametric uncertainties.

- Reconstruction uncertainty results from truncated EOTs when “observations” are perfect.

- Parametric uncertainty is defined by STD of 1000-member ensemble varied with 24 internal parameter.

- SST uncertainty is large in regions with sparse observations (before 1900 & in WW I-II) and small in regions with dense observation in modern period.

- Uncertainty is much smaller in globally averaged SST than in local SST.

- ERSST uncertainty is mostly consistent with other similar products.

- Impacts of uncertainty to SST trends is small for long-term, but larger in short-term.
Three strongest El Nino events

La Nina events