



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

**(Huang et al., 2016, J. Climate)**

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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 Reconstructed 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

$$\text{Total uncertainty: } U_t^2 = U_r^2 + U_p^2$$

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

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

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

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

(ignored in ERSSTv4)

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

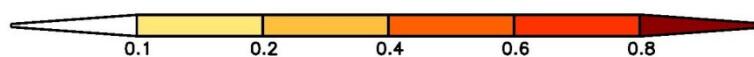
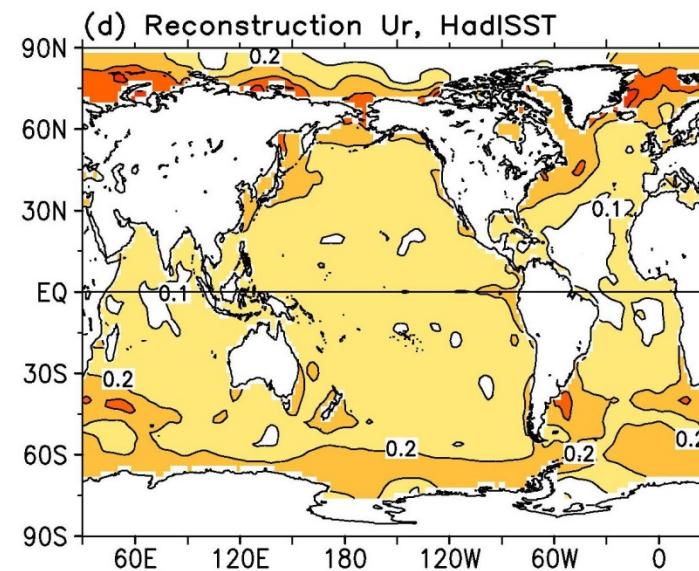
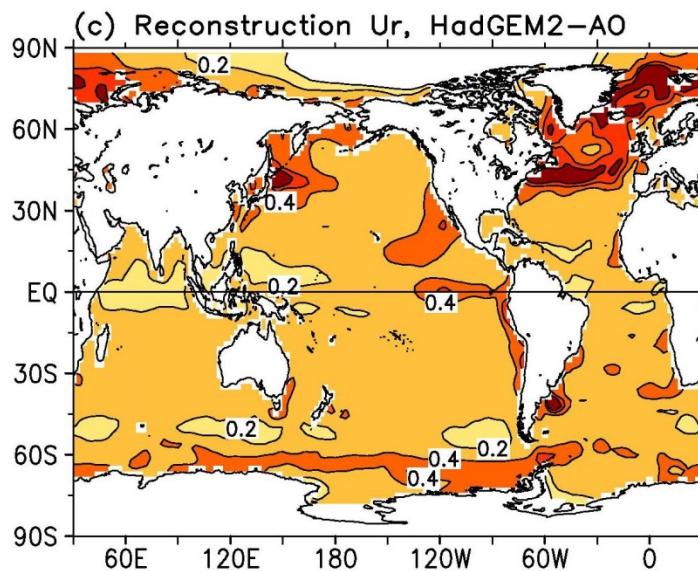
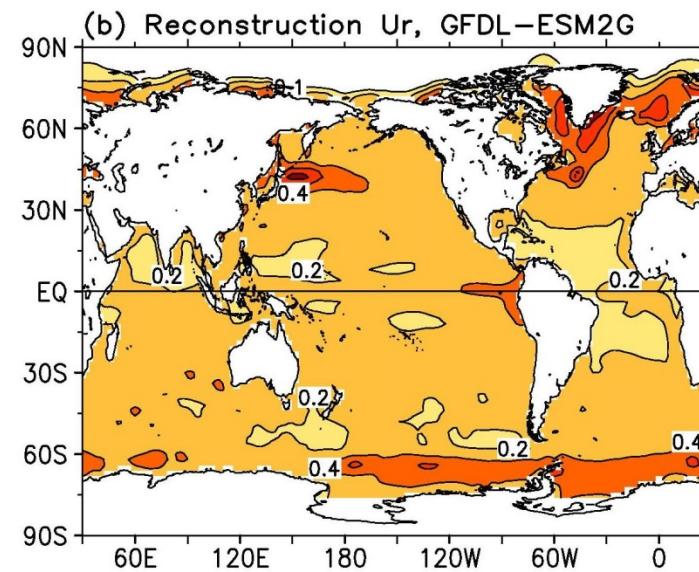
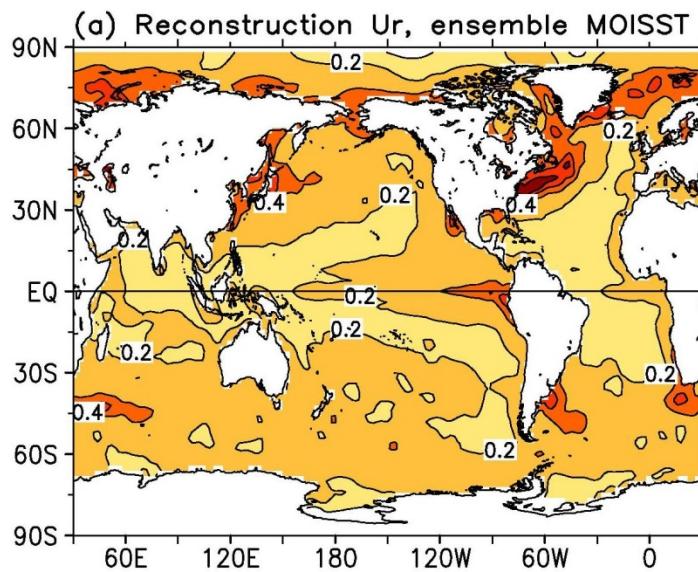
SST products	Spatial resolution	Temporal resolution	Data ingest	Analysis method	External forcing
GFDL-ESM2G	$1 \times 0.9^\circ$ Global	Daily 1861-2005	N/A	Coupled model simulation	Greenhouse gases, Trace gases, Aerosols, Ozone, Land use
HadGEM2-AO	$1 \times 0.8^\circ$ Global	Monthly 1860-2006	N/A	Coupled model simulation	Greenhouse gases, Aerosols
HadISST	$1 \times 1^\circ$ Global	Monthly 1871-2013	In situ SST Satellite SST	EOF based reduced space optimal interpolation	N/A
MOISST	$1 \times 1^\circ$ Global	Monthly 1982-2013	In situ SST Satellite SST	Optimum interpolation	N/A
DOISST	$0.25 \times 0.25^\circ$ Global	Daily 1982-2013	In situ SST Satellite SST	Optimum interpolation	N/A

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

Parametric uncertainty: Ship and buoy observations

Sampling uncertainty: DOISST

## Reconstruction Uncertainty averaged from 1871 to 2005



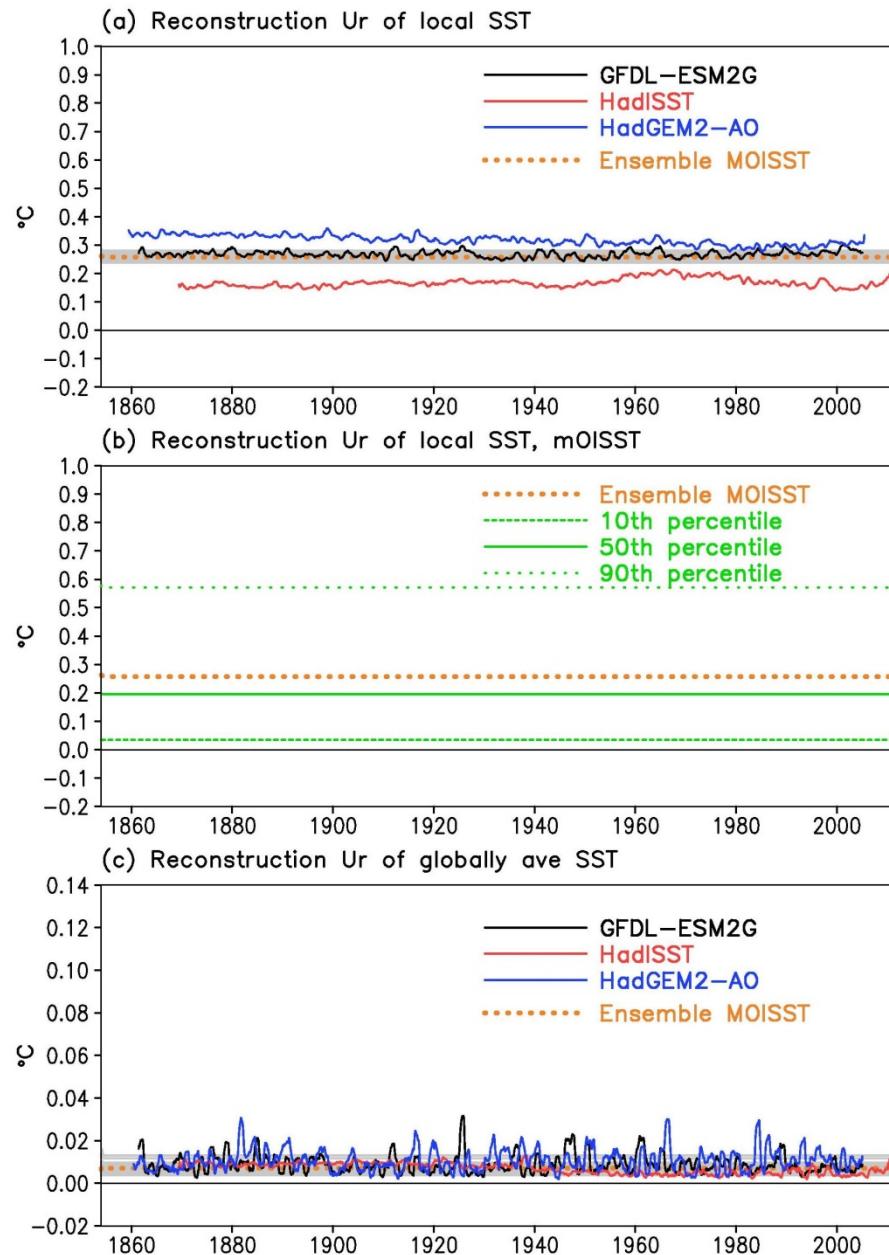


## Reconstruction Uncertainty time series

Global averaged Ur of Local SST

Percentile

Ur of global averaged SST



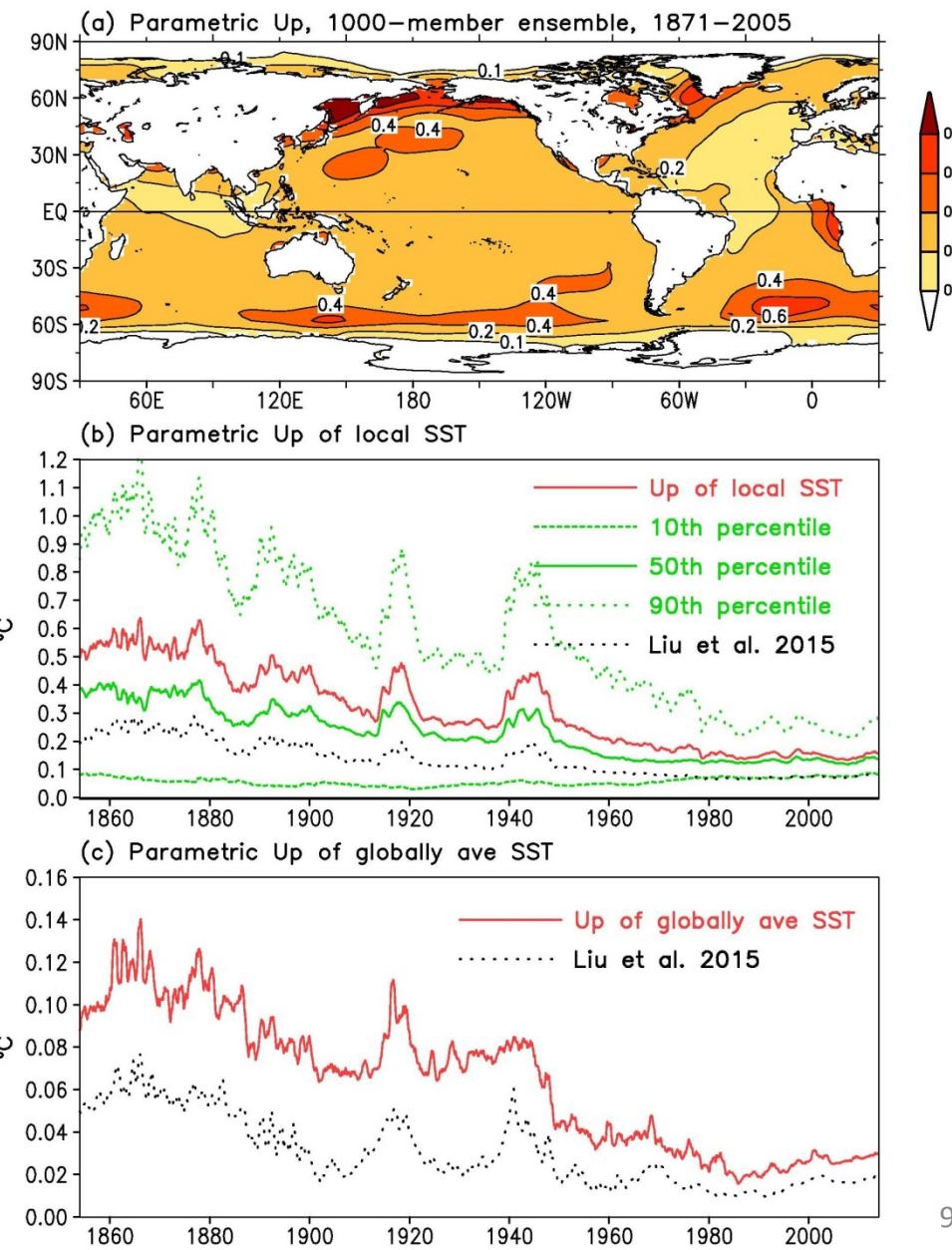


## Parametric Uncertainty

1871-2005 averaged Up

Up time series and its percentiles of local SST

Up of global averaged SST

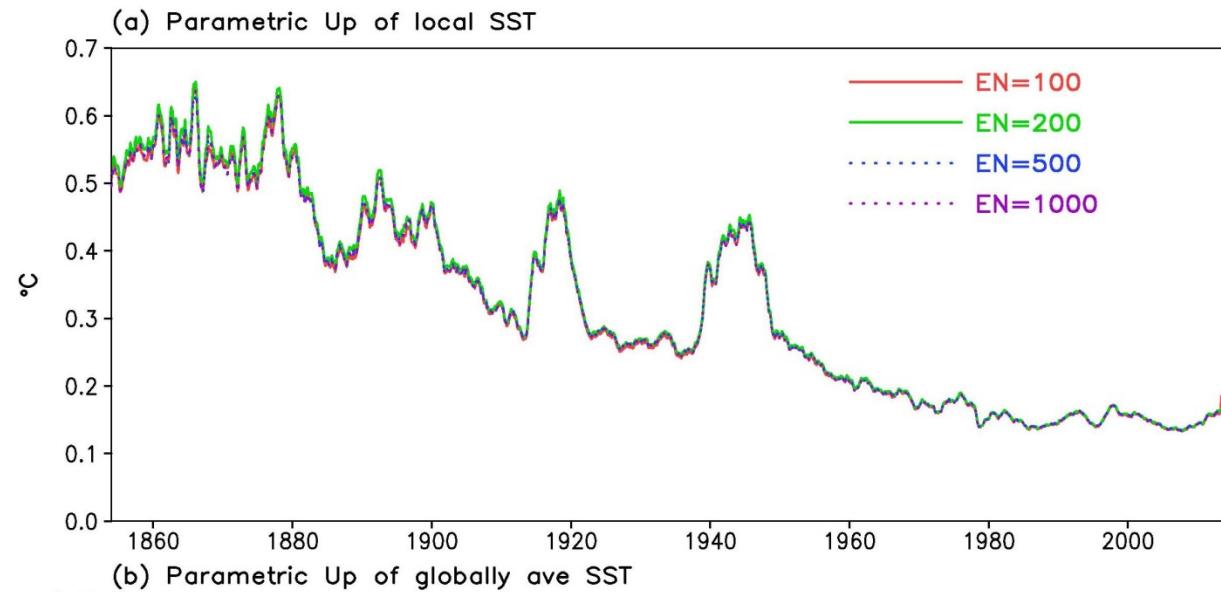




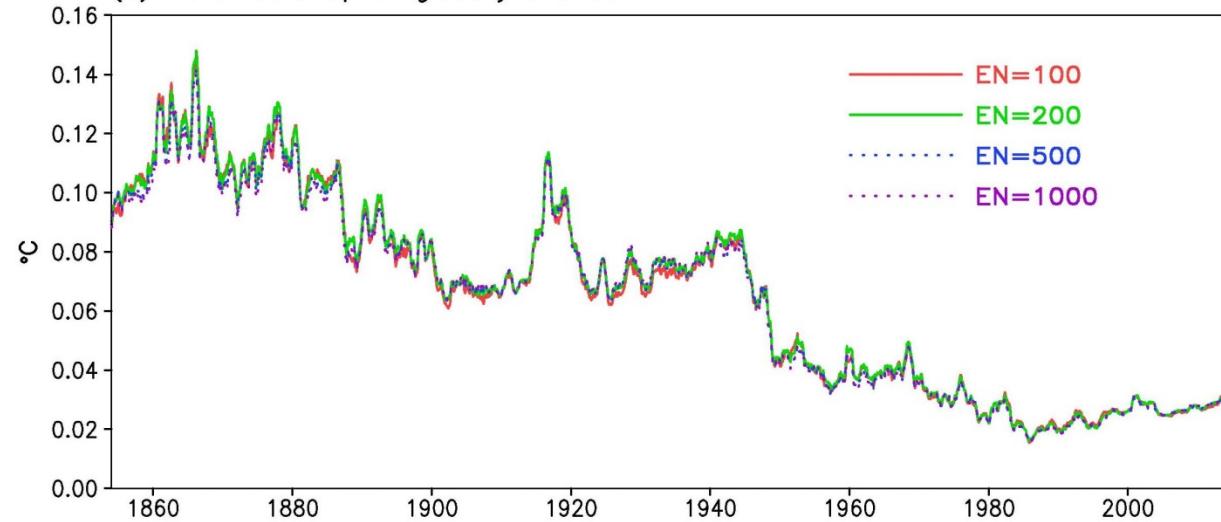
## Parametric Uncertainty and ensemble number



Up of local SST



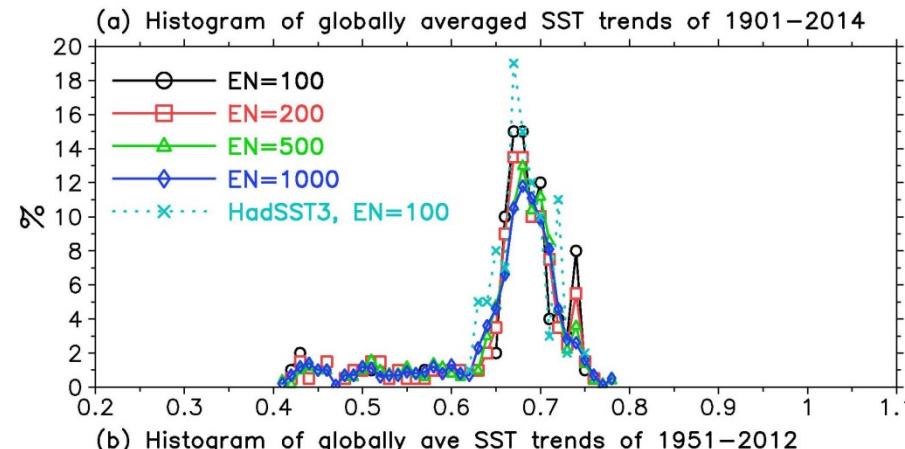
Up of global averaged SST



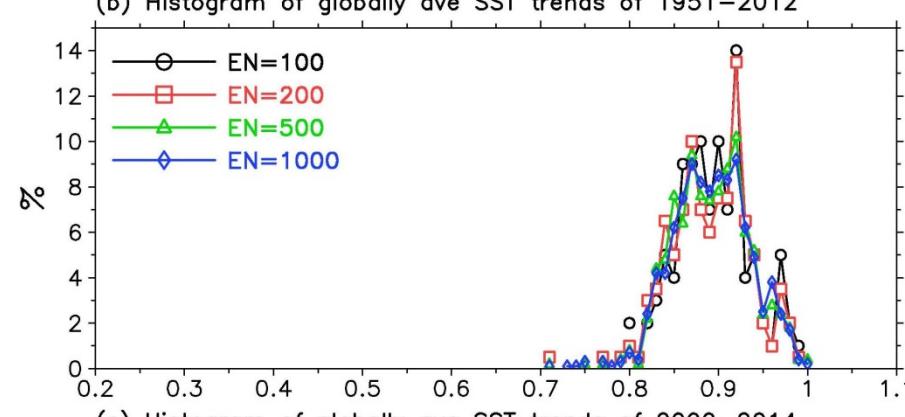


## Histograms of SST trend and ensemble number

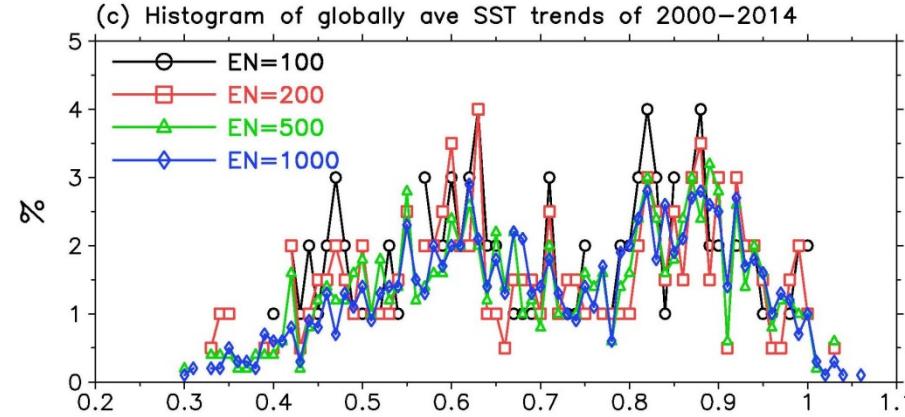
1901-2014 SST trend



1951-2012 SST trend



2000-2014 SST trend

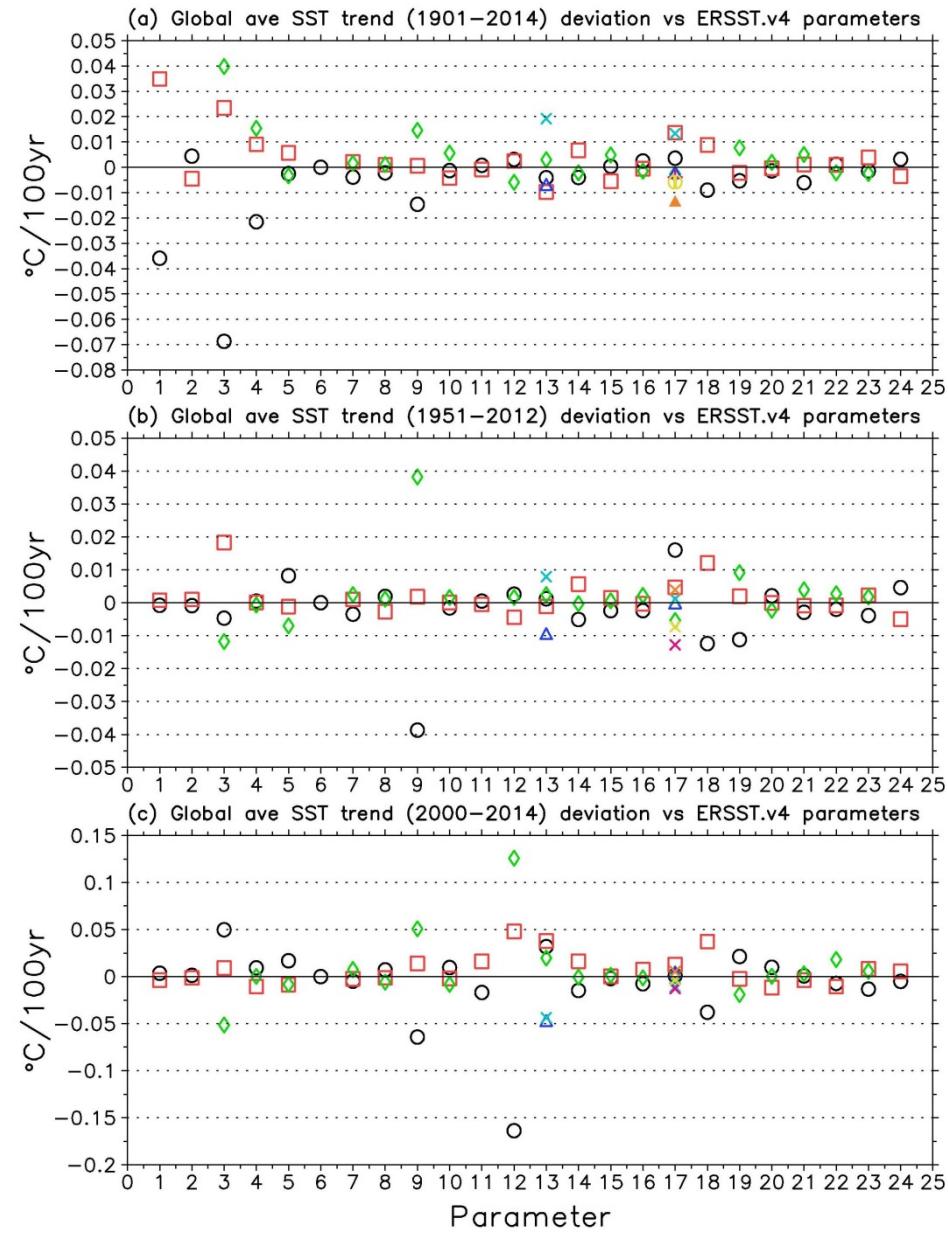




## Dominant factors affecting trend of globally averaged SST



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

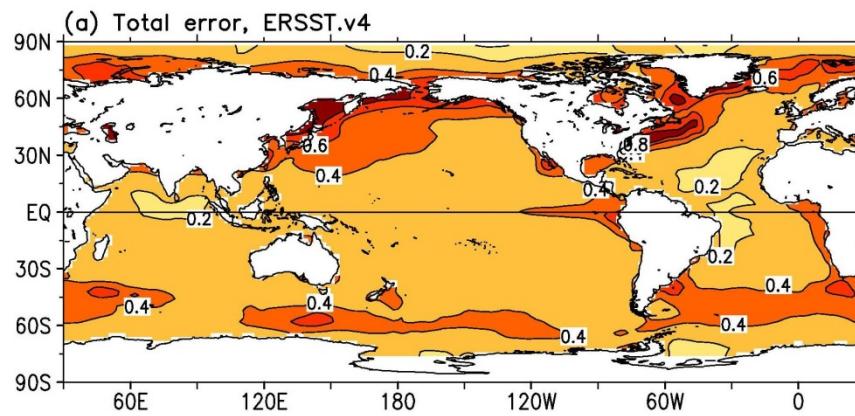


1951-2012 SST trend  
P9=ship-buoy adjustment

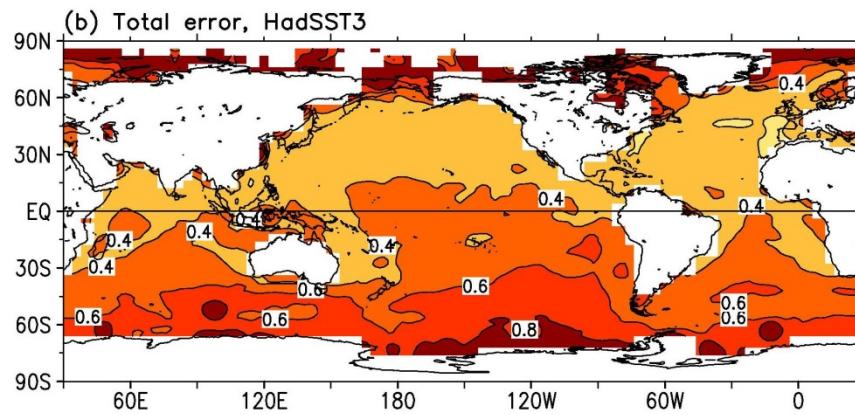
2000-2014 SST trend  
P12=NMAT

## Comparison of total uncertainty of local SST

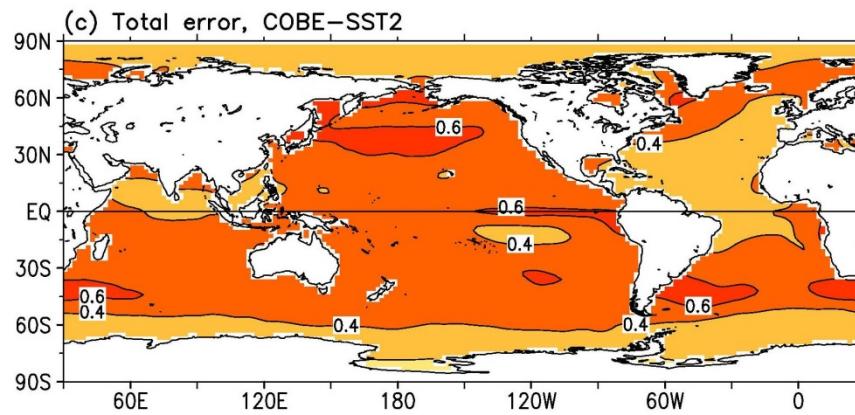
ERSSTv4



HadSST3

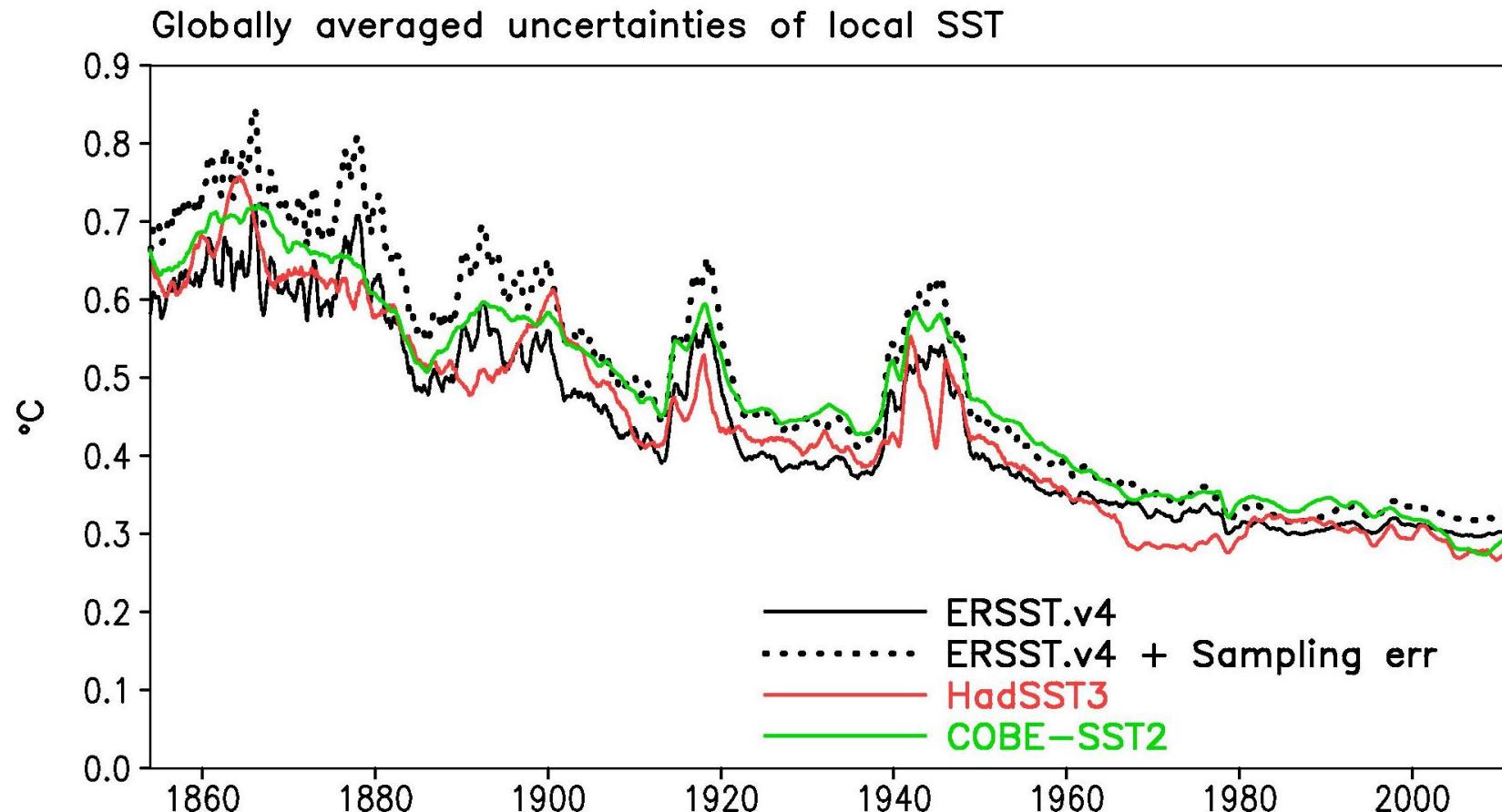
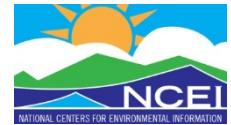


COBE-SST2





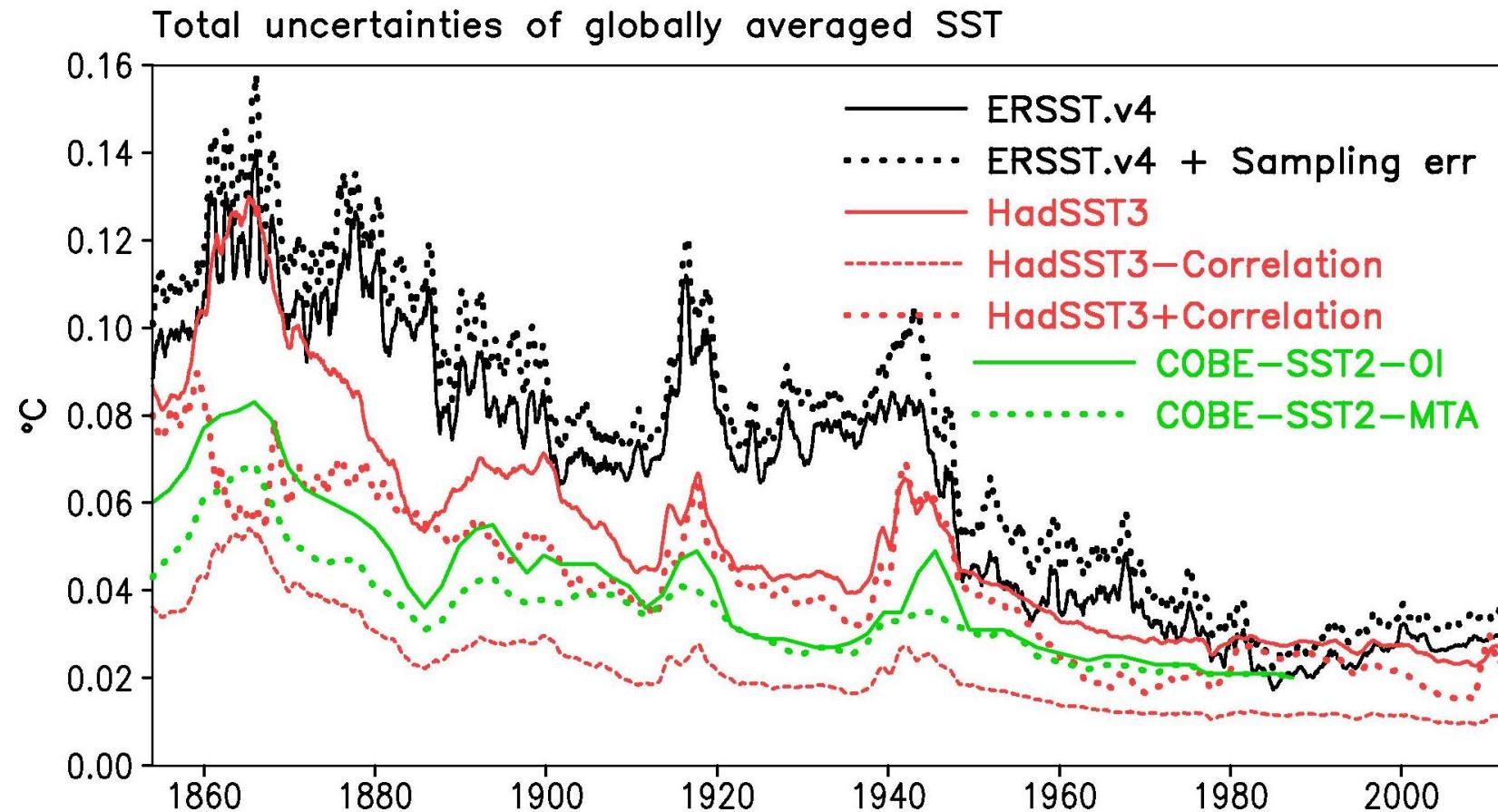
## Comparison of globally averaged total uncertainty of local SST



Sampling error/uncertainty is ignored in the total uncertainty.



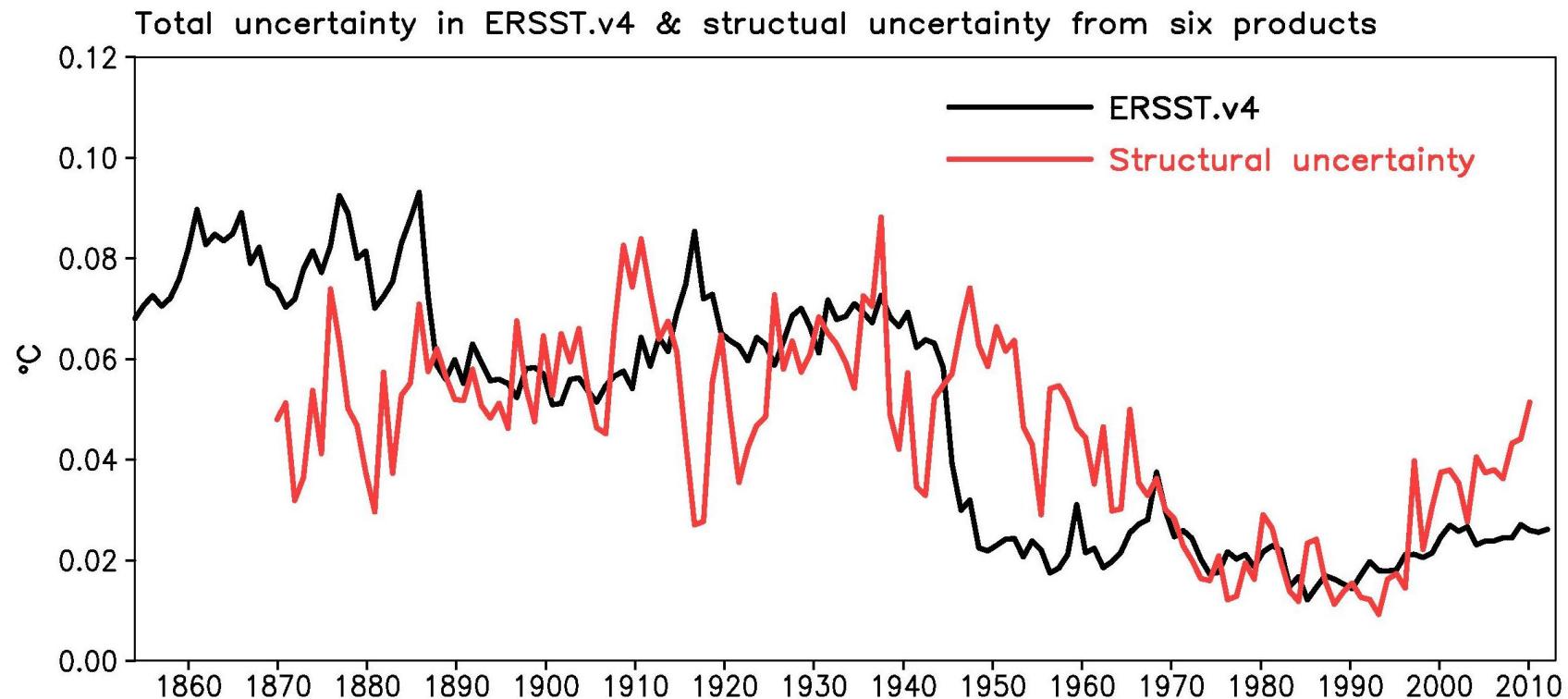
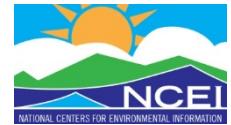
## Comparison of total uncertainty of globally averaged SST



Sampling error/uncertainty is ignored in the total uncertainty.



## Structure uncertainty of globally and annually averaged SST

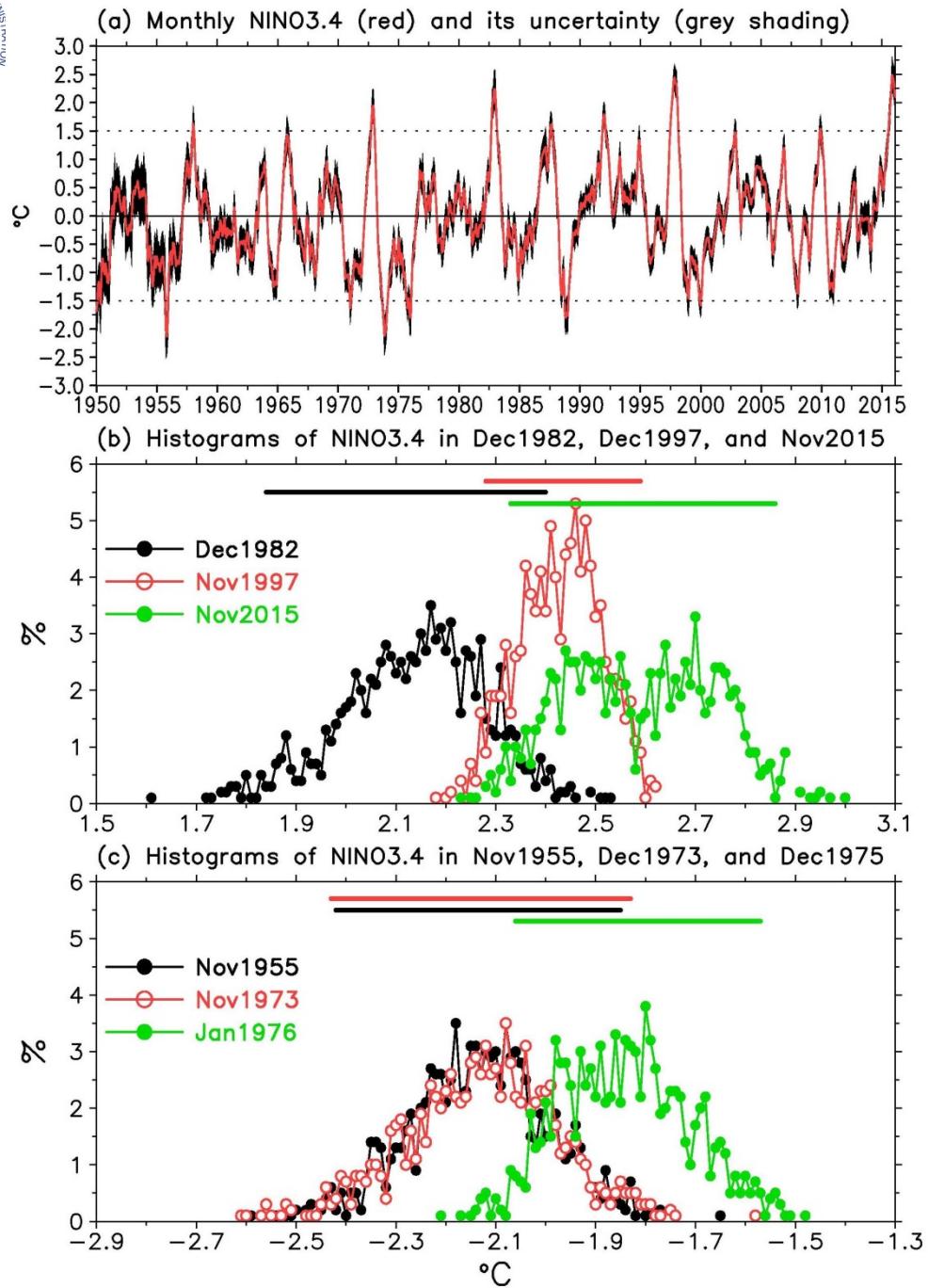


Structural uncertainty is estimate by the STD of SSTs from  
ERSST.v4, ERSST.v3b, HadSST3, HadISST, Kaplan SST, and COBE-SST2



# 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  
Niño events**

**La Niña  
events**