



Met Office
Hadley Centre

HadISST.2.1.0.0: the Met Office Hadley Centre Sea Ice and Sea- Surface Temperature data set

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What is HadISST.2.1.0.0 for?

- HadISST1 and HadISST2 are made to force long-term reanalyses and AOGCMs
- Ideally:
 - Homogeneous mean
 - Homogeneous variance
 - Globally complete
 - Consistent sea ice and SST
- HadISST.2.0.0 and HadISST.2.1.0.0 used in ECMWF reanalysis
- These characteristics also make HadISST useful for a range of other applications



HadISST.2.1.0.0

Sea ice analysis

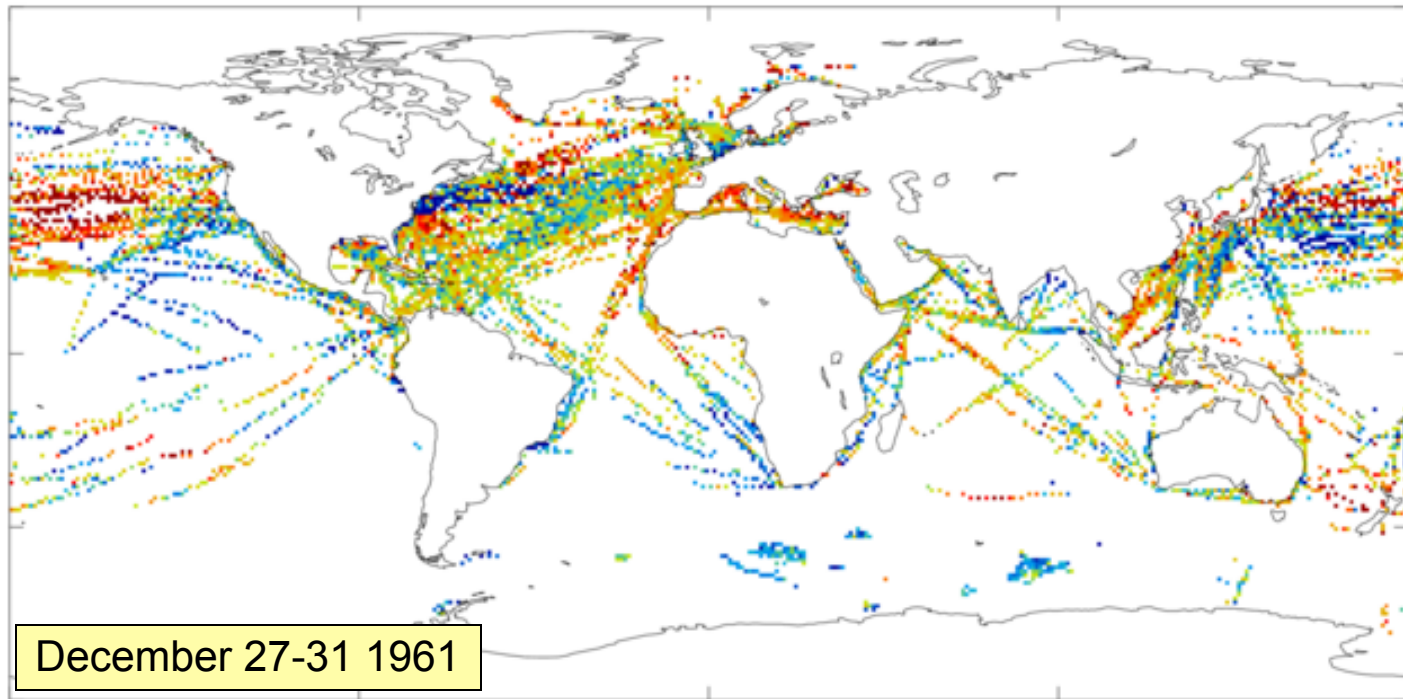
- Improved source data and bias adjustments
- More on this tomorrow

Sea-surface temperature analysis

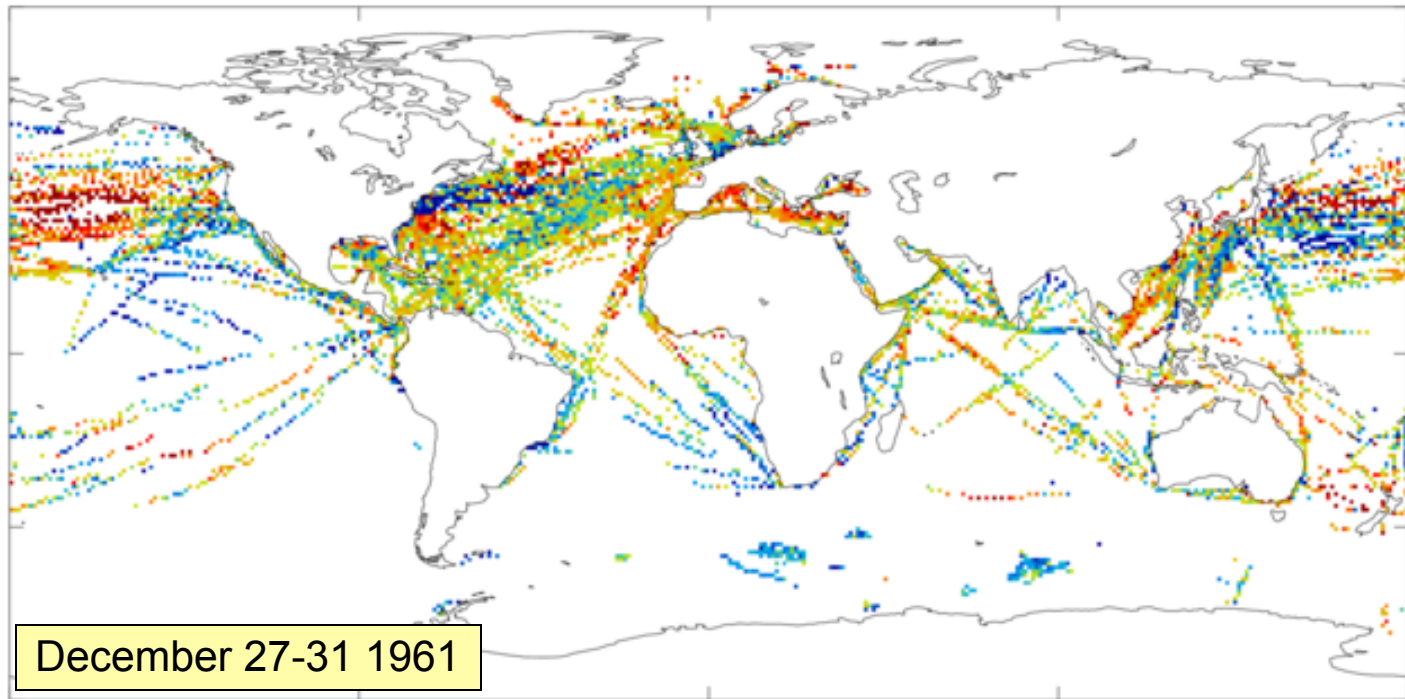
- Improved source data and techniques
- More comprehensive bias adjustments
- Improved uncertainty estimation
- Increased resolution
- More information – The Ensemble

The fundamental problem

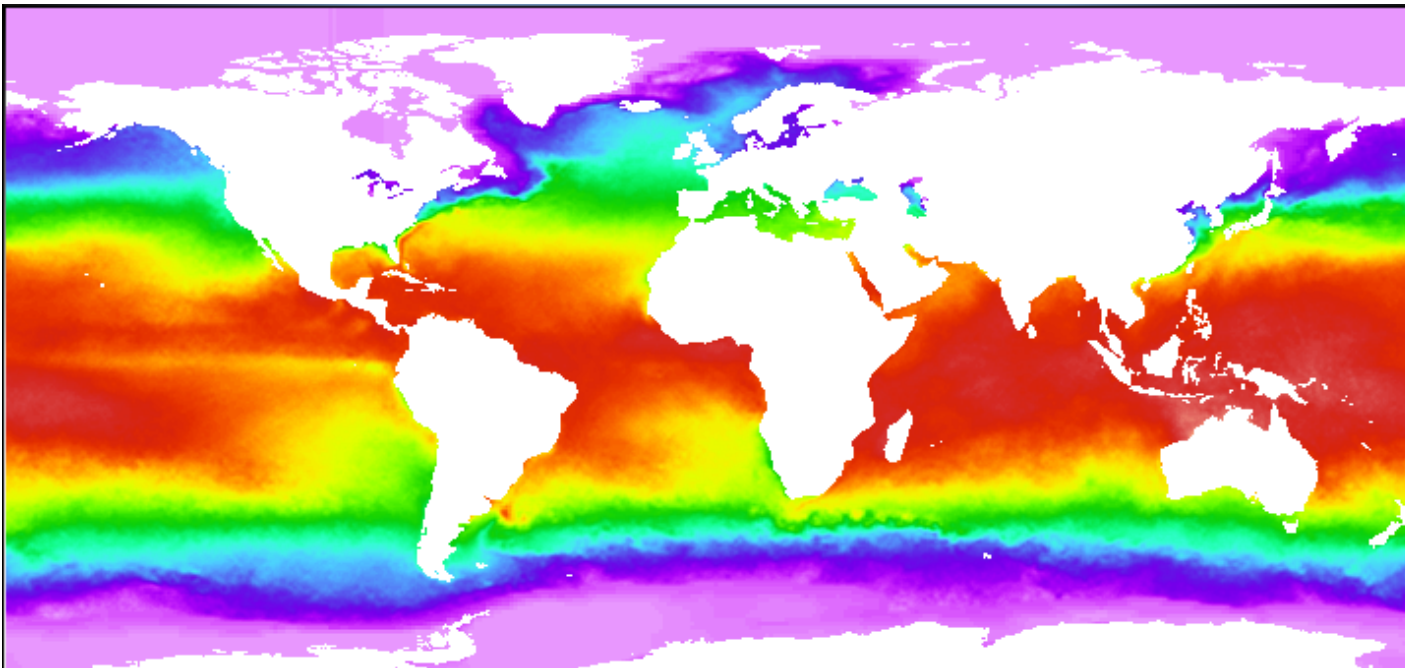
This is what
we have



This is what we have



This is what we want

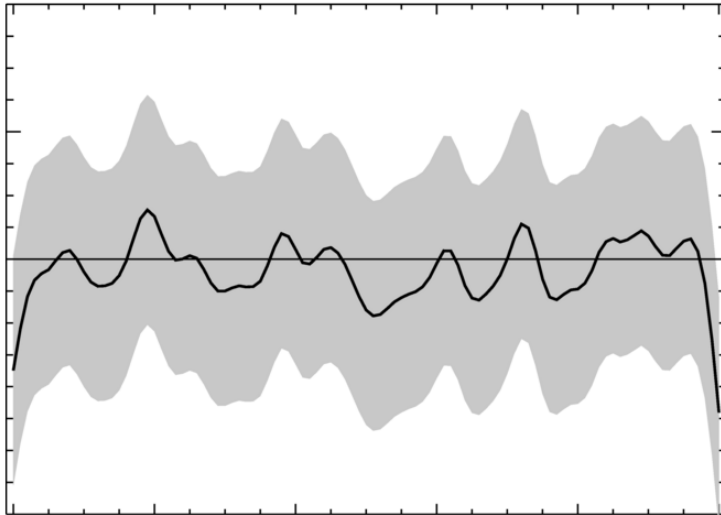


There are many pasts consistent
with the observations we have

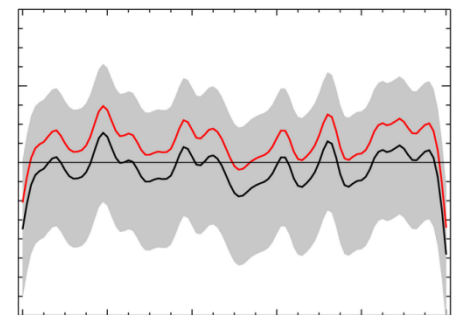
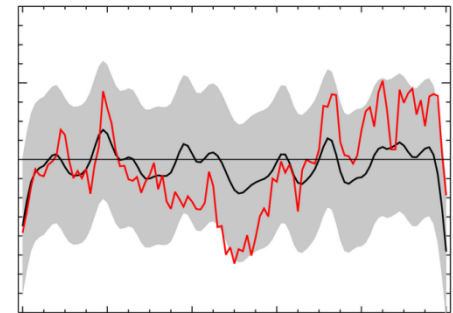
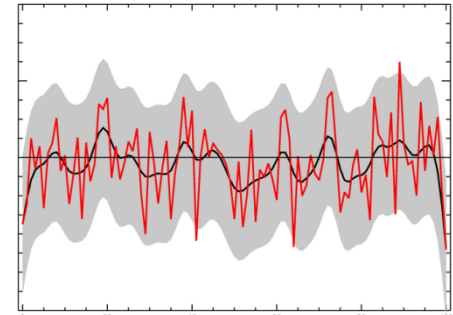
How do we deal with this?



Things found lurking in bars



=



Often we are dealing with combinations of uncertainties, each of which may be

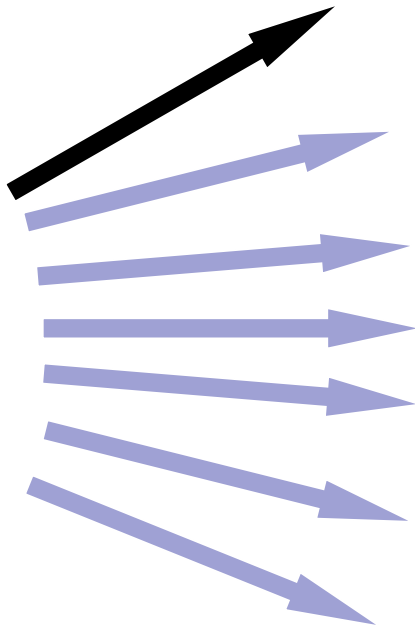
- Discontinuous
- Correlated in space
- Correlated in time
- Poorly defined

When errors have complex space
and time dependence an error bar is
not the whole story

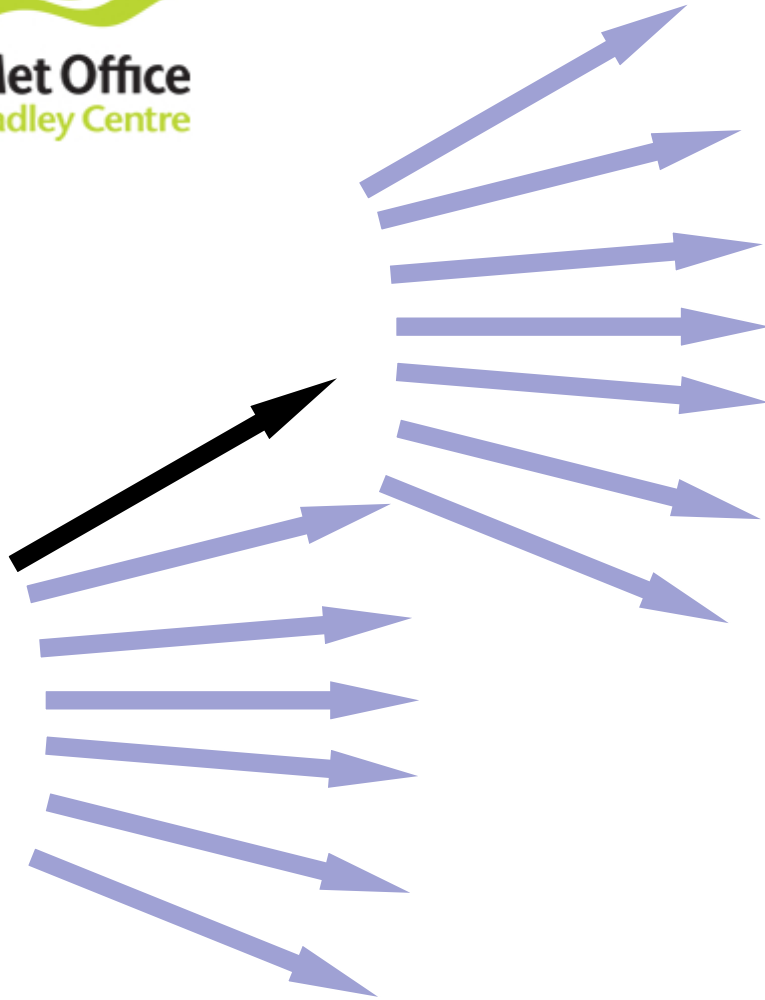
So, how do we tell the whole story?

The Story Generator

First, generate a range of plausible bias adjustments to the data

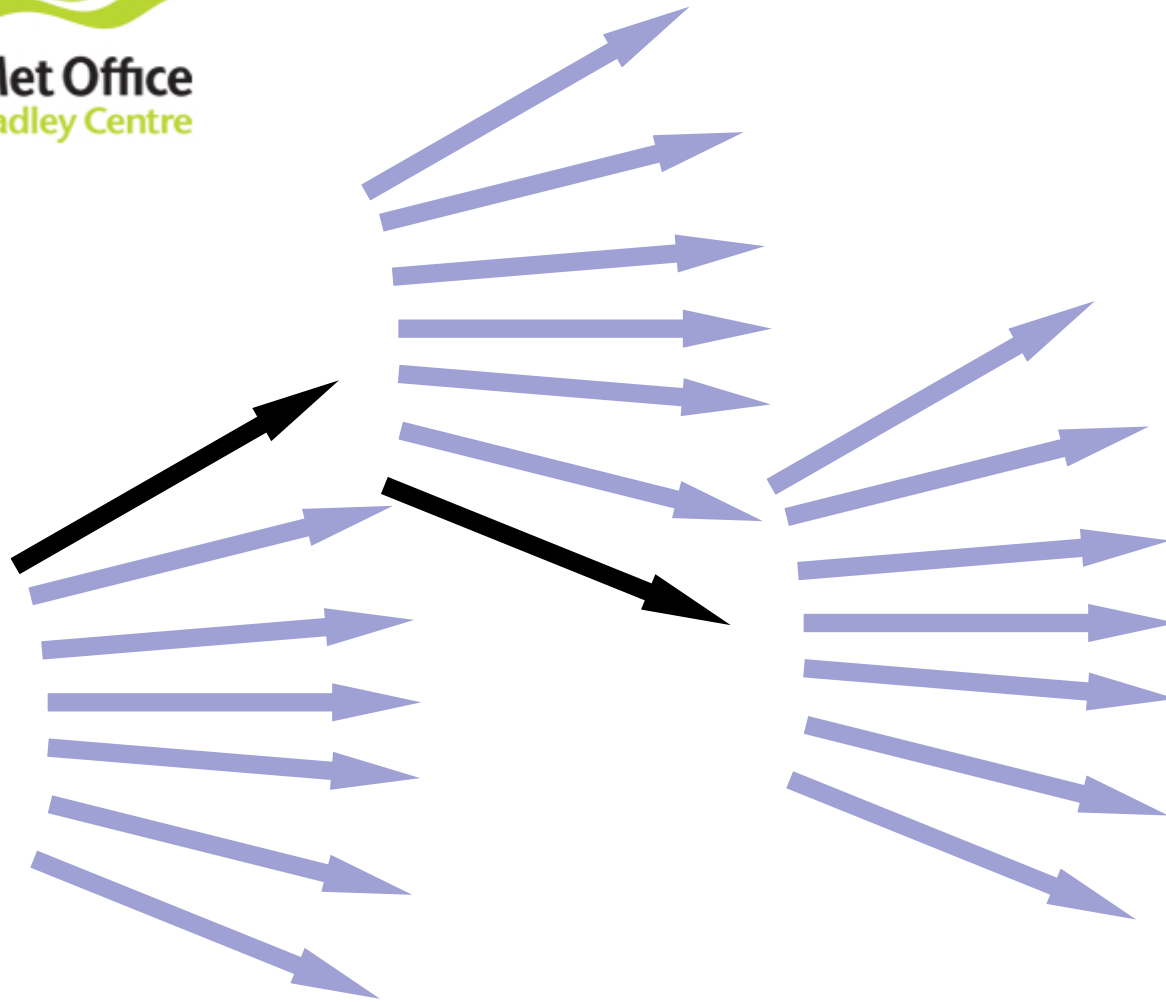


Bias adjustment



From one realisation of the in situ bias adjustments, produce 10 interchangeable realisations of the broad-scale reconstruction

Bias adjustment Broad-scale reconstruction

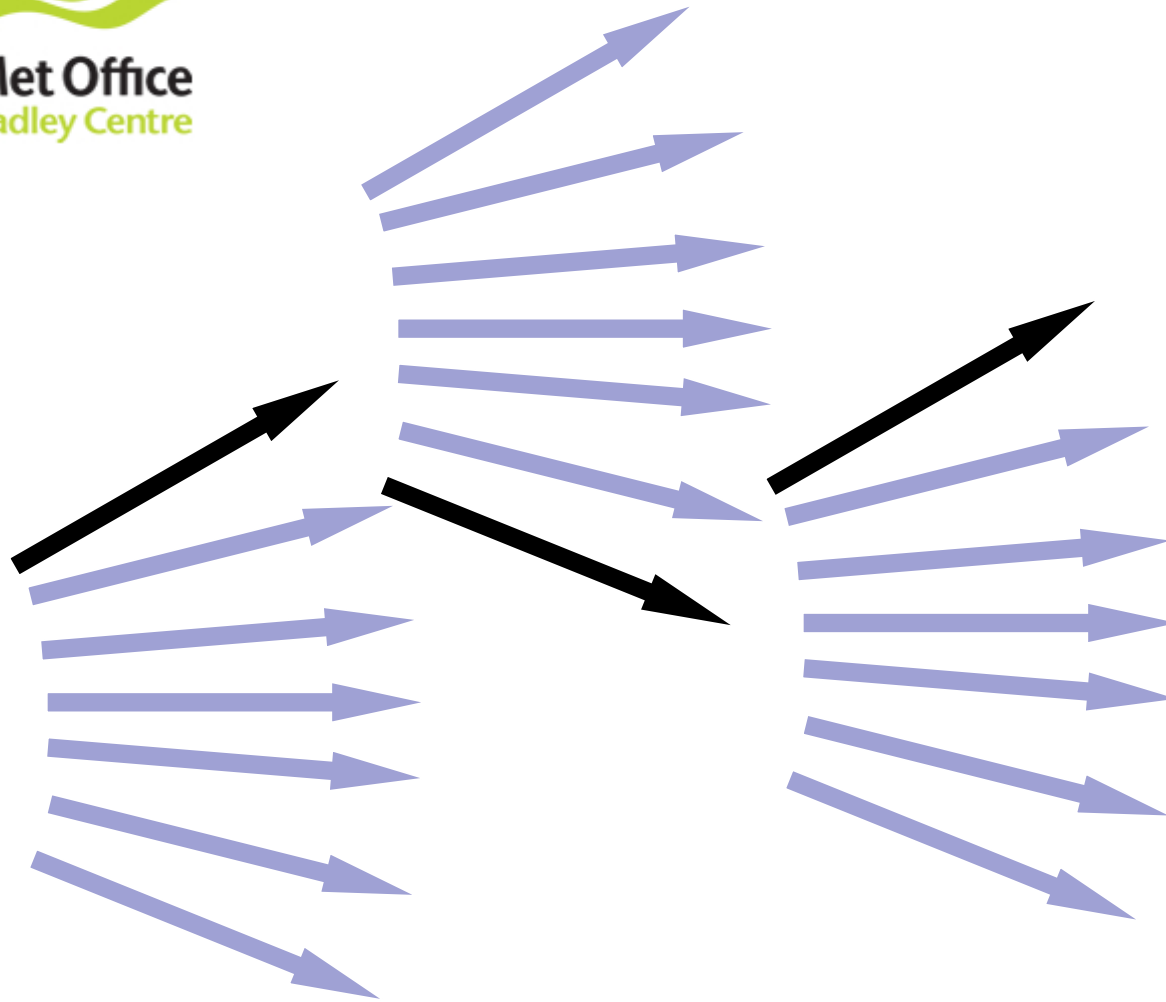


Then, from each of the 10 realisations of the broad-scale reconstruction, we can create an ensemble of interchangeable local OIs of the residuals from that reconstruction

Bias adjustment

Broad-scale reconstruction

Local OI of residuals

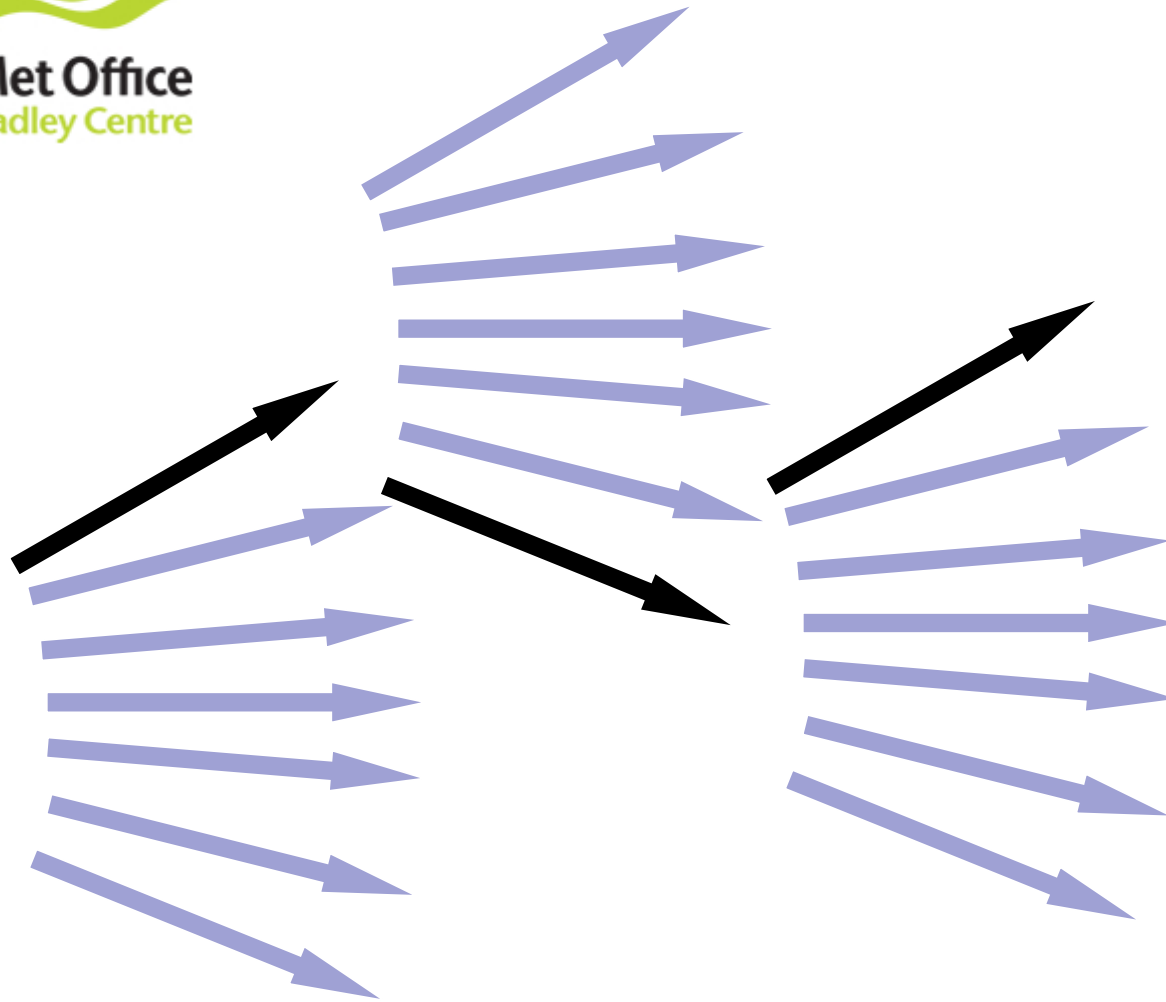


One random selection from the analyses of the residuals gives us one of our realisations of HadISST2

Bias adjustment

Broad-scale reconstruction

Local OI of residuals



Pick 10 such random paths to span the total uncertainty in the analysis and provide an ensemble of interchangeable versions of HadISST2

Bias adjustment

Broad-scale reconstruction

Local OI of residuals



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Sea surface temperature analysis

Build from the strengths of the input data sets

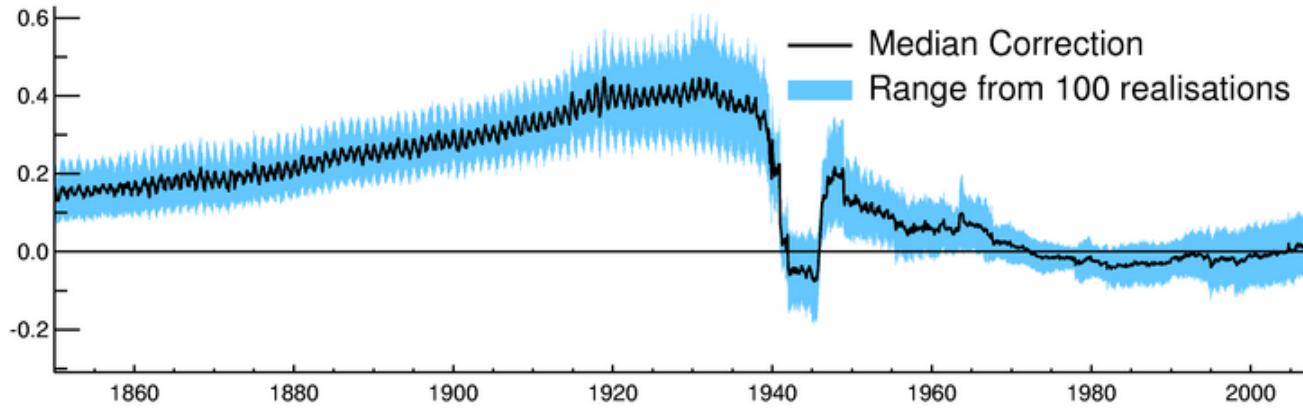
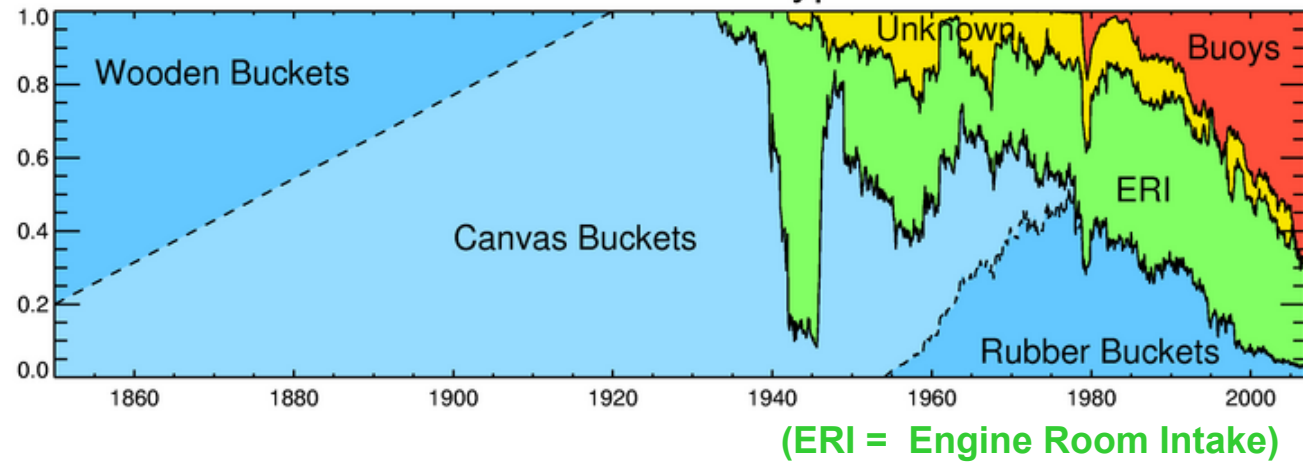
- **In Situ**
- HadSST3 from 1850
 - Poor coverage, low accuracy , long record
- **Satellite**
- ARC - ATSR Reprocessing for Climate, 1996 on
 - Lower coverage, short record, high accuracy, stable
- AVHRR Pathfinder, 1981 on
 - Excellent coverage, long record, lower accuracy

Contribution
(fraction) of
each
measurement
method

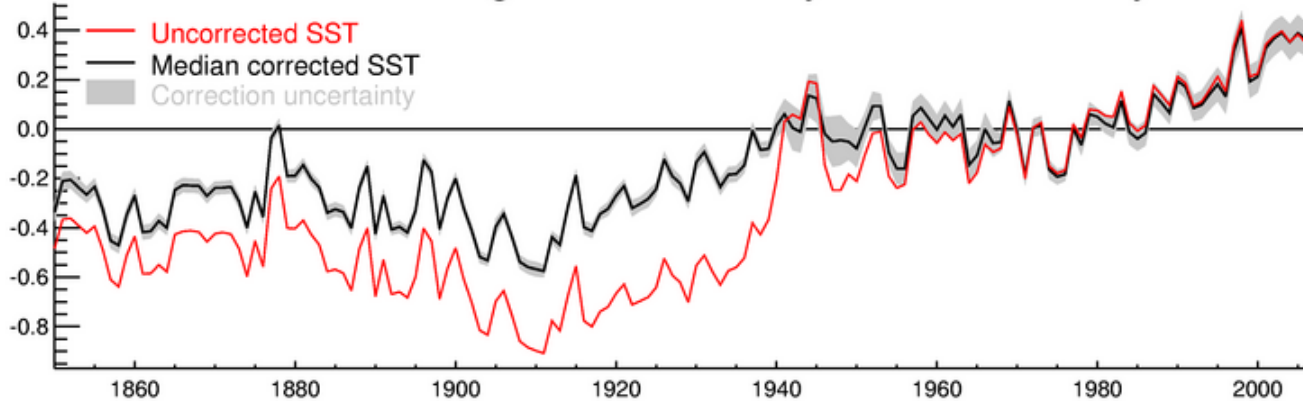
Monthly bias
corrections
from 100
realisations

Global
average
annual SST
timeseries

Fraction of Measurements from each Type in ICOADS

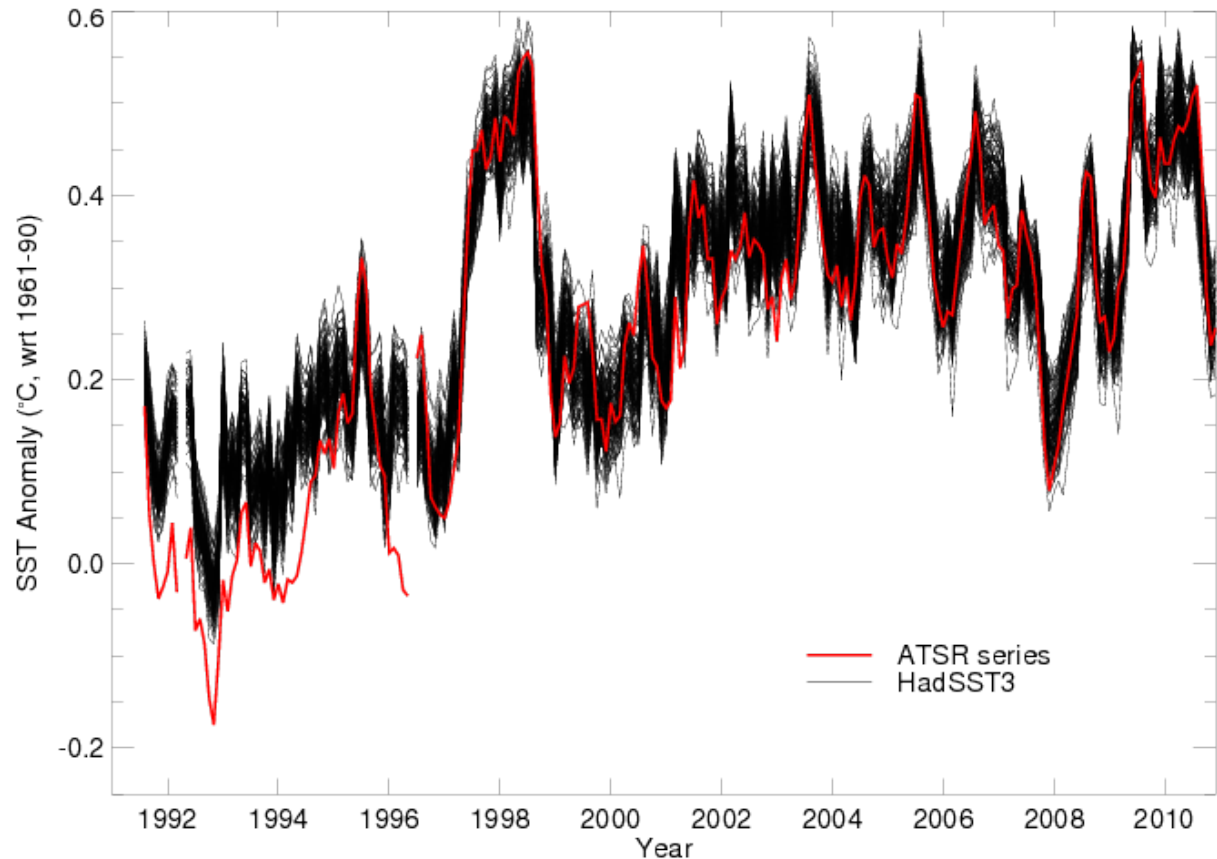


Corrected Global-Average SST Anomaly and Uncertainty



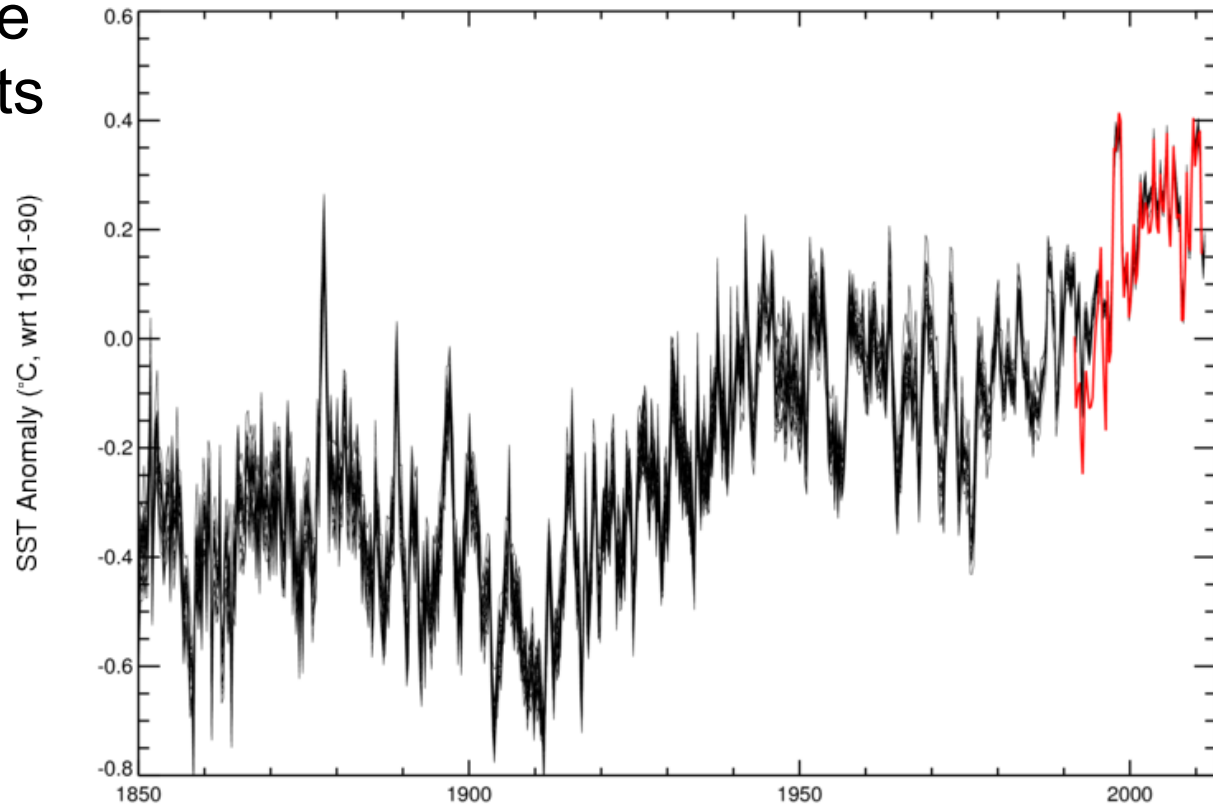
ARC – ATSR Reprocessing for Climate

- Based on Along-Track Scanning Radiometer series of instruments
- Almost independent of in situ measurements
- Shown to have biases of $<0.1\text{K}$
- And drifts of $<0.1\text{K}$ decade
- Very good random errors also.
- Agrees with in situ record within (much larger) uncertainties of in situ record.



Constrain *in situ* (black) using ARC ATSR (red)

- Spread of ensemble members represents spread from bias uncertainty
- Narrow in ARC period
- Spread widens in pre-ARC period
- Range $\sim 0.2\text{K}$



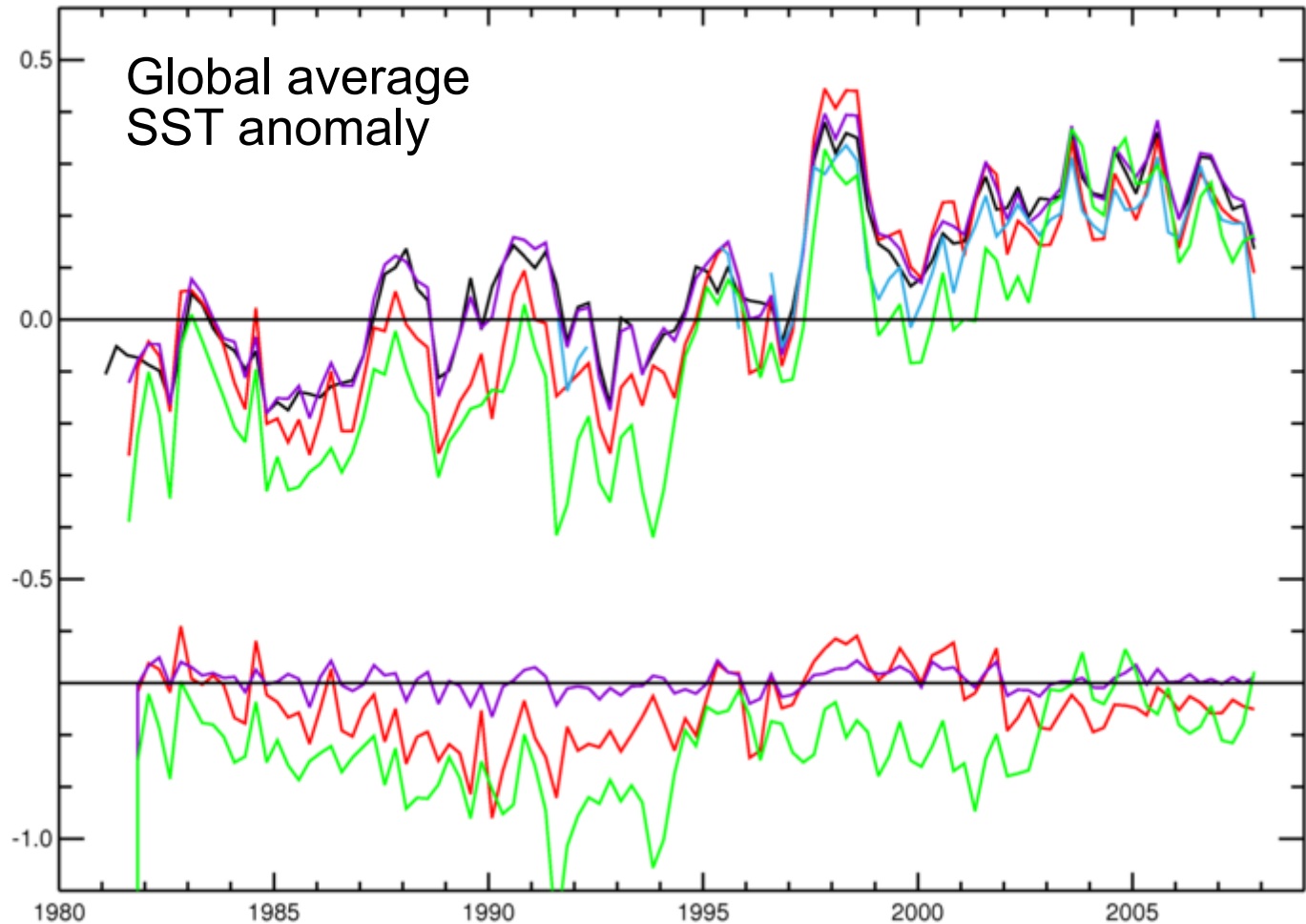
AVHRR – two step adjustment

HadSST3

AVHRR raw

AVHRR aerosol
and time of day

AVHRR final

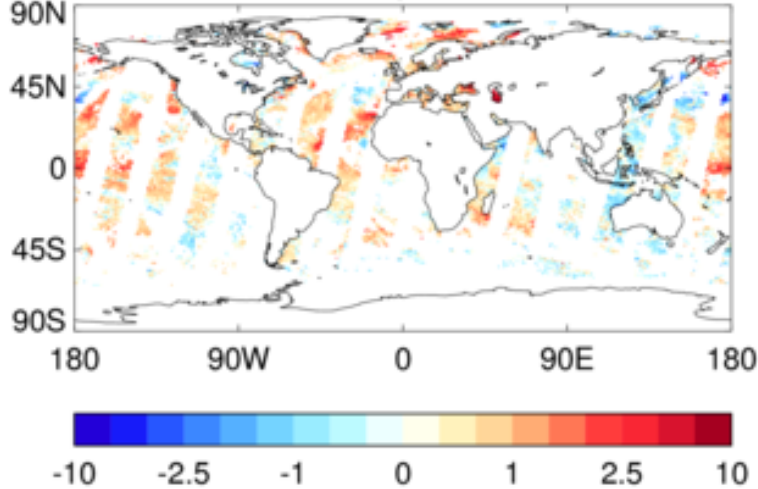




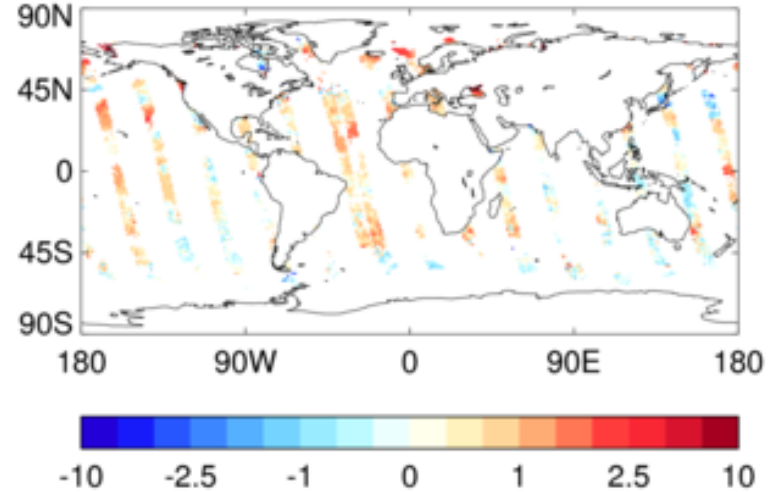
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Blending satellites - daily

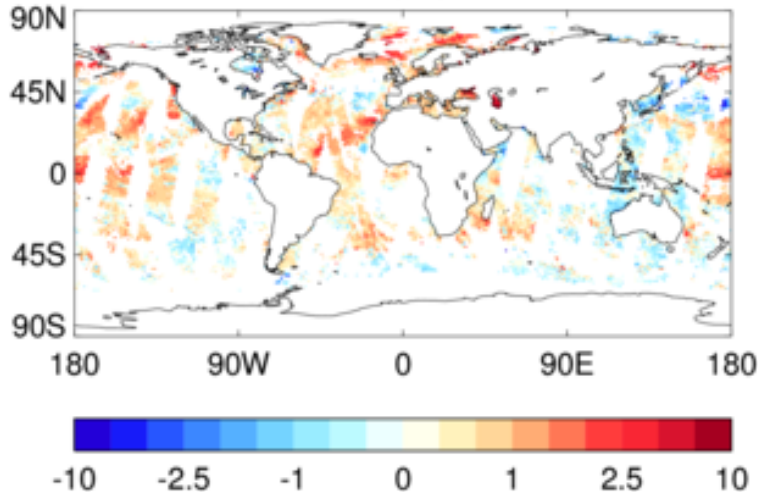
AVHRR 2 September 2004



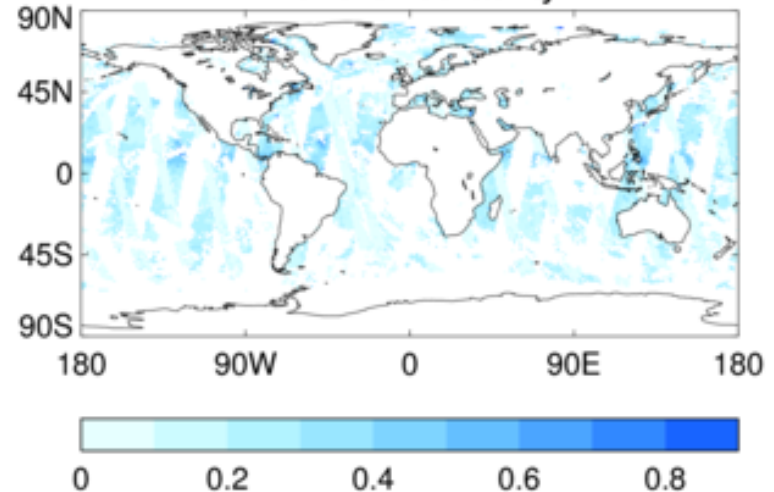
ATSR



Blend



Blend Uncertainty

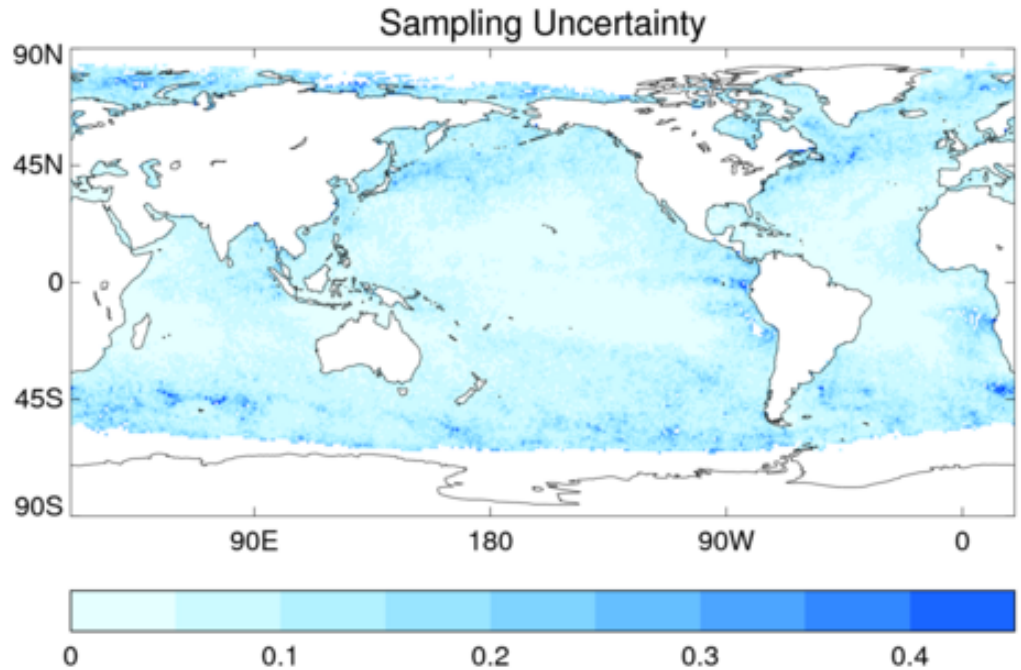
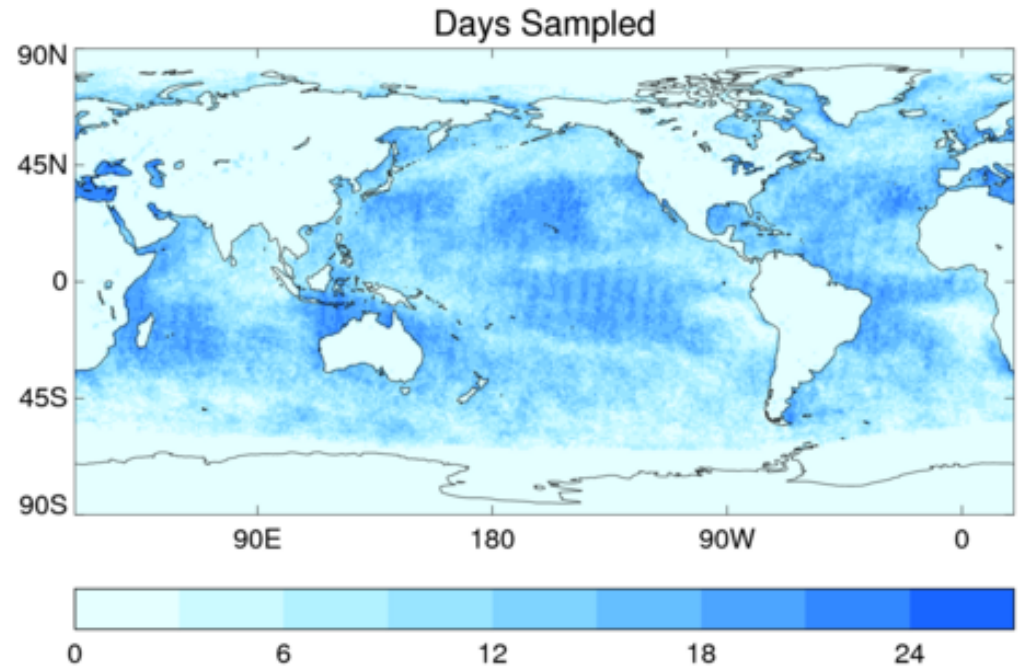


Sampling Uncertainty for Monthly averages

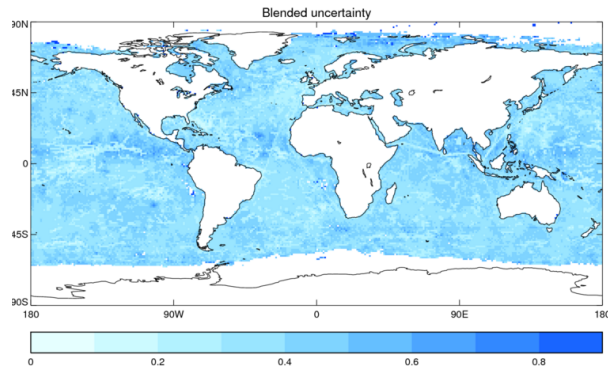
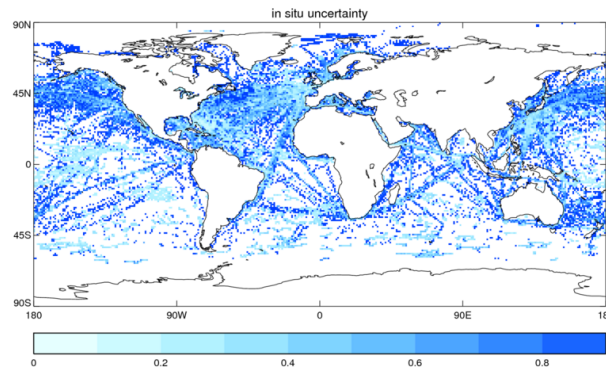
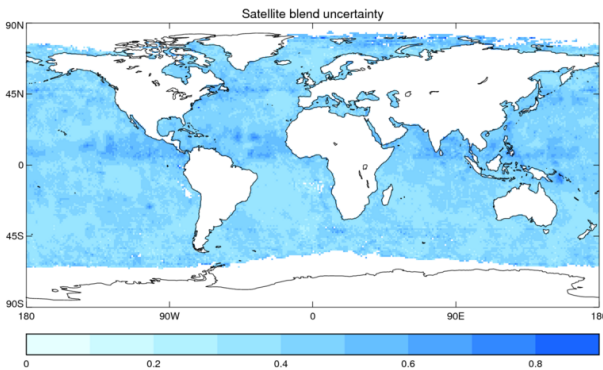
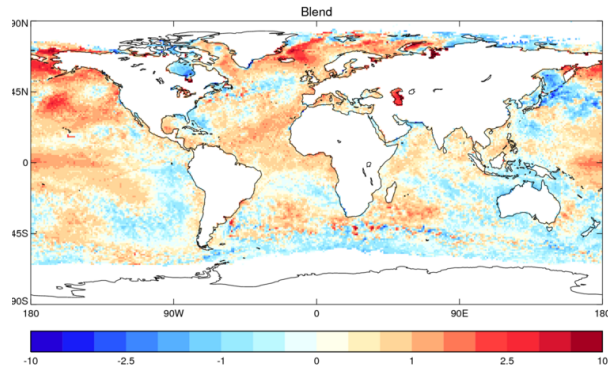
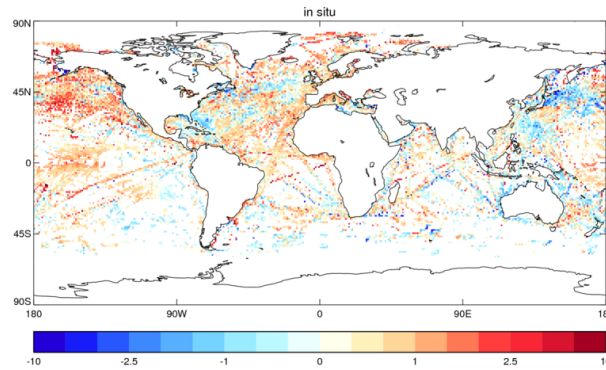
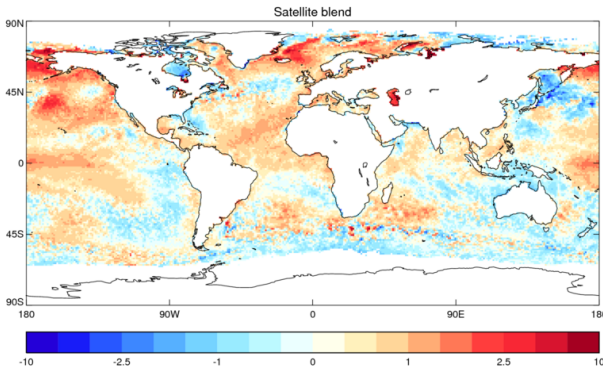
Satellite sampling is non-random

Good sampling along narrow swaths

Swaths sampled infrequently in places



Blending satellite and in situ - monthly



SATELLITE

IN SITU

BLEND

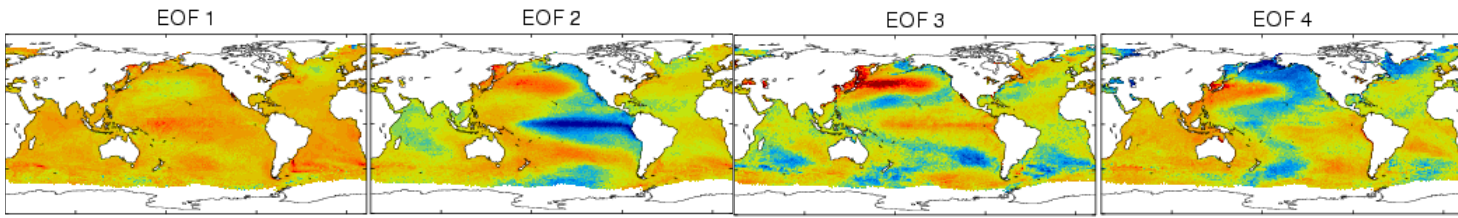
2-Step Reconstruction Technique

1. Variational Bayesian Principal Component Analysis VBPCA

- EOF-based
- Iterative
- Uses all available data
- Provides consistent reconstruction and EOFs

- Large-scale reconstruction

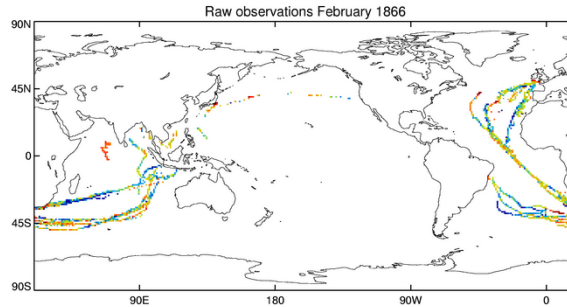
A. Ilin and A. Kaplan. Bayesian PCA for Reconstruction of Historical Sea Surface Temperatures. In Proc. of the Int. Joint Conf. on Neural Networks (IJCNN 2009), pp. 1322-1327, Atlanta, USA, 2009.



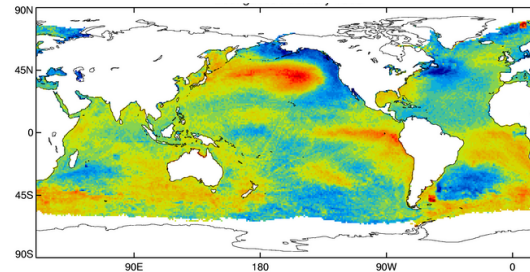
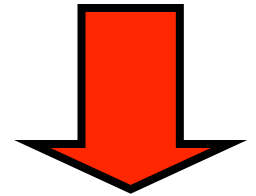
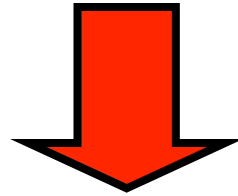
GUESS
EOFS

project on to

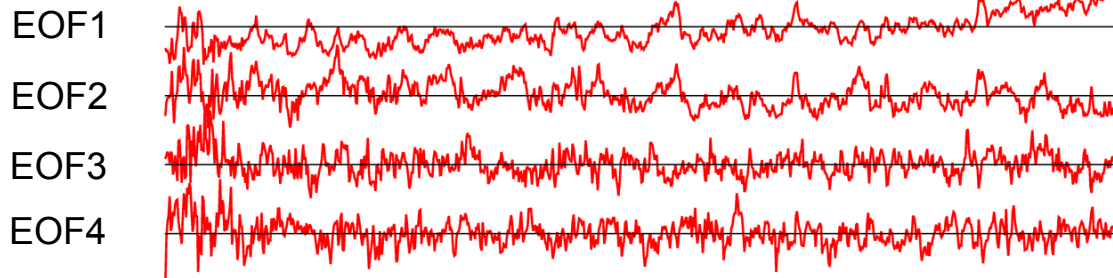
OBSERVATIONS



AT EACH TIME STEP



BROAD-SCALE
RECONSTRUCTION

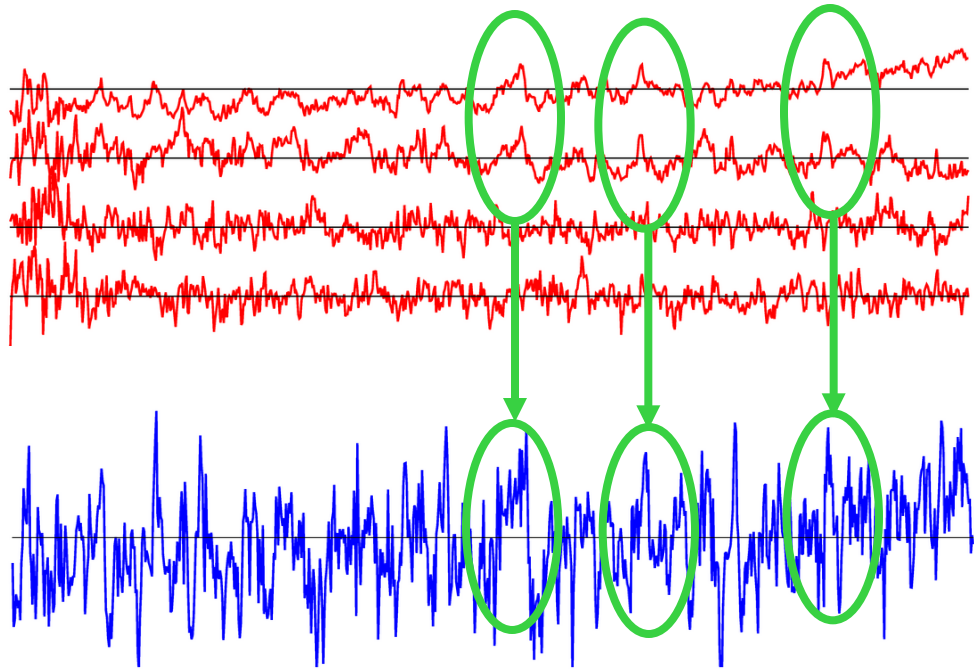


&

time series of
weights of EOFs

Bayesian PCA

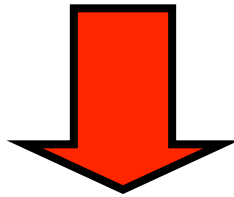
EOF1
EOF2
EOF3
EOF4



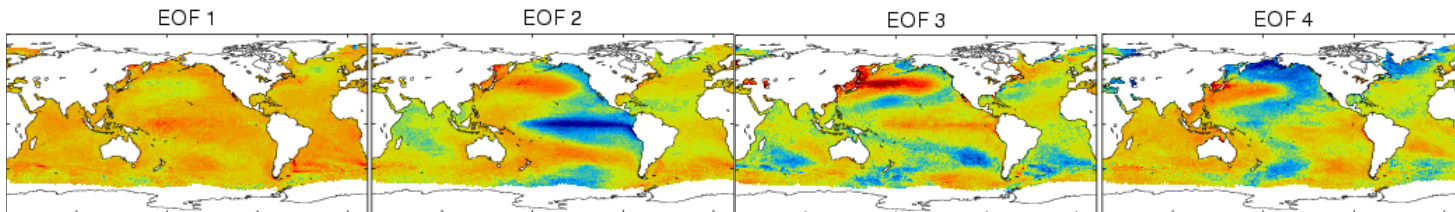
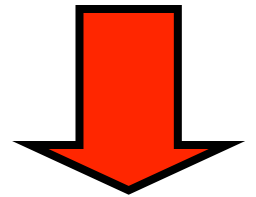
Weights
of EOFs

project on to

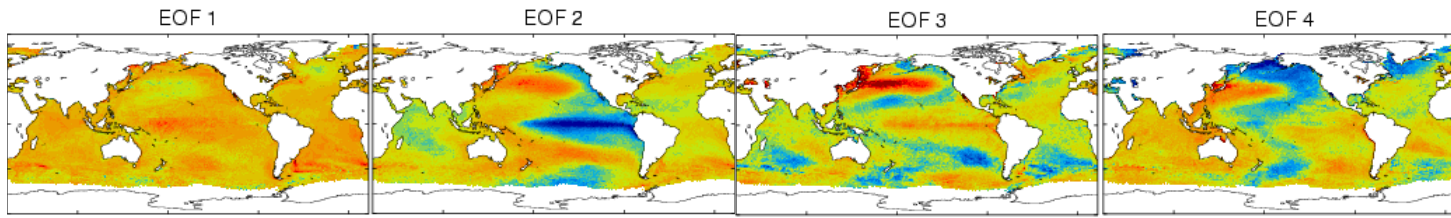
OBS



AT EACH LOCATION



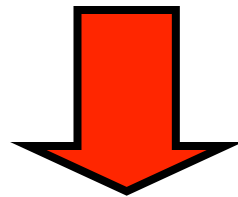
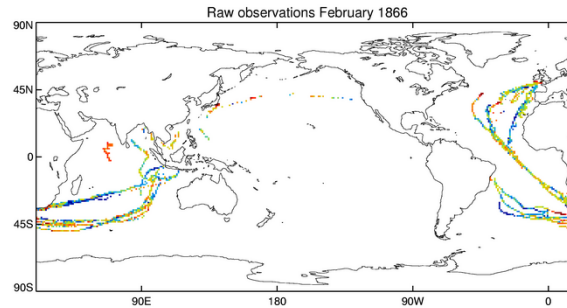
NEW
EOFs



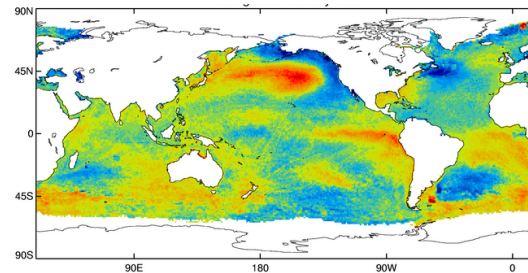
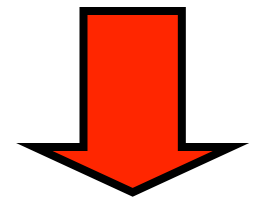
**NEW
EOFS**

project on to

OBSERVATIONS



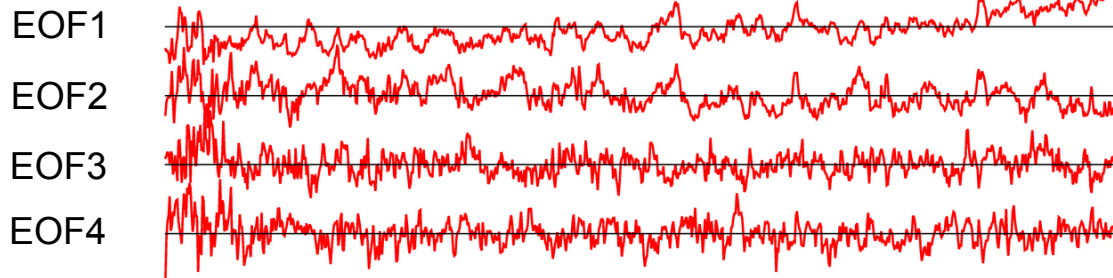
AT EACH TIME STEP



**BROAD-SCALE
RECONSTRUCTION**

&

time series of
weights of EOFs



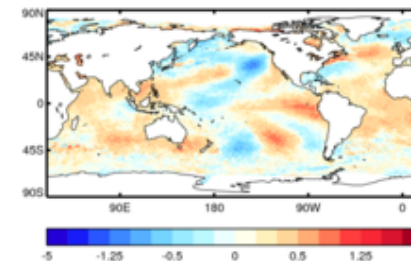
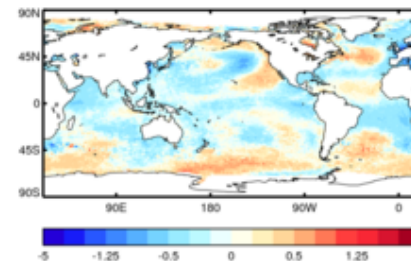
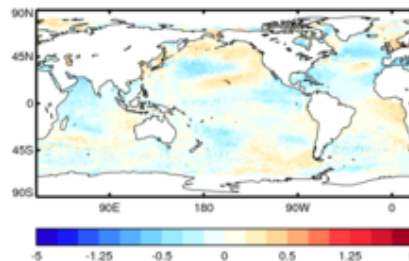
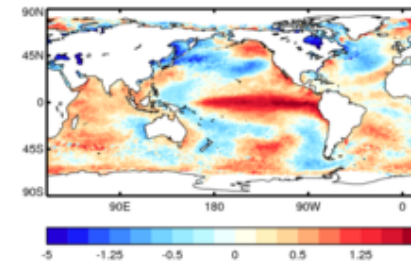
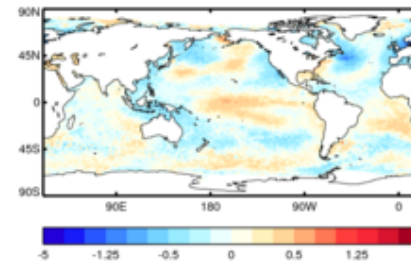
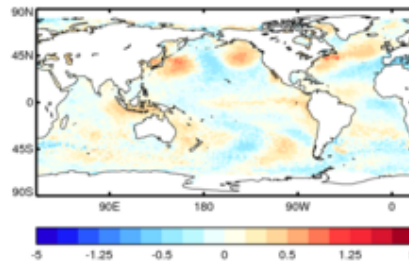
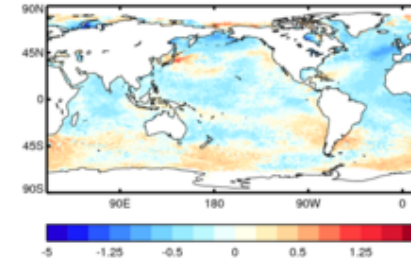
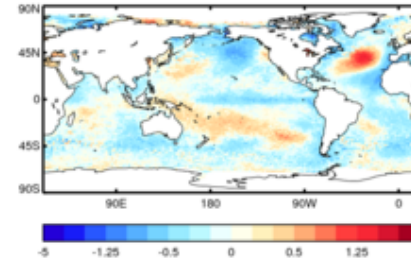
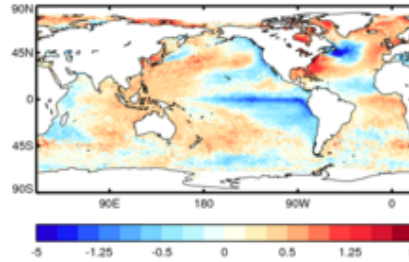
Bayesian PCA

EOFs

EOFs taken from
estimated
covariance matrix

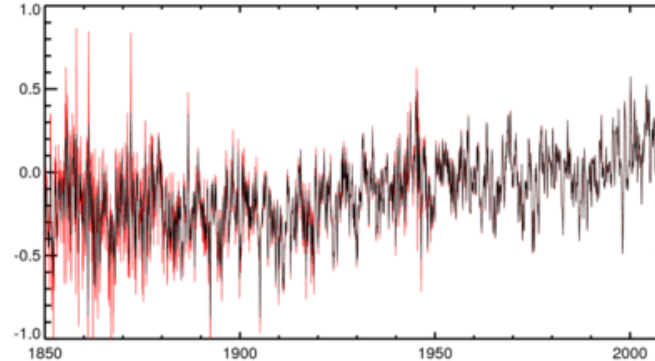
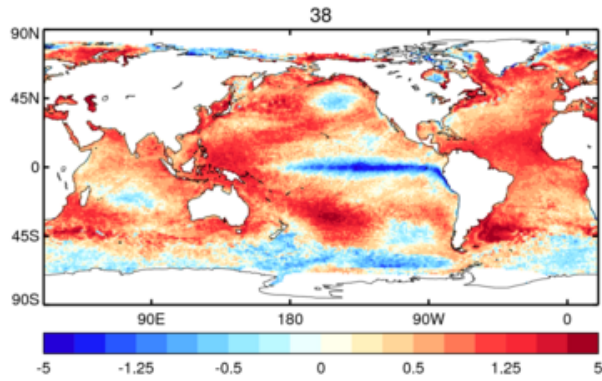
Number of EOFs
used is an input to
the algorithm

Use between 45
and 55 EOFs



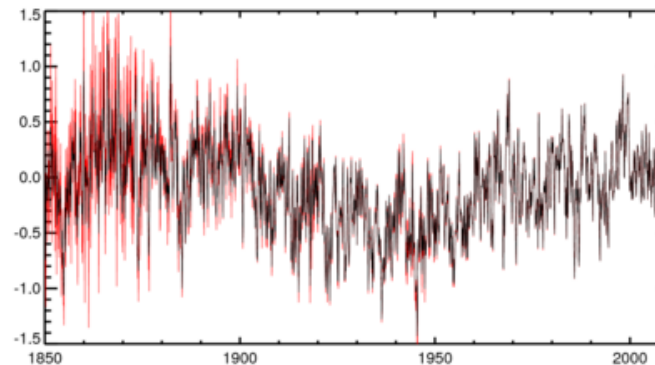
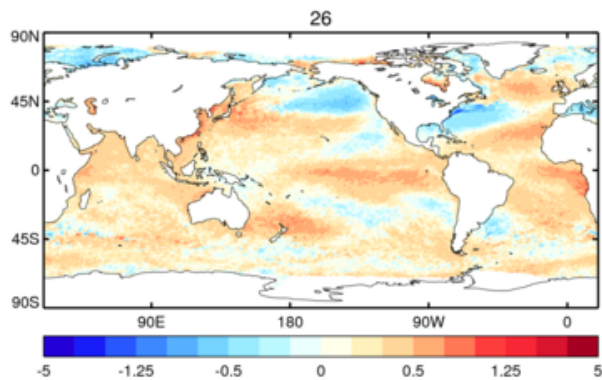
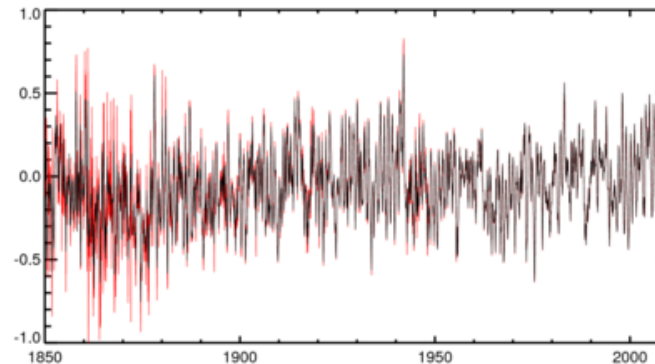
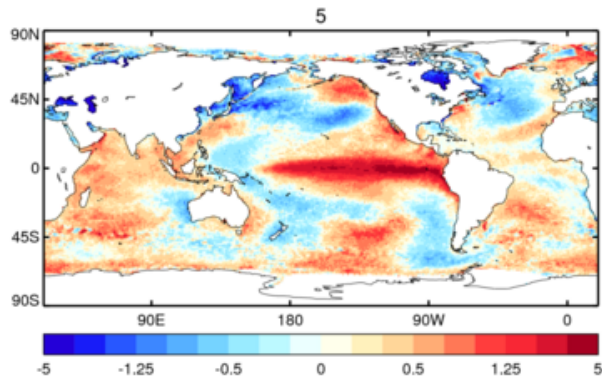
EOF

Principal Component



Red – RAW PC

Black - Smoothed

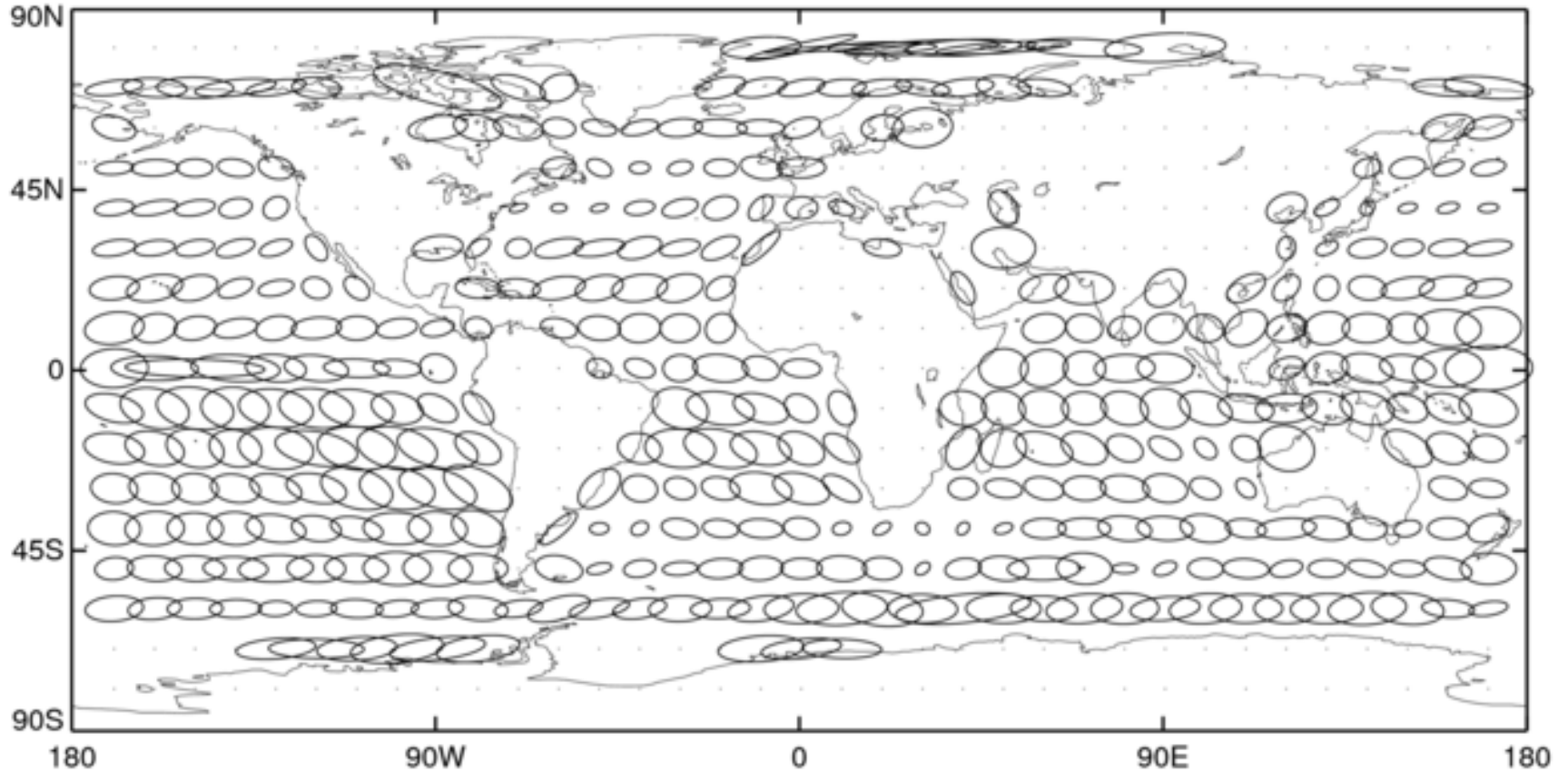


2. Local Optimal Interpolation

- Use local OI
- Length scale and angle vary with location
- Covariances based on Karspeck et al. 2012

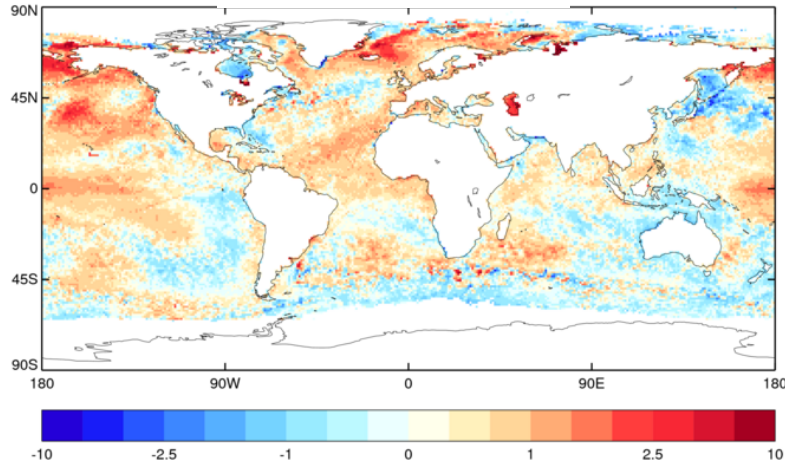
Karspeck, A. R., Kaplan, A. and Sain, S. R. (2012), Bayesian modelling and ensemble reconstruction of mid-scale spatial variability in North Atlantic sea-surface temperatures for 1850–2008. *Q.J.R. Meteorol. Soc.*, 138: 234–248. doi: 10.1002/qj.900

Non-stationary local covariances

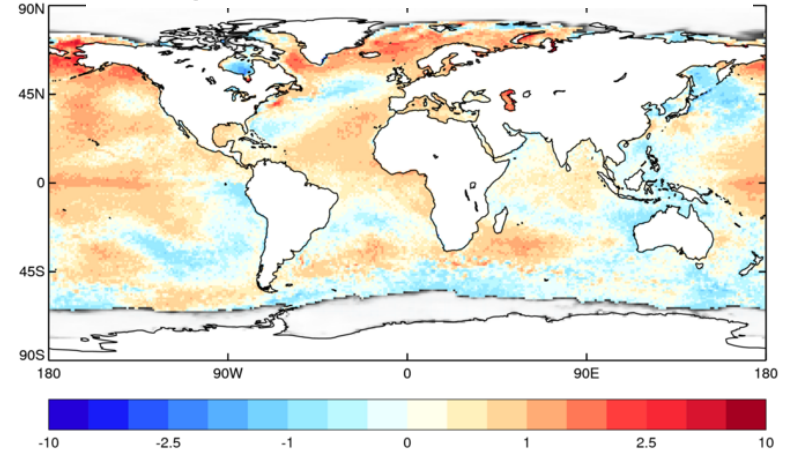


Multi step reconstruction, Sept 2004

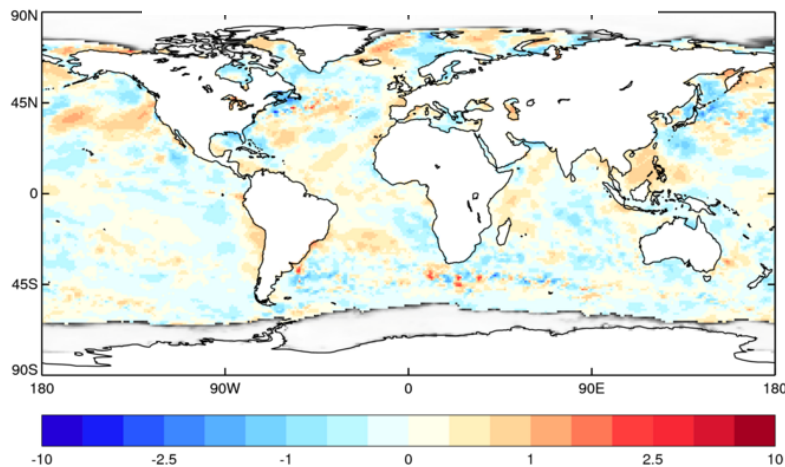
Observations



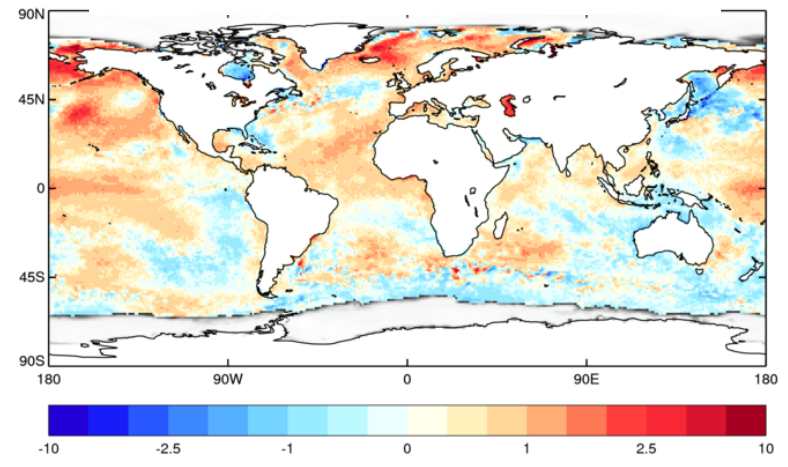
Large-scale reconstruction



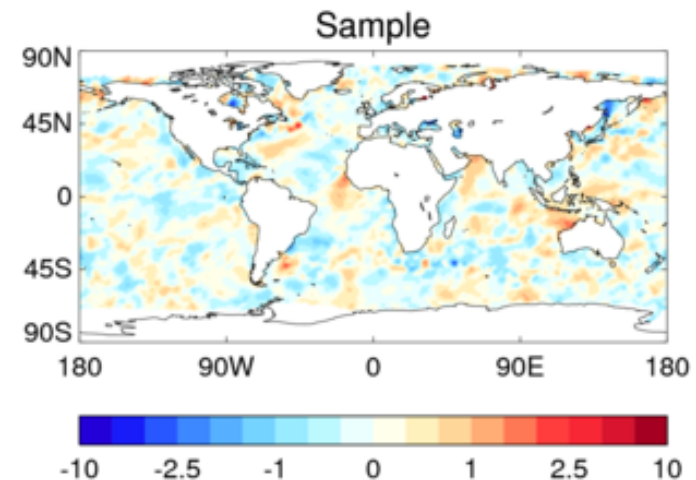
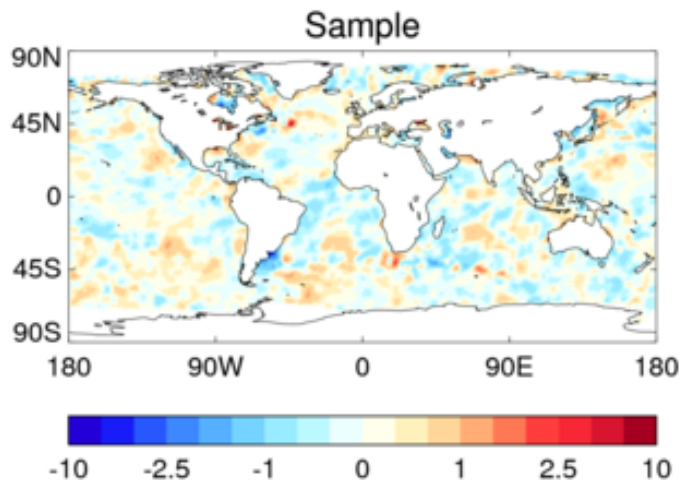
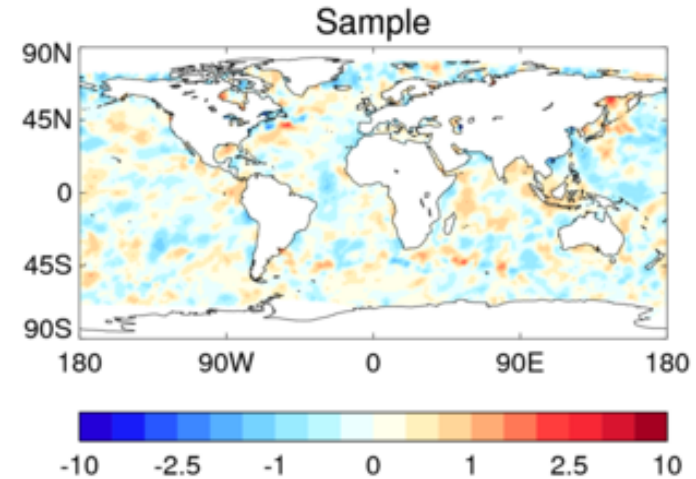
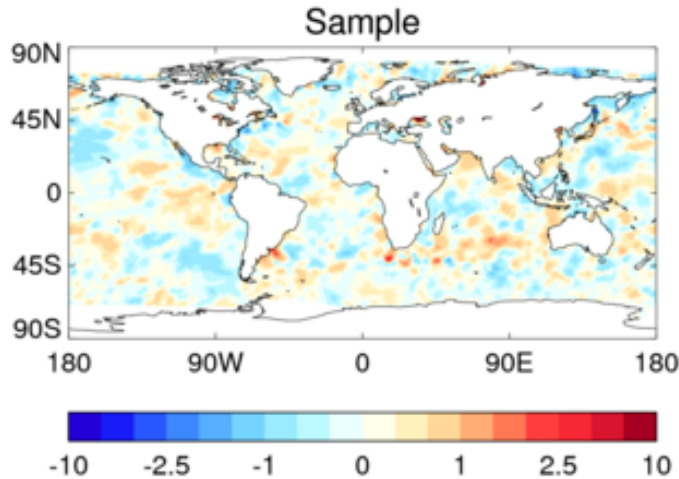
Local reconstruction

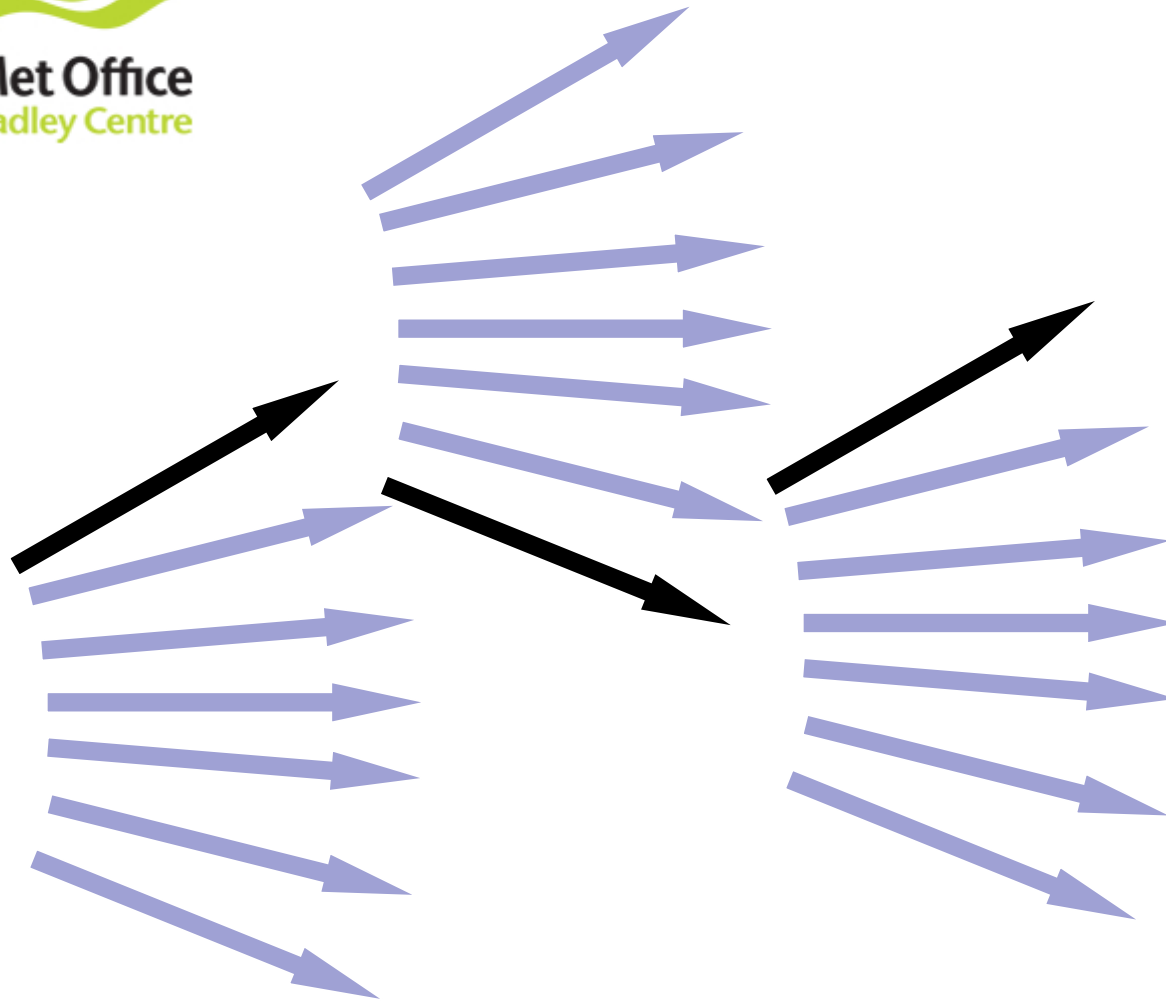


Combined reconstruction



Final step – add local variability in data sparse regions





Pick 10 such random paths to span the total uncertainty in the analysis and provide an ensemble of interchangeable versions of HadISST2

Bias adjustment

Broad-scale reconstruction

Local OI of residuals



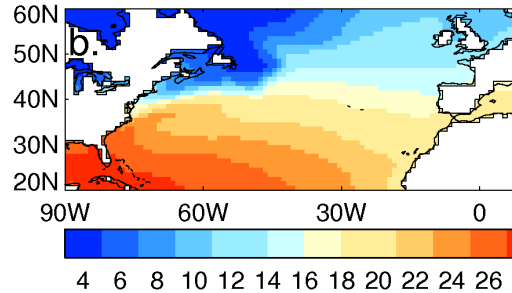
Global Completion

Increased resolution climatology

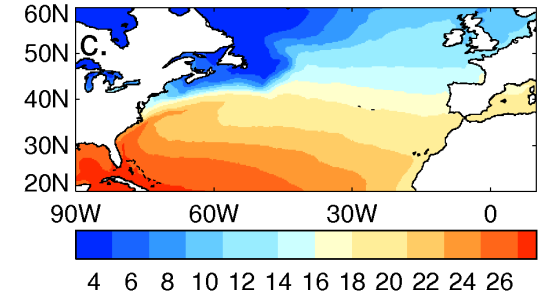
based on Reynolds OI

- Daily
- 0.25 degree resolution
- Adjusted to 1961-1990

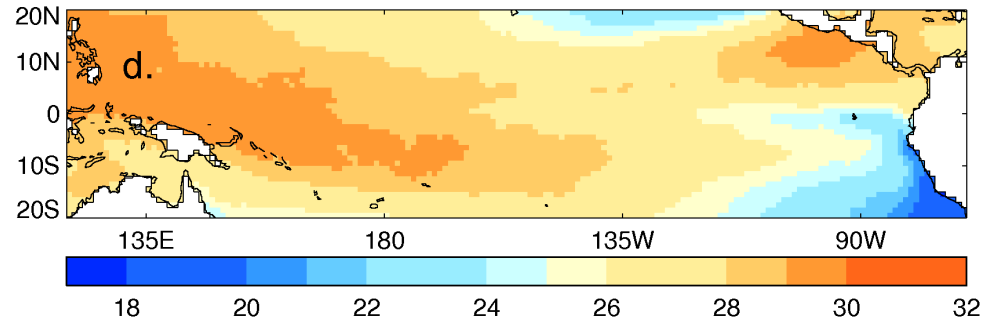
HadISST1



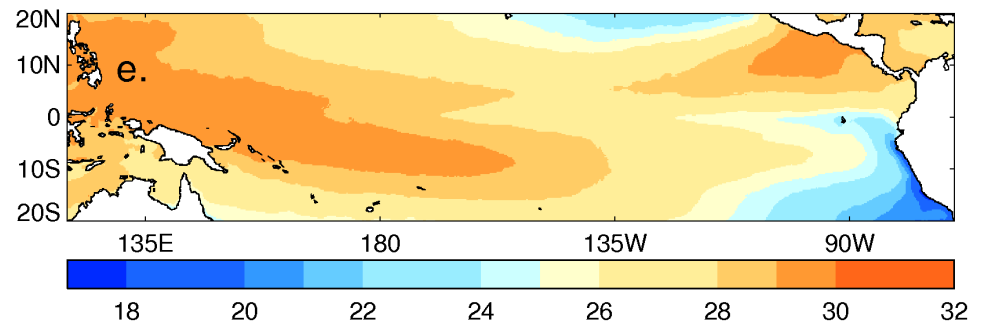
HadISST2



HadISST1



HadISST2



Marginal Ice Zone SST and sea ice concentration

Spatially and monthly varying relationships developed between SST and sea ice concentration in partially ice covered grid boxes

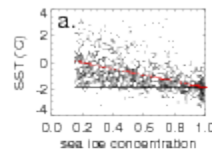
Used to specify the SST

21° longitude region centred on 0.5°E

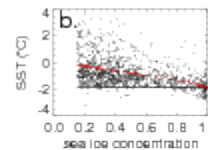
Arctic

Antarctic

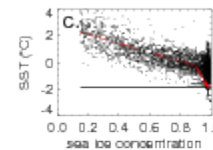
Jan



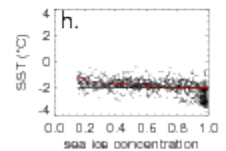
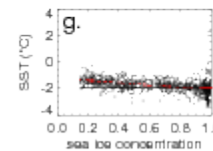
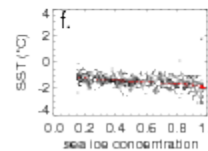
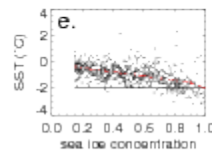
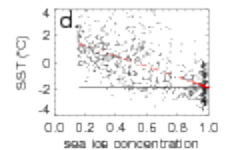
April



July



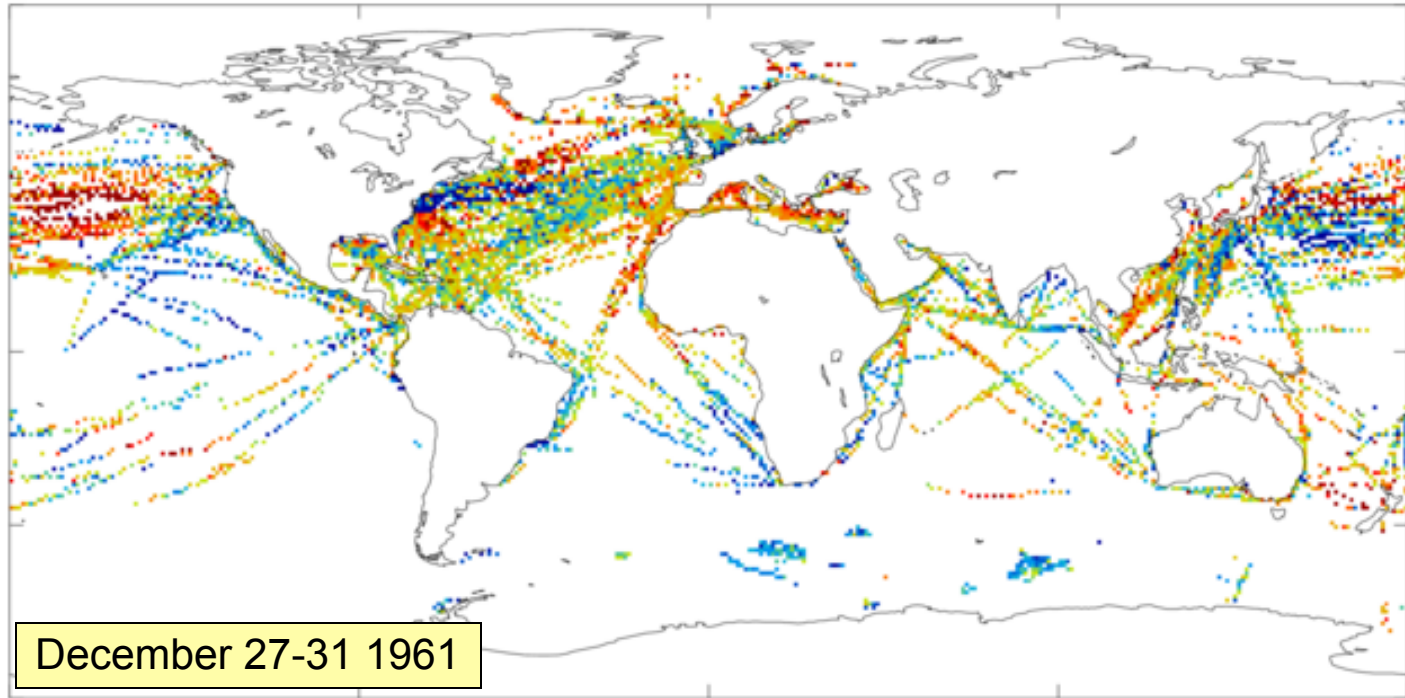
Oct



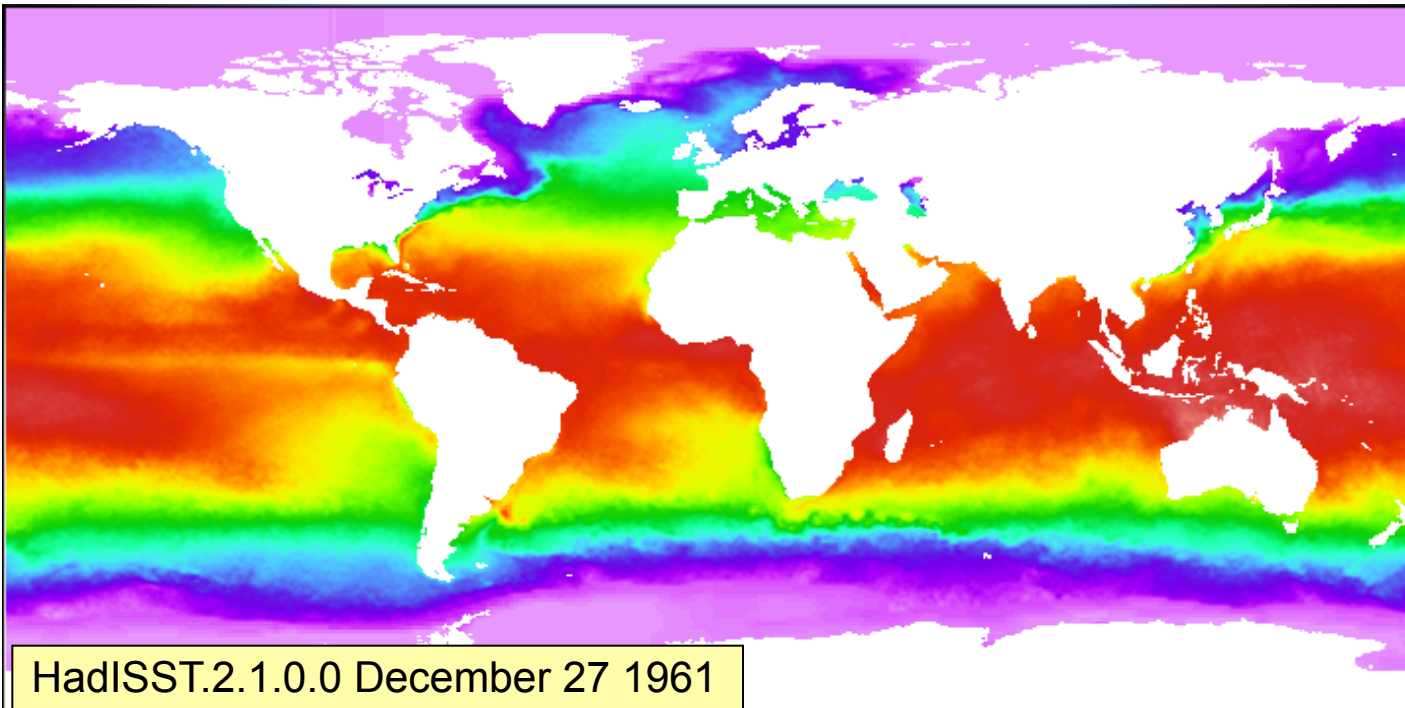
Global completion

- Trim SST reconstruction back from ice edge
- Add Marginal Ice Zone Temperature
- Fill gap using Laplacian of the climatology

This is what we had

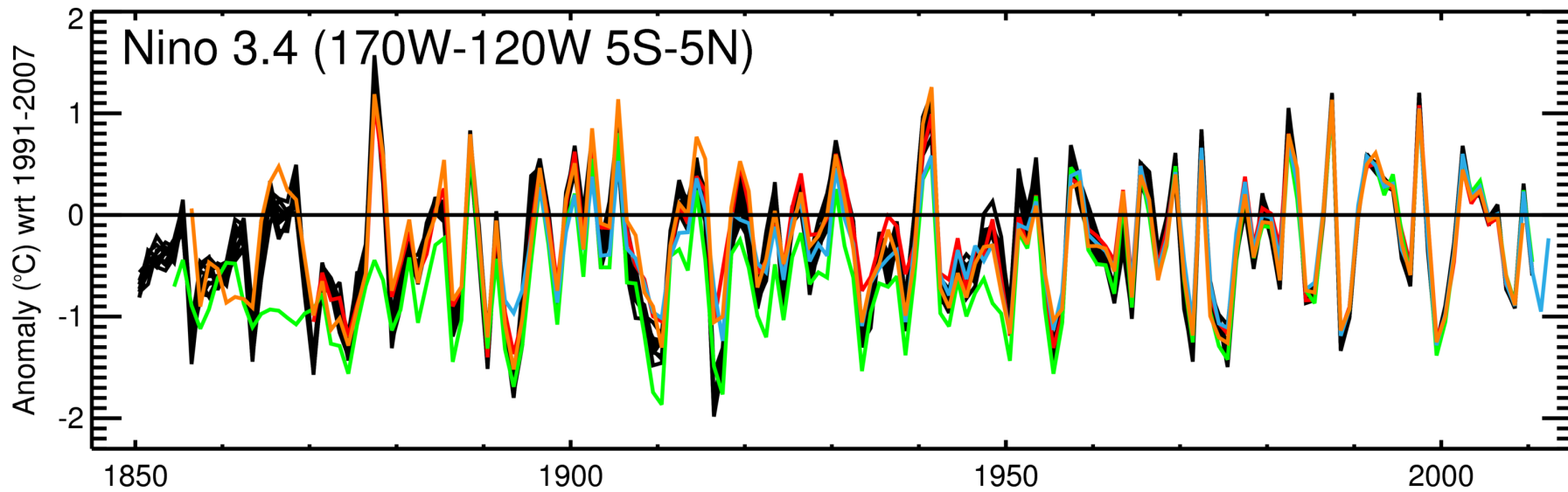
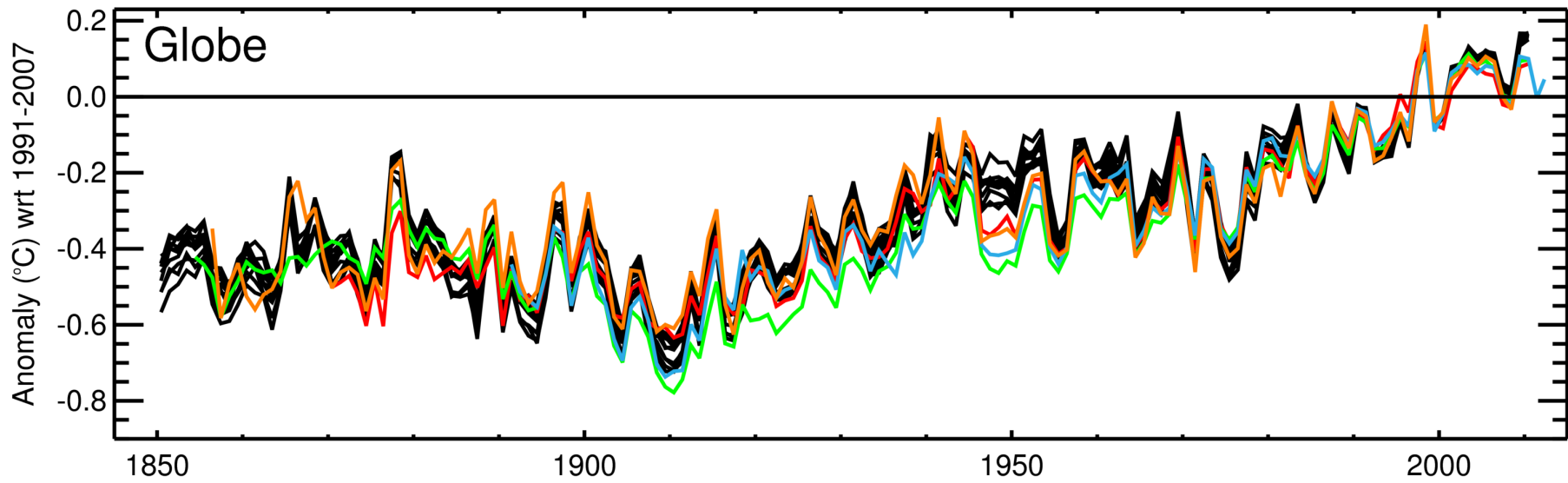


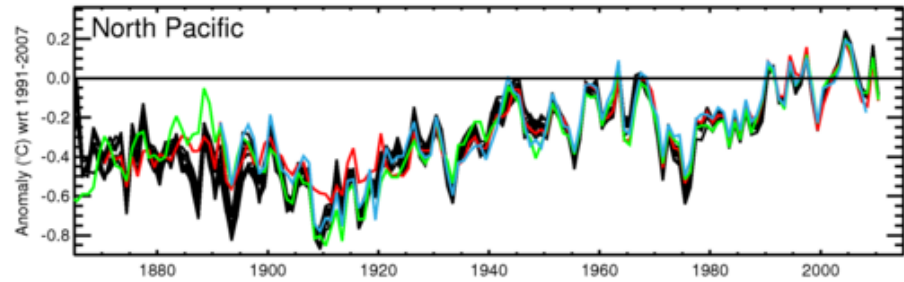
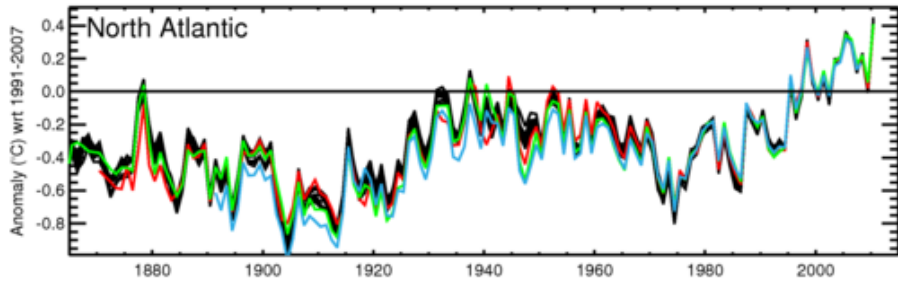
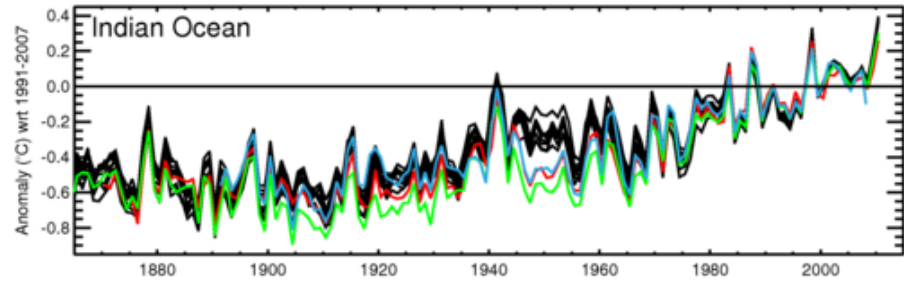
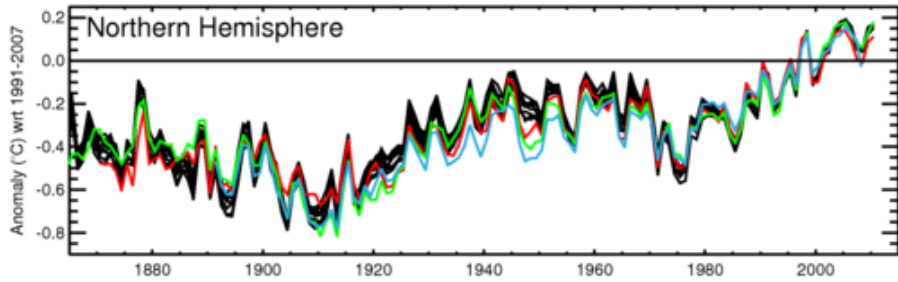
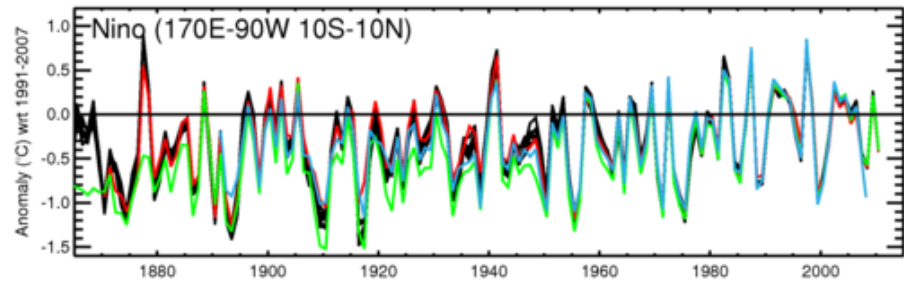
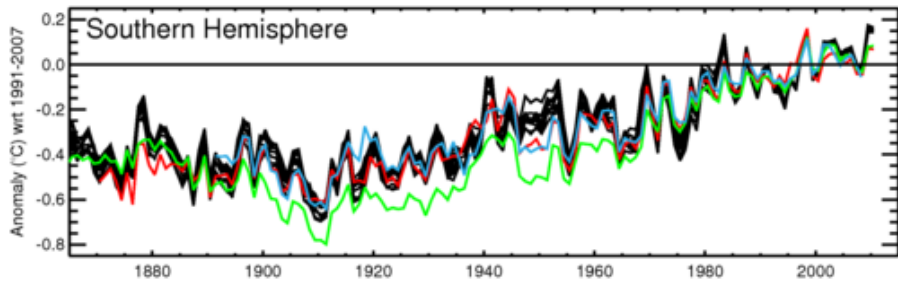
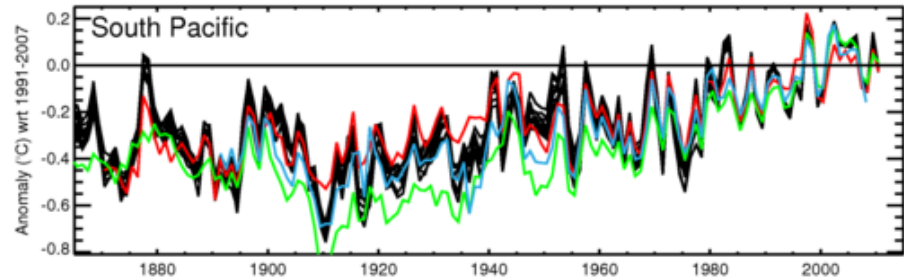
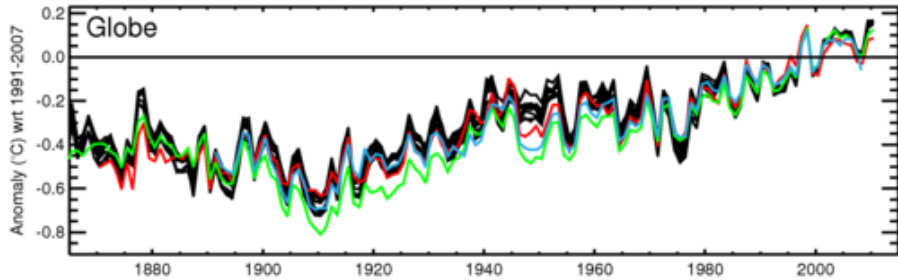
This is what we get



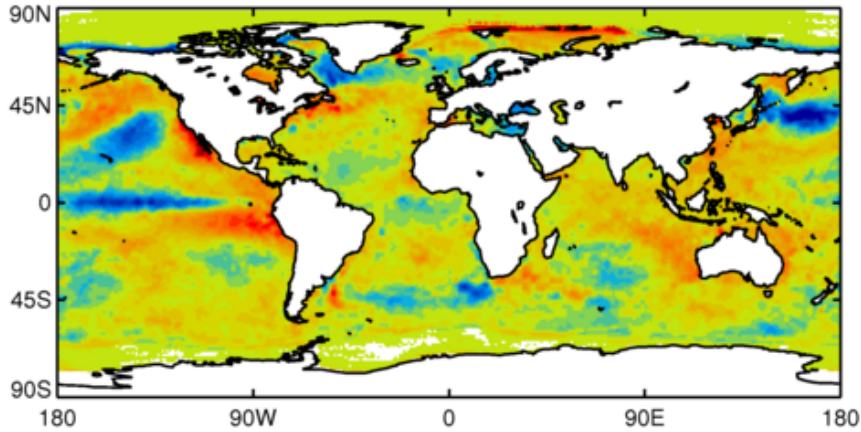


Results

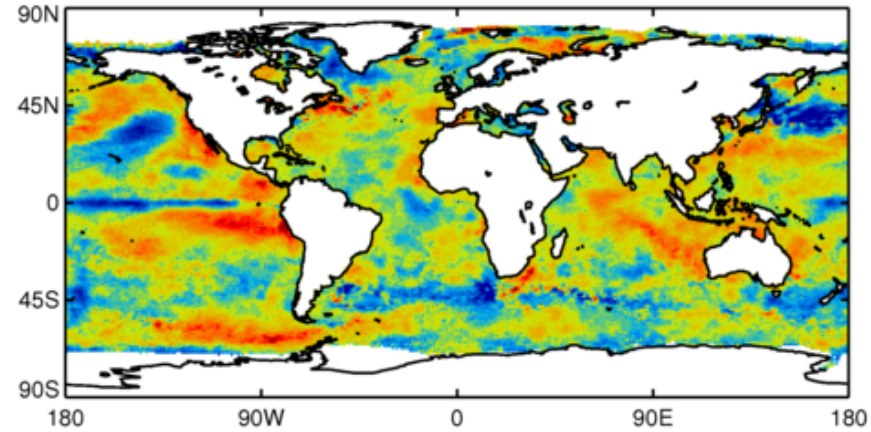




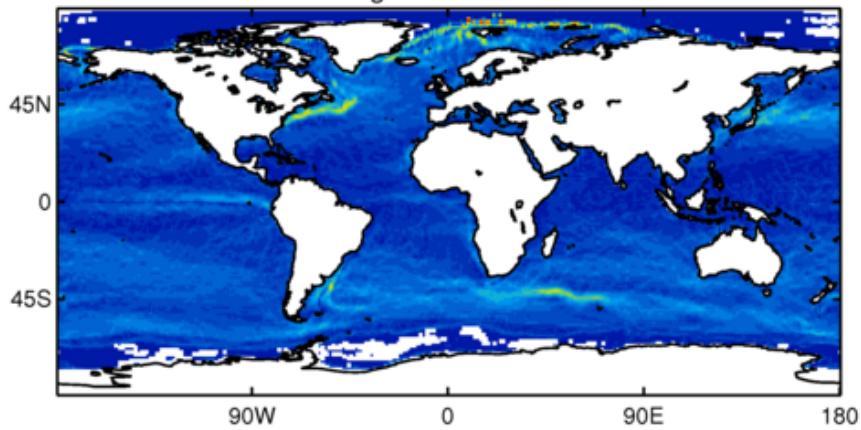
HadISST1 anomalies October 1983



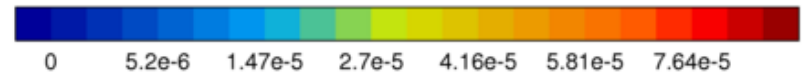
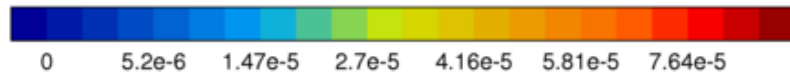
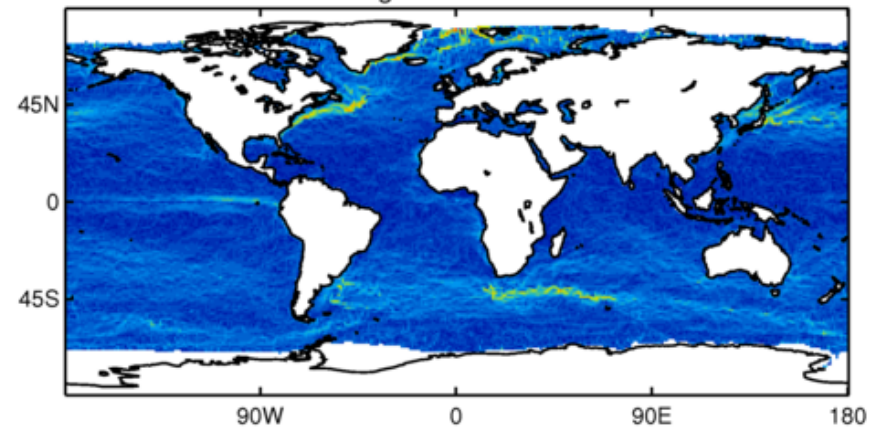
HadISST2 anomalies October 1983



HadISST1 gradients October 1983

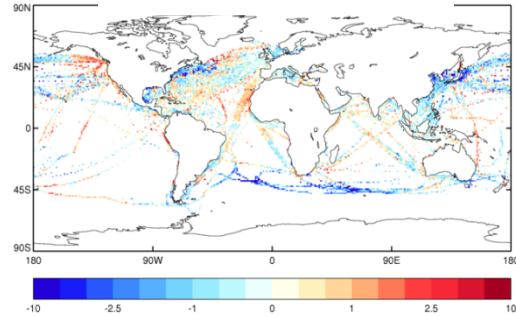


HadISST2 gradients October 1983

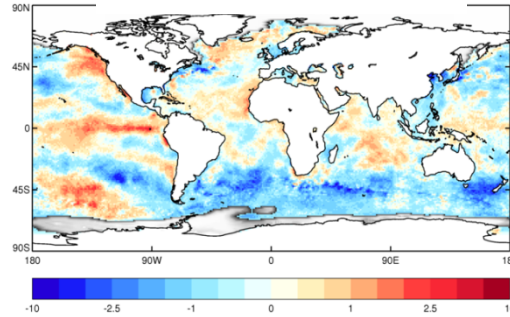


SST anomaly ensemble, January 1926

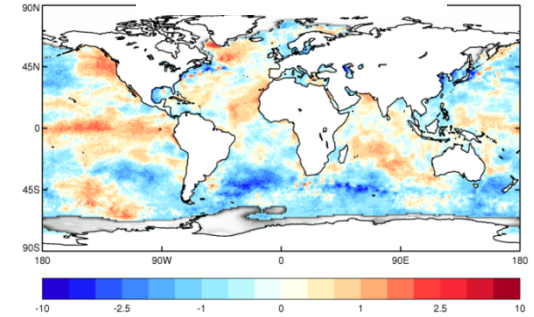
Observations



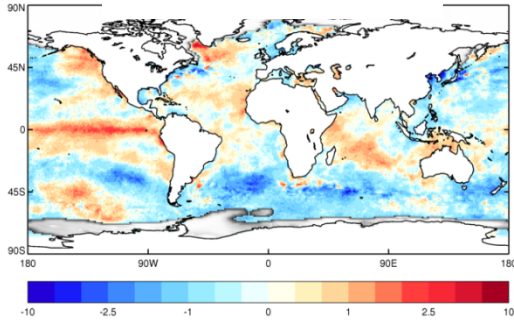
Member 1466



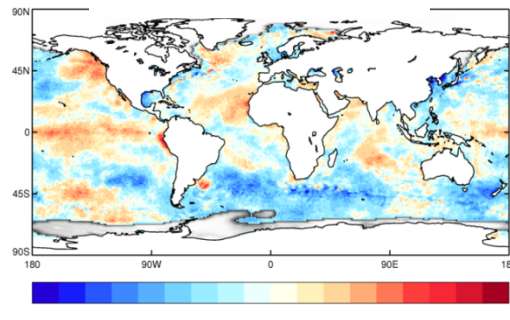
Member 69



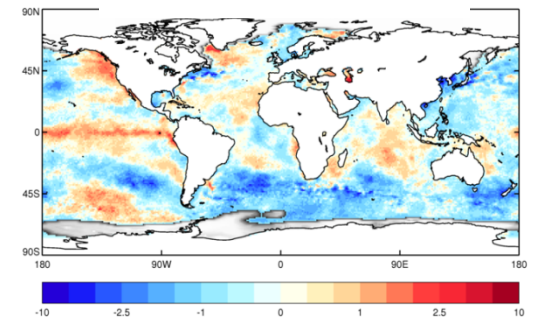
Member 137



Member 396

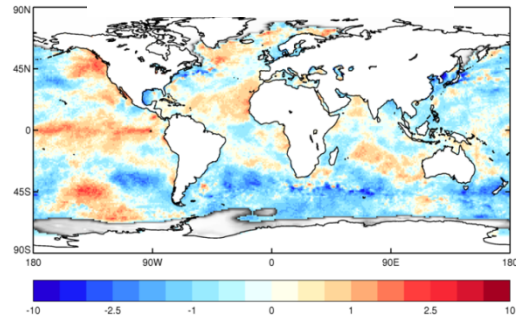


Member 1346

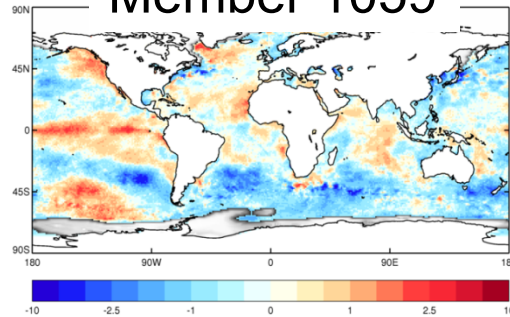


-10 -2.5 -1 0 1 2.5 10

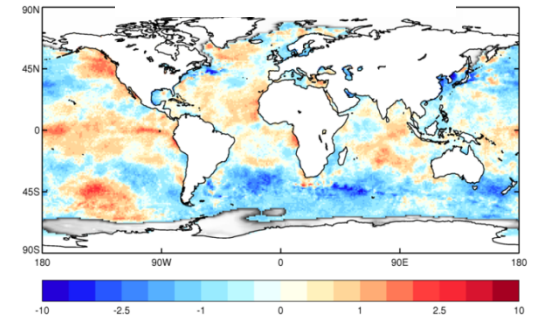
Member 1194



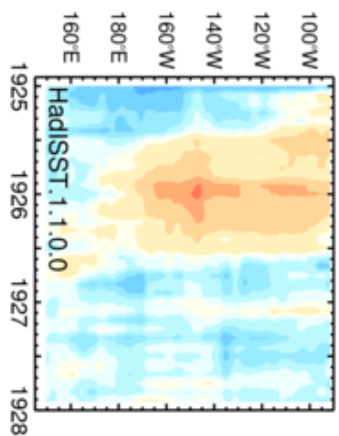
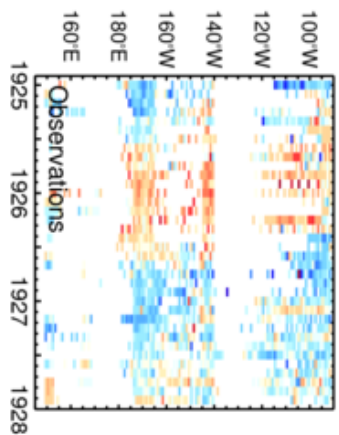
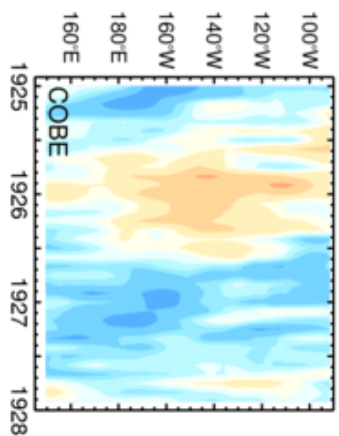
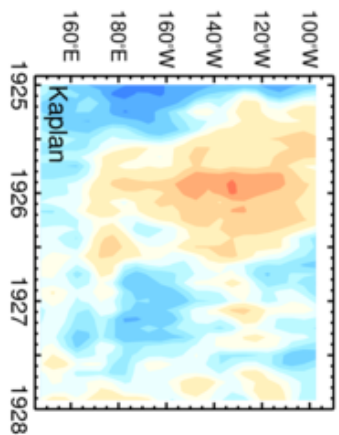
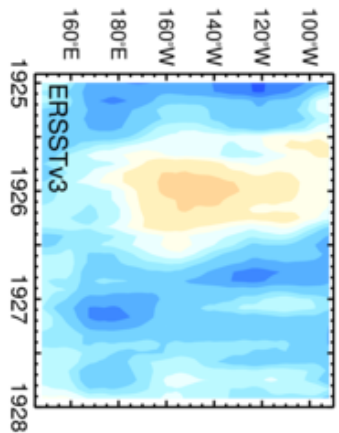
Member 1059



Member 400



Based on Yasunaka et al. 2011

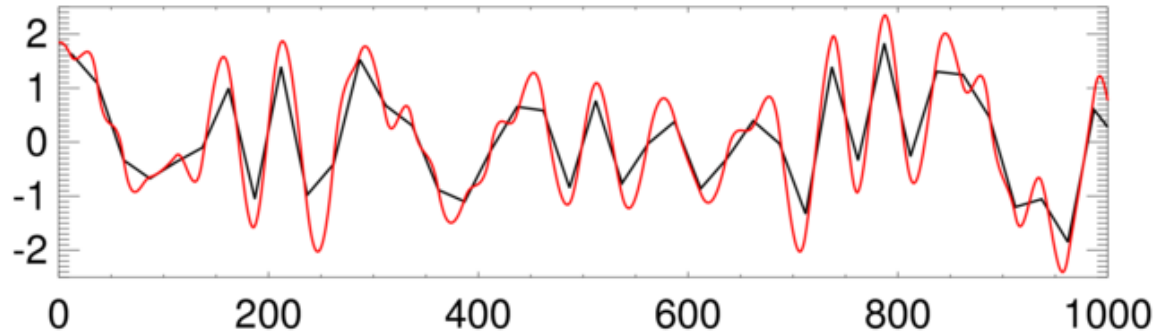


Tailoring for particular applications

ECMWF reanalysis

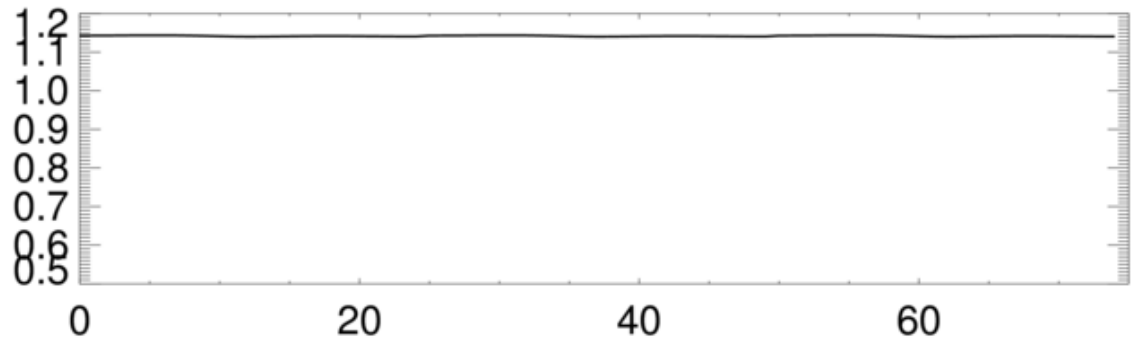
Interpolation to daily

Linear Interpolation
does not yield
consistent variance



Variance highest at
mid-month values

Cubic interpolation
can be tuned to give
consistent variance





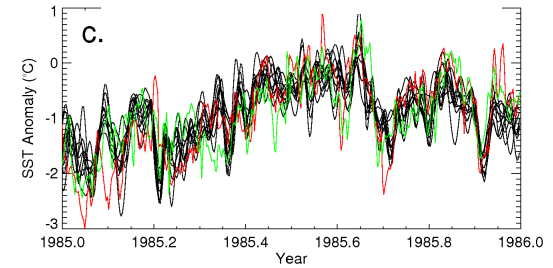
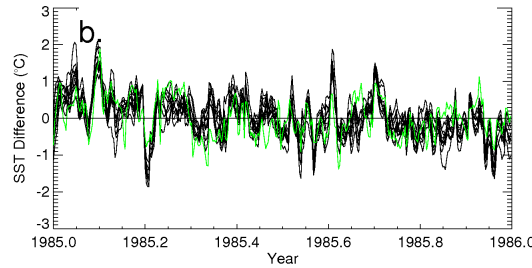
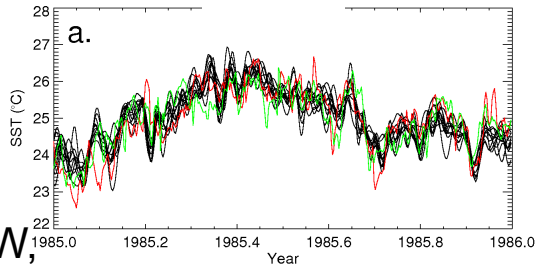
Met
Hadley

Comparison to daily analyses

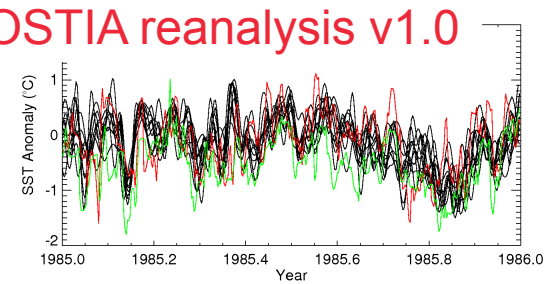
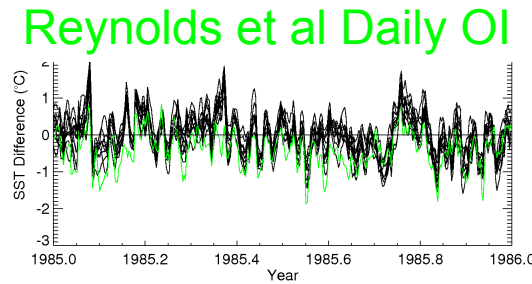
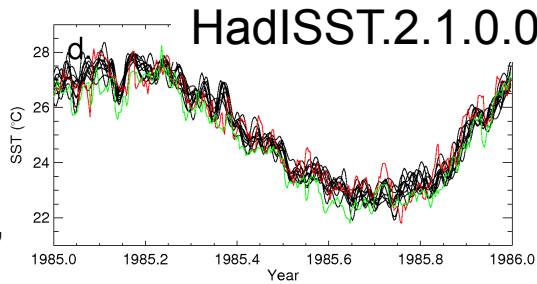
SST

SST differences

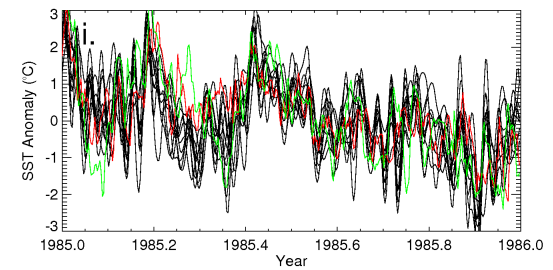
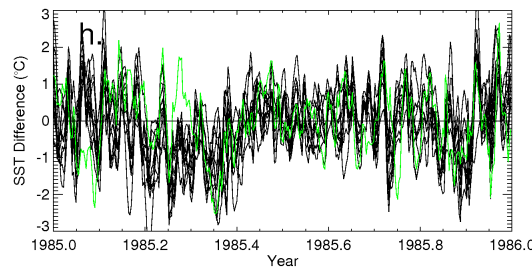
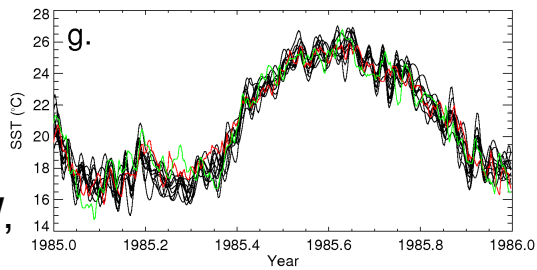
SST anomalies



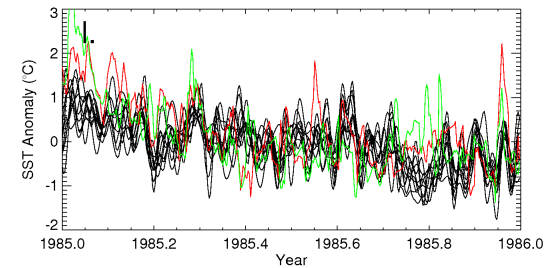
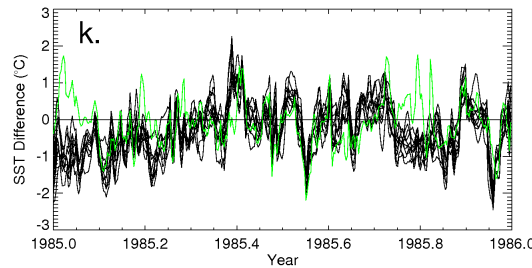
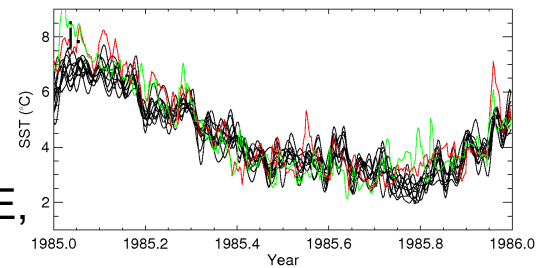
[139.125°W,
0.125°S]



[60.125°E,
20.125°S]



[59.775°W,
39.775°N]



[160.125°E,
55.125°S]



Summary



HadISST.2.1.0.0

- Improved source data
 - High accuracy, high stability ATSR data
 - Long, bias adjusted series from in situ data
 - Good coverage from AVHRR
- Two step reconstruction
 - Uses all available data
 - Allows representative samples to be drawn
- Ensemble approach
 - User has access to comprehensive uncertainties
- Frequent updates planned



Met Office
Hadley Centre



Questions! Answers?