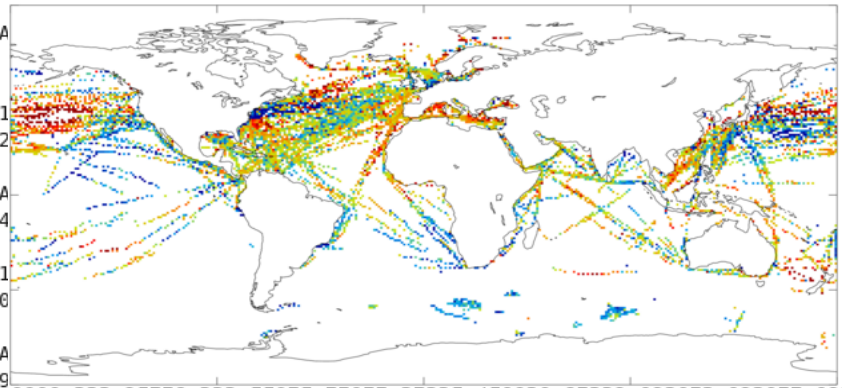
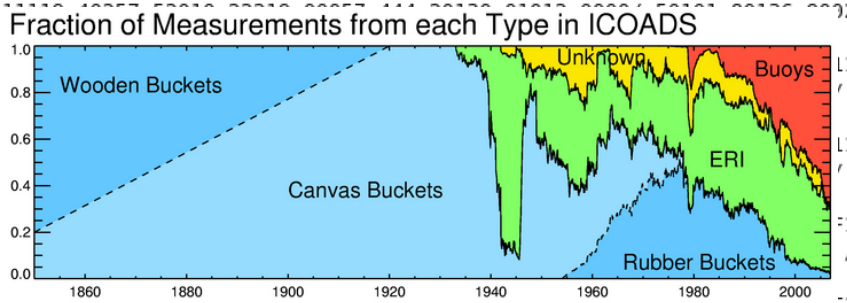
Met Office
Hadley Centre

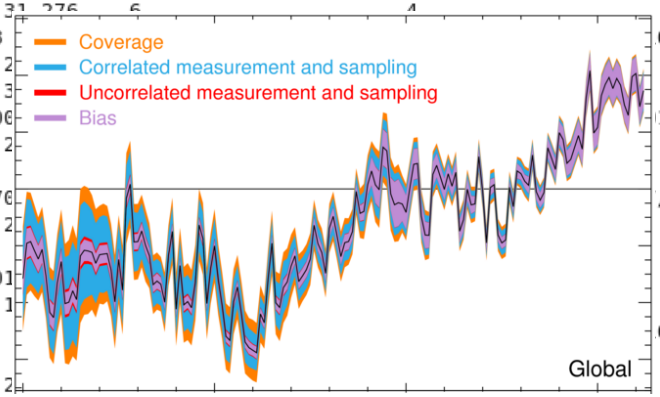
The Met Office Hadley Centre Sea Ice and Sea-surface Temperature Dataset, HadISST.2.2.0.0

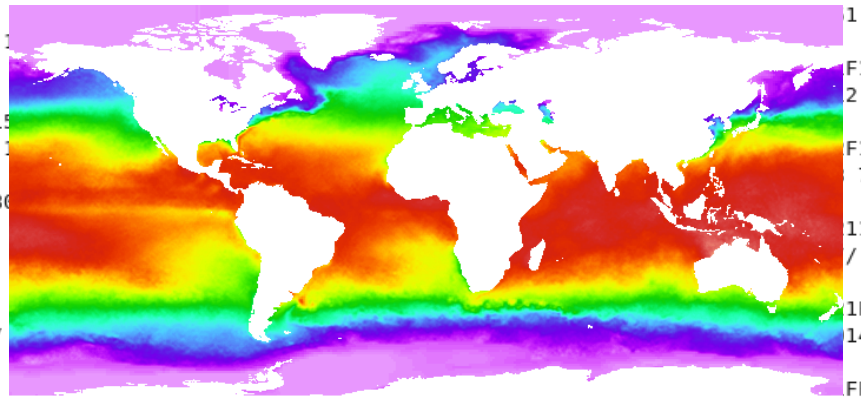
J.J. Kennedy, N.A. Rayner, C. Atkinson, H.A. Titchner

MARCDAT IV, Southampton, 20 July 2016




Fraction of Measurements from each Type in ICOADS
Wooden Buckets
Canvas Buckets
Unknown
Buoys
ERI
Rubber Buckets
1.0
0.8
0.6
0.4
0.2
0.0
1860
1880
1900
1920
1940
1960
1980
2000

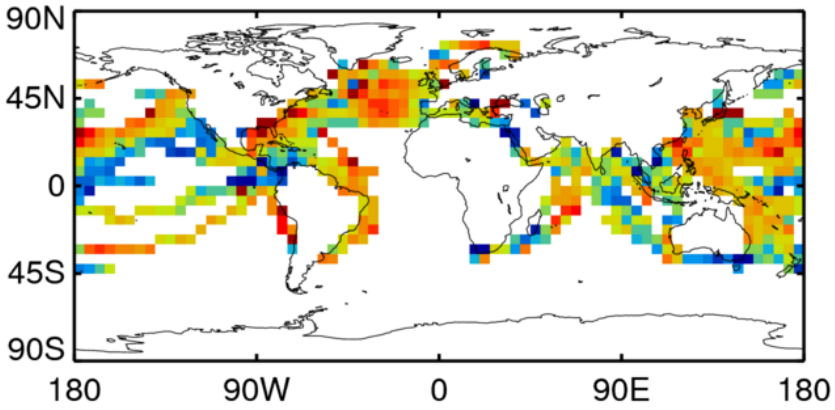

Coverage
Correlated measurement and sampling
Uncorrelated measurement and sampling
Bias
Global



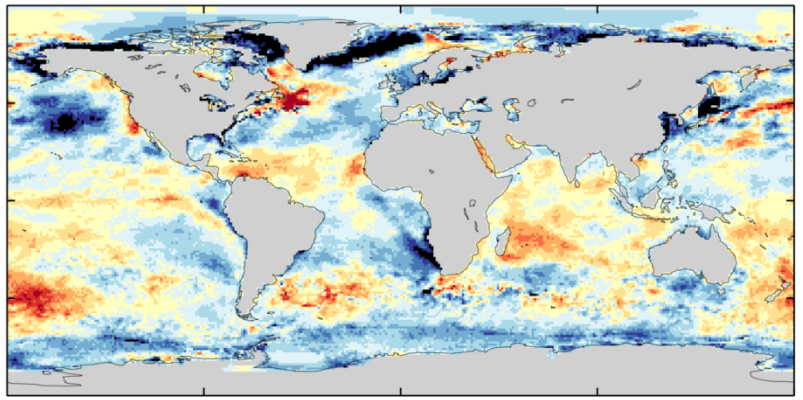
Consistent data sets across a range of applications

- **HadIOD** (Atkinson et al. 2014)
  - Integrated Ocean Database
  - Designed for assimilation into reanalysis
- **HadSST.3.2.0.0**
  - Lower resolution, missing data
  - Incorporates in situ data only
  - Fully bias adjusted, uncertainty estimates
  - Designed for monitoring long-term change
  - Incorporated in HadCRUT4, used in Detection and Attribution
- **HadISST.2.2.0.0**
  - High-resolution, globally complete analysis
  - Incorporates in situ and satellite data
  - Designed for forcing Reanalysis, Atmospheric-only runs
  - Turns out to be useful for a wide range of applications

HadSST.X.X.X.X



HadISST.2.2.0.0



HadISST.2.2.0.0

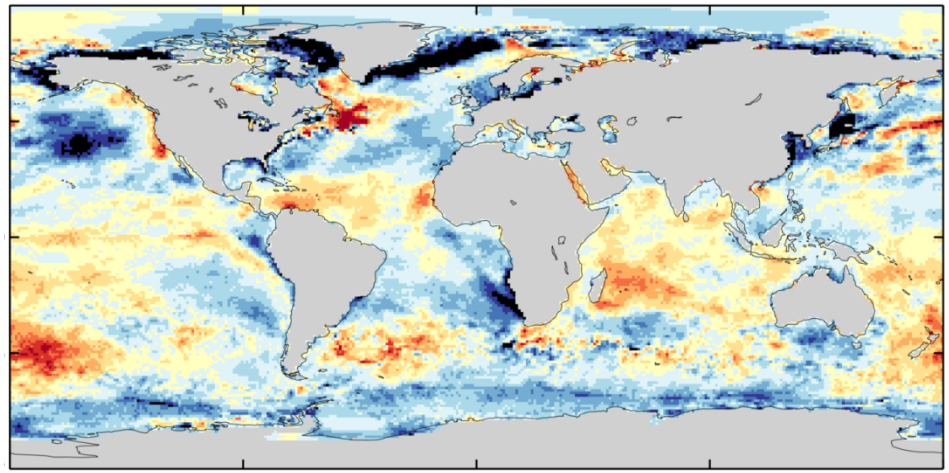
5-day 1°x1° lat-lon,

1961-2010

10 Ensemble members

Interpolated to 0.25° daily resolution

1. Input datasets
2. Bias adjustments of data sets
3. Blending of data sets
4. 2-step reconstruction technique
5. Ensemble production
6. Results



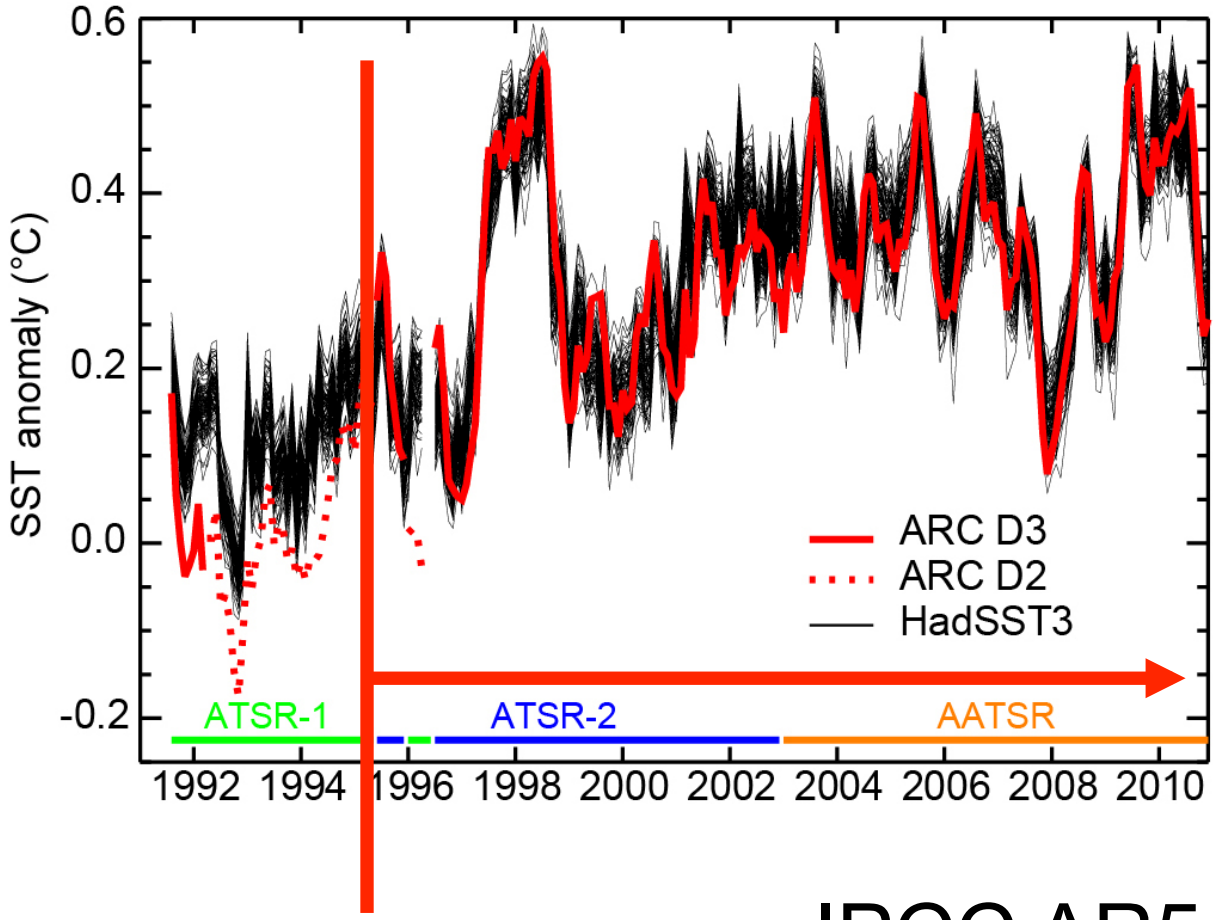
Build from the strengths of the input data sets

- **In Situ**
- HadSST3 from 1850-present
  - Poor coverage, low accuracy, long record
- **Satellite**
- ARC - ATSR Reprocessing for Climate, 1996-2010
  - Lower coverage, short record, high accuracy, stable
- SST CCI AVHRR, 1991-2010
  - Excellent coverage, long record, lower accuracy

- **Bias adjust then blend**

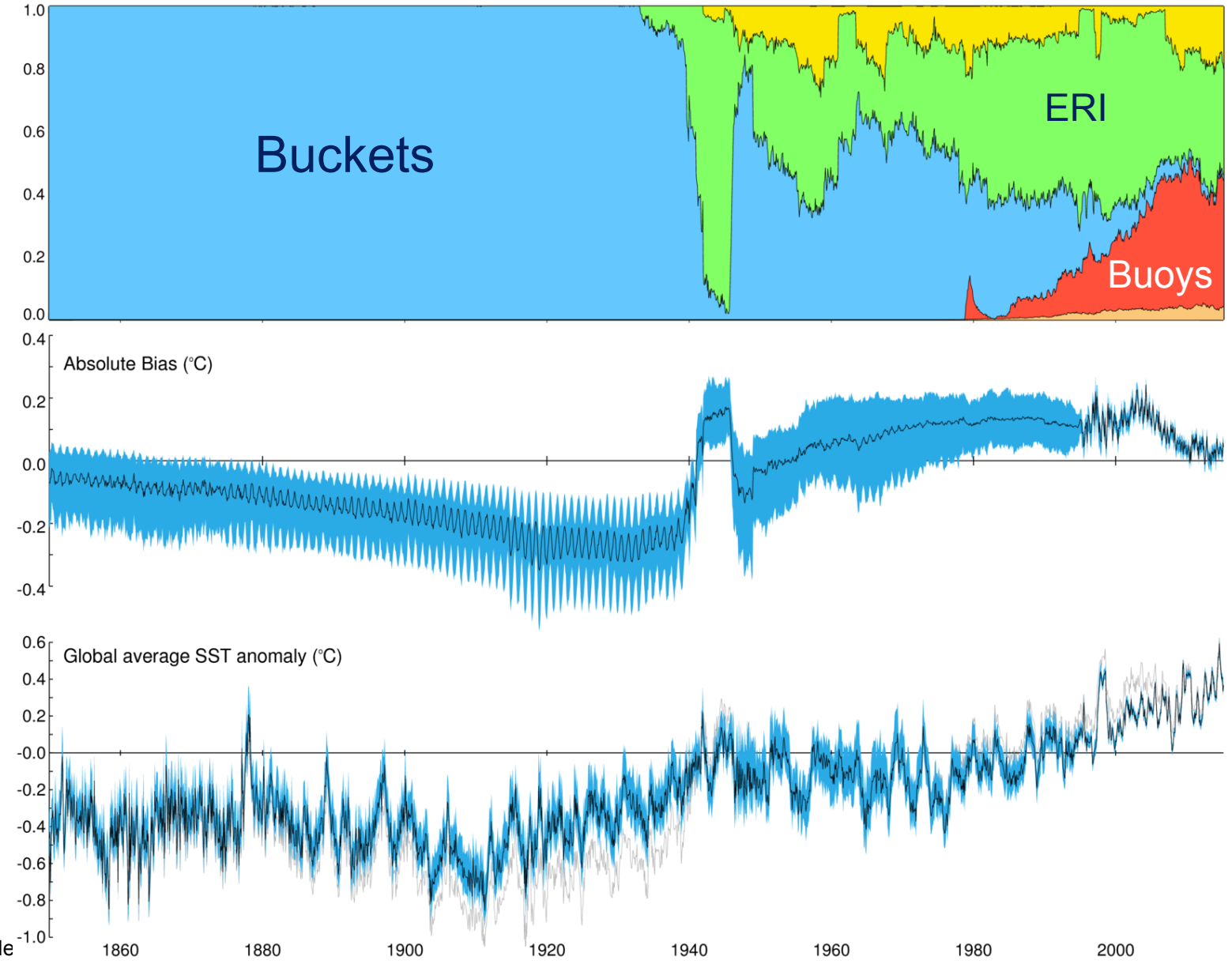
ARC – ATSR Reprocessing for Climate

- Based on Along-Track Scanning Radiometer series of instruments
- Almost independent of in situ measurements
- Shown to have biases of <0.1K
- And drifts of <0.1K decade 1995-2010
- Very small random errors also.
- Agrees with in situ record within (much larger) uncertainties of in situ record.



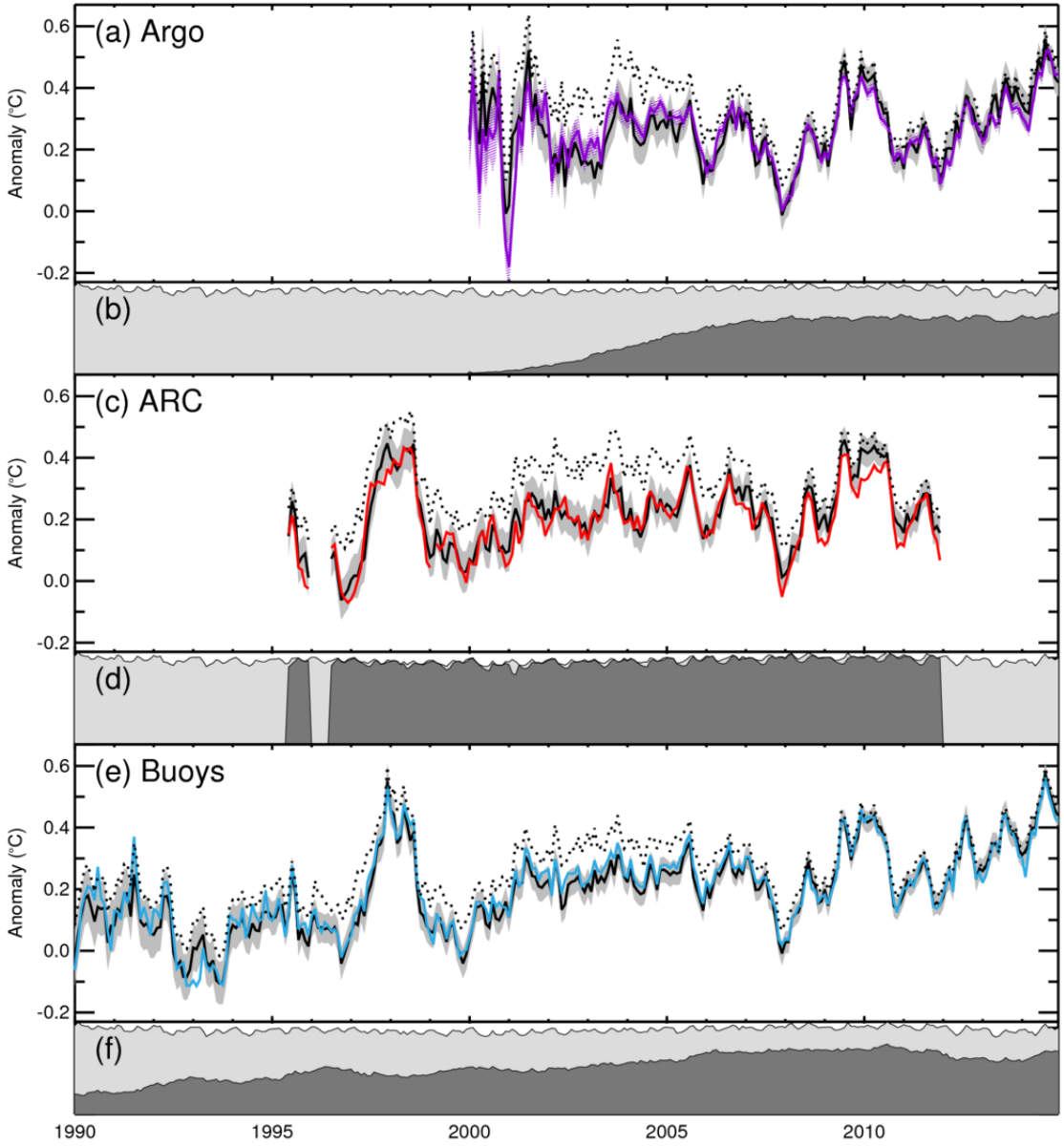
IPCC AR5

In situ data -

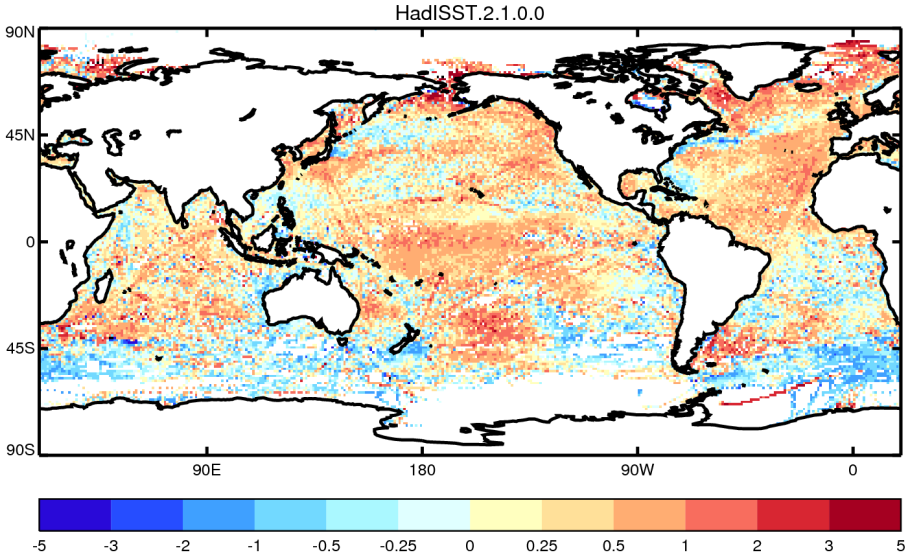


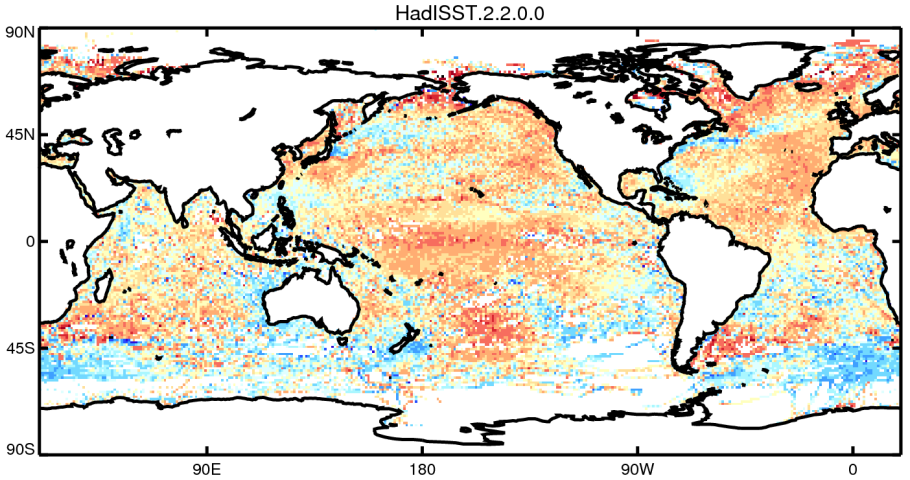
In situ data

- Improvements to in situ ensemble
- Baseline relative to drifters
- Improved ship bias estimates using drifter-ship comparisons



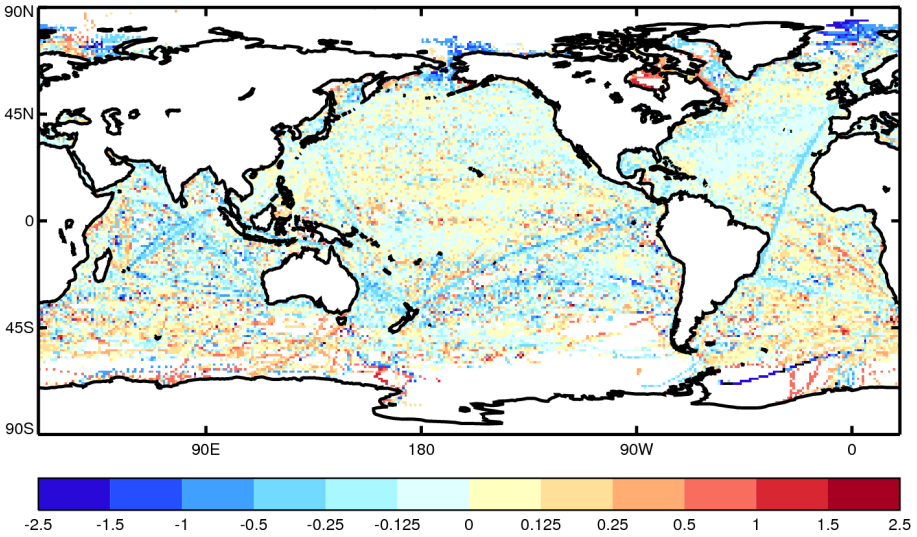
Ship-by-ship adjustments





- Based on in situ data only
- Uses low-res interpolation from HadSST3
- Can be applied whenever we have ship IDs/tracks

Difference for 2004

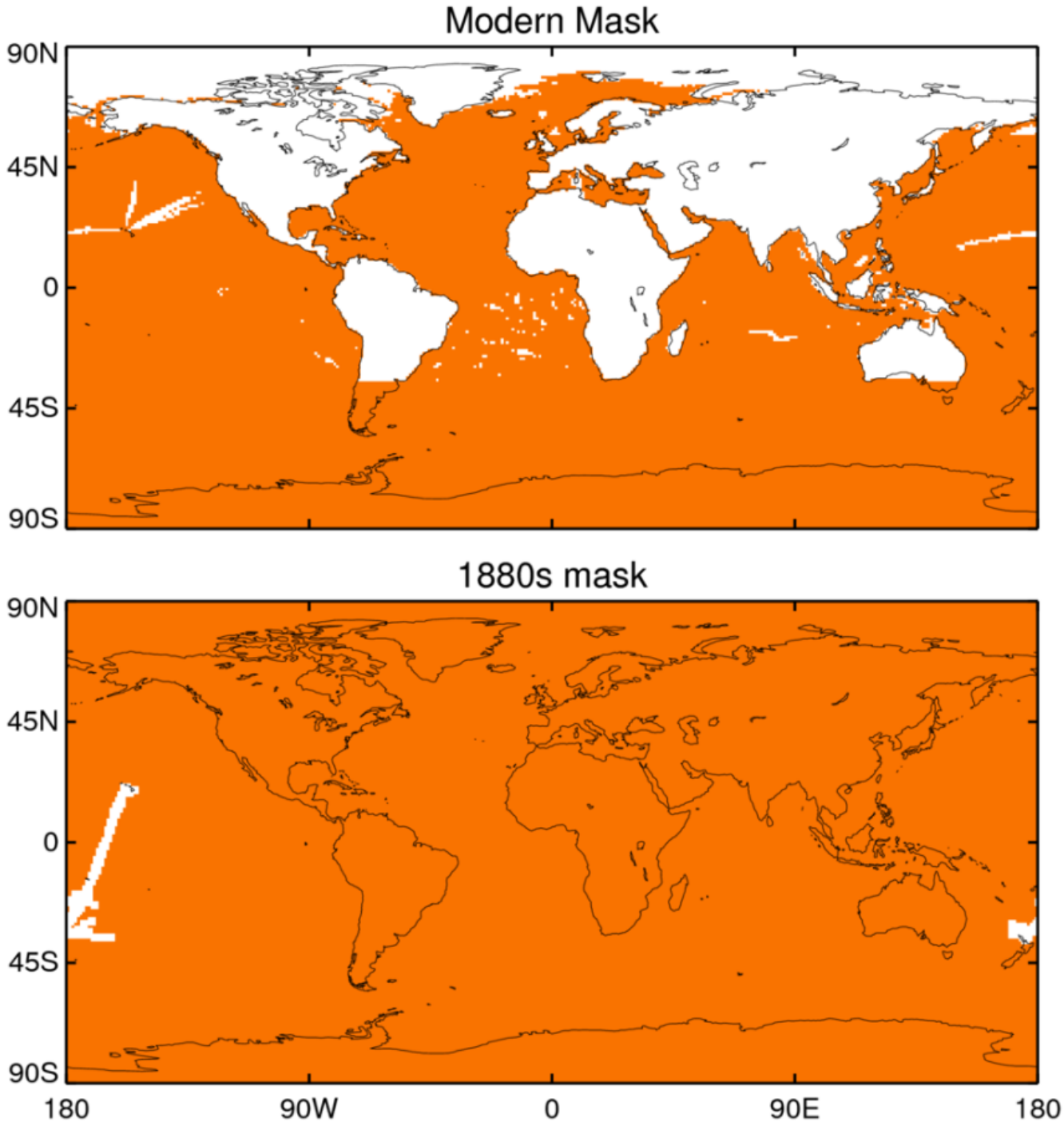


Met Office
Hadley Centre

M

- Persistent s
  - Can affect
  - Also effec
- Run throug
  non-climatic
- Use estima
  bad observ
- Rerun anal

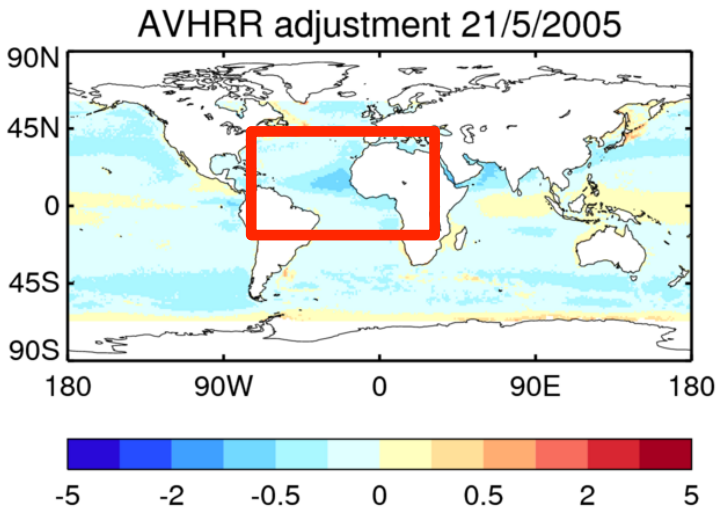
- In addition,
  masked du
  - Western P
    buoys dur

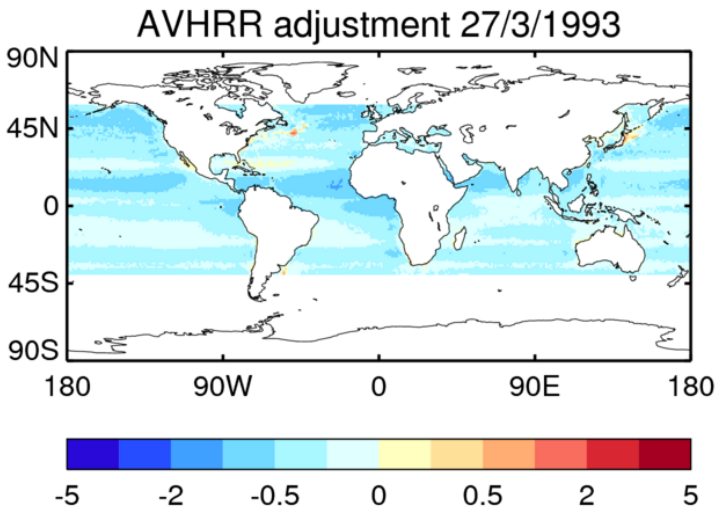


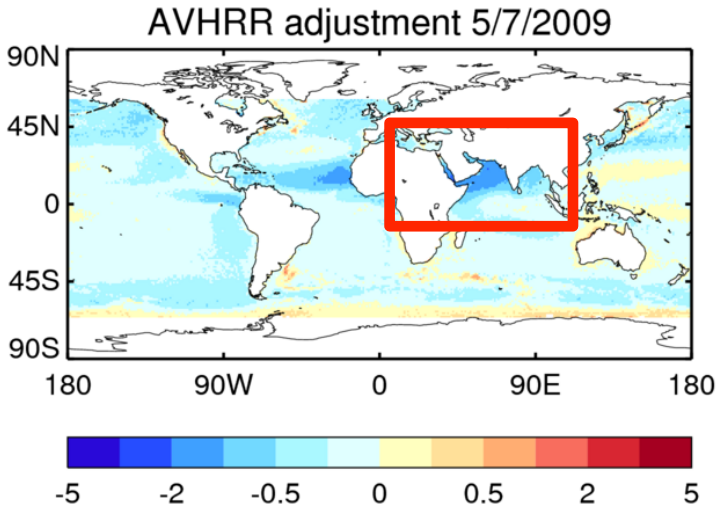
AVHRR from SST CCI

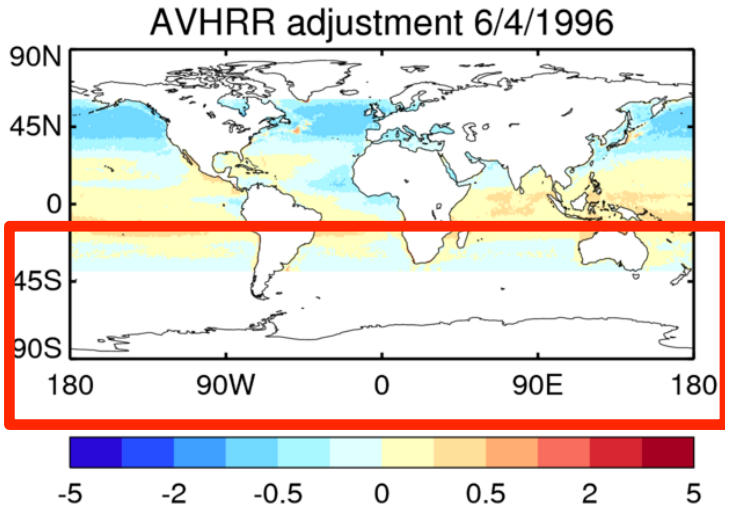
- SST CCI has improved L2 AVHRR data
  - Improved homogeneity
  - Improved uncertainty estimation with a breakdown into random, locally systematic (100km, 1 day) and globally systematic
- Still has residual biases with structure between local and global ~1000km 5-30 day
- Adjust AVHRR relative to in situ and ATSR data
  - Smoothed Zonal-mean adjustment for each 5-day period
  - EOF based analysis using VBPCA with 25 EOFs

AVHRR adjustments







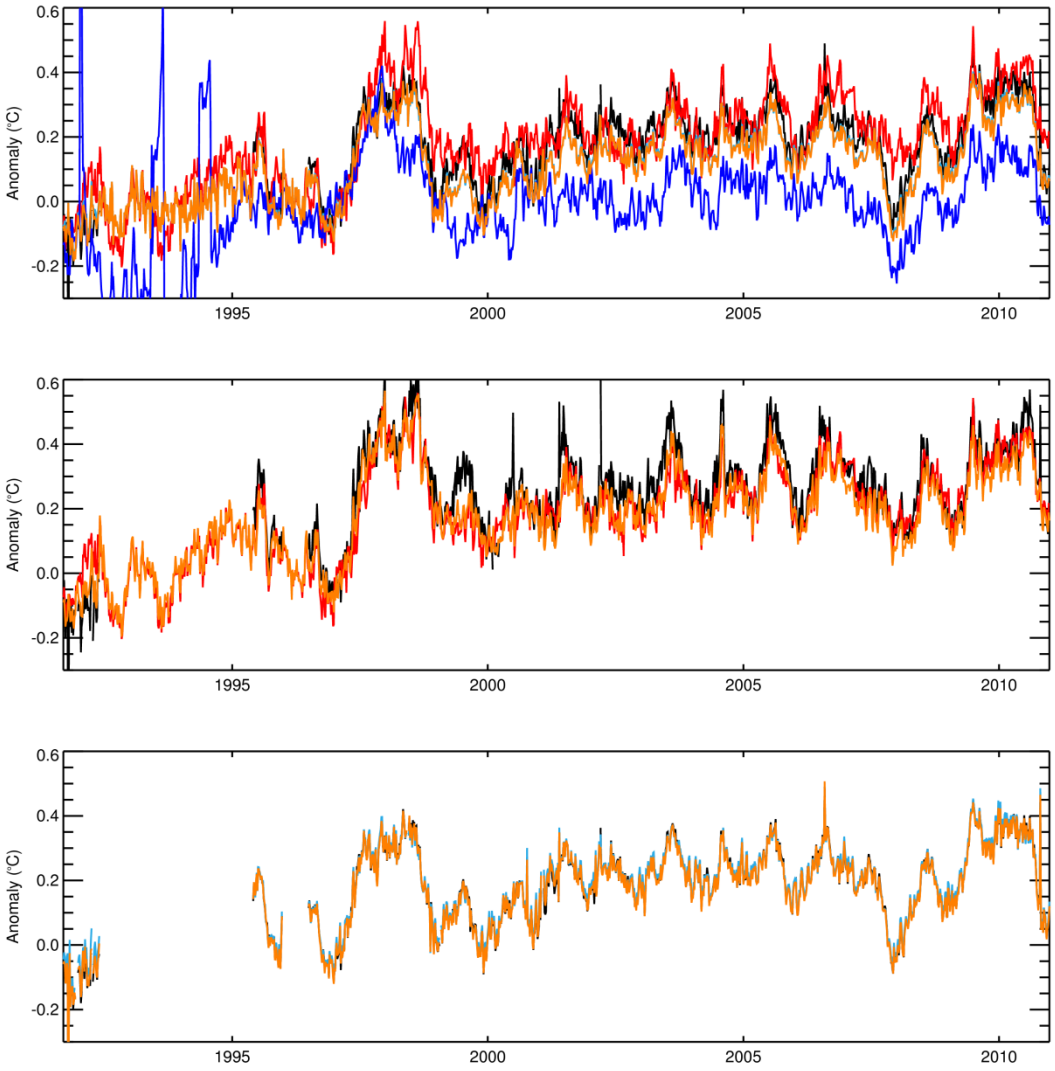


AVHRR data

Full coverage data sets

Colocated with in situ data

Colocated with ATSR



IN SITU - HadSST

AVHRR RAW – SST CCI

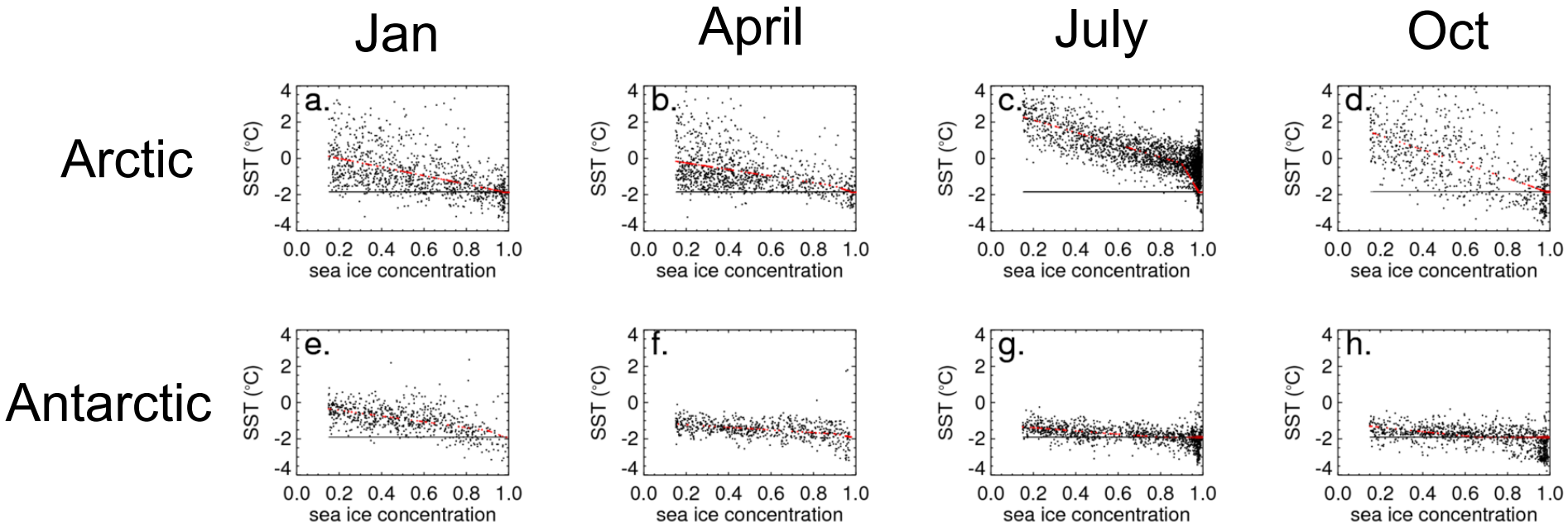
AVHRR ADJUSTED

ATSR - ARC

ARC IN SITU AVHRR BLEND

Marginal Ice Zone SST and sea ice concentration

- Spatially and monthly varying relationships between ARC SST and sea ice concentration
- Used to specify the SST

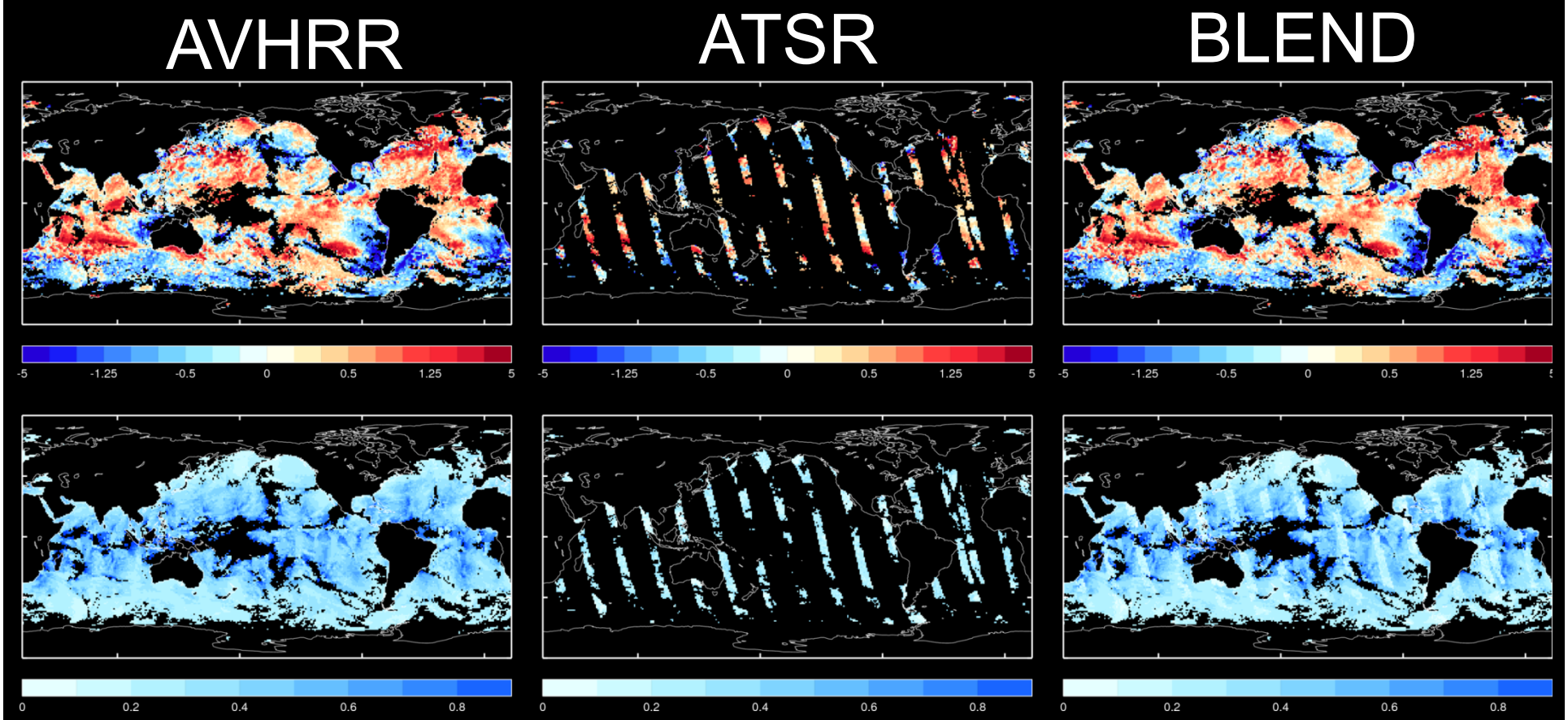


21° longitude region centred on 0.5°E

Met Office
Hadley Centre

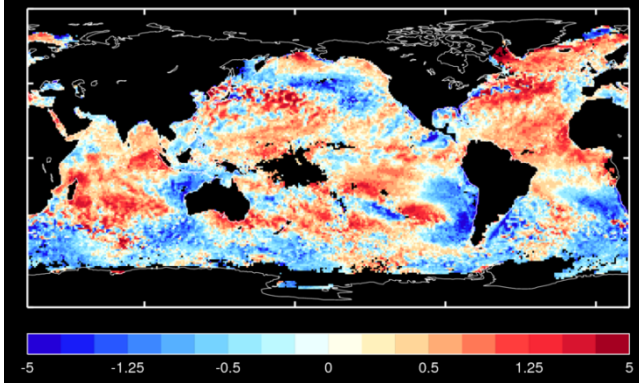
Blending Data Sources

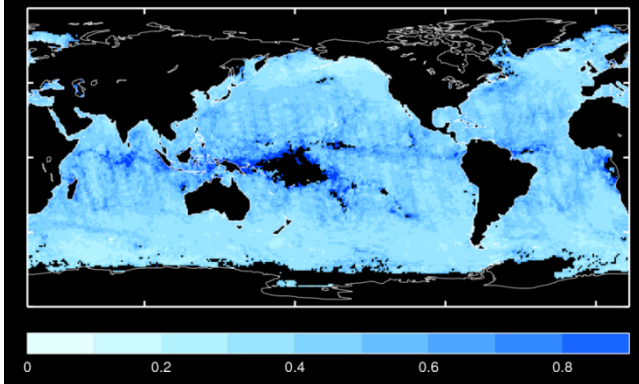
Blending satellites - daily



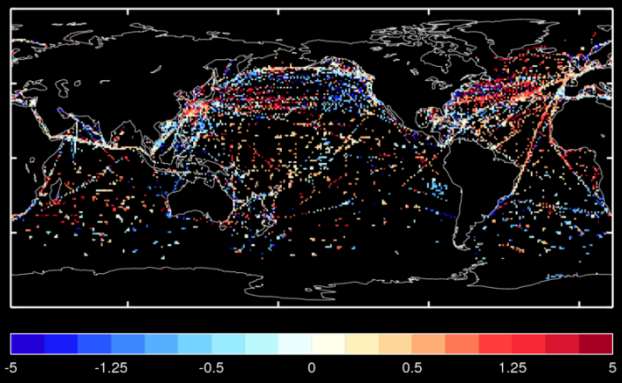
Blending satellite and in situ - pentad

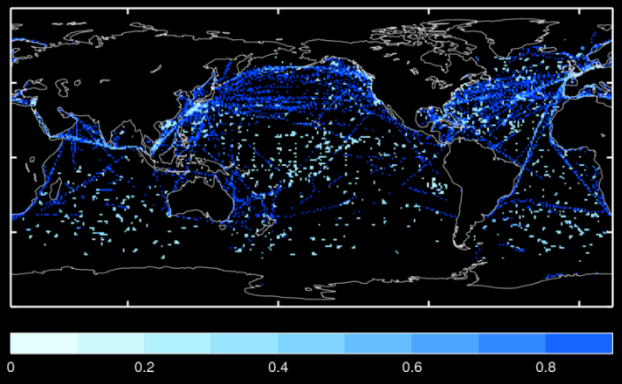
SATELLITE



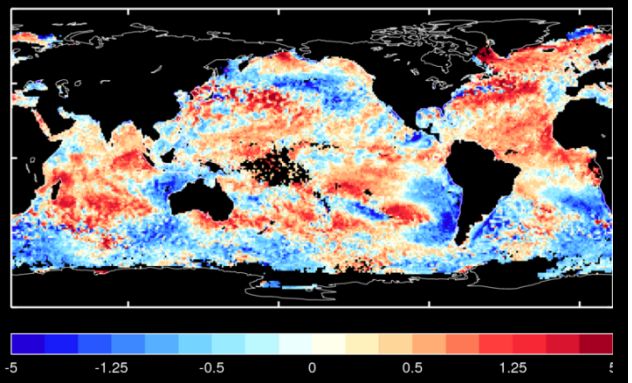


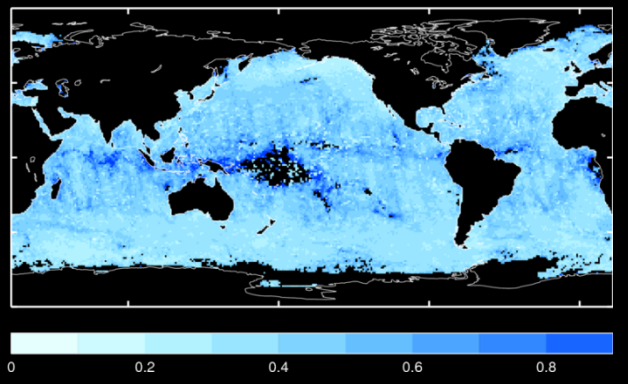
IN SITU





BLEND





Met Office
Hadley Centre

2-Step Reconstruction Technique

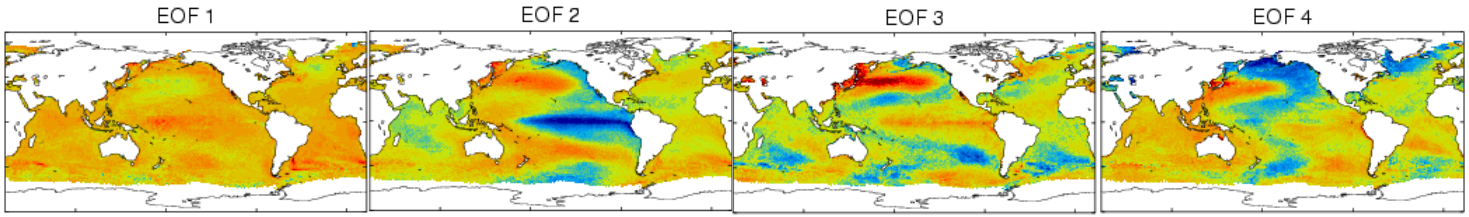
Large scale – Small scale

1. Variational Bayesian Principal Component Analysis VBPCA

- EOF-based
- Iterative
- Uses all available data
- Doesn't mind gappy data
- Provides consistent reconstruction, EOFs and uncertainties
- Fast

- Large-scale reconstruction

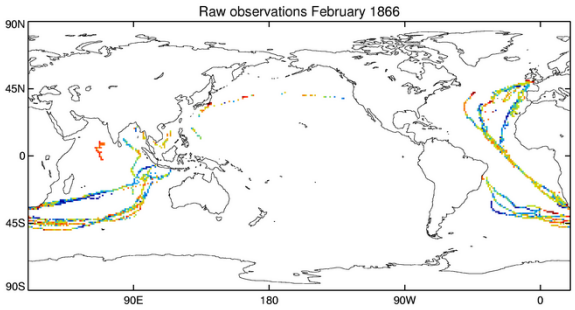
A. Ilin and A. Kaplan. Bayesian PCA for Reconstruction of Historical Sea Surface Temperatures. In Proc. of the Int. Joint Conf. on Neural Networks (IJCNN 2009), pp. 1322-1327, Atlanta, USA, 2009.



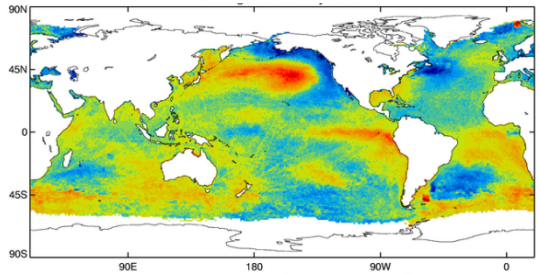
GUESS EOFS

project on to

OBSERVATIONS



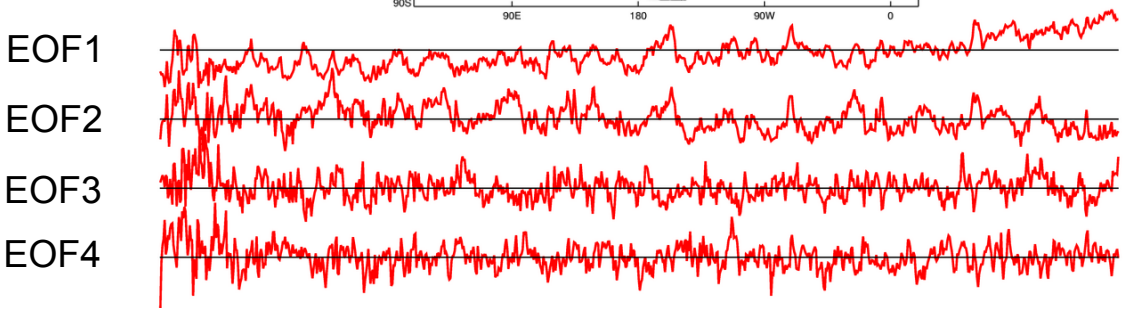
AT EACH TIME STEP



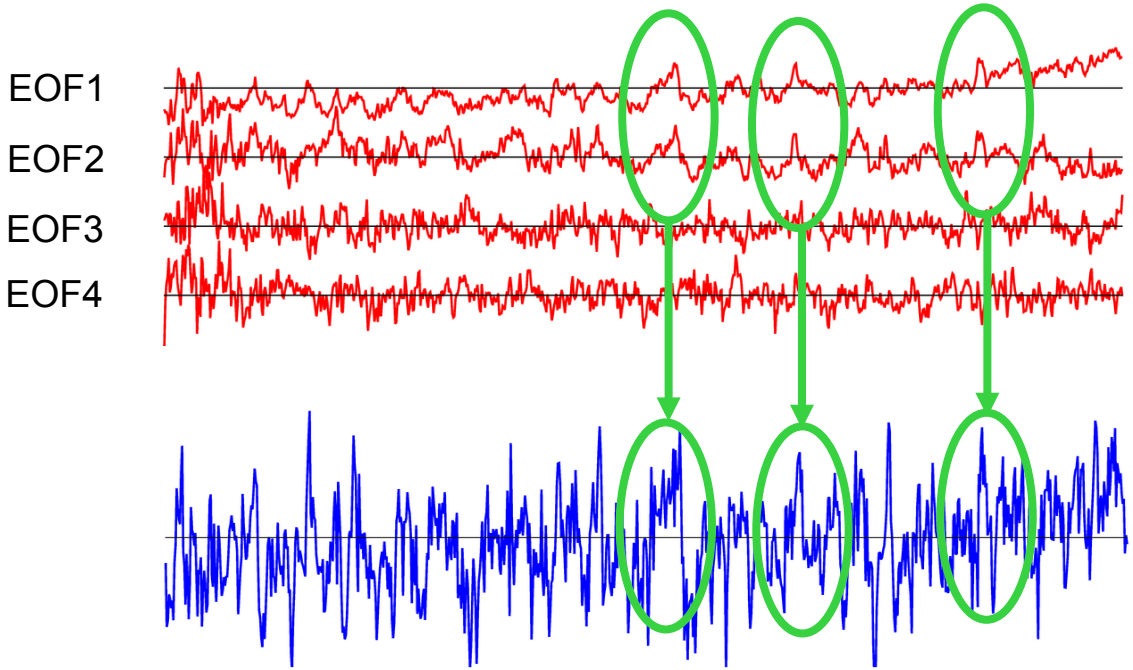
BROAD-SCALE RECONSTRUCTION

&

time series of weights of EOFs



Bayesian PCA

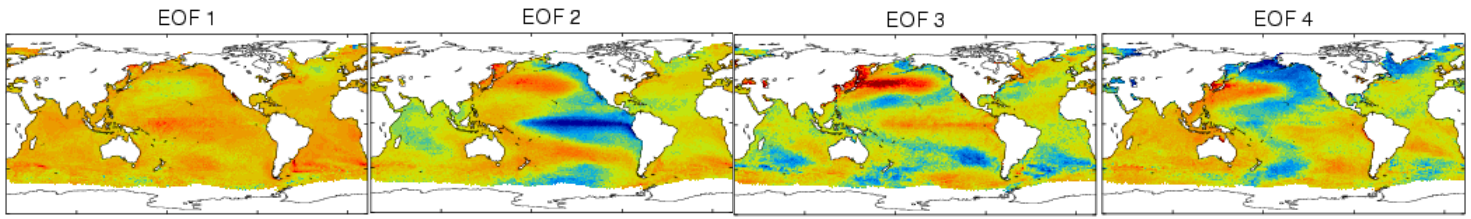


Weights of EOFS

project on to

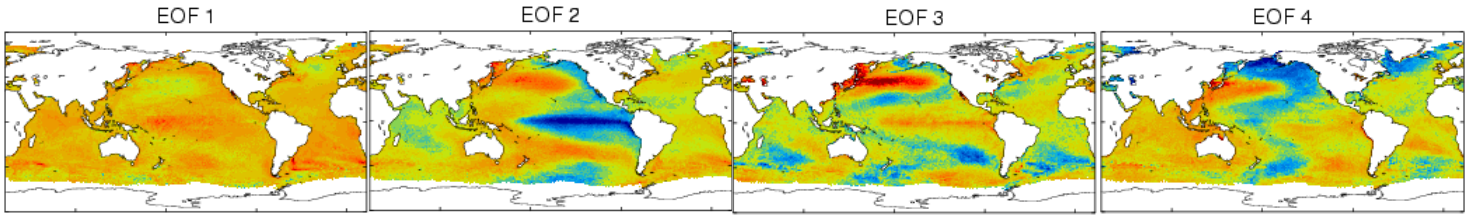
OBS

AT EACH *LOCATION*



NEW EOFs

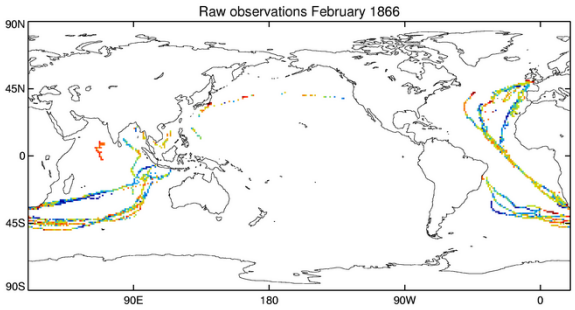
Bayesian PCA



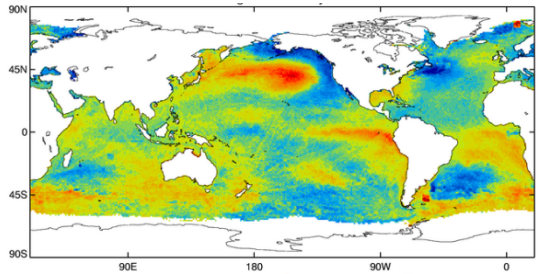
NEW EOFS

project on to

OBSERVATIONS



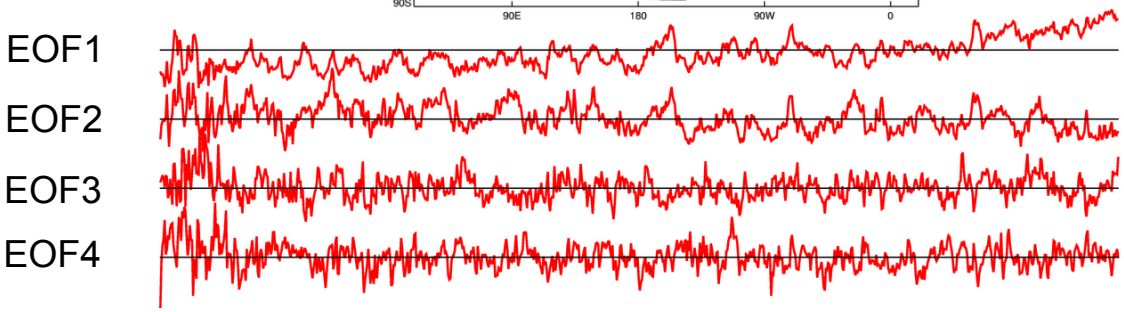
AT EACH TIME STEP



BROAD-SCALE RECONSTRUCTION

&

time series of weights of EOFs



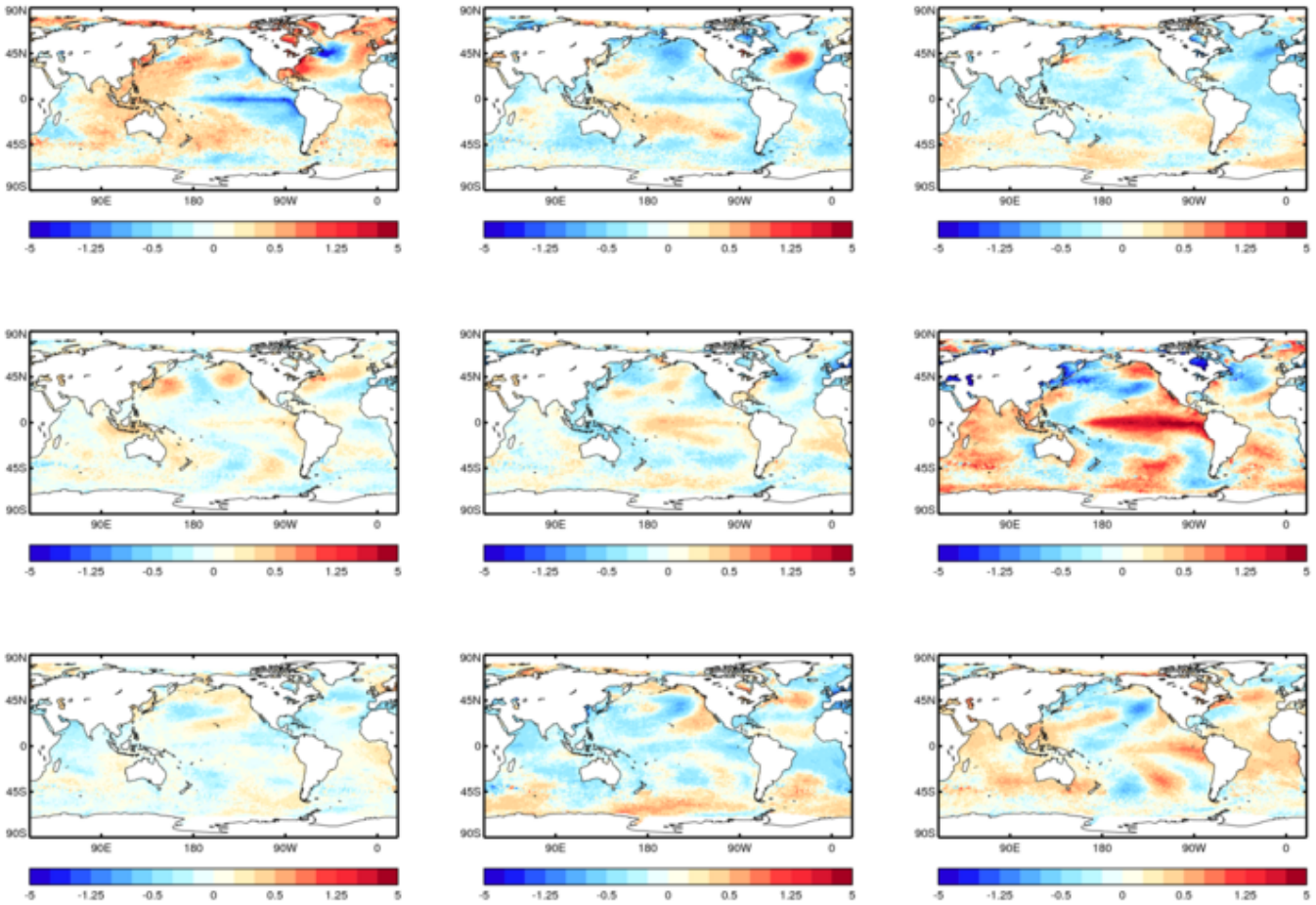
Bayesian PCA

EOFs

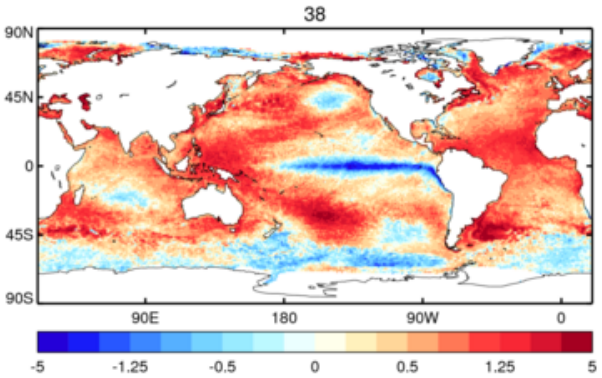
EOFs taken from estimated covariance matrix

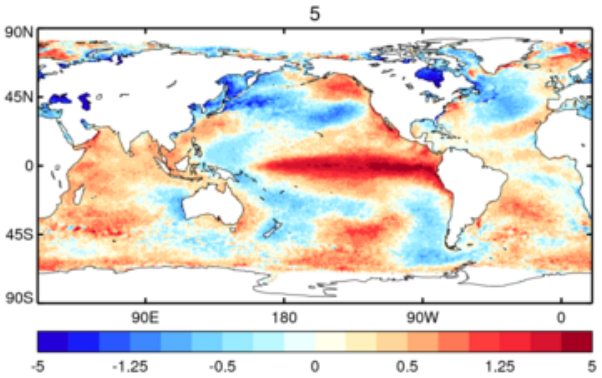
Number of EOFs used is an input to the algorithm

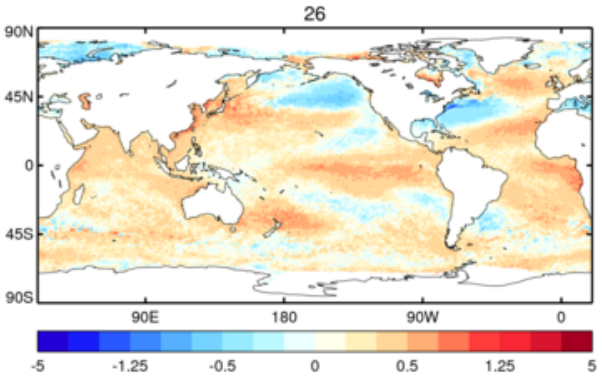
Use 45 EOFs



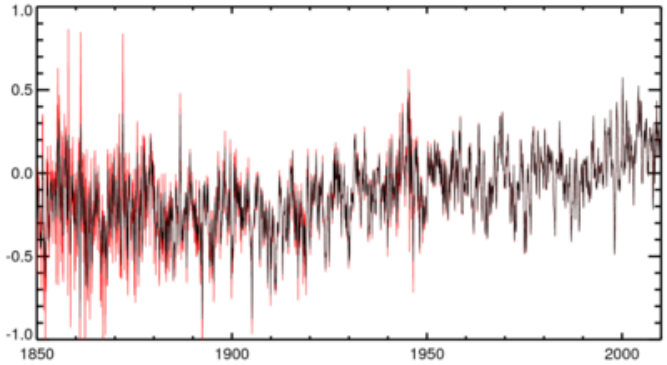
EOF

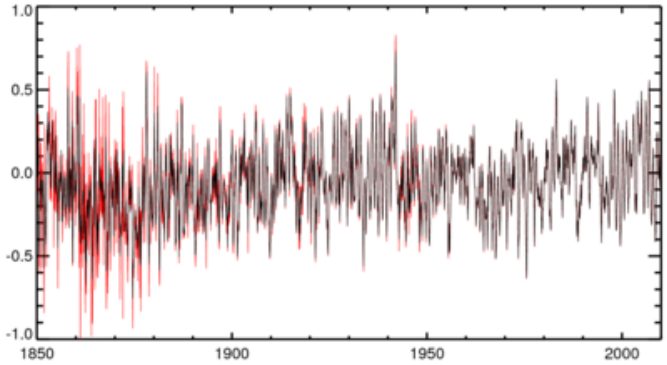


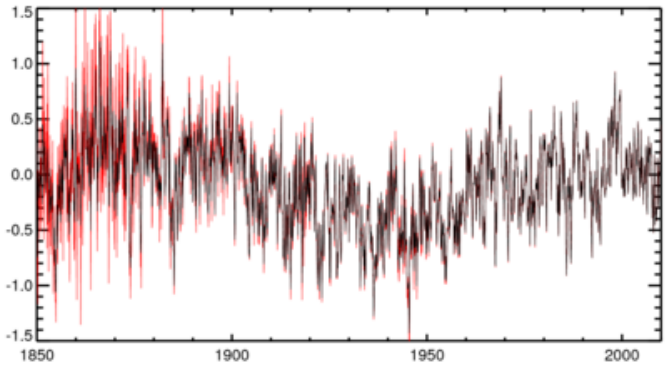




Principal Component







Red – RAW PC

Black - Smoothed

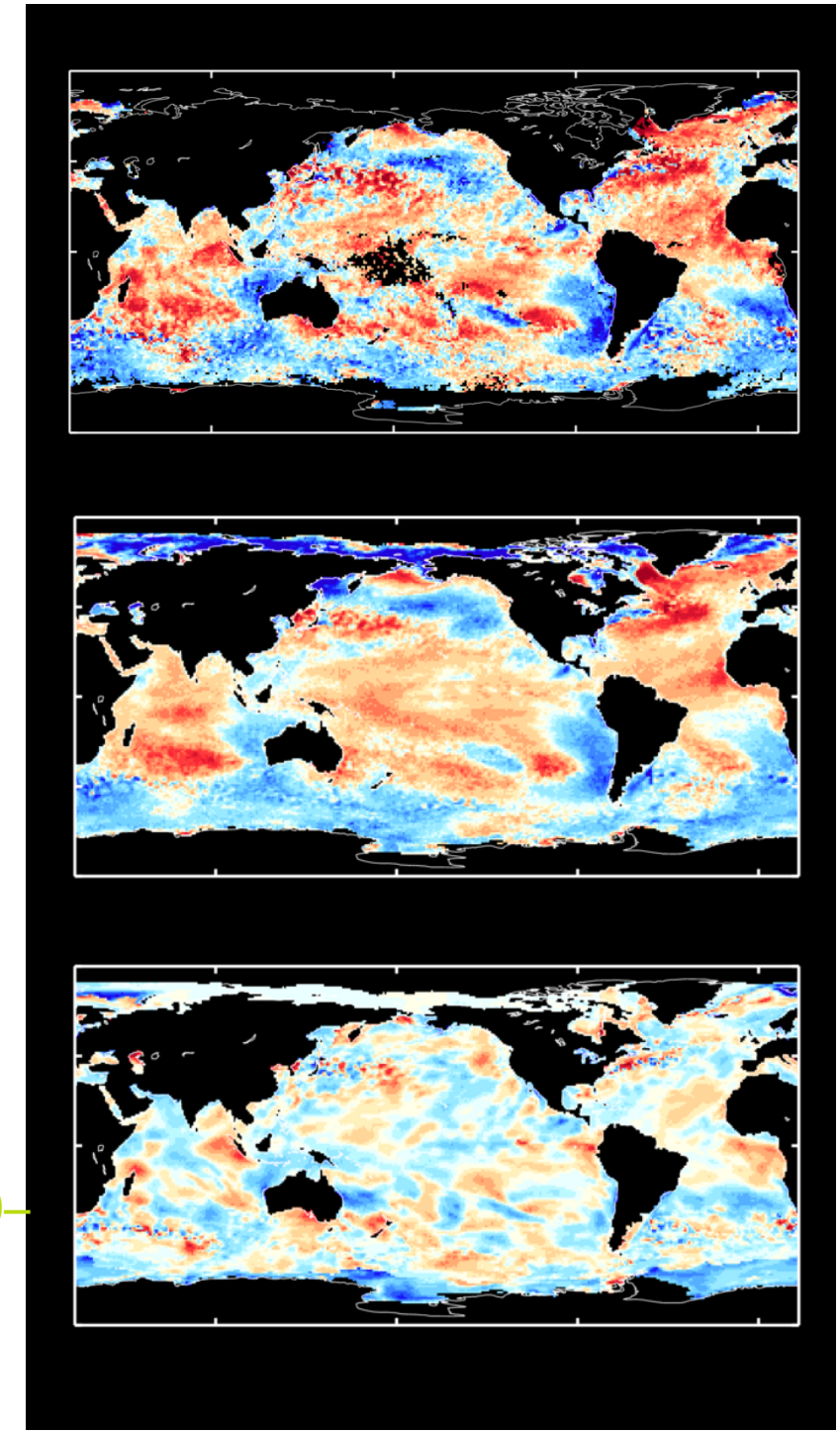
Sampling from large scale reconstruction

- This is very cheap and efficient
- We have a set of mean weights for each EOF
- And a covariance matrix for the uncertainty in those weights
- Sampling from a 50x50 matrix is easy

- In practice, the reconstruction uncertainty is too small.
  - Correlated observational uncertainty
  - Uncertainty in the EOF patterns not represented
  - Residual noise term uncorrelated also

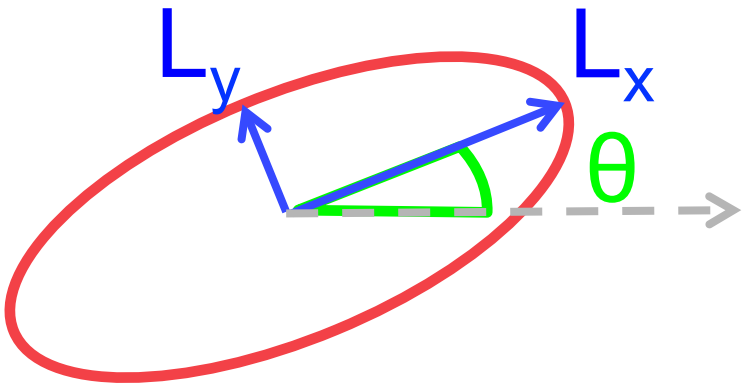
Local Optimal Interpolation

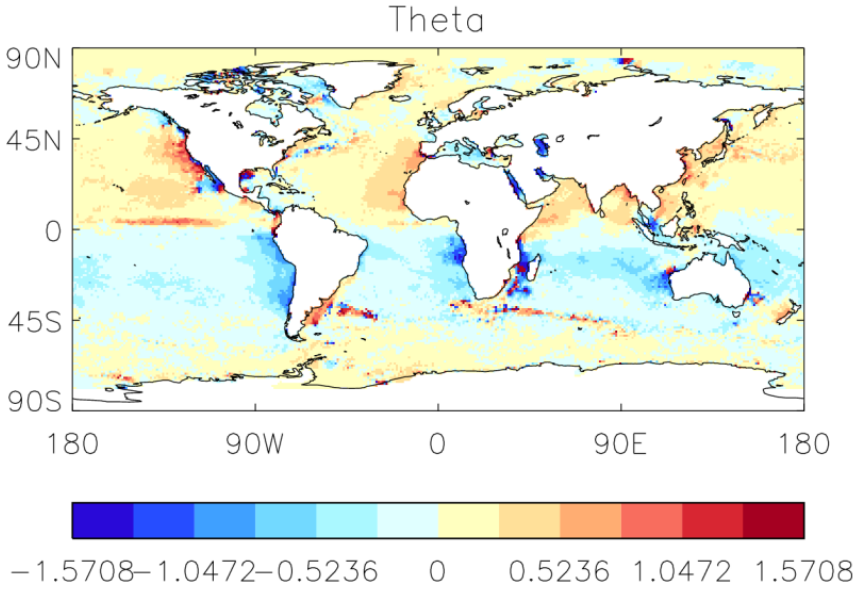
- Analyse residual difference
- Use local OI
- Angular length scales and angle vary with location
- Covariances based on Karspeck et al. 2012

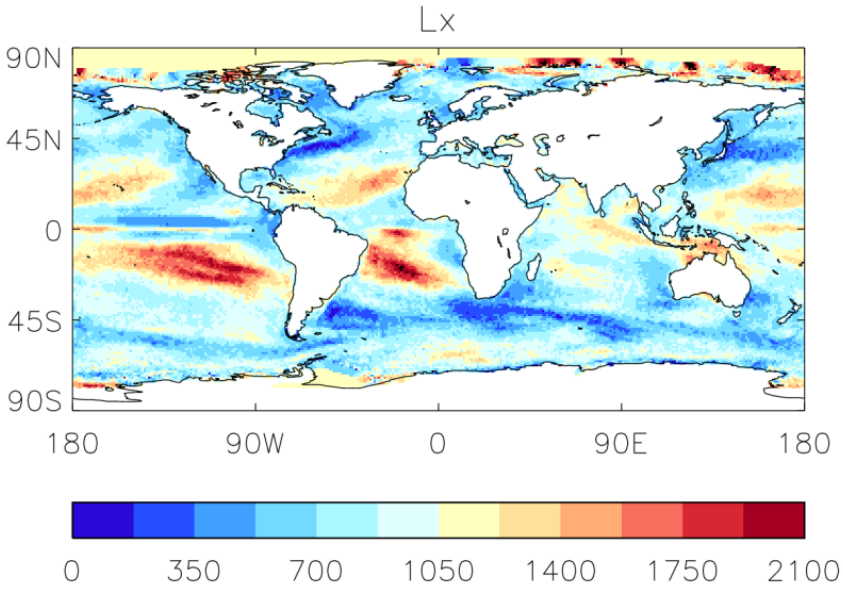


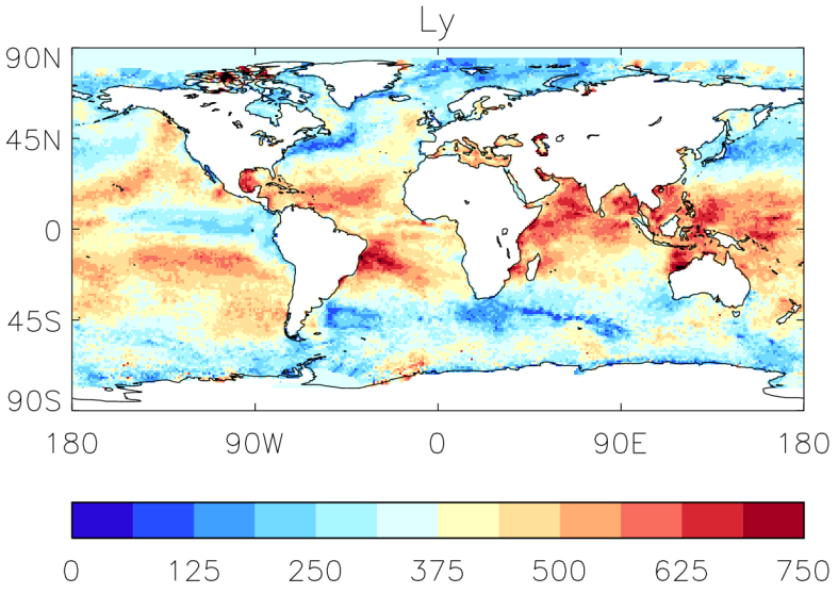
Karspeck, A. R., Kaplan, A. and Sain, S. R. (2012), Bayesian modelling and ensemble reconstruction of mid-scale spatial variability in North Atlantic sea-surface temperatures for 1850–2008. Q.J.R. Meteorol. Soc., 138: 234–248. doi: 10.1002/qj.900

Non-stationary local covariances

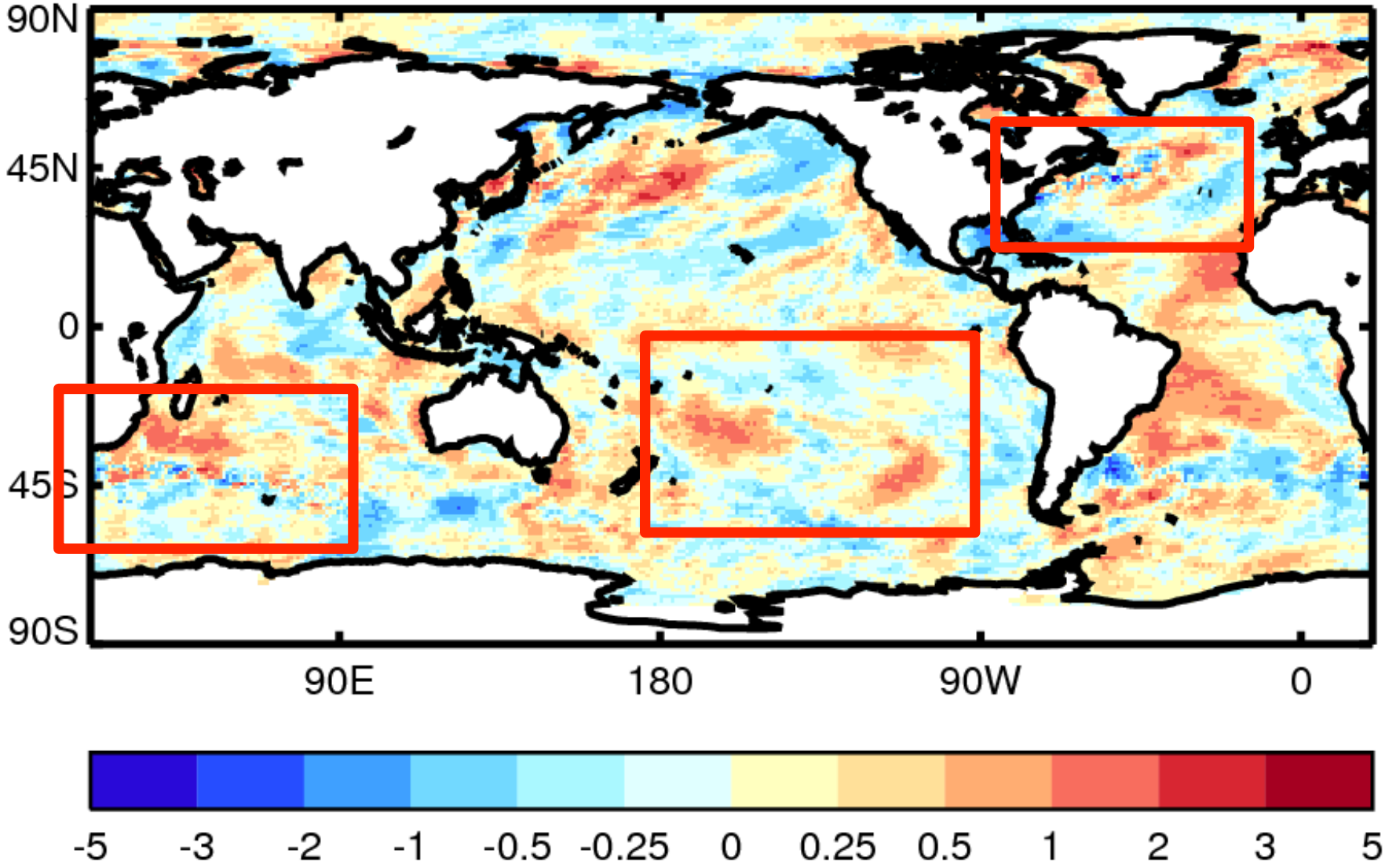




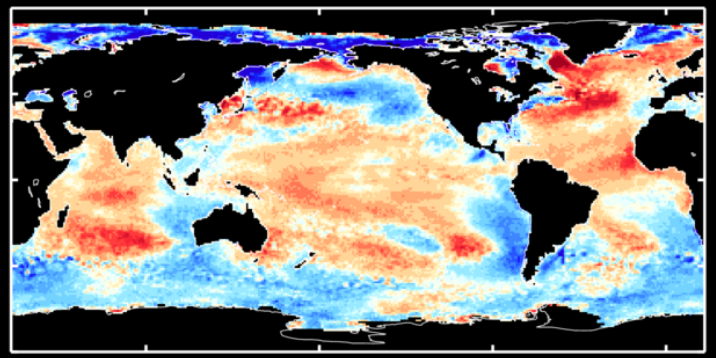


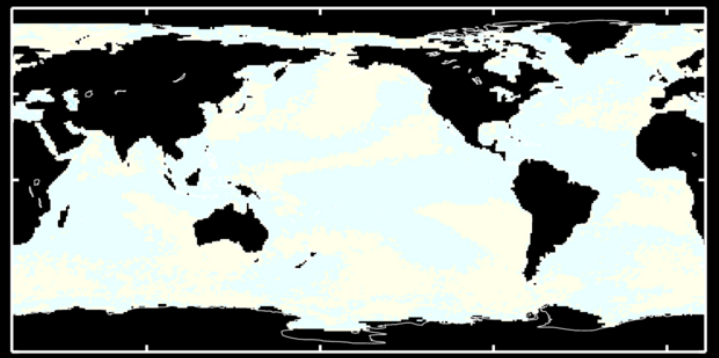


Drawing samples from Local



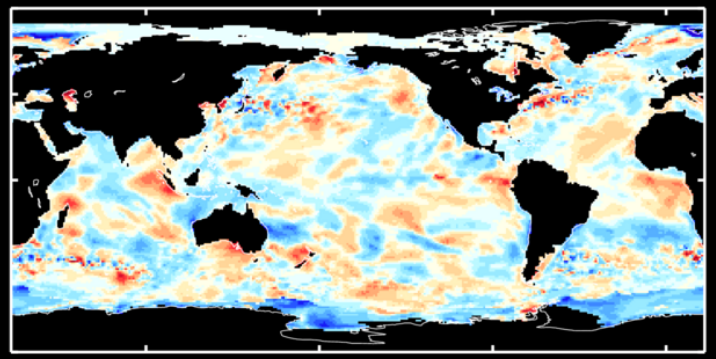
Multi step reconstruction, January 1-5 2004

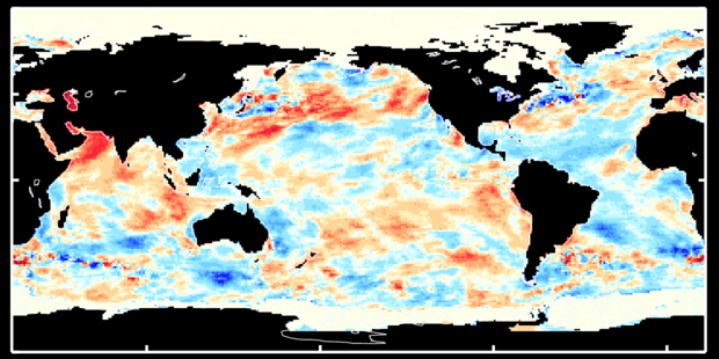




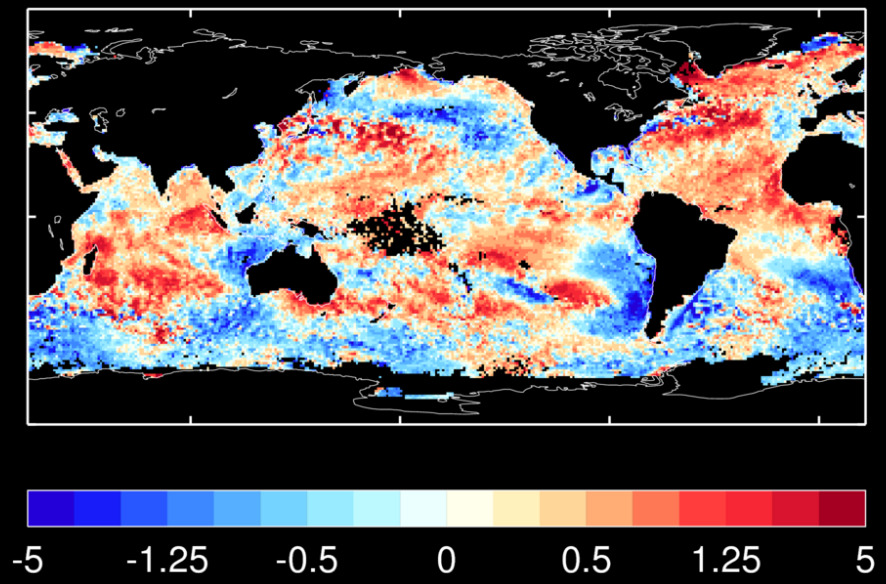
-5 -1.25 -0.5 0 0.5 1.25 5

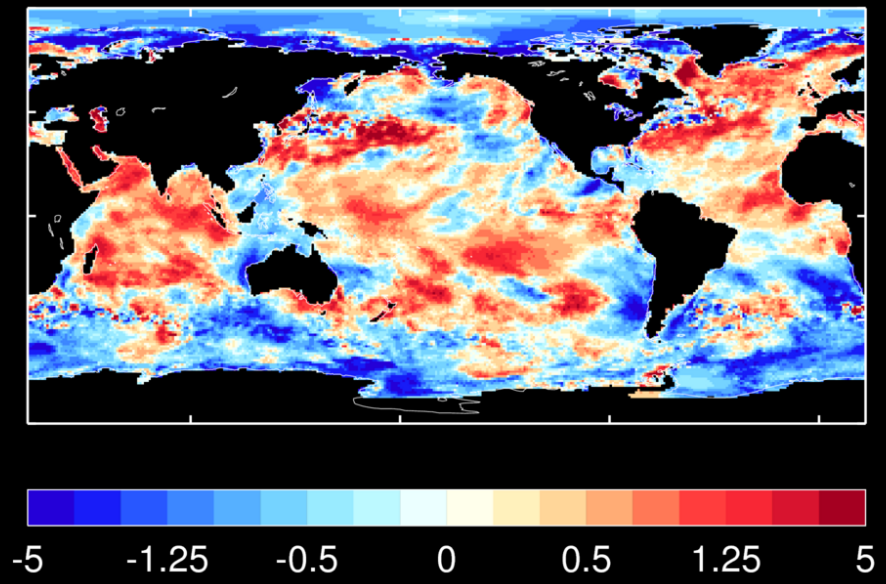
-5 -1.25 -0.5 0 0.5 1.25 5

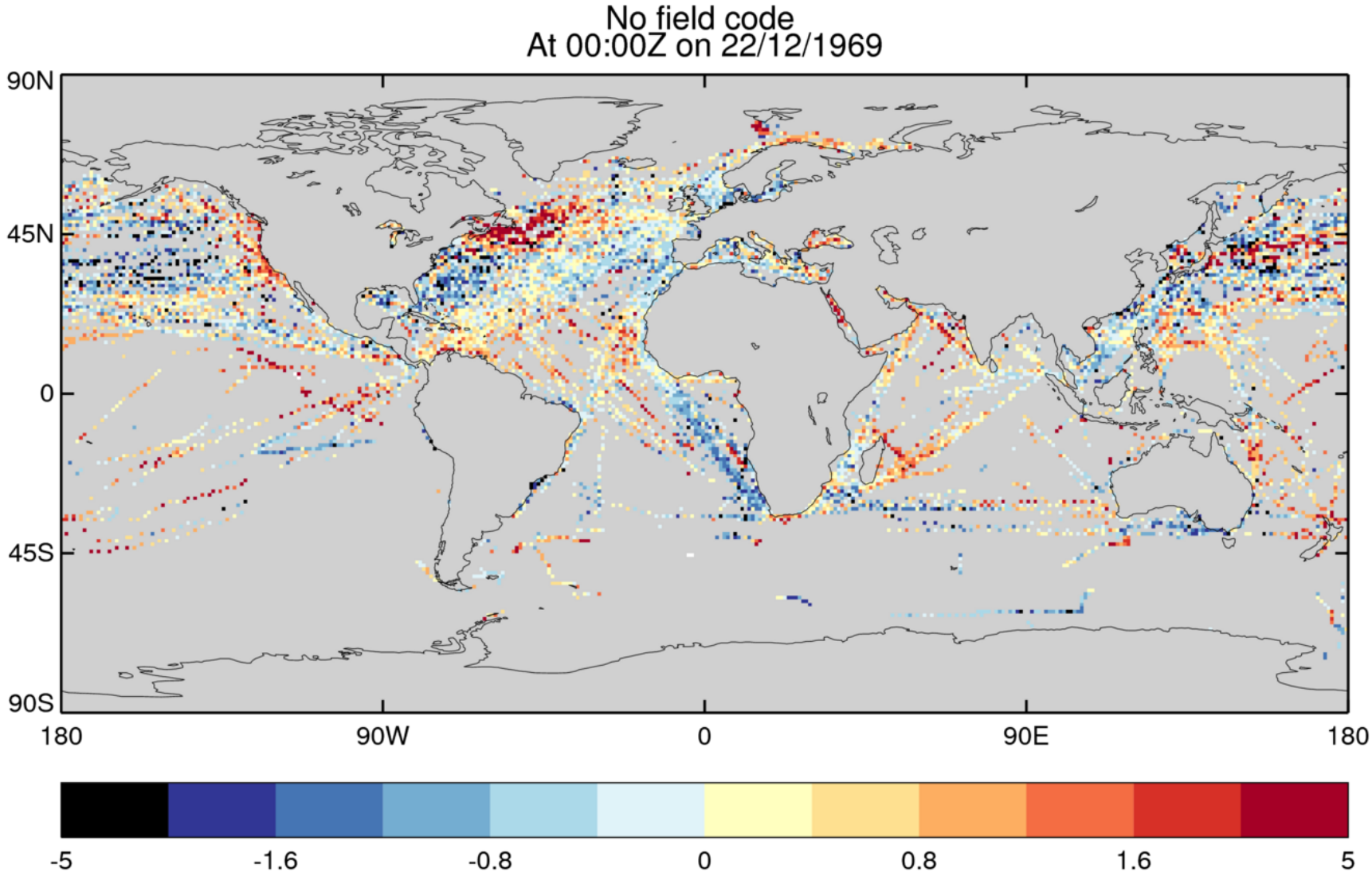


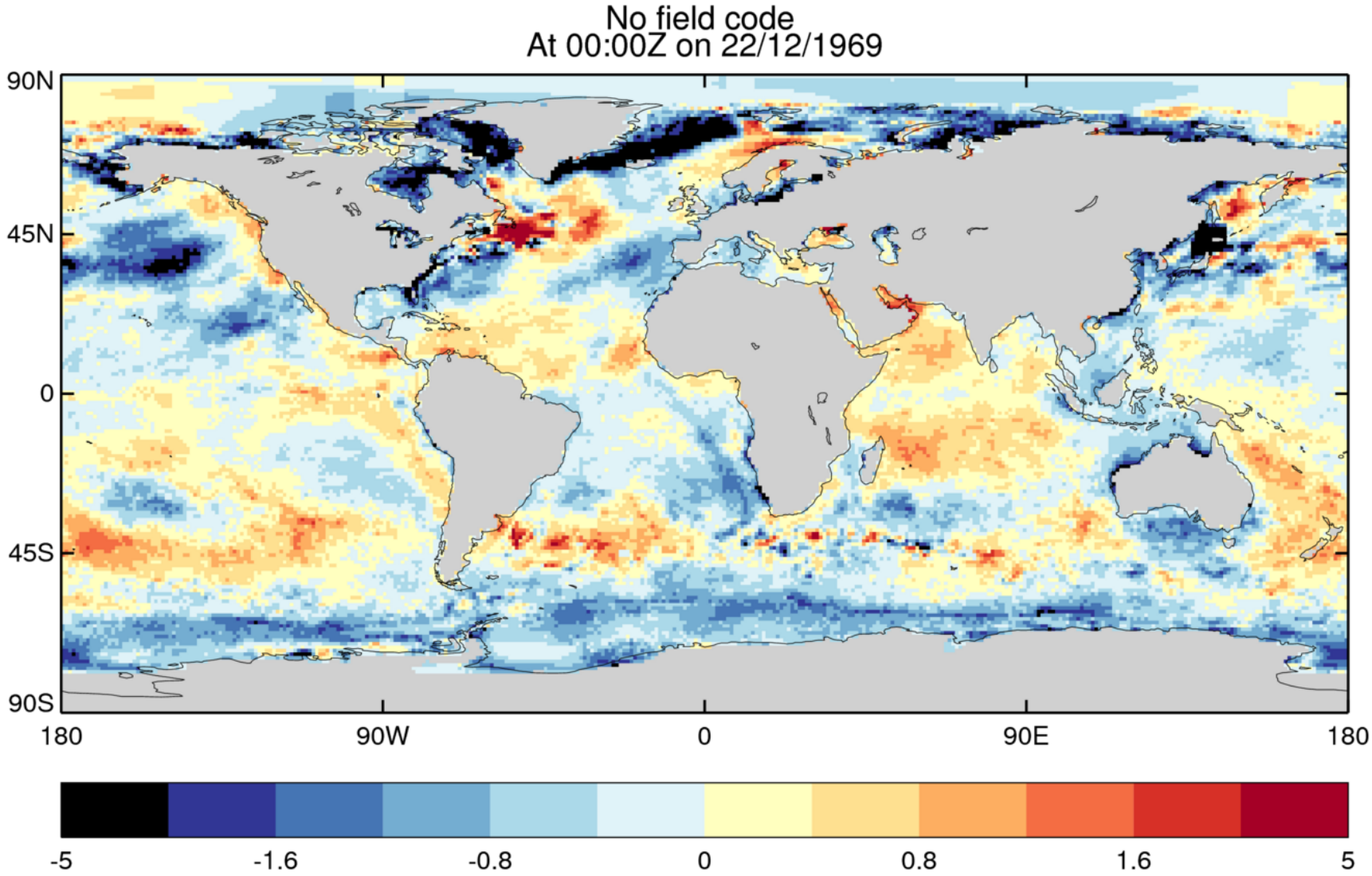


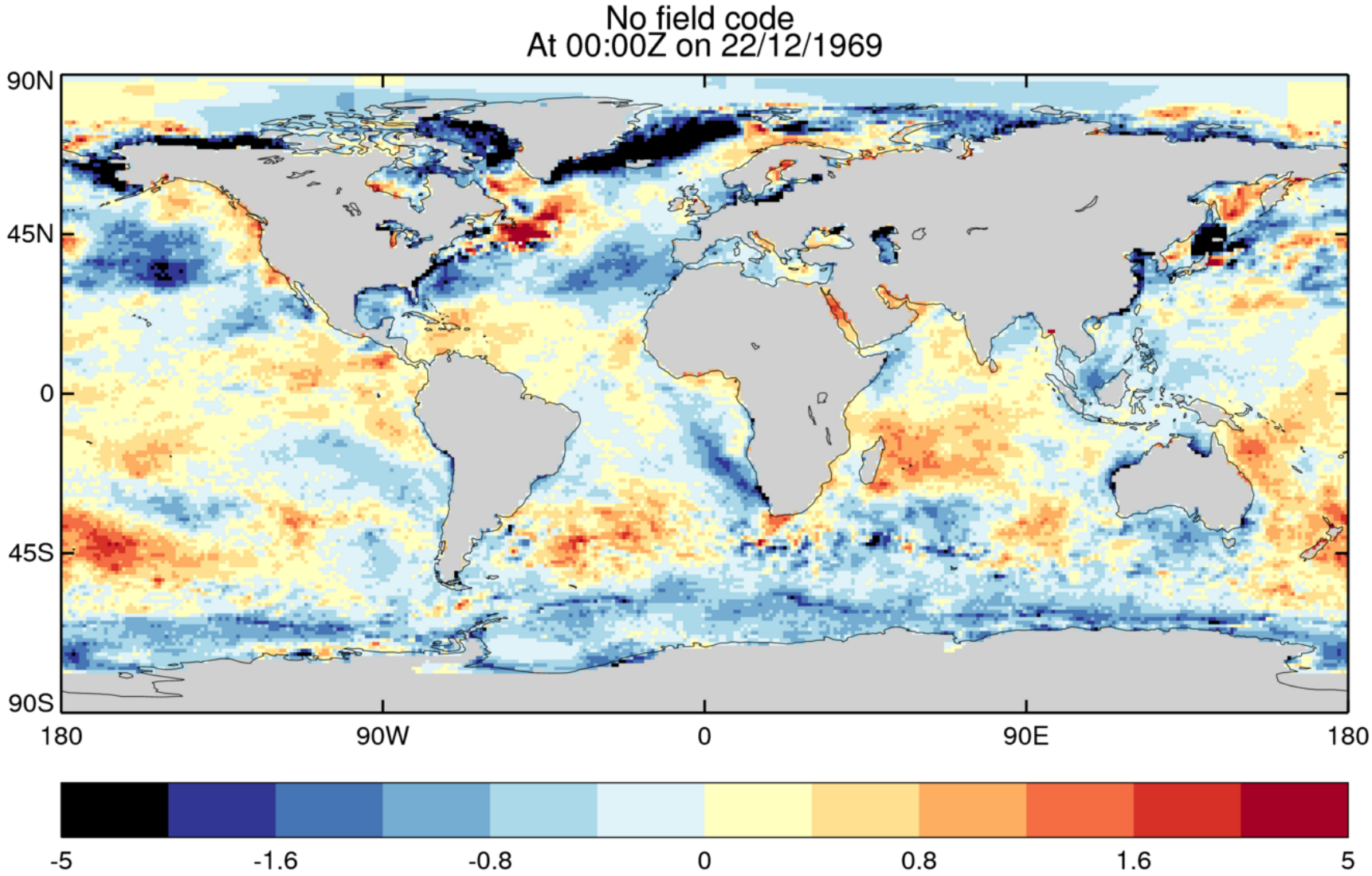
Multi step reconstruction, January 1-5 2004

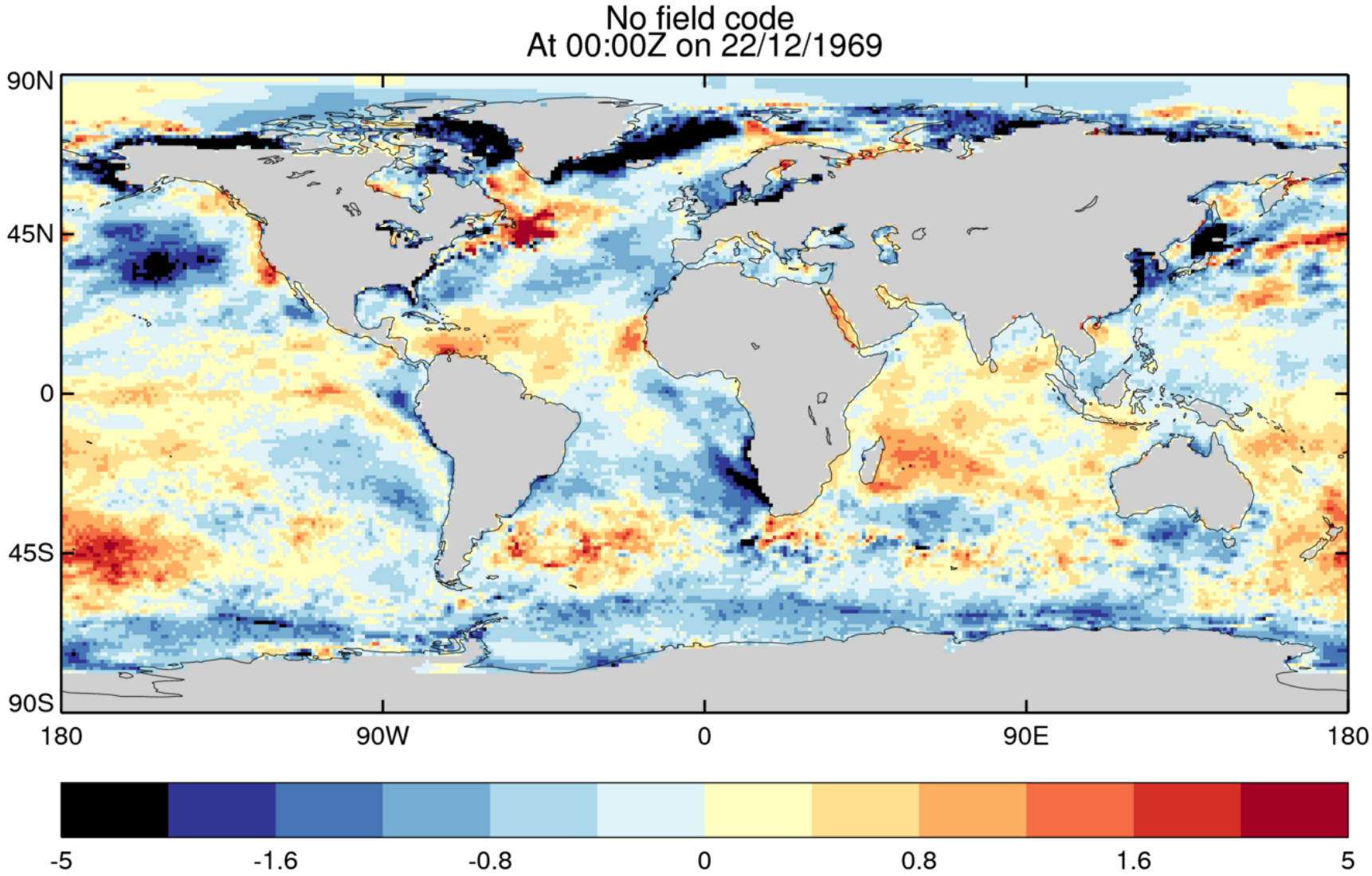


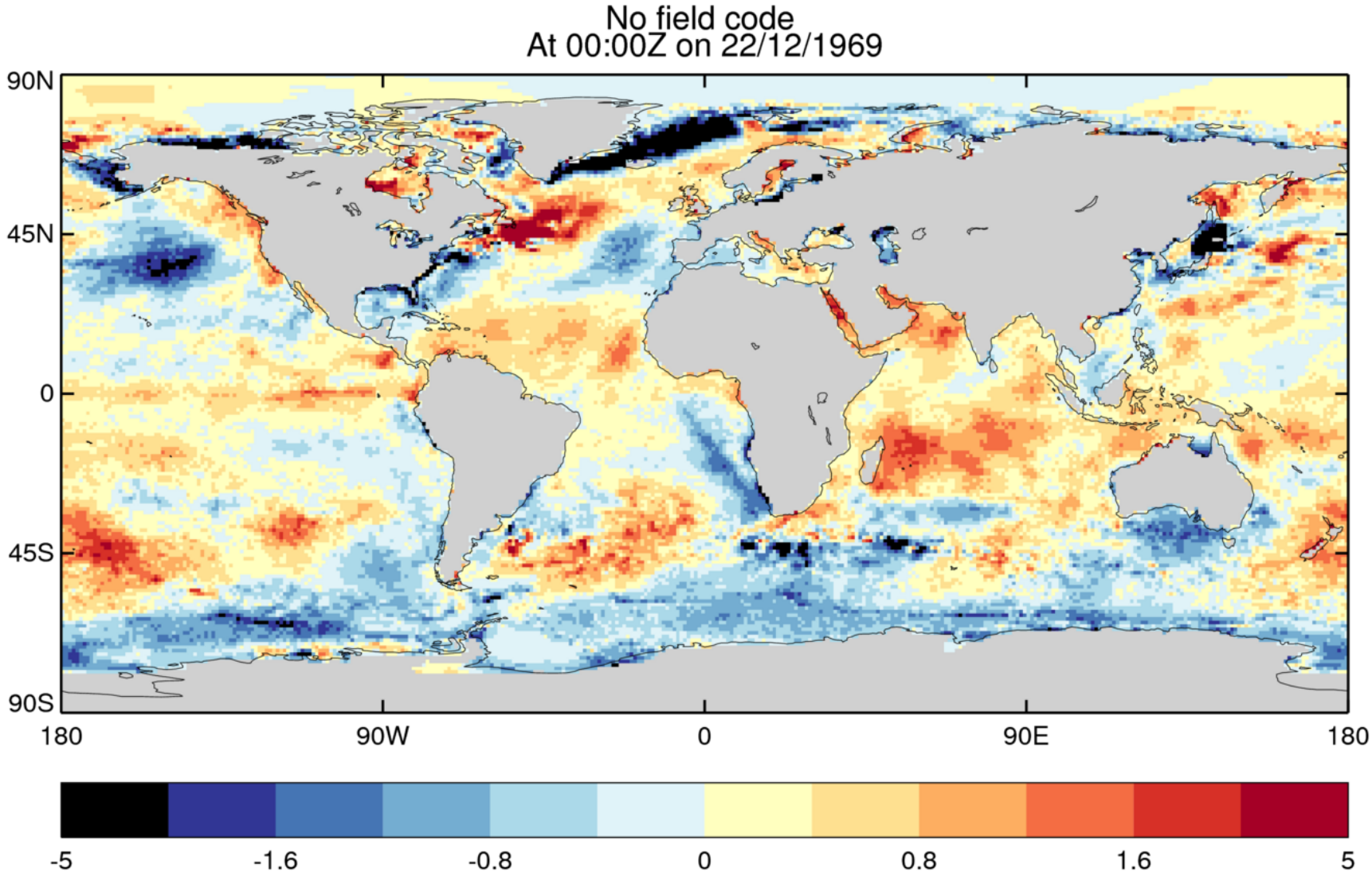


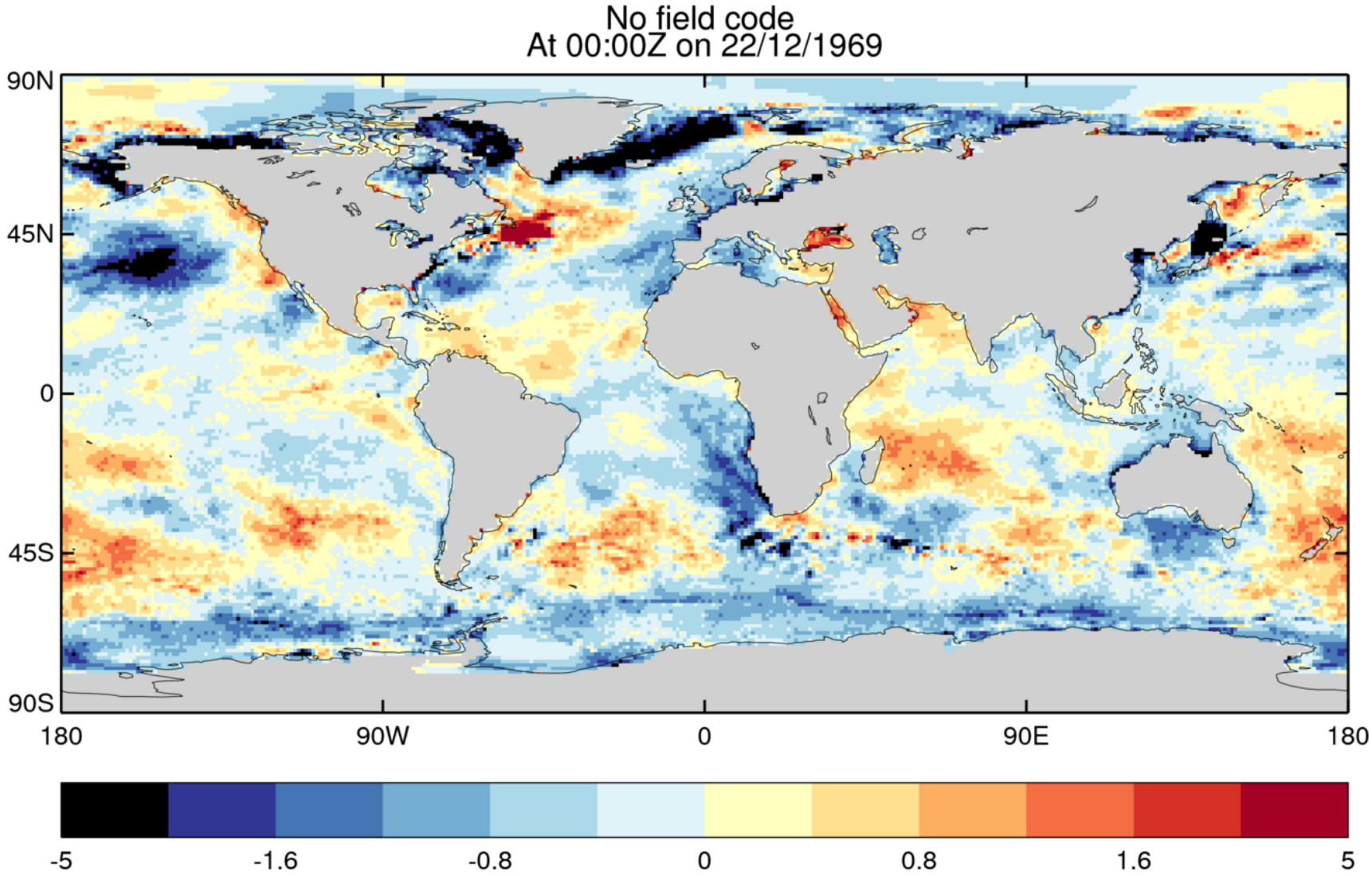

No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5

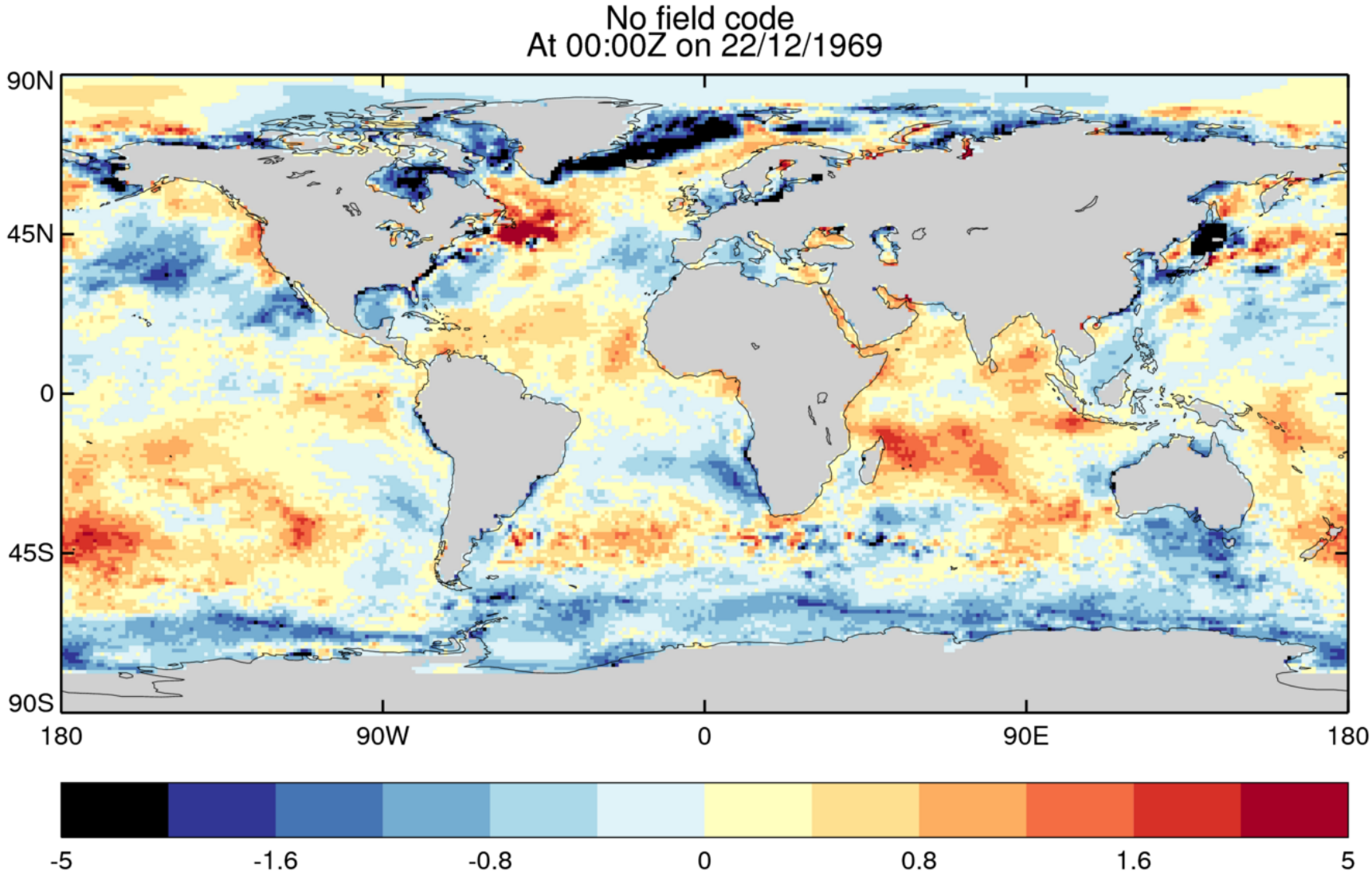

No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5

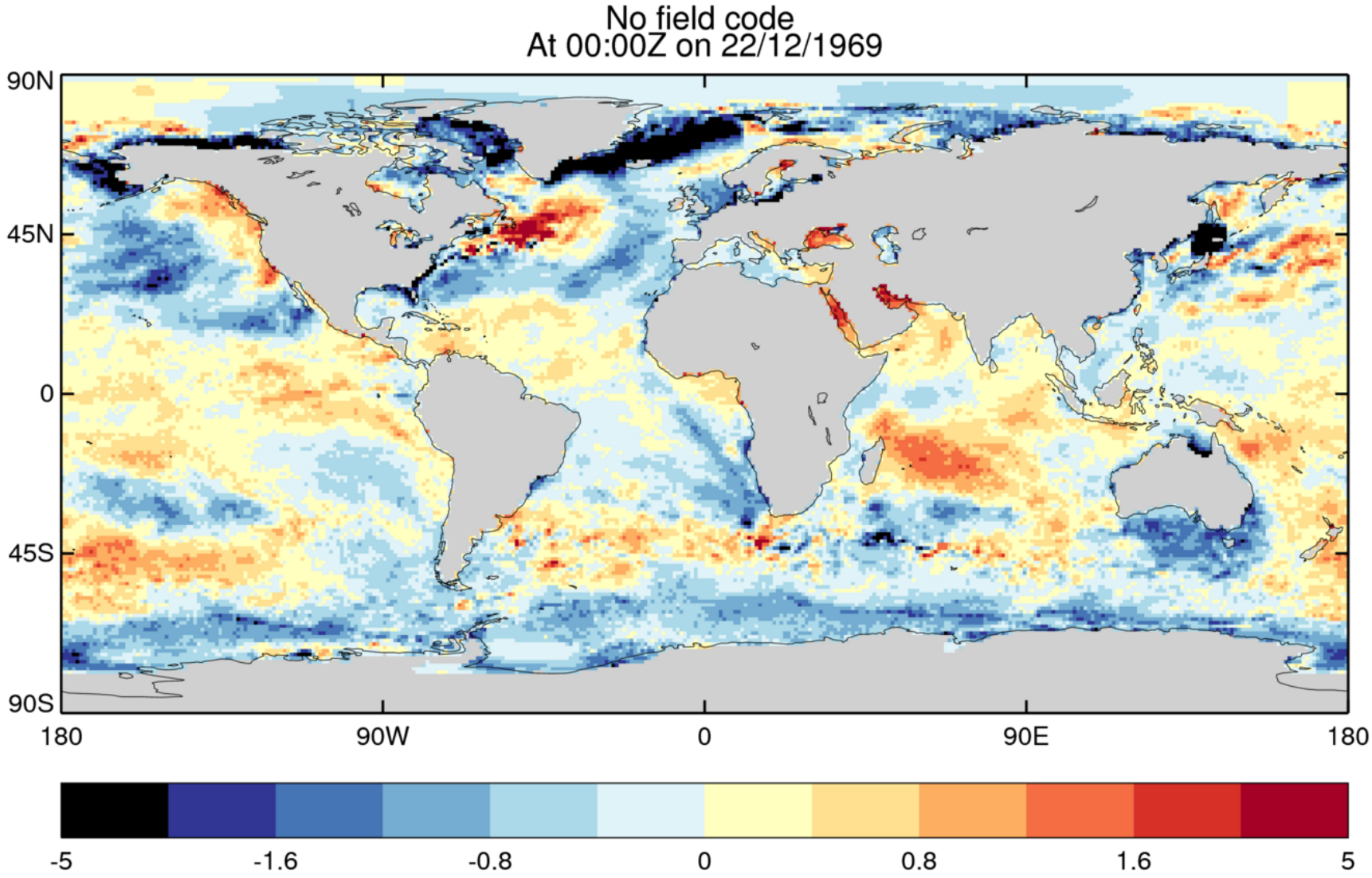

No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5

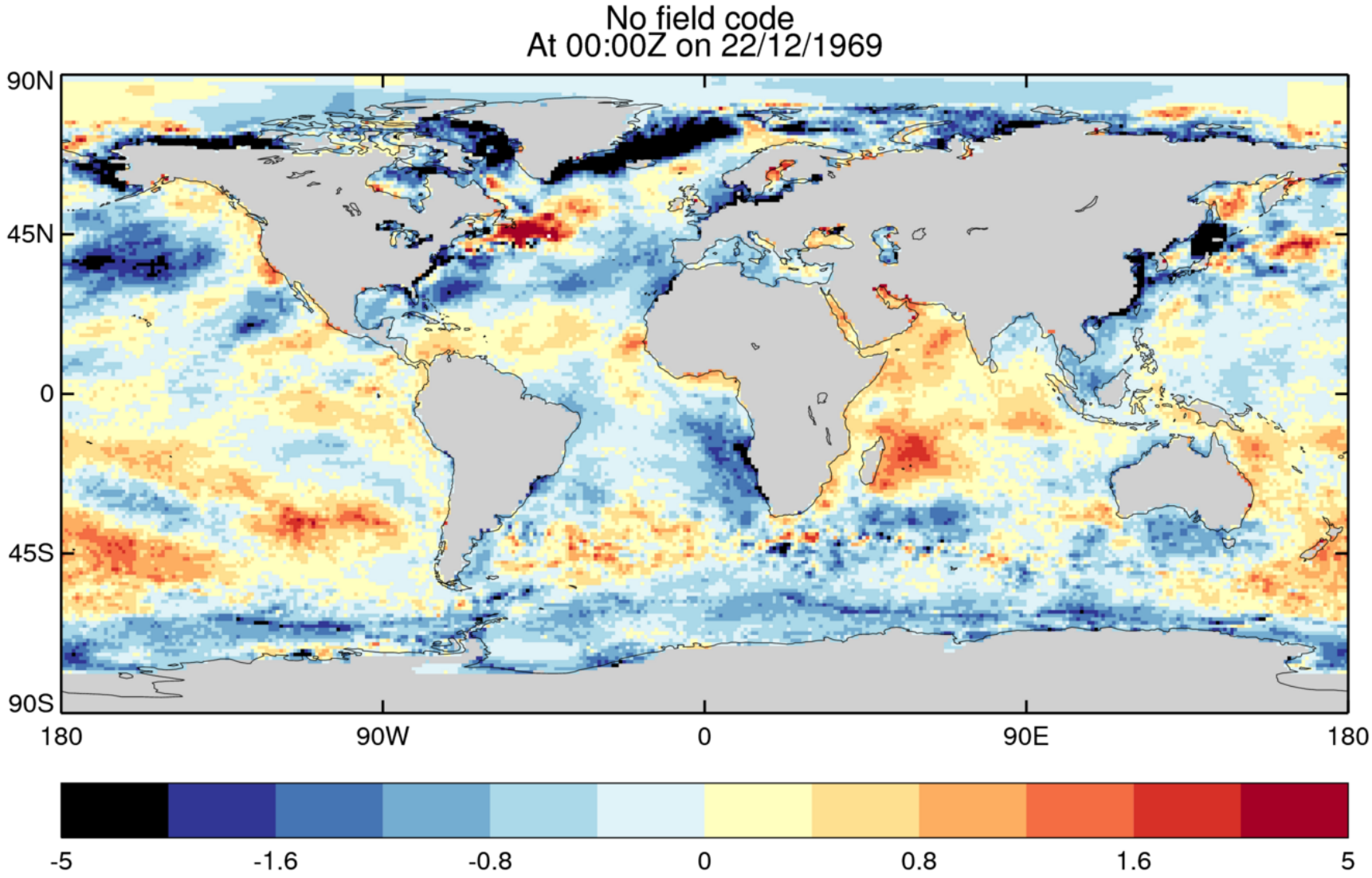

No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5

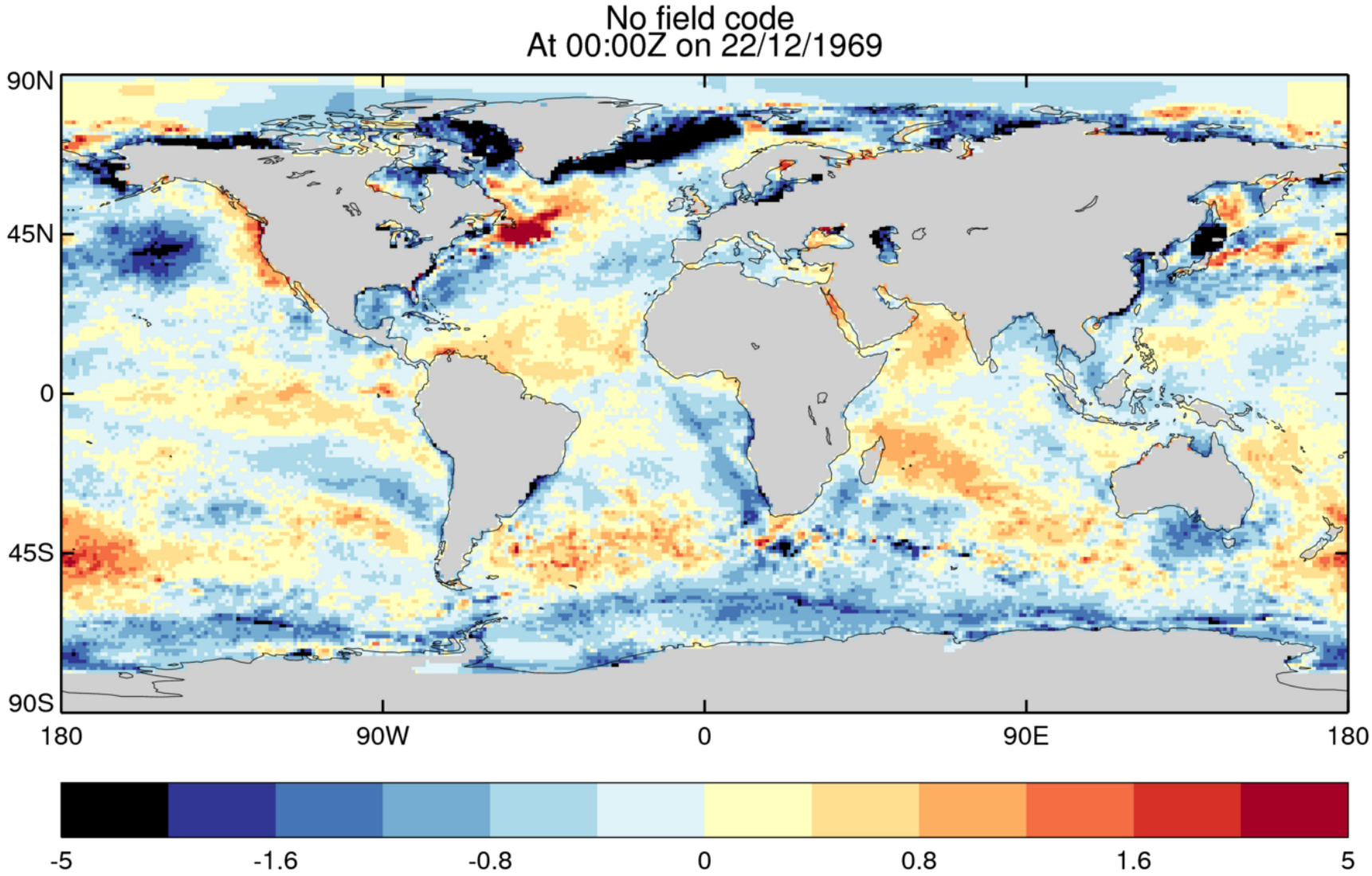

No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5

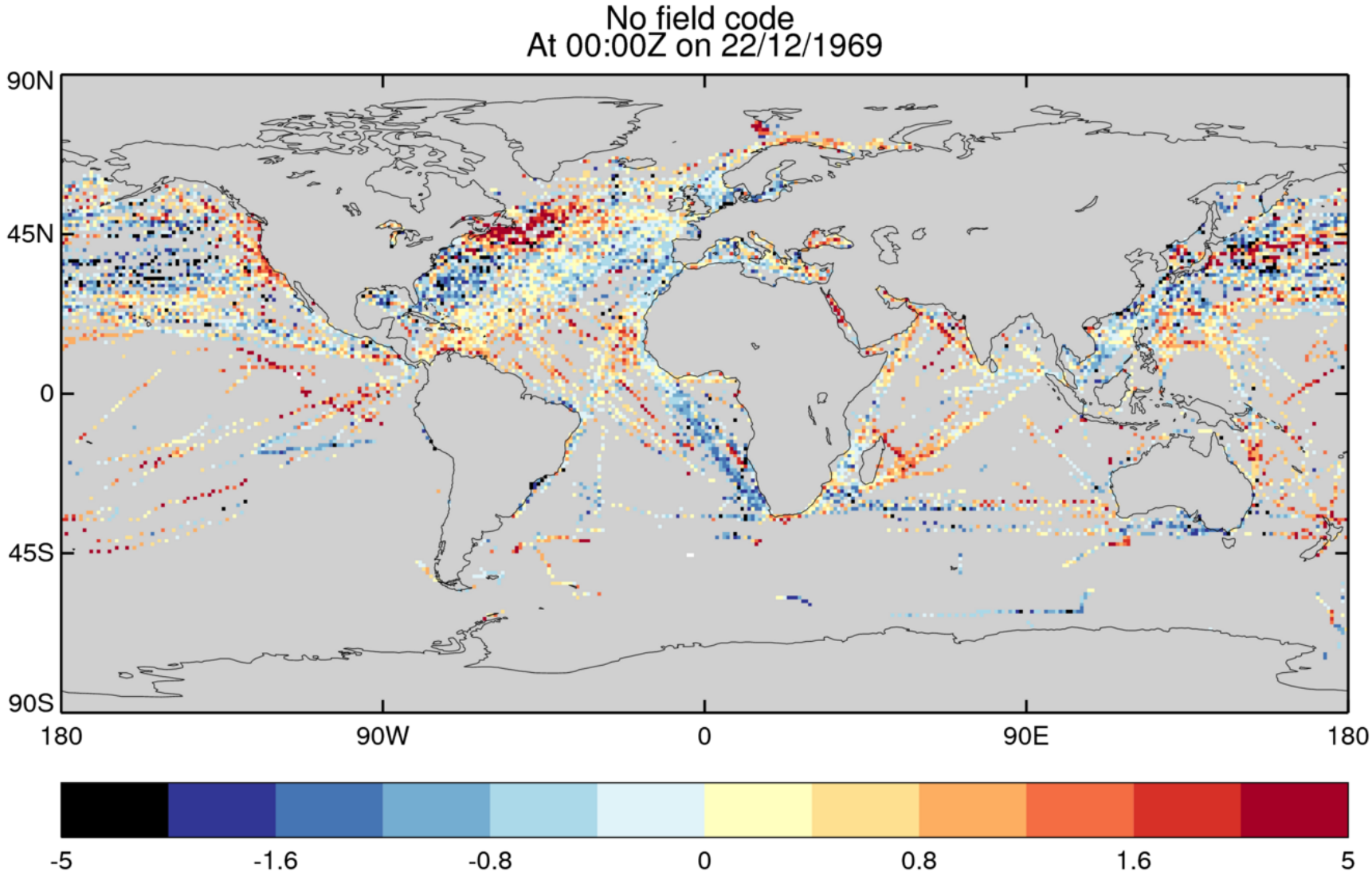

No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5

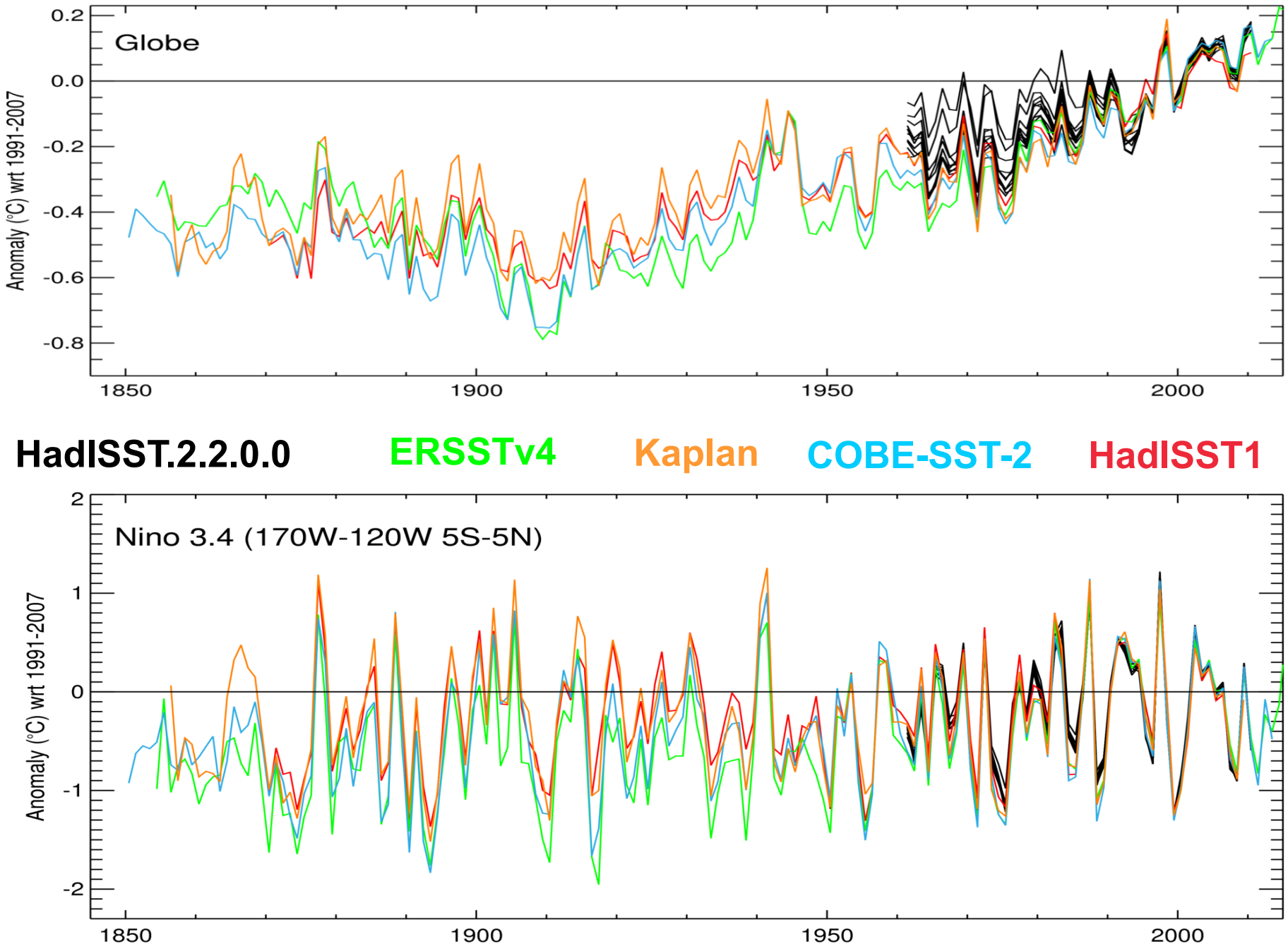

No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5


No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5


No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5


No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5


No field code
At 00:00Z on 22/12/1969
90N
45N
0
45S
90S
180
90W
0
90E
180
-5
-1.6
-0.8
0
0.8
1.6
5


Globe
Anomaly (°C) wrt 1991-2007
0.2
0.0
-0.2
-0.4
-0.6
-0.8
1850
1900
1950
2000
HadISST.2.2.0.0
ERSSTv4
Kaplan
COBE-SST-2
HadISST1
Nino 3.4 (170W-120W 5S-5N)
Anomaly (°C) wrt 1991-2007
2
1
0
-1
-2
1850
1900
1950
2000

Summary and plans

HadISST.2.2.0.0

5-day 1°x1° lat-lon, 1961-2010

10 Ensemble members

Bias adjustments for inputs

2-Step Reconstruction

Just finished extension to 2016 using METOP

Monthly 1850-2016 version soon

HadISST.2.1.0.0

Monthly 1°x1° lat-lon, 1850-2010

10 Ensemble members

Questions! Answers?