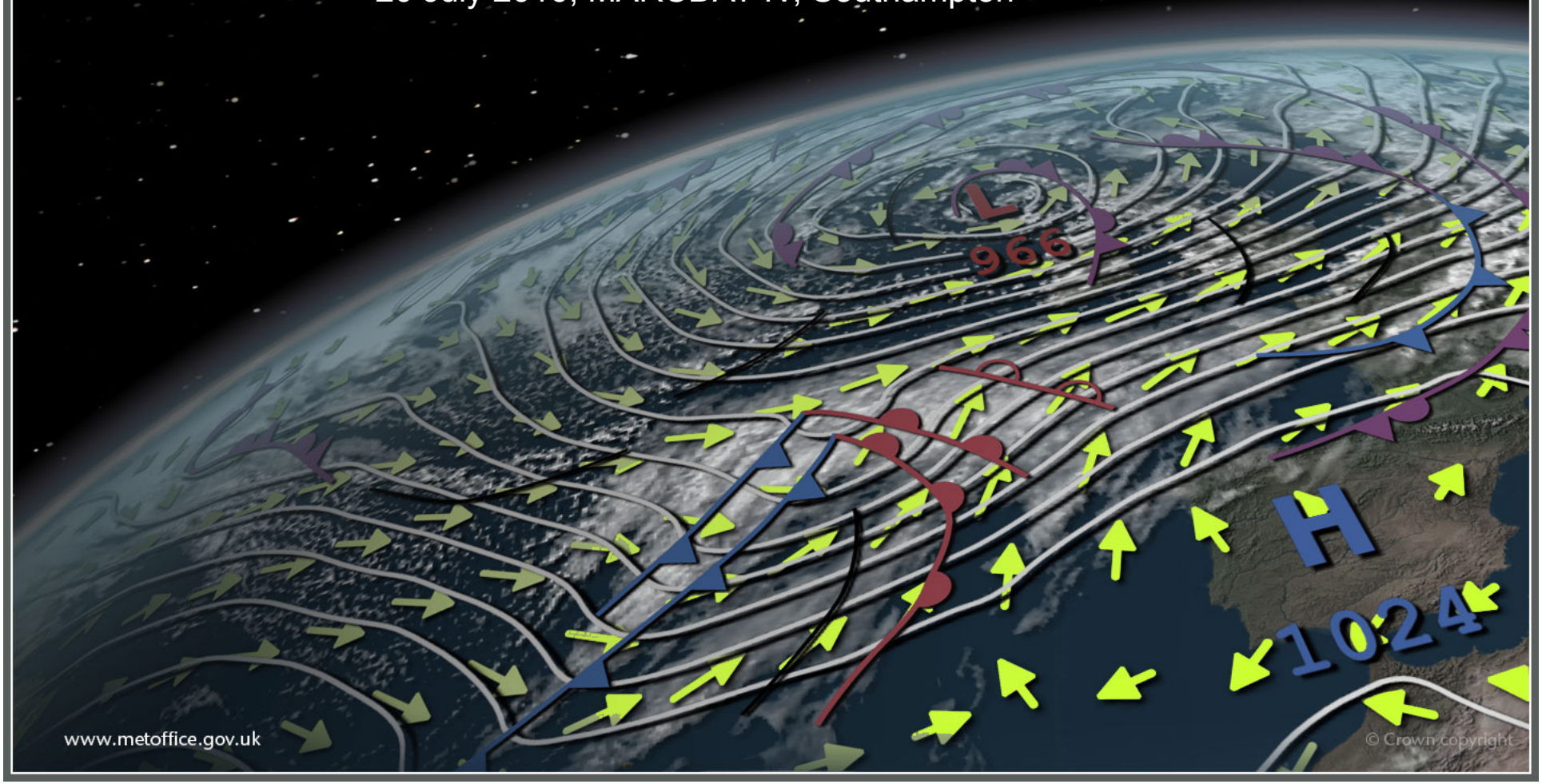
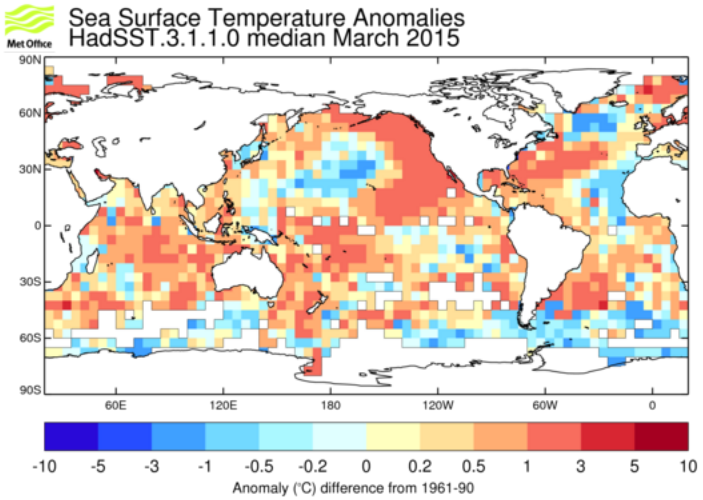
Improvements to the low-resolution Met Office Hadley Centre Sea-Surface Temperature Data Set: HadSST

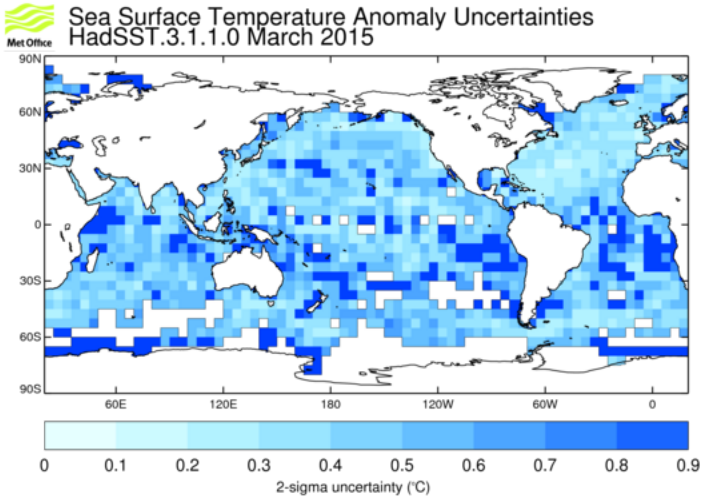
John Kennedy, Chris Atkinson, David Parker, Nick Rayner

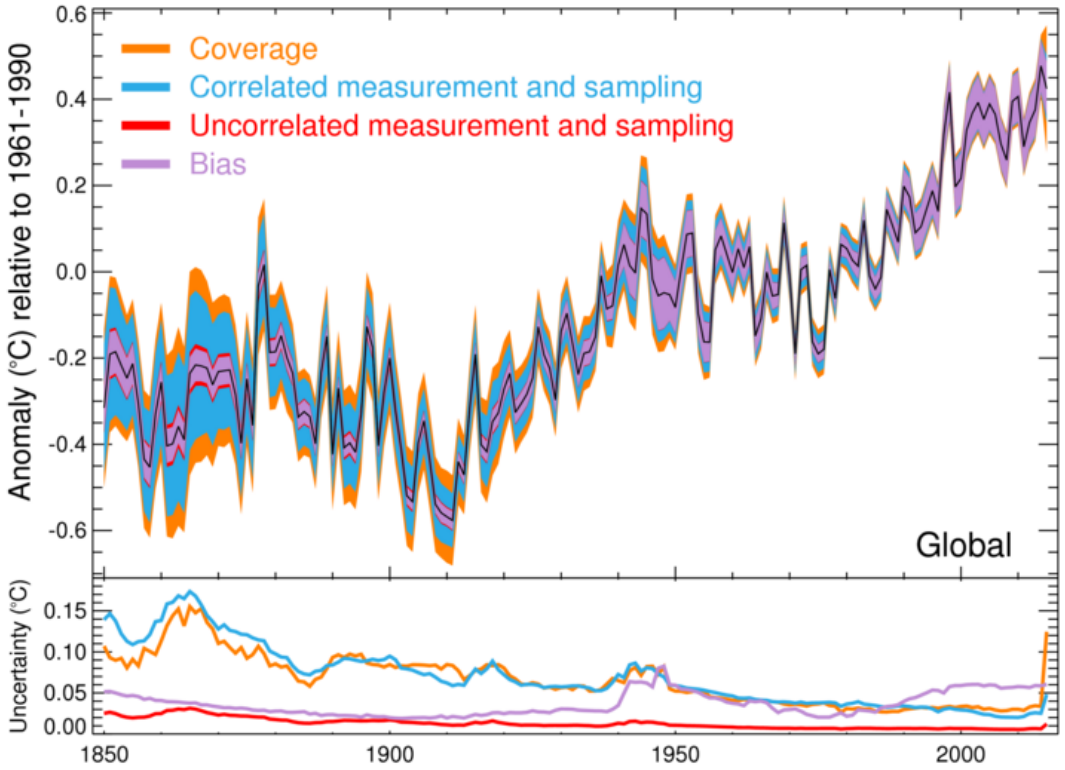
20 July 2016, MARCDAT-IV, Southampton



HadSST.3.1.1.0


Sea Surface Temperature Anomalies
HadSST.3.1.1.0 median March 2015
90N
60N
30N
0
30S
60S
90S
60E
120E
180
120W
60W
0
-10 -5 -3 -1 -0.5 -0.2 0 0.2 0.5 1 3 5 10
Anomaly (°C) difference from 1961-90


Sea Surface Temperature Anomaly Uncertainties
HadSST.3.1.1.0 March 2015
90N
60N
30N
0
30S
60S
90S
60E
120E
180
120W
60W
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
2-sigma uncertainty (°C)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-0.4
-0.6
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0.15
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0.05
0.00
1850
1900
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2000

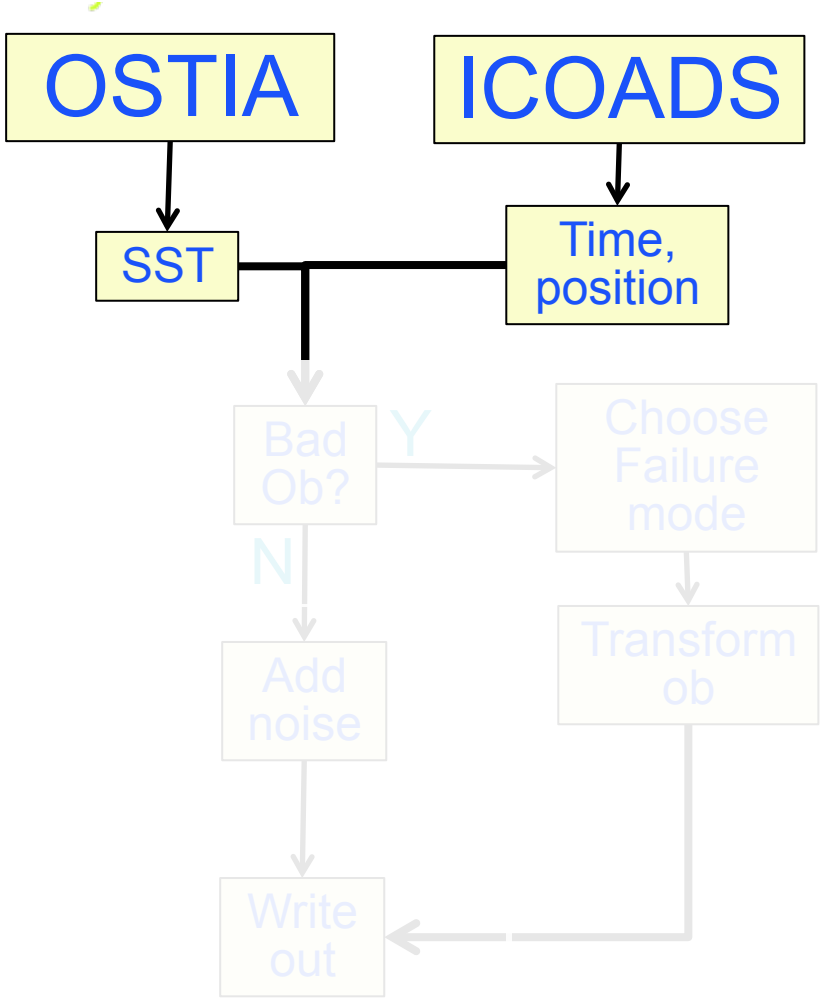
Basic upgrades

- Quality Control – recoded in Python.
  - Climatology checks
  - Buddy check reimplemented
  - Repeated value checks
  - Track checks
  - Some IQUAM checks: track and spike
  - Improved Kill File
- Gridding
  - Gridding and uncertainty estimation integrated so that uncertainties are propagated correctly
  - Improved estimates of sampling uncertainty

More selective use of data sources

- Still using ICOADS 2.5 (because it's awesome)
- Excluding Deck 780 – World Ocean Database
- Excluding CMAN stations
- Excluding ad hoc moorings

SST Benchmarks for QC



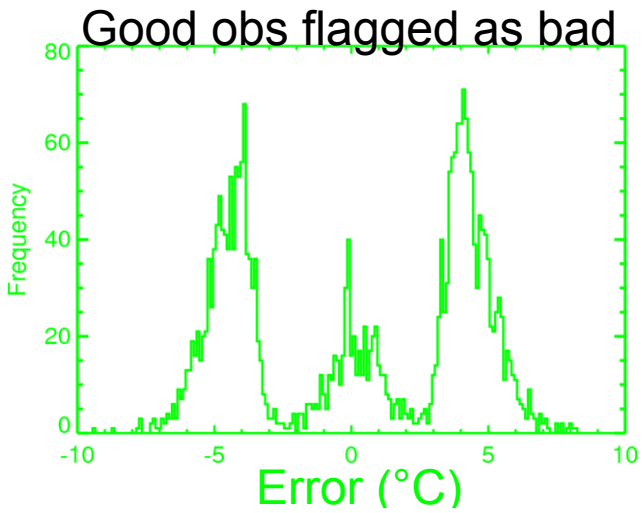
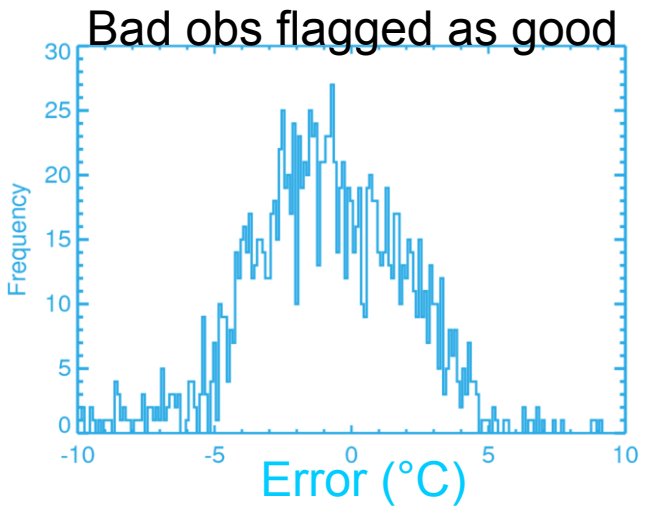
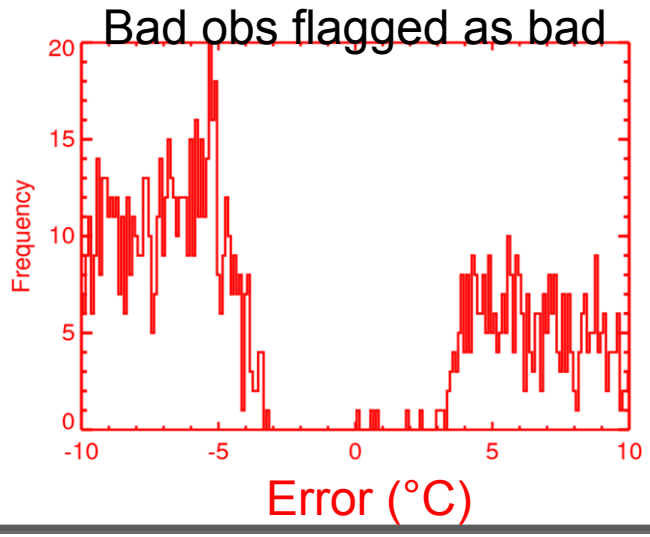
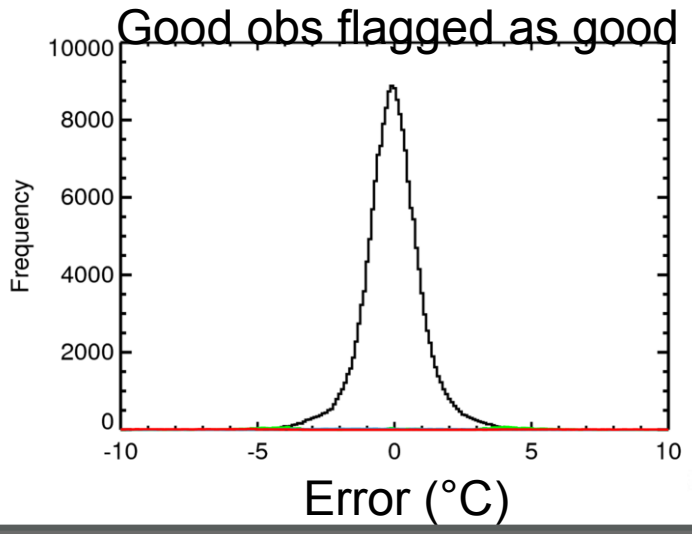
Failure modes

- Utterly scrambled
- Factors of ten
- Mysterious zeroes
- Scale transformations F˚→C˚
- Large Gaussian error
- Badship

Parameters

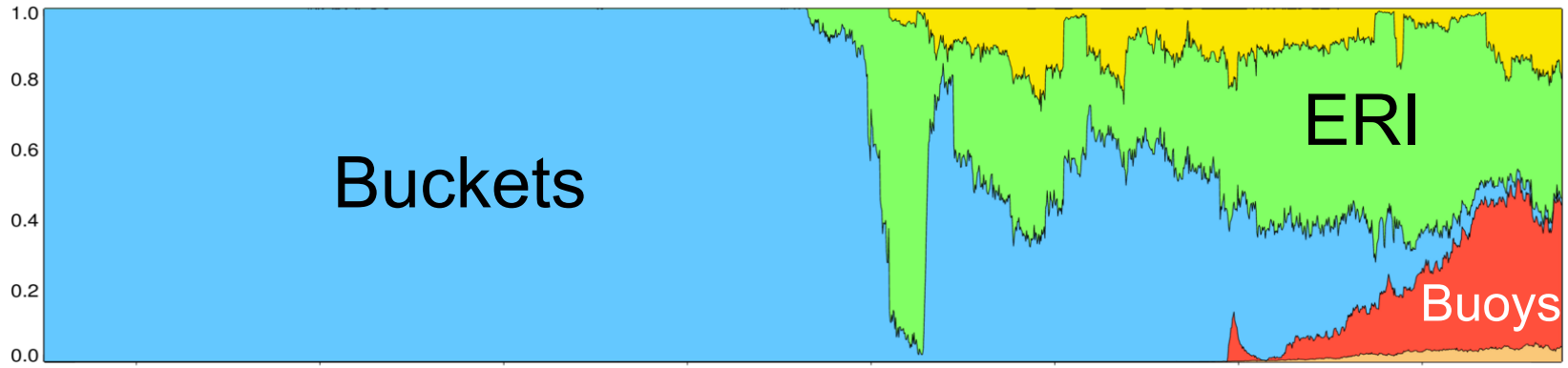
- Fraction of bad obs
- Fraction of rounded obs
- Measurement error uncertainty
- Distribution shape
- Ship microbias uncertainty

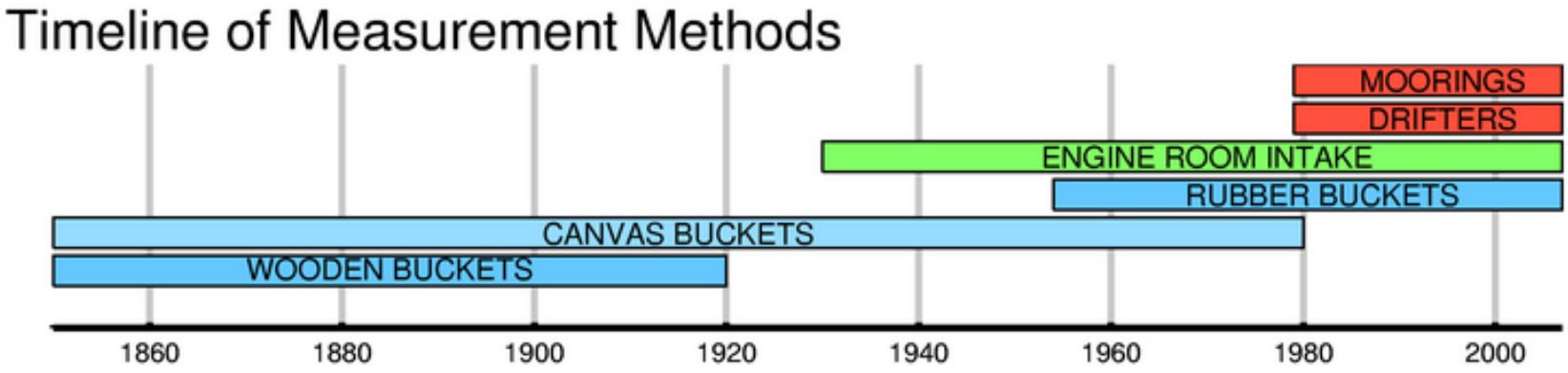
SST benchmark tests

	Fail	Pass
BAD		
GOOD		

Estimating Biases

Measurement methods





Buoys as baseline

- Now have good evidence that drifters are a reasonable reference data set

- Previous version of HadSST used ships, which increases uncertainty

$$B_{tr} = \frac{B_r\left(1-\bar{f}_c\right) + \bar{f}_c B_c + \overline{f_e E} + \bar{f}_d D}{\left(1-\bar{f}_r-\bar{f}_c\right)}$$

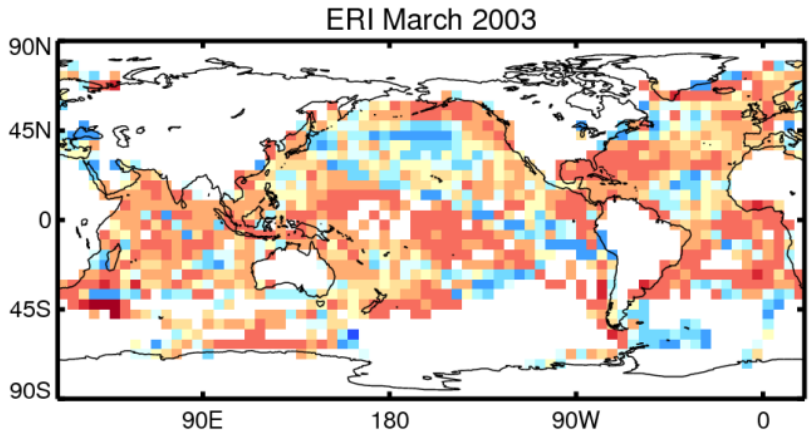
$$B_{tc} = \frac{B_c\left(1-\bar{f}_r\right) + \bar{f}_r B_r + \overline{f_e E} + \bar{f}_d D}{\left(1-\bar{f}_r-\bar{f}_c\right)}$$

Broader range of parameters to twiddle

1. Bucket uncertainty from Rayner et al. 2006
2. NMAT data set used to estimate bucket fractions
3. NMAT uncertainty
4. Alternative bucket model Smith and Reynolds 2002
5. Adjustments for modern buckets
6. Metadata uncertainty
7. Transition from canvas to rubber
8. Unknown measurement types
9. ERI bias (BIG UNCERTAINTY)

How are we going to estimate ERI bias?

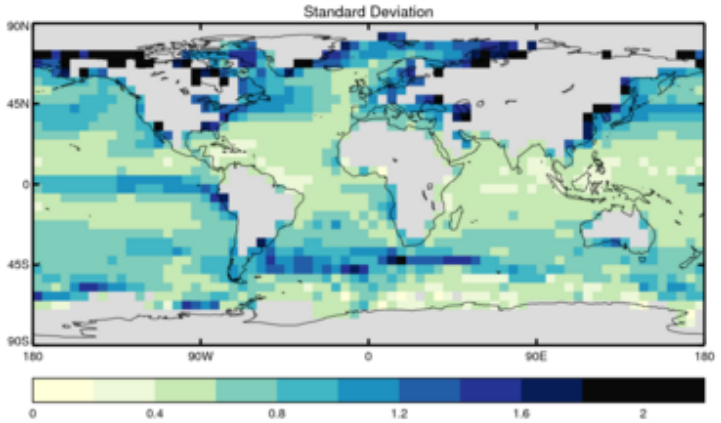
- Use coarsely gridded SST data
- 5 degree latitude by 5 degree longitude monthly
- Model the global SST field as a multivariate Gaussian random field

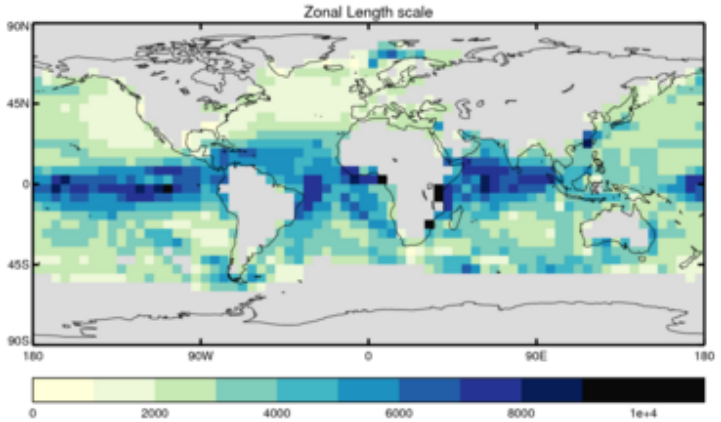


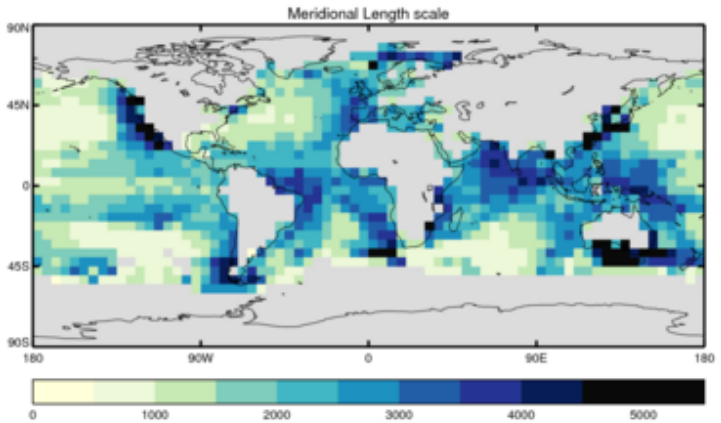
$$SST \sim N(0, C)$$

C - Spatial Covariance

- Spatial covariance a simple function of the zonal and meridional separation between points
- Construct spatially-varying length scale and variance
- Using method of Karspeck et al. 2012

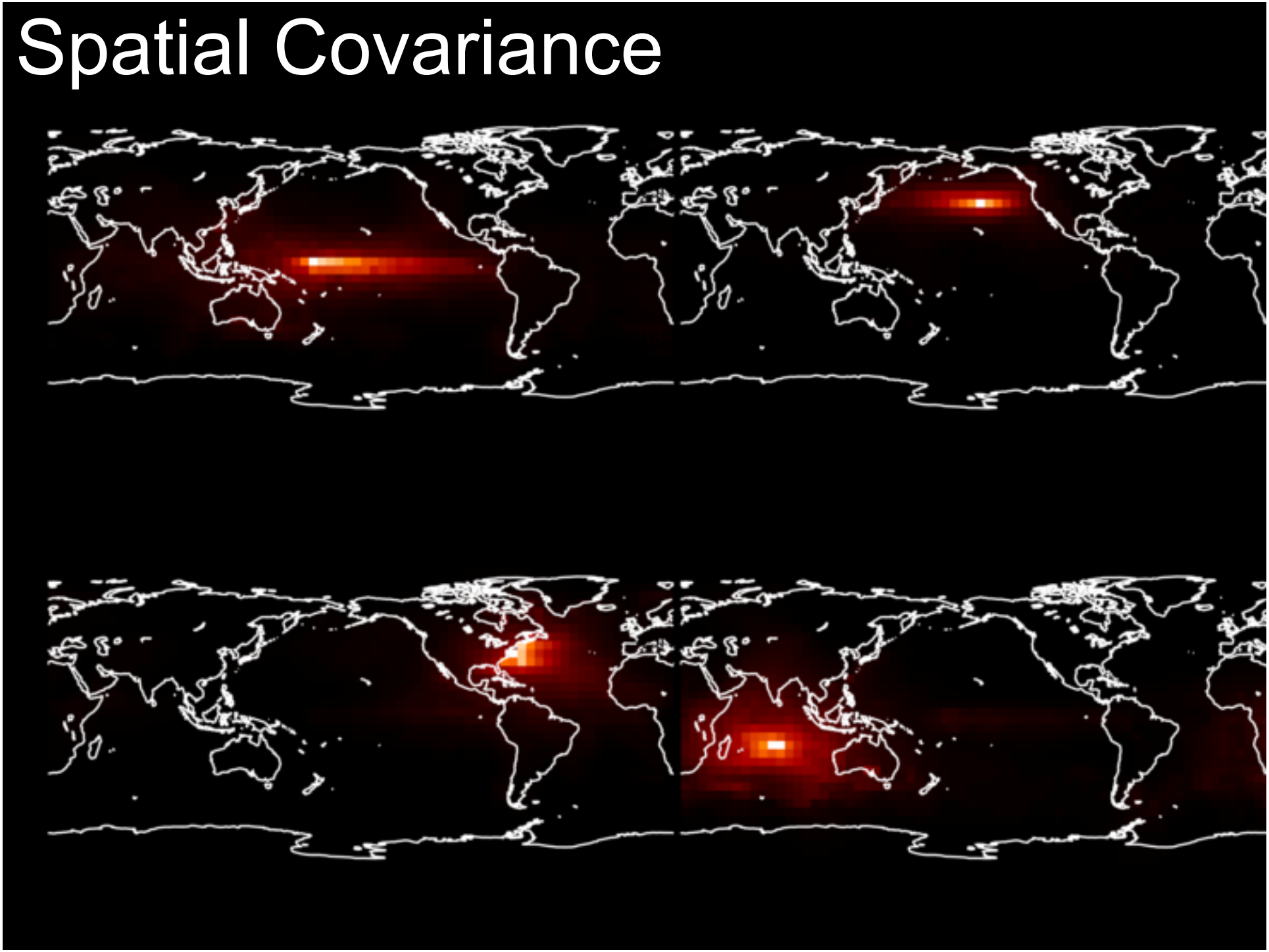






Karspeck, A. R., Kaplan, A. and Sain, S. R. (2012), Bayesian modelling and ensemble reconstruction of mid-scale spatial variability in North Atlantic sea-surface temperatures for 1850–2008. Q.J.R. Meteorol. Soc., 138: 234–248. doi: 10.1002/qj.900

Spatial Covariance



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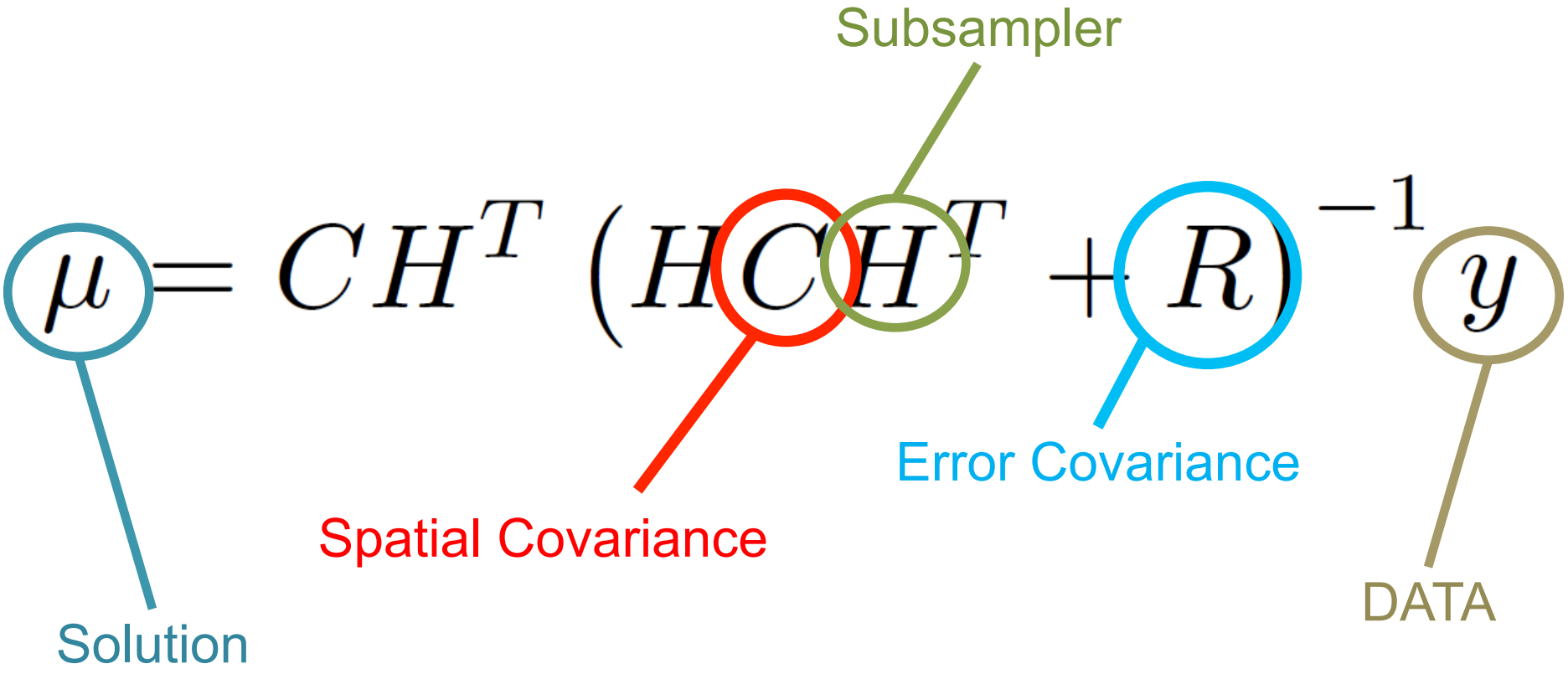


How are we going to estimate ERI bias?

$$\mu = R\left(HCH^T + R\right)^{-1} y$$

Estimate of error

DATA

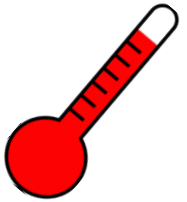
The really nice thing about R is that you can break it down into separate components: individual ships, all German ships, all ships using a particular measurement system

Error covariance (R)

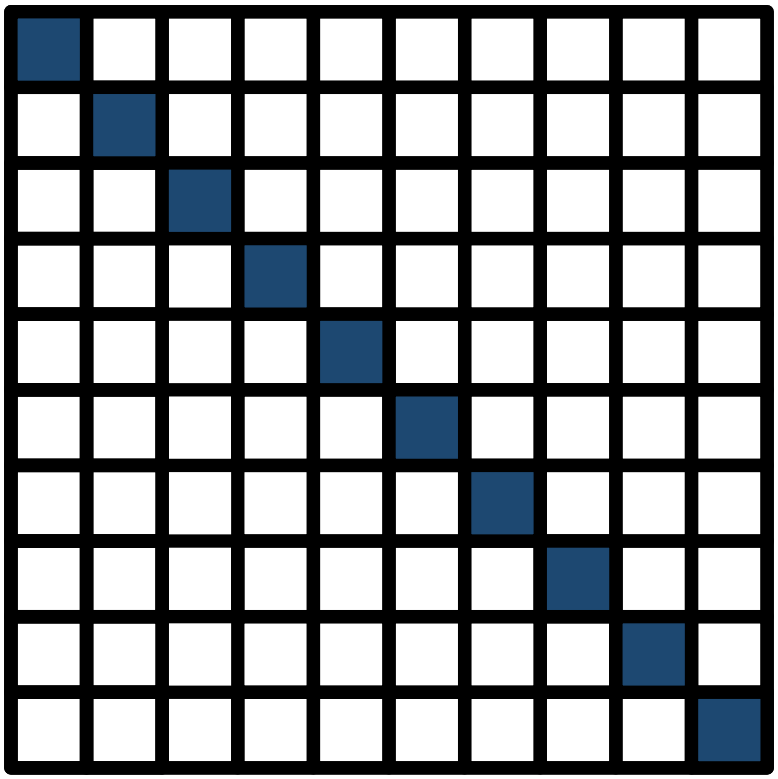
Observation = SST + a bunch of error terms

Error covariance (R)

Errors which affect each measurement differently



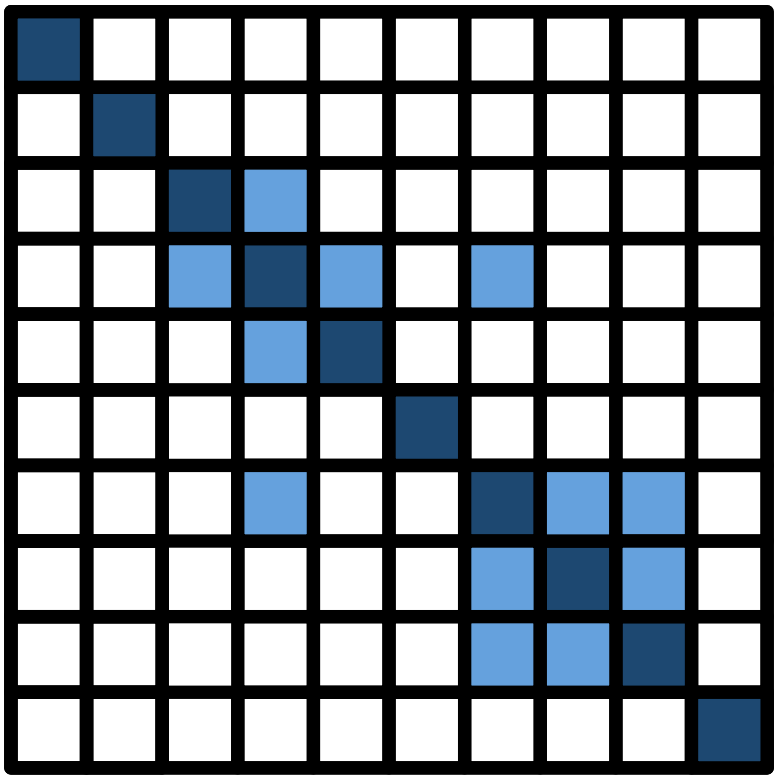
Observation = SST + Uncorrelated error



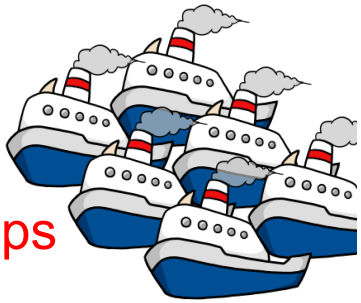
Error covariance (R)

Errors which affect each ship differently

Observation = SST + Uncorrelated error + Micro bias

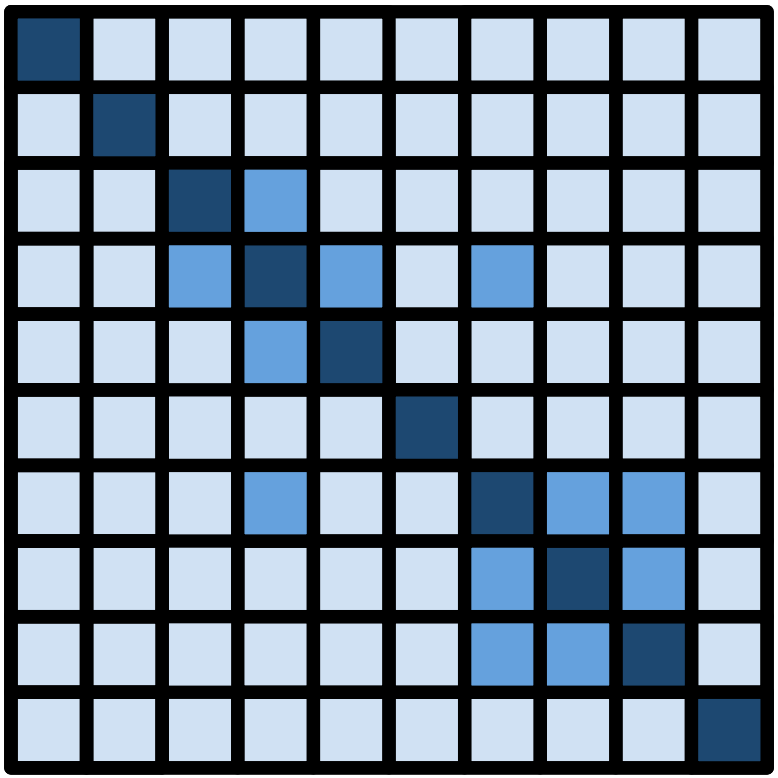


Error covariance (R)

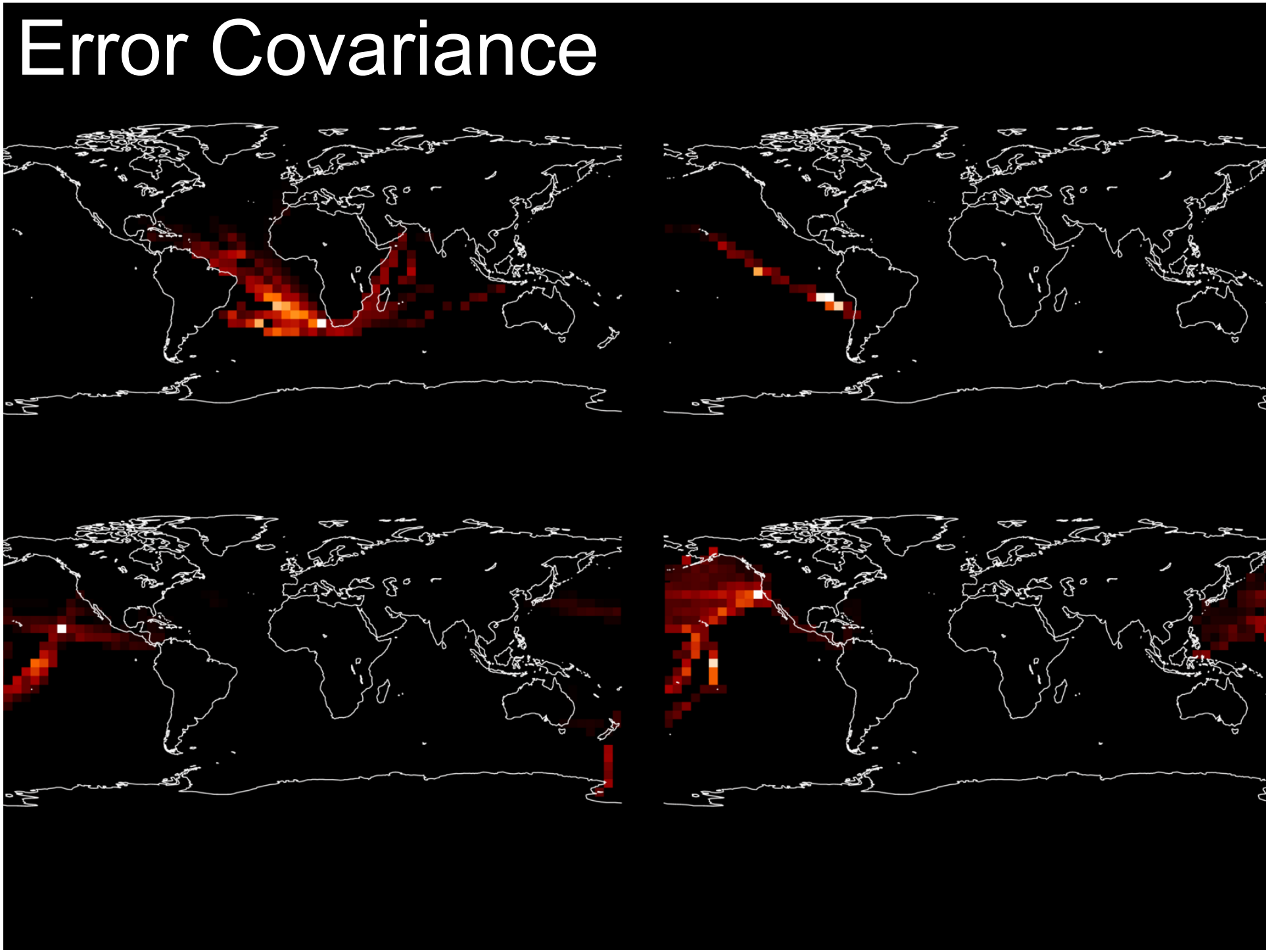


Errors which affect the whole global fleet of ships

Observation = SST + Uncorrelated error + Micro bias + Macro bias



Error Covariance



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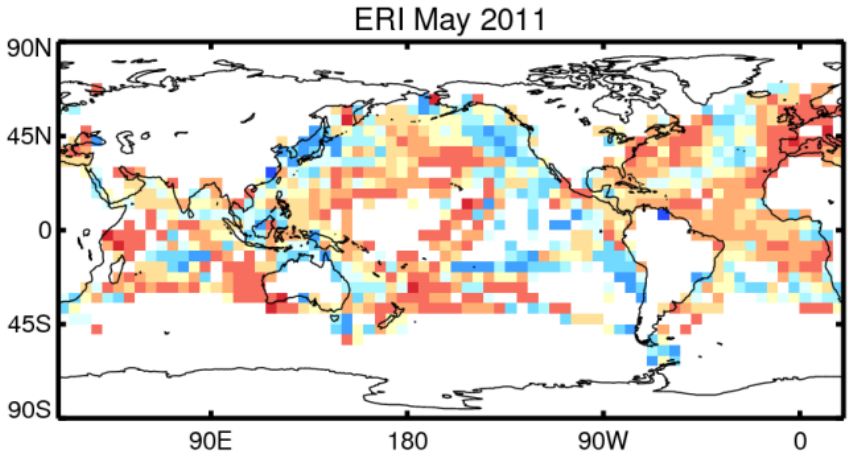
Two step assimilation of data

1. Make spatial covariance
2. Assimilate buoy data
3. Update mean and covariance
4. Assimilate Engine Room data
5. Estimate macro and micro bias terms

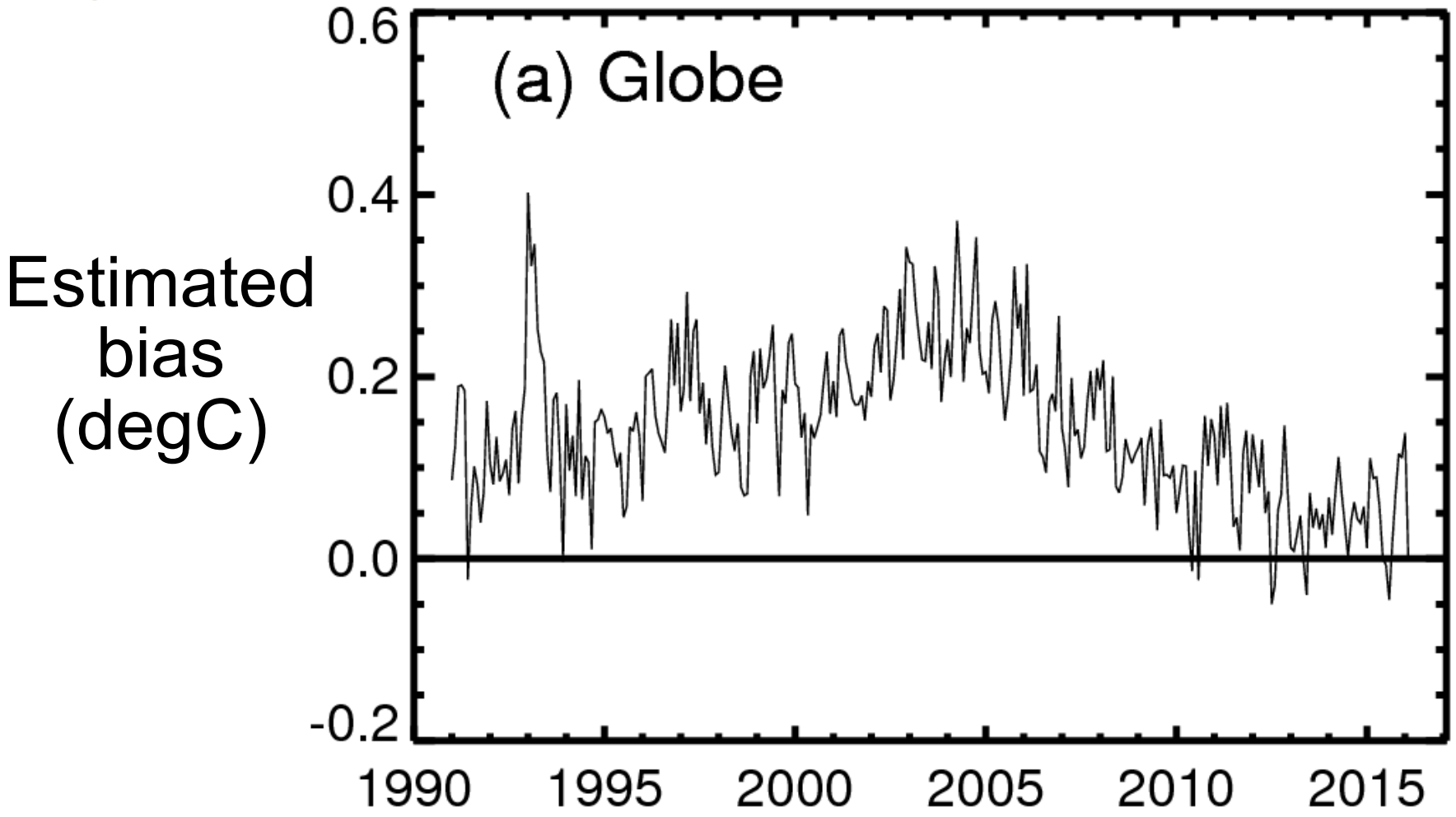
Compare ship data to reliable satellite estimates

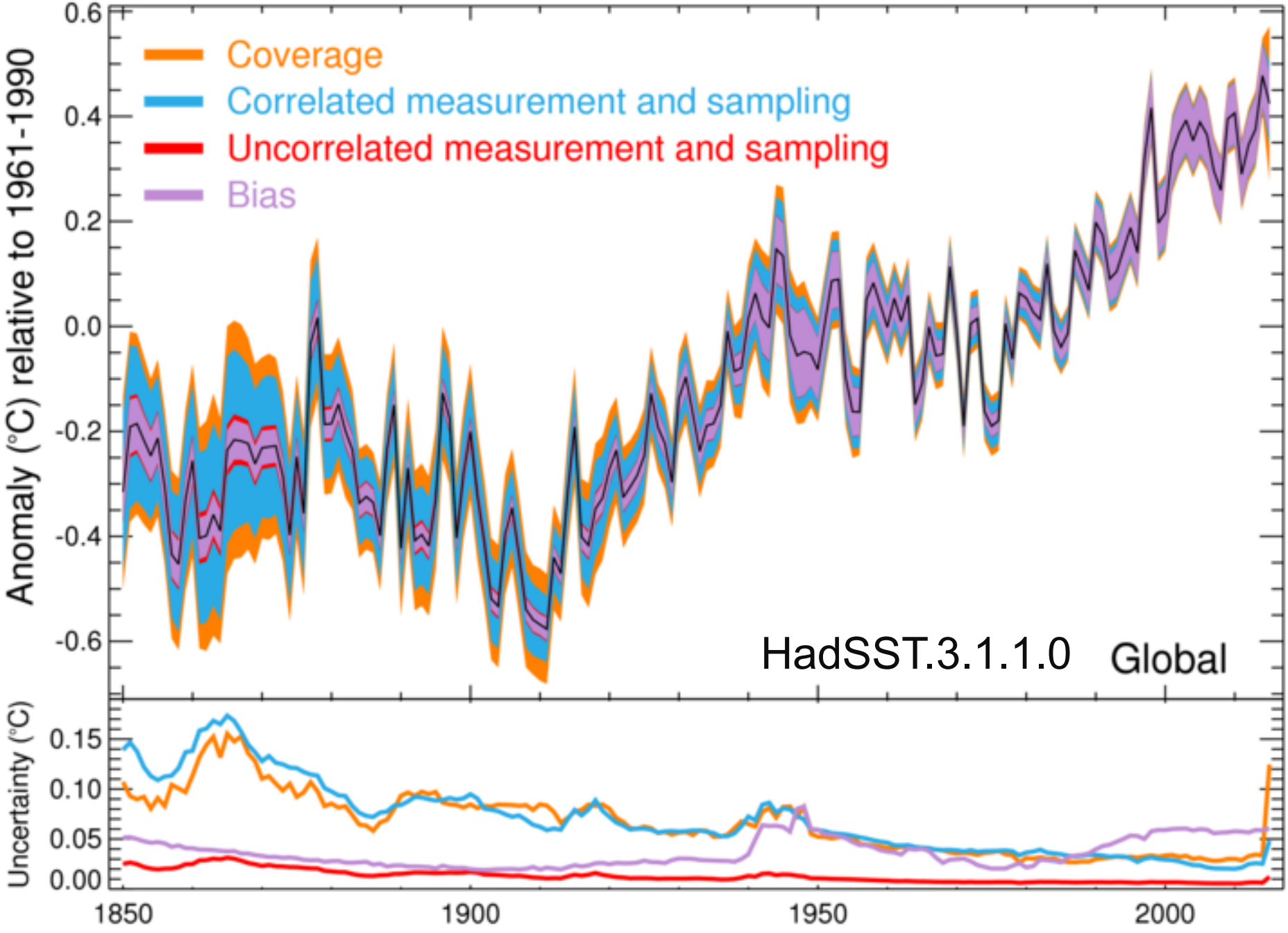


SST retrievals from the Along Track Scanning Radiometer instruments as processed in the ARC project (ATSR Reanalysis for Climate)

Merchant, C. J., et al. (2012), A 20 year independent record of sea surface temperature for climate from Along-Track Scanning Radiometers, J. Geophys. Res., 117, C12013, doi:10.1029/2012JC008400.

Recent reduction in ERI biases

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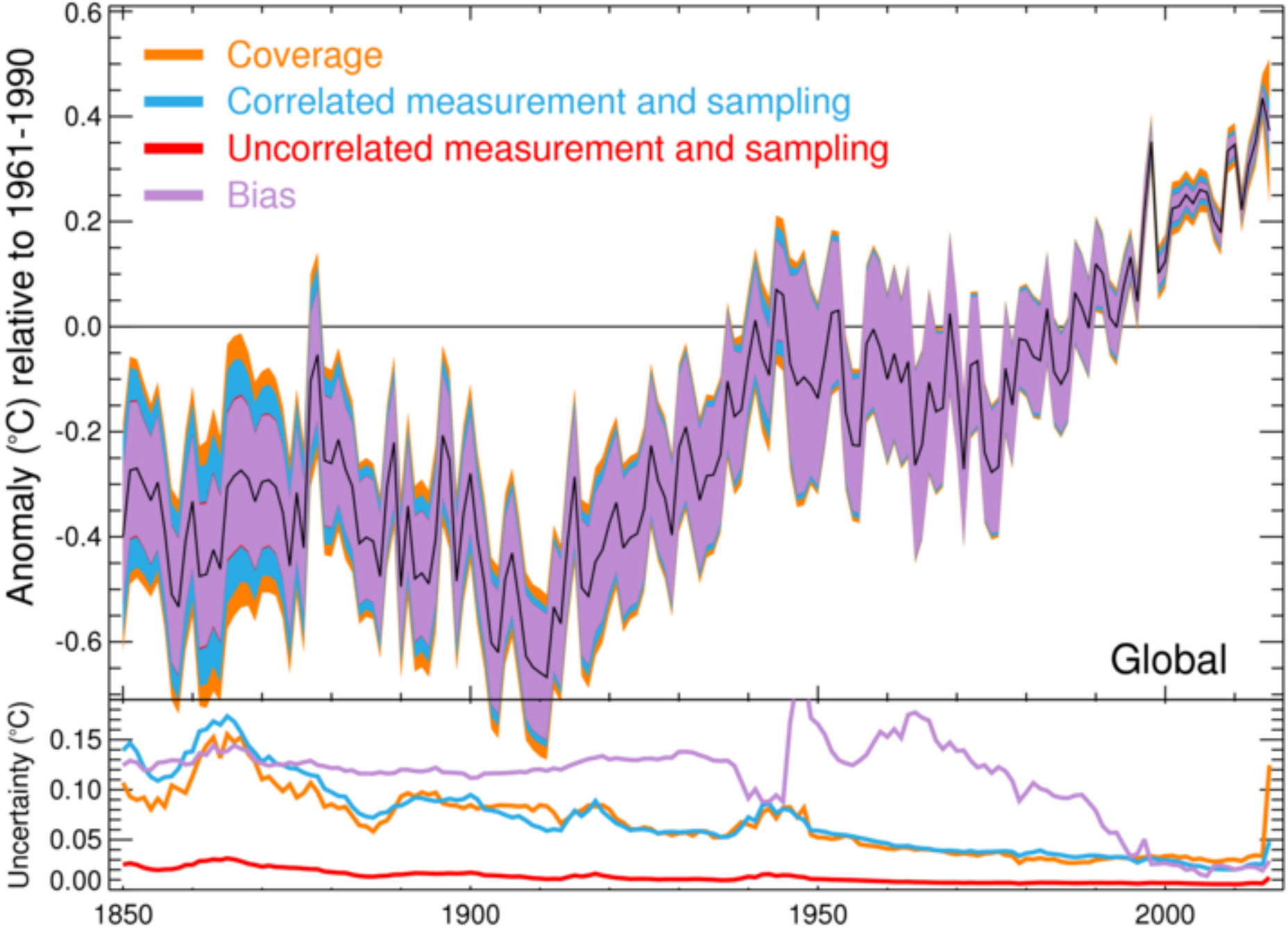
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Summary

Towards HadSST.3.2.0.0

- Updated QC with benchmarks
- Wider parameter range in bias adjustments
- Improved engine room bias estimation

- Aim to update with ICOADS 3.0

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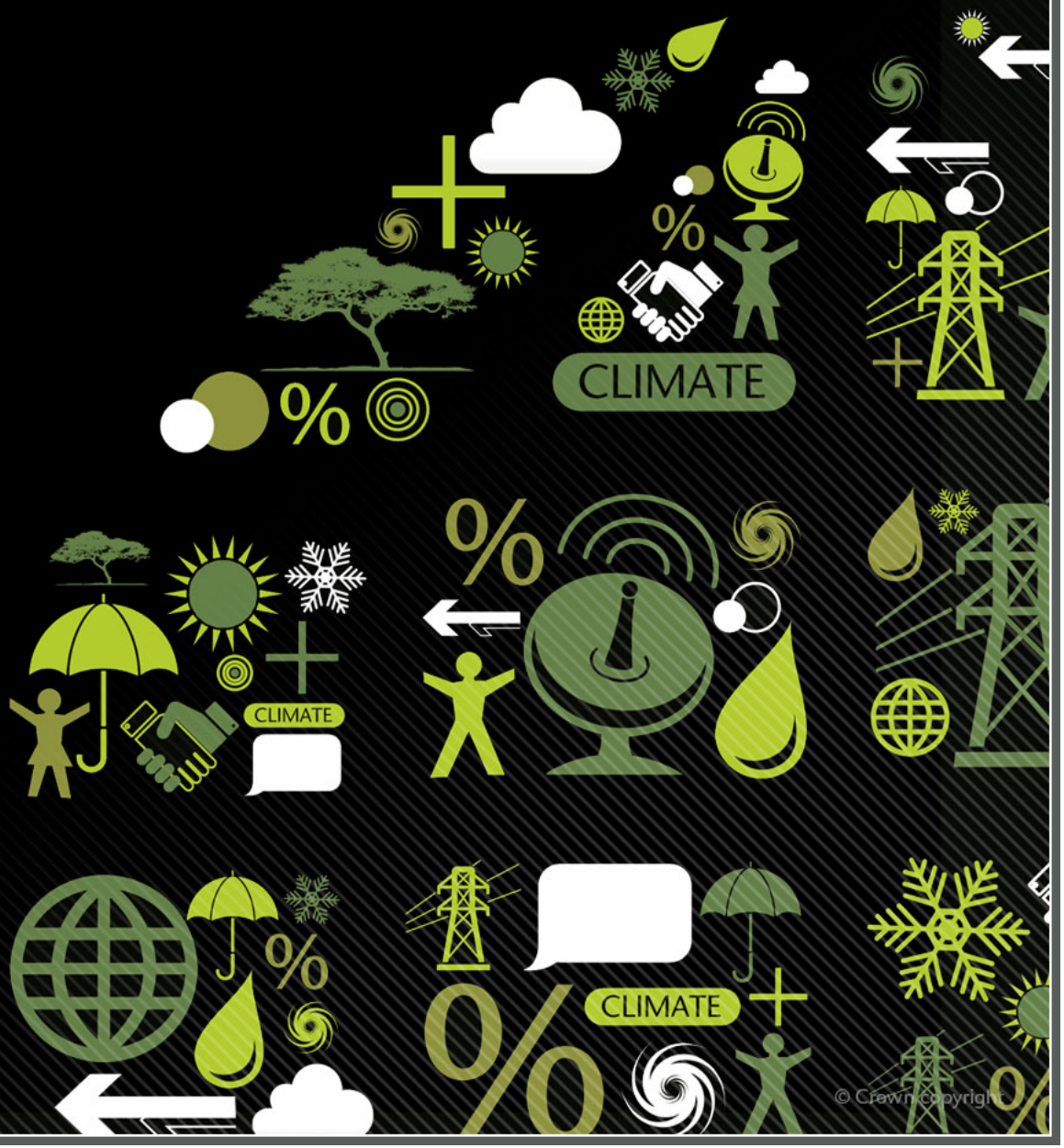
Questions?



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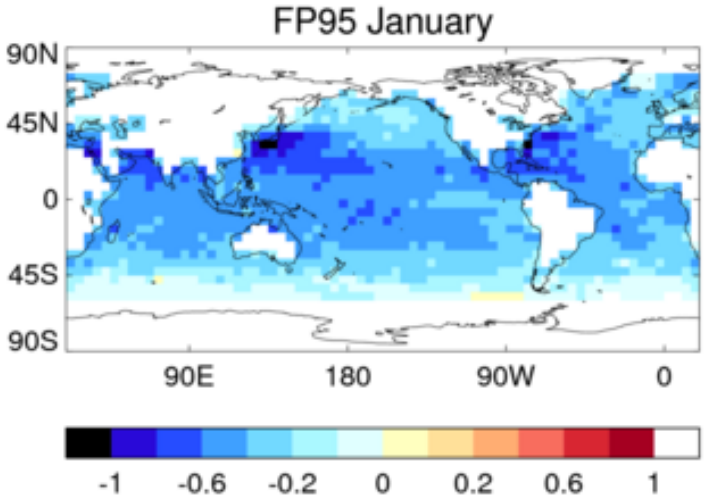
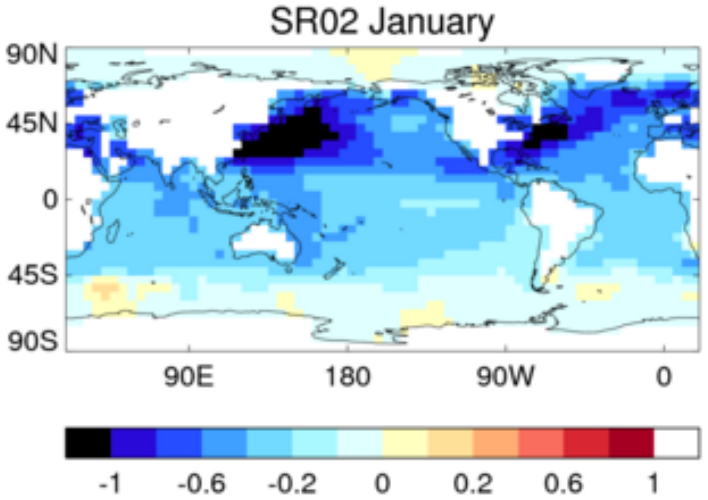
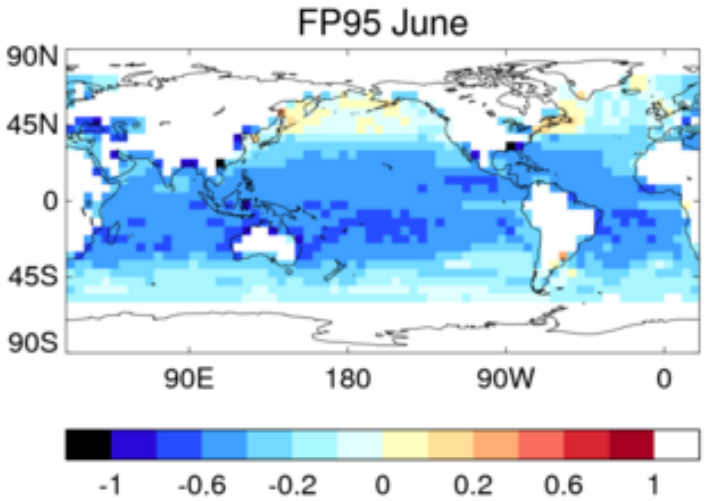
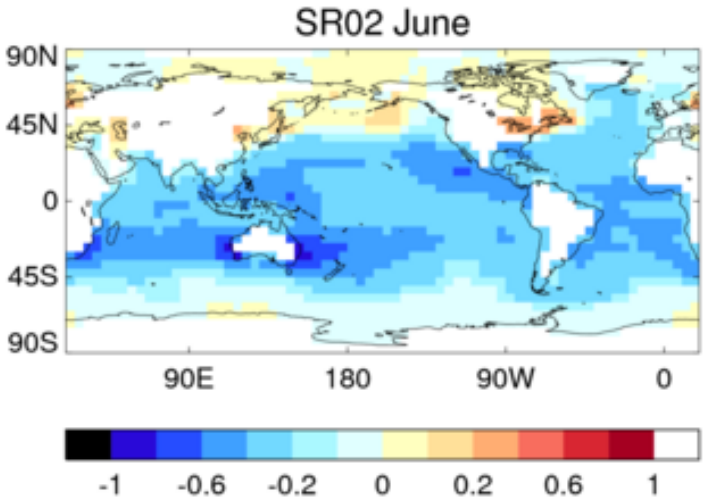
Bucket models



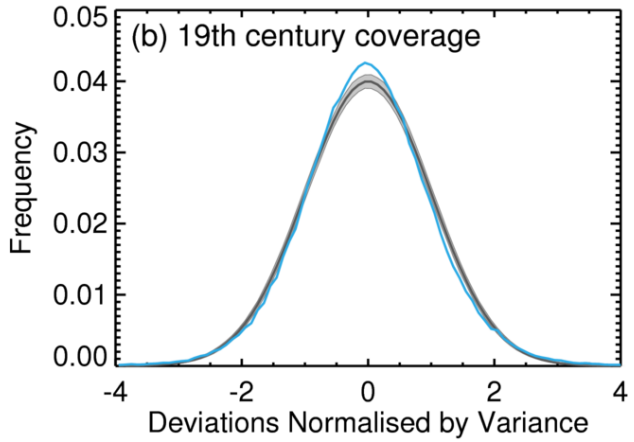


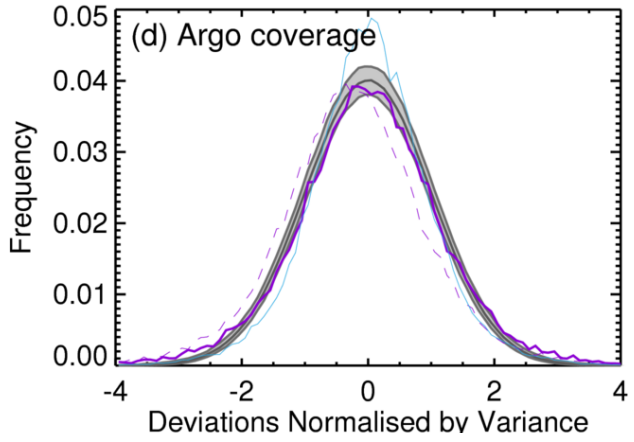


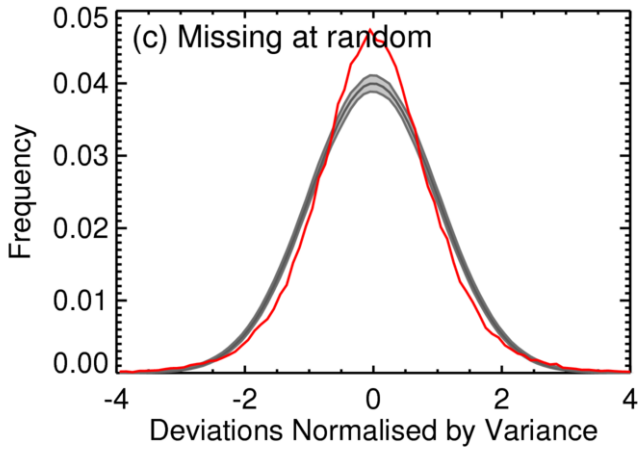


Testing the method

- Withhold data
- Reconstruct field based on remainder
- Draw samples from the posterior distribution (grey shading)
- Compare to actual deviations (coloured lines)
- Three separate tests







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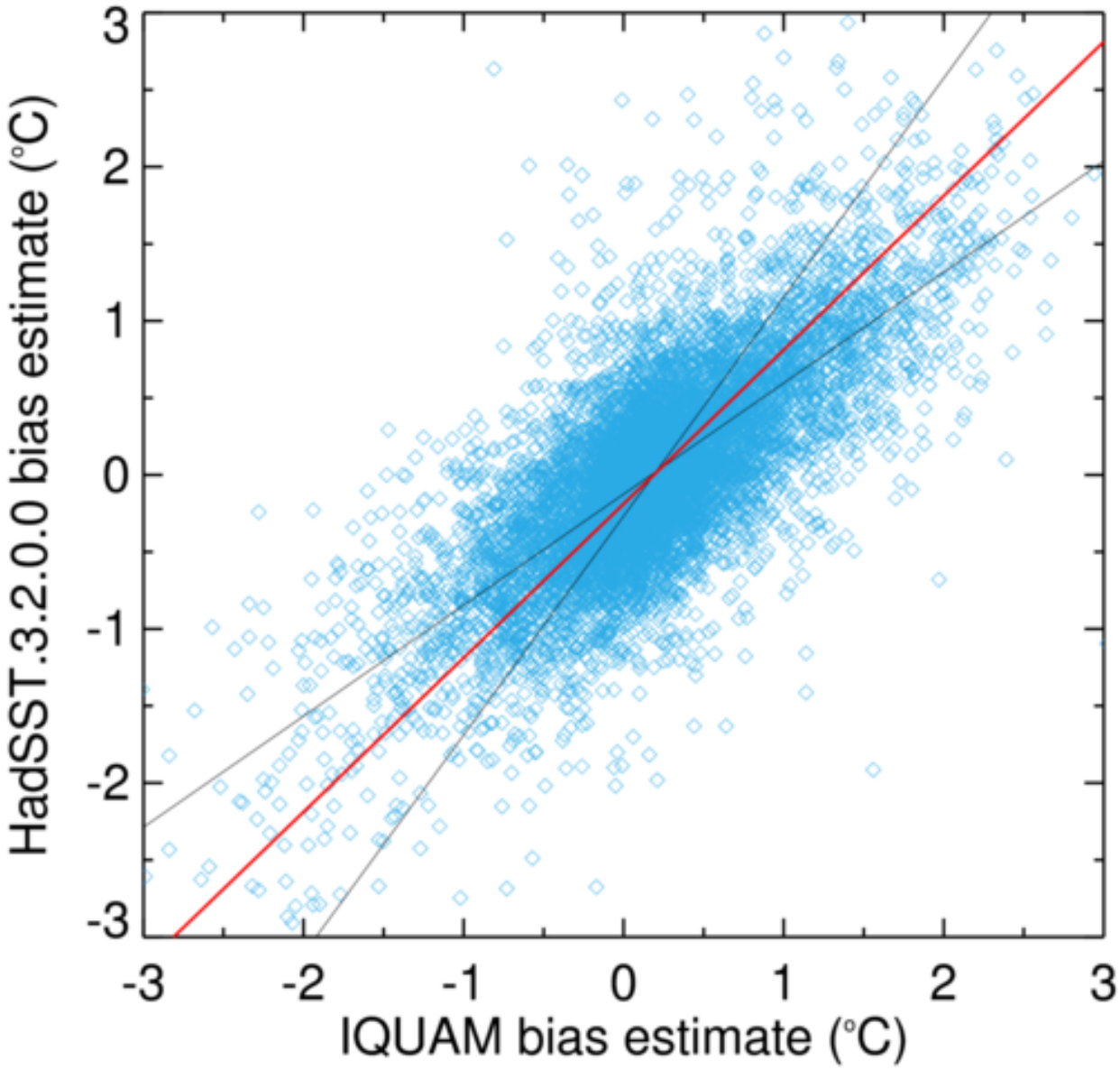
- Compare to other estimates of ship biases
- IQUAM uses a combined satellite and in situ background field to estimate ship biases



In situ SST Quality Monitor (iQuam)Feng Xu and Alexander Ignatov. Journal of Atmospheric and Oceanic Technology 2014 31:1, 164-180

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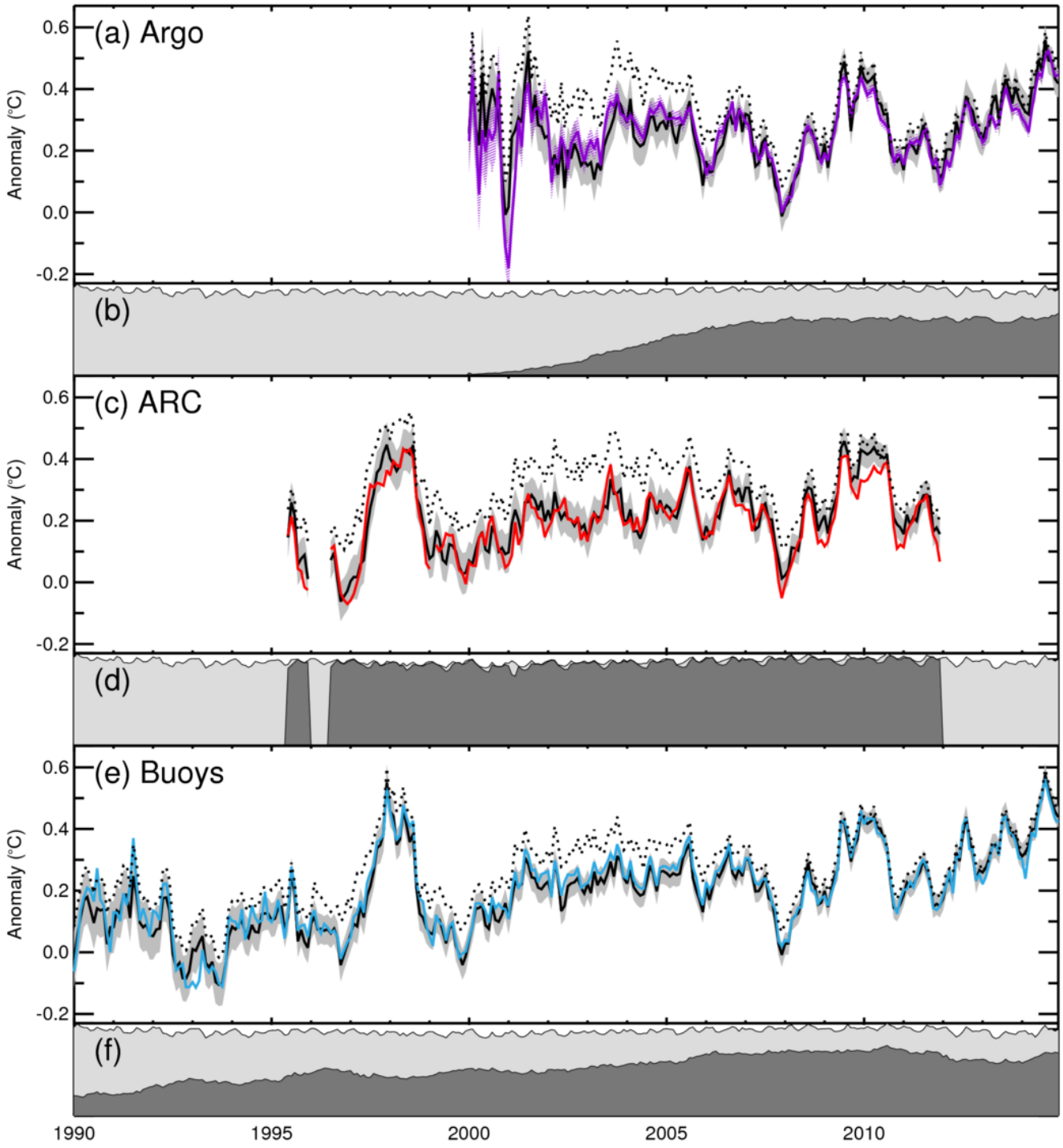
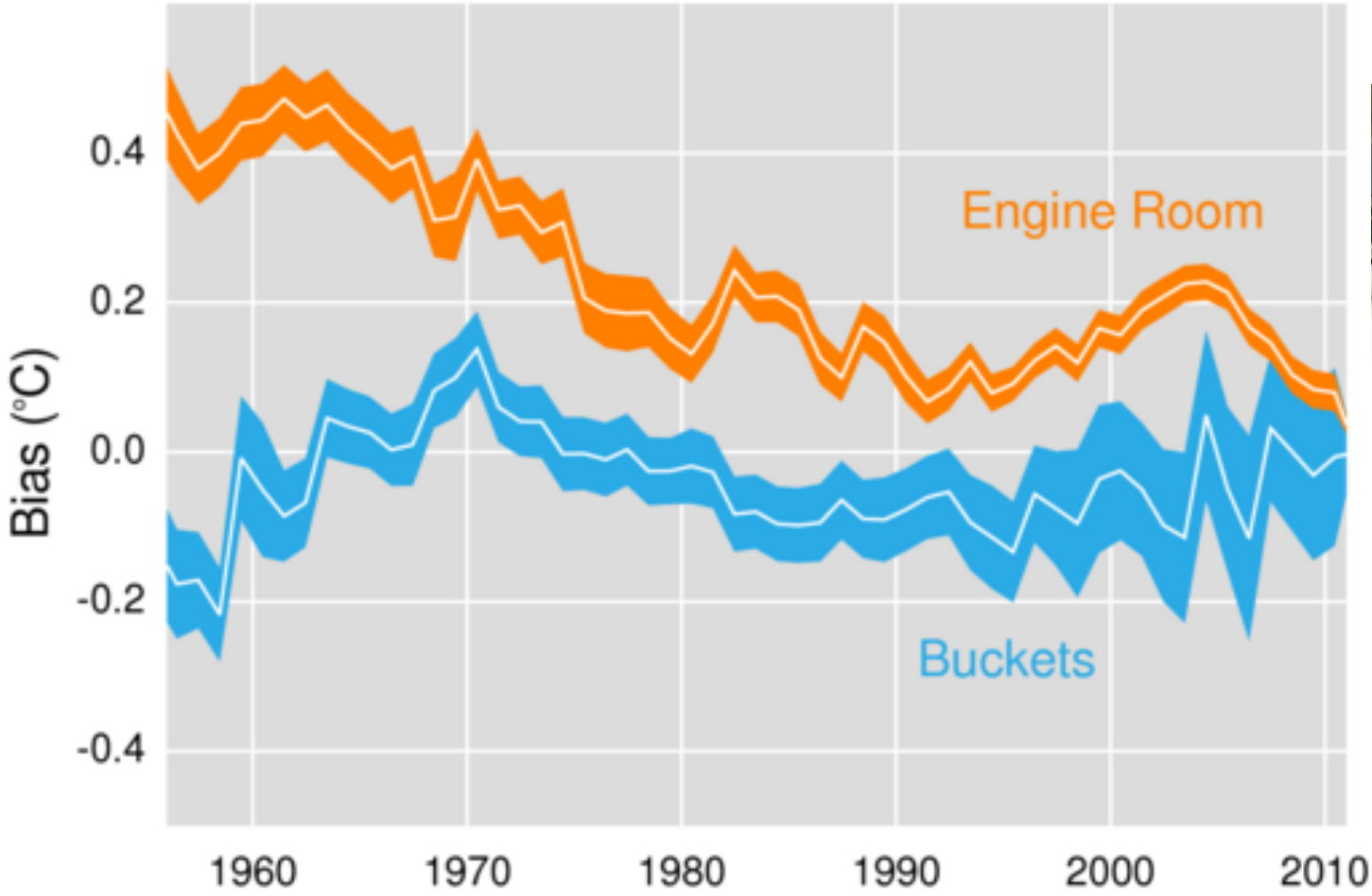


Pushing further back in time



www [10.1002/2014JC010053](10.1002/2014JC010053)

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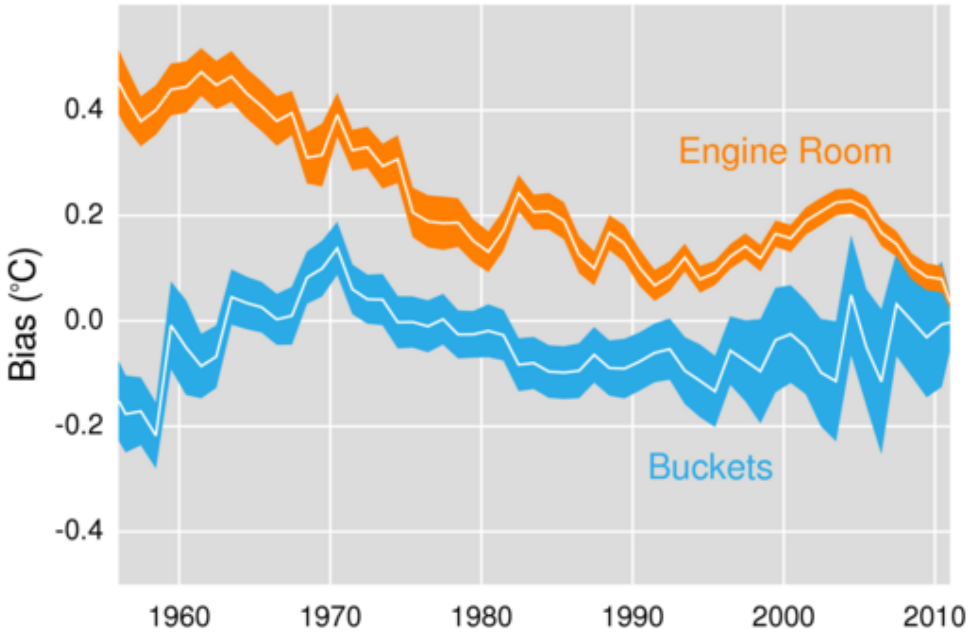

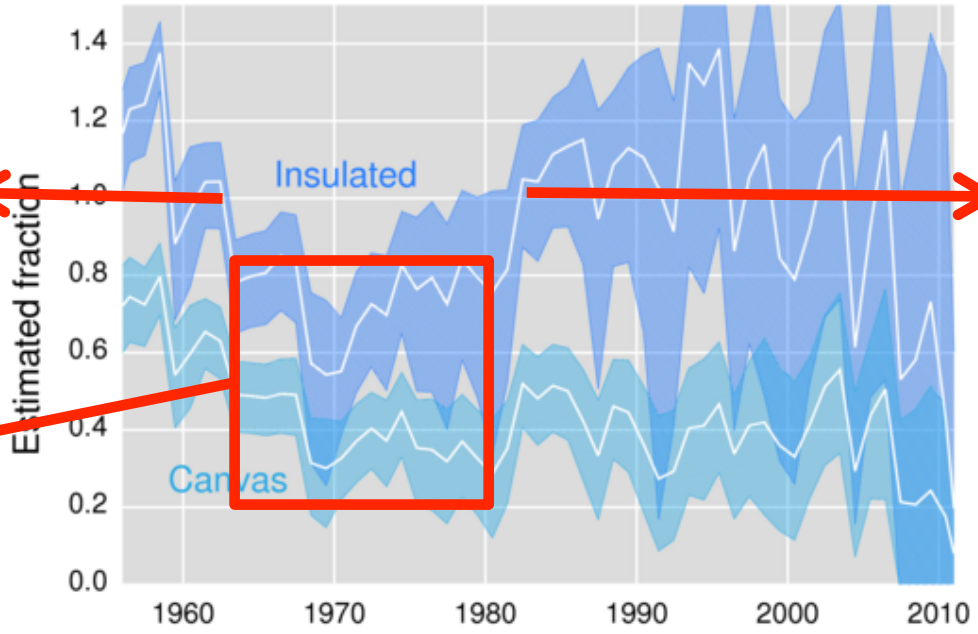

Pre-1960 data inconsistent with insulated bucket use

1960-1970 inconsistent with metadata assumptions

Modern data (post 1982) consistent with accurate metadata