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Making SST data sets for climate

John Kennedy, Nick Rayner

Fiducial Reference Temperature Measurements NPL, Teddington, 16 October 2017

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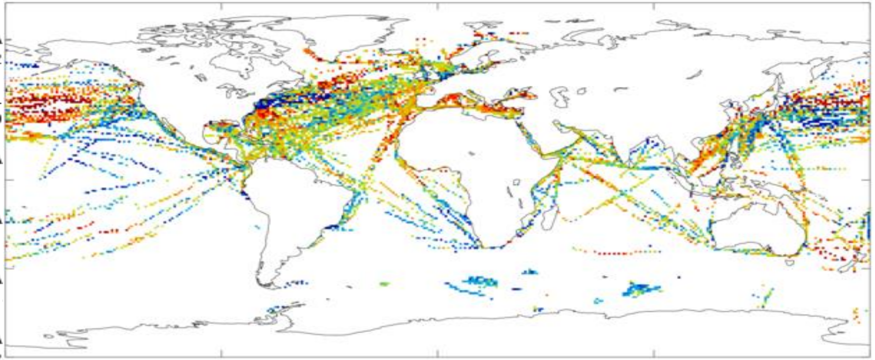

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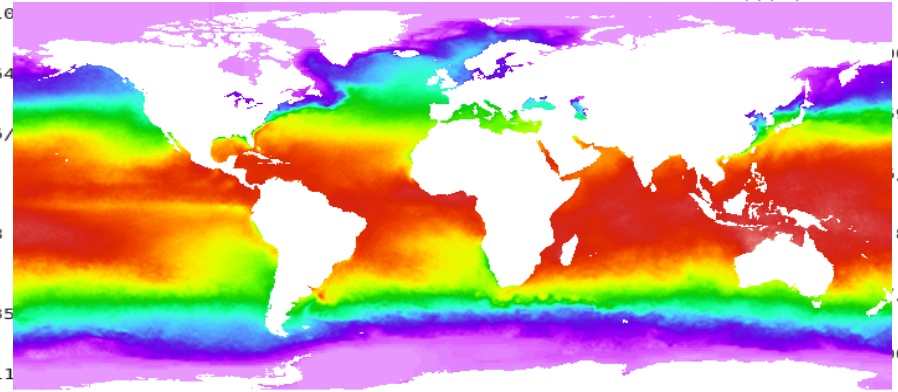

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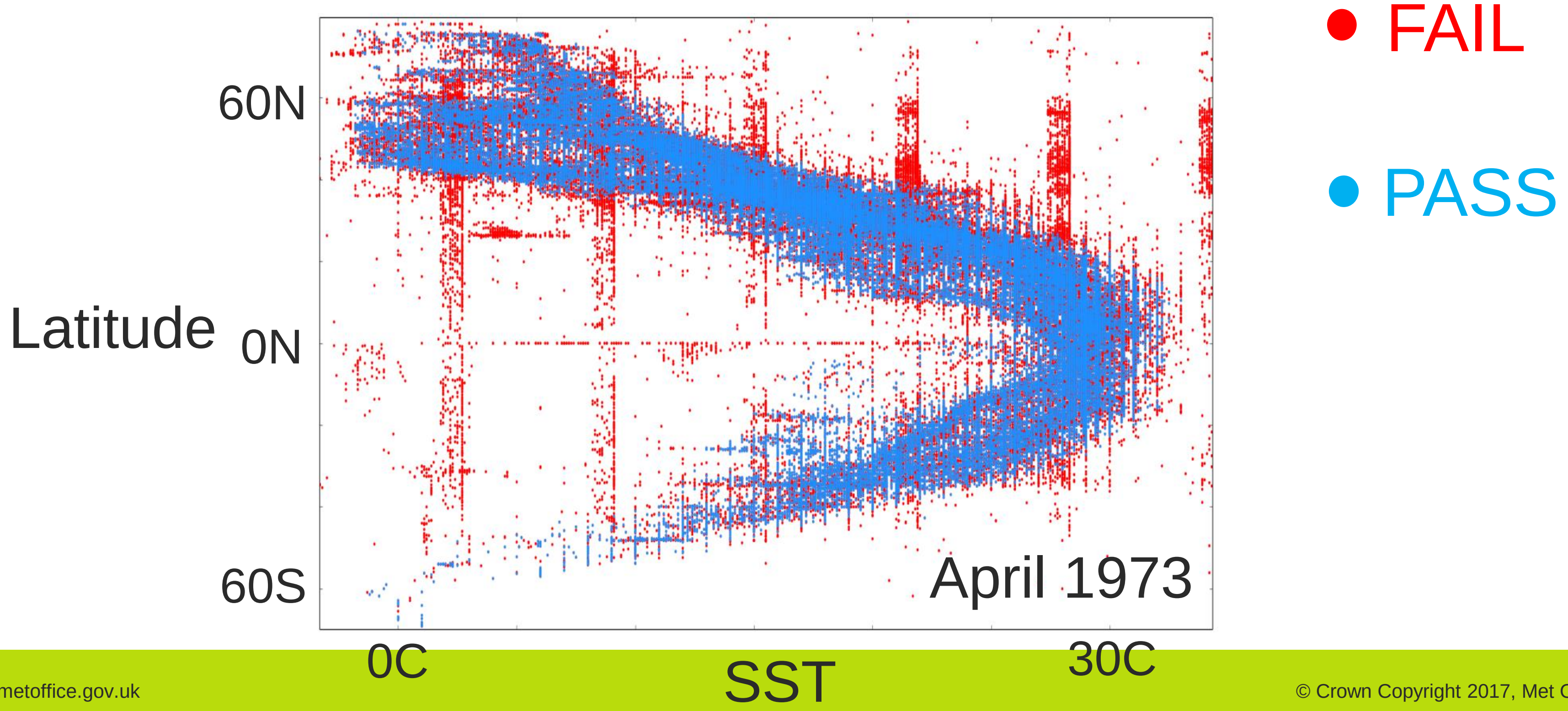
The subtle dangers of quality control

The (less) subtle dangers of quality control



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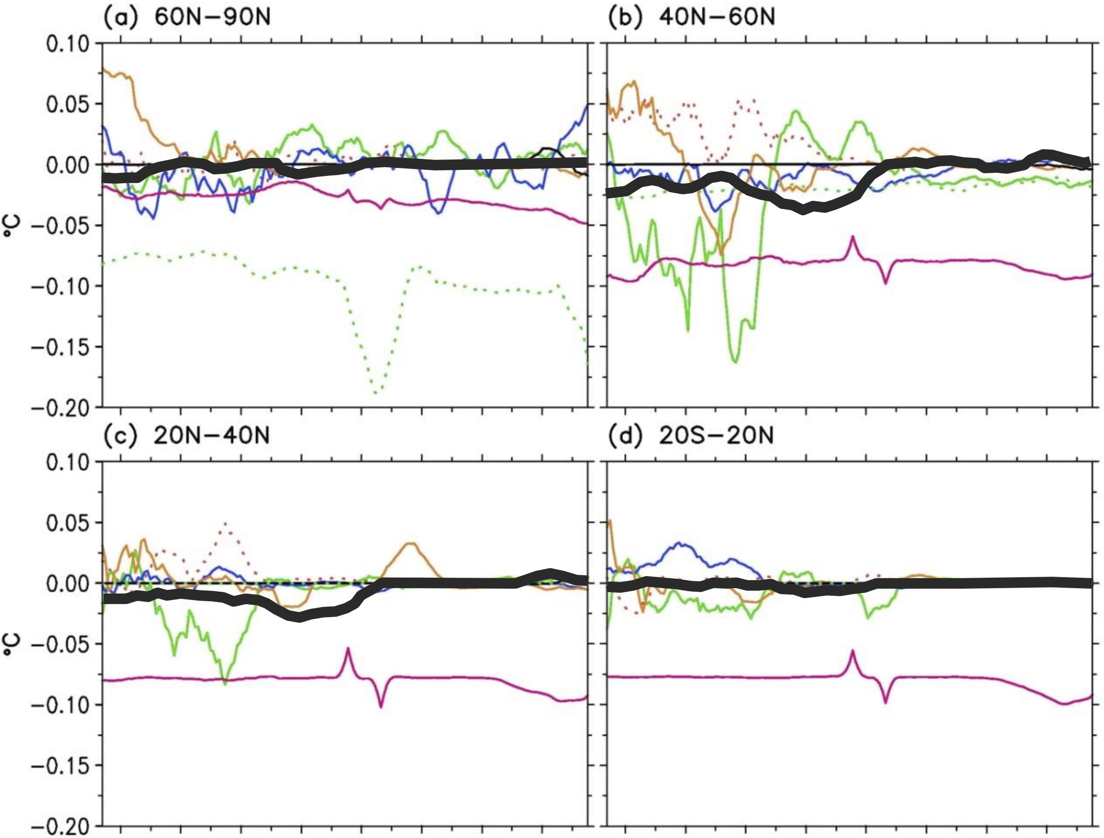
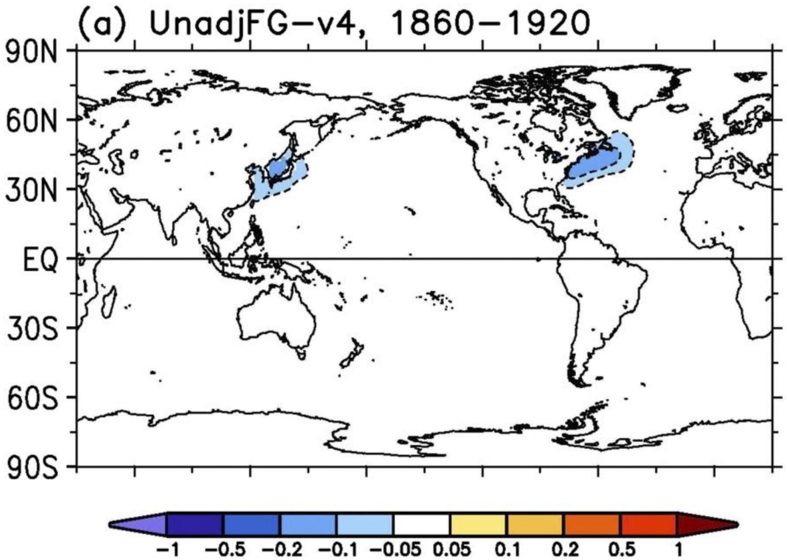
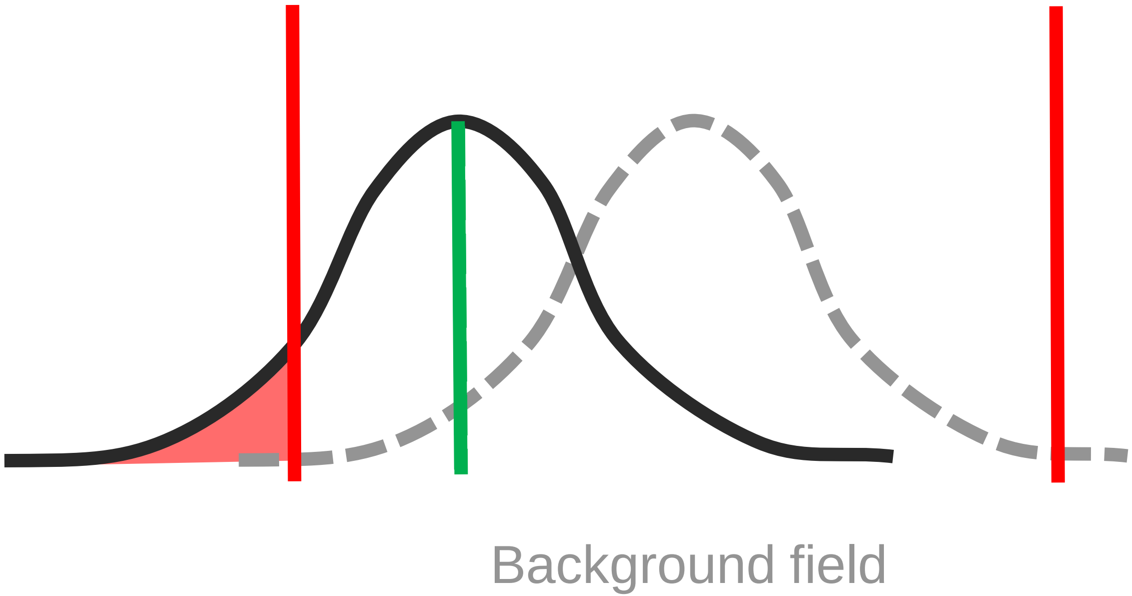




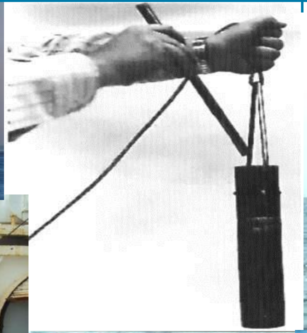
Huang, B., P.W. Thorne, V.F. Banzon, T. Boyer, G. Chepurin, J.H. Lawrimore, M.J. Menne, T.M. Smith, R.S. Vose, and H. Zhang, 2017: [Extended Reconstructed Sea Surface Temperature, Version 5 (ERSSTv5): Upgrades, Validations, and Intercomparisons.] *J. Climate,* **30**, 8179–8205, https://doi.org/10.1175/JCLI-D-16-0836.1

The subtle dangers of quality control

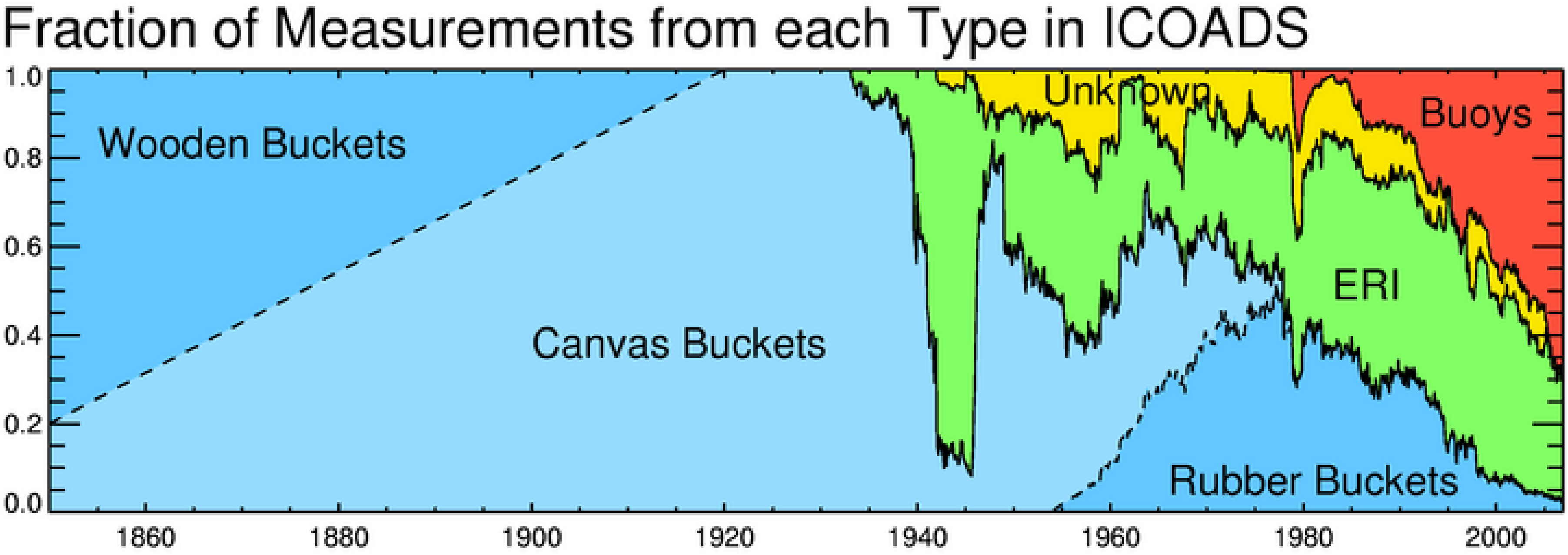


The complicated structures of systematic error

Measurement Methods



Evolution of the observing system



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In situ biases

Differences between measurement methods are large

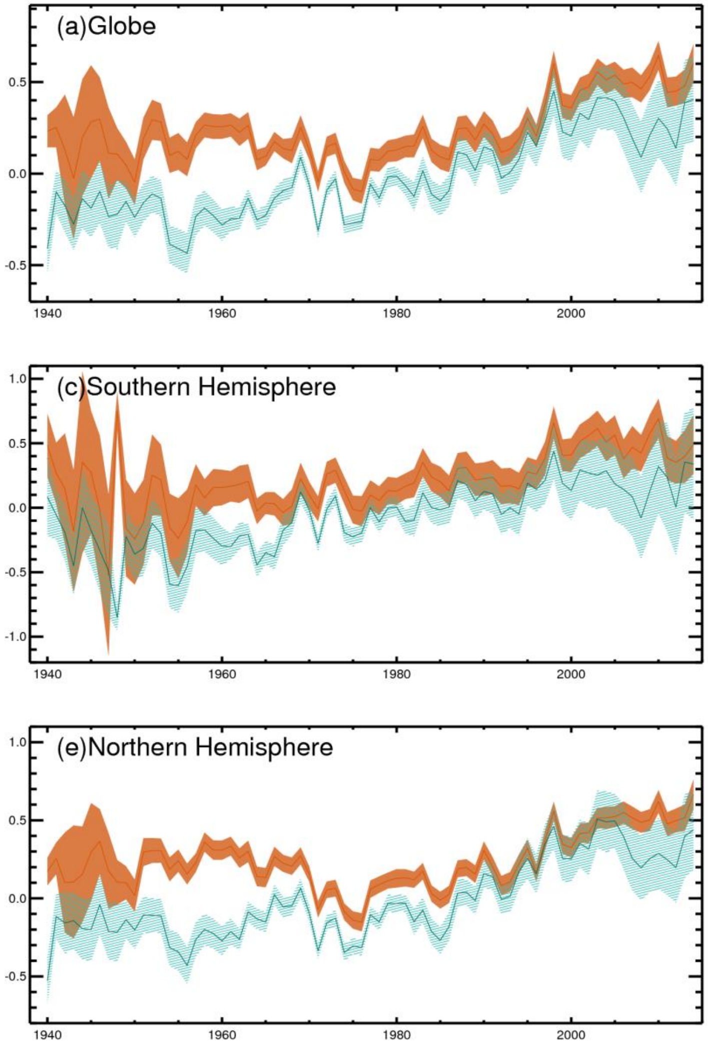
Occasionally greater than 0.5C

Geographically varying biases in both

Metadata assignment is not certain

ERI

Buckets



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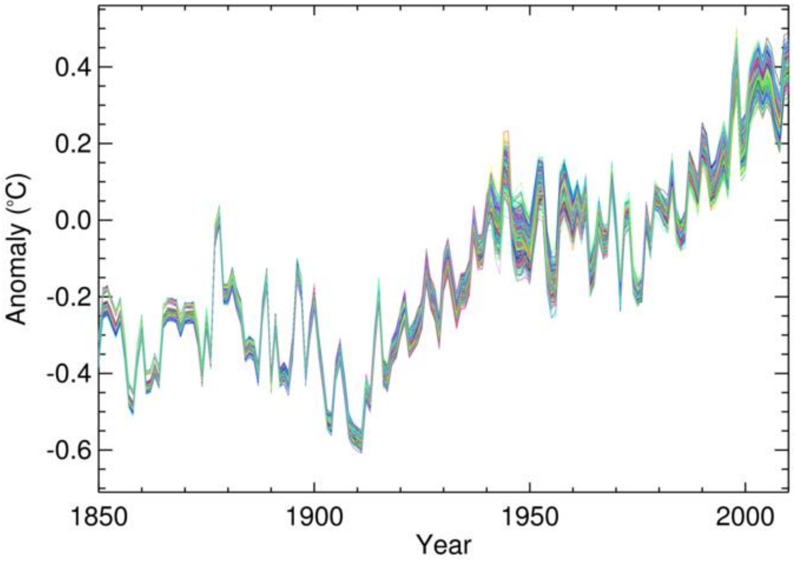
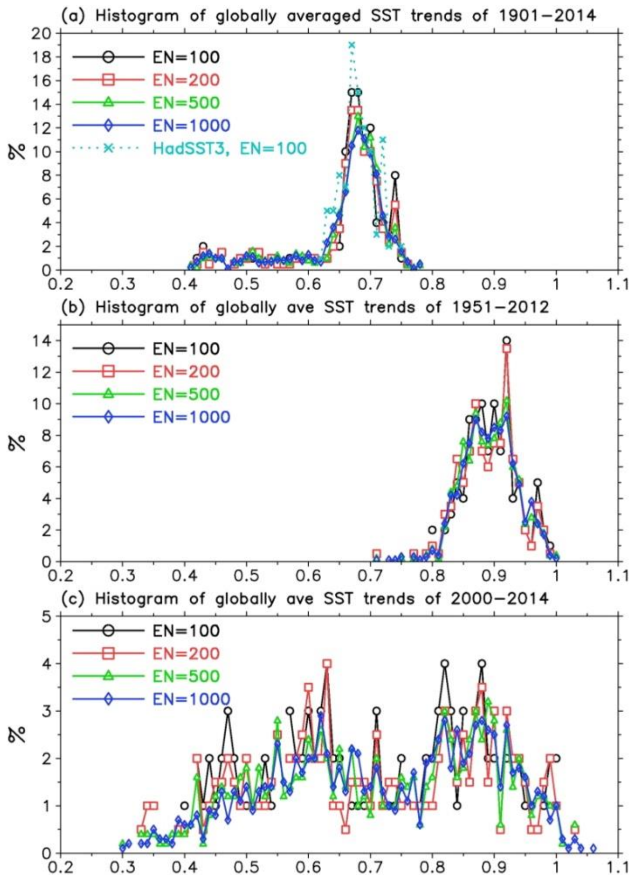
Ensembles to represent complex uncertainties





Huang, B., P.W. Thorne, T.M. Smith, W. Liu, J. Lawrimore, V.F. Banzon, H. Zhang, T.C. Peterson, and M. Menne, 2016: [Further Exploring and Quantifying Uncertainties for Extended Reconstructed Sea Surface Temperature (ERSST) Version 4 (v4).](https://doi.org/10.1175/JCLI-D-15-0430.1) *J. Climate,* **29**, 3119–3142, https://doi.org/10.1175/JCLI-D-15-0430.1

A Call for New Approaches to Quantifying Biases in Observations of Sea Surface Temperature

Kent et al. (2017) BAMS
https://doi.org/10.1175/BAMS-D-15-00251.1

Recommendations

1: Add more data and metadata to ICOADS

2: Reprocess existing ICOADS records

3: Improve information on observational methods.

4: Improve physical models of SST bias.

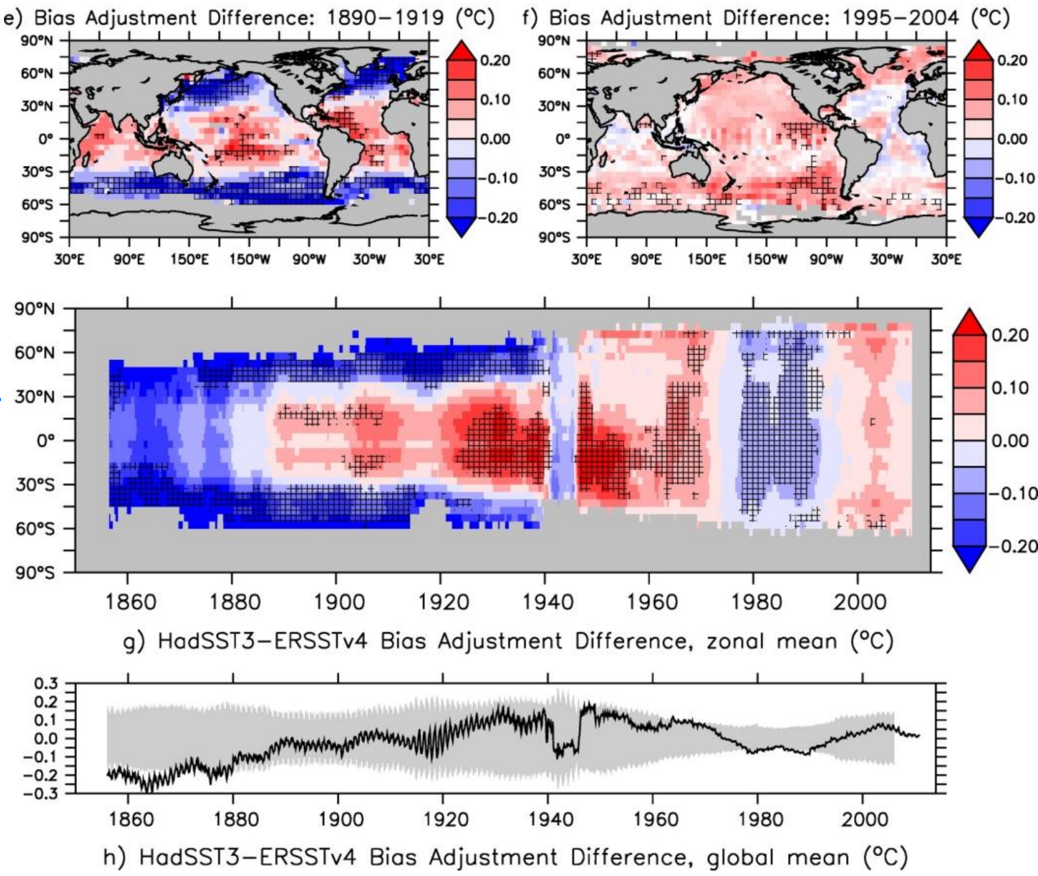
5: Improve statistical models of SST bias.

6: Maintain and extend the range of different estimates of SST bias

7: Expand data sources for validation and extend use of measures of internal consistency in validation.

8: Ensure adequacy and continuity of the observing system.

9: Improve openness and access to information.



How systematic errors are handled
Part 2: Space and the CCI SST

Total Error = Uncorrelated errors + Locally correlated + Fully-correlated error

Sensor noise

Atmospheric
1-day 100km

Average out very quickly

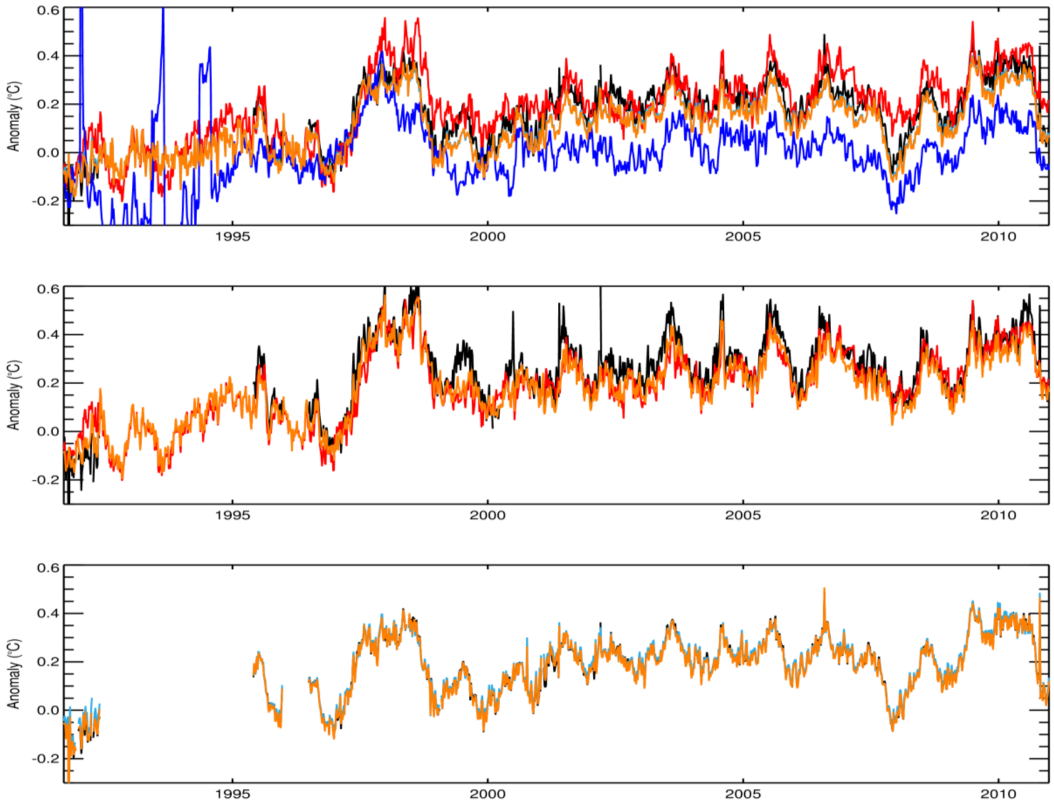
Retrieval error
Uniform,
perfectly
correlated

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

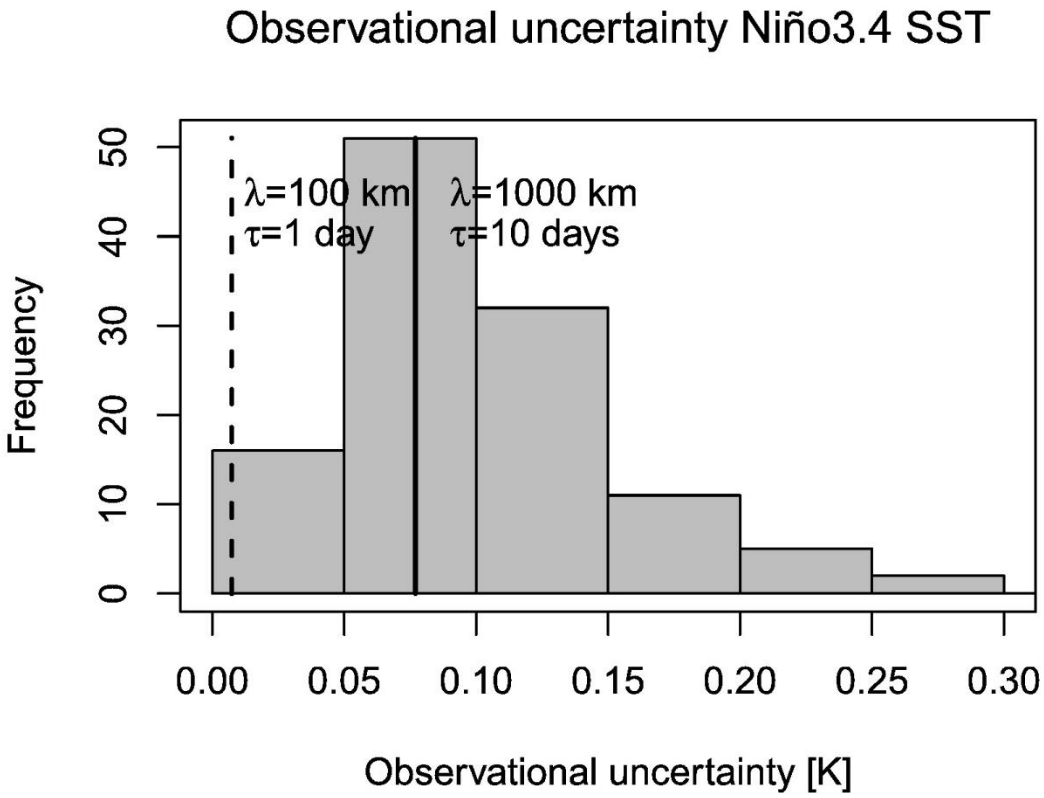
SST CCI error propagation

Propagating uncertainty to large scales yields depends strongly on the assumed correlation structure.

Using L4 data with assumed 1-day, 100 km correlations

"*This estimate is arguably too small and indicates that systematic uncertainties operating at larger scales are present*"

Uncertainty propagation in observational references to climate model scales (2017) Bellprat Massonnet Siegert Prodhommea Macias-Gómeza, Guemas, Doblas-Reyes. **Remote Sensing of Environment** https://doi.org/10.1016/j.rse.2017.06.034



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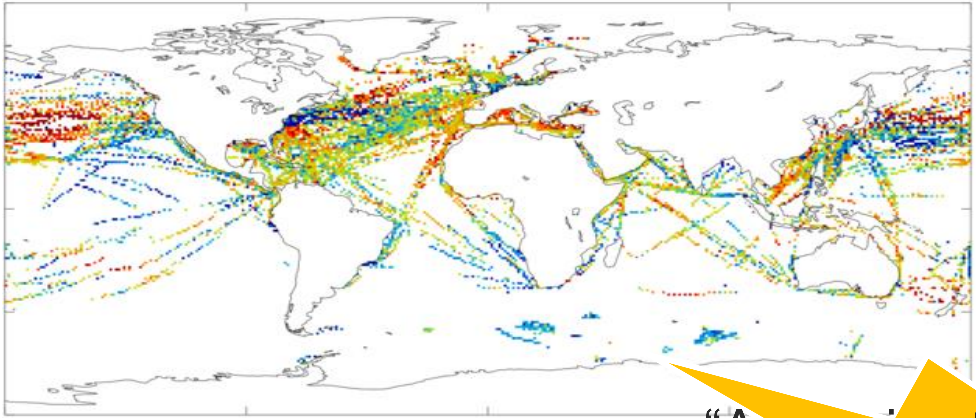
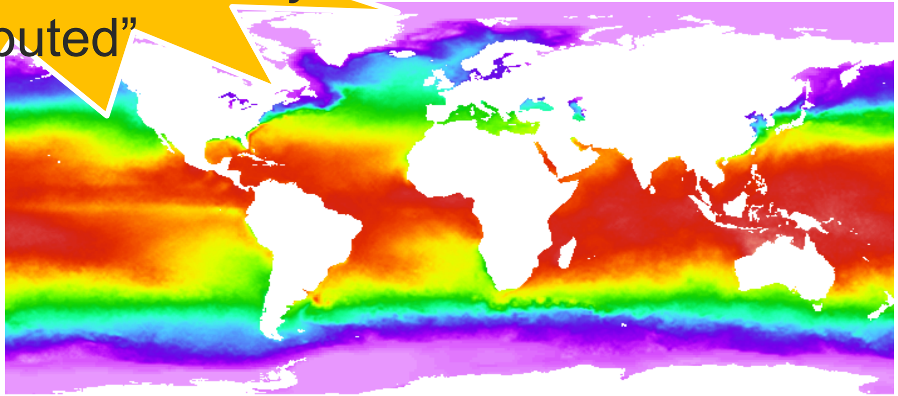
Optimal methods in a suboptimal world



“Assuming the errors are uncorrelated and normally distributed”



To learn the magic words read:

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

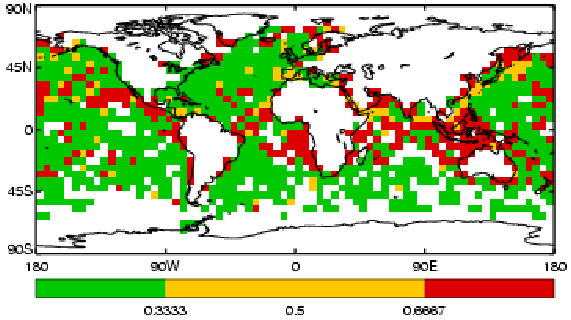
Ilin, A., and A. Kaplan (2009), Bayesian PCA for reconstruction of historical sea surface temperatures, in Proceedings of the International Joint Conference on Neural Networks (IJCNN 2009), pp. 1322–1327, Atlanta, U.S.A, doi:10.1109/IJCNN.2009.5178744.

Non-Gaussian distributions

1-7 June 2006

Requirements usually a number interpreted as a standard deviation

A different way to think of requirements is probability of exceeding a particular error threshold



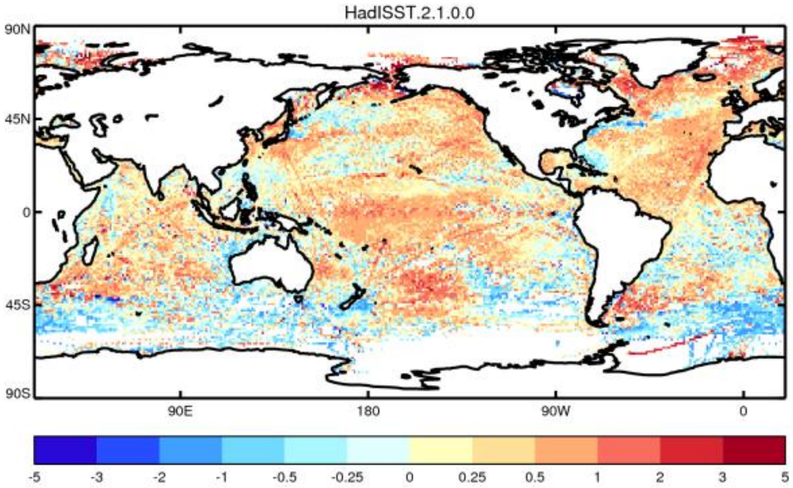
Assume normal and uncorrelated

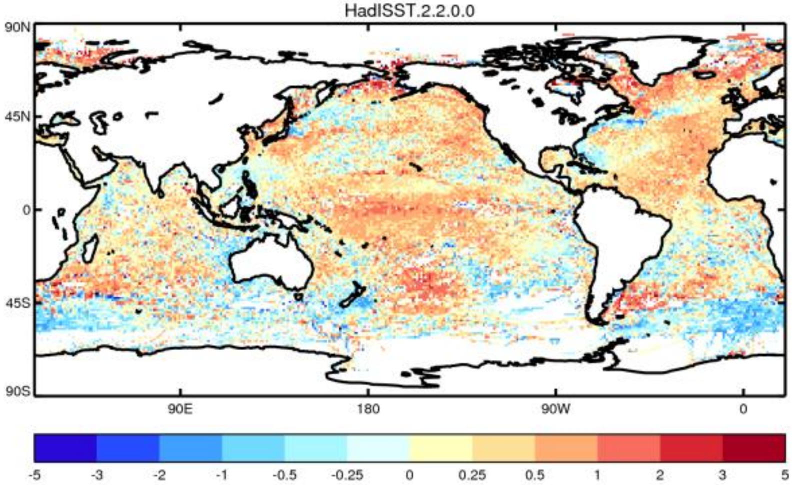
Correlated errors

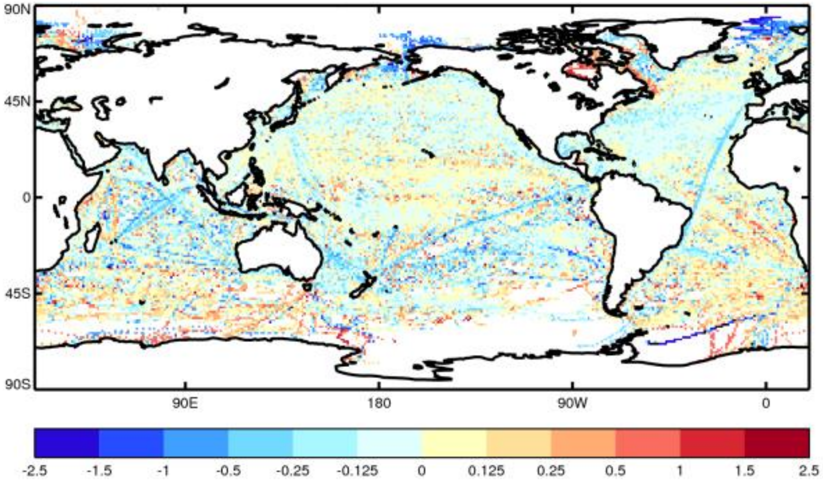
Assume the errors ARE correlated

Computationally challenging but possible

See the EUSTACE poster







Validation without validation data

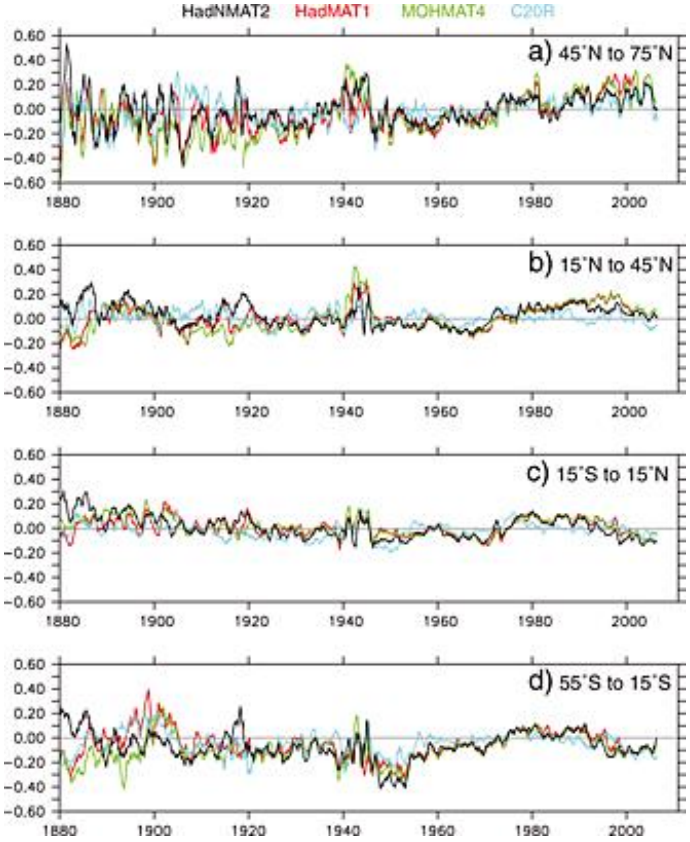
Validation without validation data

No **long-term** silver(ish)-standard reference datasets

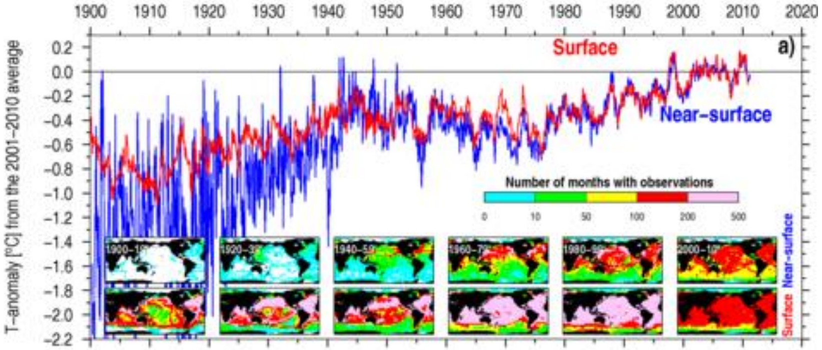
- Maybe Argo
- SST CCI stability only assessed in Tropical Pacific thanks to TAO array (Merchant et al. 2012)

Have to rely on:

- Intercomparisons
- Multiple data set creation attempts, structural uncertainty (Thorne et al. 2005)
- Comparison with physically related variables (also potentially problematic)
- Experiments: buckets in laboratories (Carella et al 2017) and students on ships (Matthews and Matthews 2013)



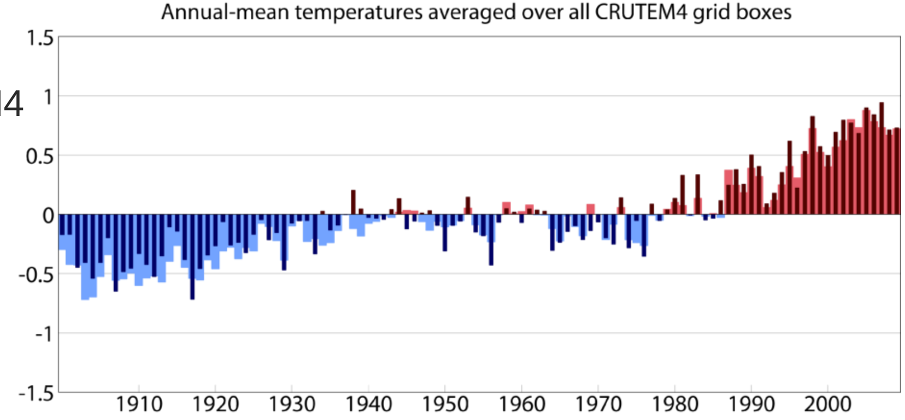
E.C. Kent, N.A. Rayner, D.I. Berry, M. Saunby, B.I. Moat, J.J. Kennedy, D.E. Parker (2013) Global analysis of night marine air temperature and its uncertainty since 1880: the HadNMAT2 Dataset JGR Atmos. doi: 10.1002/jgrd.50152



Gouretski, V., J. Kennedy, T. Boyer, and A. Köhl (2012), Consistent near-surface ocean warming since 1900 in two largely independent observing networks, Geophys. Res. Lett., 39, L19606, doi:[10.1029/2012GL052975](10.1029/2012GL052975).

CRUTEM4

ERA



A new era of precision climatology?

A new era of precision climatology?

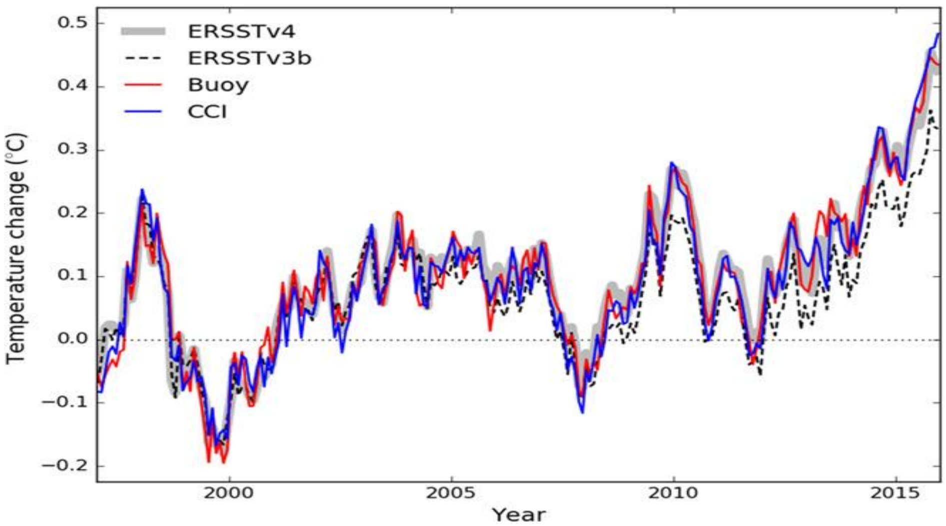
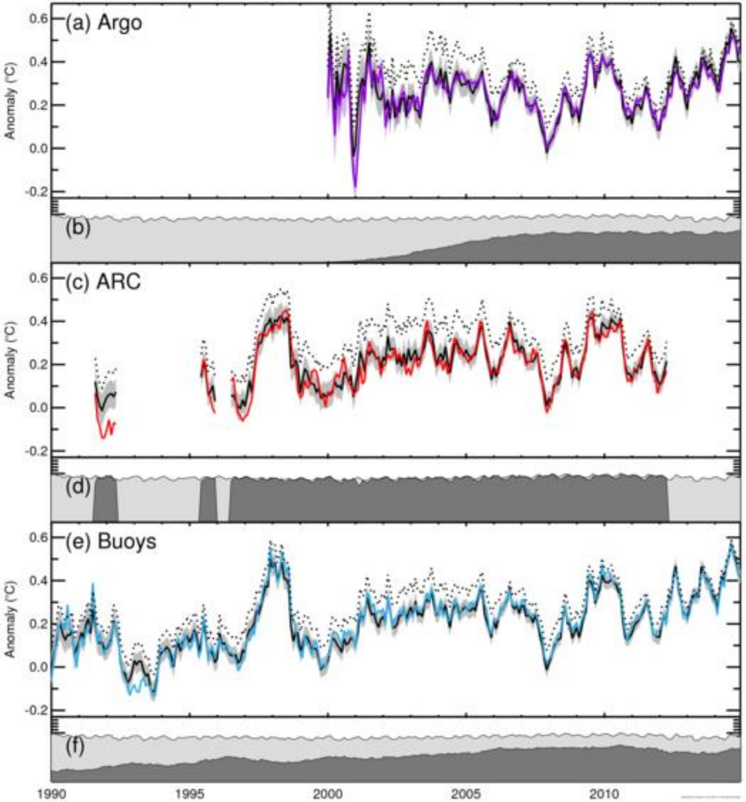


Fig. 1 Comparison of the different ERSSTv3b, ERSSTv4, buoy-only, and CCI SST monthly anomalies from January 1997 to December 2015, restricting all series to common coverage.

Zeke Hausfather et al. Sci Adv 2017;3:e1601207

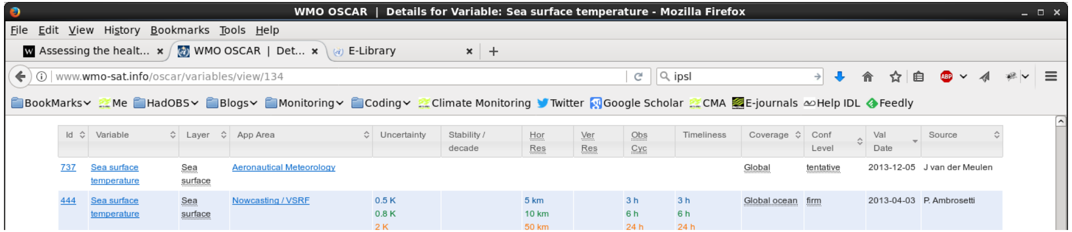
Science Advances

Published by AAAS



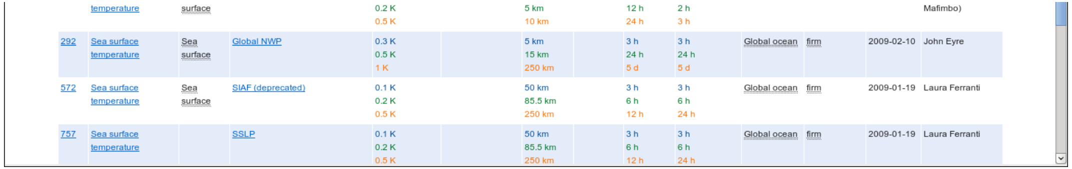
Climate Requirements

Variable	Application area	level	Uncertainty (K)	Horizontal resolution (km)	Observing cycle (h)
SST	Climate -AOPC	Goal	0.250	10	3
		Threshold	0.200	500	24
SST stability	GCOS	-	0.03K/ decade	100	decades



Target Requirements

Variable/ Parameter	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Accuracy	Stability
SST	10km	N/A	Daily	0.1K over 100km scales	Less than 0.03K over 100km scales



Berry and Kent (2017), Assessing the health of the in situ global surface marine climate observing system. Int. J. Clim., 37:2248-2259. doi:10.1002/joc.4914

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Summary – raindrops on roses

Most important requirements are qualitative, not quantitative

- Small uncertainties at the smallest and largest scales are very useful, but we will use what we have.
- Uncertainty information we can use and trust:
  1. Quantified
  2. A scheme for propagating that information to all spatial and temporal scales
  3. All components validated: standard deviation, correlations, distributions, stability
  4. Limitations clearly expressed
- Validation data. Everywhere
- And whiskers on kittens

Some other references

Carella, G., Morris, A. K. R., Pascal, R. W., Yelland, M. J., Berry, D. I., Morak-Bozzo, S., Merchant, C. J. and Kent, E. C. (2017), Measurements and models of the temperature change of water samples in sea-surface temperature buckets. Q.J.R. Meteorol. Soc., 143: 2198–2209. doi:10.1002/qj.3078

Matthews, J. B. R. and Matthews, J. B (2013): Comparing historical and modern methods of sea surface temperature measurement – Part 2: Field comparison in the central tropical Pacific, Ocean Sci., 9, 695-711, https://doi.org/10.5194/os-9-695-2013, 2013.

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Systematic Observation Requirements for Satellite-based Products for Climate Supplemental details to the satellite-based component of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC: 2011 update https://library.wmo.int/opac/doc_num.php?explnum_id=3710

OSCAR WMO Observing System Capability Analysis and Review Tool http://www.wmo-sat.info/oscar/observingrequirements