Satellite observations of Sea Surface Temperature as a Climate Data Record

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SST from space: not ‘old hat’

“**old hat”:** old-fashioned,
over-used and over-familiar

- Reduced biases
- Stability / homogenity
- Sensitivity
- Uncertainty information
- Independence

A Tale of Two Projects

ATSR Reprocessing for Climate (ARC)

- Completed June 2011
- ATSR series SSTs
- 1991 to mid 2011

For data:

- www.neodc.rl.ac.uk/browse/neodc/arc

Climate Change Initiative(SST CCI)

- Ongoing (in year 2 of 3)
- SST CDR user requirements
- New SST products in 2012
  - ATSRs and AVHRRs

- For report:
- www.esa-sst-cci.org

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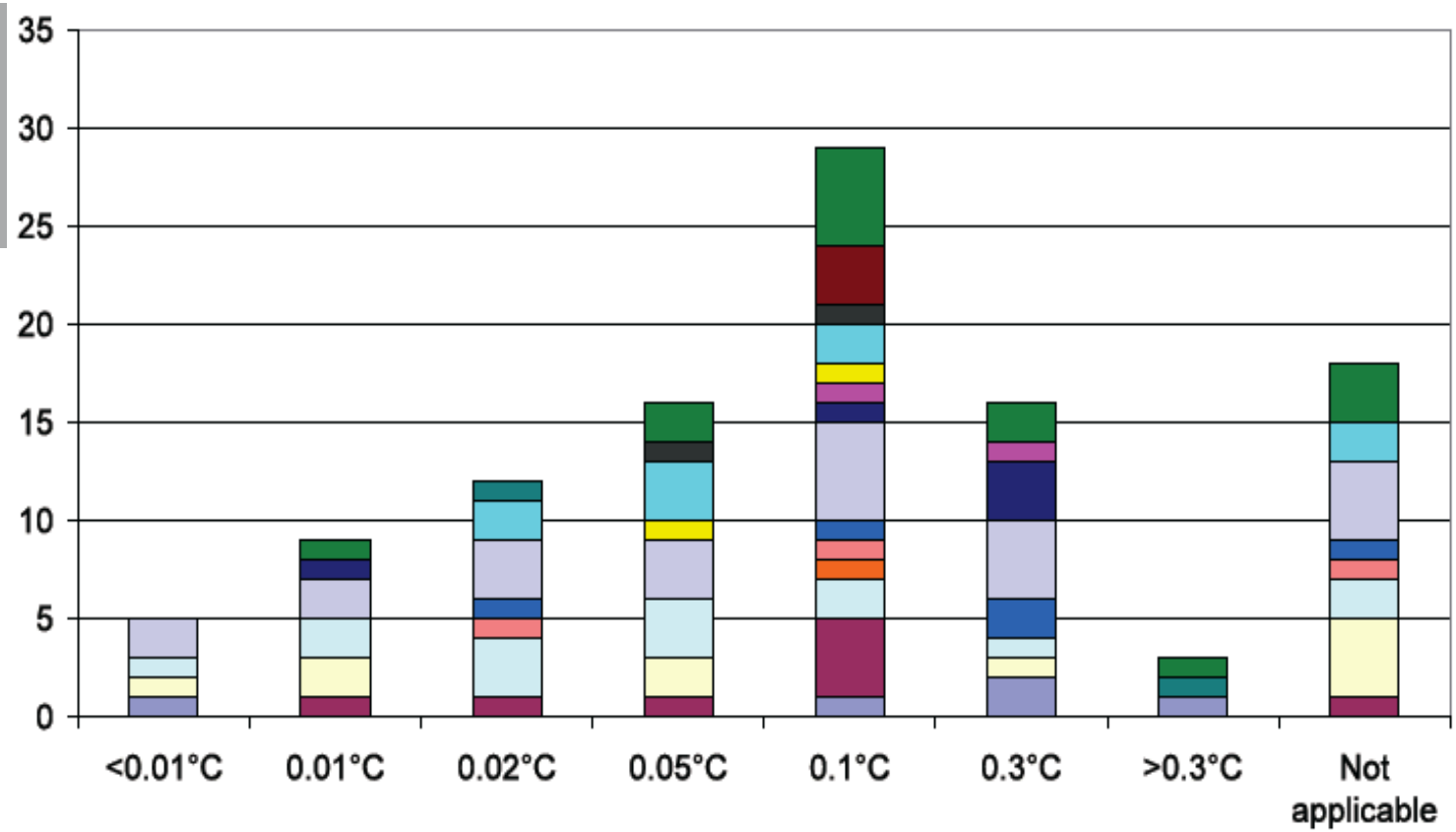
Reduced biases



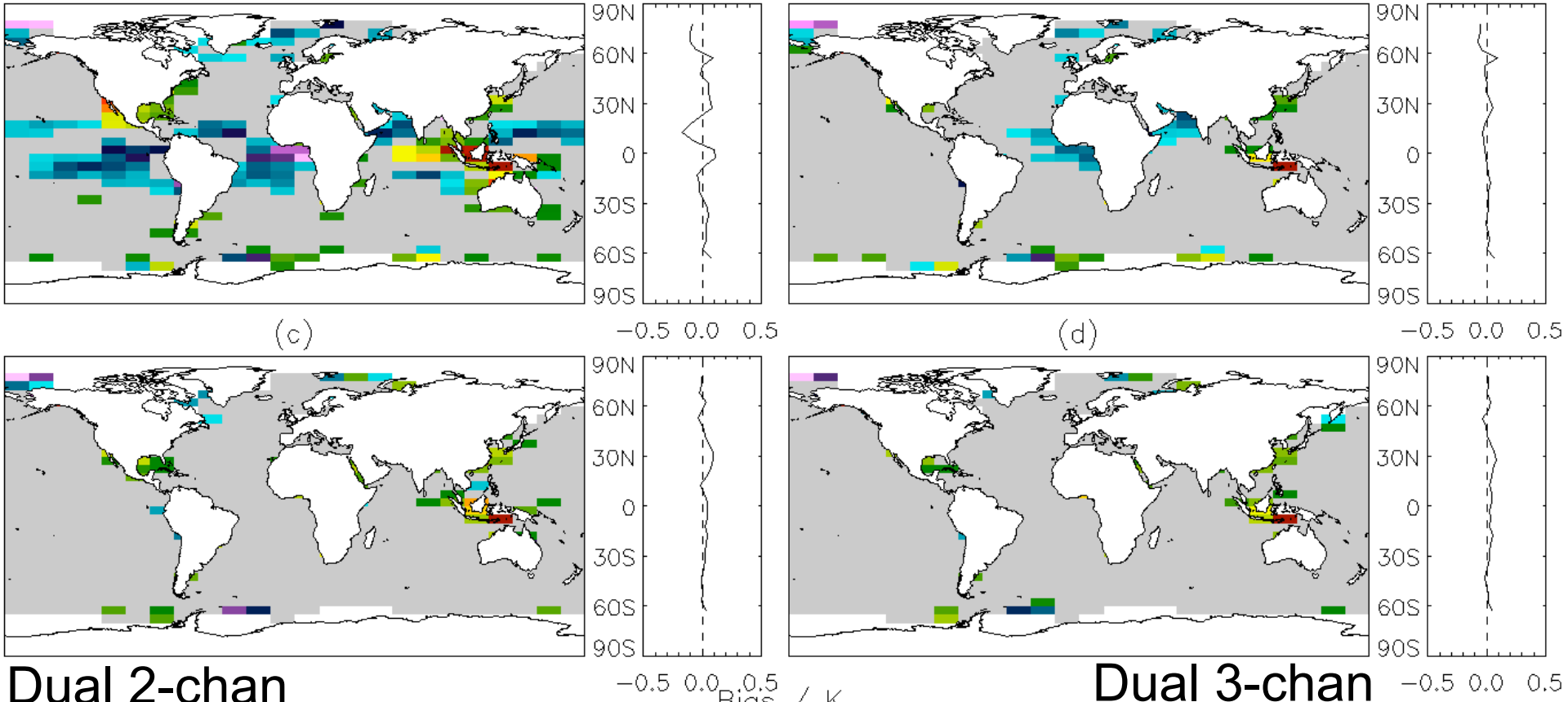
Aggregated over all spatial scales			
Data level	Threshold	Break-through	Objective
2	0.1°C	0.05°C	0.01°C

Requirements for acceptable level of bias to satisfy at least two thirds of the user group.

ARC $SST_{0.2m}$ minus drifting buoys

Nadir 2-chan

Nadir 3-chan



Dual 2-chan

Dual 3-chan

-0.5 K

0.5 K

Stability / homogeneity

- Matters for change detection and trends
- Need low upper limit on trend artifacts in the record
  - E.g., drifting satellite calibration or overpass time
- Discontinuities should be negligible
  - E.g., jumps as different sensors come in and out of record
  - Bias correct SSTs with care!

Aggregated over all spatial scales			
Data level	Threshold	Break-through	Objective
2	0.05°C/dec	0.02°C/dec	0.01°C/dec
	5 mK/yr	2 mK/yr	1 mK/yr

Stability assessment in ARC

- Assessed discrepancy between ARC SST_{1m} and Global Tropical Moored Buoy Array (GTMBA) for trends

Region	Period	Time of day	Trend / mK yr^{-1}	95% conf. int. / mK yr^{-1}
Tropics	1993 - end	Day	-0.6	-2.6 < trend < 1.5
Tropics	1993 - end	Night	1.0	-1.4 < trend < 3.4

Sensitivity to SST

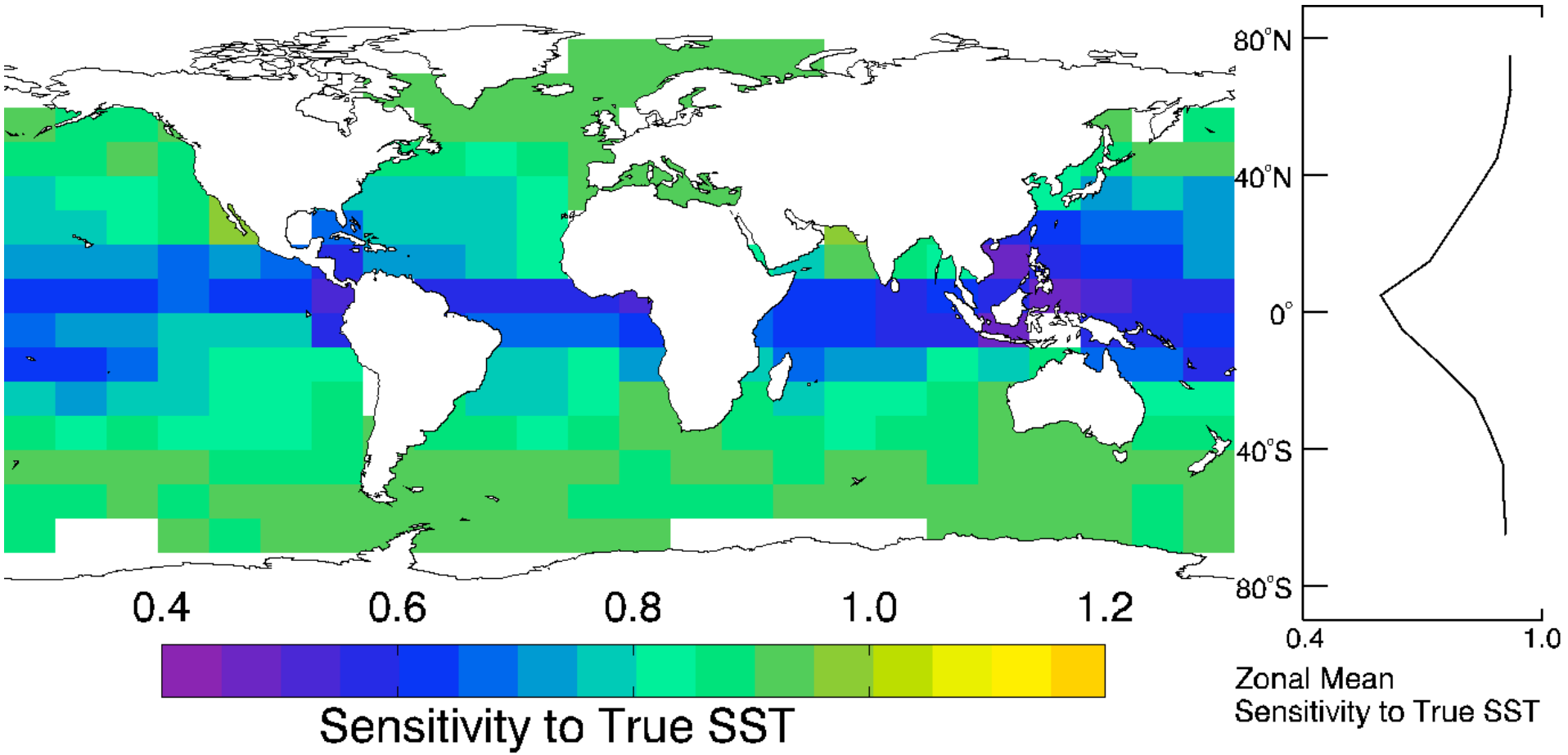
- Satellite retrieval of SST is a subtle inverse process
- Wherever prior information explicitly or implicitly enters the inverse process, the retrieved SST may not fully reflect SST variability

- Sensitivity to true SST variation should be a criterion for assessing SST CDRs

- Ideally $\frac{\partial \hat{x}}{\partial x} = 1$ for a CDR

- Can be calculated using simulation of the inversion

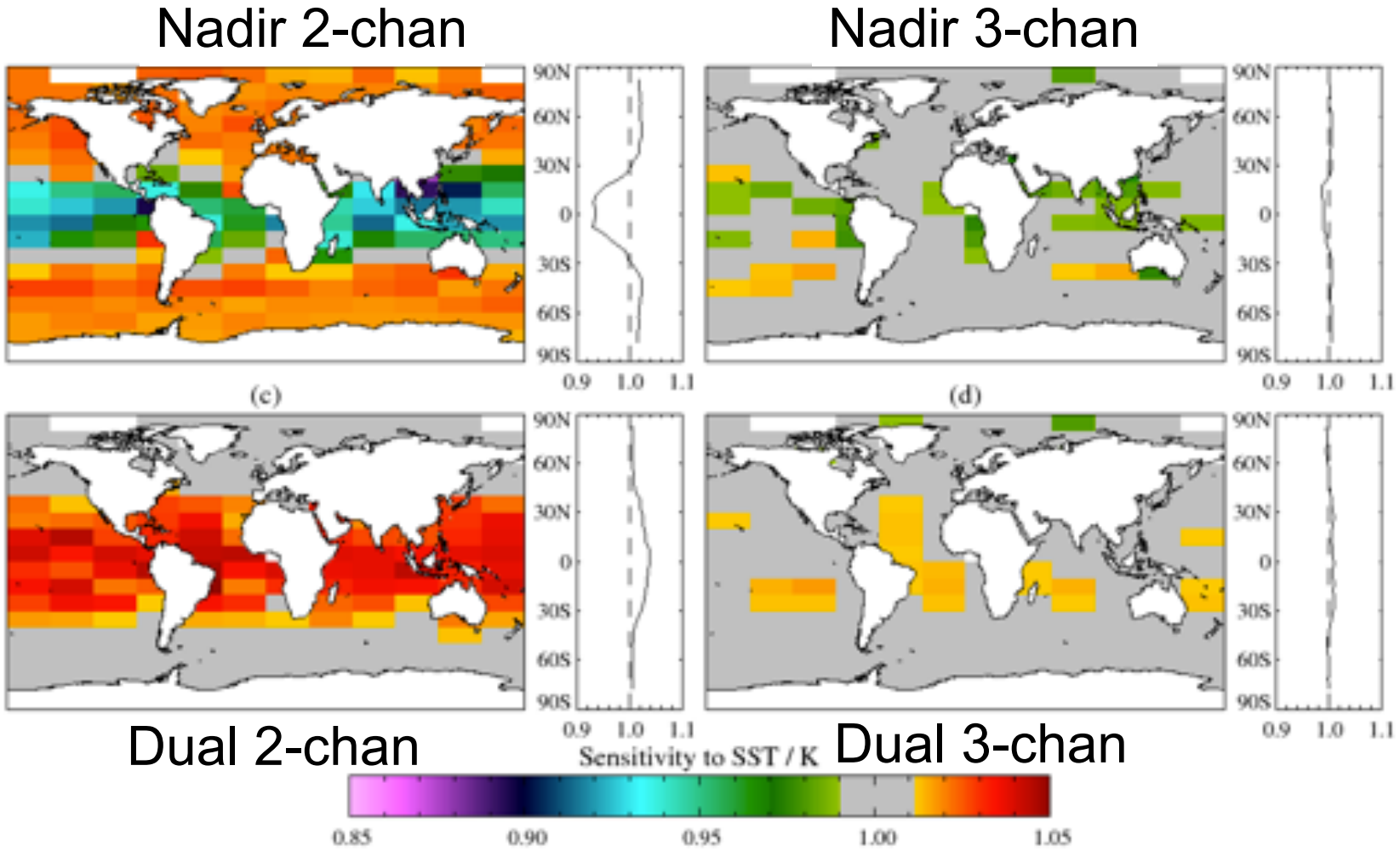
Typical AVHRR retrieval (NLSST)



Change in AVHRR SST for a 1 K change in SST

Merchant et al, 2009, GRL
doi:10.1029/2009GL039843

Sensitivity in ARC SST



0.85

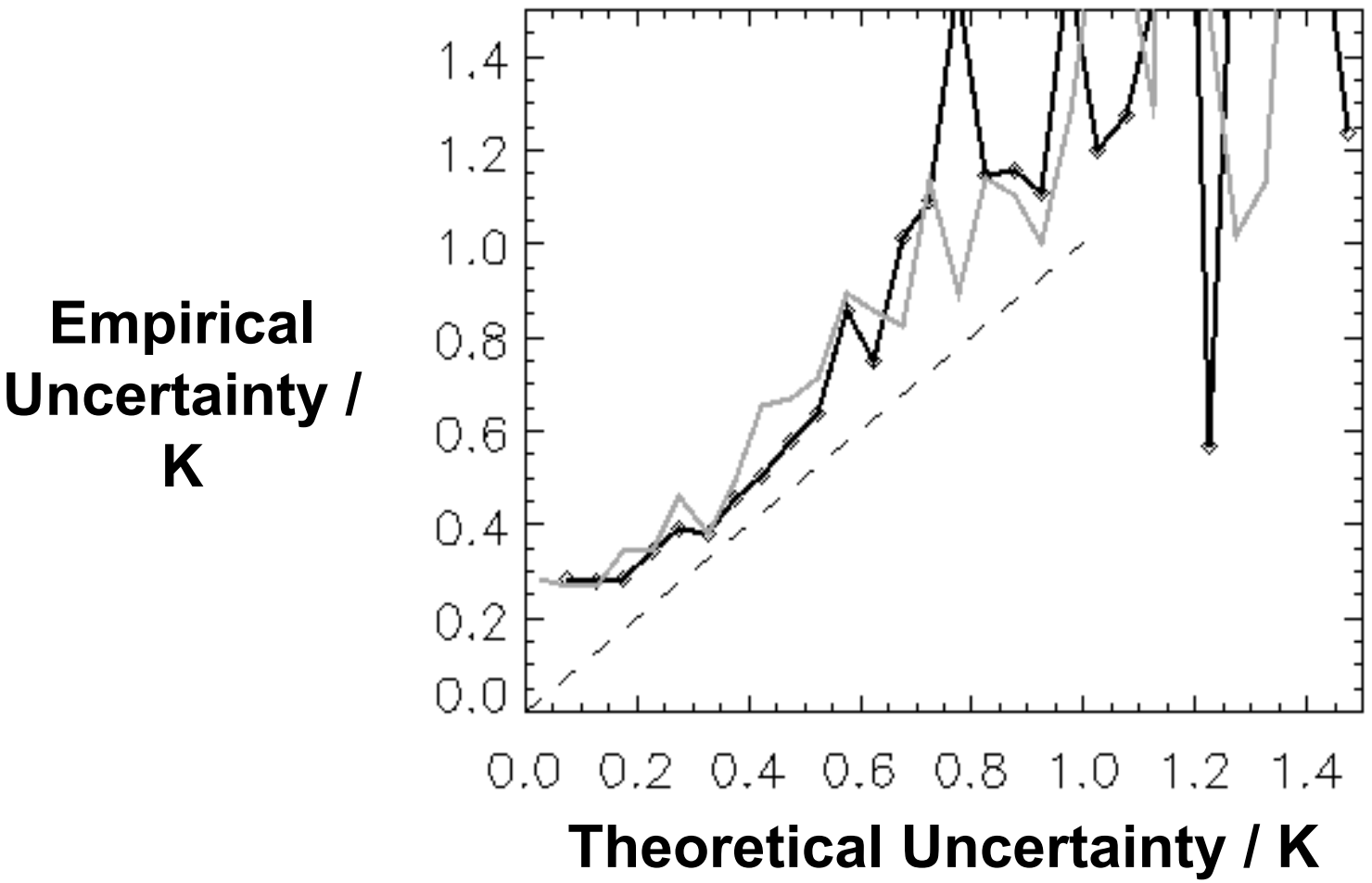
1.05

Uncertainty information

- Need to improve uncertainty information in satellite SST datasets for climate users

- Within ARC and the SST CCI an uncertainty is attached to every SST
- Uncertainty model accounts for
  - Propagated radiometric noise
  - Knowledge (from simulation studies) of the limitations of the retrieval algorithm
  - Sub-sampling (observations are gappy due to clouds)
- The uncertainty needs to be validated too

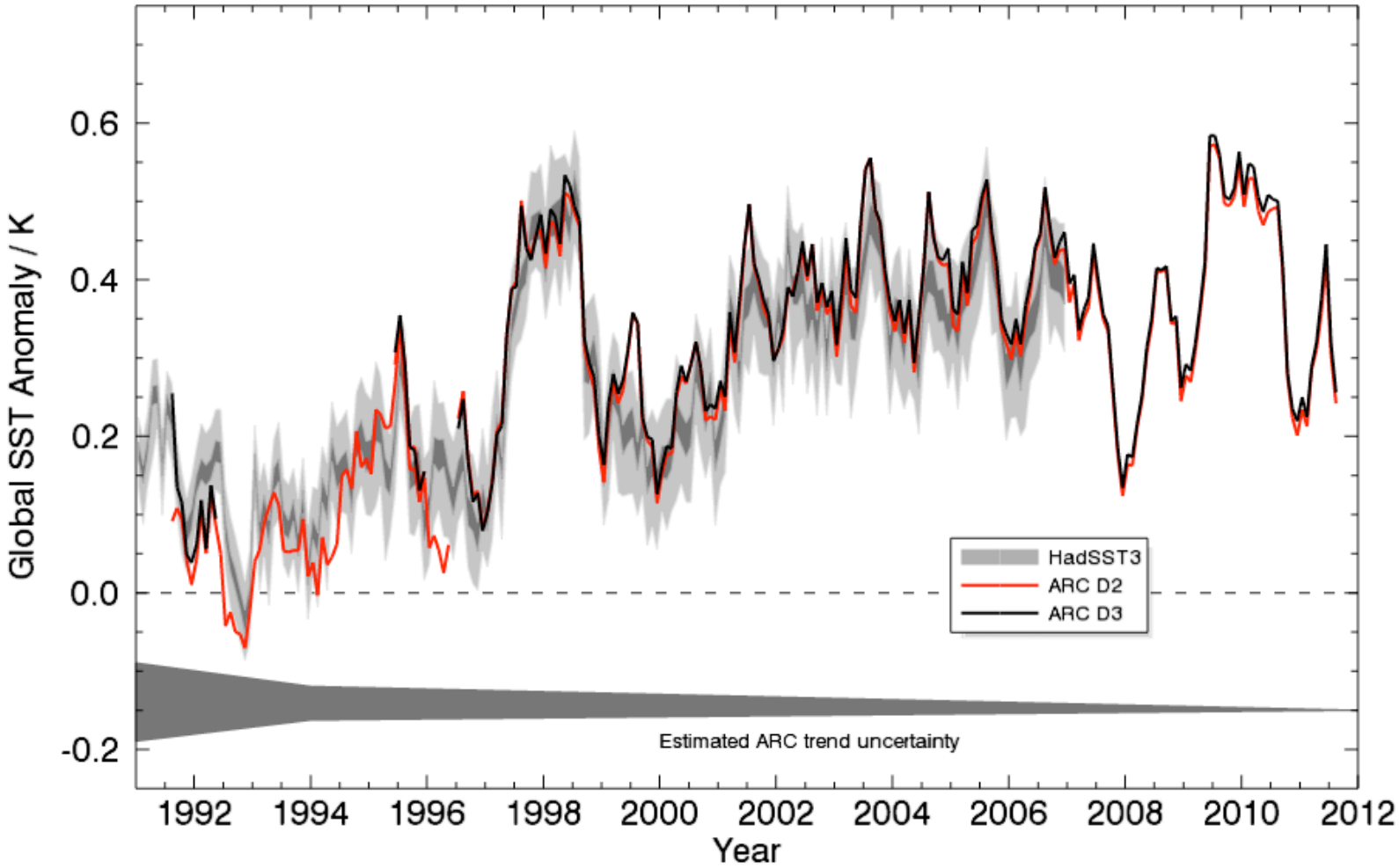
Validation of ARC uncertainty estimates



Independence

- In the SST CCI survey of climate users
  - 15% stated that it was essential for satellite SST CDR to be independent of *in situ* SST
  - 45% stated it was preferable
- To retrieve SST independently of *in situ* SST
  - Need to do retrieval by radiative transfer
  - Need excellent characterisation of sensor
- For ARC SSTs
  - Skin SST retrieval algorithm is fully independent of *in situ* SST
  - Cloud screening is weakly dependent on *in situ* SST
  - Skin to depth model used *in situ* in parameter tuning

Nearly-independent time series



Summary

- Climate users require lower SST biases (0.1 K or better) than are found in traditional meteorological SST products
- Stability is a key parameter. Excellent stability (mK/yr) is possible for ATSRs with careful exploitation of overlaps
- Sensitivity (or, equivalently, the amount of prior SST information embedded in CDR) should be quantified
- Uncertainty estimates should be part of the SST CDR and can be validated in their own right
- ARC SSTs are nearly independent of in situ observations, yet confirm the evolution of global SSTA in HadSST3

Acknowledgements

- ARC was funded by UK agencies:
  - Natural Environment Research Council
  - Defence Science and Technology Laboratory
  - Department of Energy and Climate Change
- SST CCI is funded by the European Space Agency
  - and builds on both ARC and work funded via the UK's National Centre for Earth Observation (NCEO)

- A few of the **many** contributing scientists are:
  - Owen Embury Gary Corlett Lizzie Good
  - Nick Rayner Roger Saunders David Llewellyn-Jones
  - David Berry Liz Kent Katie Lean
  - Pierre Le Borgne

Further Information

- I will be standing by standing by my poster in session C34 10:30-12:00 Wednesday

- If you are interested in using the CCI data for the user assessment email:
- nick.rayner@metoffice.gov.uk

- For general info: c.merchant@ed.ac.uk
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Further information

- For ARC project:
  - Embury et al., 2011, Rem Sens Env, doi: 10.1016/j.rse.2010.10.016
  - Embury and Merchant, 2011, RSE, doi: 10.1016/j.rse.2010.11.020
  - Embury et al., 2011, Rem Sens Env, doi: 10.1016/j.rse.2011.02.028
  - www.neodc.rl.ac.uk/browse/neodc/arc
- For bias and sensitivity issues SST retrieval
  - Merchant et al., 2009, GRL, doi: 10.1029/2009GL039843
- SST CCI User Requirements Document
  - www.esa-sst-cci.org → Resources → Documents

- Further questions: c.merchant@ed.ac.uk