SST_cci

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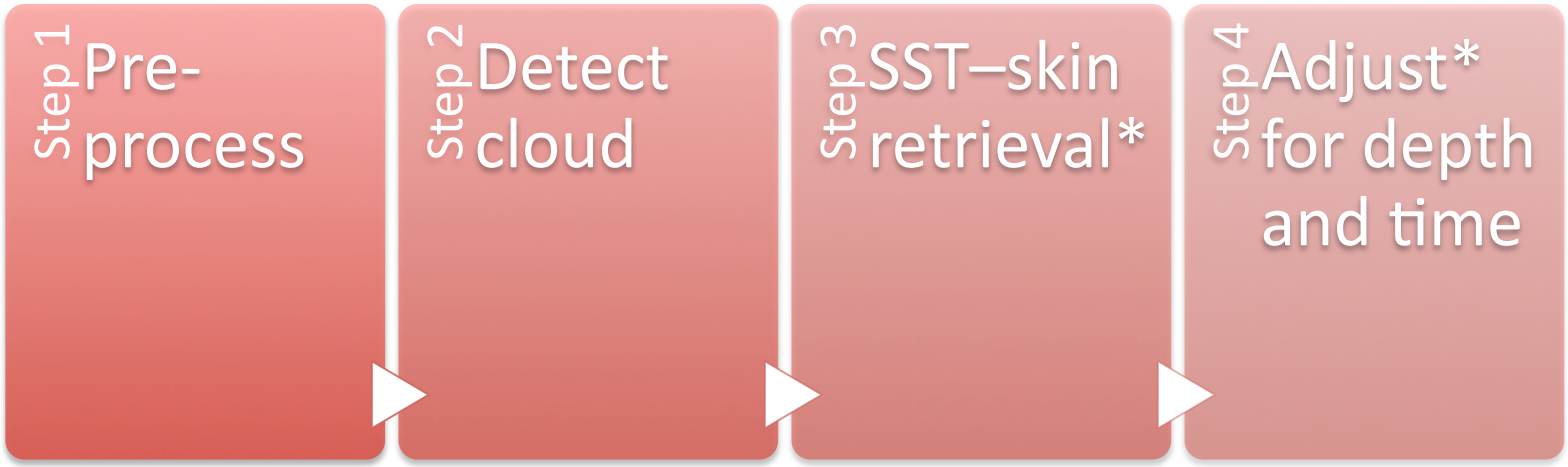
Outline

- Bluffer's Guide to satellite SST
- What is "climate quality" for SST from space?
- Climate quality is possible … AATSR example.
- Going further: SST Climate Change Initiative
- The long view: Sentinels and beyond

1. Bluffer’s Guide

Traditional

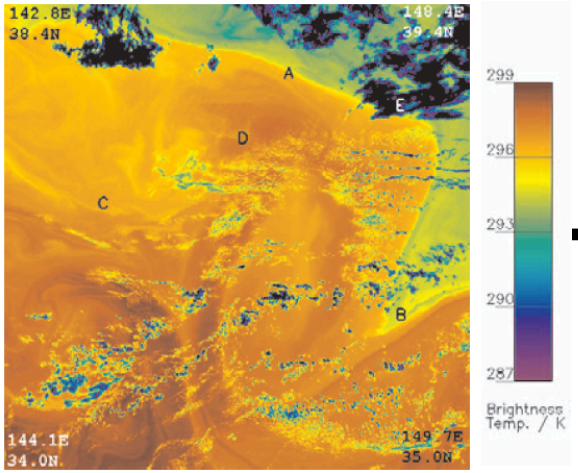
Physics based



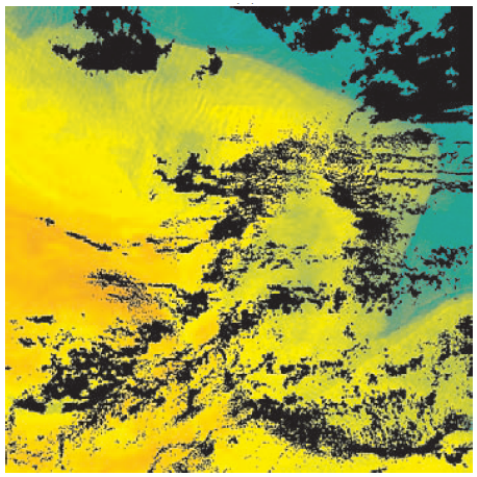
*with uncertainty estimation

Cloud Detection

Knowledge of sensor & channels



Cloud detection algorithm



Cloud mask

Imagery

Knowledge of atmosphere (climatological or NWP)

General SST retrieval expression

$$\hat{x} = a_0 + \sum a_i y_i$$

?

Empirical regression to matched *in situ* observations

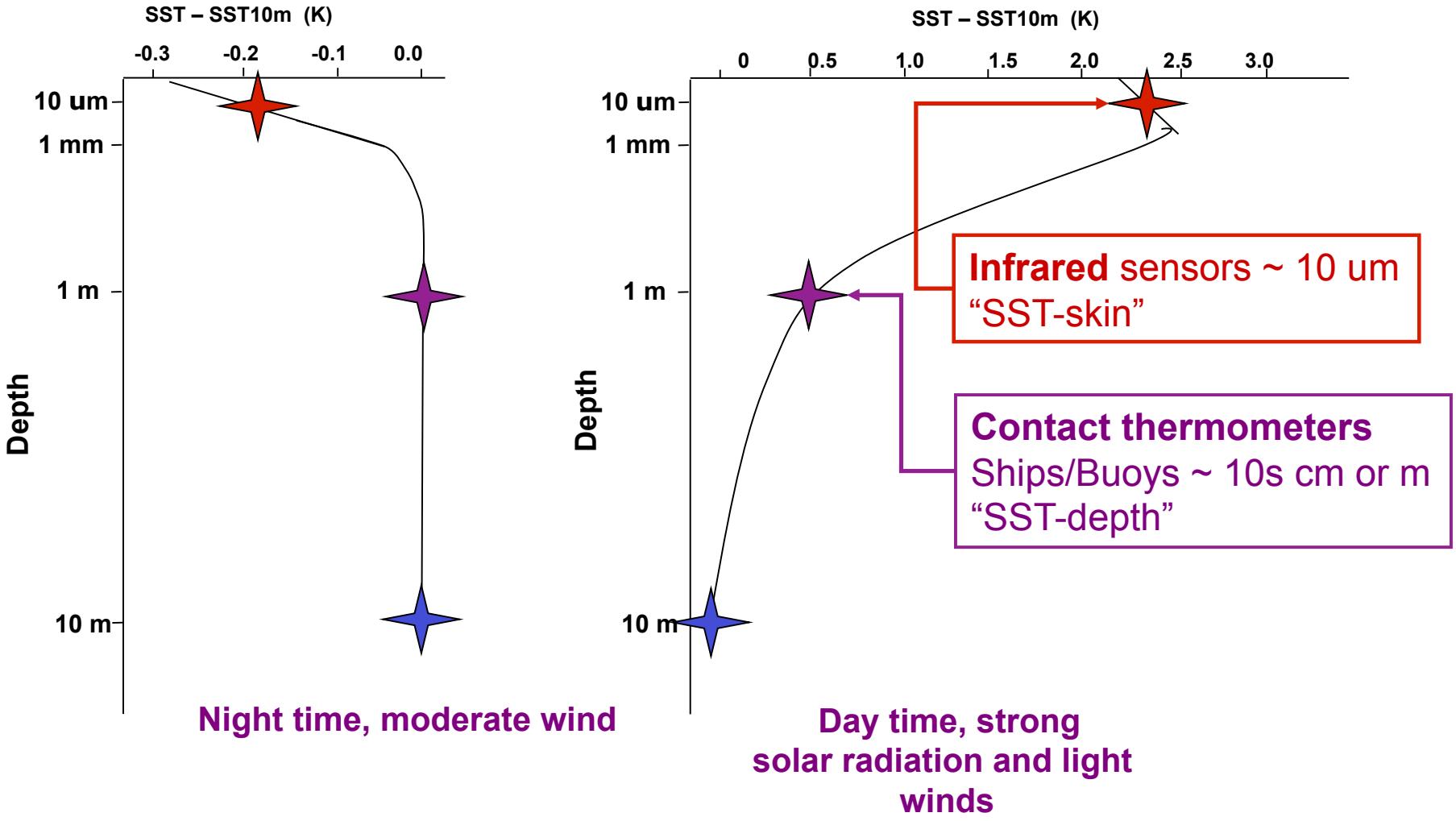
Most products except …

Regression based on radiative transfer simulations

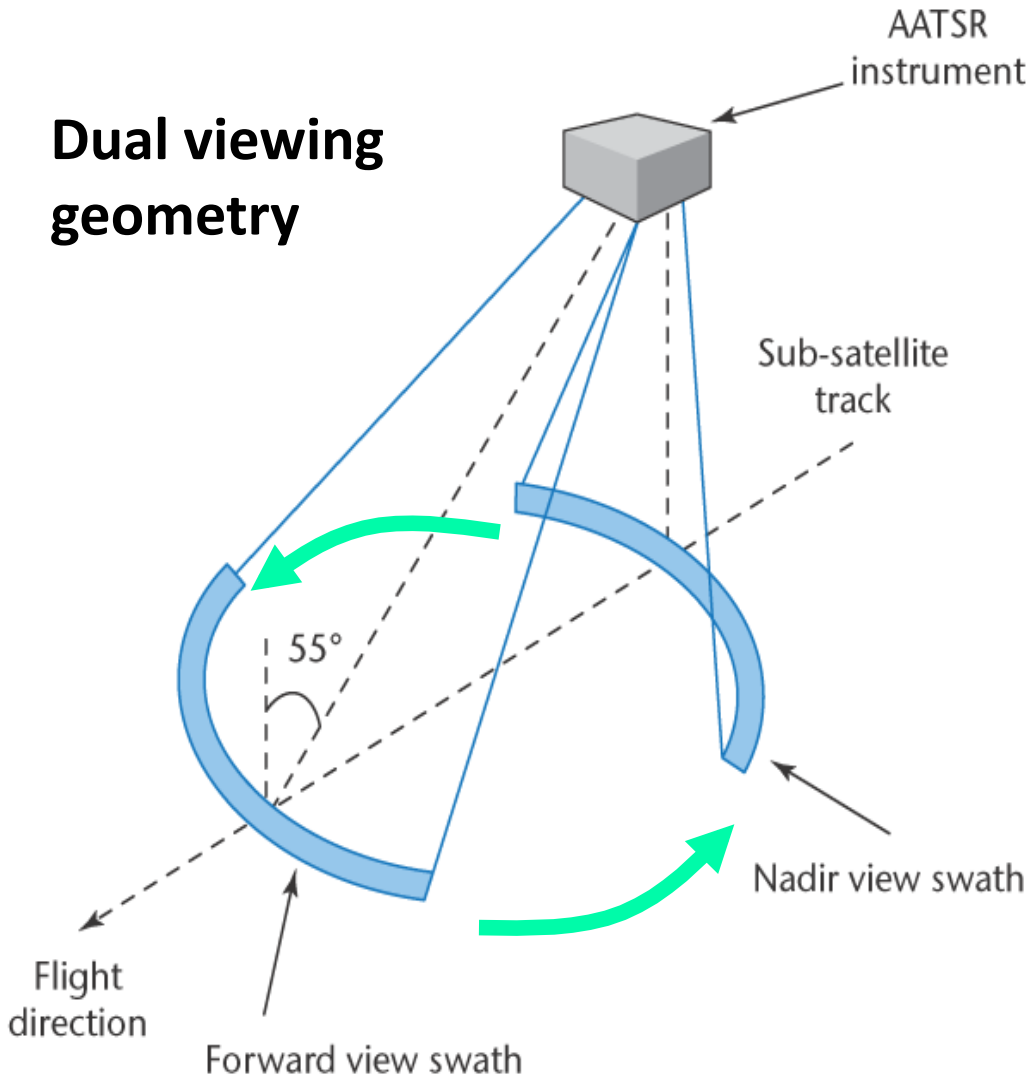
… (A)ATSRs, Meteo-France, NOAA-GOES

Merchant C J and Le Borgne P, *J Atmos Oceanic Technology*, 22 (11) 1734-1746, **2004**.

Definitions of SST



Dual viewing geometry

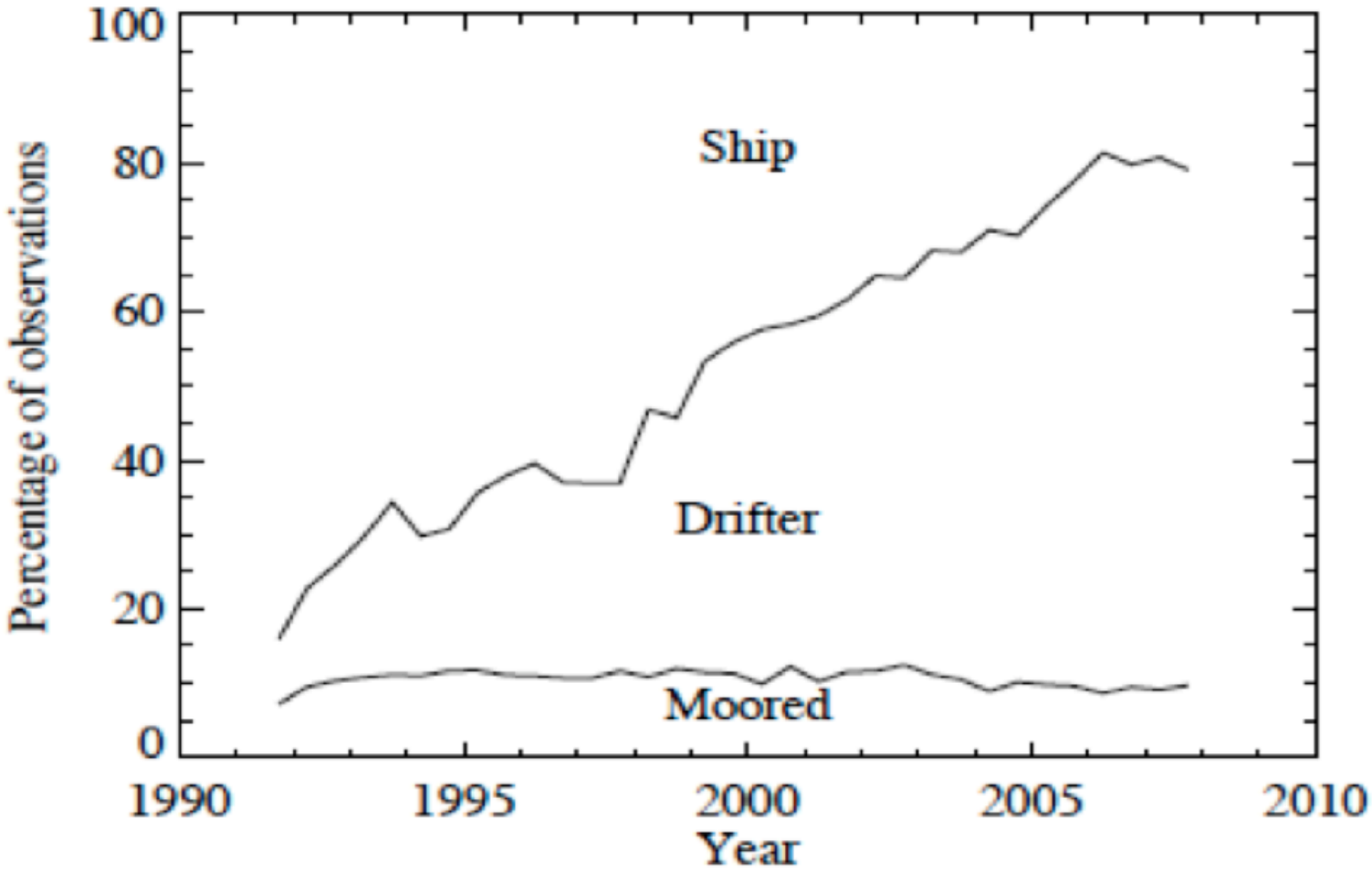


- 1991 – present from ATSR, ATSR-2, AATSR
- High spec:
  - Two point calibration
  - Cal drift <3 cK / mission
  - Noise ~0.05 K
  - Dual-view
  - Spectral response accurately known
- Retrievals by **radiative transfer modelling**
- **Designed for SST/climate** not weather operations

2. Climate quality satellite SST?

Why satellite SST for climate?

- Stable, accurate, independent record of SST
  - to re-assess recent global change
  - to extend the assessment of change into regions where in situ observations are too sparse
  - at higher spatial resolution for new climate models
  - to re-evaluate modes of SST variability & historical reconstructions
  - to initialise ocean for seasonal to decadal climate prediction


100
80
60
40
20
0
Percentage of observations
Ship
Drifter
Moored
1990
1995
2000
2005
2010
Year

Challenges

- Challenges for ‘climate quality’ from satellite SST
  - Indirect mode of observation -- credibility
  - Few sensors … global consistency, but …
    - systematic errors and stability are critical
    - some error components are correlated
    - homogenisation, e.g., using overlaps of missions
  - Skin SST is observed: how to relate historically?
  - Changing local time of observations: risk of aliasing

ATSR Reprocessing for Climate

- >15 years global coverage, 0.1 deg
- Accuracy < 0.1 K
- Stability of 0.05 K per decade
- Both skin and depth SSTs
- Homogeneous
- Comprehensive error characterization
- Independent of other records (in situ)

Merchant C J, D Llewellyn-Jones, R W Saunders, N A Rayner, E C Kent, et al. (2008), Deriving a sea surface temperature record suitable for climate change research from the along-track scanning radiometers, Adv. Sp. Res, 41 (1), 1-11. doi:10.1016/j.asr.2007.07.041

Requirement	GCOS(2006)	ATSR Reprocessing for Climate	SST CCI URD L3/L4 breakthru'	SST CCI plan (baseline)
Accuracy / demonstrated on scale	0.25 K	0.1 K	0.02 K / 100 km	0.1 K / 1000 km
Precision	None	No target	0.05 K / 100 km	Varies, quantify it
Stability	0.1 K / decade	0.05 K per decade	0.02 K per decade; 0.05 K seasonally, diurnally	0.05 K per decade, seasonally, diurnally
Spatial resolution	1 km	0.1 deg	0.1 deg	0.05 deg
Temporal resolution	3 hourly "observing cycle"	Day/night on standardized local time (L3)	Day/night (UTC)	Day/night on standardized local time (L3)
Uncertainty information	None	Characterize	Total uncertainty	Total, systematic and uncorrelated
Type of SST	Blended	Skin and buoy-depth	Skin & buoy-depth	Skin and buoy-depth
Period		1991 - 2009	~1980 - now	1991 - 2010

User requirement for validated uncertainty information

- Uncertainty in an EO product is not a straightforward quantity

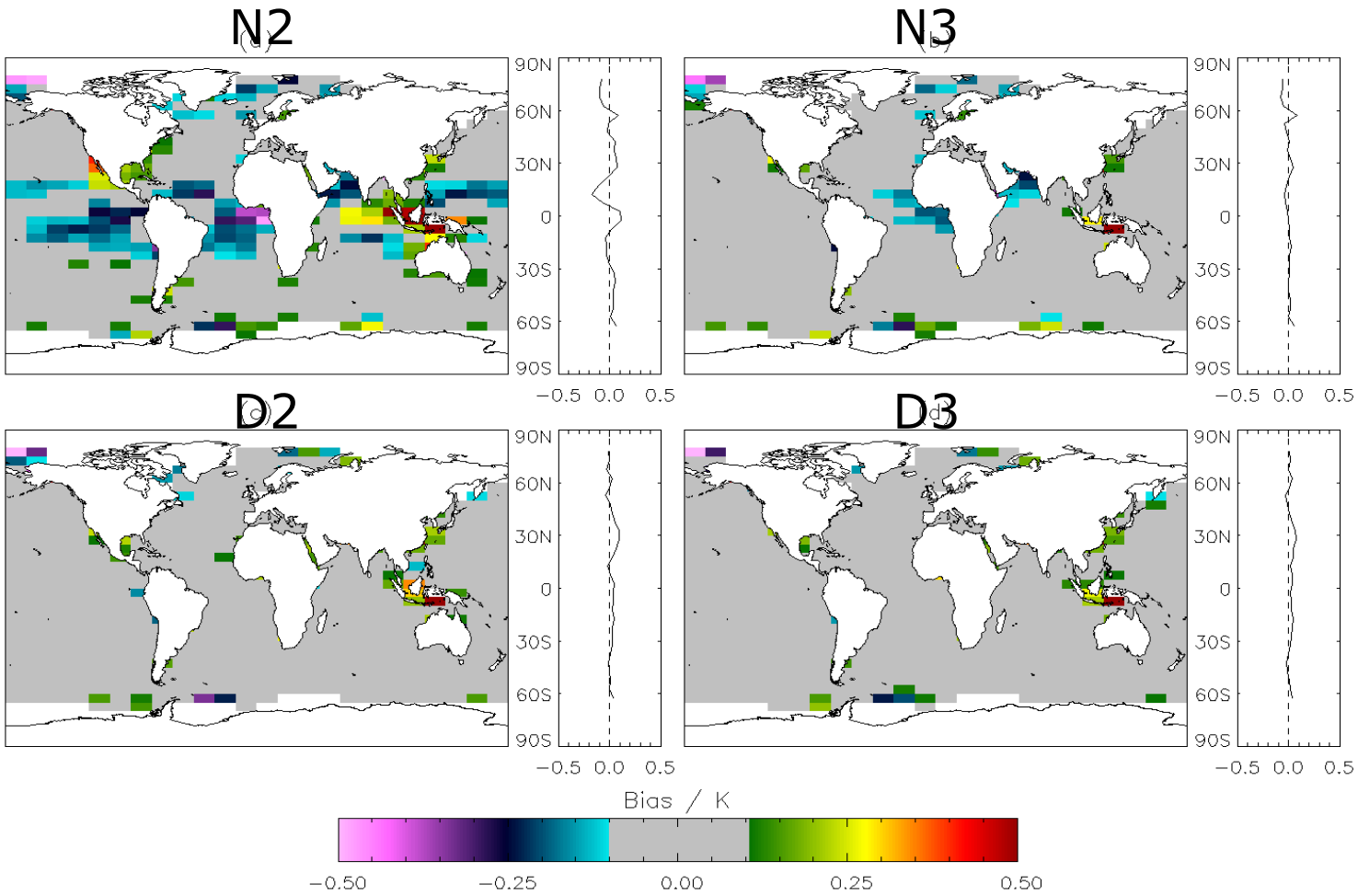
- For SST, there are three or four components
  - Calibration / forward model uncertainty
    - Highly correlated over time and space
  - Radiometric uncertainty
    - Uncorrelated over time and space
  - Retrieval ("algorithmic") uncertainty
    - Partially decorrelates above synoptic time and space scales
  - Contamination uncertainty
    - Low frequency, erratic in time and space, asymmetric

- A single statistic (such as total uncertainty) is inadequate for some purposes

3. Climate quality is possible

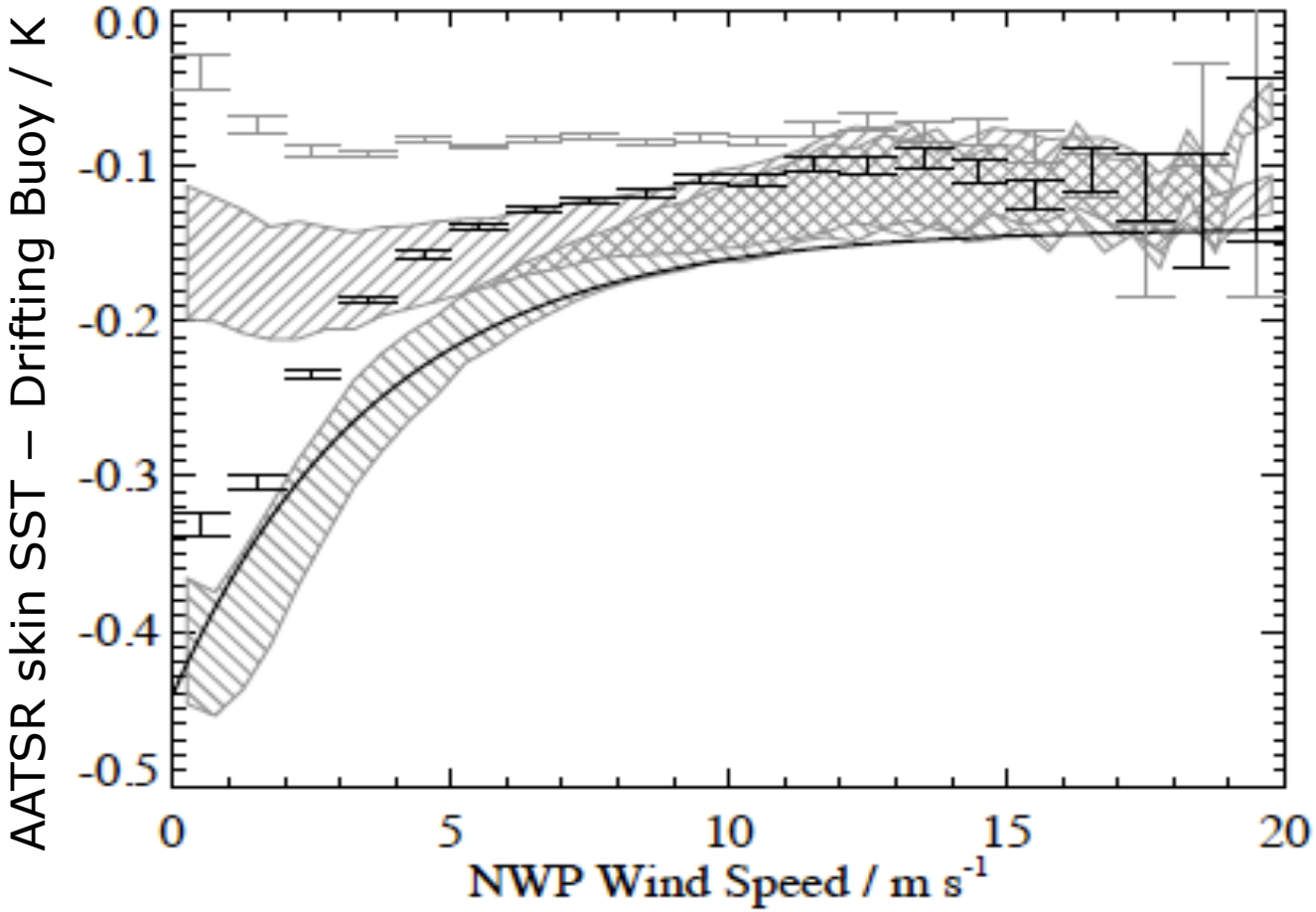
Example of AATSR from ARC project

ARC AATSR SST bias cf. drifting buoys



Embury, O., C. J. Merchant and G. K. Corlett (accepted), A Reprocessing for Climate of Sea Surface Temperature from the Along-Track Scanning Radiometers: Preliminary validation, accounting for skin and diurnal variability, Rem. Sens. Env.

Skin-to-depth model validation in ARC



NIGHT

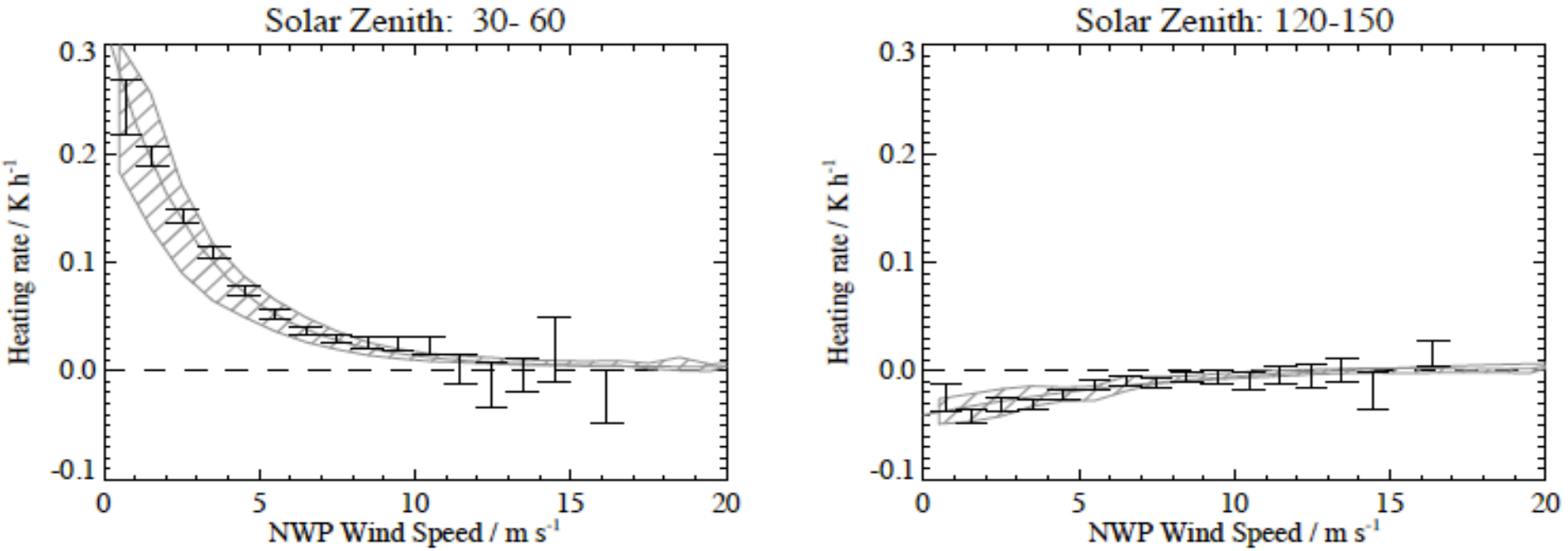
DAY

Bars: Observed

Hatched: Modelled

Diurnal treatment in ARC

- SST-skin[obs t] → SST-depth[ref t]
- Reference time: 1030 h / 2230 h



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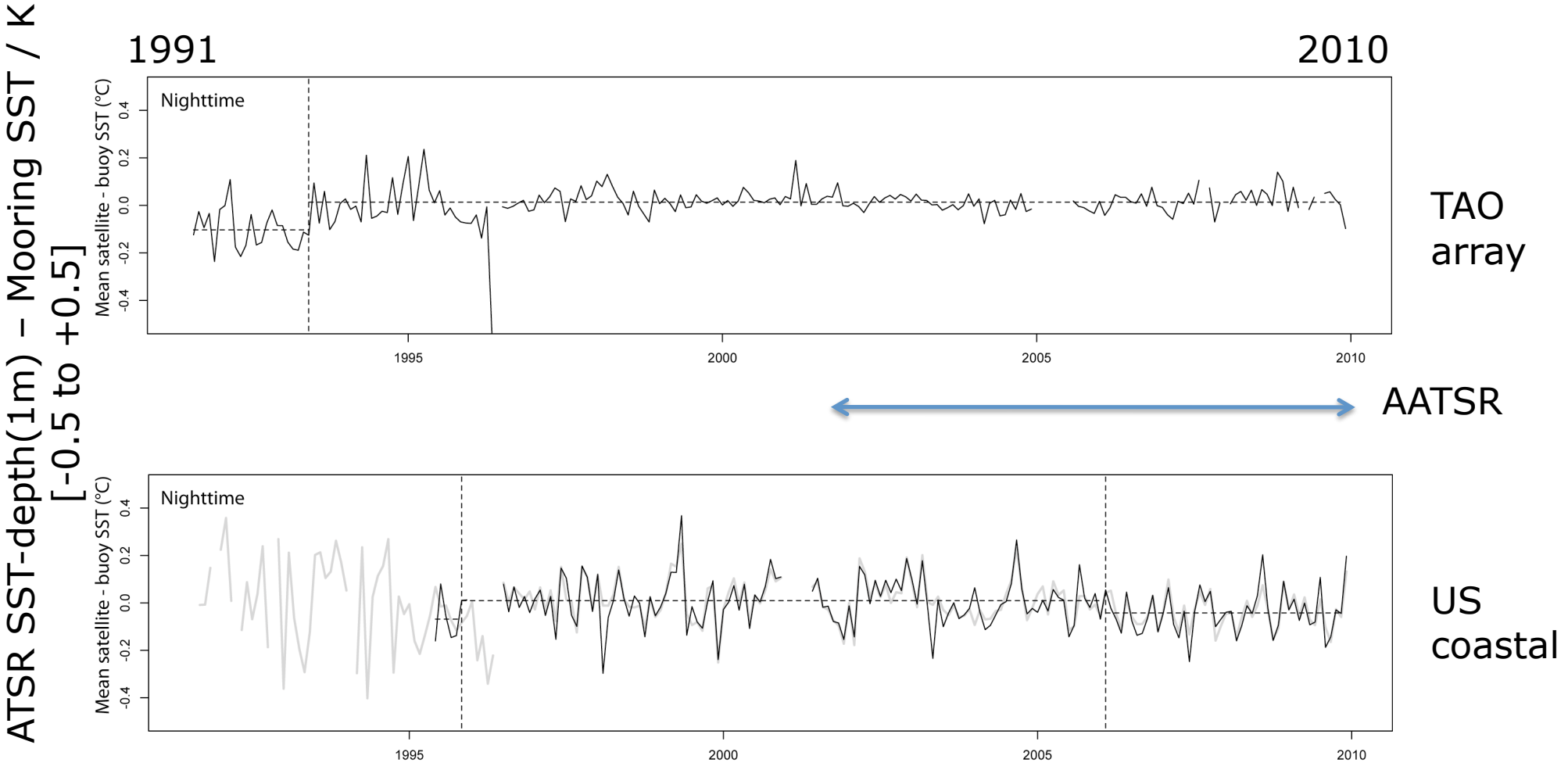
Stability against moorings



See Dave Berry's poster

Stability against moorings

Region	Period	Time of day	Trend (°C decade^{-1})	95% confidence interval (°C decade^{-1})
Tropics	*All (1991 – 2009)*	*Day*	*0.026*	*0.006 < trend < 0.045*
Tropics	*All (1991 – 2009)*	*Night*	*0.044*	*0.020 < trend < 0.069*
Tropics	> 1993	Day	-0.006	-0.026 < trend < 0.015
Tropics	> 1993	Night	0.010	-0.014 < trend < 0.034
Tropics	ATSR2/AATSR	Day	-0.014	-0.037 < trend < 0.009
Tropics	ATSR2/AATSR	Night	-0.002	-0.020 < trend < 0.016

See Dave Berry's poster

4. Going further: SST CCI

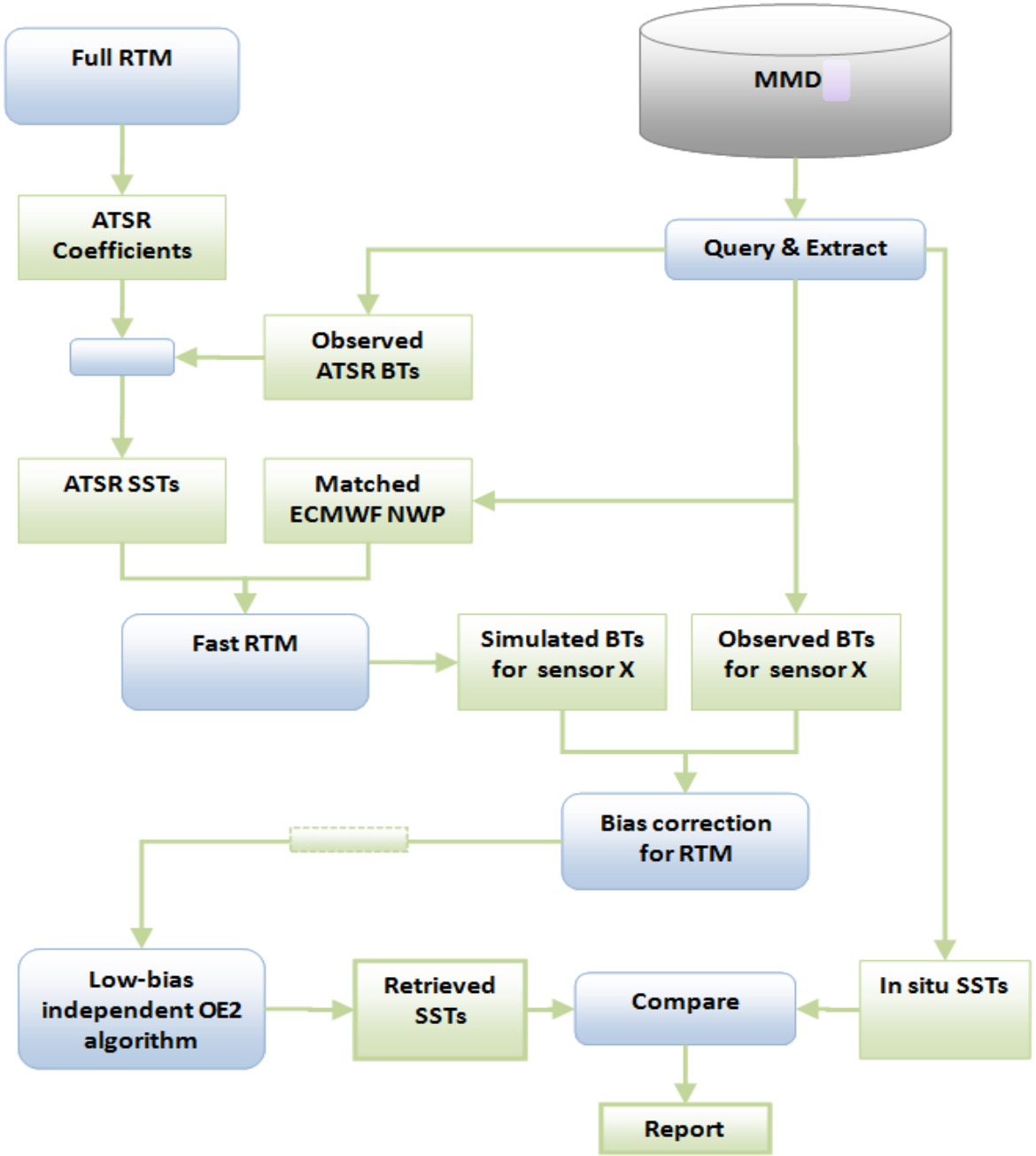
Characteristics of Long Term CCI SST

	PATHFINDER	ARC	CCI SST
Sensors	AVHRR	ATSR	AVHRR + ATSR
Tied to	Drifting buoys	Independent	Independent
Homogenized	No	Yes	Yes
Accounting for diurnal effects	No	Yes	Yes
Meets GCOS accuracy (0.25 K)	No	Yes	Yes
Meets ARC target accuracy (0.1 K)	No	Mostly	Yes/mostly
Retrieval method (TBC)	Coefficients	Coefficients	Optimal
Meets GCOS stability	No	Likely	Likely
Stability quantified	No	Yes	Yes
Clearly defined SST	No	SST-skin, depth	SST-skin, sub-skin, depth
Quantified uncertainties	No	Yes	Yes
Spatial resolution	4 km	0.1^{o}	4 km / 0.05^{o}
GHRSST & netCDF compliant	No	No	Yes
Period	1984 onwards	1991 - 2009	1991 - 2010

New independent SST retrieval

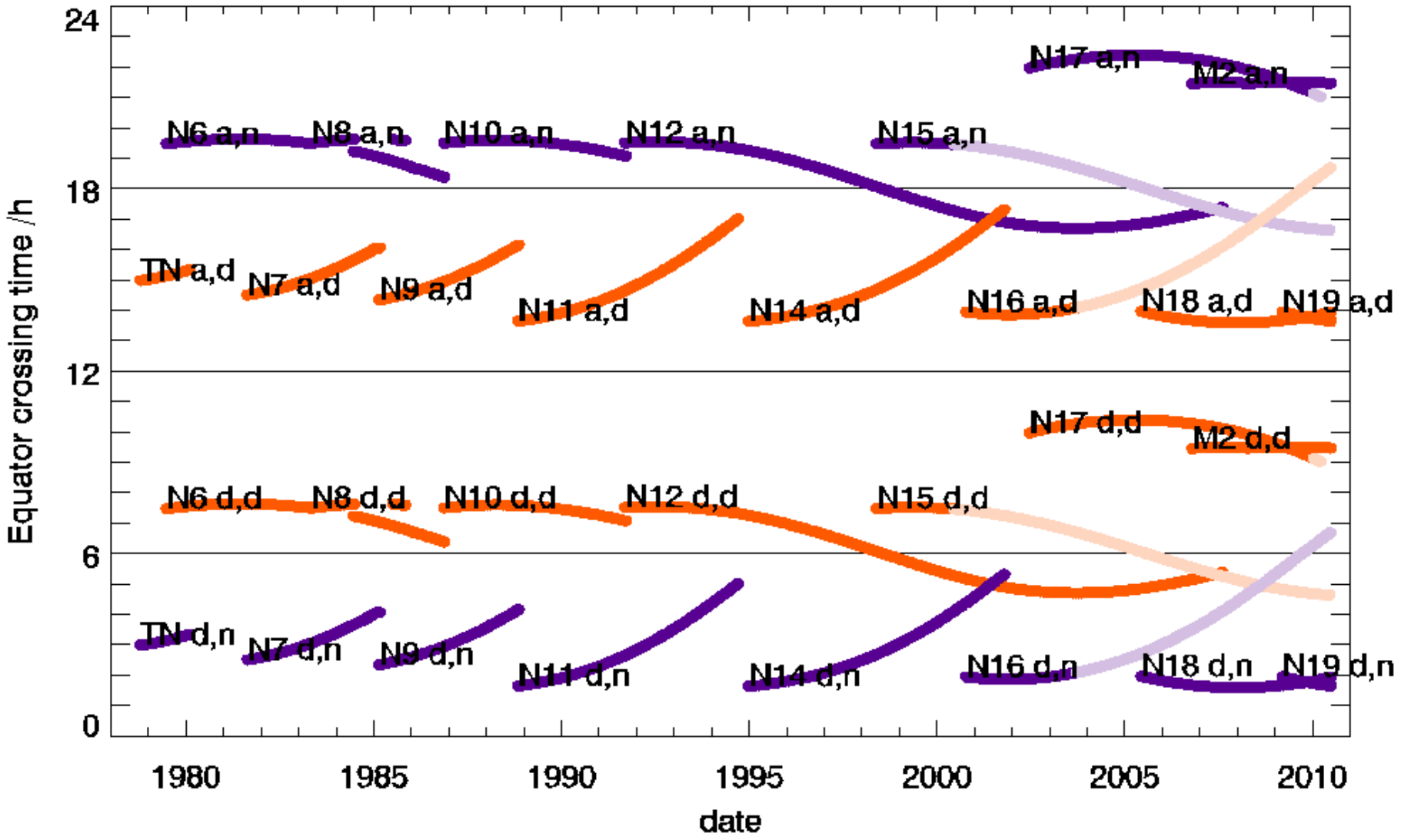
- Shared multi-sensor match-up dataset (MMD)

- Optimal estimation (OE)
  - AVHRRs tied to ATSRs (brightness temperatures)
  - this will give accuracy, stability & independence
  - OE necessary for required single-view accuracy

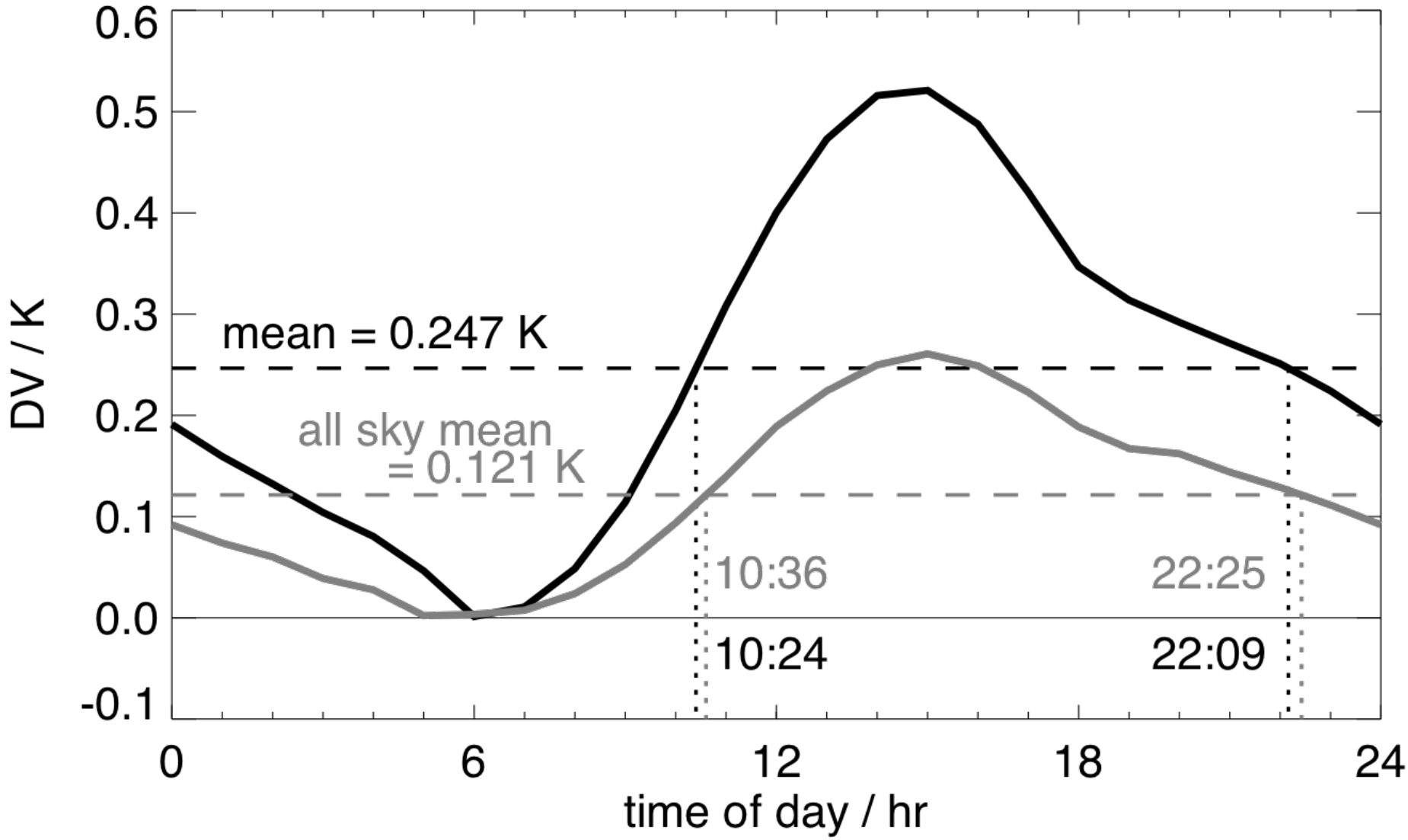


Development logic for OE

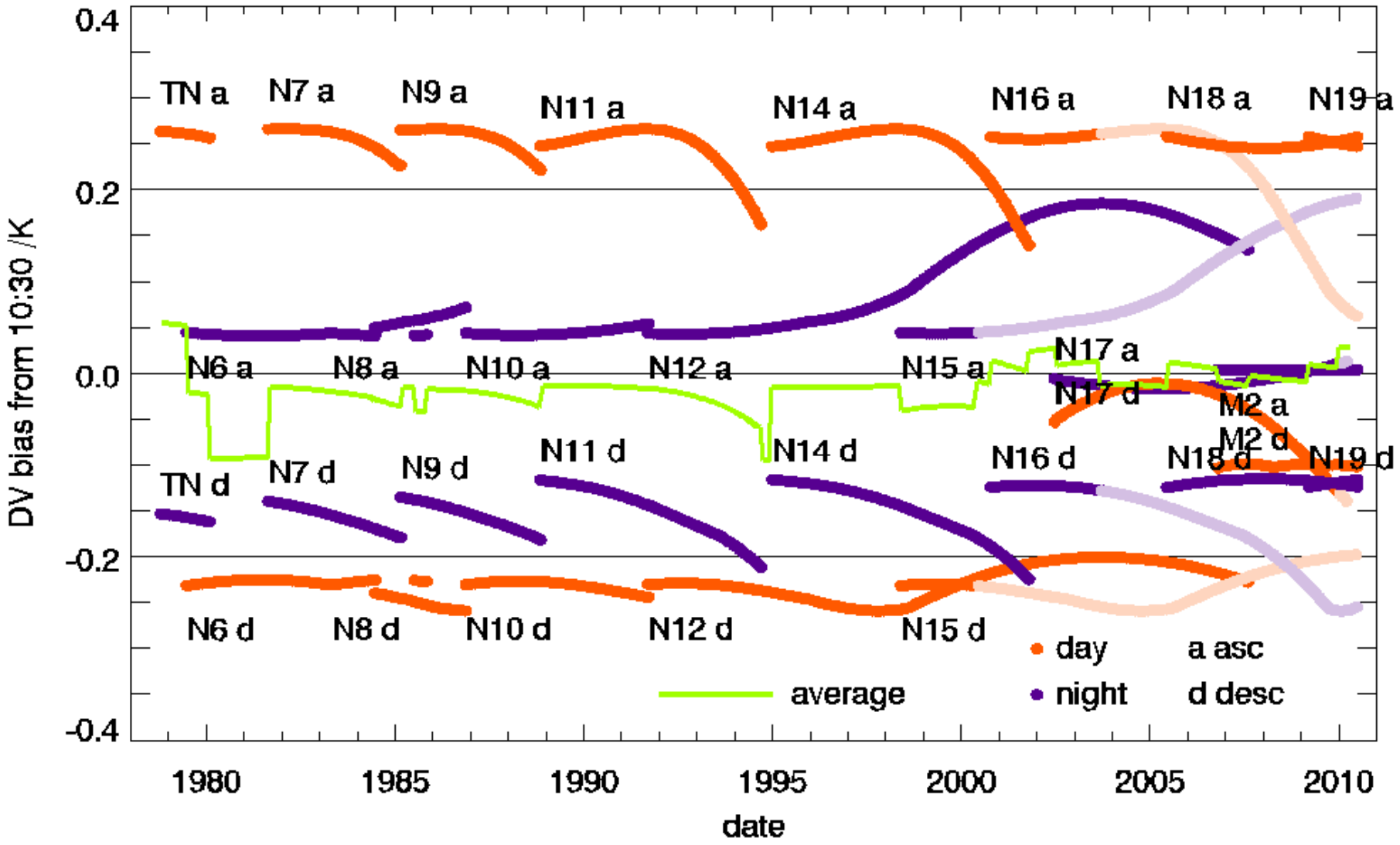
AVHRR orbit drift



Mean diurnal cycle



AVHRR orbit drift



Approach to uncertainty

- Uncertainty estimation is part of retrieval
- (Some) users need to know about variability of uncertainty – need an uncertainty for every SST
- Components of uncertainty have different correlation properties. Propagation of uncertainty from L2 to L3 and L4 needs to address each component appropriately.
- Uncertainty estimates need to be validated

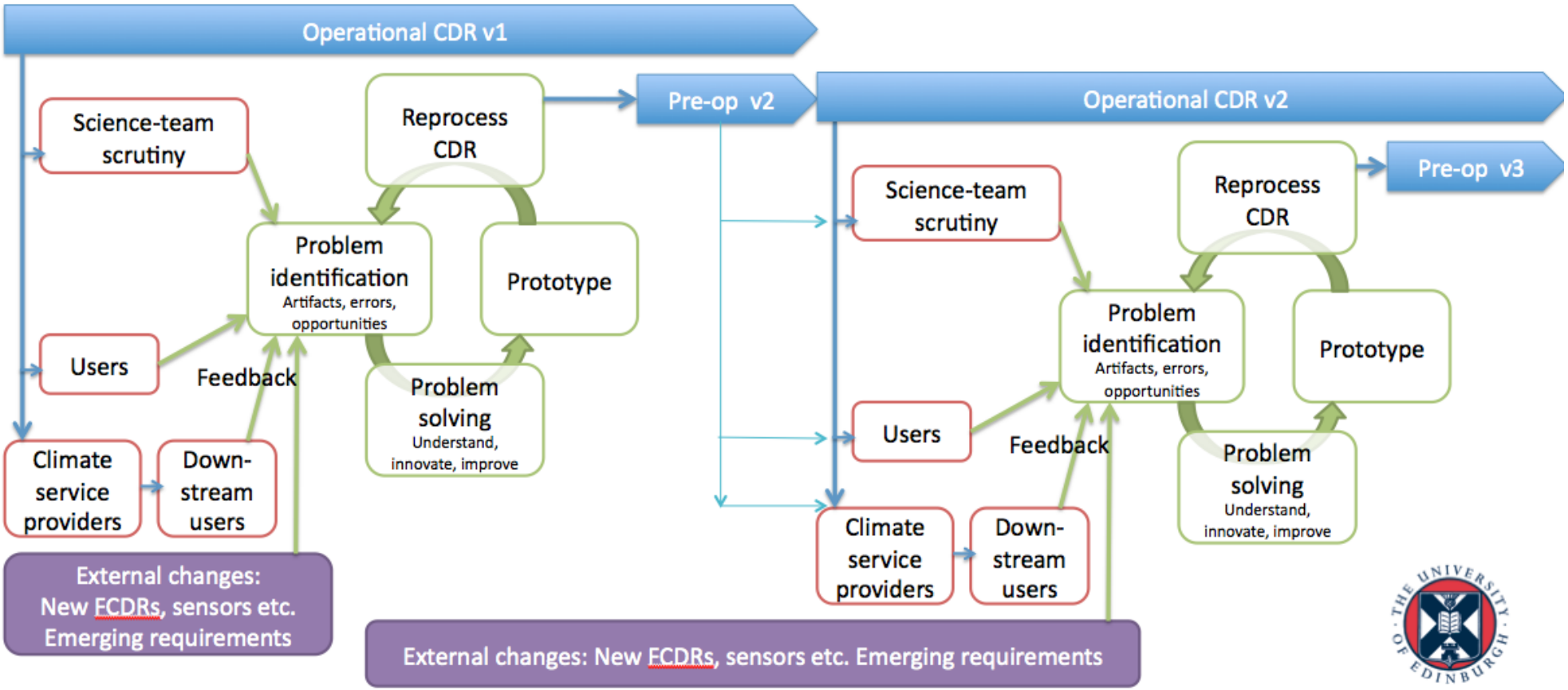
Algorithm R&D & validation

- Open algorithm selection exercise
  - Test, train, blind methodology
- Fully independent product validation
  - Reserved in situ data
  - Validate SSTs and their attached uncertainties

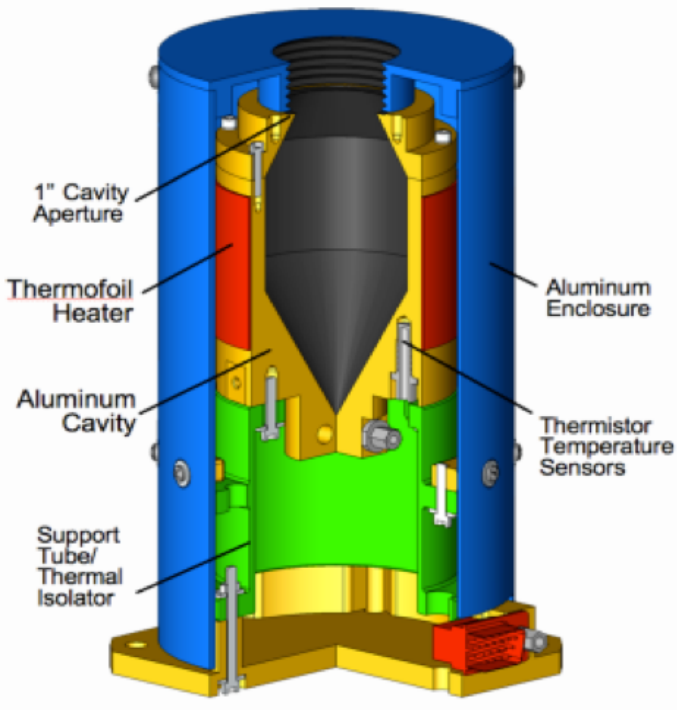
5. The long view

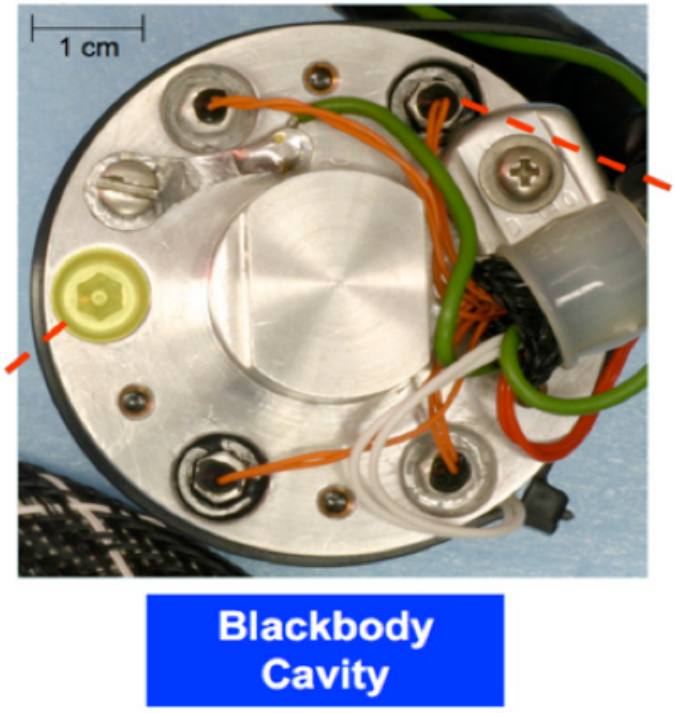
Sentinel 3 inc. SLSTR

Climate Data Record operations



New technology for accuracy & stability





http://www.ssec.wisc.edu/media/newsletter/winter09/sensormaterials.pdf

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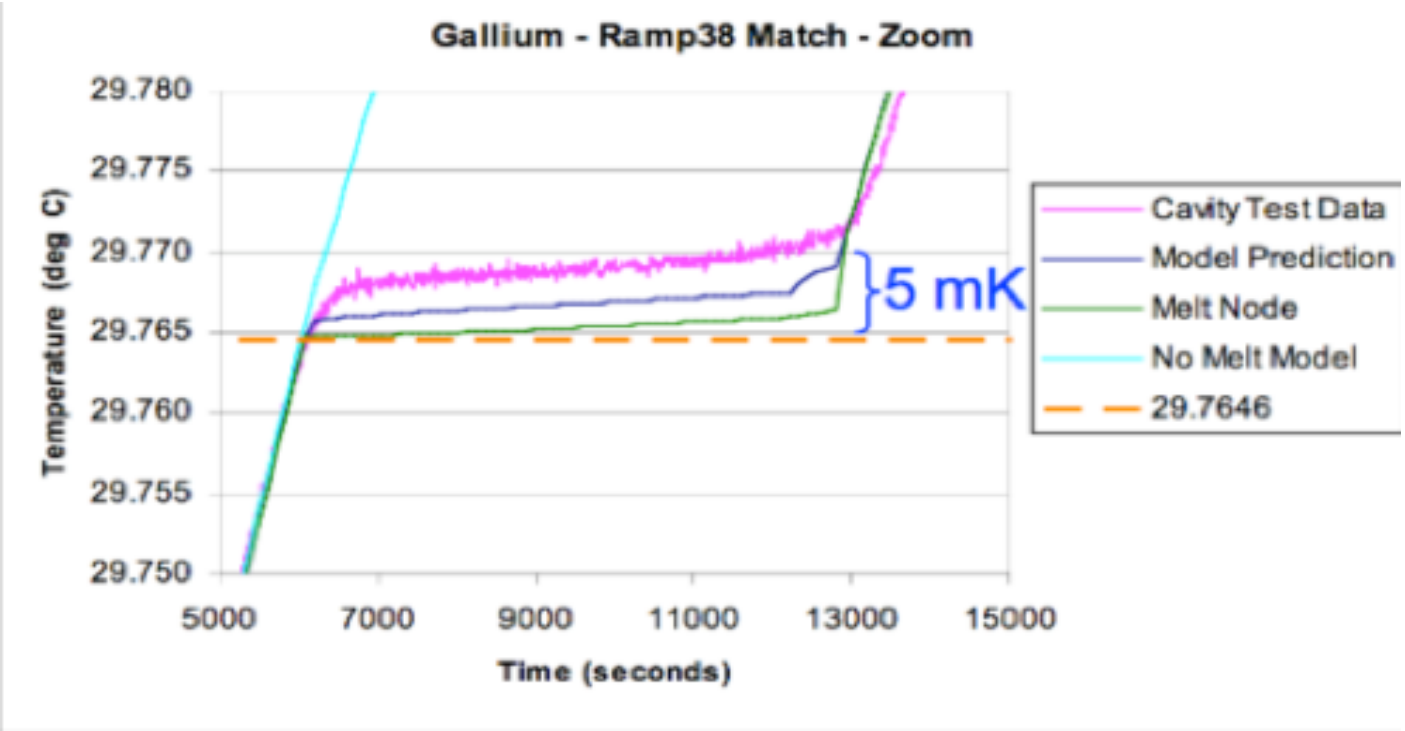

http://www.ssec.wisc.edu/media/newsletter/winter09/sensormaterials.pdf

Long-term prospect

- Better integration and use of complementarity
  - John Kennedy, Tuesday a.m.
- 21st C climate records will be satellite + in situ SST
- Climate quality can be achieved with right instrument
- Challenge is to better exploit this throughout the satellite constellation, for the long run