ESA Climate Change Initiative Phase-II

Sea Surface Temperature (SST)

www.esa-sst-cci.org

An uncertainty budget for validating satellite derived sea surface temperature measurements

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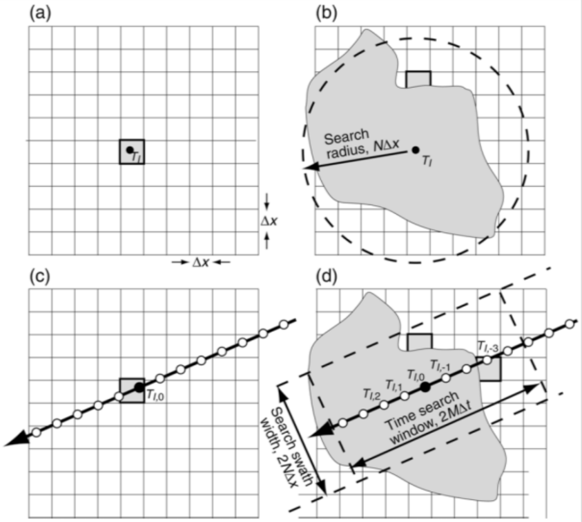
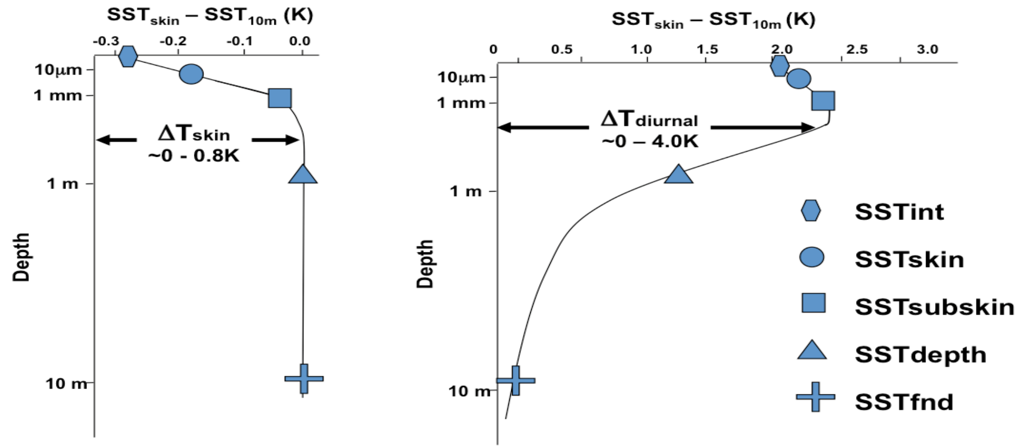
Understanding the problem (1)

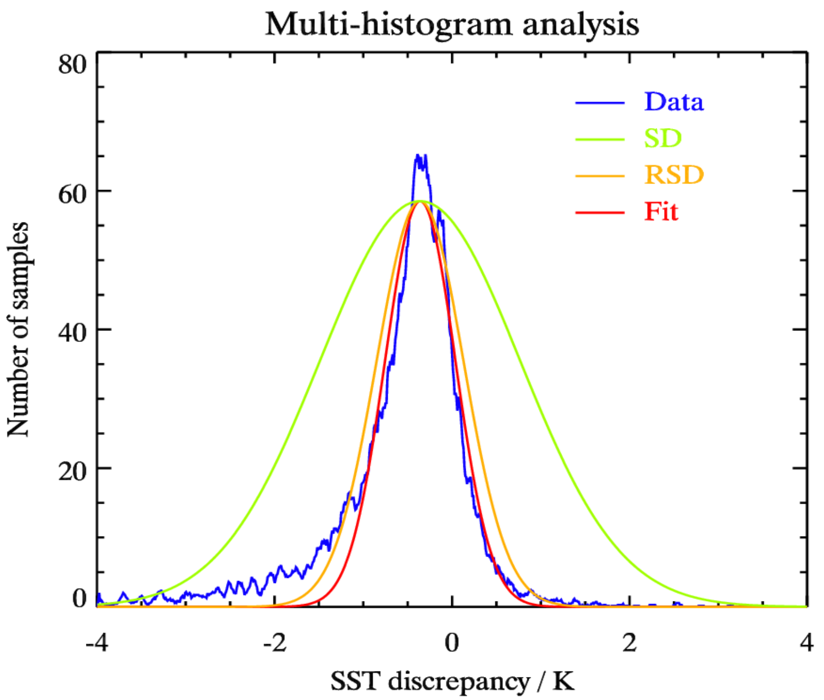




(a) Night time situation, light wind

(b) Day time time situation, strong solar radiation and light winds

Understanding the problem (2)



- Assessment of uncertainty of satellite measurements involves comparison to a reference dataset
    - Create dataset of match-up coincidences within predefined spatial and temporal limits
- The bias and standard deviation calculated from such a comparison do not provide the uncertainty of each dataset individually, but are simply the mean bias and combined uncertainty of a two dataset comparison.
- Consequently, the resulting statistics are often dominated by real changes in the SST that can occur within the predefined spatial and temporal limits.

Provides an upper limit on the total matchup uncertainty

Validation uncertainty budget

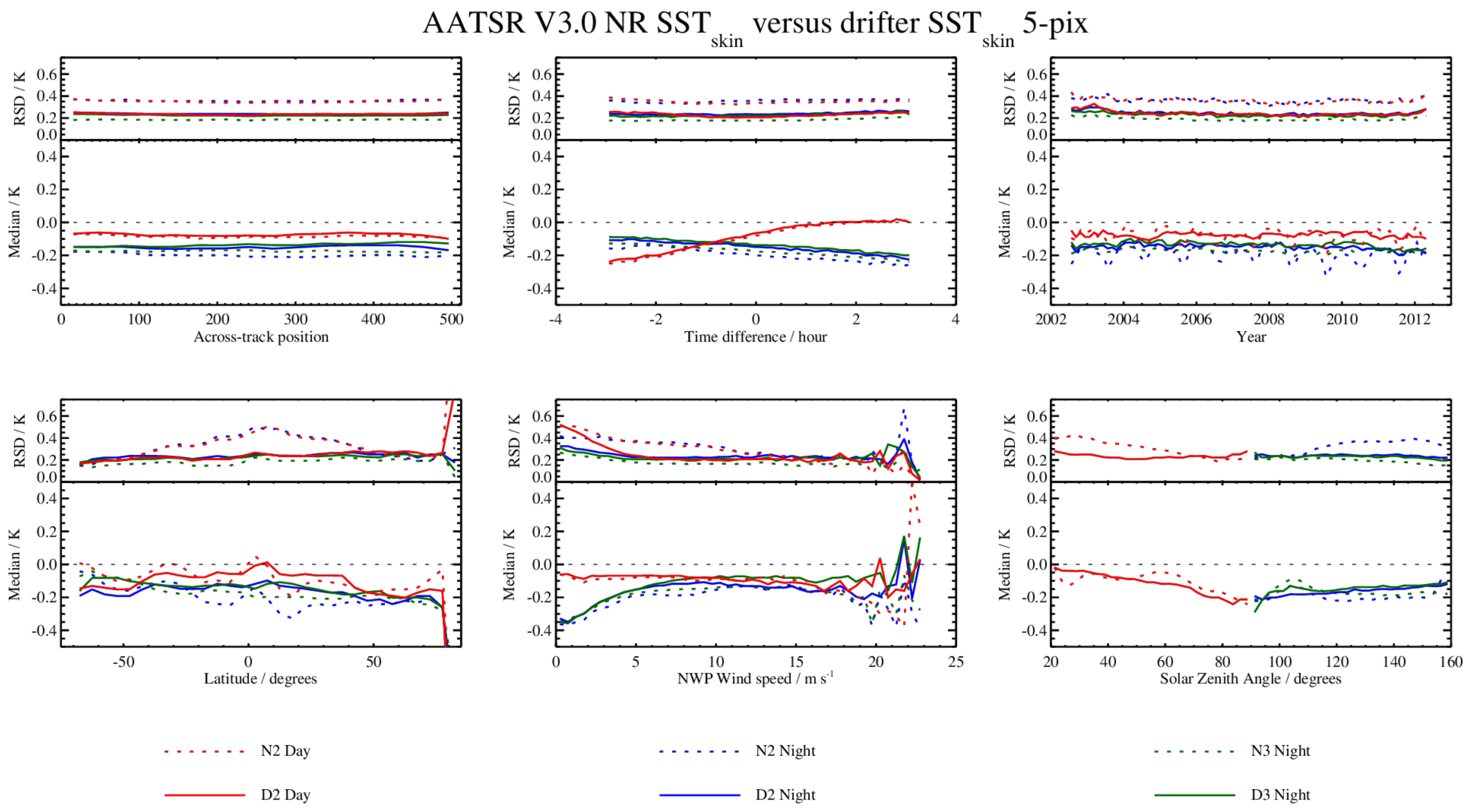
$$\sigma_{Total} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \sigma_4^2 + \sigma_5^2}$$

- Satellite (σ_1)
  - Varies pixel by pixel
- Reference (σ_2)
  - Generally unknown; Estimate of *O*(0.1 K) for GTMBA moorings and radiometers; *O*(0.2 K) for drifters; negligible (?) for Argo
- Geophysical: spatial – surface (σ_3)
  - Systematic for single match-up; pseudo-random for large dataset
  - Can be reduced through pixel averaging (e.g. sample 11 by 11 instead of 1 by 1)
  - Includes uncertainty in geolocation (may be systematic even for large numbers)
- Geophysical: spatial – depth (σ_4)
  - Systematic for single match-up for different depths; pseudo-random for large dataset at different depths (with combined diurnal/skin model)
- Geophysical: temporal (σ_5)
  - Systematic for single match-up; may be reduced for large dataset (if match-up window small enough)
  - Can be reduced with combined diurnal/skin model

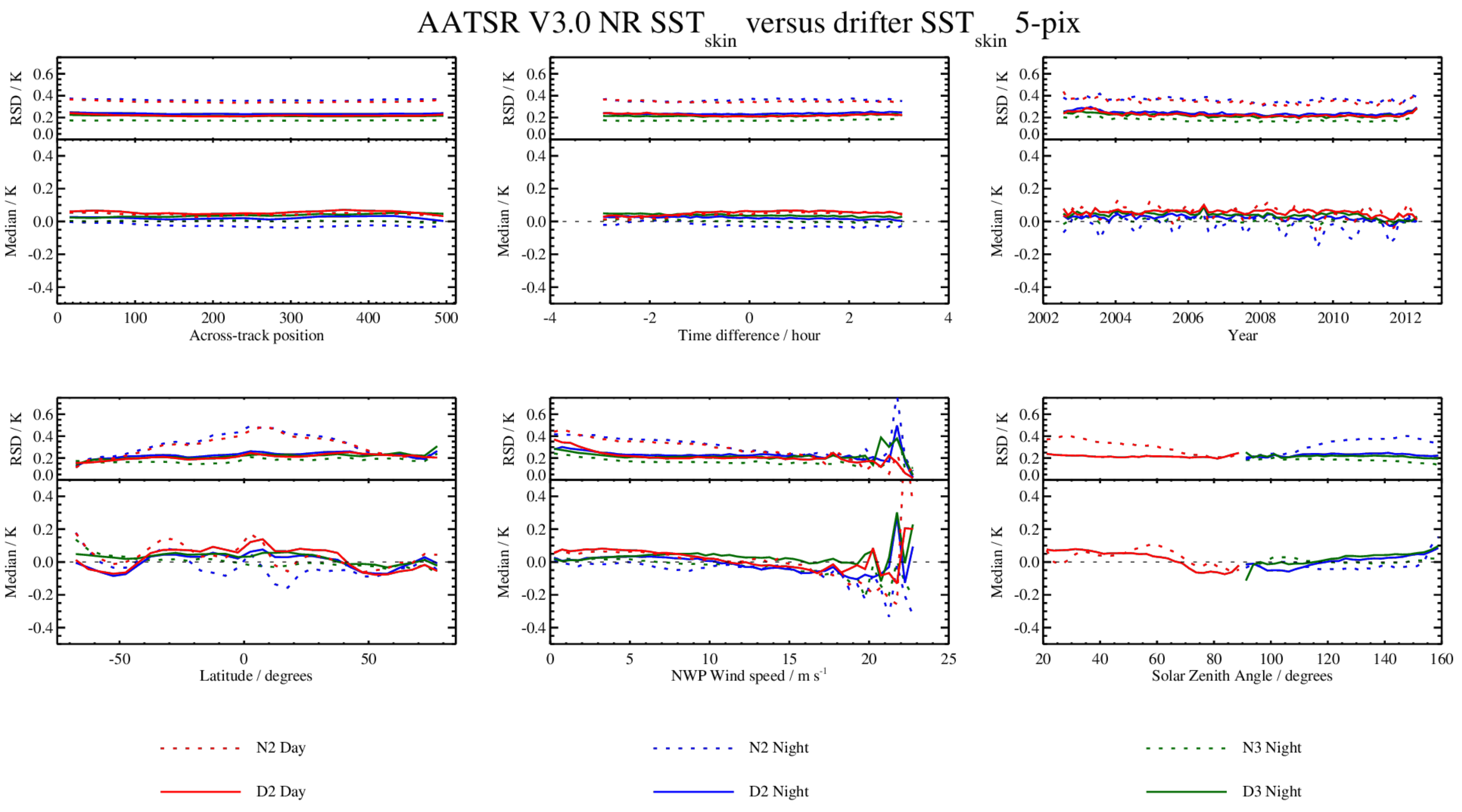
Primary reference measurements for validation

Data type	Year	Coverage	SST*	Uncertainty
Ship-borne IR radiometers	1998 -	Repeated tracks in the Caribbean Sea, North Atlantic Ocean, North Pacific Ocean, and the Bay of Biscay; episodic deployments elsewhere in the world's oceans.	SSTskin	0.10 K
Argo floats	2000 -	Global# from ~ 2004 onwards.	SST-5m	0.05 K
GTMBA	1979 -	Tropical Pacific Ocean array completed in 1998; tropical Atlantic and Indian Ocean arrays installed later.	SST-1m	0.10 K
Drifting buoys	1991 -	Global# from ~ 2000 onwards.	SST-20cm	0.20 K

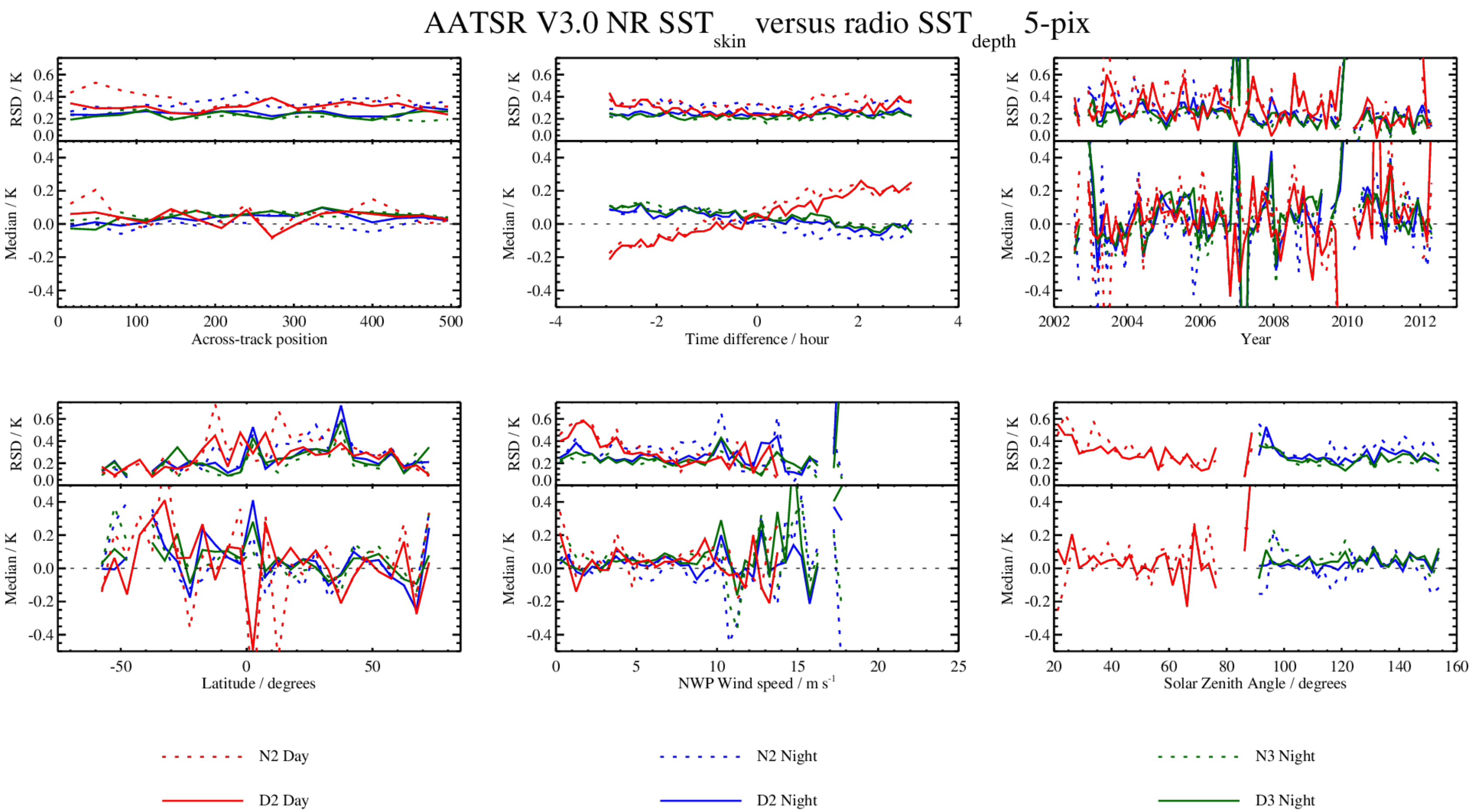
Drifters – raw



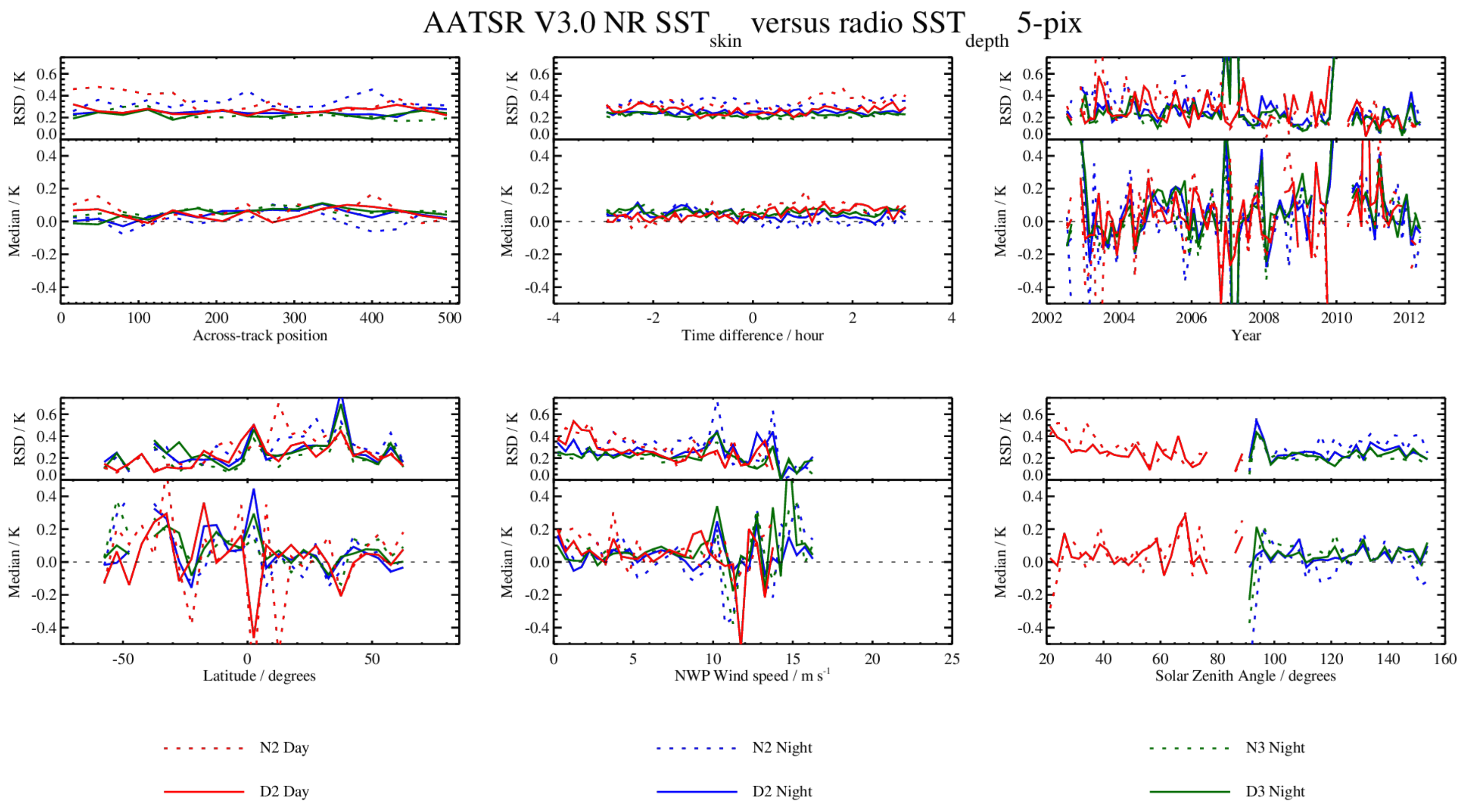
Drifters – with FKC adjustments



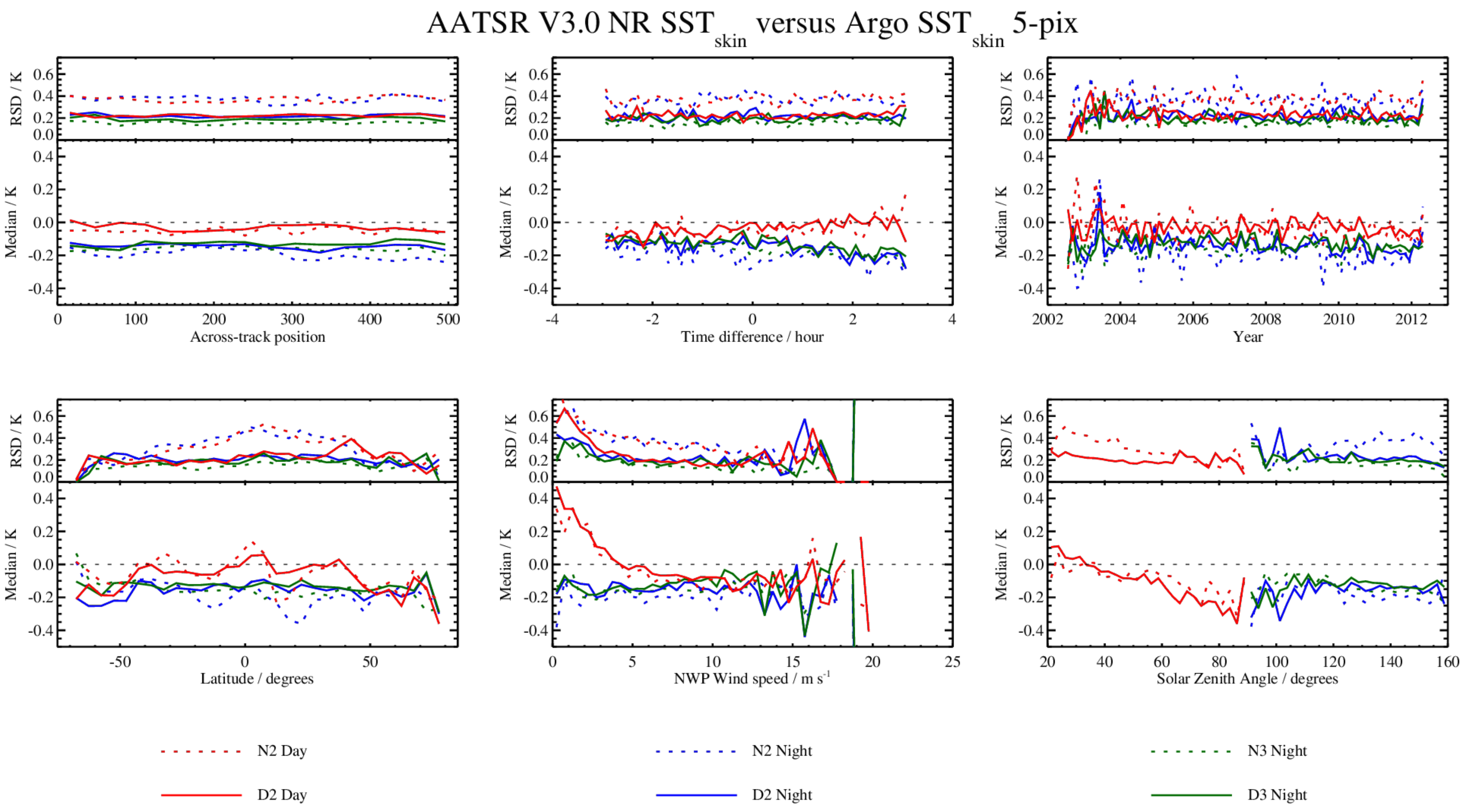
Radiometers – raw



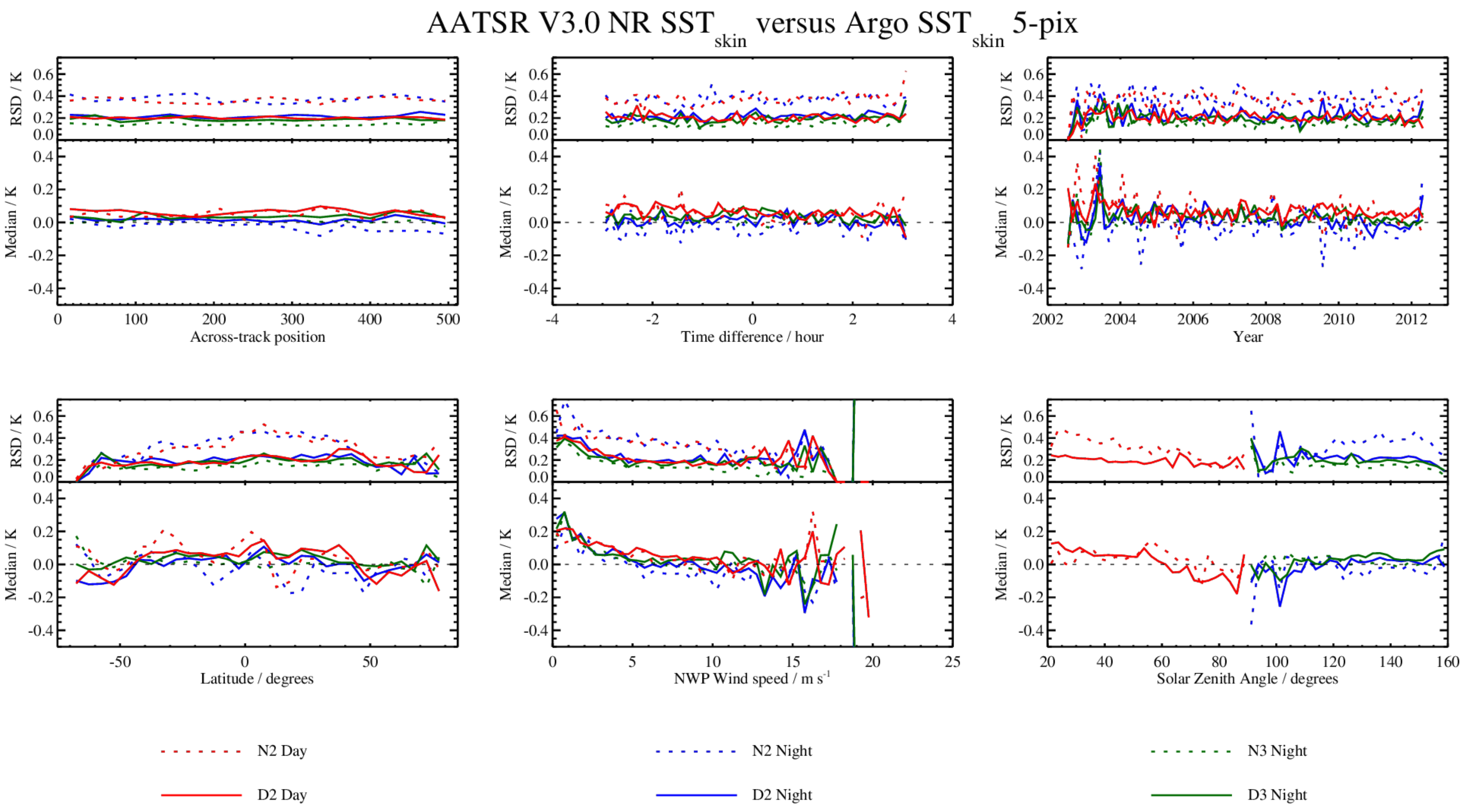
Radiometers – with FKC adjustments



Argo – raw


AATSR V3.0 NR SST skin versus Argo SST skin 5-pix
RSD / K
Median / K
Across-track position
Time difference / hour
Year
Latitude / degrees
NWP Wind speed / m s-1
Solar Zenith Angle / degrees
N2 Day
D2 Day
N2 Night
D2 Night
N3 Night
D3 Night

Argo – with FKC adjustments

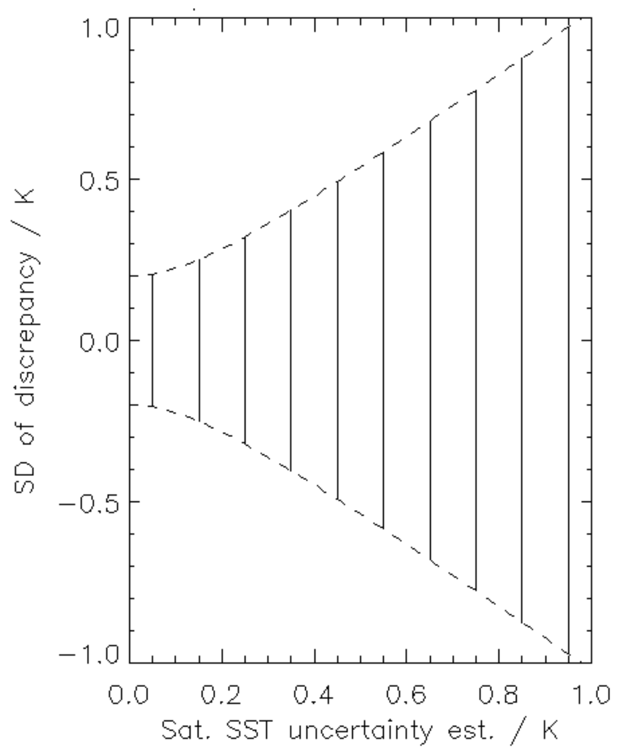


How to validate uncertainty?

- Example using drifters
- Use mean uncertainty of 0.2 K for σ_2
- Use large number of match-ups, area averaging and diurnal & skin model to randomise σ_3 and σ_4
- Use diurnal & skin model to reduce σ_5
- Uncertainty budget reduces to:

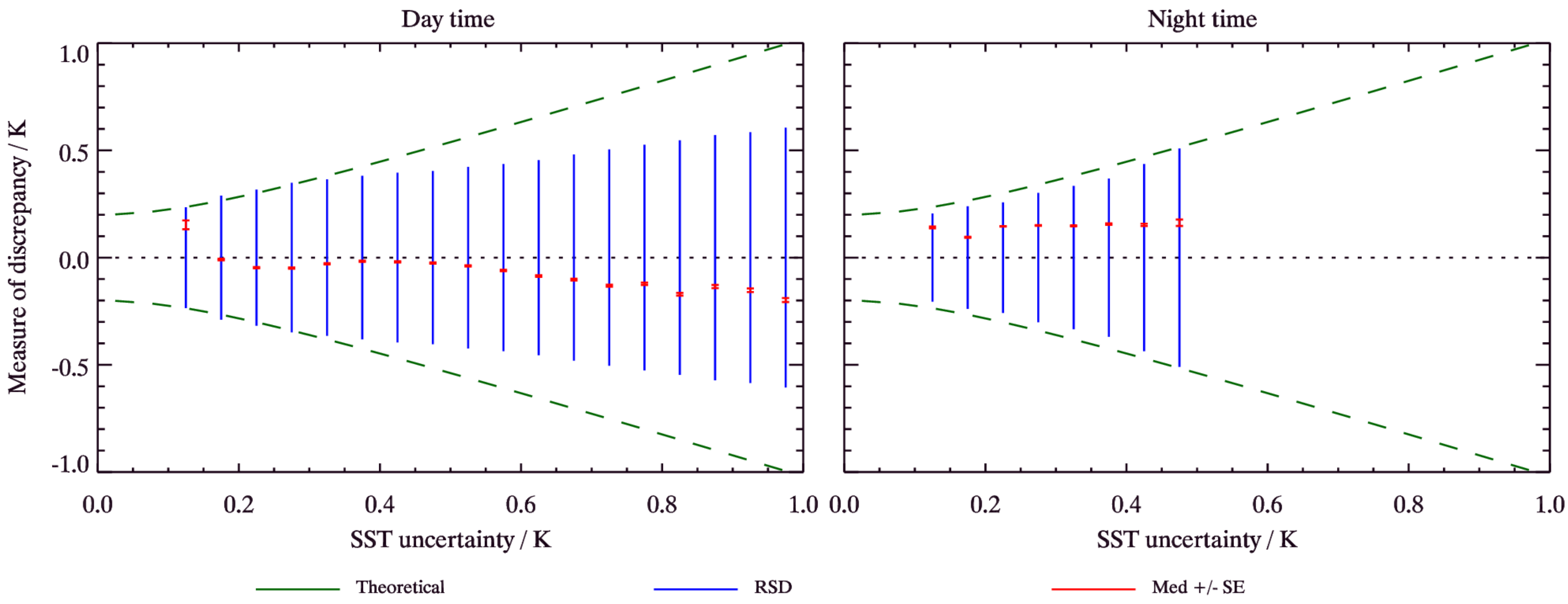
$$s_{sat-ref} = \sqrt{s_{sat}^2 + s_{ref}^2}$$

- Theoretical distribution:

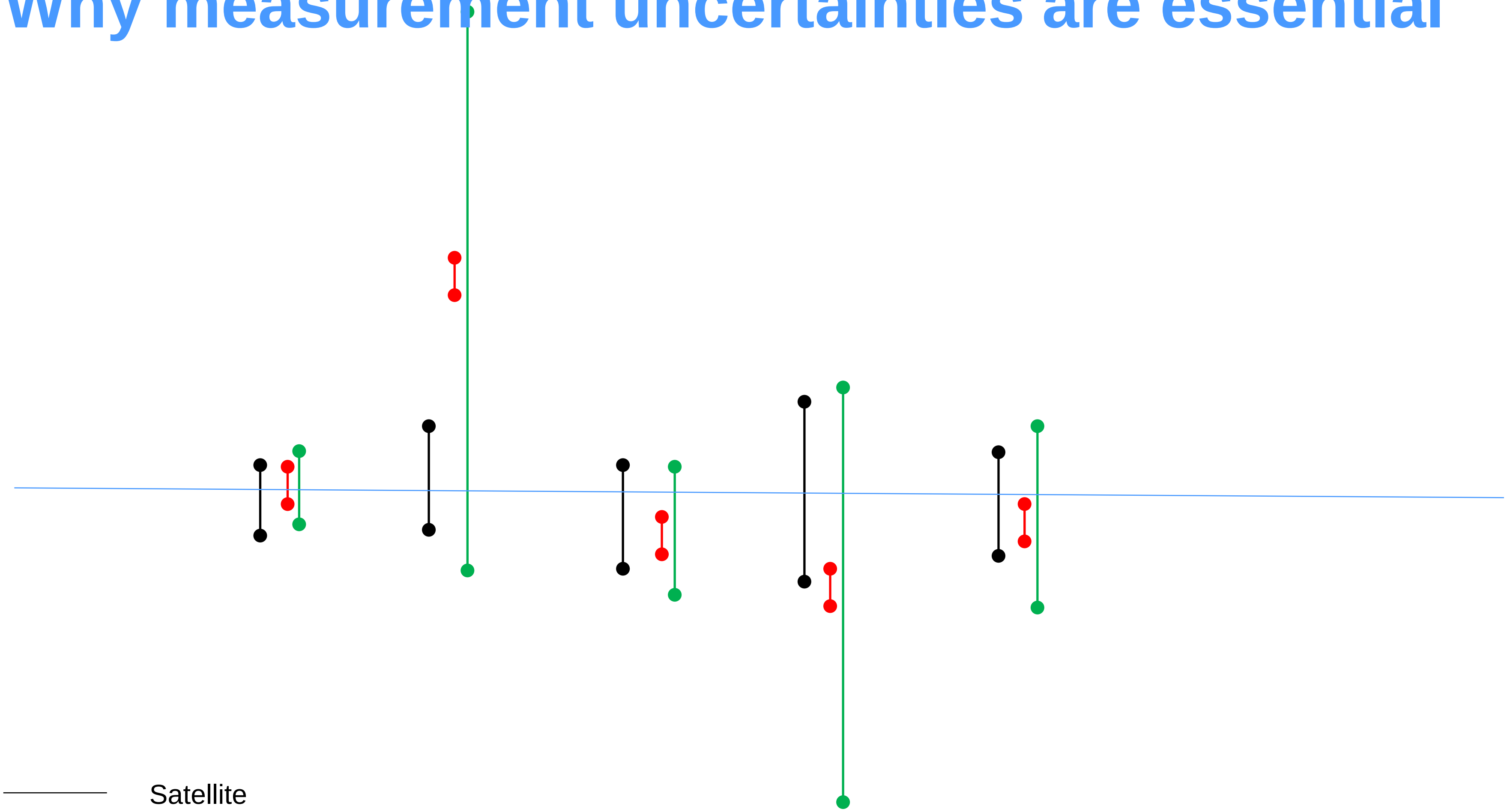


Results: AVHRR L2P

ESA SST_CCI AVHRR NOAA-18 L2P $SST_{0.2m}$ versus drifters



Why measurement uncertainties are essential



Satellite

Poorly characterised reference leads to apparent unstable time series of discrepancies within quoted uncertainties

Well characterised reference confirms stable time series of discrepancies within quoted uncertainties

Summary

- Validation of satellite data using (F)RM requires consideration of all likely sources of error
  - **Geophysical terms will often dominate**
  - Will contribute to overall uncertainty budget if not corrected

- Validation of satellite data requires full coverage of the “validation space”
  - Key dependences of the retrieval algorithm, sensor and orbit

- Uncertainties should be validated
  - **FRM should have validated uncertainties**