Comparison (of shipborne radiometers) with other in situ measurements

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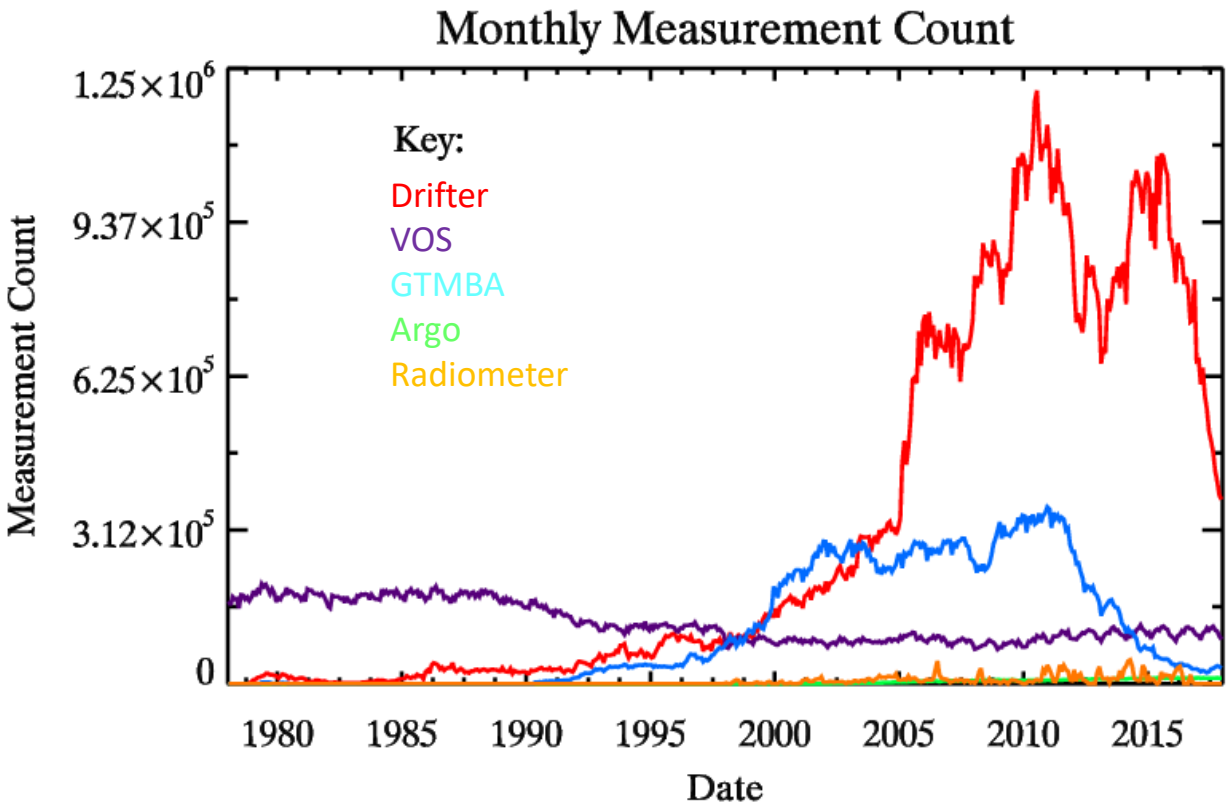
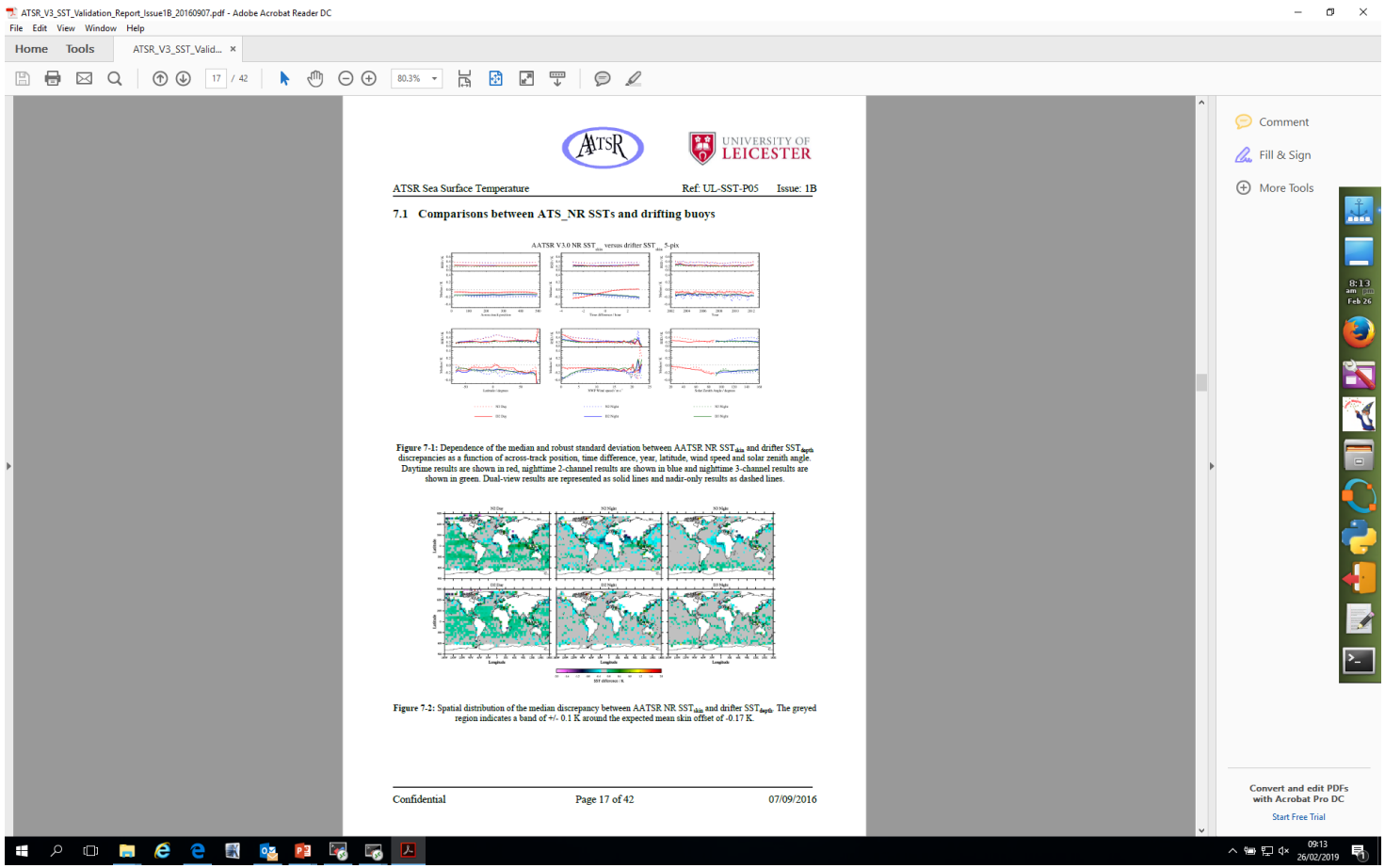
Reference datasets

- Ship-borne radiometers
  - Traceable to SI; SST-skin; very-high accuracy; very-poor coverage
- Drifting buoys
  - Unknown calibration; global data; SST-depth; good coverage in recent ~decade
- Argo near-surface
  - Global; acceptable sampling; very-low uncertainty (calibration method to be analysed)
- GTMBA
  - Better calibration; SST-1m; acceptable coverage (influenced by data collection);
- VOS and VOSclim
  - Generally poor coverage; very high uncertainty on single sample
- Everything else…

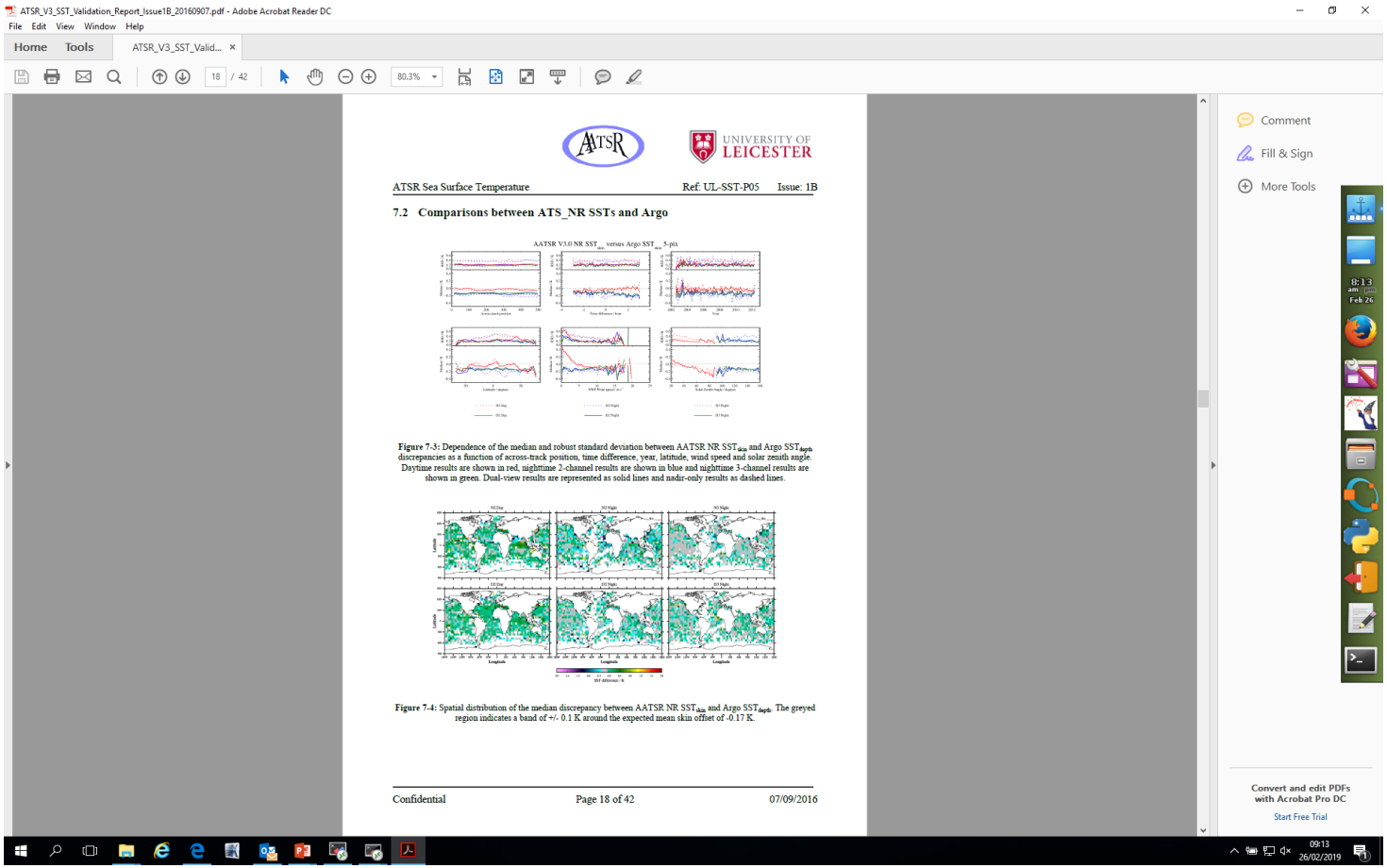
Data coverage



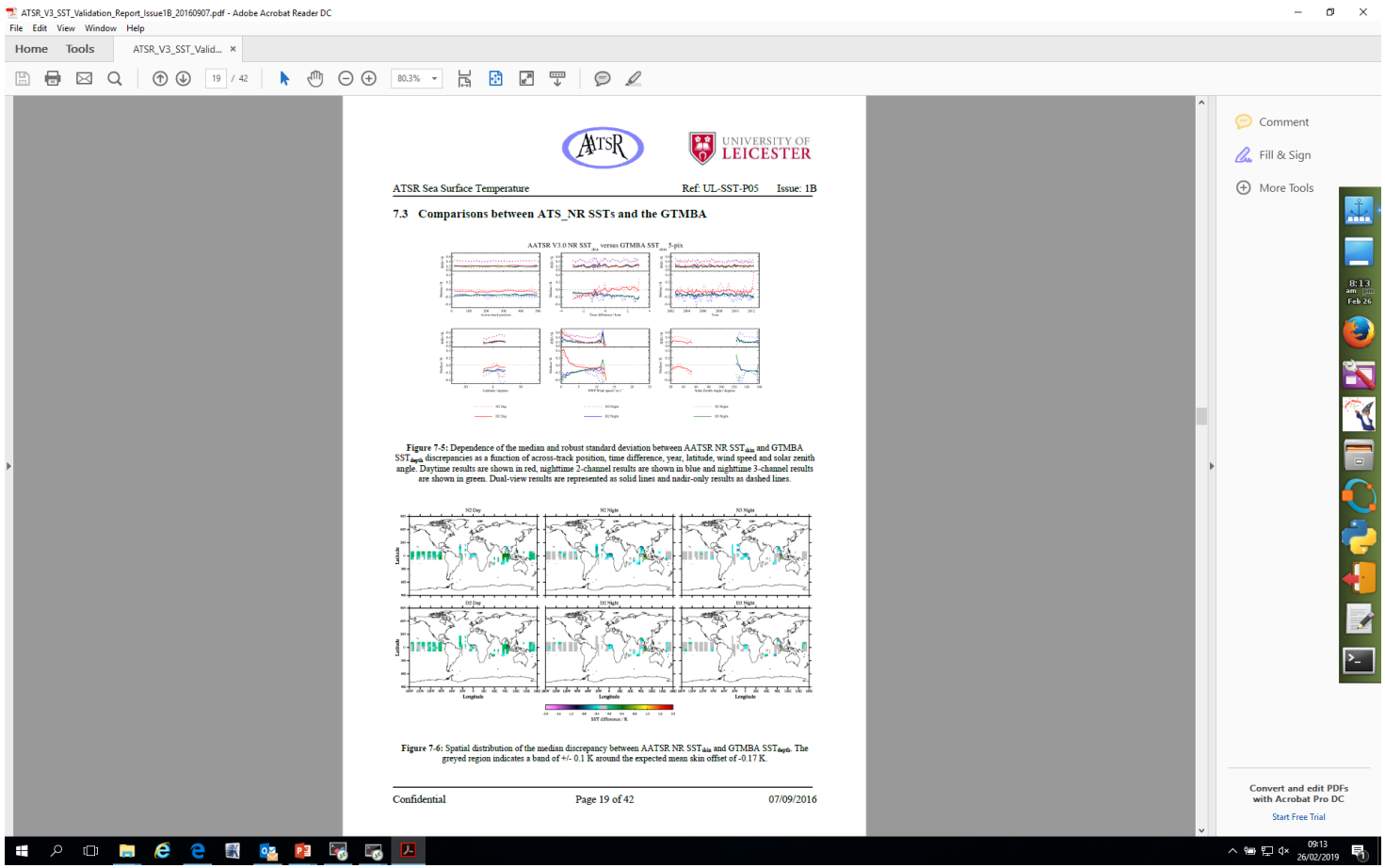
Match-ups: drifters



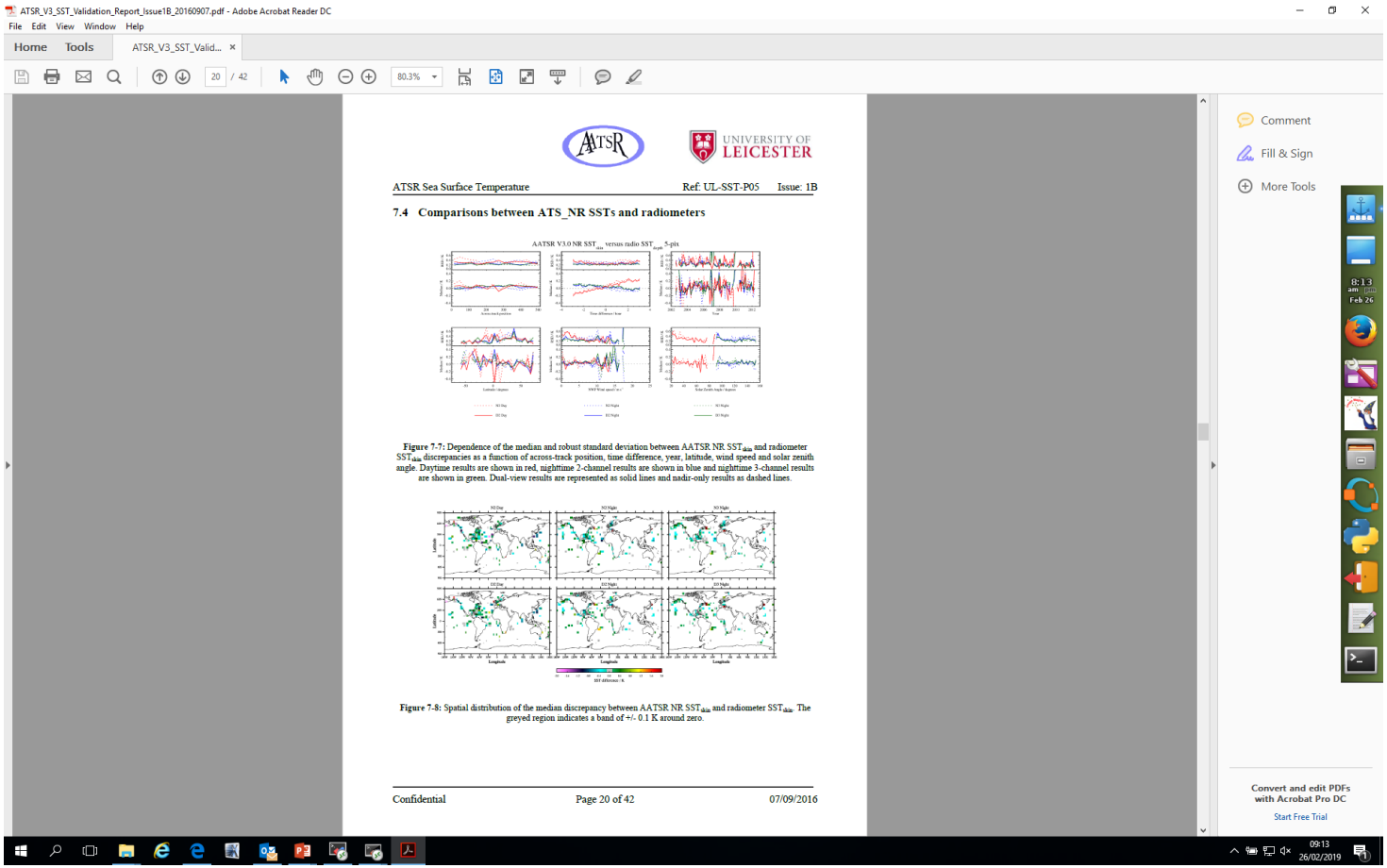
Match-ups: Argo



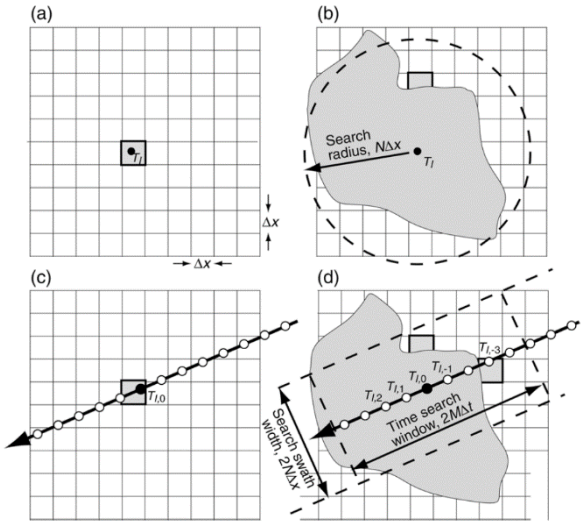
Match-ups: GTMBA

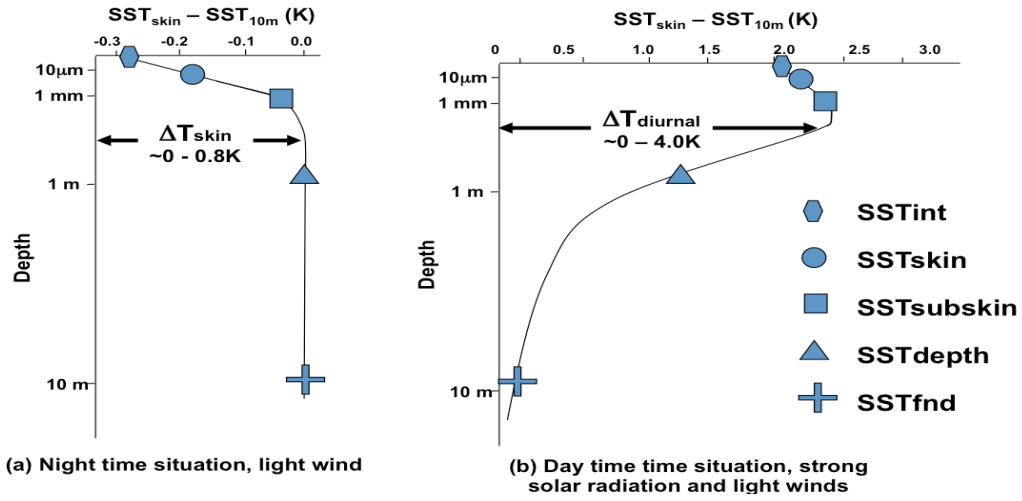


Match-ups: radiometers



Understanding the problem (1)



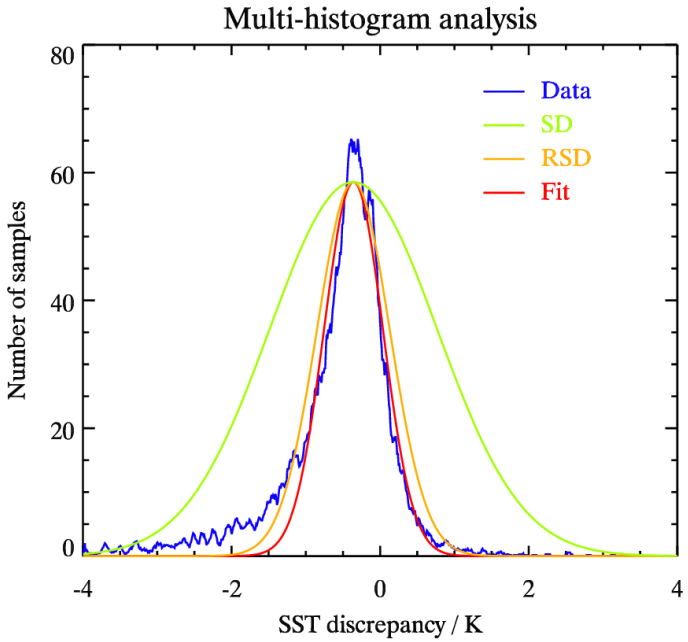


(a) Night time situation, light wind

(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.



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 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 diurnal & skin model

Uncertainty estimates for various reference datasets

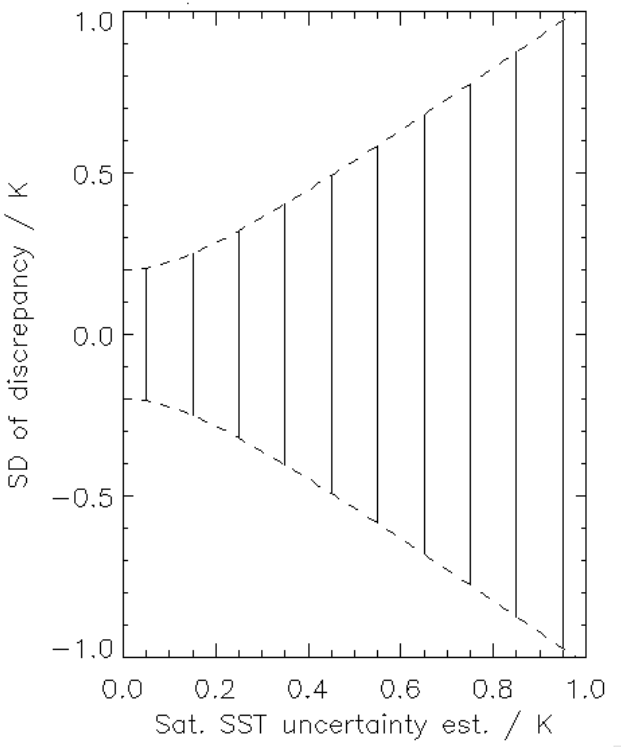
Data type	Year	Coverage	SST*	Uncertainty
Ship-borne IR radiometers	1998 -	Repeated tracks in the Caribbean Sea, North Atlantic Ocean, North Pacific Ocean, and the Bay of Biscay; episodic deployments elsewhere in the world's oceans.	SSTskin	0.10 K
Argo floats	2000 -	Global[#] from ~ 2004 onwards.	SST-5m	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

How to validate uncertainty?

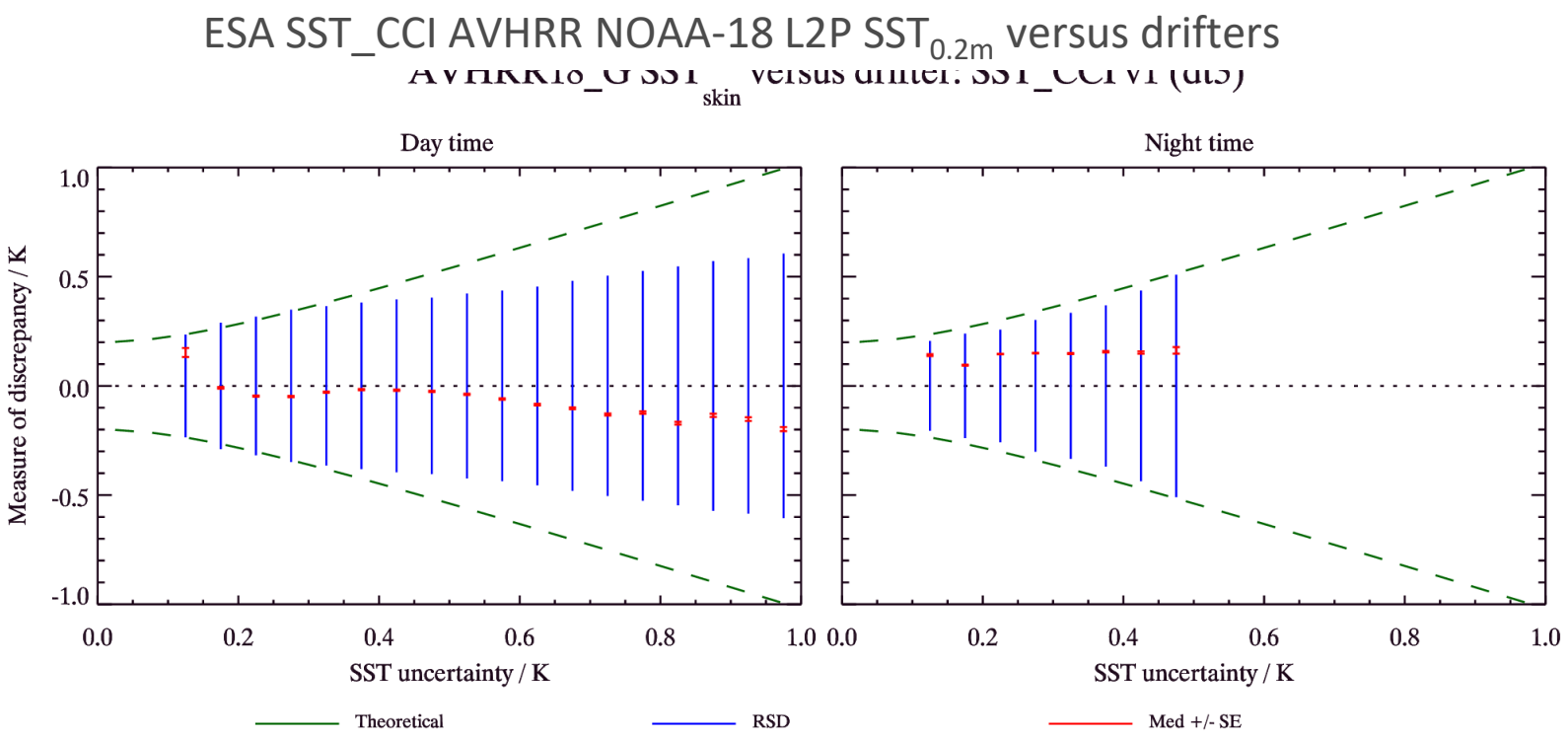
- Example using drifters
- Use mean uncertainty of 0.2 K for σ_2
- Use large number of match-ups, area averaging and diurnal & skin model to randomise σ_3 and σ_4
- Use diurnal & skin model to reduce σ_5
- Uncertainty budget reduces to:

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

- Theoretical distribution:



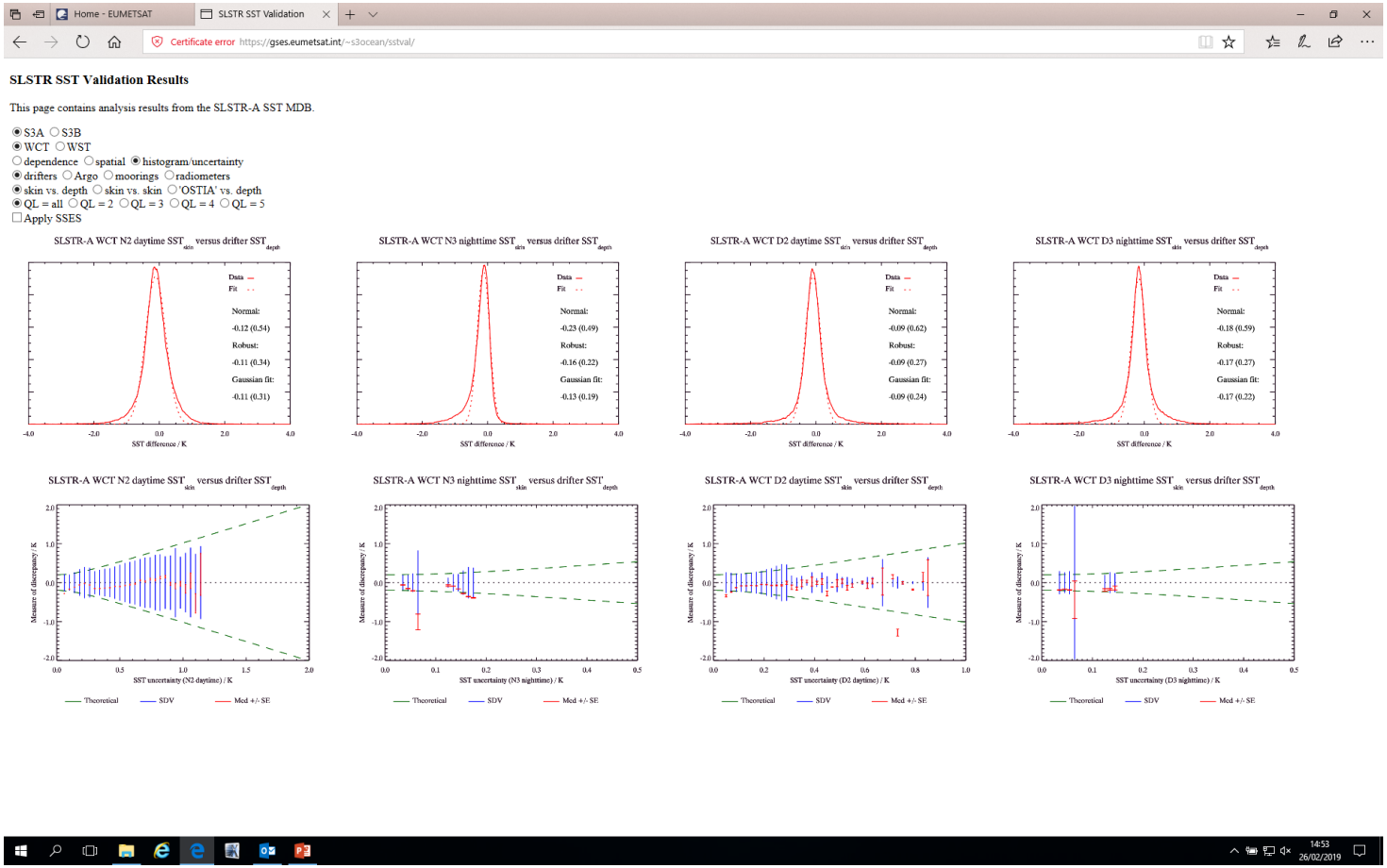
Example results: AVHRR L2P



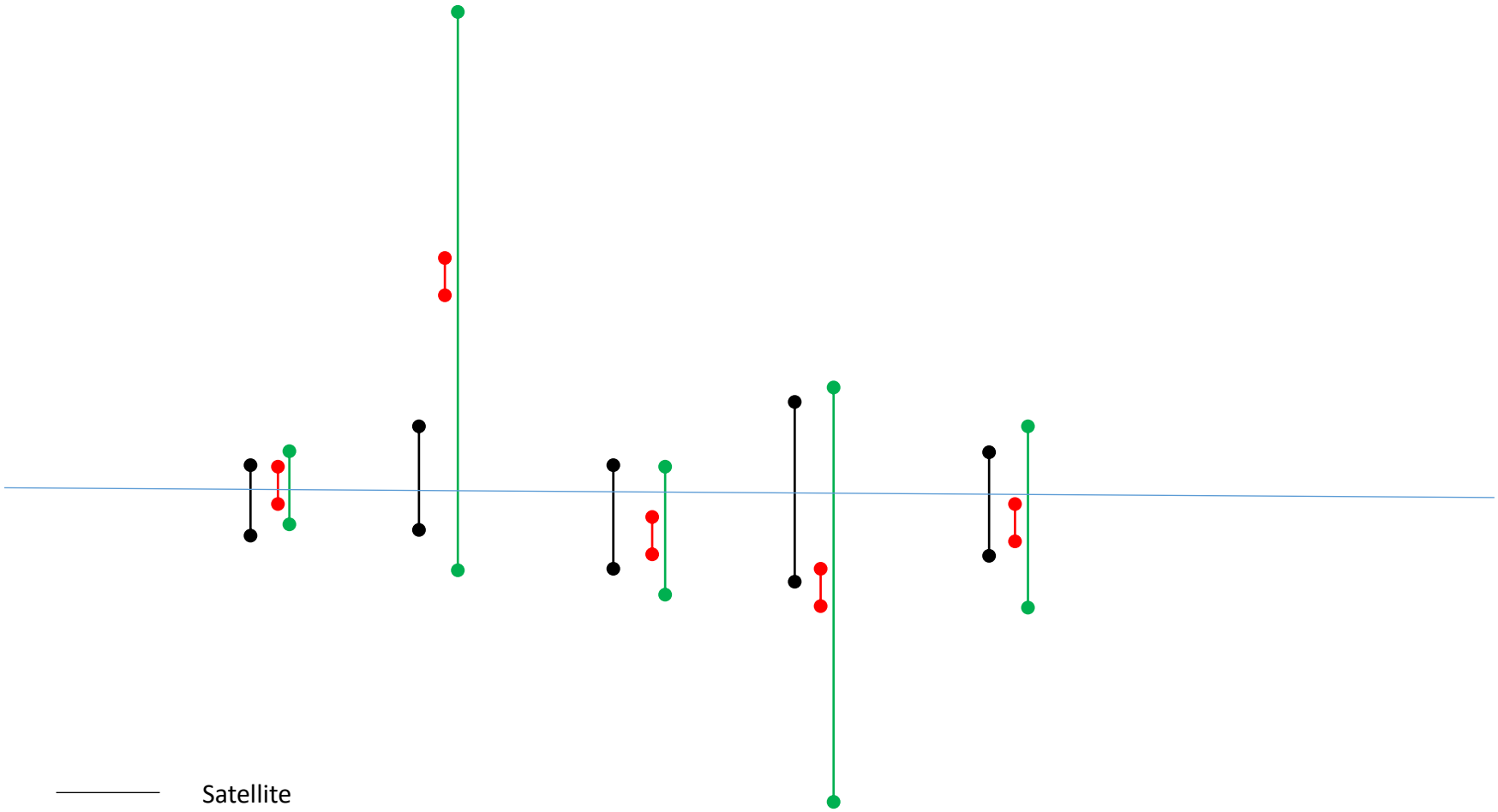
AATSR match-up statistics

		N2	N3	D2	D3
Drifters					
Day	450733	-0.09 (0.35)		-0.08 (0.24)	
Night	510338	-0.20 (0.36)	-0.18 (0.19)	-0.15 (0.24)	-0.14 (0.22)
GTMBA					
Day	17961	-0.03 (0.42)		-0.05 (0.22)	
Night	19662	-0.20 (0.43)	-0.18 (0.16)	-0.15 (0.21)	-0.15 (0.19)
Argo					
Day	5283	-0.05 (0.37)		-0.03 (0.26)	
Night	3946	-0.20 (0.37)	-0.16 (0.16)	-0.15 (0.21)	-0.13 (0.19)
Radiometers					
Day	9596	+0.06 (0.36)		+0.04 (0.26)	
Night	14264	+0.01 (0.33)	+0.06 (0.22)	+0.03 (0.25)	+0.05 (0.23)

Histograms


Home - EUMETSAT
SLSTR SST Validation
Certificate error https://gses.eumetsat.int/~s3ocean/sstval/
SLSTR SST Validation Results
This page contains analysis results from the SLSTR-A SST MDB.
S3A S3B
WCT WST
dependence spatial histogram/uncertainty
drifters Argo moorings radiometers
skin vs. depth skin vs. skin 'OSTIA' vs. depth
QL = all QL = 2 QL = 3 QL = 4 QL = 5
Apply SSES
SLSTR-A WCT N2 daytime SST skin versus drifter SST depth
Data
Fit
Normal:
-0.12 (0.54)
Robust:
-0.11 (0.34)
Gaussian fit:
-0.11 (0.31)
SST difference / K
SLSTR-A WCT N3 nighttime SST skin versus drifter SST depth
Normal:
-0.23 (0.49)
Robust:
-0.16 (0.22)
Gaussian fit:
-0.13 (0.19)
SST difference / K
SLSTR-A WCT D2 daytime SST skin versus drifter SST depth
Normal:
-0.09 (0.62)
Robust:
-0.09 (0.27)
Gaussian fit:
-0.09 (0.24)
SST difference / K
SLSTR-A WCT D3 nighttime SST skin versus drifter SST depth
Normal:
-0.18 (0.59)
Robust:
-0.17 (0.27)
Gaussian fit:
-0.17 (0.22)
SST difference / K
SLSTR-A WCT N2 daytime SST skin versus drifter SST depth
Measure of discrepancy / K
SST uncertainty (N2 daytime) / K
SLSTR-A WCT N3 nighttime SST skin versus drifter SST depth
SST uncertainty (N3 nighttime) / K
SLSTR-A WCT D2 daytime SST skin versus drifter SST depth
SST uncertainty (D2 daytime) / K
SLSTR-A WCT D3 nighttime SST skin versus drifter SST depth
SST uncertainty (D3 nighttime) / K
Theoretical
SDV
Med +/- SE
14:53
26/02/2019

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

- Validating satellite SST retrievals using reference data sets has many sources of error that cannot easily be corrected
  - By considering each term we end up with a validation uncertainty budget
- We can minimise the magnitude of certain effects using our knowledge of variability in upper ocean temperature
  - We should always be retrieving SST_{skin} from IR radiometers and using the physics to compare to reference data at different depths
- Radiometers provide an essential source of data for satellite SST_{skin} validation
  - Resulting statistics are generally noisier than for other primary in situ types
- Either uncertainty model is wrong or radiometer "measurement" uncertainty is higher than 0.1 K
  - Not enough results yet to try uncertainty validation