

Impact on Data Quality: Improved AATSR L2P Error Statistics

Gary Corlett

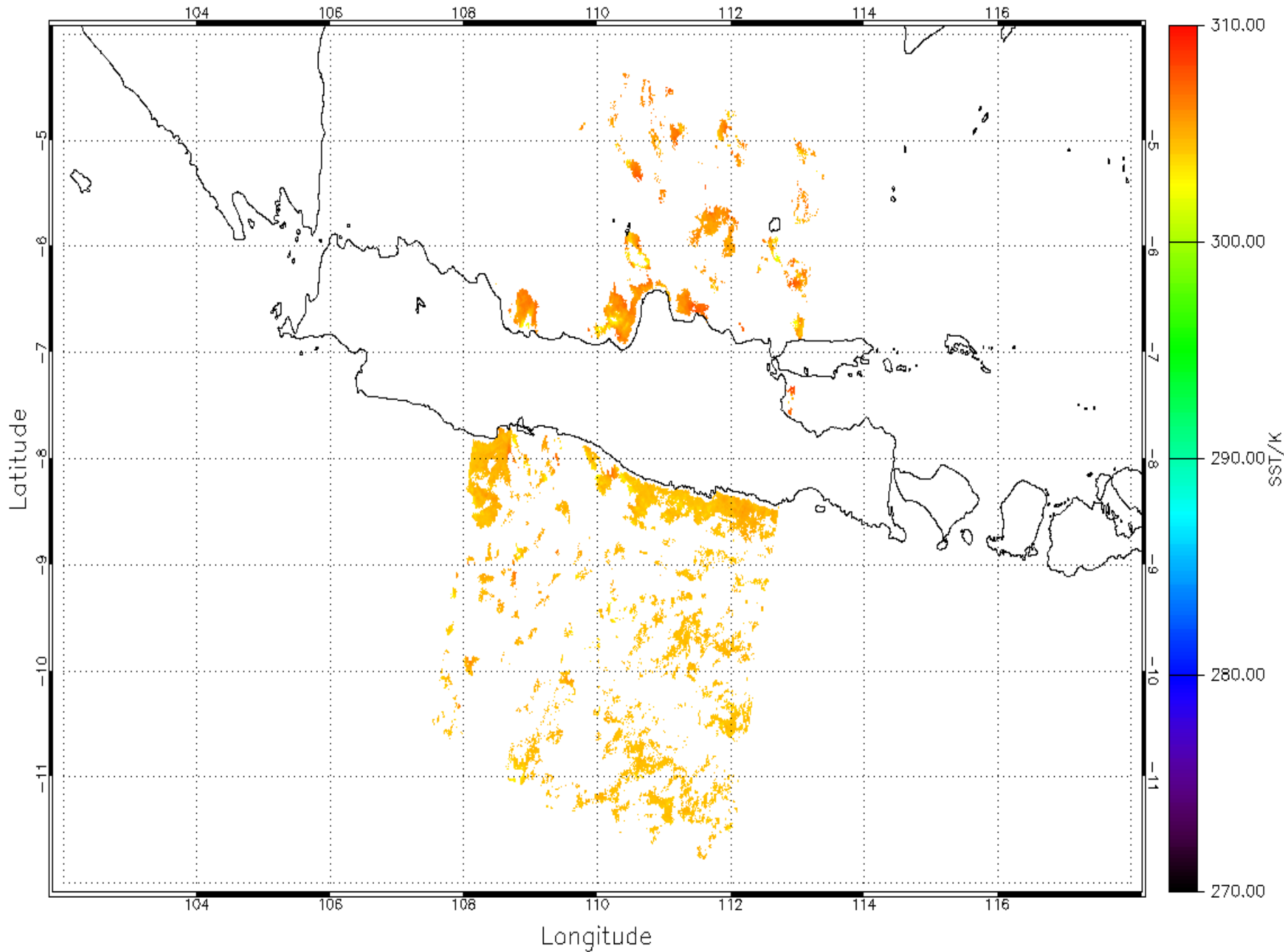
AATSR Validation Scientist

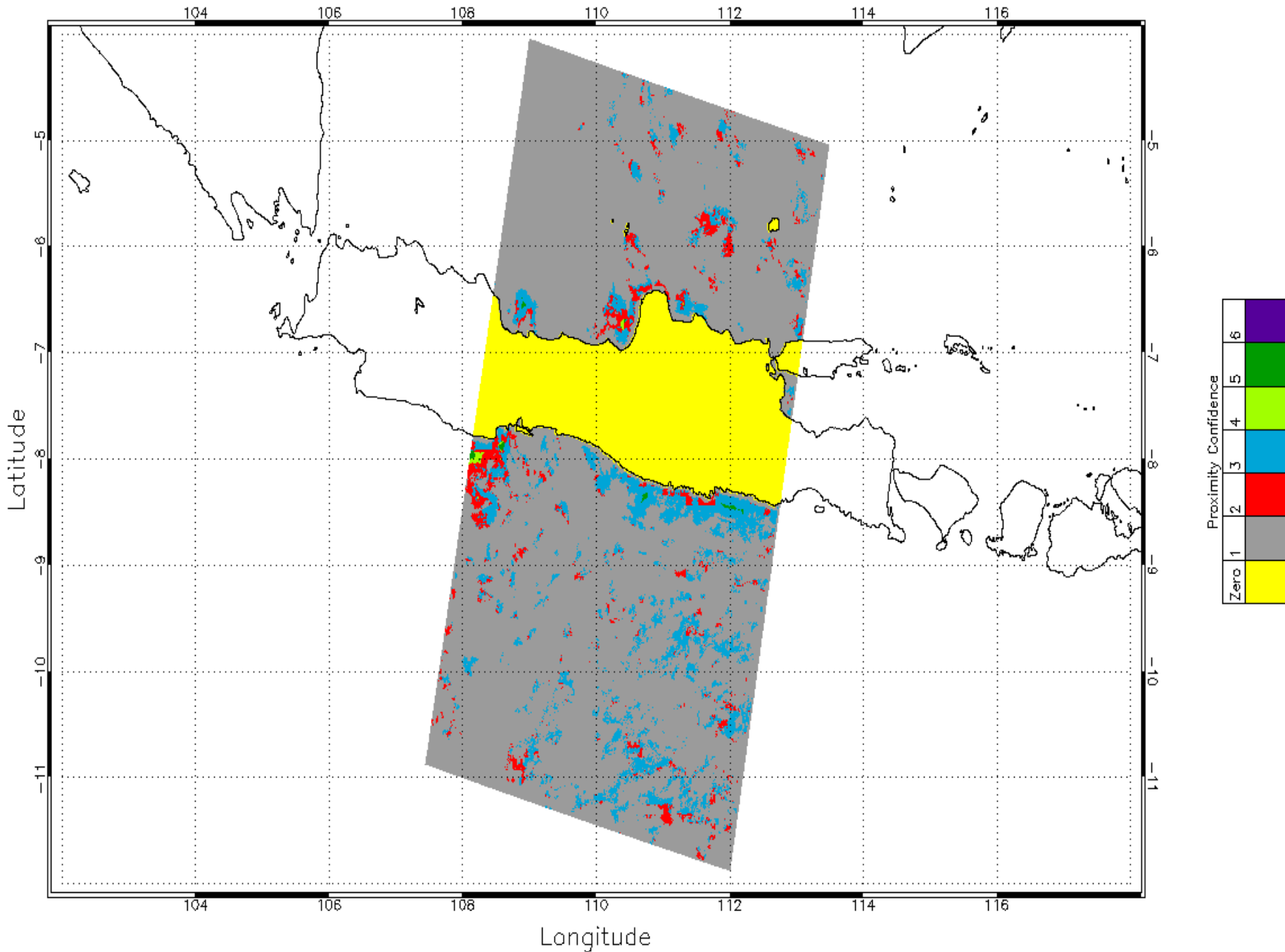
Content

- Reminder of current SSES scheme
- What affects the quality of AATSR SSTs?
- An alternate scheme using view differences
- (A)ATSR SSES
- (A)ATSR as a reference sensor
- Summary & Conclusions

Original SSES scheme for AATSR L2P

Threshold values for DT_min. (K)>				
> IPCVThres1	3 (Suspect)	3 (Suspect)	5 (Excellent)	
< IPCVThres1	2 (Bad)	2 (Bad)	4 (Acceptable)	
> IPCVThres2	1 (Cloudy)	2 (Bad)	4 (Acceptable)	
< IPCVThres3	1 (Cloudy)	(Cloudy)	6 (Suspect, Cool skin, upwelling, riverine inputs etc.)	
	IPCV_D1 (close)	IPCV_D2 (near)	> IPCV_D2 (far)	Distance from nearest cloudy pixel (km)



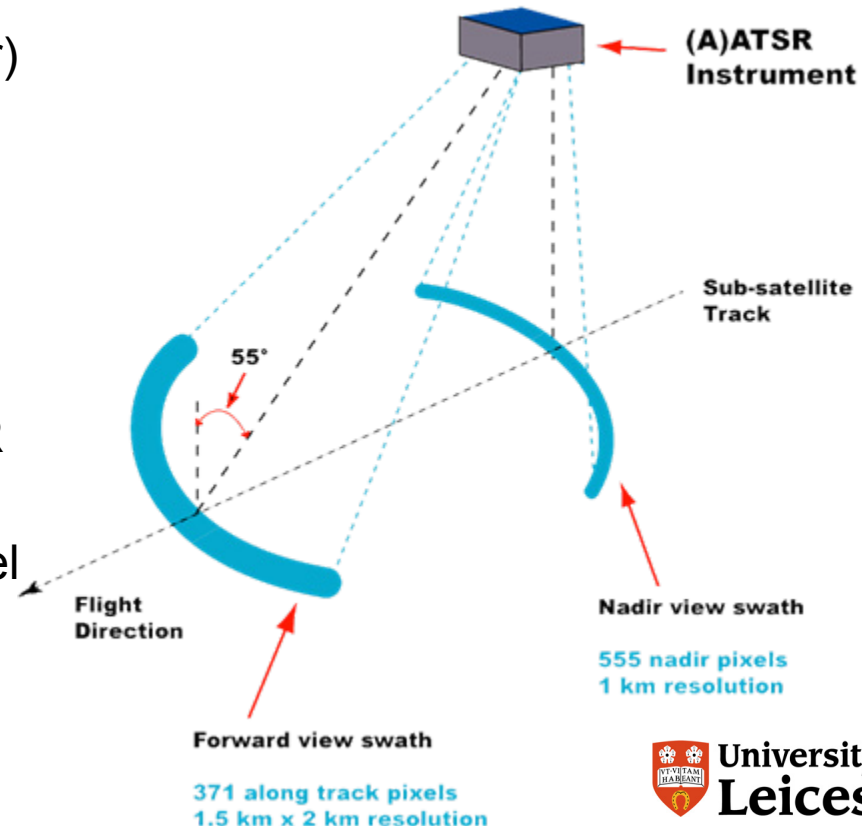


Impact of Medspiration

- Feedback from users showed initial SSES scheme was not optimal
 - A lot of good quality data was classified as being poor quality
- Medspiration challenged AATSR team to provide improved error flagging scheme for L2P product
- New scheme based on knowledge gained from validation program
 - You need long-term validation to fully understand and monitor the sensor performance

What is (A)ATSR?

- Imaging infrared and visible radiometer on ENVISAT
 - Similar channels to AVHRR & MODIS.
- Dual view (nadir and 55° to nadir)
 - Along-track scanning, two views of same scene at different angles, for better atmospheric correction
- On-board calibration
 - 2 on-board black bodies for IR calibration
 - VISCAL unit for visible channel calibration (not ATSR-1)
- 500 km swath
- 1 km IFOV at nadir
- Stirling Cycle Coolers, cooling low noise detectors to 80K, for optimum signal-to-noise ratios

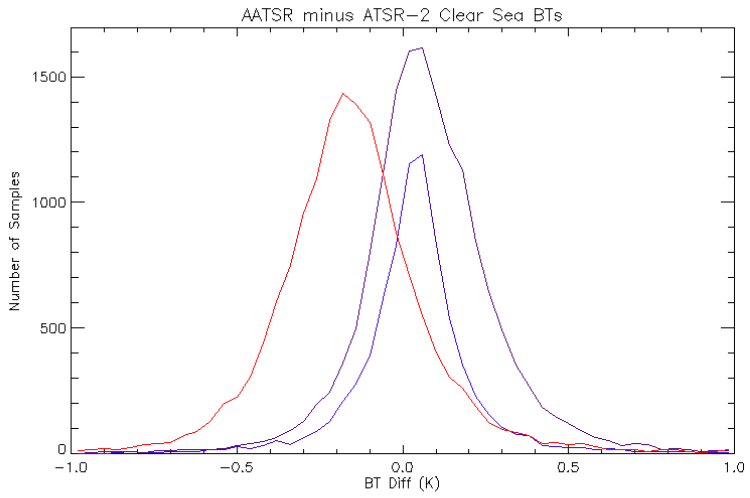


What Affects the Quality of AATSR SSTs?

- For December 2005 coefficients
 - **D2-D3 bias** (the latitude dependent correction)
 - Also small residual bias (≈ 0.15 K at $T < 280$ K) most likely due to temperature dependent emissivity
 - These issues are being addressed in (A)RC project
 - **Suspected $12 \mu\text{m}$ calibration error**
 - In process of analysing flight-spare FPA
 - **Clouds and aerosols (claerosols)**
 - AATSR cloud screening is over-zealous
 - AATSR is designed for climate SSTs
 - Much better during day owing to $1.6 \mu\text{m}$ channel
 - Observable edge effects at night
 - Dual-view corrects for tropospheric aerosol
 - But not quite!
 - Being addressed in (A)RC project
 - **Relative alignment of nadir and forward views**
 - Systematic offset confirmed by Andrew Birks
 - Awaiting correction from AATSR QWG

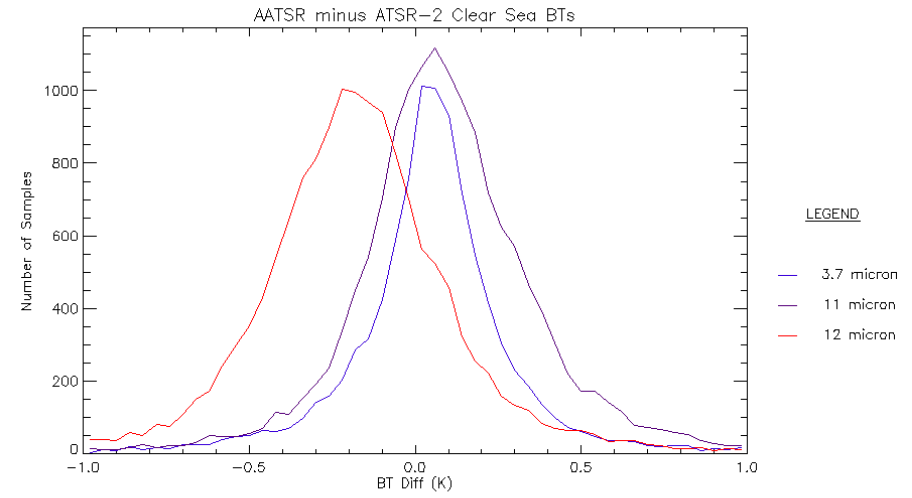
Compare AATSR and ATSR-2 BTs

Nadir View



AATSR file: ATS_MET_2PSUPA20030101_045033_000062202012_00319_04381_1787.N1.gz
 ATSR-2 file: ATS_MET_2PSRAL20030101_051856_000000001080_00319_40253_D000.N1.gz

Forward View



AATSR file: ATS_MET_2PSUPA20030101_045033_000062202012_00319_04381_1787.N1.gz
 ATSR-2 file: ATS_MET_2PSRAL20030101_051856_000000001080_00319_40253_D000.N1.gz

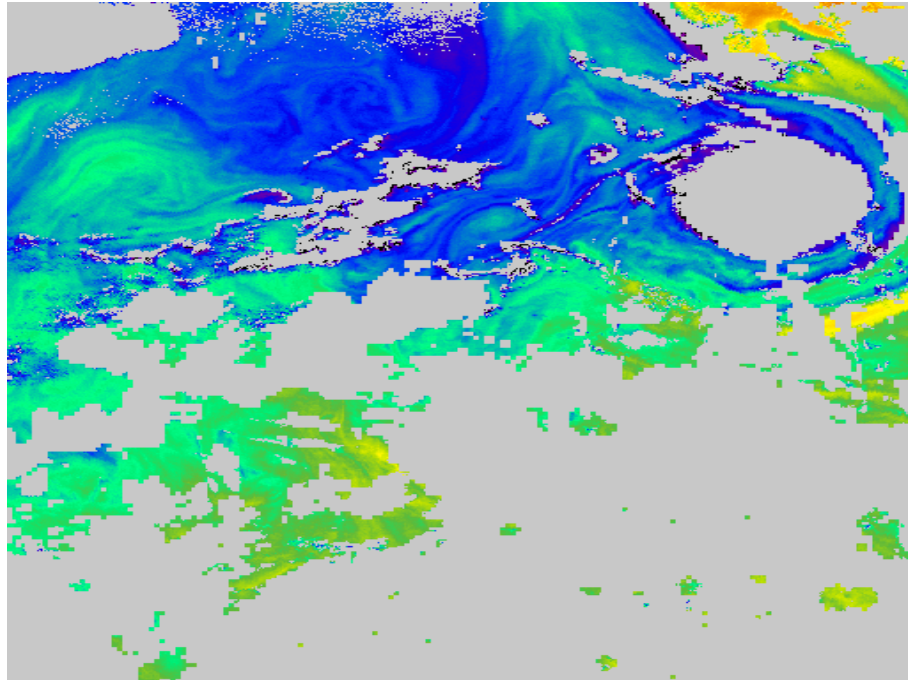
Suspected 12 μm Error: Implication for SSTs

- Calibration offset seen between AATSR and ATSR-2 12 μm clear-sky SEA BTs
 - ATS_MET_2P and AT2_MET_2P products analysed
 - Validation results suggest AATSR is incorrect
 - Results in increase in latitude dependent D2-D3 bias

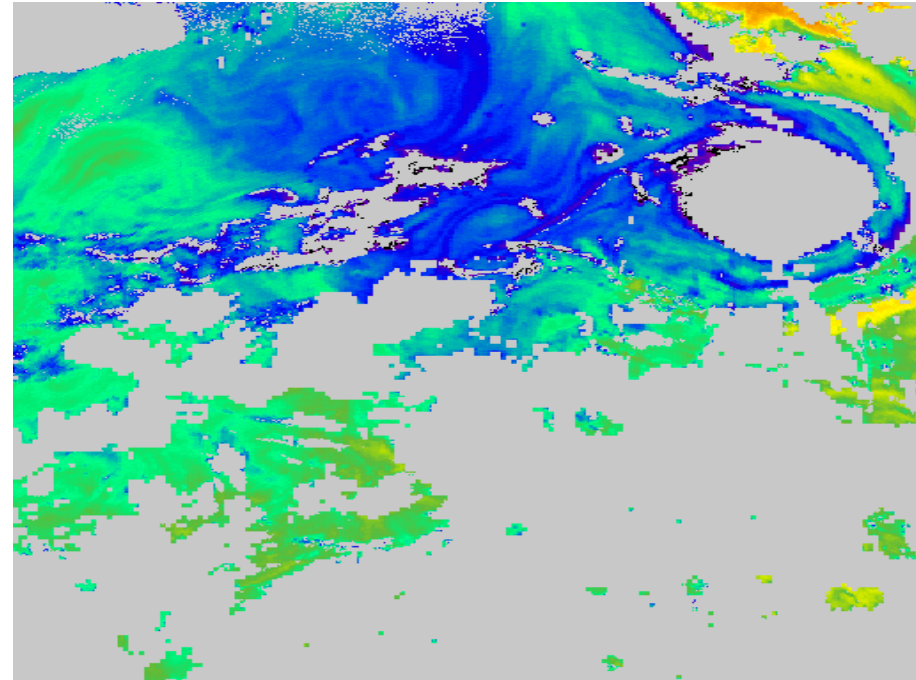
- Effect on current D3 SSTs is + 0.05 K
- Effect on current D2 SSTs is - 0.04 K
 - Allowed for in SSES

Relative alignment of forward and nadir views (1)

Nadir view



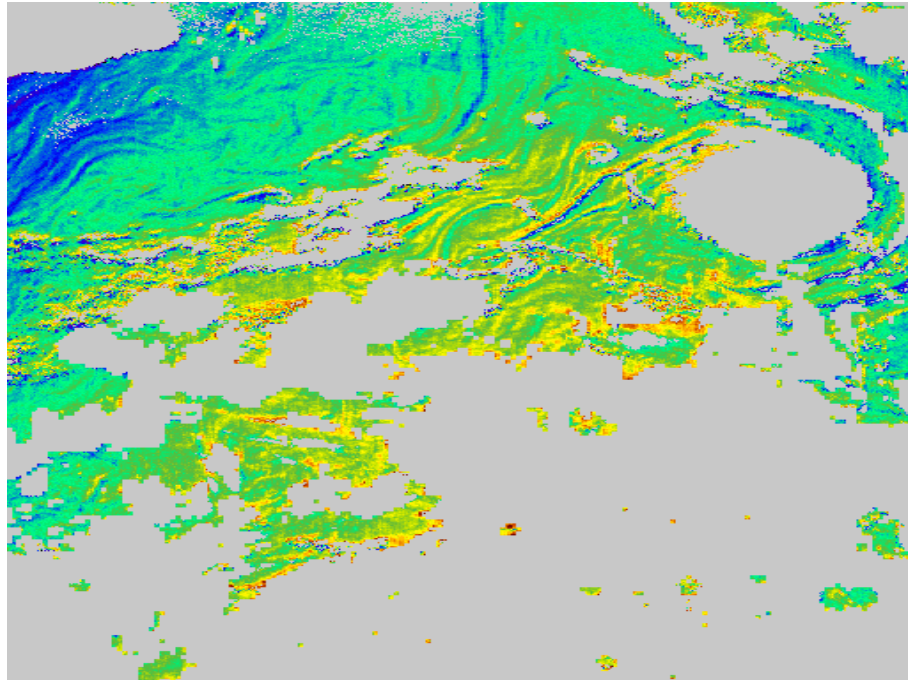
Forward view



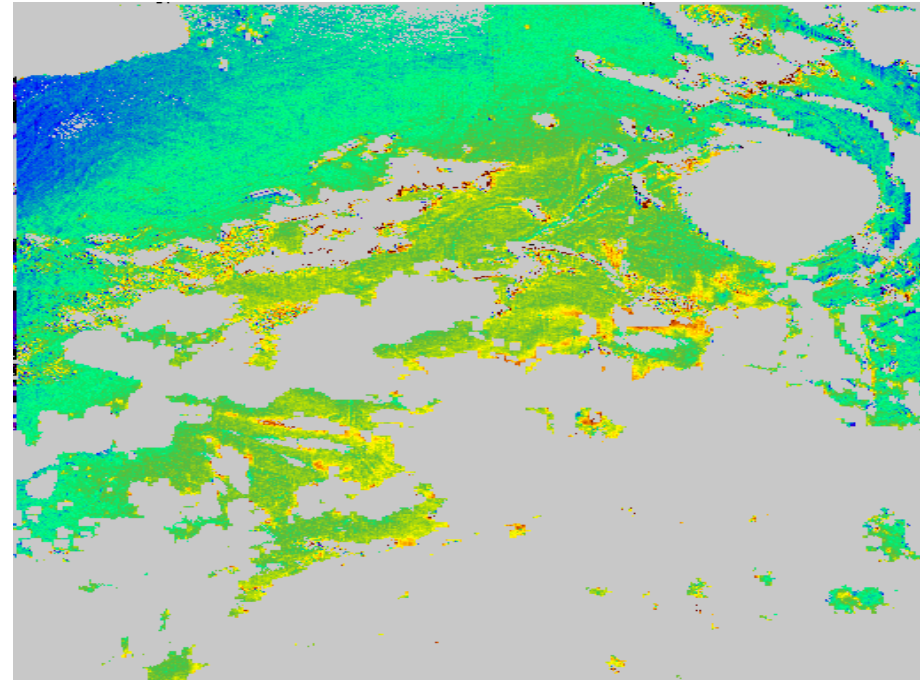
From Owen Embury (University of Edinburgh)

Relative alignment of forward and nadir views (2)

Without Shift

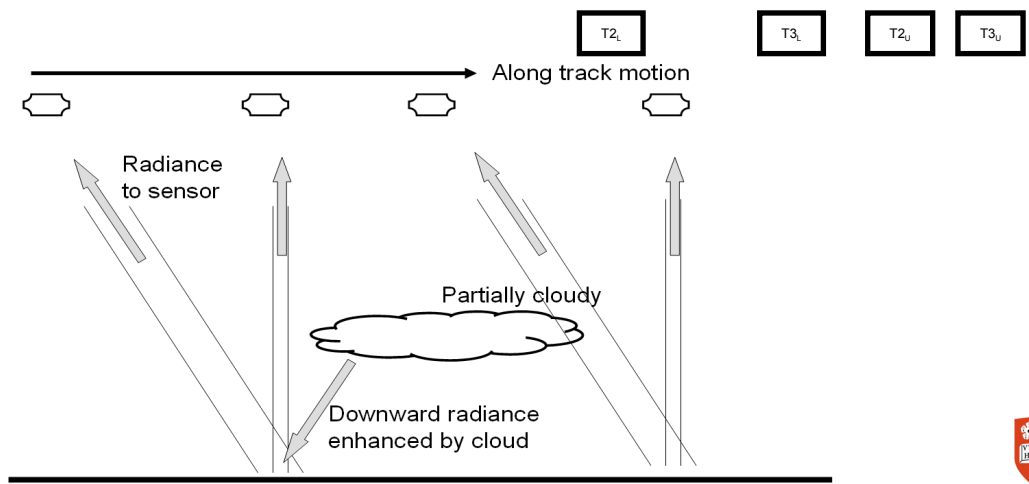
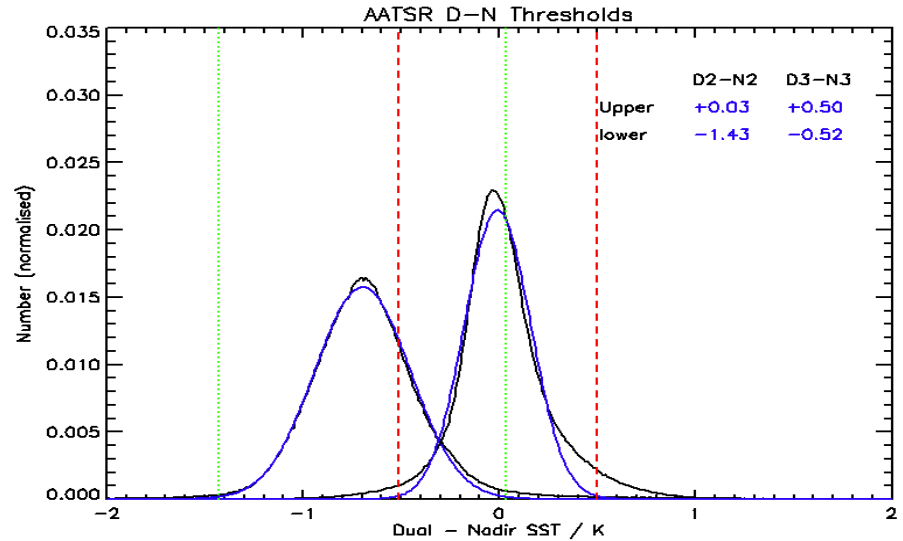
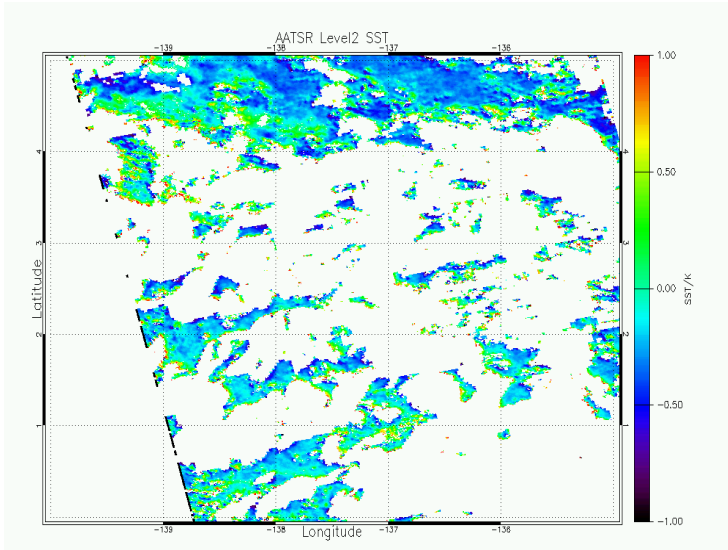


With Shift



From Owen Embury (University of Edinburgh)

The Dual-Nadir Difference Test (1)



The Dual-Nadir Difference Test (2)

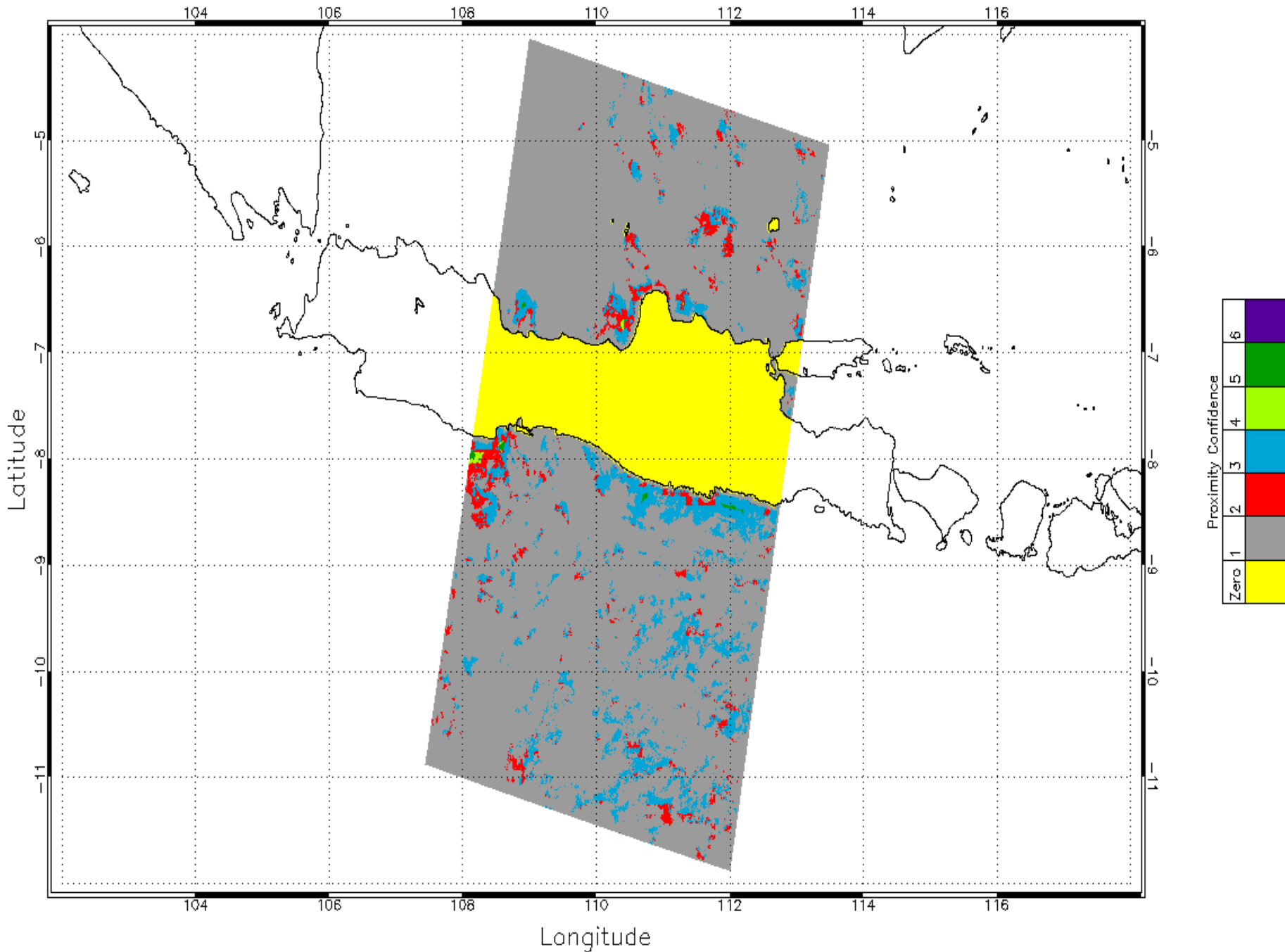
- Effect of clouds and aerosols can be accounted for using D-N SST differences
 - Should get well-defined normal distribution
 - Can set thresholds to remove data not in normal distribution
- Suspected alignment error between forward and nadir views will contribute to D-N differences
 - Significant positive edge structures still seen after view-difference shift
 - D-N test is designed for current AATSR data
 - Will need revising if and when relative alignment is corrected
- 12 μ m calibration error will contribute to D-N differences
 - D-N test is designed for current AATSR data
 - Will need revising if and when 12 μ m calibration error is corrected

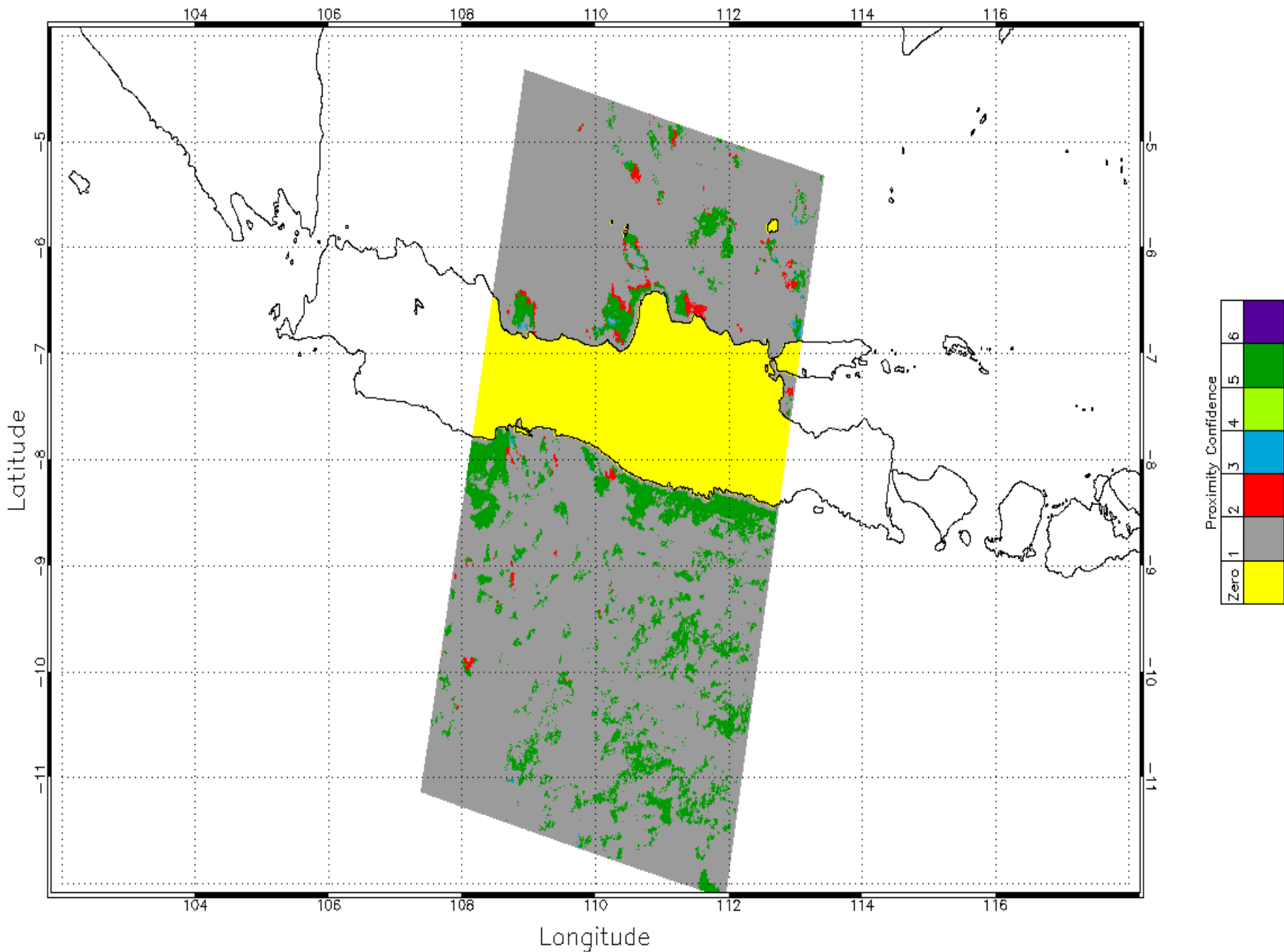
Alternate SSES Scheme

- Have developed improved quality flag for AATSR
 - Use D-N SST difference to identify retrievals affected by aerosols
 - Threshold = mode + 3 * sigma
 - Additional stratification according to wind speed
 - AATSR provides skin SSTs

Stratification	
If 2-channel Retrieval	If 3-channel Retrieval
$TL_2 < \mathbf{D-N} < TU_2$	$TL_3 < \mathbf{D-N} < TU_3$
$\mathbf{D-N} < TL_2$	$\mathbf{D-N} < TL_3$
$\mathbf{D-N} > TU_2$	$\mathbf{D-N} > TU_3$

A further stratification at 6 ms⁻¹ wind speed is also applied





Requirements for AATSR SSES

- Need, per pixel:
 - Bias & standard deviation
 - To a common standard – drifting buoys if possible
 - Quality flag
 - Common scale of 1-5
 - 1: Cloudy
 - 2: Bad
 - 3: Acceptable (defined by provider)
 - 4: Good
 - 5: Excellent

(A)ATSR MDB

- Medspiration project produced an MDB for AATSR
 - First detailed comparison of AATSR 1 km SSTs to drifting buoys

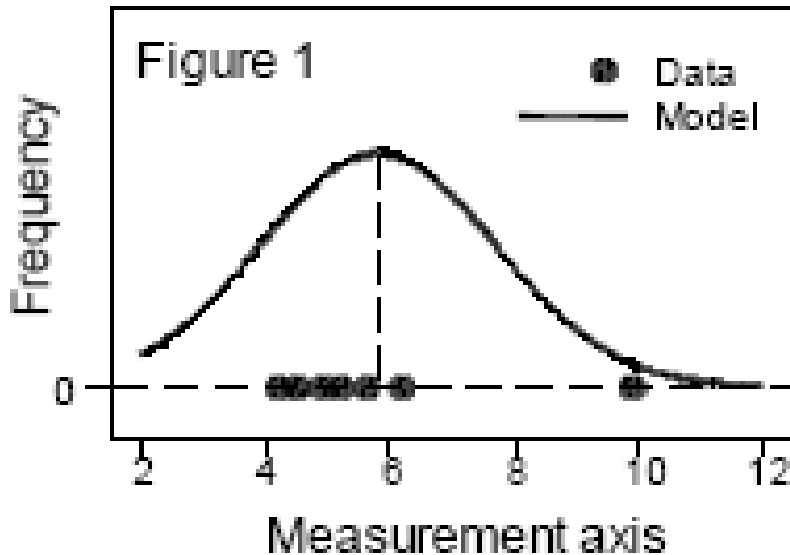
- Archive L2P project has produced a MDB for entire (A)ATSR data set
 - Nearest pixel; 2 hours; ICOADS in situ; ECMWF wind speed
 - TAO/TRITON/PIRATA identified using list provided by Met Office

- Cloudy and clear sky versions
 - AATSR cloudy/clear-sky/months: 553449/65073/14
 - ATSR-2 cloudy/clear-sky/months: 832585/107482/55
 - ATSR-1 cloudy/clear-sky/months: 699324/93775/59

- Analysis using AATSR SSES scheme developed for Medspiration

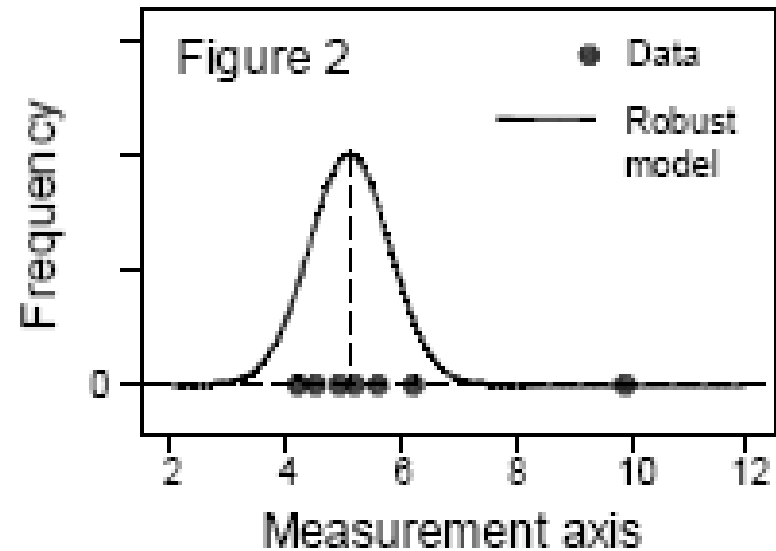
Robust Statistics: Coping With Outliers

Standard Statistics



mean = 5.8; sigma = 1.9

Robust Statistics



mean = 5.1; sigma = 0.7

As recommended by Merchant and Harris (1999)

Medspiration AATSR SSES (no wind speed)

Stratification Case	Matchups	Median	RSD	Confidence Value
Case 1 & 2:	12664	+0.20	0.31	5
Case 3 & 4:	260	-0.24	0.73	3
Case 5 & 6:	371	+0.70	0.67	3
Case 7 & 8:	14133	+0.10	0.29	5
Case 9 & 10:	242	-0.66	0.46	4
Case 11 & 12:	933	+0.67	0.27	4

Biases have been converted to skin biases by adding 0.17 K

L2P AATSR SSES (no wind speed)

Stratification Case	Matchups	Median	RSD	Confidence Value
Case 1 & 2:	8301	+0.20	0.33	5
Case 3 & 4:	161	-0.41	0.71	3
Case 5 & 6:	261	+0.71	0.64	3
Case 7 & 8:	10682	+0.11	0.32	5
Case 9 & 10:	207	-0.65	0.49	4
Case 11 & 12:	718	+0.69	0.32	4

Biases have been converted to skin biases by adding 0.17 K

Drifters

Dataset	Number	Mean (°C)	SD (°C)	Median (°C)	RSD (°C)
AATSR Day	8301	+0.03	0.37	+0.03	0.33
ATSR-2 Day	5334	-0.15	0.79	-0.10	0.43
ATSR-1 Day	4890	+0.02	0.84	+0.05	0.67
AATSR Night	10682	-0.08	0.36	-0.06	0.32
ATSR-2 Night	5019	-0.14	0.59	-0.11	0.35
ATSR-1 Night 2-ch	2295	-0.03	0.82	-0.01	0.65
ATSR-1 Night 3-ch	240	-0.10	0.79	-0.11	0.49

Ships

Dataset	Number	Mean (°C)	SD (°C)	Median (°C)	RSD (°C)
AATSR Day	3367	-0.11	1.38	-0.16	1.16
ATSR-2 Day	19636	-0.18	1.45	-0.22	1.21
ATSR-1 Day	36390	-0.08	1.55	-0.06	1.37
AATSR Night	3720	-0.11	1.42	-0.20	1.11
ATSR-2 Night	16534	-0.16	1.36	-0.18	1.09
ATSR-1 Night 2-ch	14280	-0.13	1.52	-0.09	1.35
ATSR-1 Night 3-ch	3206	-0.17	1.44	-0.15	1.25

Moored

Dataset	Number	Mean (°C)	SD (°C)	Median (°C)	RSD (°C)
AATSR Day	884	-0.11	0.76	-0.09	0.56
ATSR-2 Day	2654	-0.06	0.65	-0.08	0.52
ATSR-1 Day	3552	-0.03	0.87	0.00	0.74
AATSR Night	1115	-0.06	0.62	-0.09	0.41
ATSR-2 Night	2472	-0.09	0.48	-0.07	0.40
ATSR-1 Night 2-ch	1545	-0.12	0.88	-0.07	0.72
ATSR-1 Night 3-ch	217	-0.06	0.52	-0.09	0.47

TAO/TRITON/PIRATA

Dataset	Number	Mean (°C)	SD (°C)	Median (°C)	RSD (°C)
AATSR Day	235	-0.01	0.32	+0.02	0.31
ATSR-2 Day	644	-0.13	0.33	-0.12	0.30
ATSR-1 Day	1550	+0.02	0.54	+0.01	0.54
AATSR Night	443	-0.12	0.27	-0.09	0.27
ATSR-2 Night	581	-0.17	0.27	-0.15	0.26
ATSR-1 Night 2-ch	920	-0.07	0.54	-0.08	0.54
ATSR-1 Night 3-ch	56	-0.19	0.32	-0.18	0.30

Which Statistics to Include in SSES?

- Current SSES scheme for AATSR uses mean bias and standard deviation

- Analysis of (A)ATSR MDB using robust standard deviation indicates significant effect of outliers
 - Mainly for AATSR-2

- QWG approved use of median bias and robust standard deviation for archive (A)ATSR L2P SSES
 - Increased confidence from AATSR and from TAO/TRITON/PIRATA
 - Non-robust analysis to remain for NRT product

AATSR as a reference

- For AATSR to be a reference sensor, it has to be shown to be the most stable (precise) SST data set
 - What about accuracy?
- Requires comprehensive validation
 - Traceability to agreed national standards
- Requires a consistent constant time series
 - Likely to be a gap between AATSR and SLSTR
 - SLSTR may have two satellites for increased redundancy

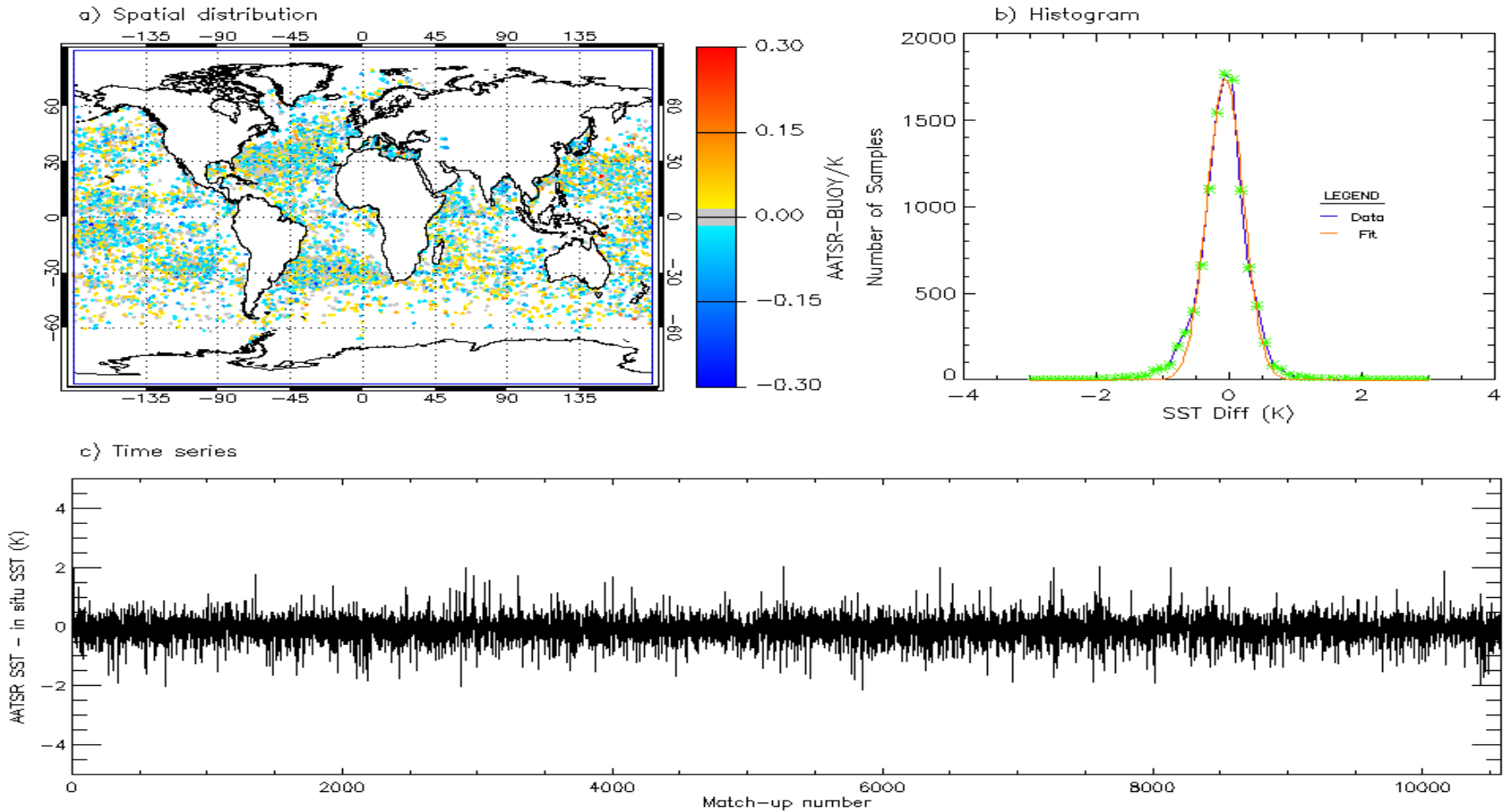
Time Series Comparisons to Drifting Buoys

- (A)ATSR data matched to drifting buoys
 - Nearest pixel; +/- 2 hours

- Good for long-term monitoring of stability
 - Large number of drifting buoy

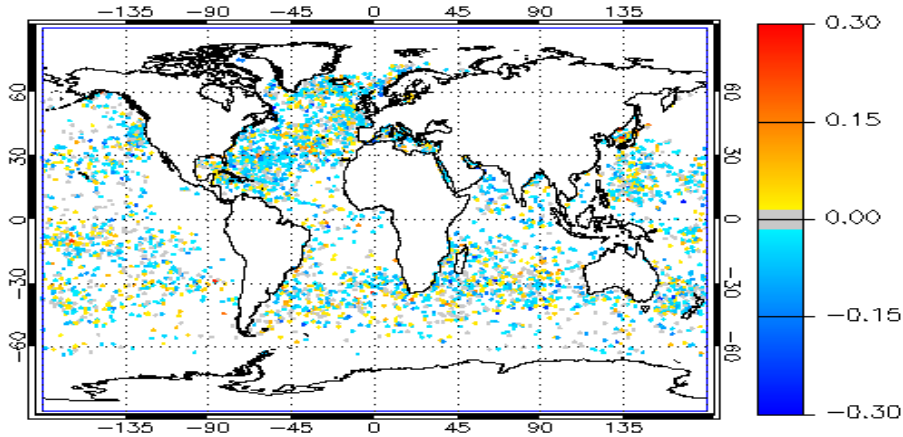
- GHRSSST SSES applied to data
 - Results for PC5 shown
 - Results shown in match-up (time) order

AATSR: Night time PC5

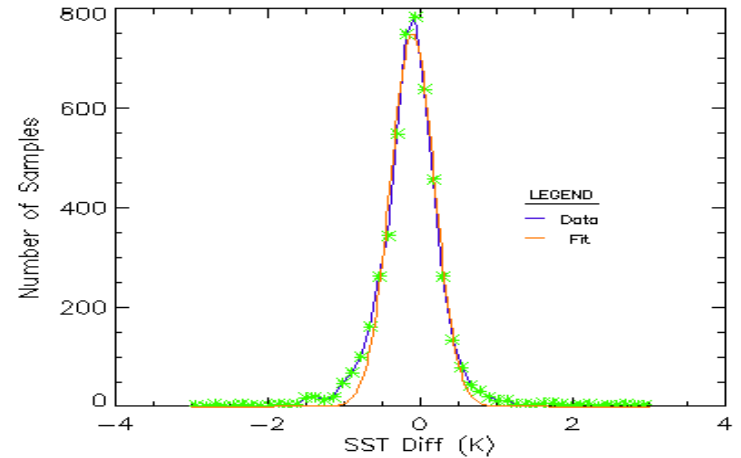


ATSR-2: Night time PC5

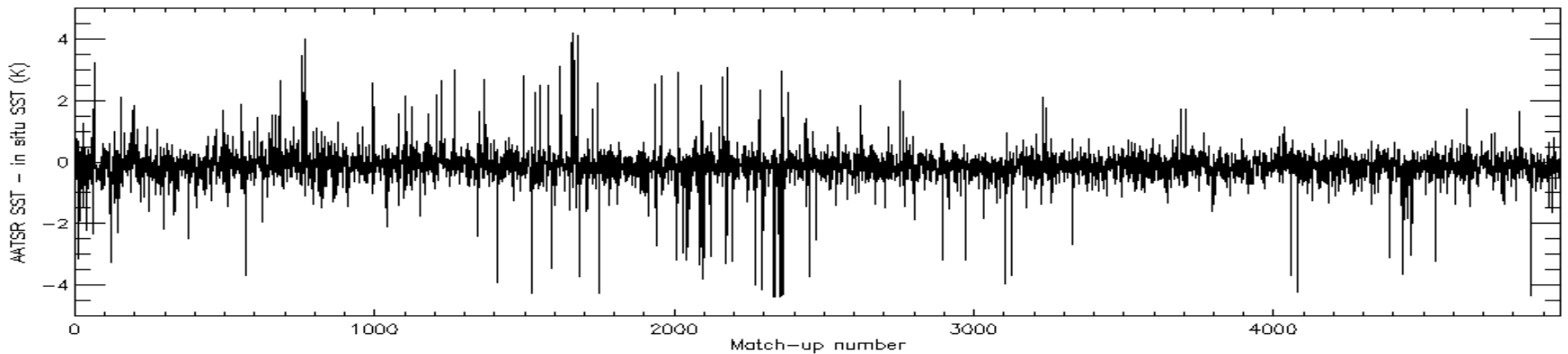
a) Spatial distribution



b) Histogram

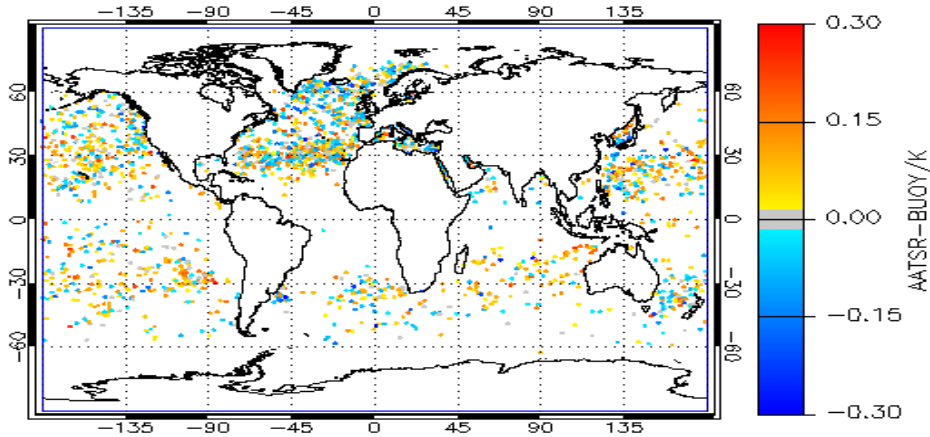


c) Time series

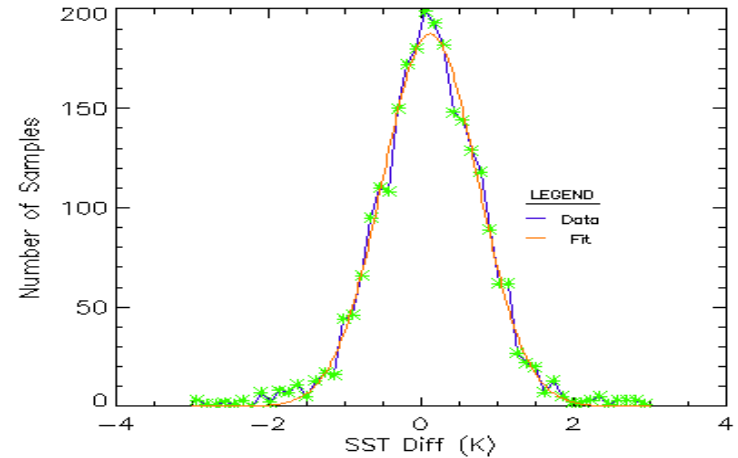


ATSR-1: Night time PC5

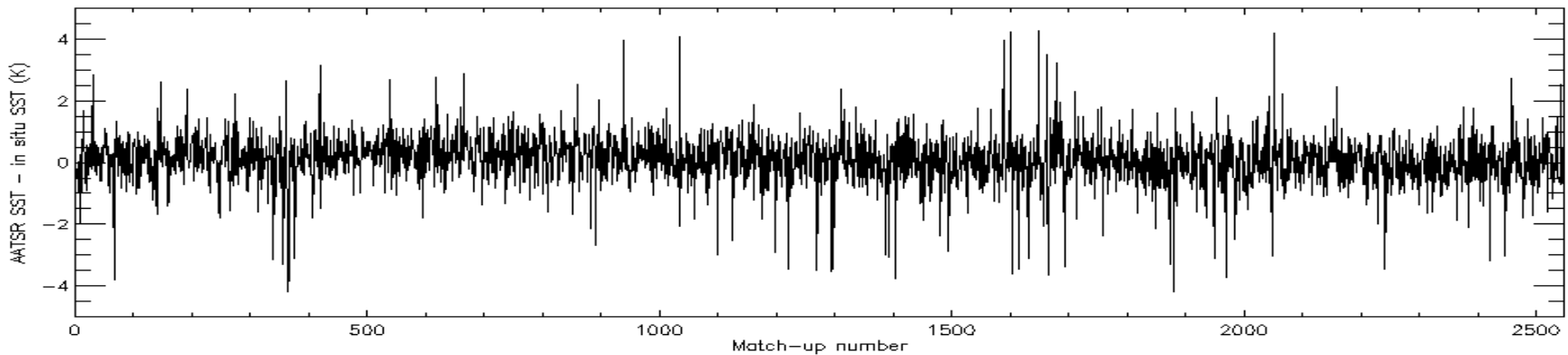
a) Spatial distribution



b) Histogram



c) Time series



Comparisons to radiometers

- (A)ATSR data matched to radiometers
 - Nearest pixel; +/- 2 hours

- Only independent method to confirm the absolute accuracy and traceability of AATSR SST retrievals

- GHRSSST SSES applied to data
 - Results for PC5 shown

Compare M-AERI and ISAR: Dual-view SST

Dual-view	M-AERI			ISAR		
	Match-ups	No.	Bias	St. Dev.	No.	Bias
Day time 2-channel	400	+0.13	0.40	777	+0.02	0.44
Night time 2-channel	936	+0.14	0.39	1126	+0.05	0.30
Night time 3-channel	936	+0.09	0.29	1130	+0.02	0.24

Ground data from Peter Minnett (RSMAS), Werenfrid Wimmer (NOCS)

Summary & Conclusions (1)

- First SSES scheme used in L2P applied to AATSR data is more appropriate for nadir-only IR radiometer
 - Does not take into account the unique features of AATSR

- Updated SSES scheme has been developed
 - Use D-N difference to identify retrievals affected by clerosols
 - Threshold = mode + 3 * sigma
 - Link to DT_min not suitable for AATSR

- Scheme has been successfully applied to ATSR-2 and ATSR-1

Summary & Conclusions (2)

- Night-time sub-skin correction
 - No current agreement on how to correct (consistently)
 - What about diurnal correction?
- Would only recommend QF 5 data if using AATSR as reference
- Limit of QF 5 will remove dual-view SSTs in very high aerosol loading that are okay
 - Is this okay for operational users?
- Issues with buoy data quality need addressing
- Propose that archive L2P SSES report median bias and robust standard deviation in L2P files

Summary & Conclusions (3)

- Comparisons to drifting buoys shows excellent stability for all three (A)ATSR sensors
 - Significant improvement for AATSR; might be due to improvements in drifting buoy coverage and performance
- Accuracy assessed using radiometers
 - Traceable validation needed for CDR
 - Small latitude dependent bias
 - Currently being addressed in (A)RC project
- Results confirm capability of using (A)ATSR as reference SST data set

Impact of Medspiration on AATSR Data Quality

- Without Medspiration we would not have
 - (A)ATSR L2P
 - (A)ATSR SSES
 - A significant increase in (A)ATSR data users
 - A “new” reference standard for SST