STATUS of MODIS AQUA and TERRA SST Transition from V5 to V6

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Outline

- LATBAND SST retrieval algorithm
- Additional instrument corrections (mirror side, scan angle), outstanding challenges
- MODIS match-up data base
- V5 and V6 algorithm comparison, Collection 6 LUT
- Comparison of SST reference fields
- Radiometer Observations, M-AERI Mk1 & 2, ISAR

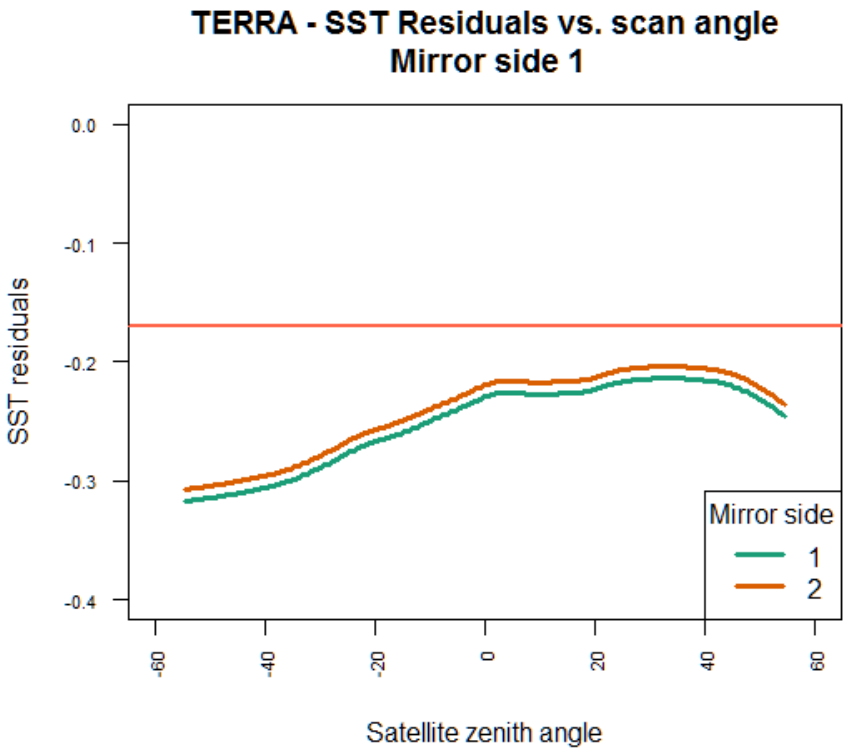
MODIS V6 Topics

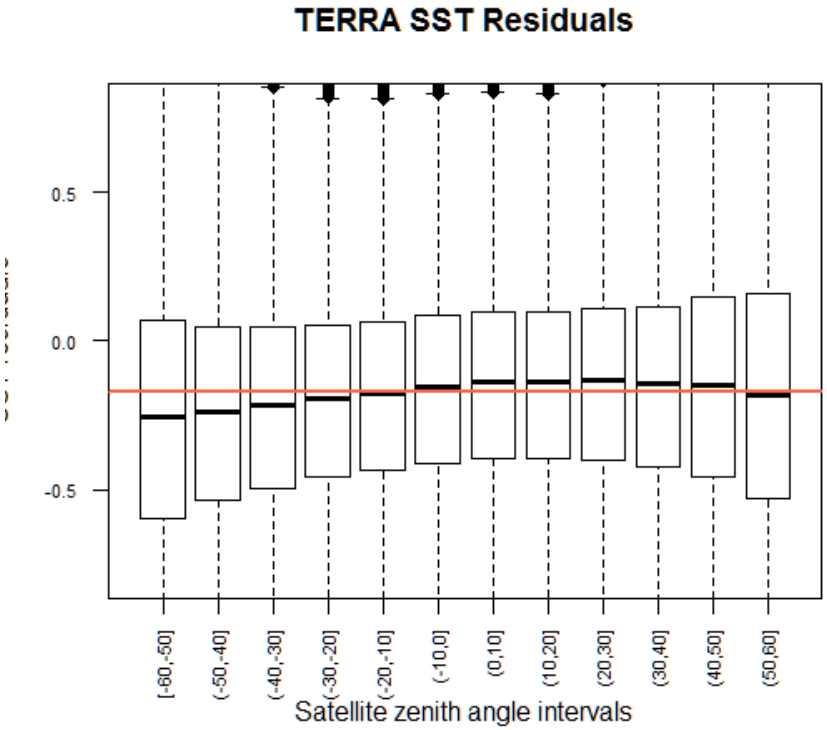
- Satellite Zenith Angle offset due to scan mirror
- Mirror side offset
- MODIS SST referenced to 'skin temperature', validated by M-AERI spectro-interferometer
- Temporal offset (TERRA 4µm only, A-B-A side electronics changes)
- LATBAND (monthly coefficient sets for six zonal bands)
- Hypercube pixel level uncertainty estimates
- Code implementation in SeaDAS 6.4
- Verified through comparison with satellite-buoy match-up data base and processing of 2009-2012, M-AERI comparisons.

V6 LATBAND SST Algorithm

- LATBAND algorithm implements SST (MODIS bands 31& 32) and SST4 (Modis bands 22 & 23) in 6 zonal bands:
  - **Latitude ≤ 40^{o}S**
  - **40^{o}S < Latitude ≤ 20^{o}S**
  - **20^{o}S < Latitude ≤ Equator**
  - **Equator < Latitude ≤ 20^{o}N**
  - **20^{o}N < Latitude ≤ 40^{o}N**
  - **Latitude > 40^{o}N**
- SST retrieval coefficients are estimated monthly using a 5 month window. Coefficients repeat yearly

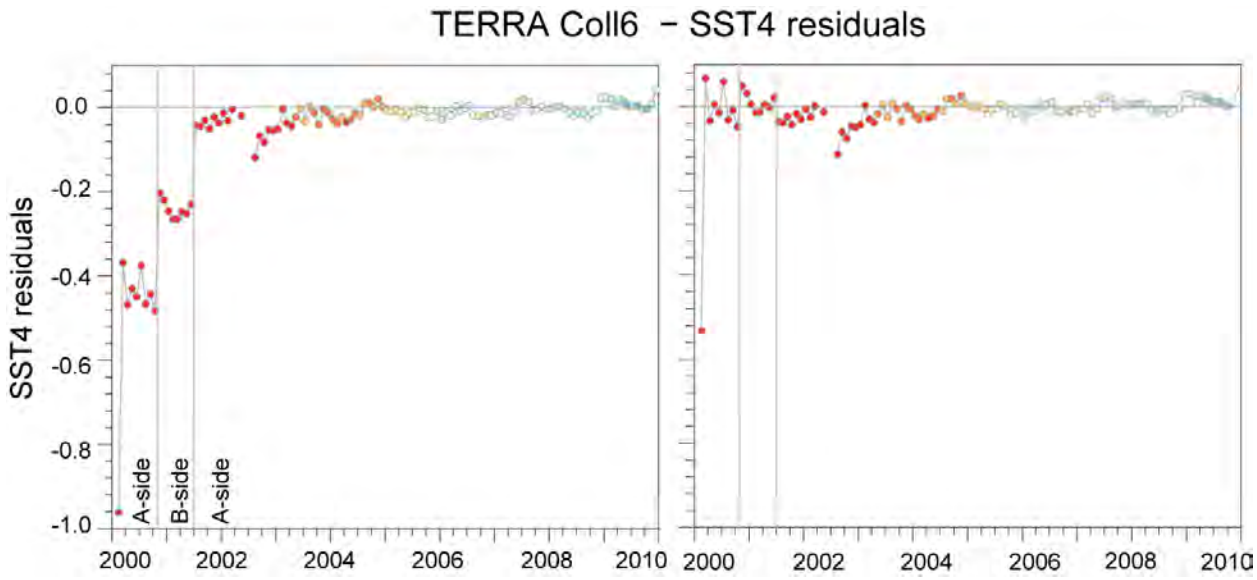
TERRA Mirror Side and Scan Angle Correction (SST)
No Mirror Side Correction needed for AQUA





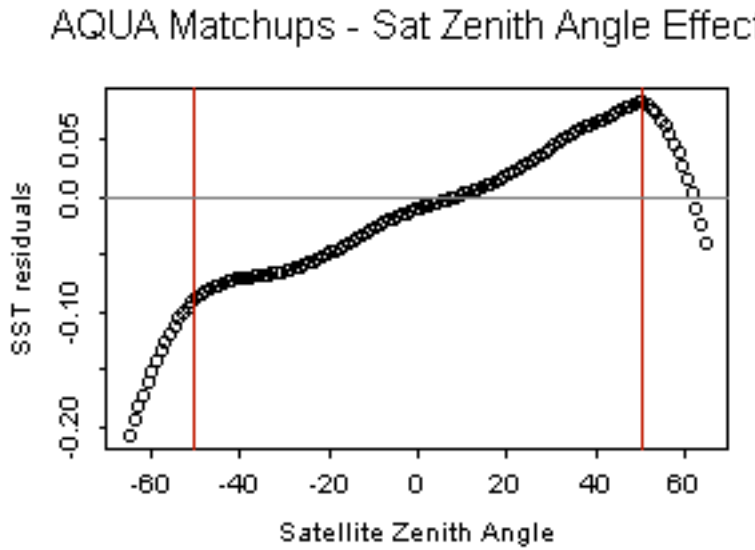
TERRA SST4 Instrument Configuration Correction

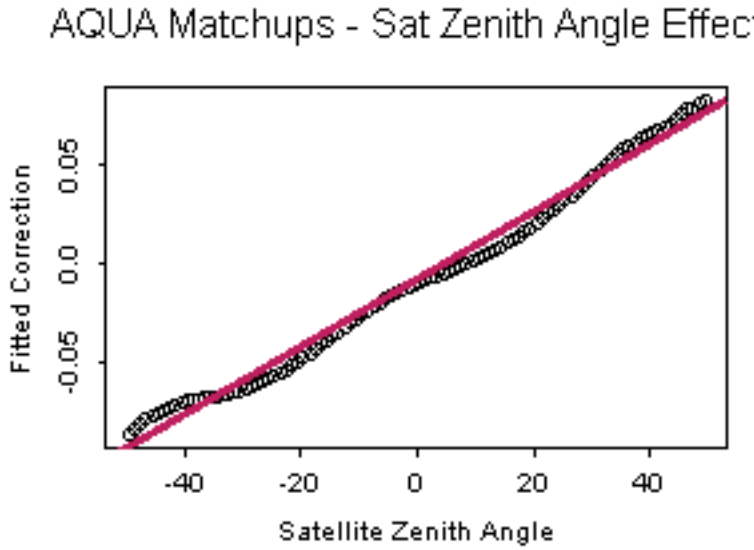
No correction required for AQUA SST/SST4 or TERRA SST

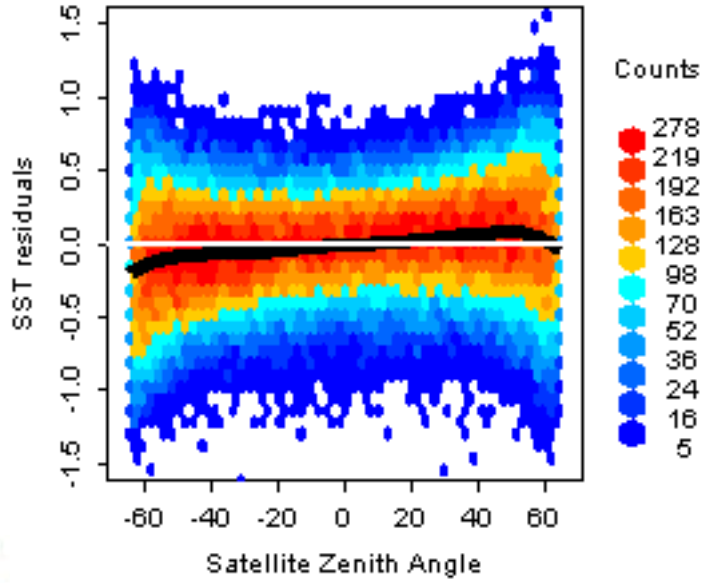


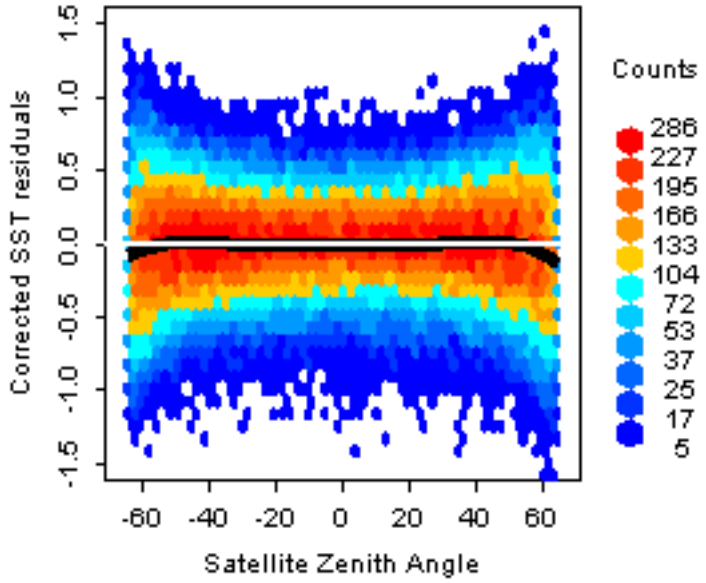
The A-side, B-side, A-side switch in TERRA instrument configuration introduced a bias only in the SST4 short-wave algorithm. A constant offset was included in the TERRA SST4 for each configuration epoch.

AQUA Residual Scan Angle CORRECTION for SST



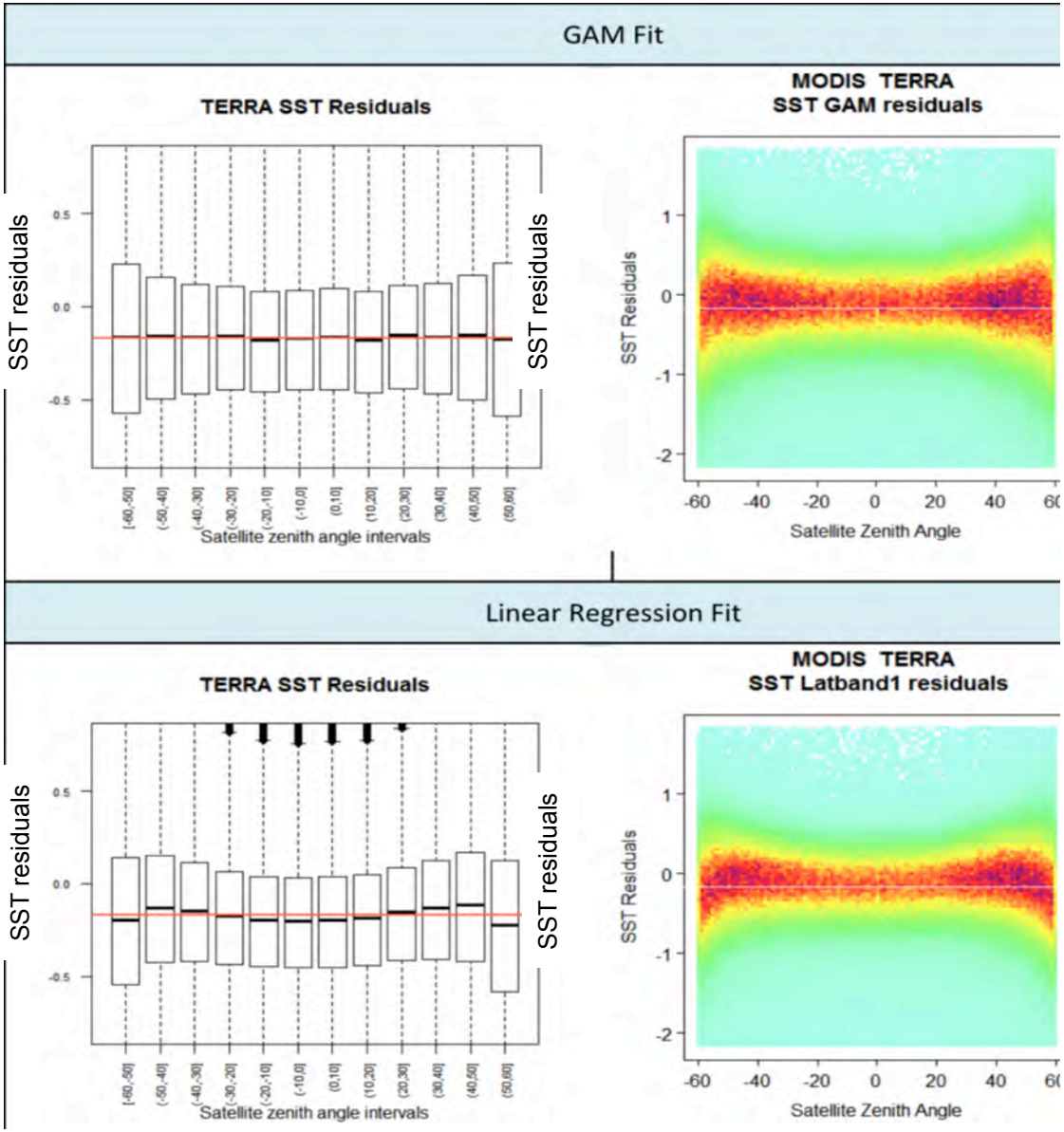






Remaining Scan Angle Issue

SST residuals relative to match-ups or reference SST fields are flat and "zero" biased for Quality=0 (55^{o} scan angle). For larger scan angles the SST retrieval algorithm produces SSTs with increasing negative bias with increased scan angle. Several alternative approaches are being investigated to minimize the scan angle cold trend. One promising approach is use of General Additive Models (GAM) to determine better weighting functions for each of the algorithm terms.



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MODIS AQUA Match-up data base

TERRA MDB is similar but includes 2000-2001

Matchup year	Raw number of matchups	Number of matchups eliminated	Number of matchups kept
2002	121,022	97,107	23,915
2003	286,122	231,220	54,902
2004	313,829	254,442	59,387
2005	348,540	281,318	67,222
2006	553,335	449,892	103,443
2007	640,374	531,904	108,470
2008	701,109	581,705	119,404
2009	794,063	657,851	136,212
2010	867,005	709,957	157,048
2011	991,179	800,823	190,356
2012 (thru day 189)	449,004	361,371	87,633
TOTALS	6,065,582	4,957,590	1,107,992

- This table shows the numbers of 2002-2012 (through day 189) AQUA Collection 6 matchups that pass or do not pass initial tests. The TOTAL number of records kept is order ***about 18% of all matchups available. Used to estimate retrieval coefficients and uncertainty estimates.***

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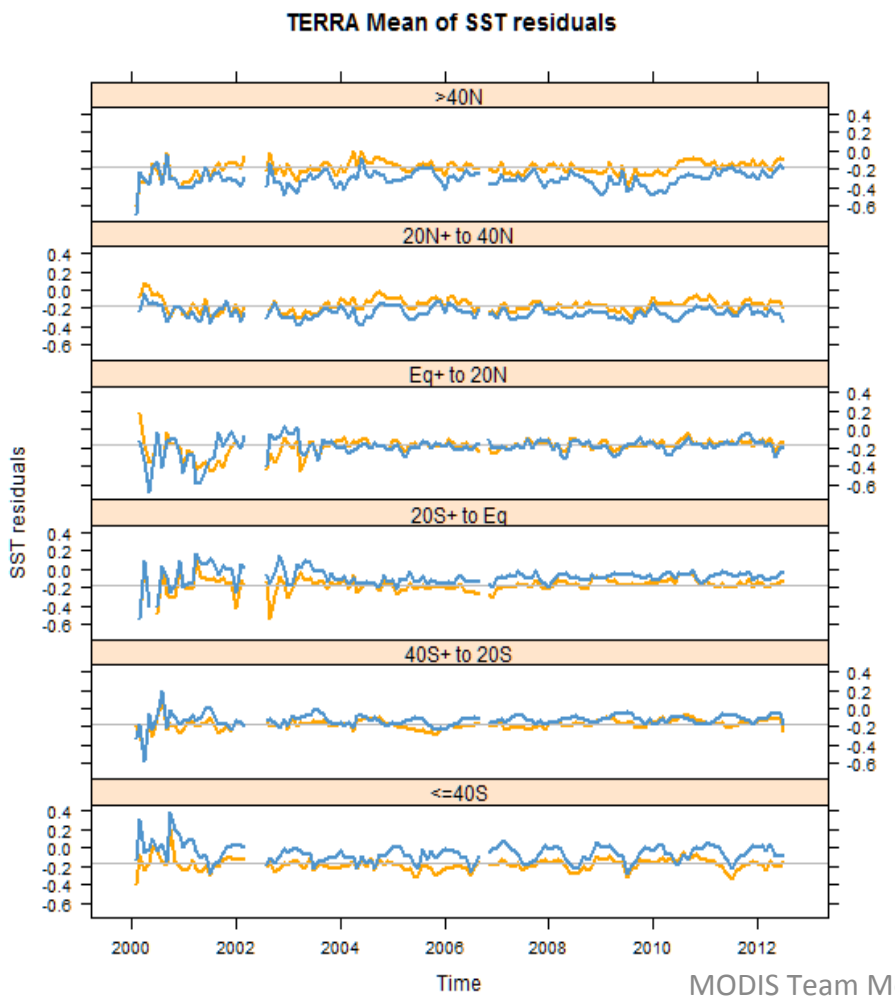
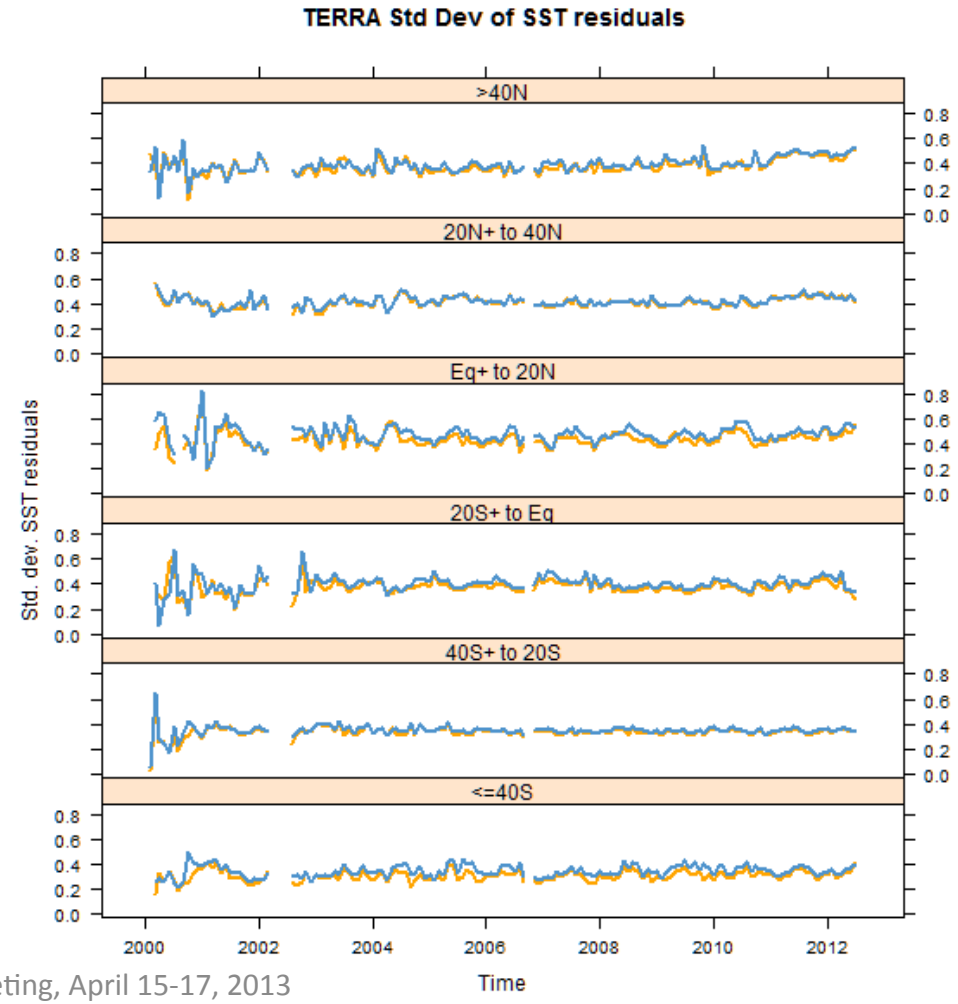
TERRA SST residuals and Std Dev vs buoys, 2000-2012

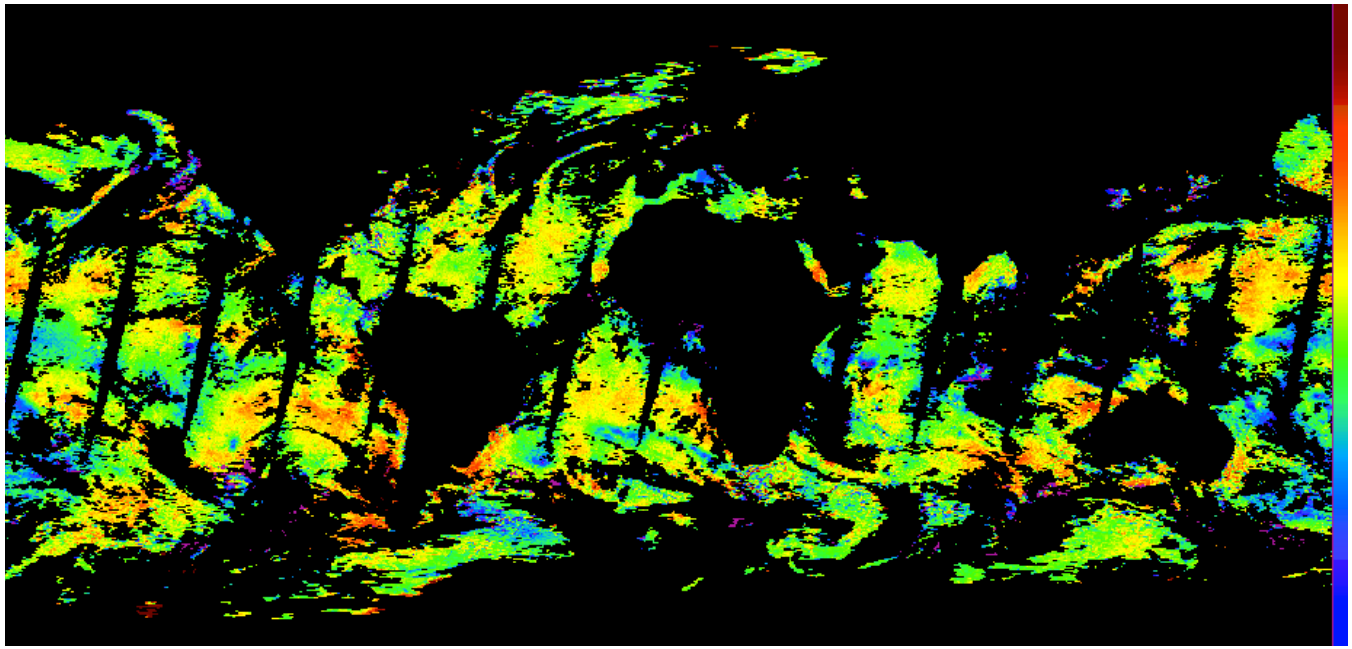
V6 removes most of seasonal and latitude bias seen with V5

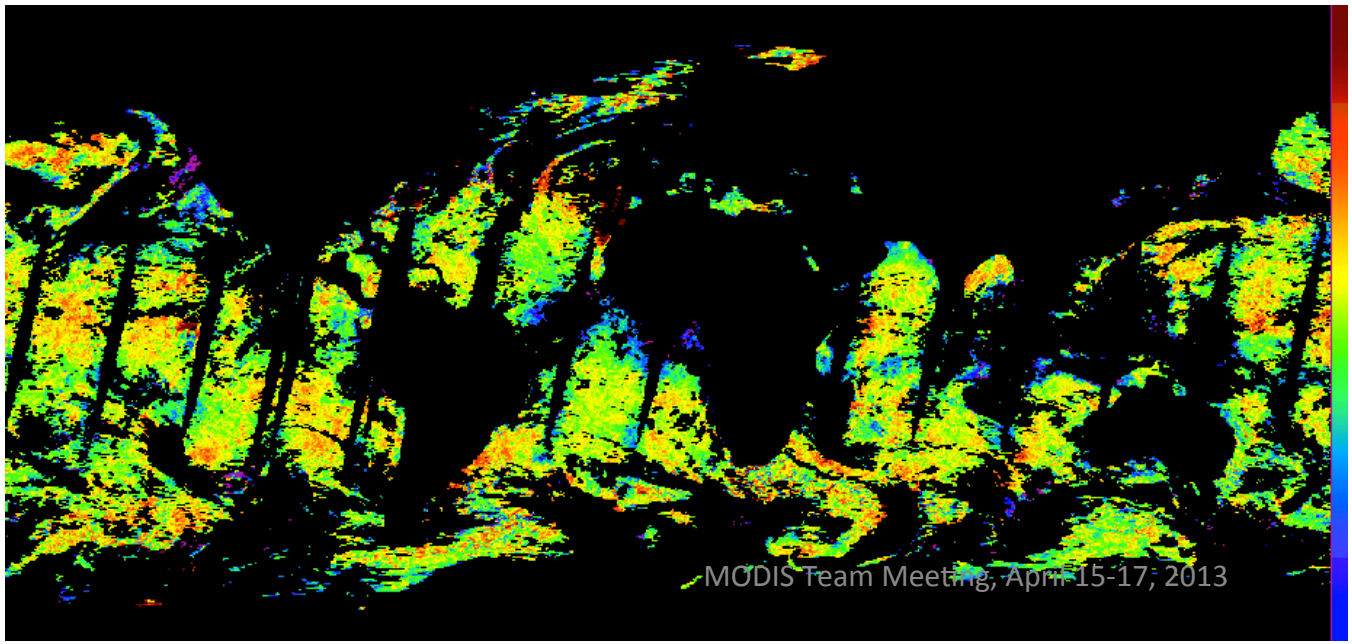
Orange line – V6, Blue is V5





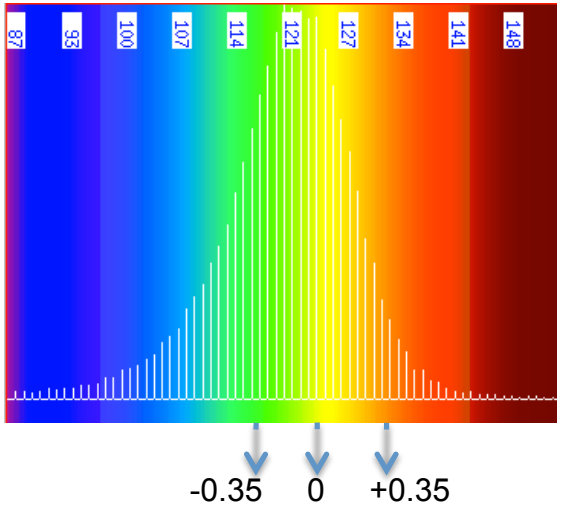
2012 047 SST4 Night residuals vs Reynolds (top) and Windsat (bottom)





Location and magnitude of residuals dependent on reference field used

Aqua-Reynolds (L4 analysis)
Daily ¼ degree OI

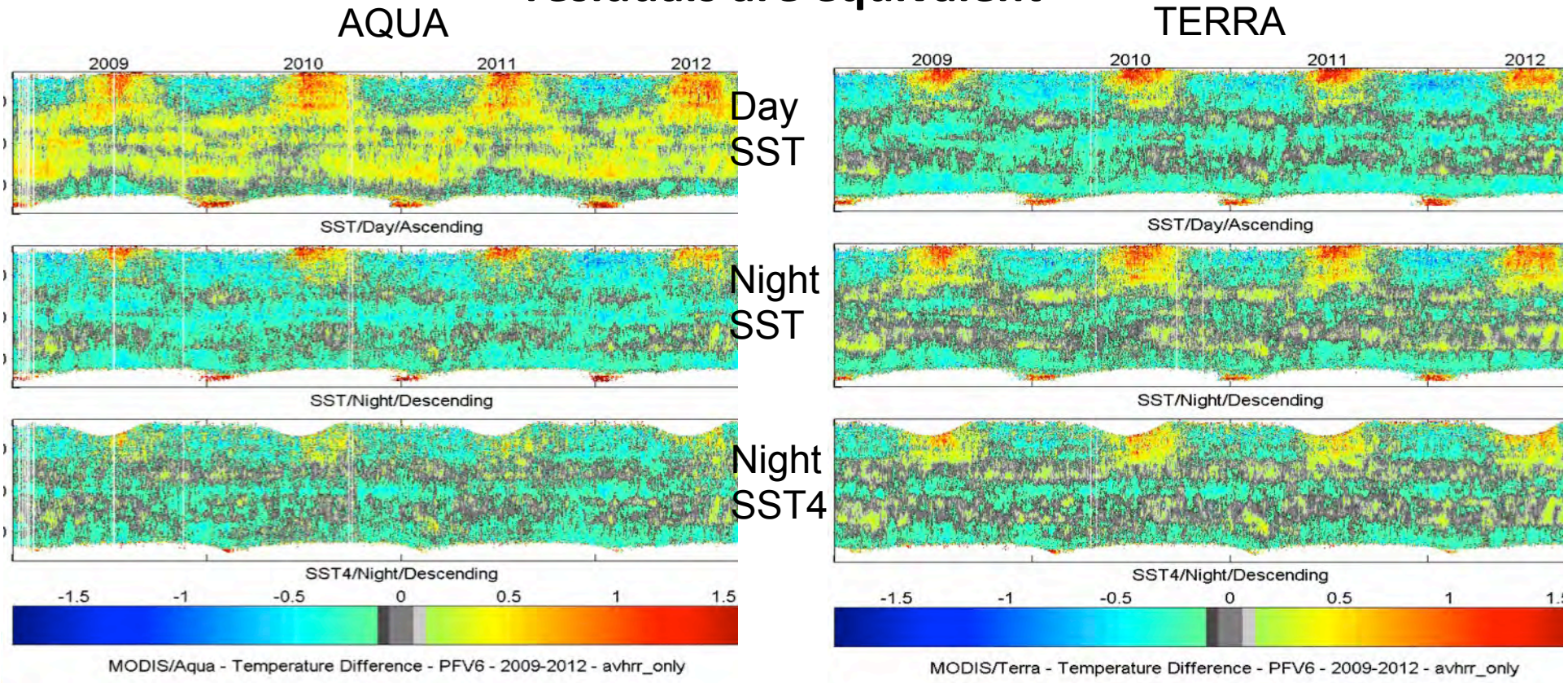


Aqua-Windsat (microwave)
5 day composite

AQUA (left) & TERRA (right) vs Reynolds Latitude, Time plots for 2009-2012

Reynolds L4 analysis, single field spanning 24 hours, does not represent diurnal warming

When referenced to separate Microwave SST day and night SST fields residuals are equivalent



SST and SST4 residual statistics for each quality level

. To assess the performance of SST and SST4 quality levels, statistics are calculated for all matchups in each quality level *vs* buoys.

AQUA SST

MODIS AQUA – SST Residual Statistics for each quality level									
Quality	Min	Q1	Median	Mean	Q3	Max	RMS	SD	MAD
0	-3.795	-0.338	-0.126	-0.130	0.081	5.776	0.411	0.389	0.310
1	-14.495	-0.350	-0.137	-0.119	0.131	4.206	0.479	0.464	0.356
2	-21.897	-0.760	-1.261	-0.515	-0.051	8.375	1.155	1.033	0.513
3	-39.373	-9.627	-8.934	-5.191	-0.346	10.597	7.677	5.656	4.649
4	NA	NA	NA	NA	NA	NA	NA	NA	NA

TERRA SST

MODIS TERRA – SST Residual Statistics for each quality level								
Min	Q1	Median	Mean	Q3	Max	RMS	SD	MAD
-5.558	-0.376	-0.129	-0.149	0.107	6.201	0.494	0.472	0.358
-6.417	-0.576	-0.207	-0.236	0.169	5.550	0.762	0.725	0.552
-6.106	-1.229	-0.329	-0.488	0.609	3.113	1.384	1.295	1.372
-7.135	-3.061	-0.468	-1.288	0.140	5.099	2.389	2.014	1.525
NA	NA	NA	NA	NA	NA	NA	NA	NA

AQUA SST4

MODIS AQUA – SST4 Residual Statistics for each quality level									
Quality	Min	Q1	Median	Mean	Q3	Max	RMS	SD	MAD
0	-4.345	-0.291	-0.138	- 0.157	0.000	3.957	0.369	0.334	0.215
1	-6.049	-0.501	-0.277	-0.326	-0.092	4.276	0.559	0.454	0.299
2	-5.729	-1.003	-0.534	-0.704	-0.245	3.894	1.104	0.850	0.520
3	-43.569	-13.824	-9.346	-8.730	-1.491	8.742	10.981	6.660	8.291
4	NA	NA	NA	NA	NA	NA	NA	NA	NA

TERRA SST4

MODIS TERRA – SST4 Residual Statistics for each quality level								
Min	Q1	Median	Mean	Q3	Max	RMS	SD	MAD
-5.490	-0.318	-0.172	-0.195	-0.043	4.036	0.391	0.338	0.203
-6.786	-0.392	-0.192	-0.283	-0.017	5.033	0.735	0.679	0.274
-5.918	-0.924	-0.374	-0.707	-0.068	3.755	1.451	1.267	0.570
-7.655	0.167	0.528	1.489	1.668	27.839	2.898	2.487	0.717
NA	NA	NA	NA	NA	NA	NA	NA	NA

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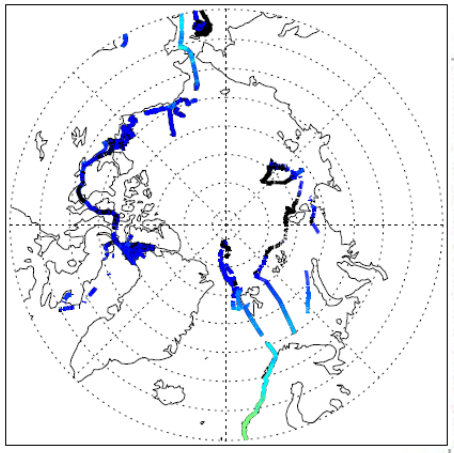
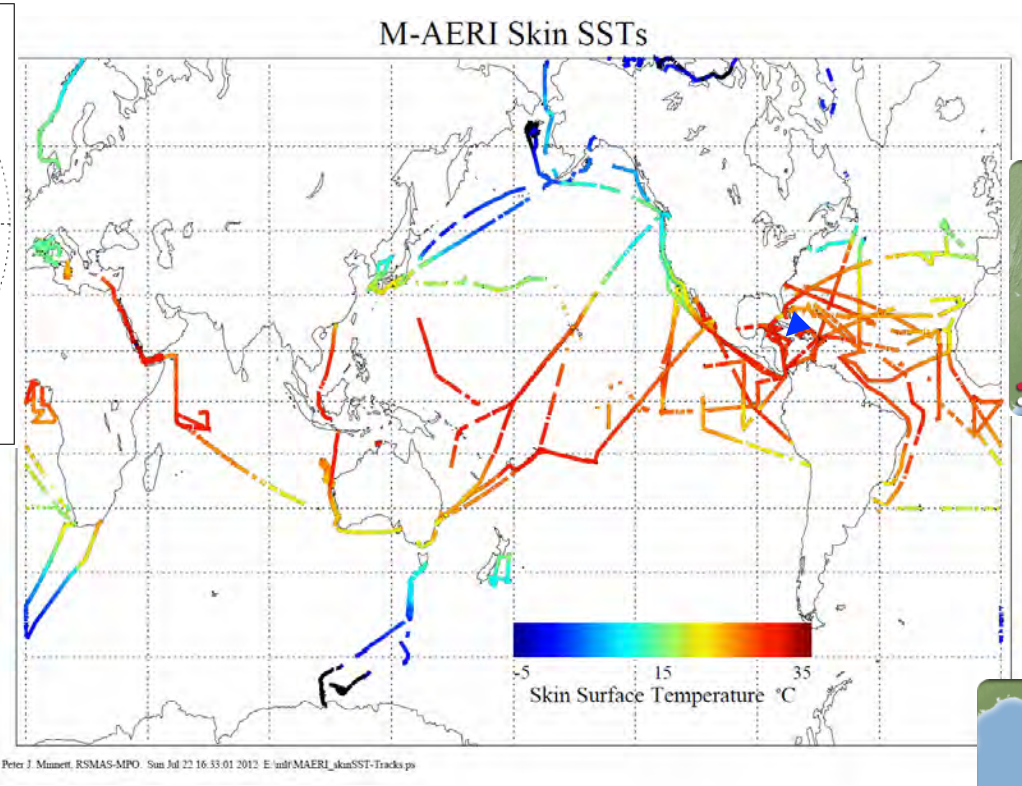
SST CDRs

- MODIS SSTs have the potential to contribute to the SST CDR.
- Traceability to SI standards is required to allow merging of satellite SSTs from multiple missions.
- Traceability can be achieved by ship-board radiometers that are calibrated against SI standards.
- Expanded presentation on poster.

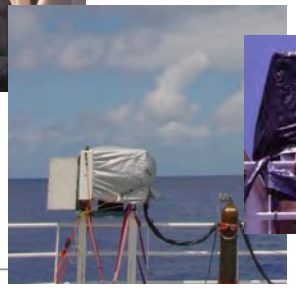
Over 40 M-AERI research cruises for MODIS SST validation

+ Explorer of the Seas: near continuous operation December 2000 – December 2007.





Explorer of the Seas



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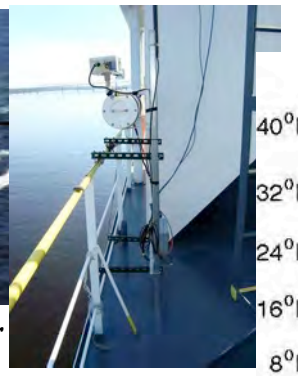
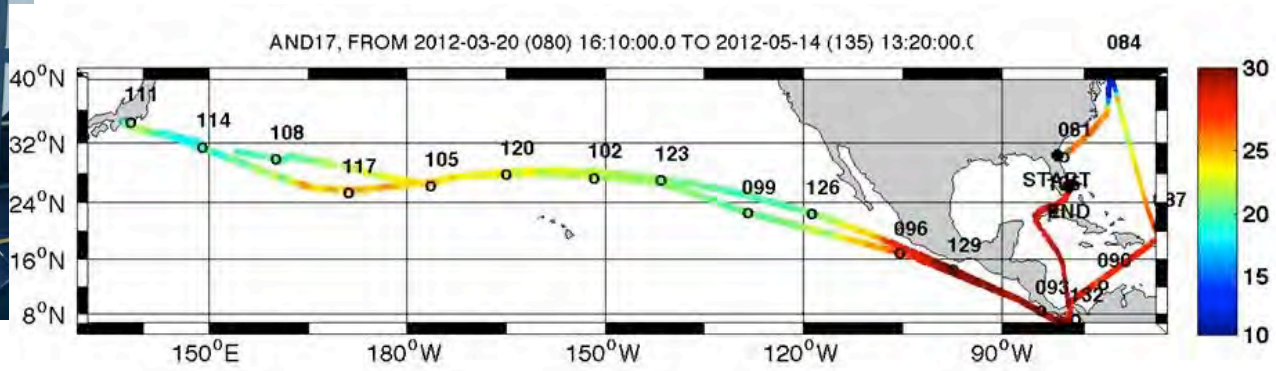
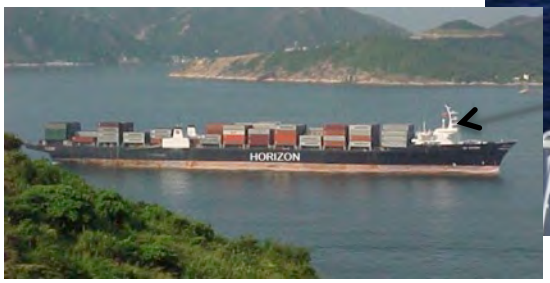
Ship radiometers: ISARs Both ISAR/M-AERI calibration traceable to NIST transfer radiometer (TXR)

M/V *Andromeda Leader*



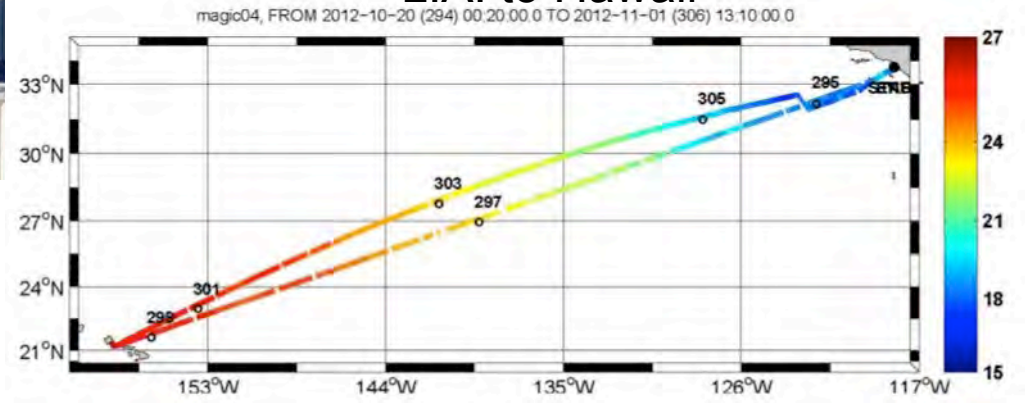


Japan to New York



M/V *Horizon Spirit*

L.A. to Hawaii



ISARs are autonomous filter radiometers with two internal blackbody calibration targets.
Pre- & post-deployment laboratory calibration against NIST-traceable calibrators.
Data relayed in real-time by Iridium.

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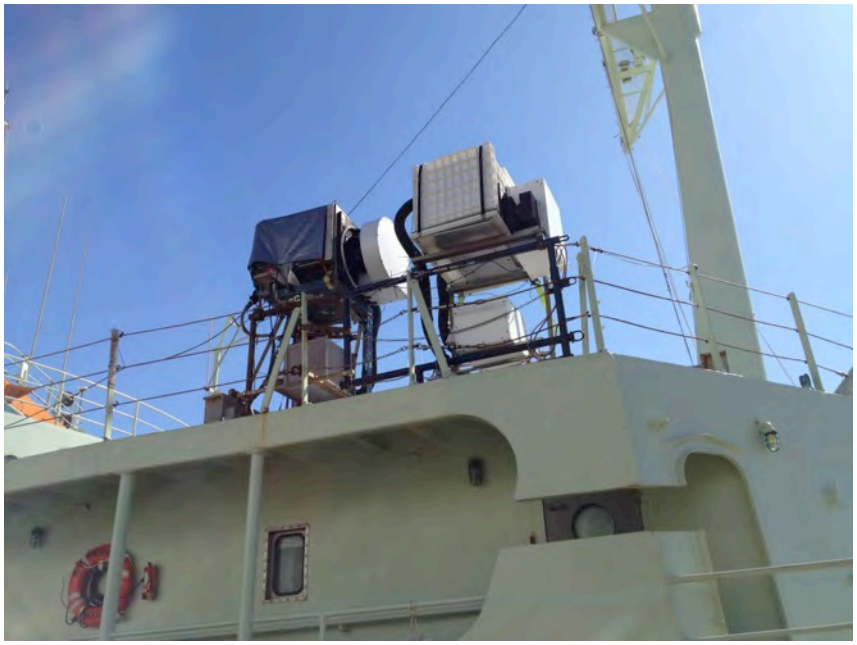
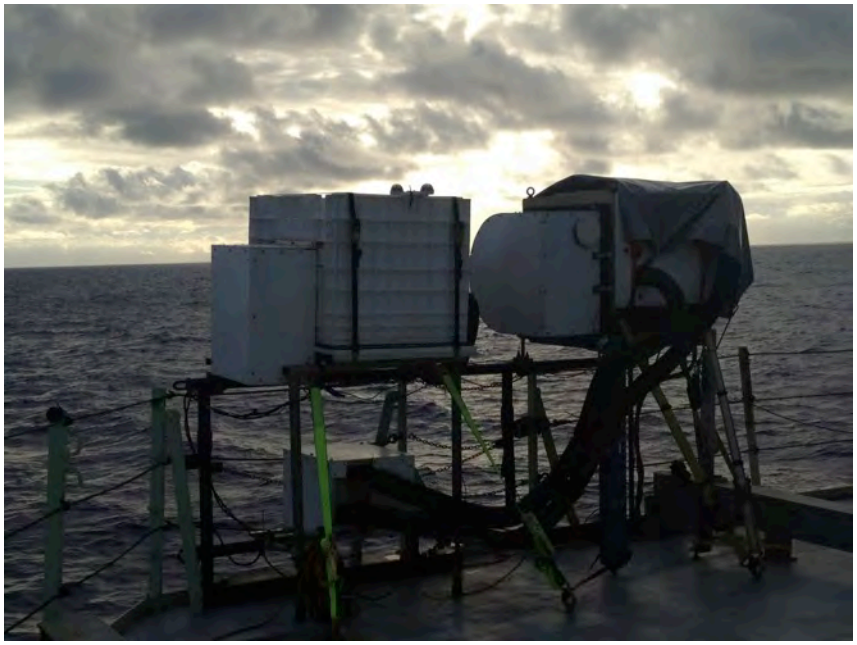
M-AERI's on R/V Knorr

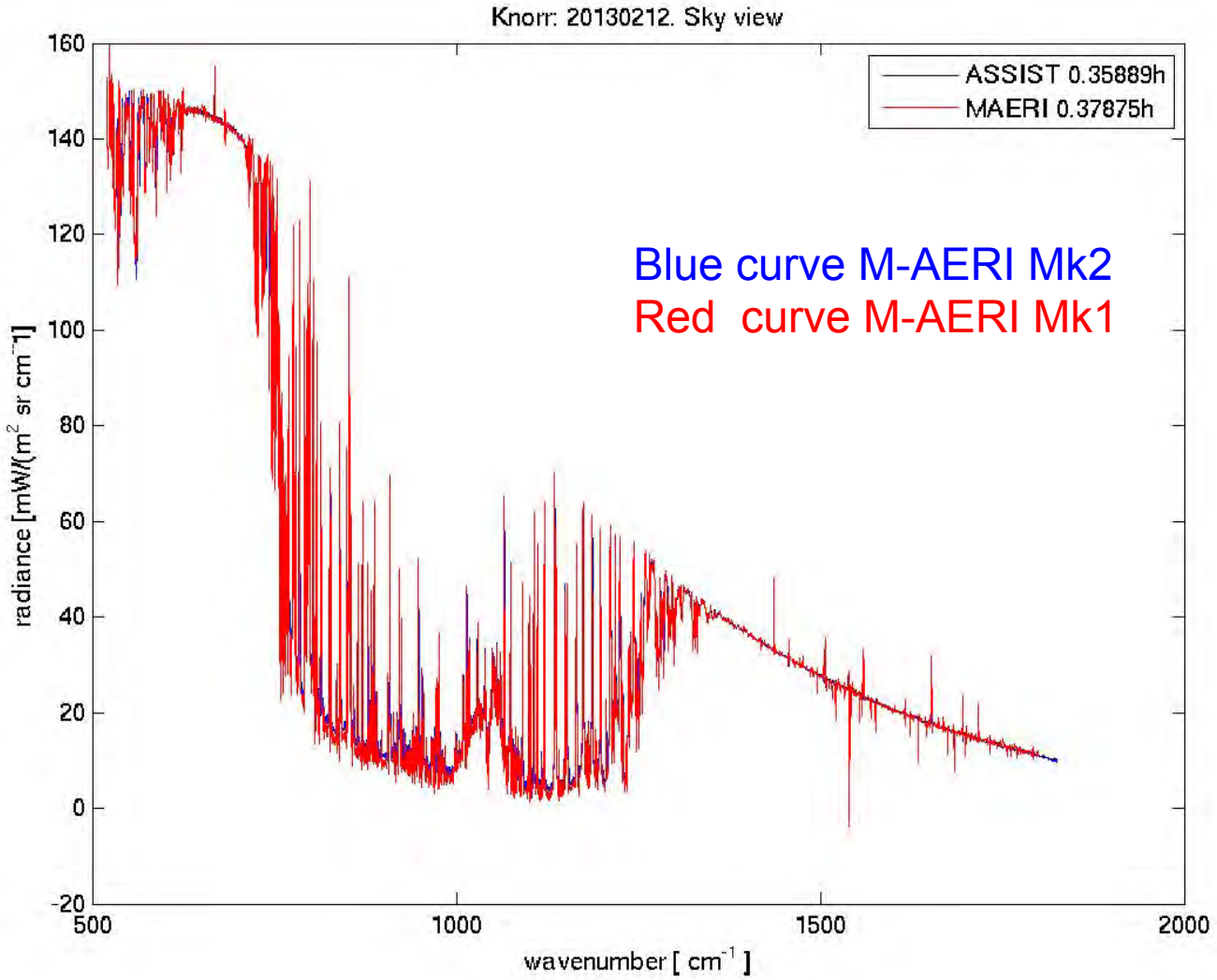
A second-generation M-AERI has been developed to extend the M-AERI measurements into the future.





Running M-AERIs old and new, side-by-side on transit from Woods Hole, to Cape Town, South Africa. Then together for a mooring recovery cruise in the Agulhas Current region.

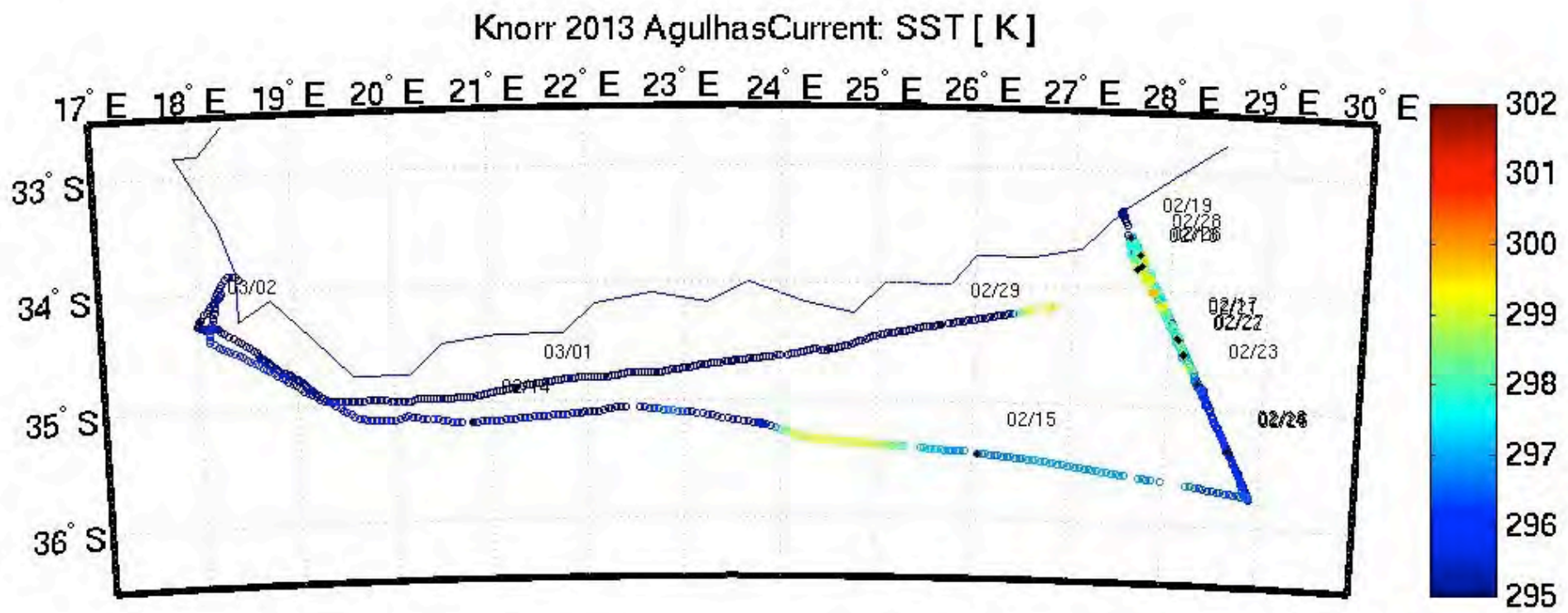
Sky spectra



M-AERI Mk2 samples at about twice the rate of M-AERI, taking ~5 min for a measurement cycle, instead of ~12 min.

Calibrated spectra are in very good agreement, showing that radiometric and spectral calibration are consistent.

M-AERI Mk 2 skin SSTs



Skin SST measurements along the path of the R/V Knorr by the M-AERI Mk2. The coastline is South Africa.

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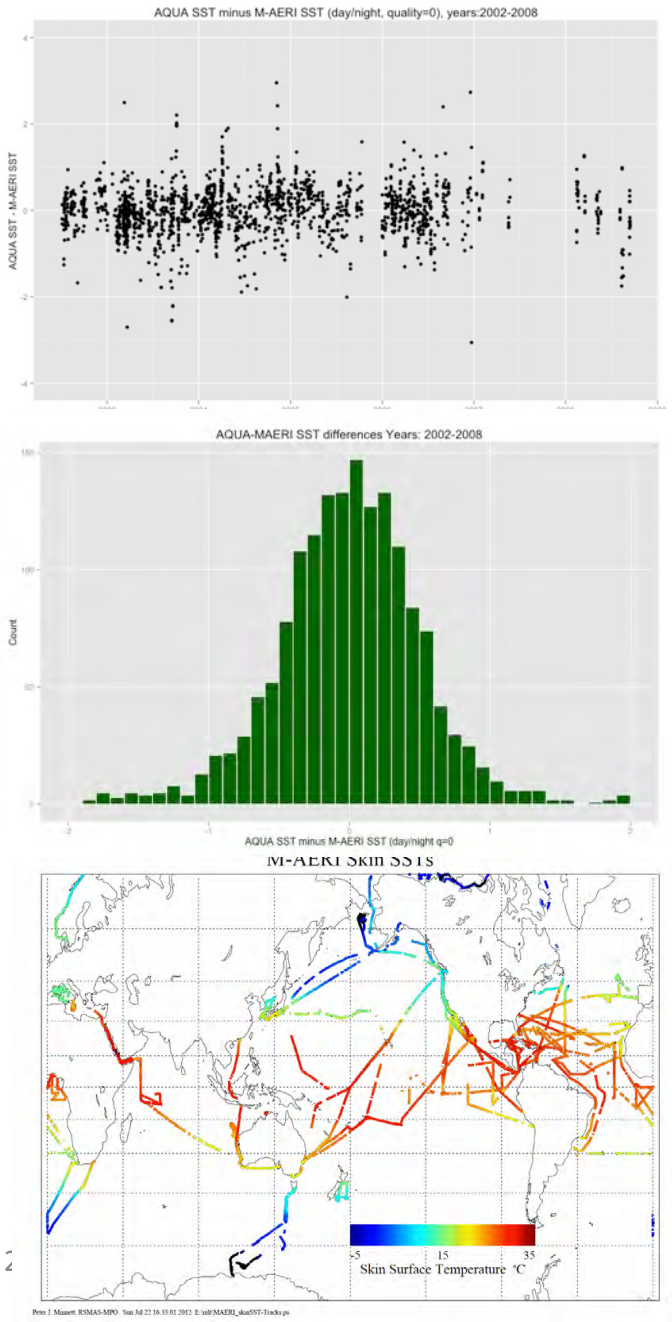
Global Statistics of MODIS - M-AERI match-ups

MODIS M-AERI matchups				
	Terra		Aqua	
2002-2008	SST	SST4	SST	SST4
Mean	0.075	0.021	0.000	-0.061
Median	0.086	0.044	0.014	-0.031
St. Devn.	0.530	0.508	0.560	0.542
N	1985	1273	1626	1023

SST is day and night; SST4 is night only

LUT6 - SST Version 5



Mean & Median uncertainties are excellent

2002-2008 Time series stable, basis for CDR

(See Poster)

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Summary

- M-AERI MkI & II and ISAR instruments are providing NIST traceable Skin Temperature reference SST
- LATBAND V6 SST algorithm coded in SeaDAS 6.4 and validated using global buoy and M-AERI, ISAR Skin Temperature
- Processing of 2009-2012 AQUA and TERRA SST & SST4 demonstrates consistent results
- Code is being prepared for transfer to OBPG.

END