

# Collect 5 Calibration Issues

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# Recent MODIS Calibration Changes and Issues

- Collect 5 DSM RVS application for Terra (MSCN?)
- Aqua AIRS – MODIS comparisons
- 5 $\mu$ m leak correction for Terra Aside 2
- TIR band destriping update (global training)
- Reminder about Aqua MODIS registration offsets.
- Terra B26 radiance change for Collect 5 due to change in 5 $\mu$ m leak correction formulation
- Earth Shine

# Terra MODIS DSM RVS

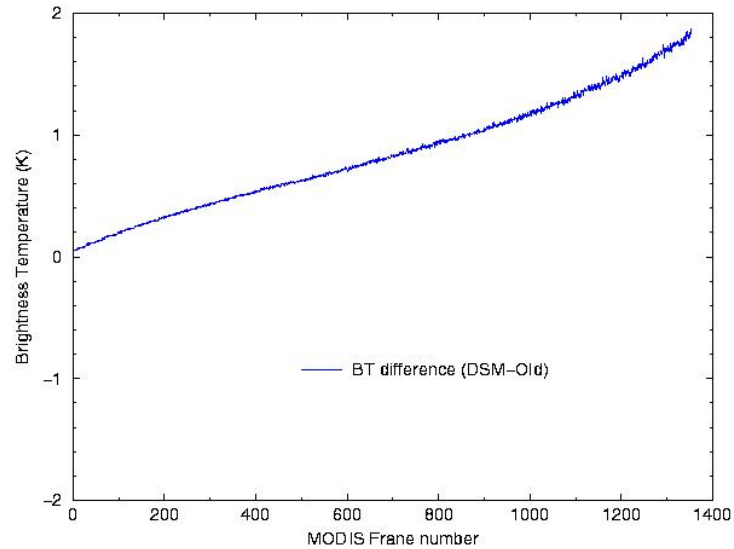
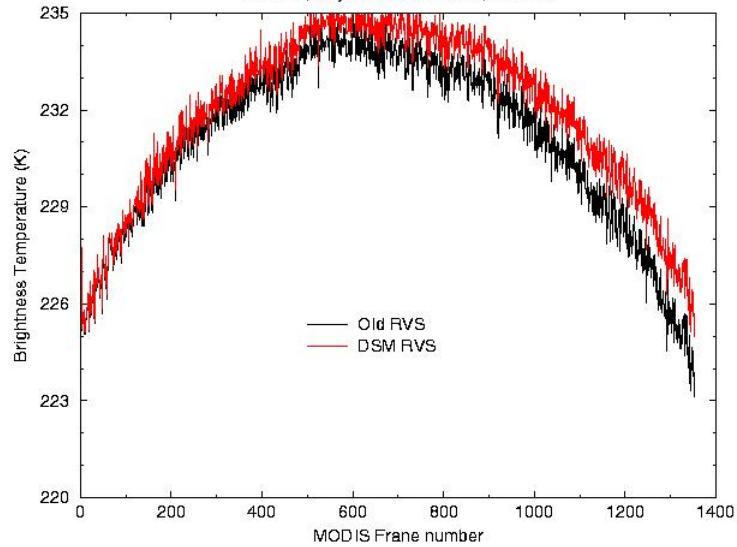
- Used for Thermal bands
- Largest impact in LWIR CO2 bands 34-36
- Cross-track asymmetry reduced
- Mirror-side striping reduced (exception: Bside)
- Examples from each of the major MODIS epochs (Aside 1, Bside, Aside 2)

# Band 36 across track profiles using old and DSM RVS

## DSM RVS improves across track symmetry, esp Mirror Side 2

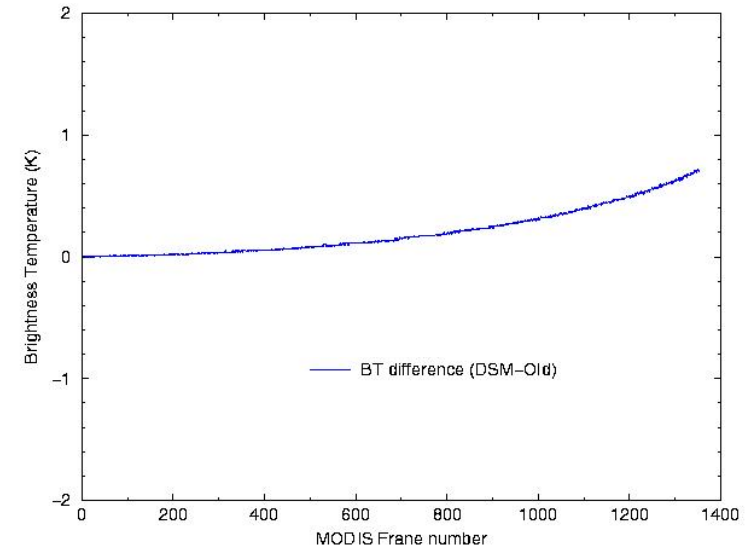
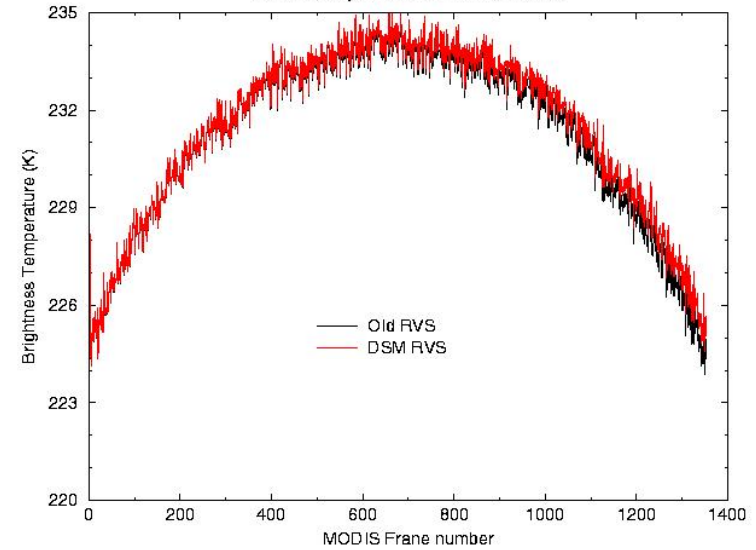
Terra MODIS RVS Assessment

Band 36; Day 03094 1740 UTC; SL 2765



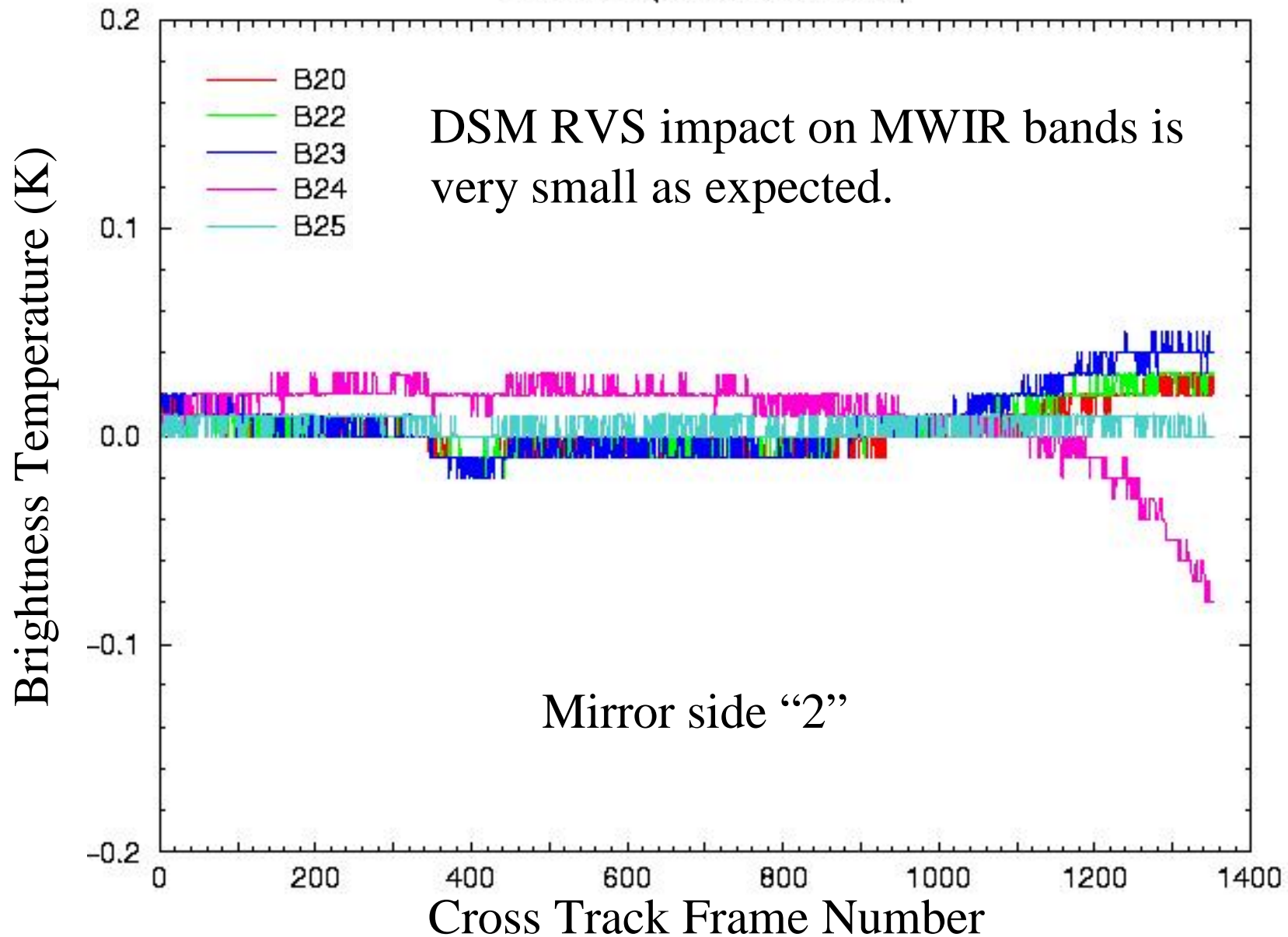
Terra MODIS RVS Assessment

Band 36; Day 03094 1740 UTC; SL 2745



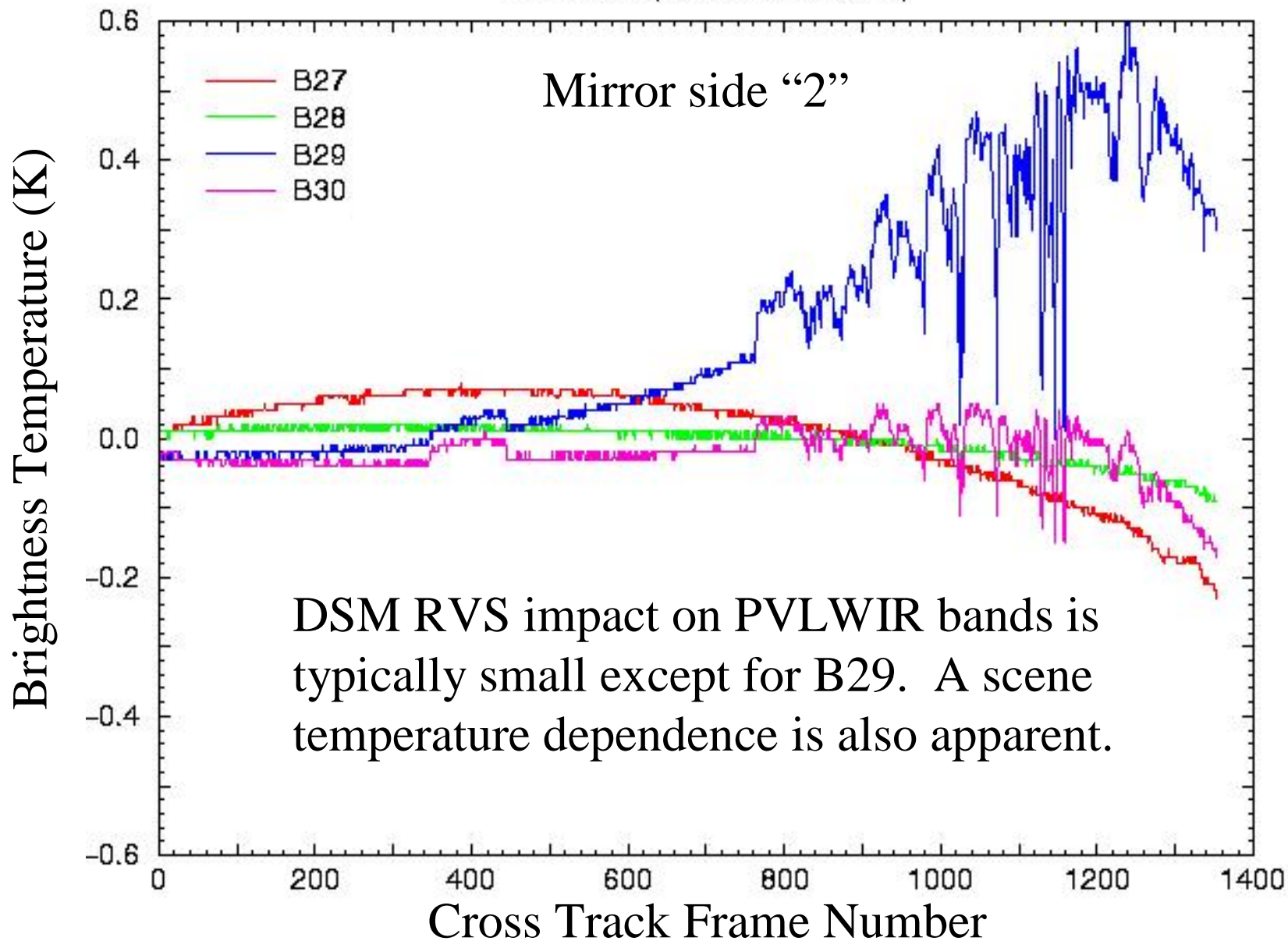
# MODIS Scene Mirror RVS

Terra RVS (Old vs. DSM 2003)



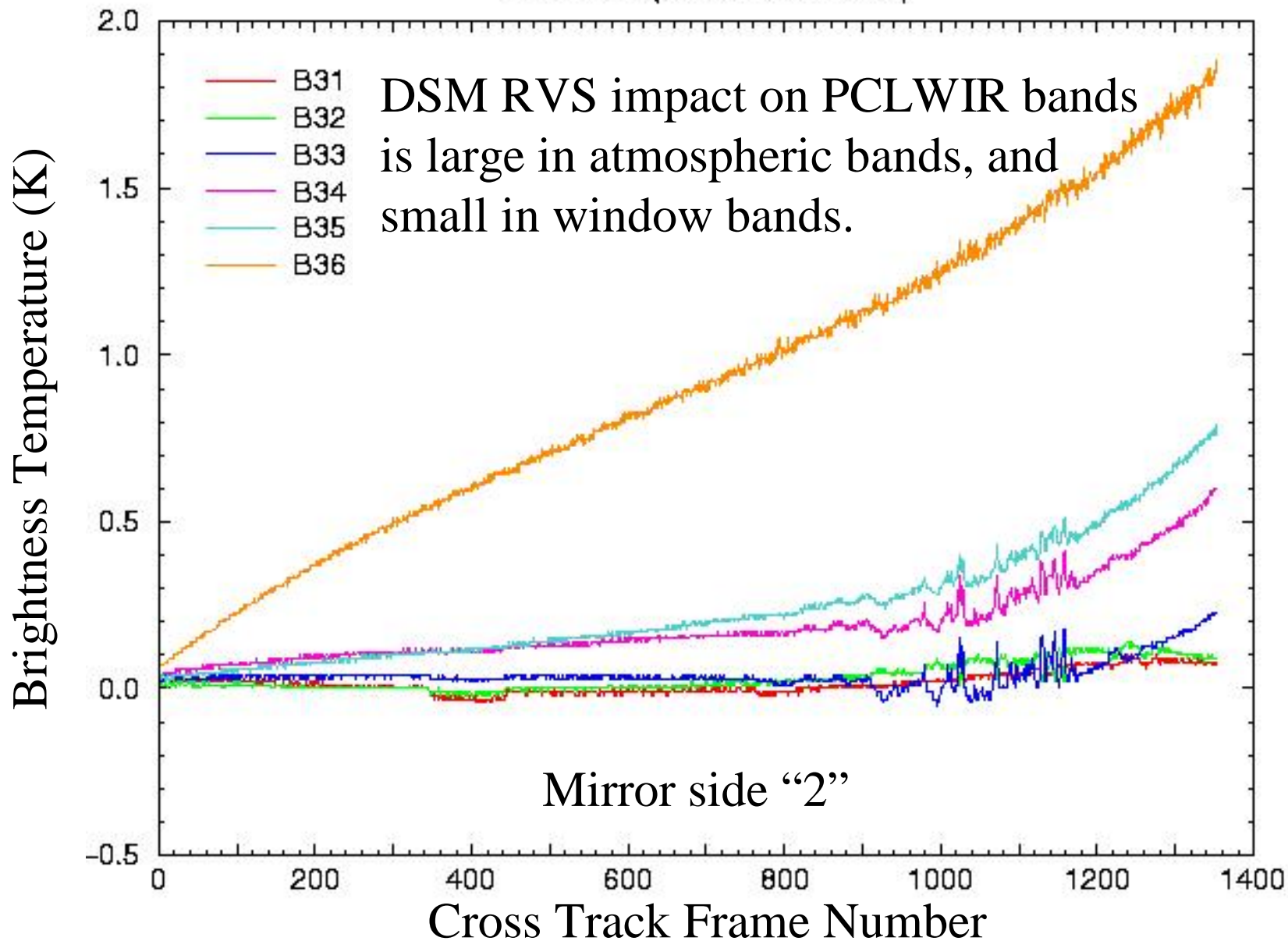
# MODIS Scene Mirror RVS

Terra RVS (Old vs. DSM 2003)



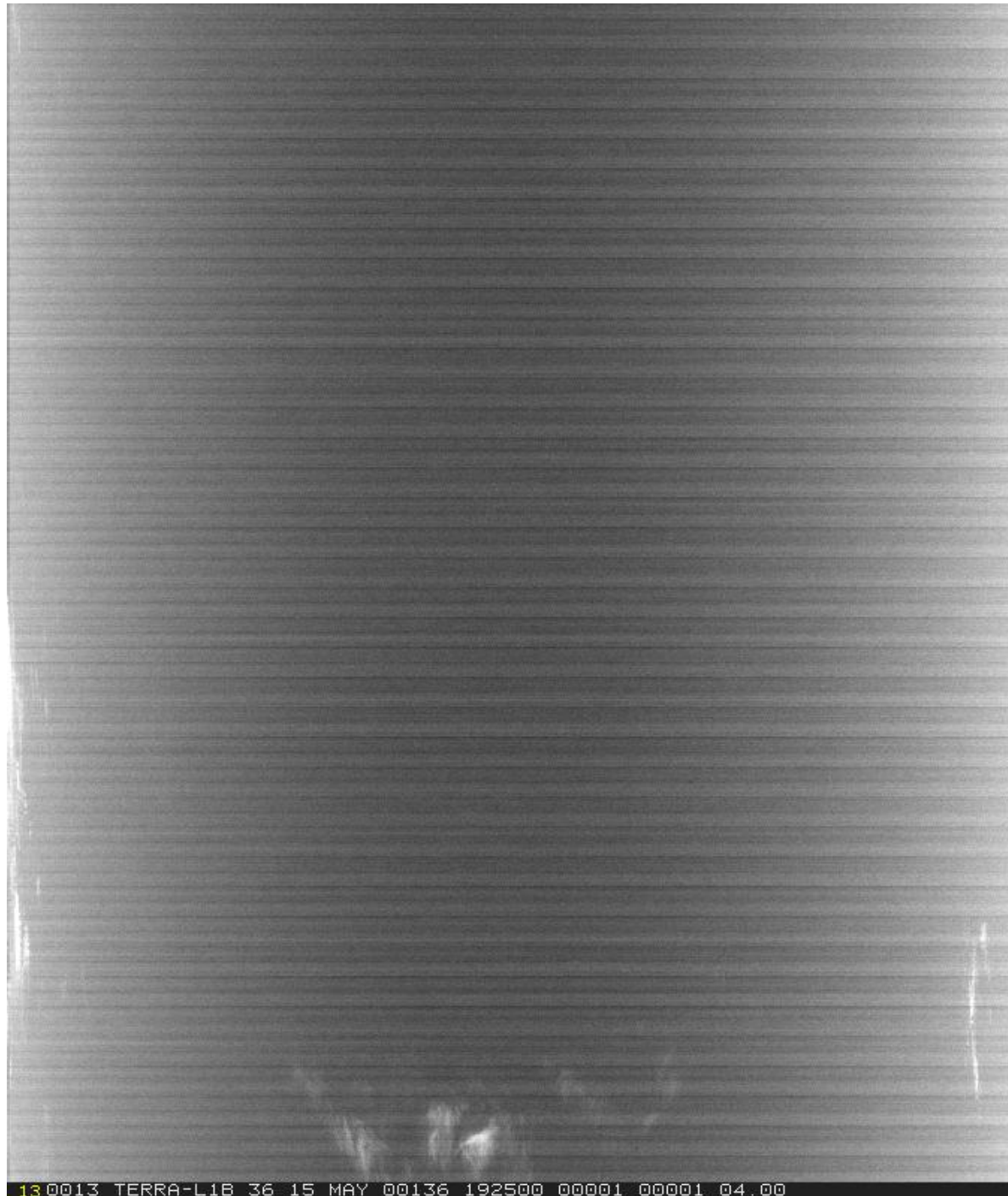
# MODIS Scene Mirror RVS

Terra RVS (Old vs. DSM 2003)



Aside 1  
Collect 4

Band 36

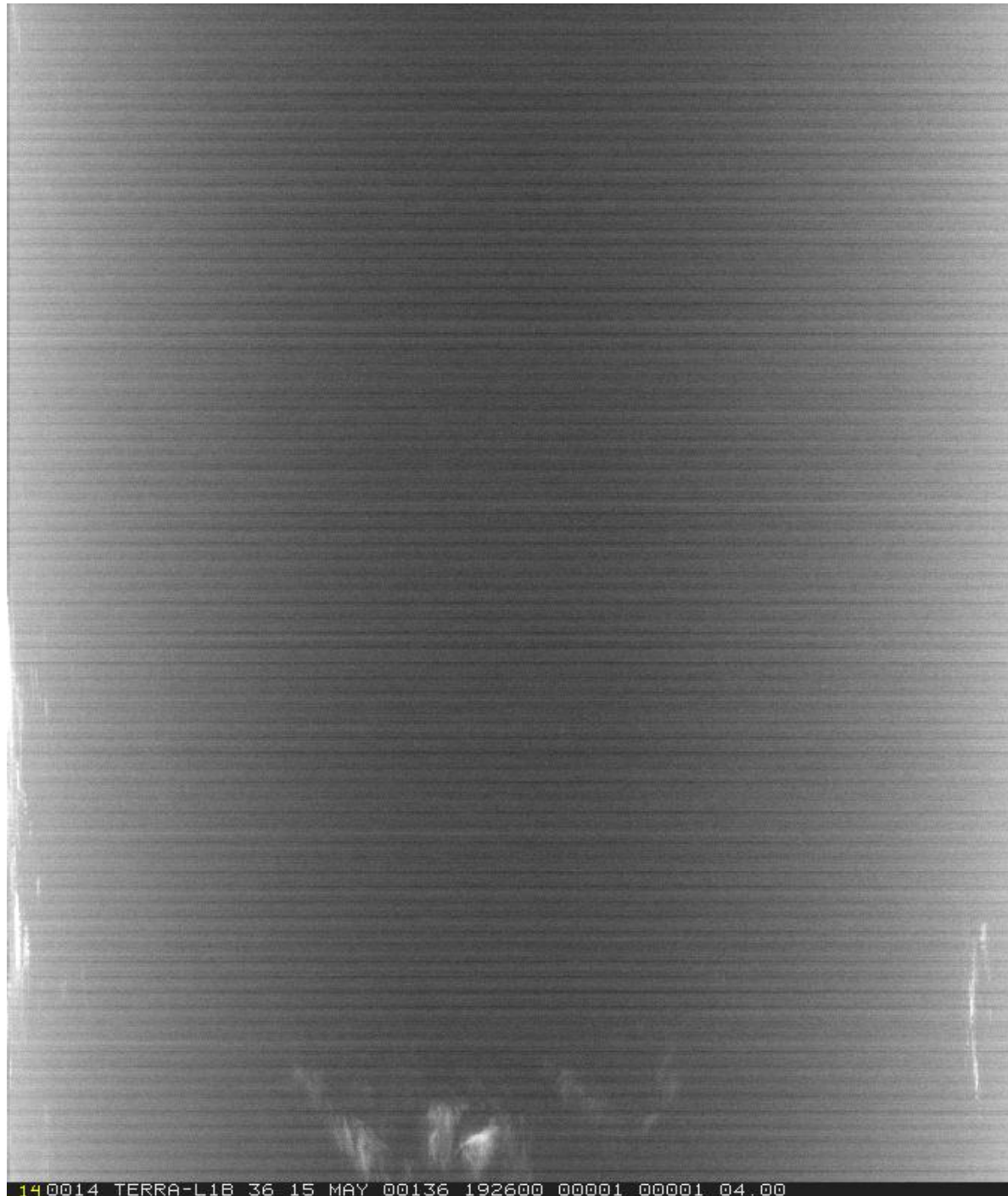


13 0013 TERRA-L1B 36 15 MAY 00136 192500 00001 00001 04.00



Aside 1  
Collect 5

Band 36



140014 TERRA-L1B 36 15 MAY 00136 192600 00001 00001 04.00

Aside 2  
Collect 4

Band 36

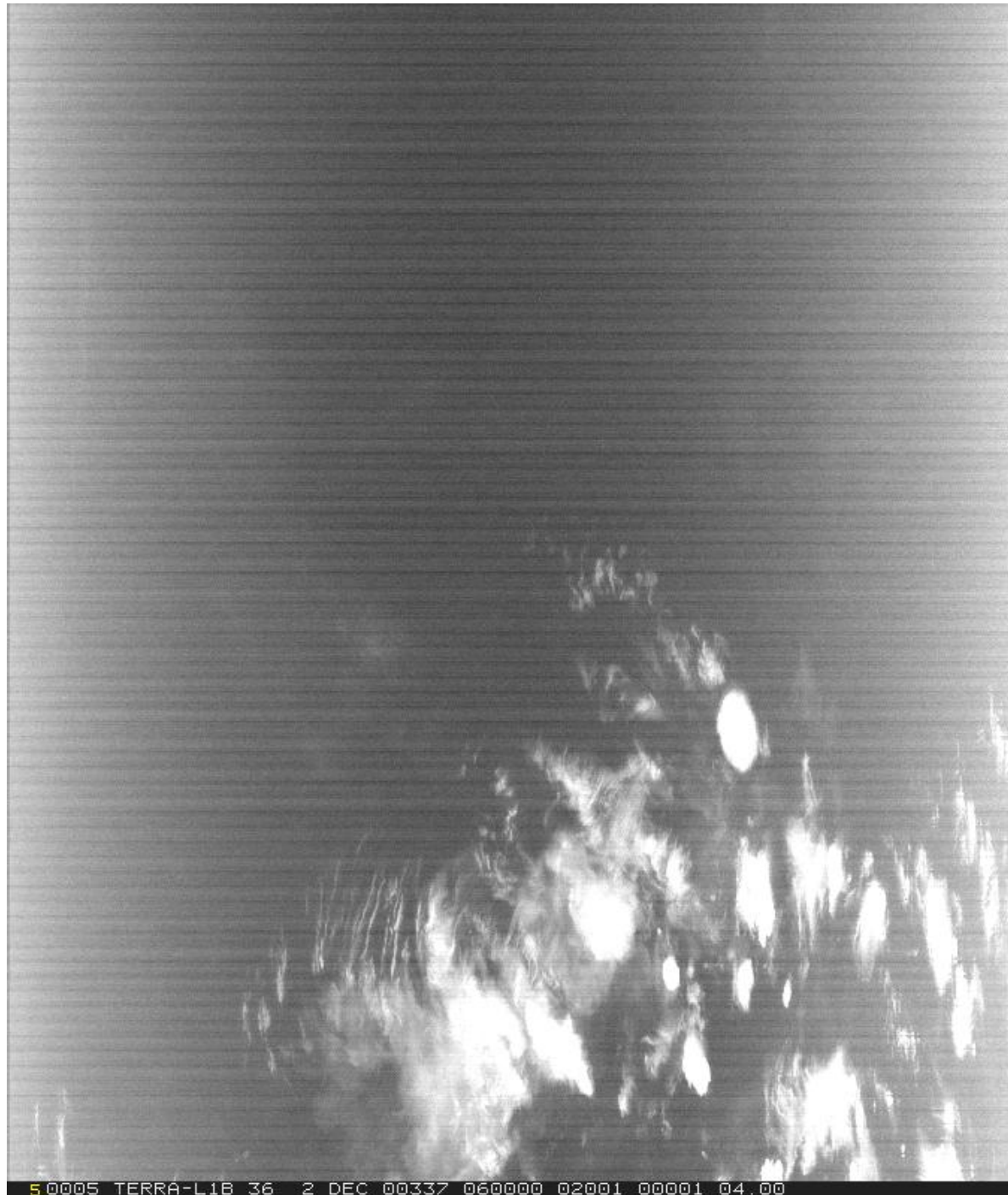
170017 TERRA-L1B 36 21 MAY 02141 024000 03601 00001 04.00

Aside 2  
Collect 5

Band 36

Bside  
Collect 4

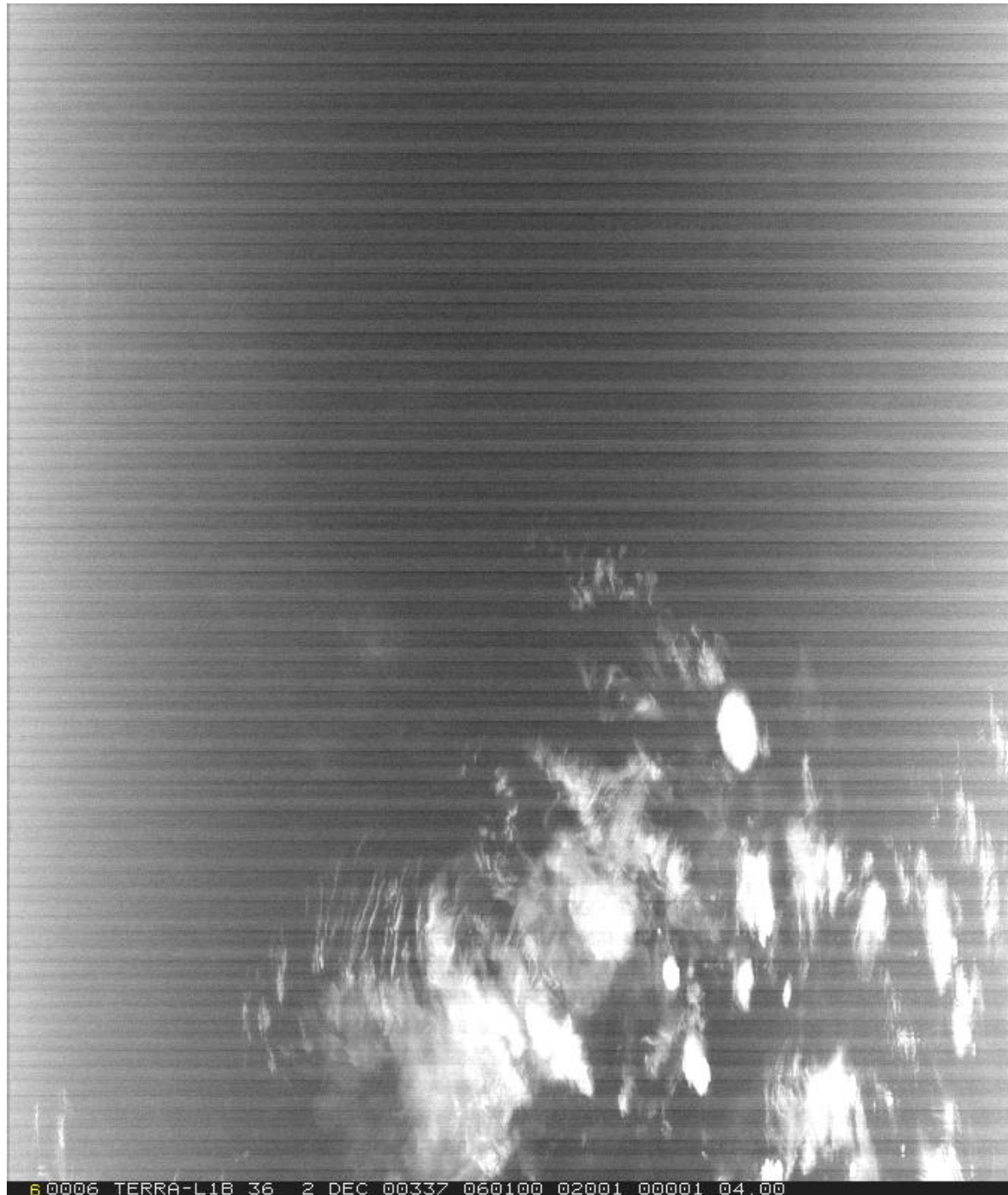
Band 36



5 0005 TERRA-L1B 36 2 DEC 00337 060000 02001 00001 04.00

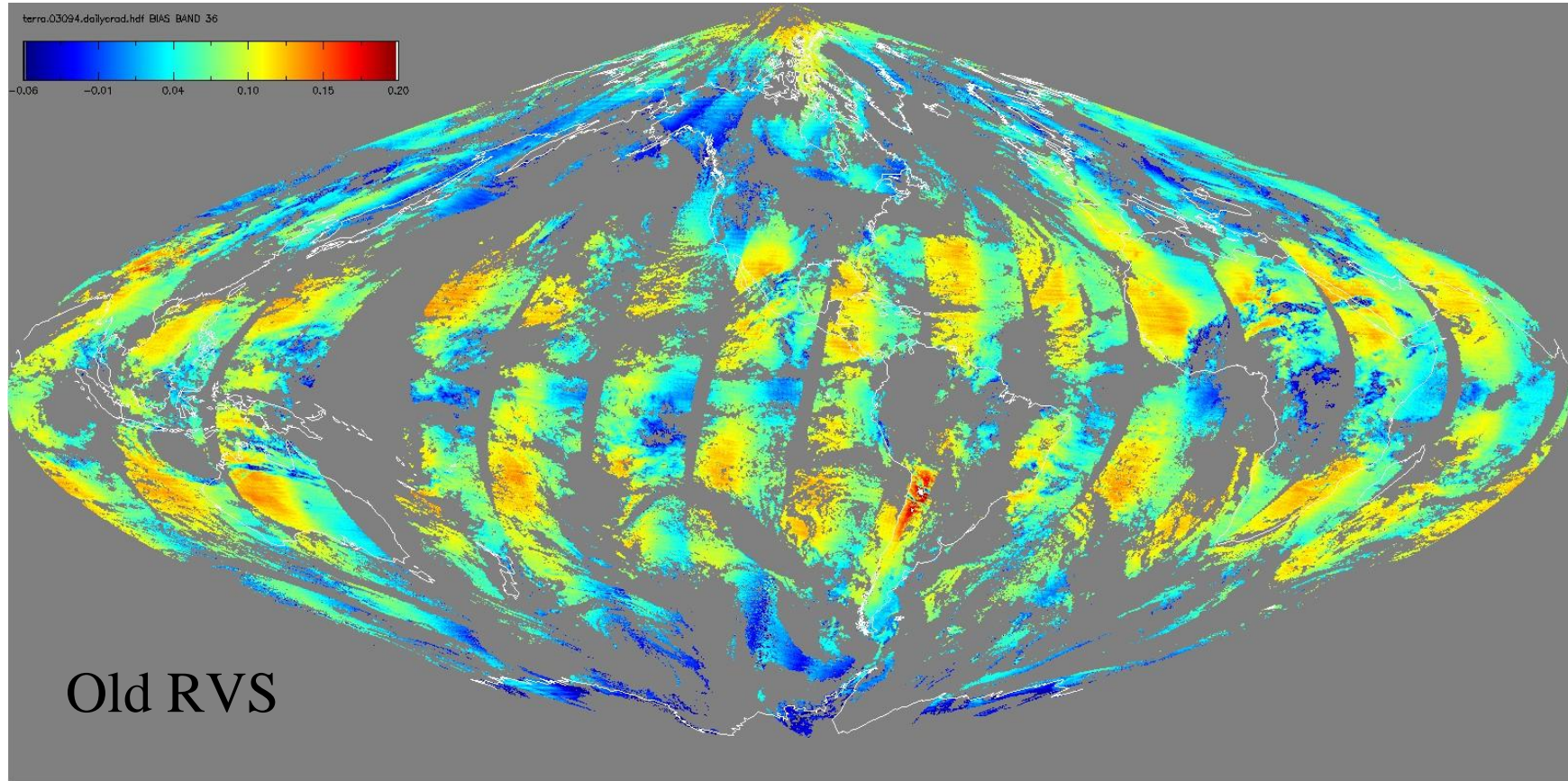
Bside  
Collect 5

Band 36



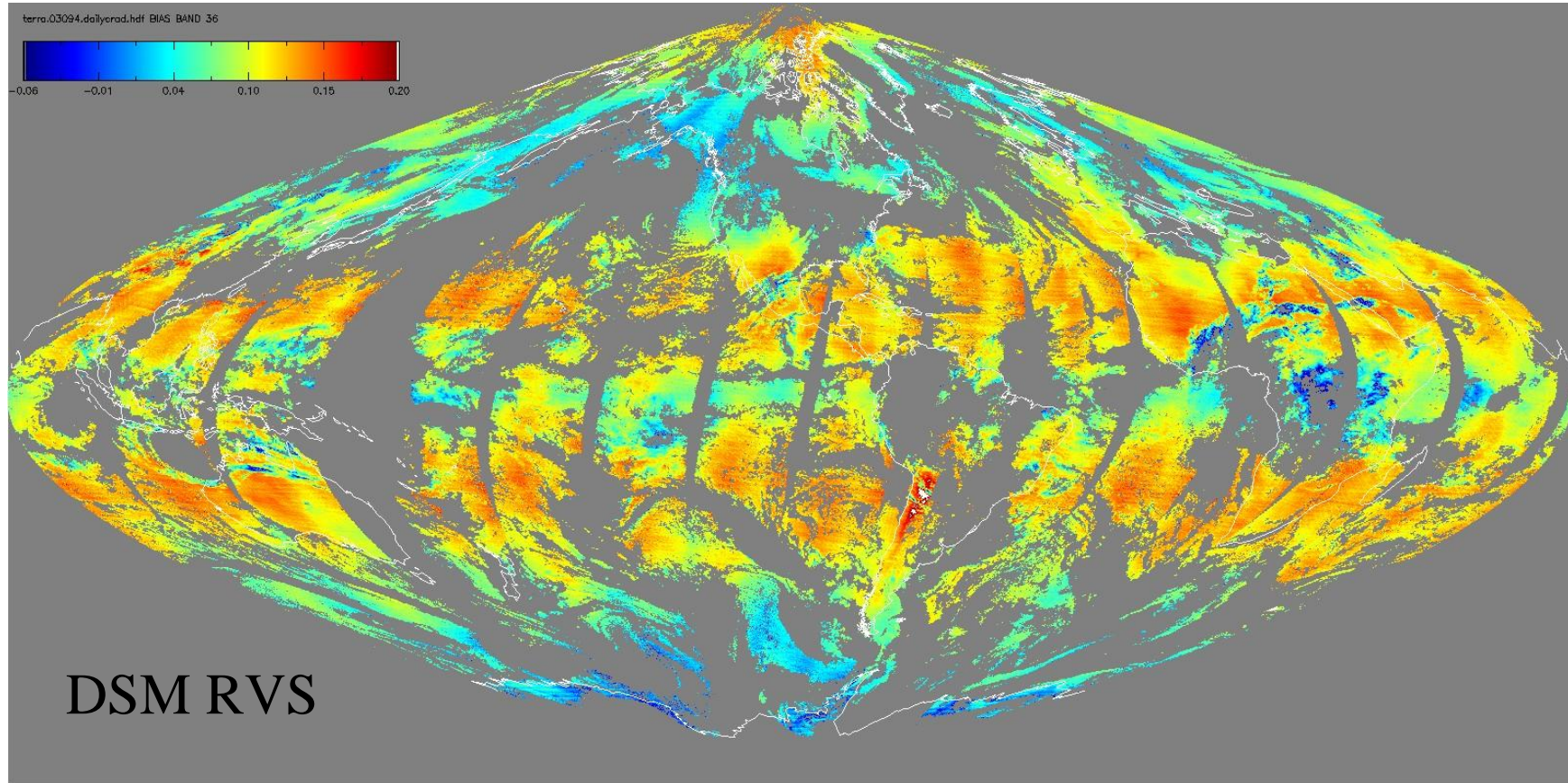
6 0006 TERRA-L1B 36 2 DEC 00337 060100 02001 00001 04.00

# Terra MODIS Clear Sky Radiance Bias (MODIS – model prediction) Band 36 (14.2 um)



The biases have a distinct dependence on scan angle

# Terra MODIS Clear Sky Radiance Bias (MODIS – model prediction) Band 36 (14.2 um)



Using DSM RVS largely removes the bias dependence on scan angle

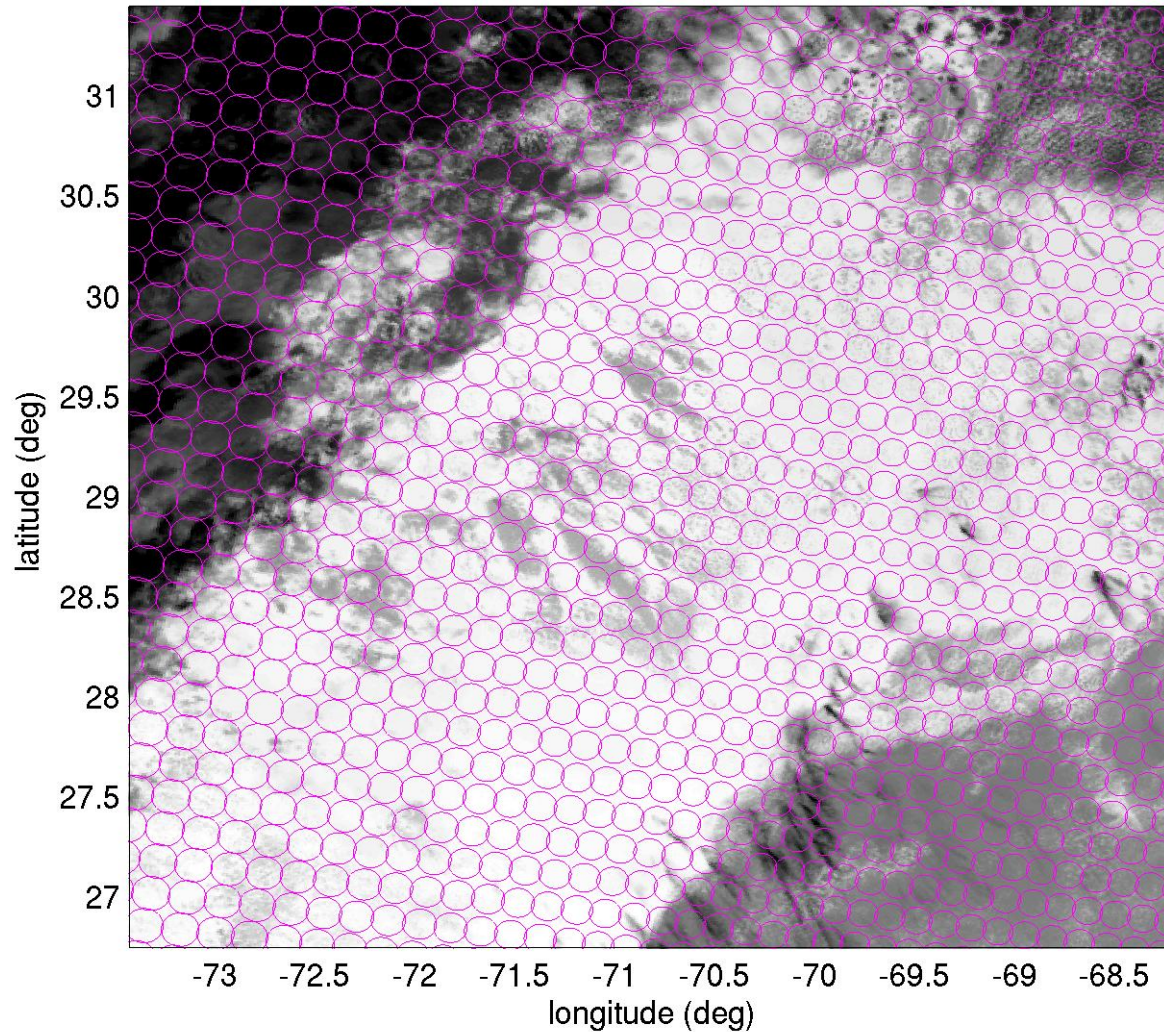
# Aqua AIRS-MODIS Comparisons

- Global day of data analyzed...uniform scenes only
- Suggests a MODIS calibration bias as function of BT.
- Suggests a MODIS Scan Mirror RVS error.

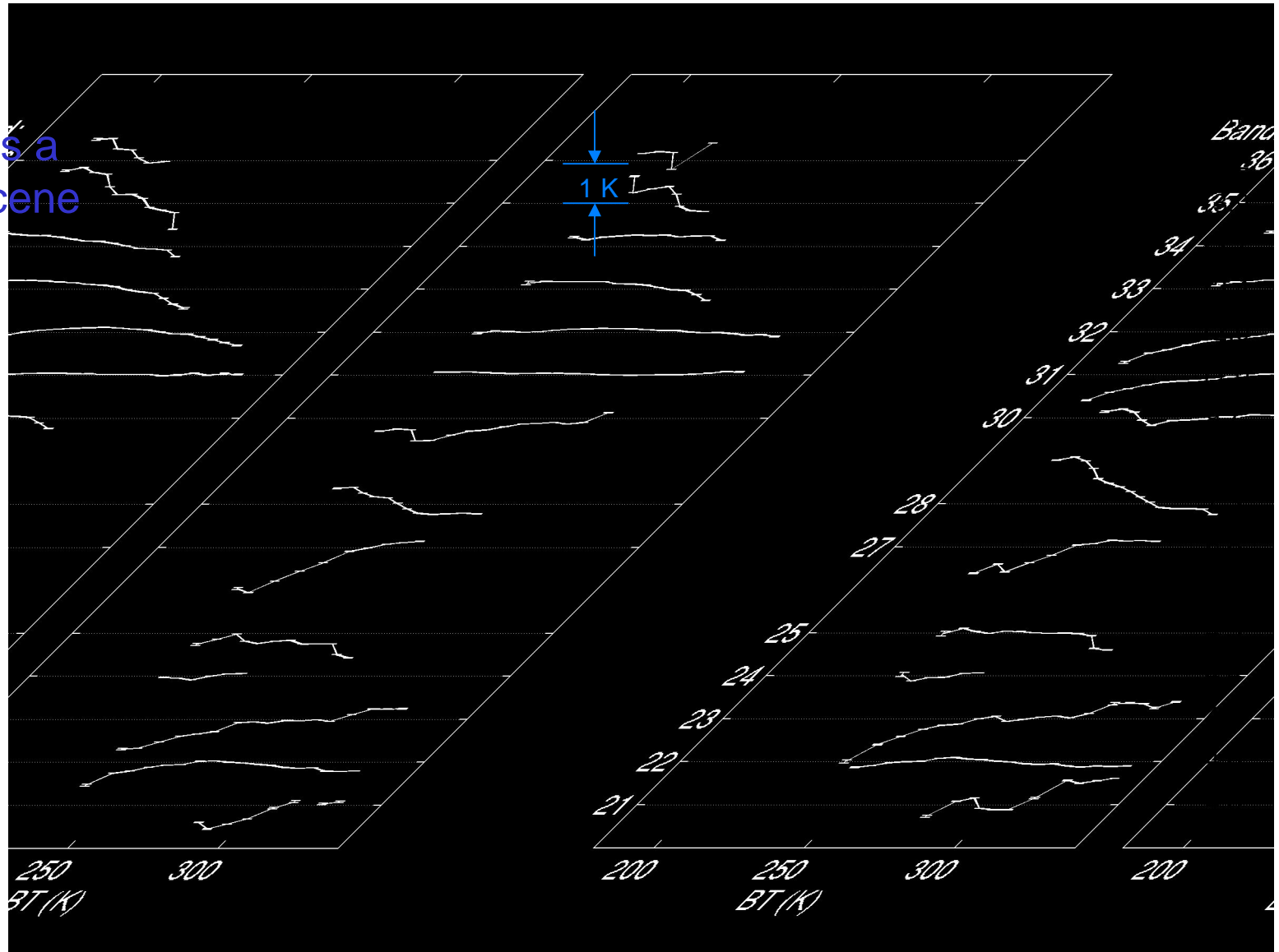


The 1 km MODIS is collocated with AIRS by representing the AIRS FOVs as slightly oversized circular footprints, and computing the mean MODIS value within those footprints for each band.

Spatially uniform scenes are selected by requiring the standard deviation of the MODIS data within each AIRS footprint to be 0.2K or less.

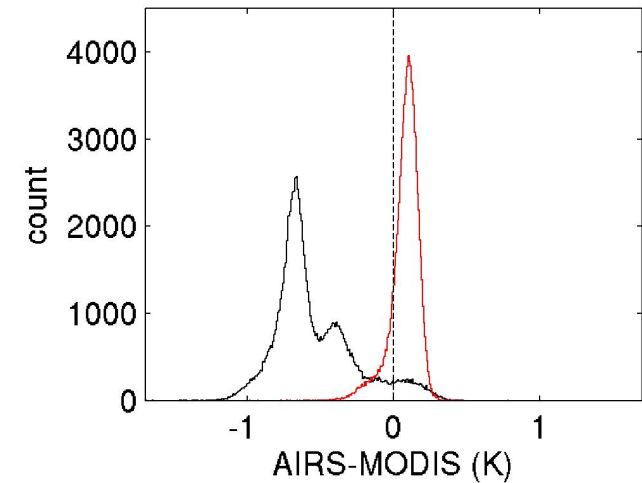
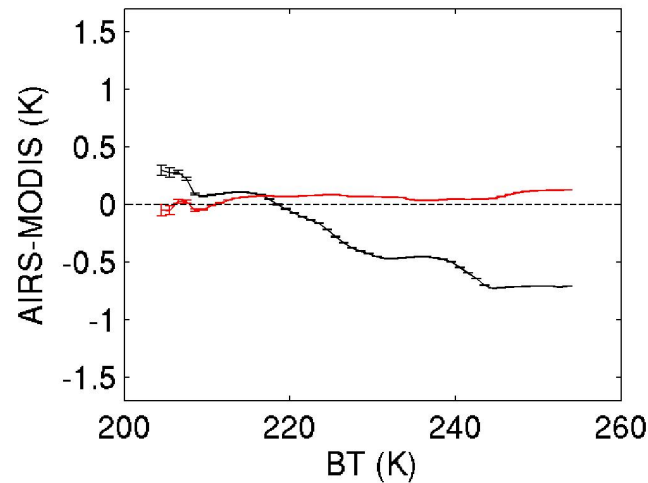
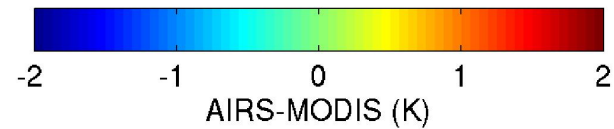
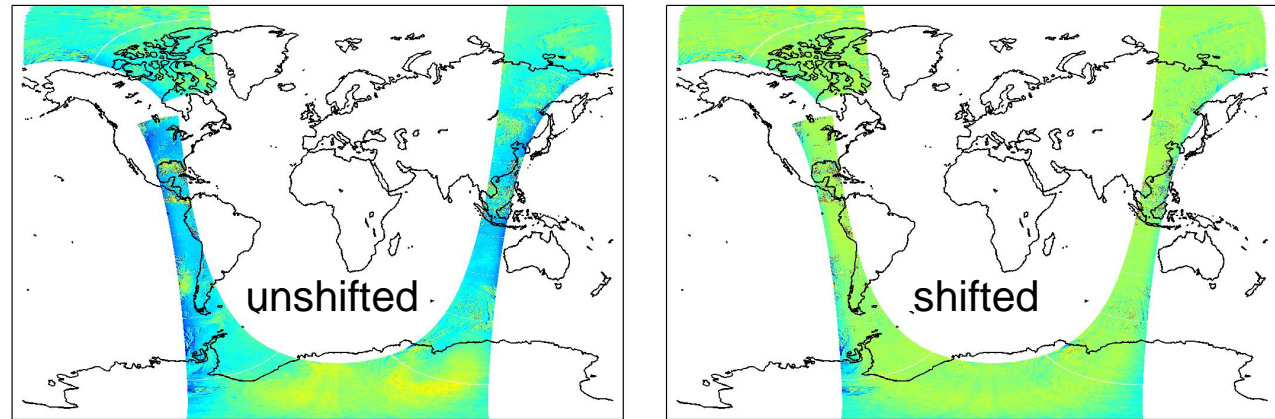


Brightness temperature differences as a function of scene temperature.

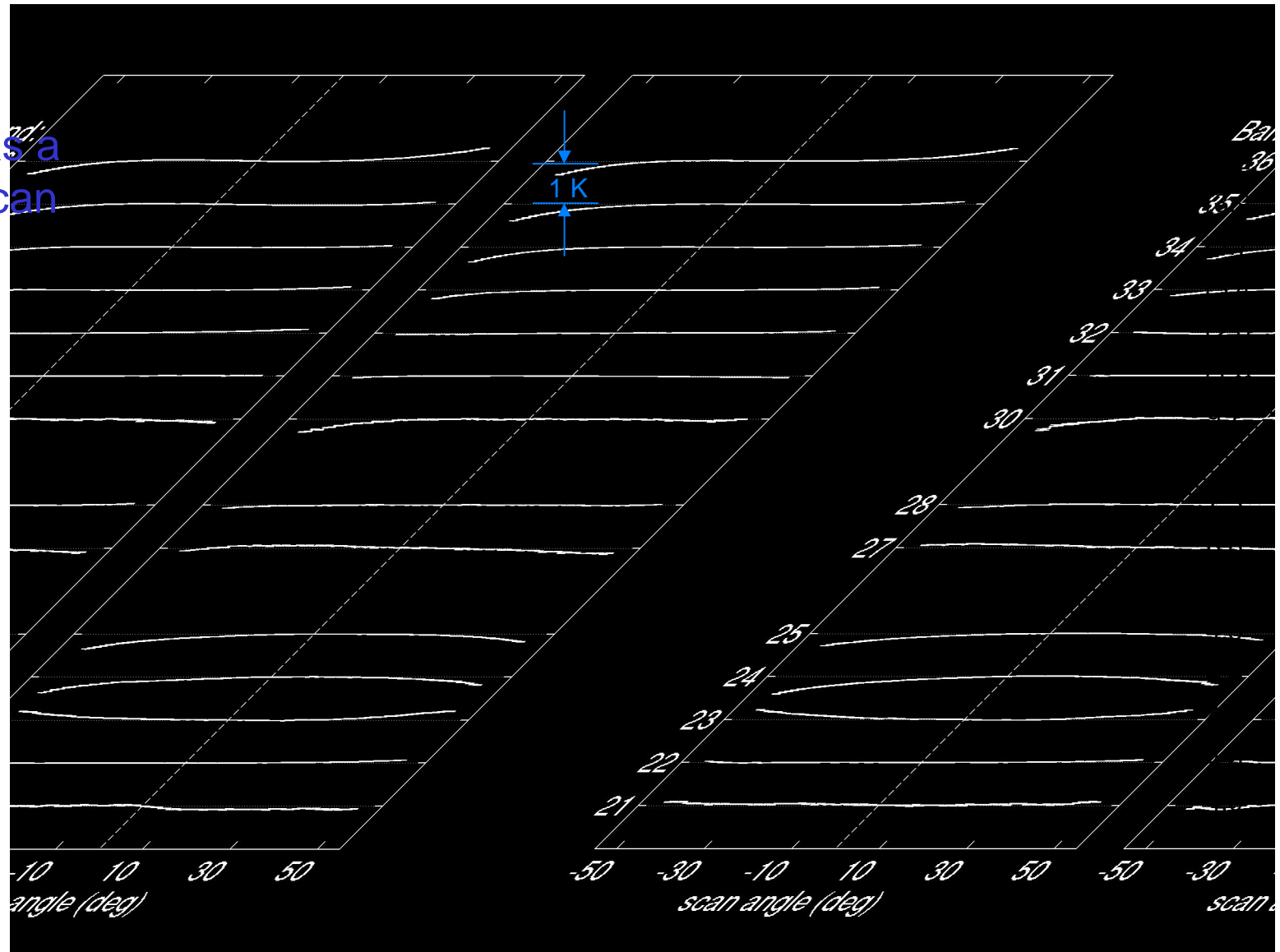


Q: What causes scene temperature dependence of bias??

Band 35 ( $13.9 \mu\text{m}$ )  
brightness temperature  
differences for one orbit  
of data on 6 Sept 2002  
using the nominal  
MODIS SRF (black) and  
using the MODIS SRF  
shifted by  $+0.8 \text{ cm}^{-1}$   
(red).



Brightness temperature differences as a function of scan angle.



# SWIR 5um Leak Correction: Terra Aside 2

- Terra MODIS Aside 2 nighttime B26 data reveals artifacts of thermal band features even after the 5um thermal leak correction has been applied in L1B. Aqua MODIS shows practically no features.
- Up to 1% (of  $L_{typ}$ ) effect in Terra MODIS B26.
- What about other Terra SWIR bands (B5-7)?  
We don't have routine nighttime data to inspect.

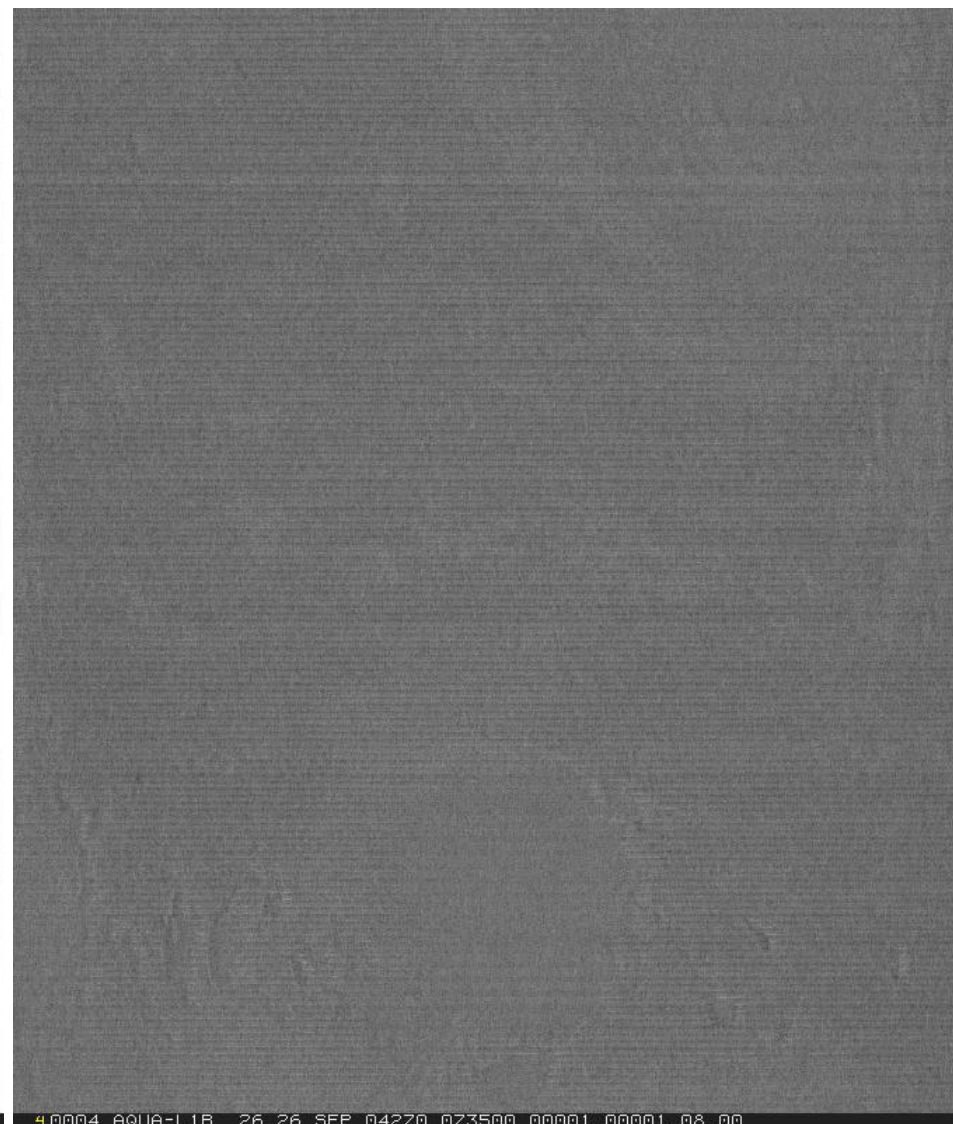
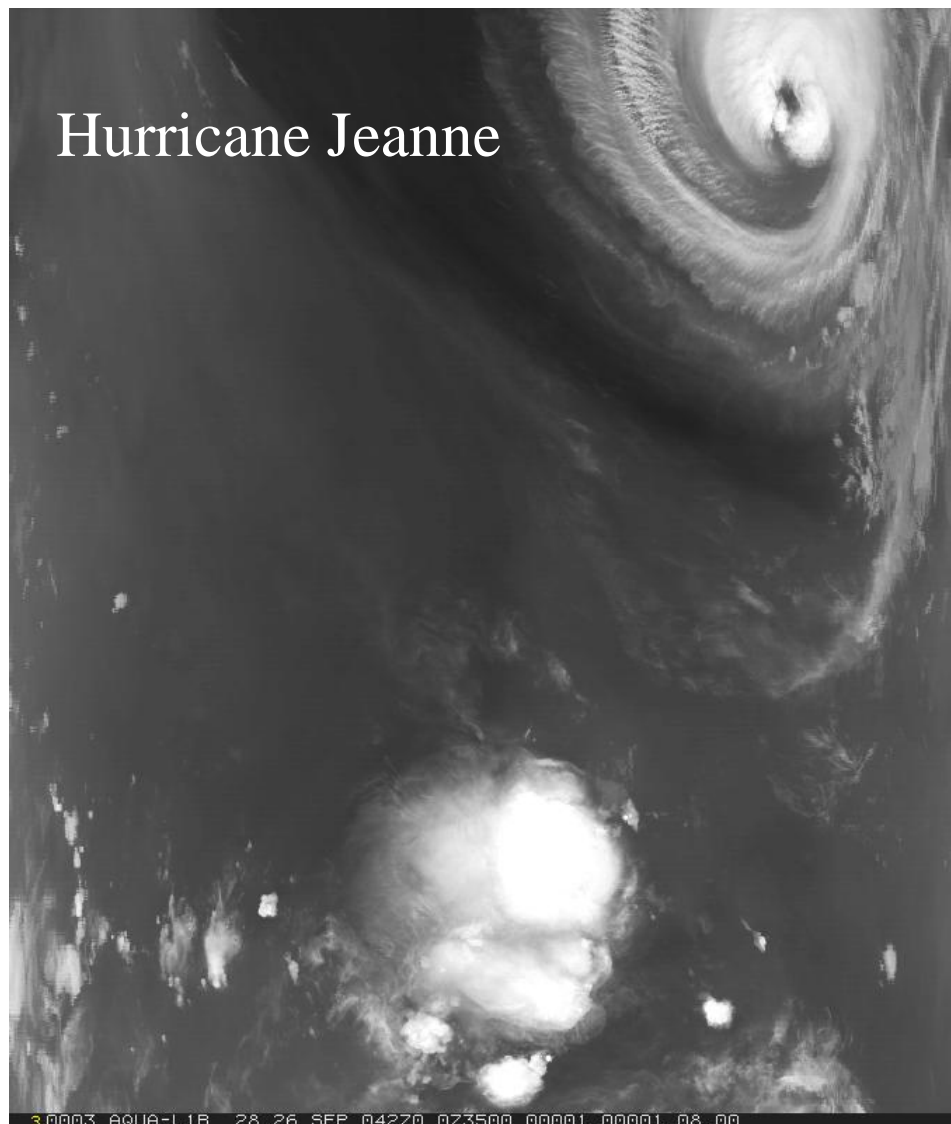
# Aqua MODIS

Day 04270

0735 UTC

7.3 um

1.38 um



3 0003 AQUA-L1B 28 26 SEP 04270 073500 00001 00001 08.00

4 0004 AQUA-L1B 26 26 SEP 04270 073500 00001 00001 08.00

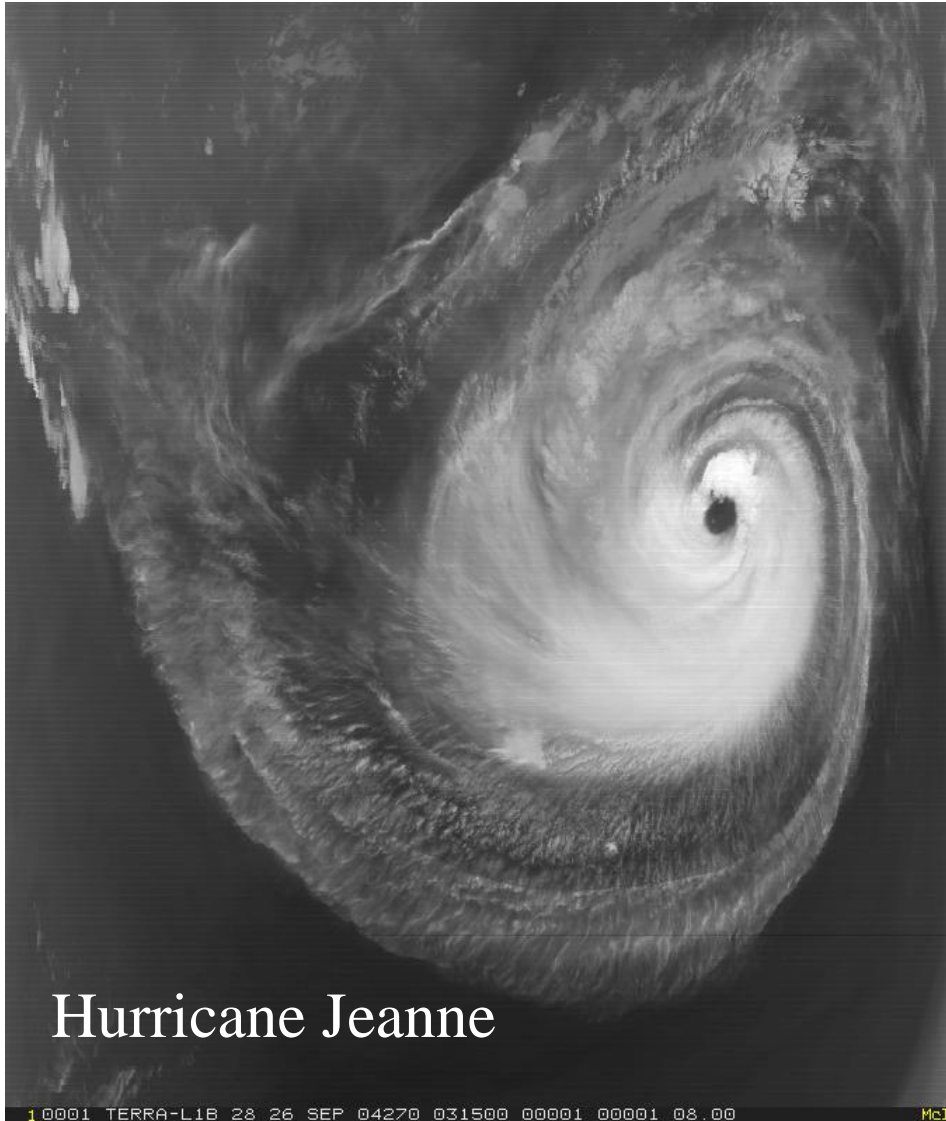
# TerraMODIS

Day 04270

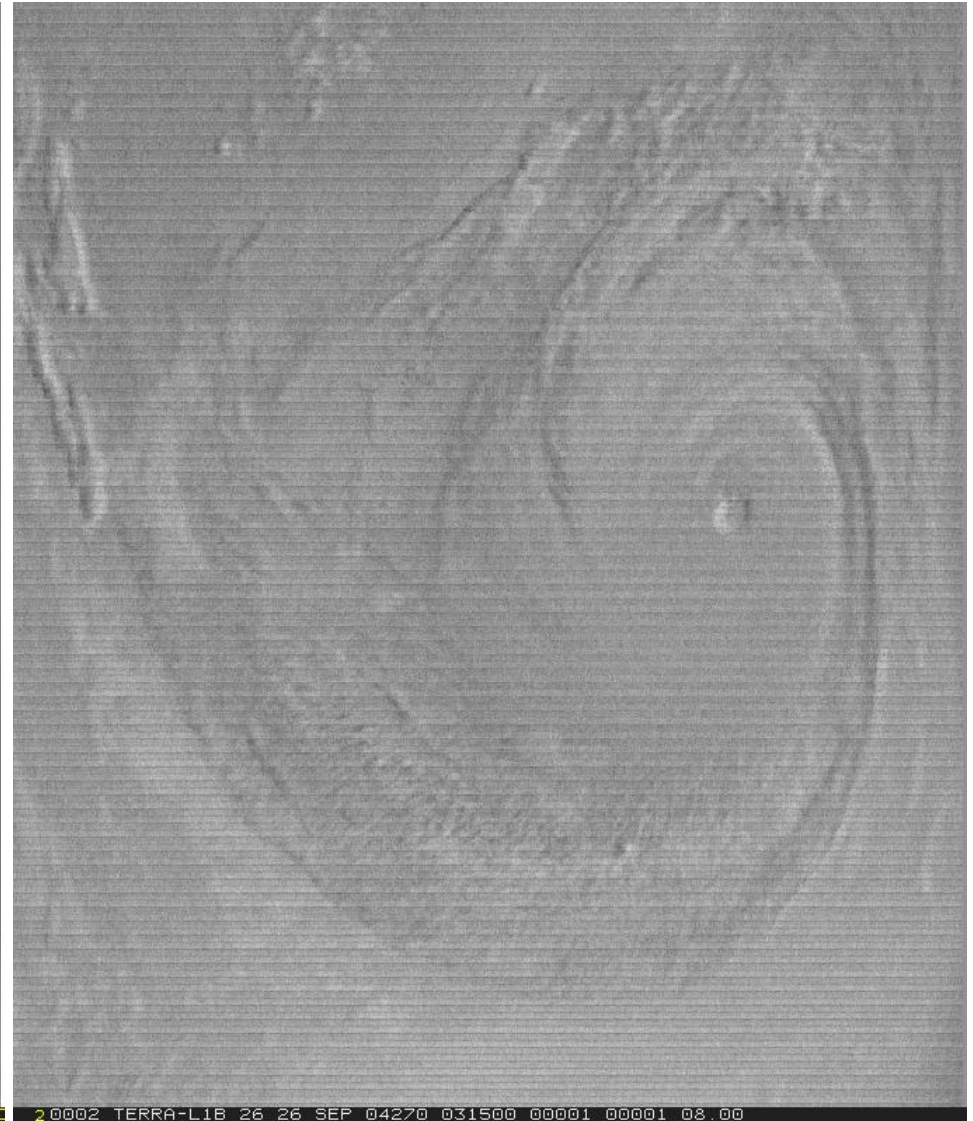
0315 UTC

7.3 um

1.38 um



Hurricane Jeanne



1 0001 TERRA-L18 28 26 SEP 04270 031500 00001 00001 08.00

McIT

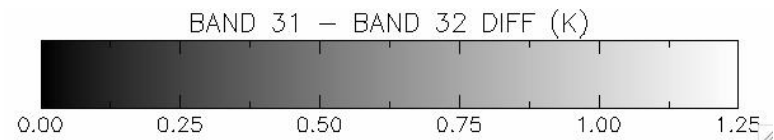
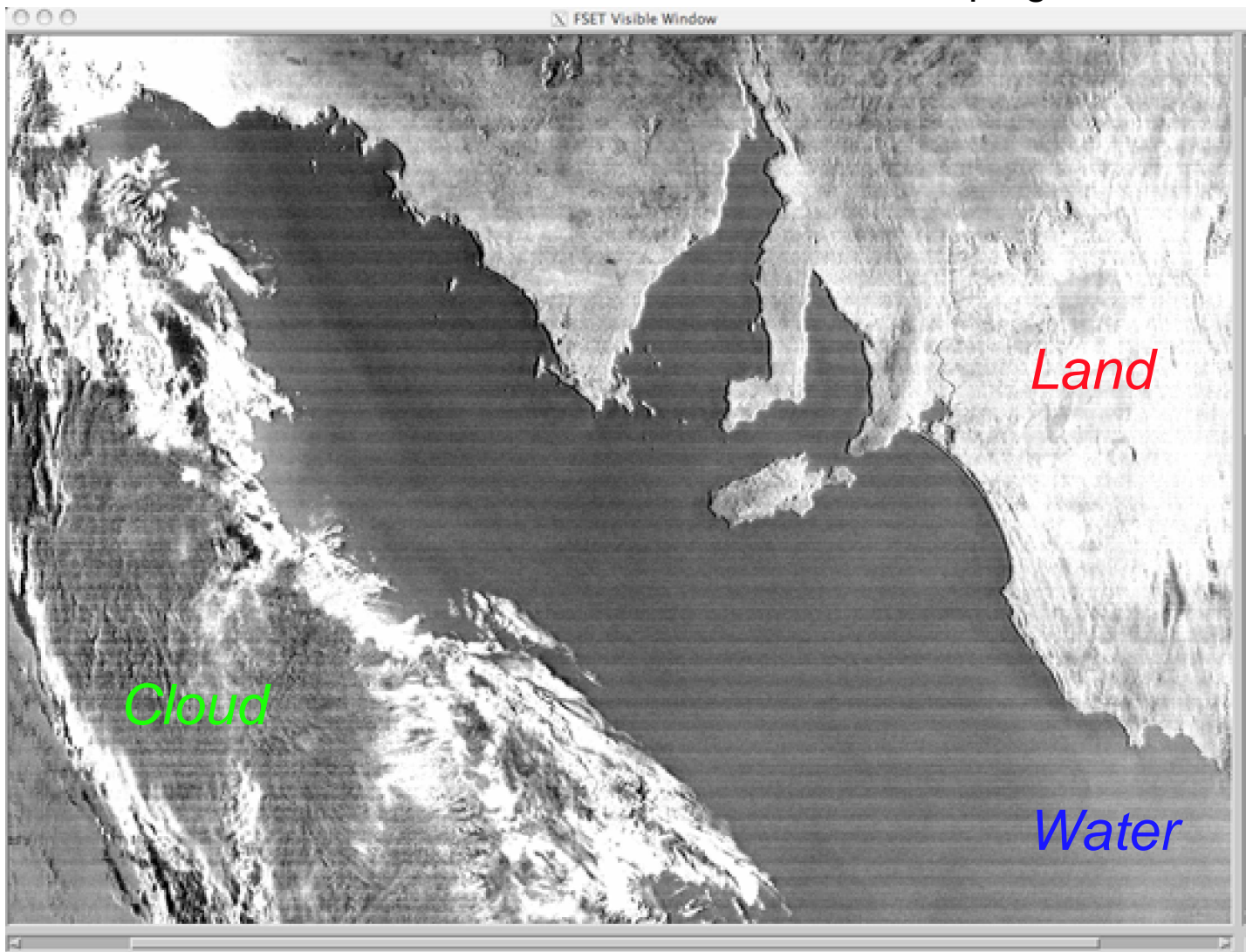
2 0002 TERRA-L18 26 26 SEP 04270 031500 00001 00001 08.00

# MODIS Emissive Band Destriping Update: Granule vs. Global Analysis

- The Atmosphere Group products for collection 5 include destriping of all emissive bands (20-25, 27-36) and band 26.
- The destriping algorithm is granule-based, and for a small percentage of granules, the impact may be equivocal in bands 31 and 32. Granules with sharp transitions between warm and cool scenes (e.g. hot land, cool ocean) may have artifacts in the scene transition zone.
- We analyzed a complete day of data (Terra MODIS 2000337, collection 5) to develop the destriping LUT for bands 31 and 32, with the expectation that sampling a wider range of scenes would remove the artifacts.

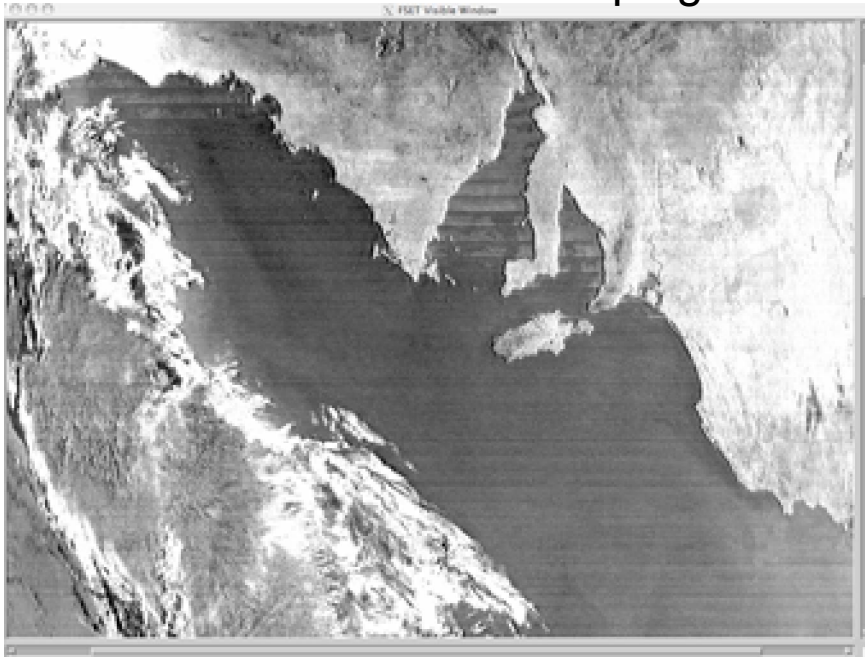


Terra MODIS 2000337 0115 UTC (South Australia)  
Band 31 - Band 32 Difference, No Destriping

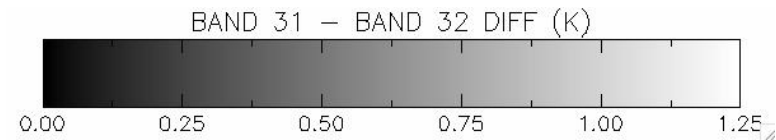
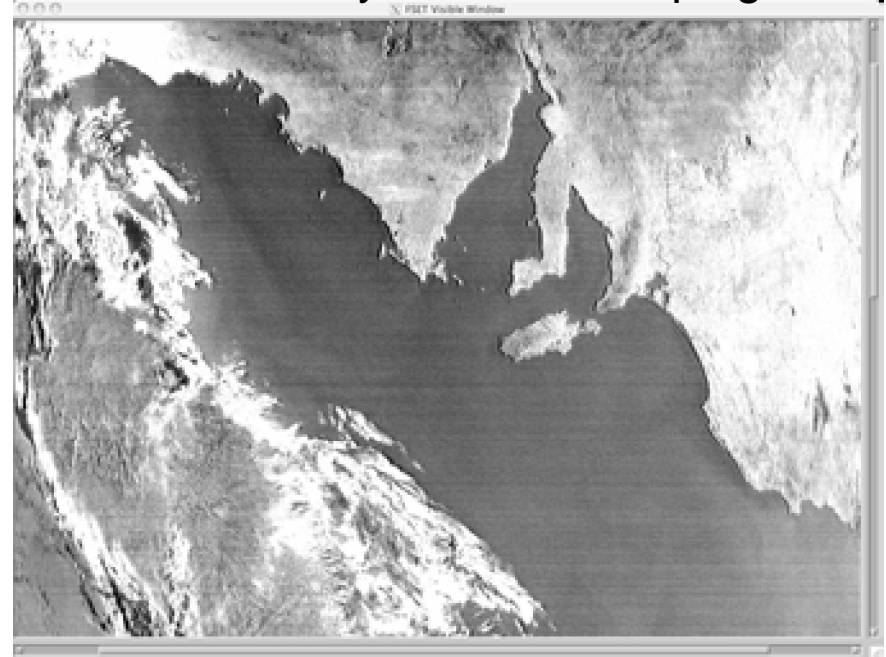


# Band 31 - Band 32 Difference, Granule-Based Destriping

## Granule-Based Destriping

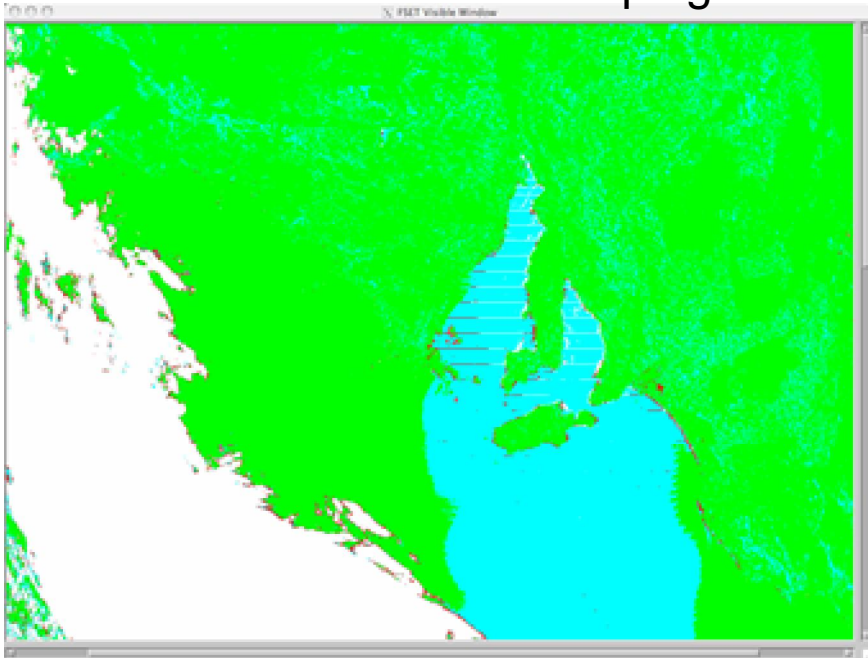


## Global Daily-Based Destriping

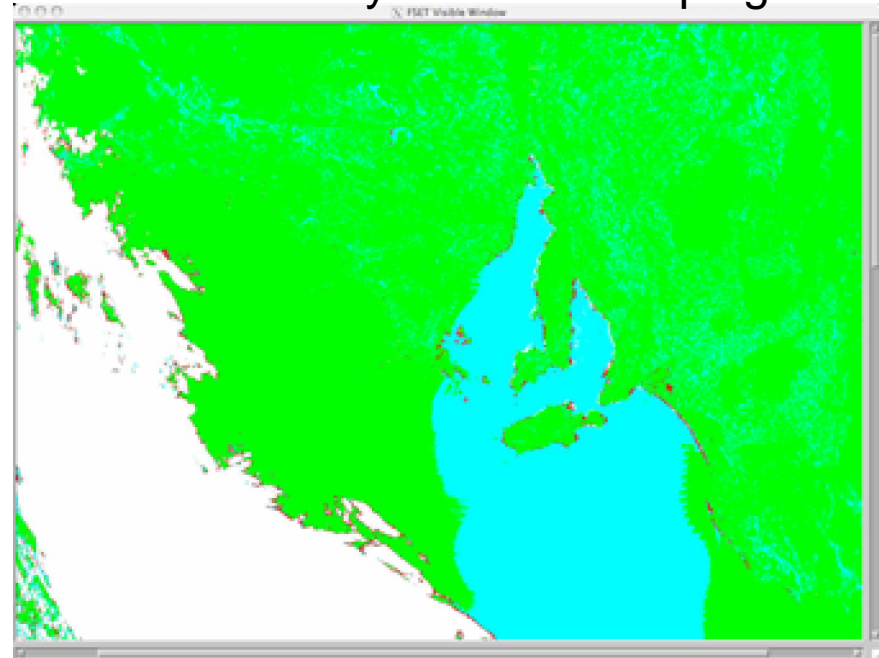


# Cloud Mask Final Result

## Granule-Based Destriping



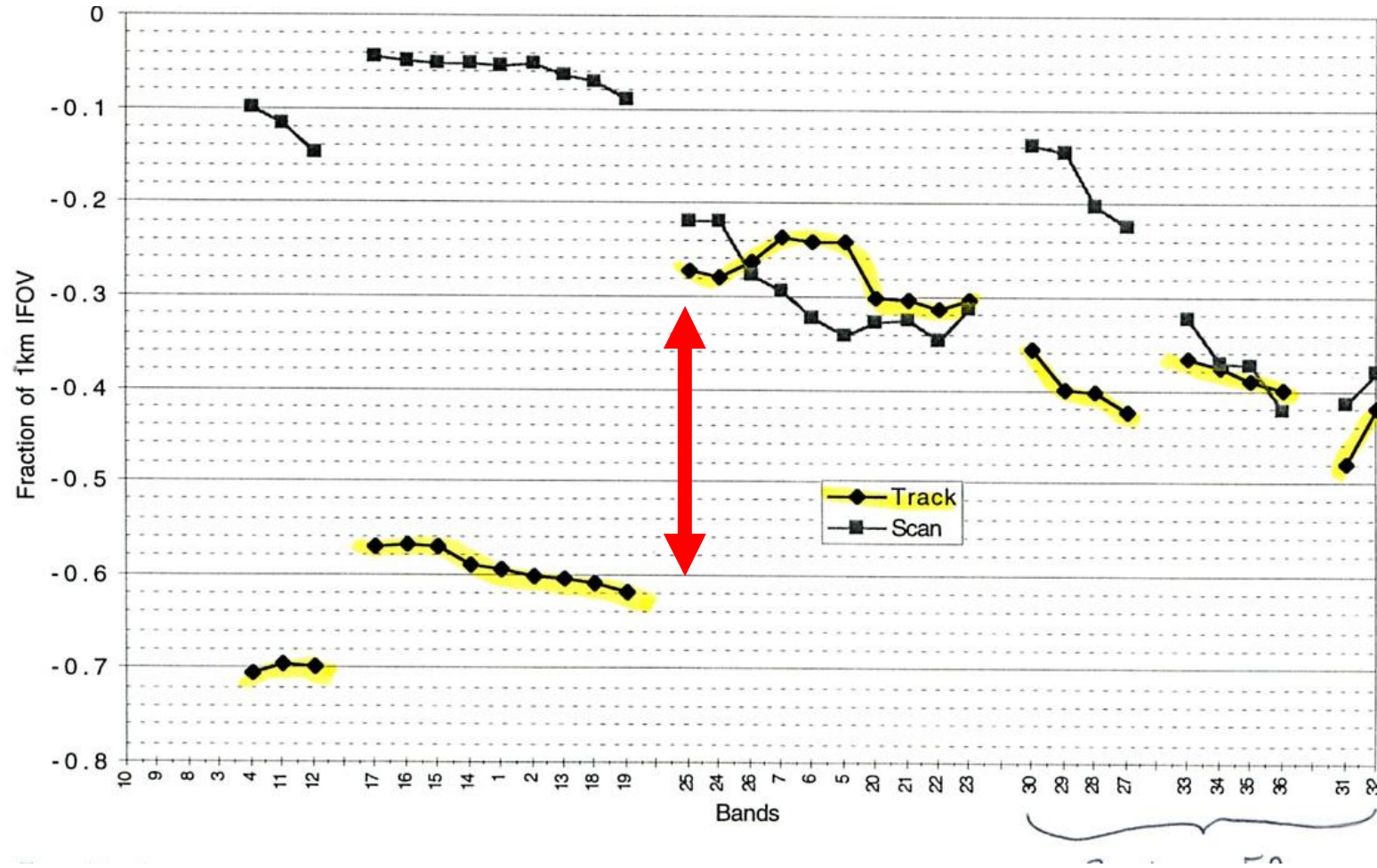
## Global Daily-Based Destriping



# Aqua MODIS Band-to-Band registration reminder

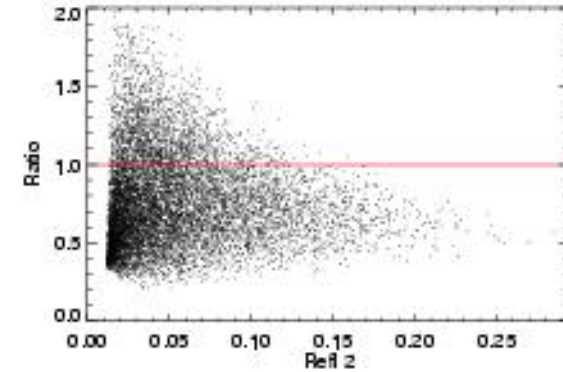
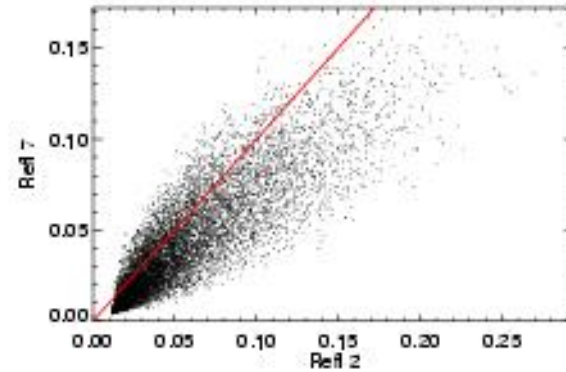
- Effective particle radius retrievals using NIR and SWIR bands show unexpected results.
- A known band-to-band misregistration is addressed to sample impact on results.

# AQUA MODIS Co-registration pre-launch

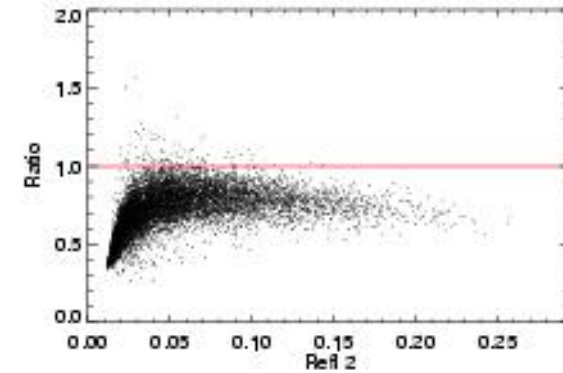
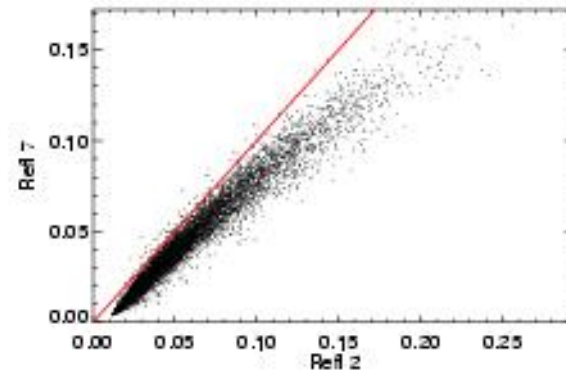


# Region 1: extremely inhomogeneous

**MODIS original**



**New**

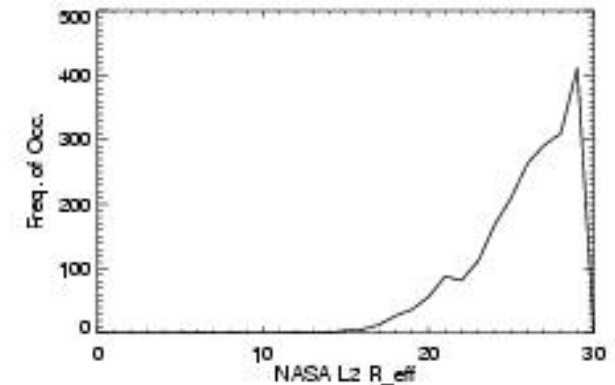
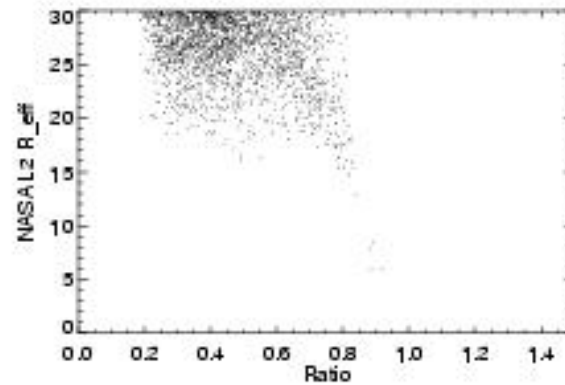
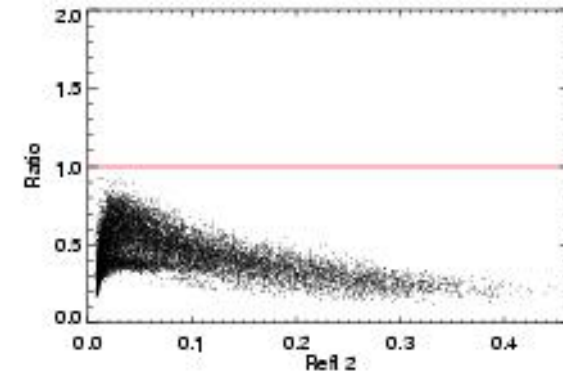
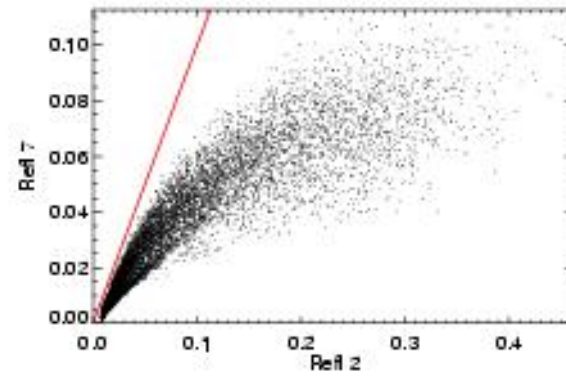
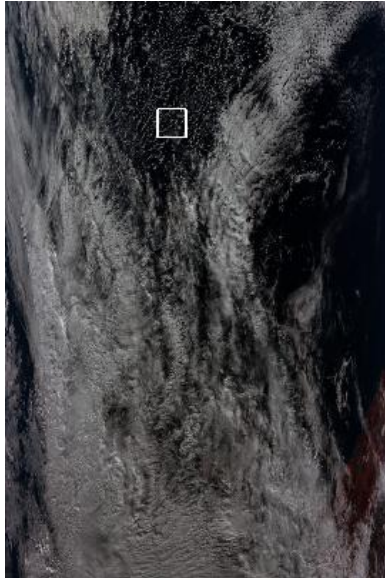


Ratios  $> 1$  (above red line) are considered aphysical

Courtesy Ralf Bennartz

# A short look at Terra MODIS (same day, roughly same area)

## MODIS Terra



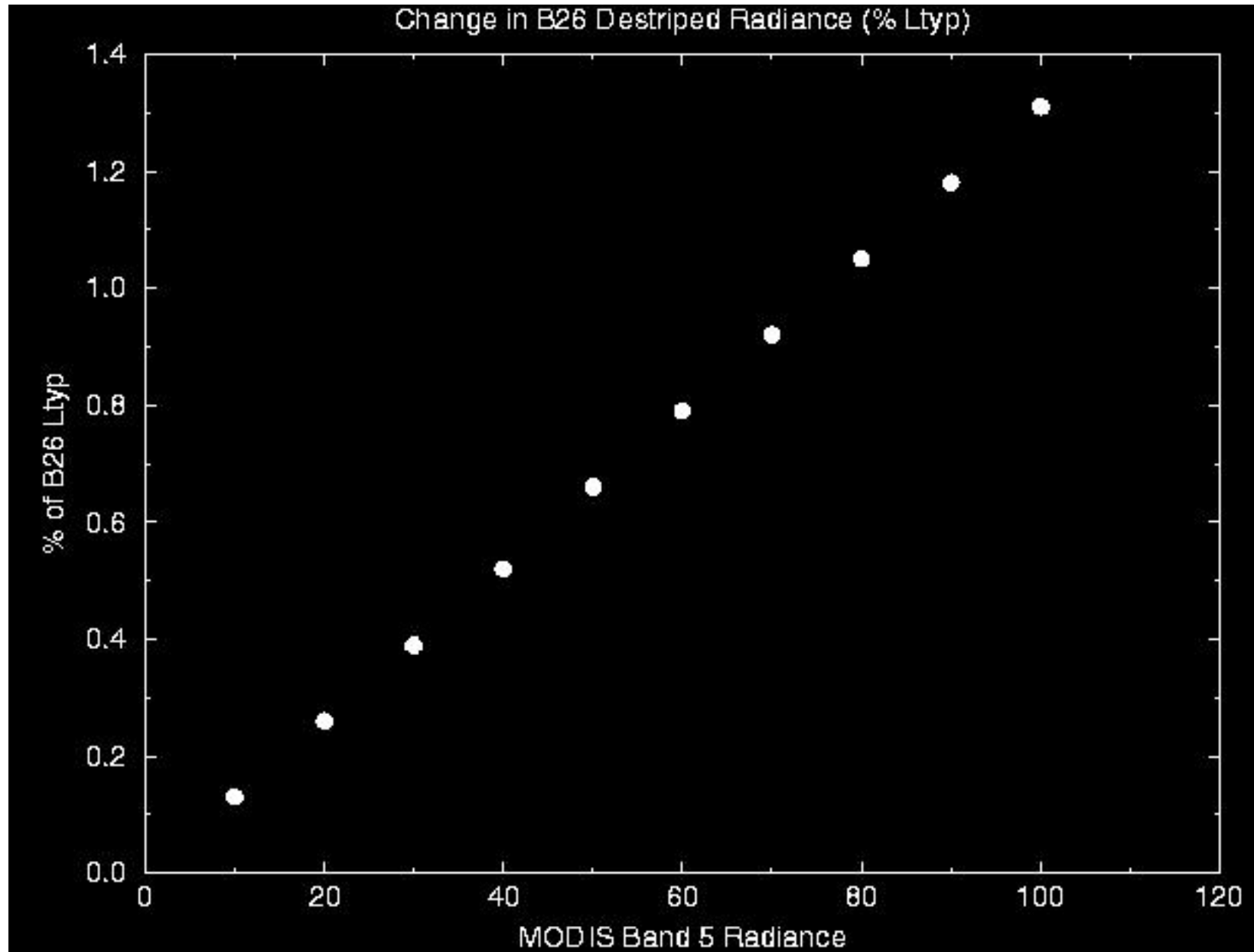
Courtesy Ralf Bennartz

# Terra MODIS Band 26 (1.38um) Destriping and OOB Correction

- Terra SWIR leak correction formulation changed for Collect 5. Now consistent with formulation used for Aqua.
- Small influence on Terra B26 destriping coefficients.



# Impact of Terra MODIS Collect 5 SWIR Correction Change



# Terra Band 26 destriping Correction: Changes from Collect 4 to Collect 5

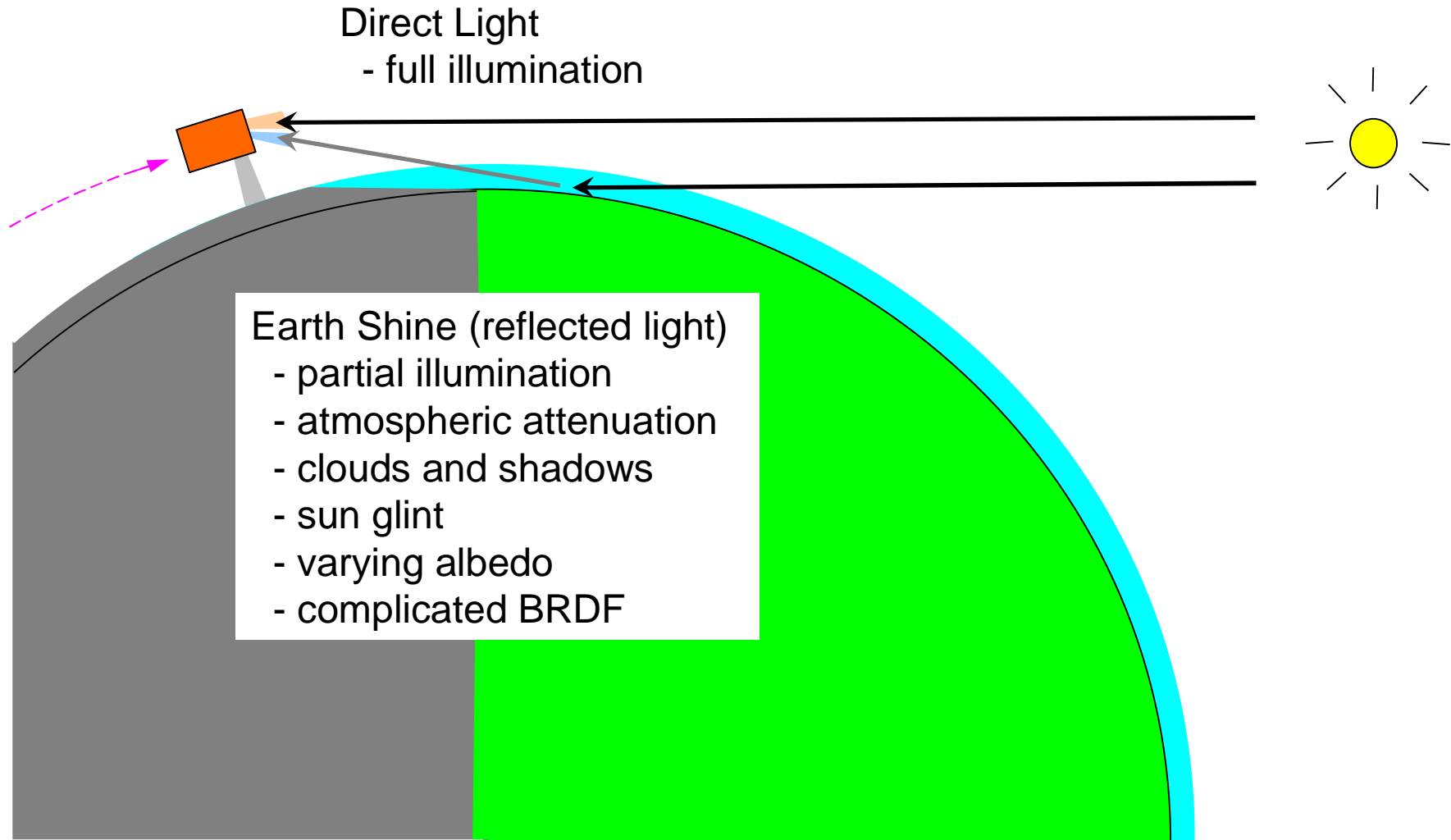
Det#	Correction Collect4	Coefficients Collect5	Radiance Collect4	Correction Collect5	Collect4-Collect5 Rad_Correction_Diff	% of B26 Ltyp
----	-----	-----	-----	-----	-----	-----
1	.0165	.0165	.5775	.5775	.0000	.00
2	.0120	.0117	.4200	.4095	.0105	.18
3	.0099	.0097	.3465	.3395	.0070	.12
4	.0093	.0090	.3255	.3150	.0105	.18
5	.0092	.0089	.3220	.3115	.0105	.18
6	.0118	.0112	.4130	.3920	.0210	.35
7	.0110	.0104	.3850	.3640	.0210	.35
8	.0136	.0133	.4760	.4655	.0105	.18
9	.0164	.0164	.5740	.5740	.0000	.00
10	.0260	.0261	.9100	.9135	-.0035	-.06

Aside2 results

# Earth Shine Influence on RSB

- Earth shine is impacting the Solar Diffuser (SD) calibrations at varying levels (dependent on earth scene conditions during SD views).
- Spectrally dependent. Scattering effect ( $\sim 0.2\%$ ) and specular effect (up to  $2\%$ )
- For Collect 5, a fitting function will be used within epochs to determine  $m_1$  values for each band. This will reduce any earth shine influence down to about  $0.1\%$  in L1B.

# Simplified Solar Diffuser Geometry





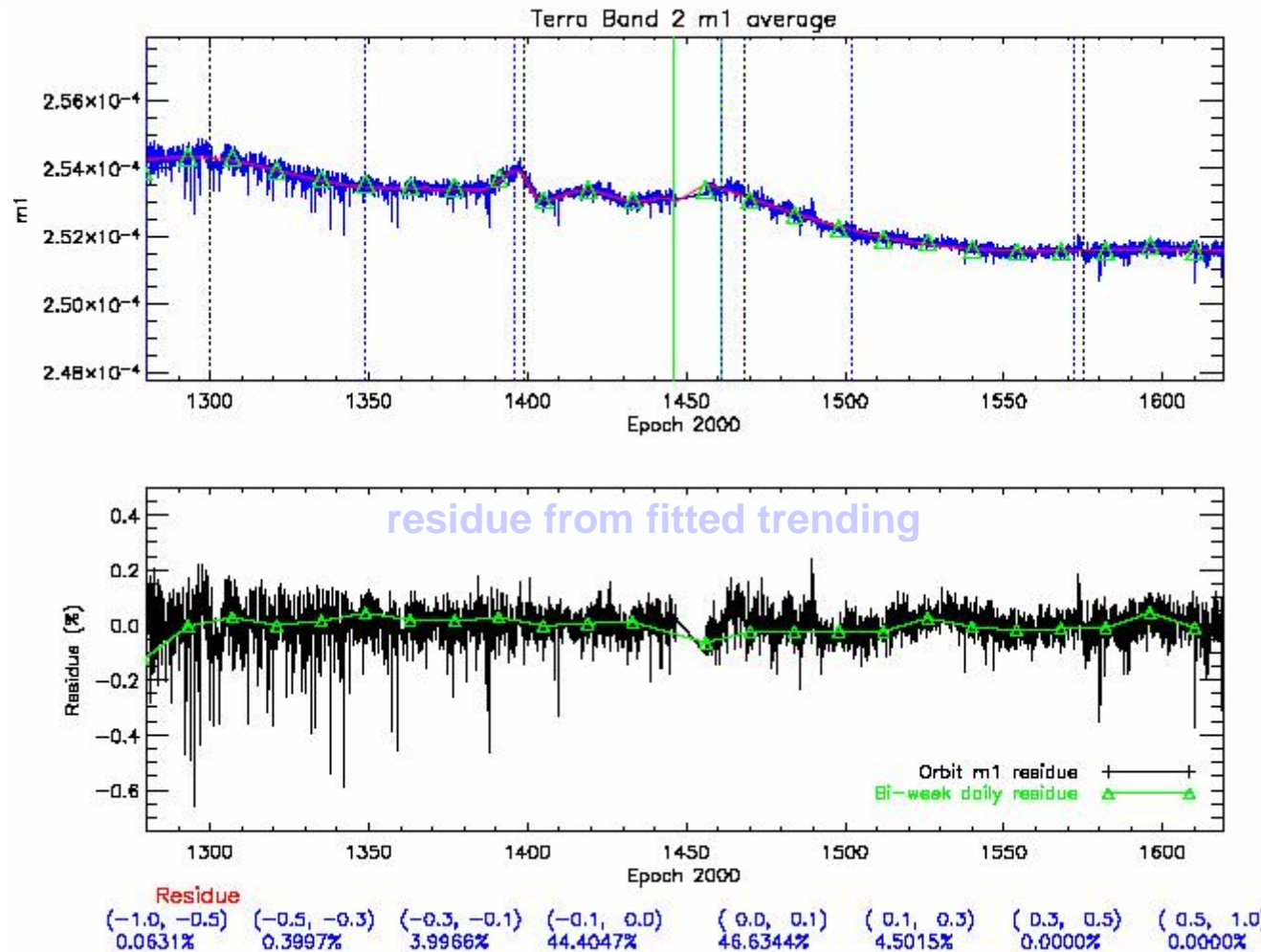
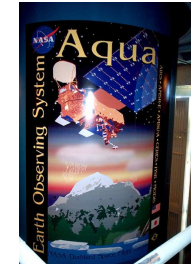
ISS007E10805

Frame 10805 Time: 10:17:01Z Nadir Sun El: -05

Pacific Ocean 07/21/2003 ISS007E 377 km Alt.



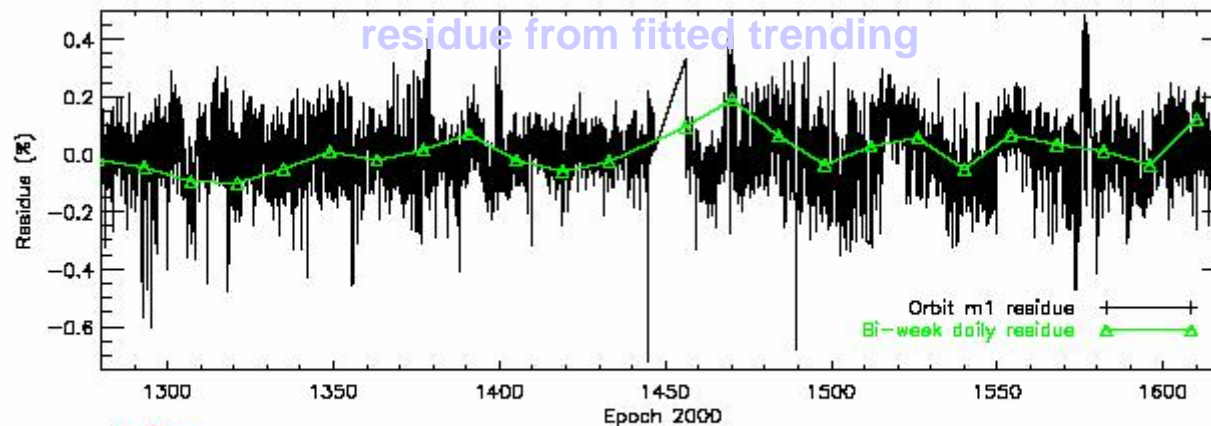
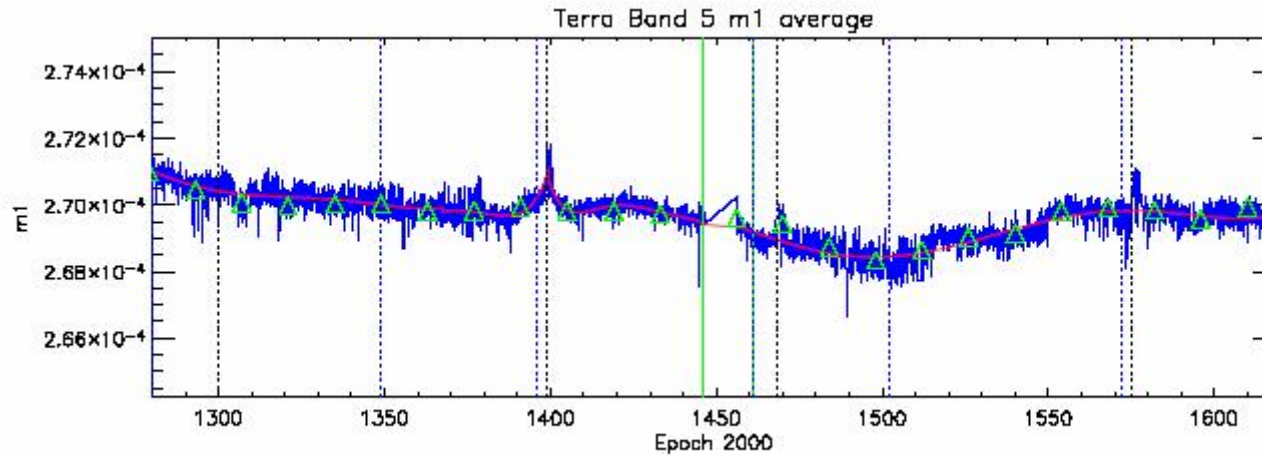
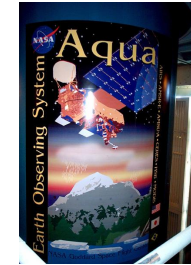
# Earthshine Impact on SD Calibration



Earthshine impact from SD aperture door is observed.  
 The variation of m1 due to Earthshine is reduced substantially in the MODIS L1B LUTs by using averaged m1 (green triangle).



# Earthshine Impact on SD Calibration



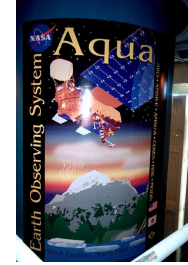
Worst Case

Residue	
(-1.0, -0.5)	0.2103%
(-0.5, -0.3)	1.0517%
(-0.3, -0.1)	16.4914%
(-0.1, 0.0)	31.8469%
(0.0, 0.1)	32.0151%
(0.1, 0.3)	17.5642%
(0.3, 0.5)	0.8204%
(0.5, 1.0)	0.0000%

Earthshine impact from SD aperture door is observed.  
 The variation of m1 due to Earthshine is reduced substantially in the MODIS L1B LUTs by using averaged m1 (green triangle).



# Earthshine Impact on SD Calibration

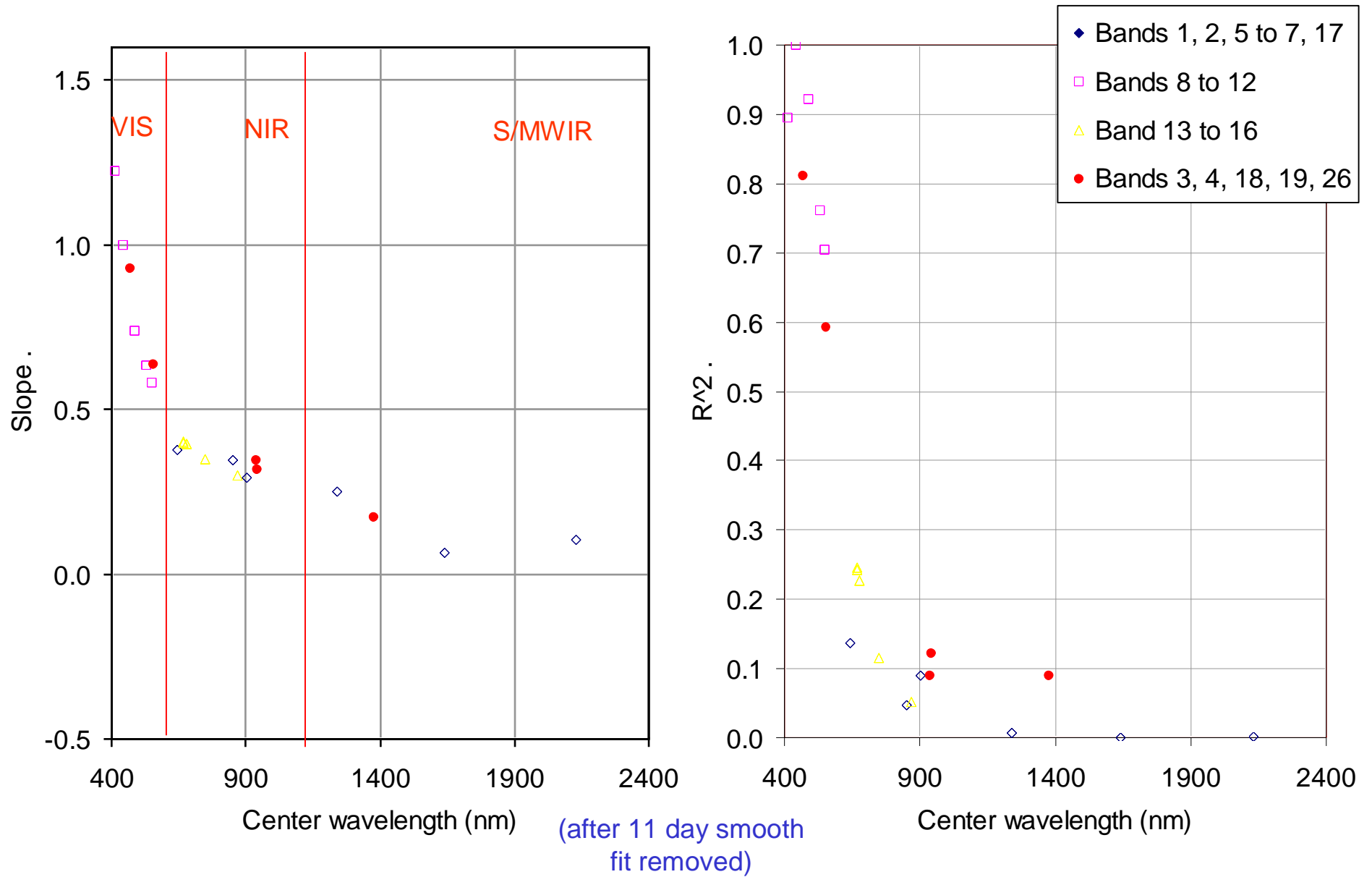


## Summary of Earthshine Impact from SD Aperture Door (all bands)

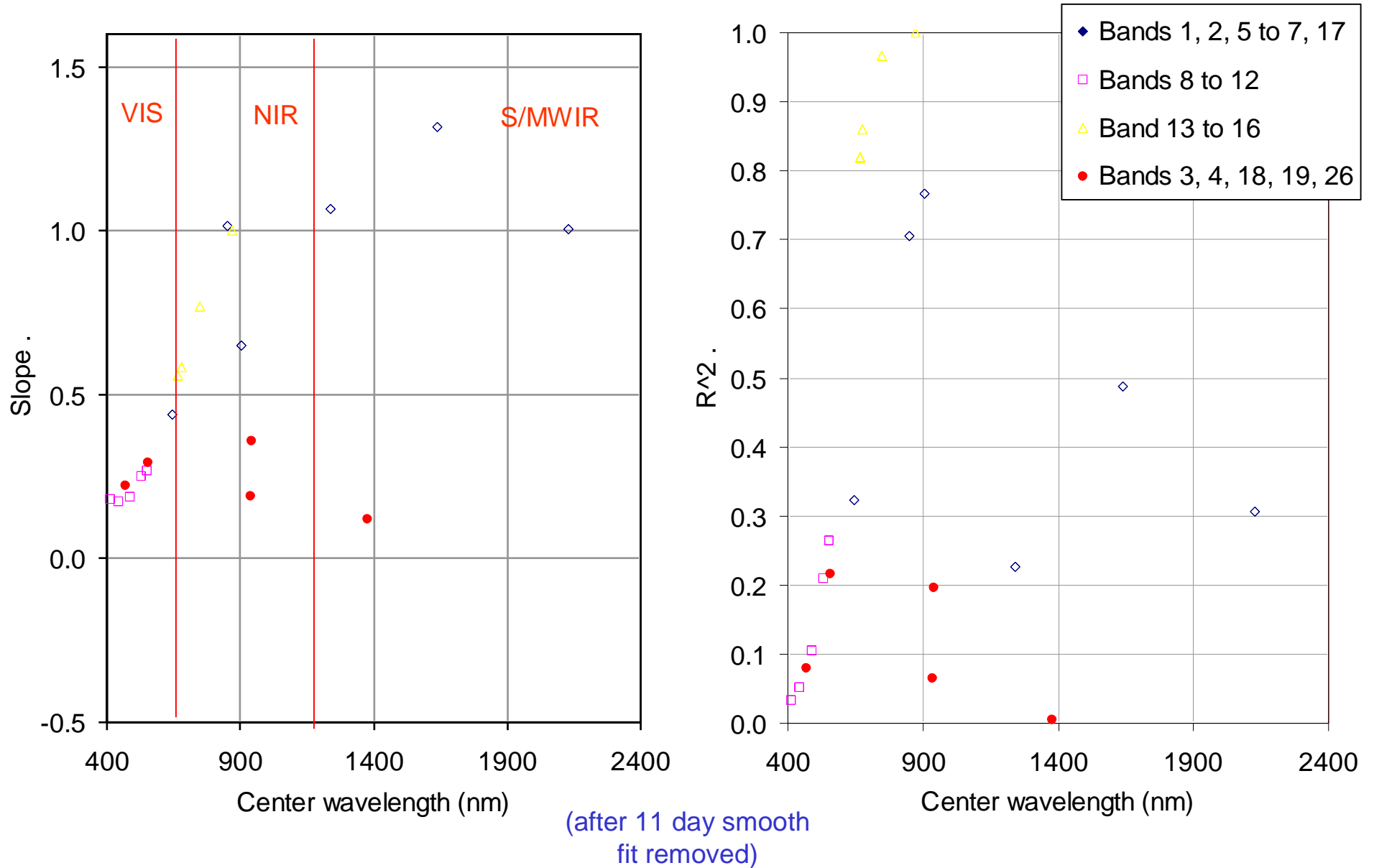
Band	<-1.0%	(-1.0%,-0.5%)	(-0.5%,-0.3%)	(-0.3%,-0.1%)	(-0.1%,0%)	(0%,0.1%)	(0.1%,0.3%)	(0.3%,0.5%)	(0.5%,1%)	>1.0%
1	0.00	0.00	0.00	1.45	48.09	49.16	1.30	0.00	0.00	0.00
2	0.00	0.06	0.40	4.00	44.40	46.63	4.50	0.00	0.00	0.00
3	0.00	0.00	0.00	4.29	45.60	46.23	3.87	0.00	0.00	0.00
4	0.00	0.00	0.00	1.94	47.77	49.37	0.93	0.00	0.00	0.00
5	0.00	0.21	1.05	1.05	31.85	32.02	17.56	0.82	0.00	0.00
6	0.00	0.23	0.67	0.67	37.67	39.38	12.24	0.08	0.00	0.00
7	0.00	0.17	0.69	0.69	34.62	38.30	13.71	0.06	0.00	0.00
8	0.00	0.00	0.17	7.26	42.09	43.44	7.05	0.00	0.00	0.00
9	0.00	0.00	0.00	3.32	47.92	44.55	4.21	0.00	0.00	0.00
10	0.00	0.00	0.00	1.09	49.45	48.23	1.22	0.00	0.00	0.00
11	0.00	0.00	0.00	0.65	49.94	48.72	0.69	0.00	0.00	0.00
12	0.00	0.00	0.00	0.55	50.72	48.06	0.67	0.00	0.00	0.00
13	0.00	0.00	0.00	1.09	47.18	51.39	0.34	0.00	0.00	0.00
13h	0.00	0.00	0.00	1.09	47.14	51.43	0.34	0.00	0.00	0.00
14	0.00	0.00	0.04	1.24	46.72	51.77	0.23	0.00	0.00	0.00
14h	0.00	0.00	0.04	1.24	46.72	51.77	0.23	0.00	0.00	0.00
15	0.00	0.00	0.15	1.96	44.01	53.43	0.46	0.00	0.00	0.00
16	0.00	0.06	0.38	2.71	40.70	55.28	0.86	0.00	0.00	0.00
17	0.00	0.00	0.06	1.47	46.07	51.68	0.72	0.00	0.00	0.00
18	0.00	0.00	0.00	1.68	45.71	52.02	0.59	0.00	0.00	0.00
19	0.00	0.00	0.04	2.36	46.32	49.98	1.30	0.00	0.00	0.00
26	0.00	0.06	0.25	12.33	34.85	40.96	11.40	0.15	0.00	0.00



# All bands vs. Band 9



# All bands vs. Band 16



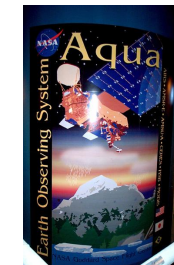
# MODIS Collect 5 Summary

- DSM RVS in place for Terra MODIS. Across track profiles and mirror side striping improved (exception for Bside epoch).
- Small ( $< 1\%$ ) influences on SWIR bands from 5.0 um leak correction changes for Terra. Some unresolved behavior in Aside 2.
- Earth shine influence on RSB well-handled in Collect 5 epoch using fitting functions. Probably some residual influence, hopefully  $< 0.2\%$
- Interesting findings in AIRS-MODIS L1B comparisons continue under review.

# Backup Slides



# MODIS Key Specifications



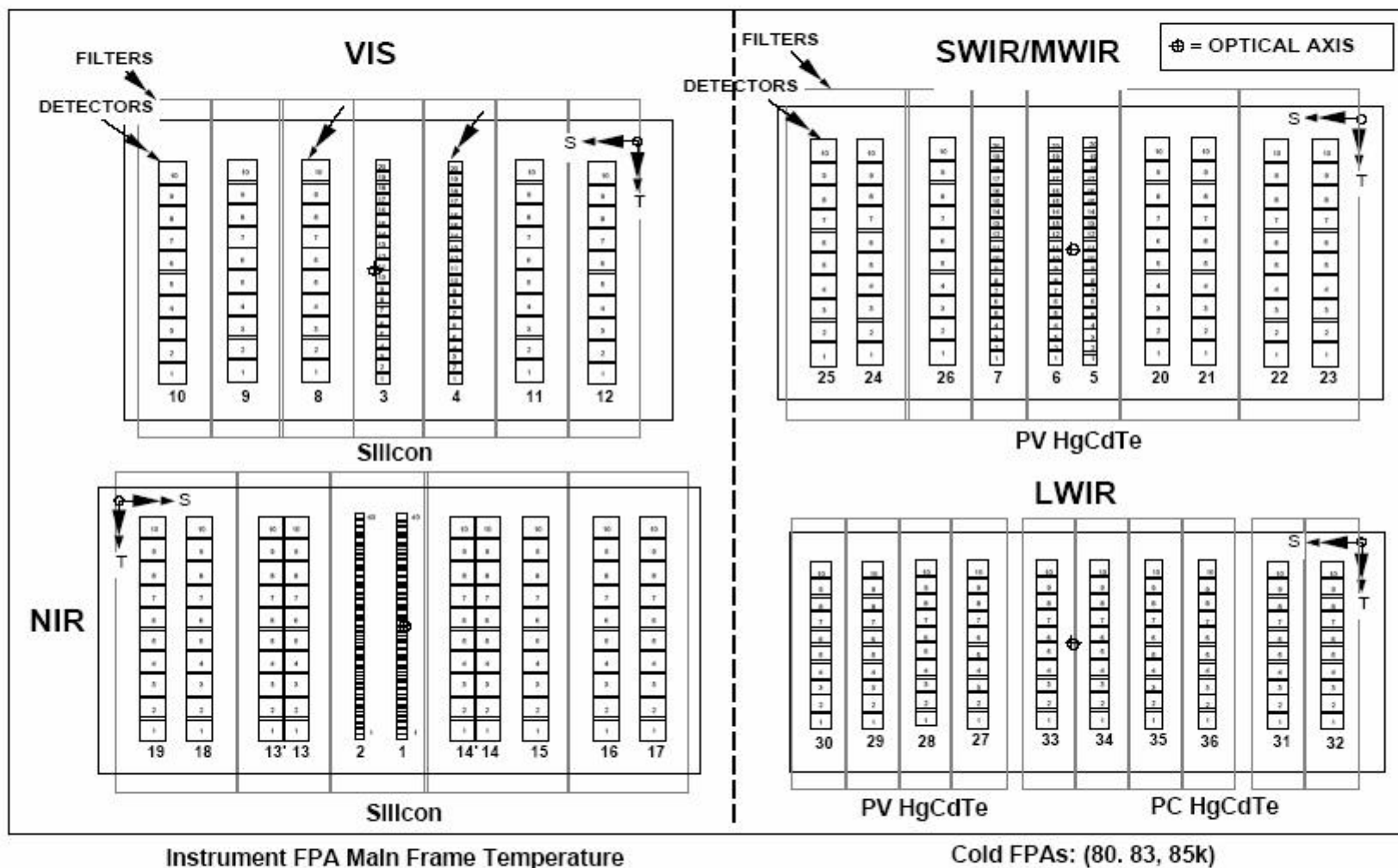
Primary Use	Band	Bandwidth <sup>1</sup>	Spectral Radiance <sup>2</sup>	Required SNR <sup>3</sup>	Primary Use	Band	Bandwidth <sup>1</sup>	Spectral Radiance <sup>2</sup>	Required NEΔT(K) <sup>4</sup>	
Land/Cloud/Aerosols Boundaries	1	620 - 670	21.8	128	Surface/Cloud Temperature	20	3.660 - 3.840	0.45 (300K)	0.05	
	2	841 - 876	24.7	201		21	3.929 - 3.989	2.38 (335K)	0.2	
Land/Cloud/Aerosols Properties	3	459 - 479	35.3	243		22	3.929 - 3.989	0.67 (300K)	0.07	
	4	545 - 565	29	228	23	4.020 - 4.080	0.79 (300K)	0.07		
	5	1230 - 1250	5.4	74	Atmospheric Temperature		24	4.433 - 4.498	0.17 (250K)	0.25
	6	1628 - 1652	7.3	275	25	4.482 - 4.549	0.59 (275K)	0.25		
	7	2105 - 2155	1	110	Cirrus Clouds Water Vapor		26	1.360 - 1.390	6	150 <sup>3</sup>
Ocean Color/ Phytoplankton/ Biogeochemistry	8	405 - 420	44.9	880	27	6.535 - 6.895	1.16 (240K)	0.25		
	9	438 - 448	41.9	838	28	7.175 - 7.475	2.18 (250K)	0.25		
	10	483 - 493	32.1	802	Cloud Properties		29	8.400 - 8.700	9.58 (300K)	0.05
	11	526 - 536	27.9	754	Ozone		30	9.580 - 9.880	3.69 (250K)	0.25
	12	546 - 556	21	750	Surface/Cloud Temperature		31	10.780 - 11.280	9.55 (300K)	0.05
	13	662 - 672	9.5	910	32	11.770 - 12.270	8.94 (300K)	0.05		
	14	673 - 683	8.7	1087	Cloud Top Altitude		33	13.185 - 13.485	4.52 (260K)	0.25
	15	743 - 753	10.2	586	34	13.485 - 13.785	3.76 (250K)	0.25		
	16	862 - 877	6.2	516	35	13.785 - 14.085	3.11 (240K)	0.25		
Atmospheric Water Vapor	17	890 - 920	10	167	36	14.085 - 14.385	2.08 (220K)	0.35		
	18	931 - 941	3.6	57	<sup>1</sup> Bands 1 to 19 are in nm; Bands 20 to 36 are in μm <sup>2</sup> Spectral Radiance values are (W/m <sup>2</sup> -μm-sr) <sup>3</sup> SNR = Signal-to-noise ratio <sup>4</sup> NEΔT = Noise-equivalent temperature difference					
	19	915 - 965	15	250						



# Instrument Overview



## MODIS Four Focal Planes



S: scan direction; T: track direction

B13 and B14 have 2 columns of detectors for TDI high and low gain output

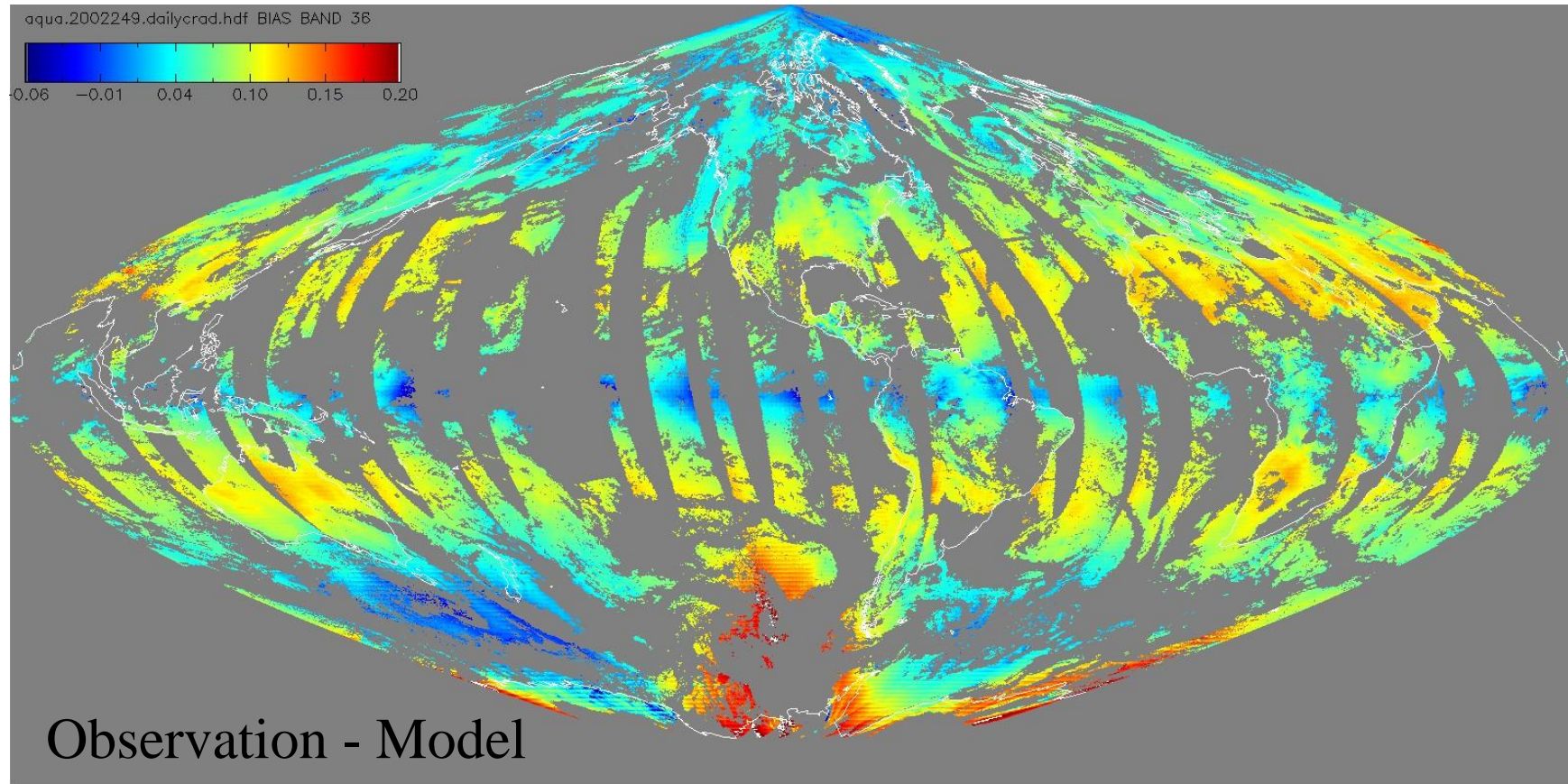


## Operational Configurations (Terra MODIS)



Date	Events	Description
Dec 18, 1999	Launch	Launched successfully
Feb 13, 2000	Science Mode	MODIS started science mode on A-side
Feb 24, 2000	Nadir Door Open	Terra MODIS First Light
June 2000	CFPA Lost Control	Ice began to cover radiative cooler surface
Aug 5, 2000	Formatter Anomaly	MODIS entered standby mode then safe mode
Aug 8, 2000	Outgas	Turned on outgas heater for two days (Back to science mode on Aug 19)
Oct 30, 2000	B-side Electronics	Transitioned to science mode on B-side
Jun 15, 2001	PS2 Anomaly	Powered supply 2 (B-side) off passing SAA
Jul 2, 2001	A-side Electronics	Returned to science mode on A-side with PS1
Mar 19, 2002	S/C Safe Hold	Anomaly during inclination maneuver (Back to science mode on Mar 23)
Sep 17, 2002	Formatter B	On A-side but cross-strapped to Formatter B
May 6, 2003	SD Door Failure	Set the SD open with screen down on July 2
Sep 24, 2003	SSR Anomaly	Science recording shuts down and is re-enabled
Nov 30, 2003	Formatter Anomaly	SFE reports Sync errors
Dec 16, 2003	ACE-B Anomaly	Anomaly due to Attitude Control Electronics (Back to science mode on Dec 22. Nadir door opened on Dec 24.
Jan 15, 2004	SFE Recycled	SFE Side-A was recycled
Feb 18, 2004	SFE Anomaly	SFE autonomously shuts down while passing through the SAA. Turned back on the same day

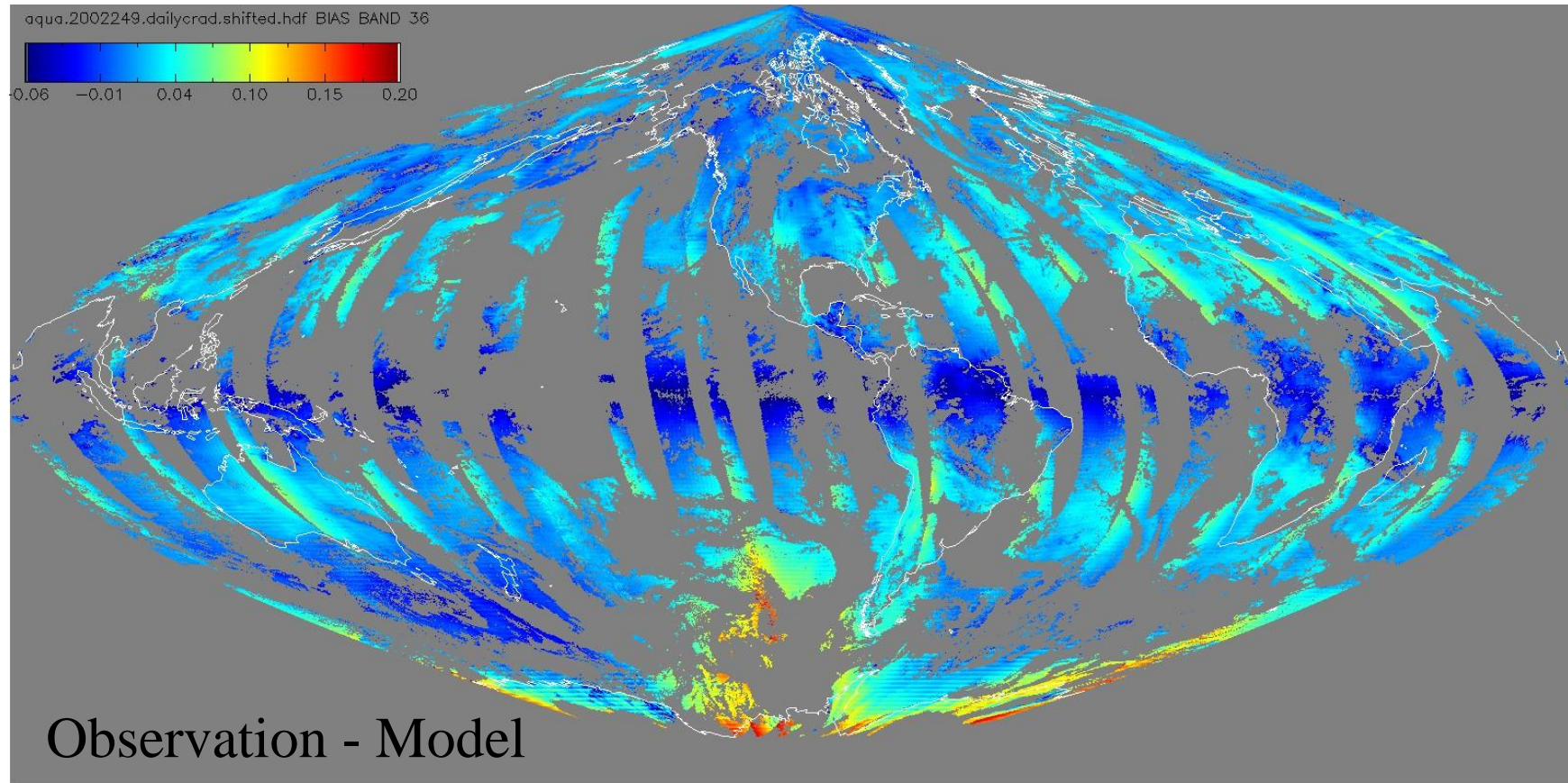
# Aqua MODIS Clear Sky Radiance Bias: Band 36



Before spectral shift



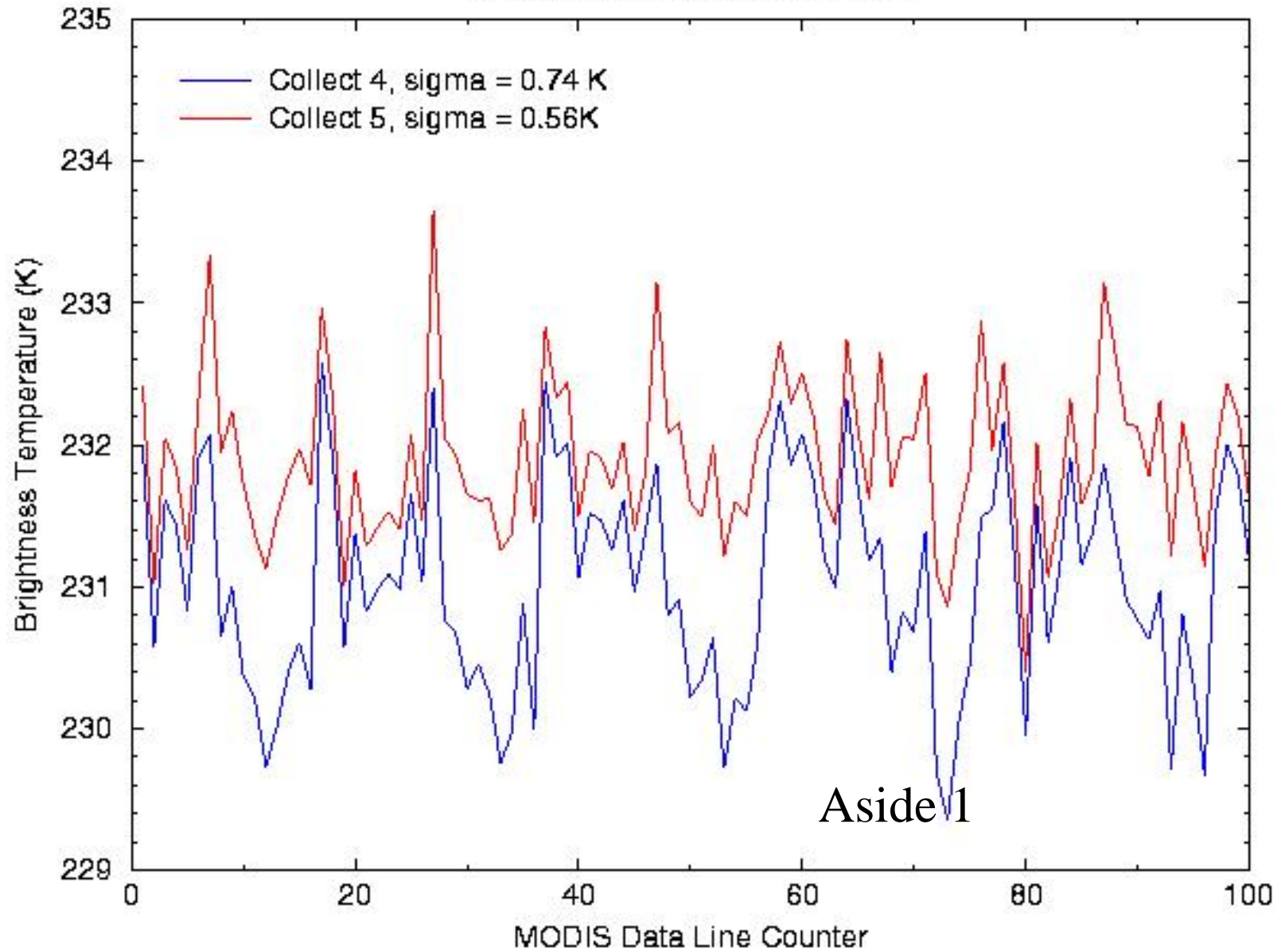
# Aqua MODIS Clear Sky Radiance Bias: Band 36



After spectral shift

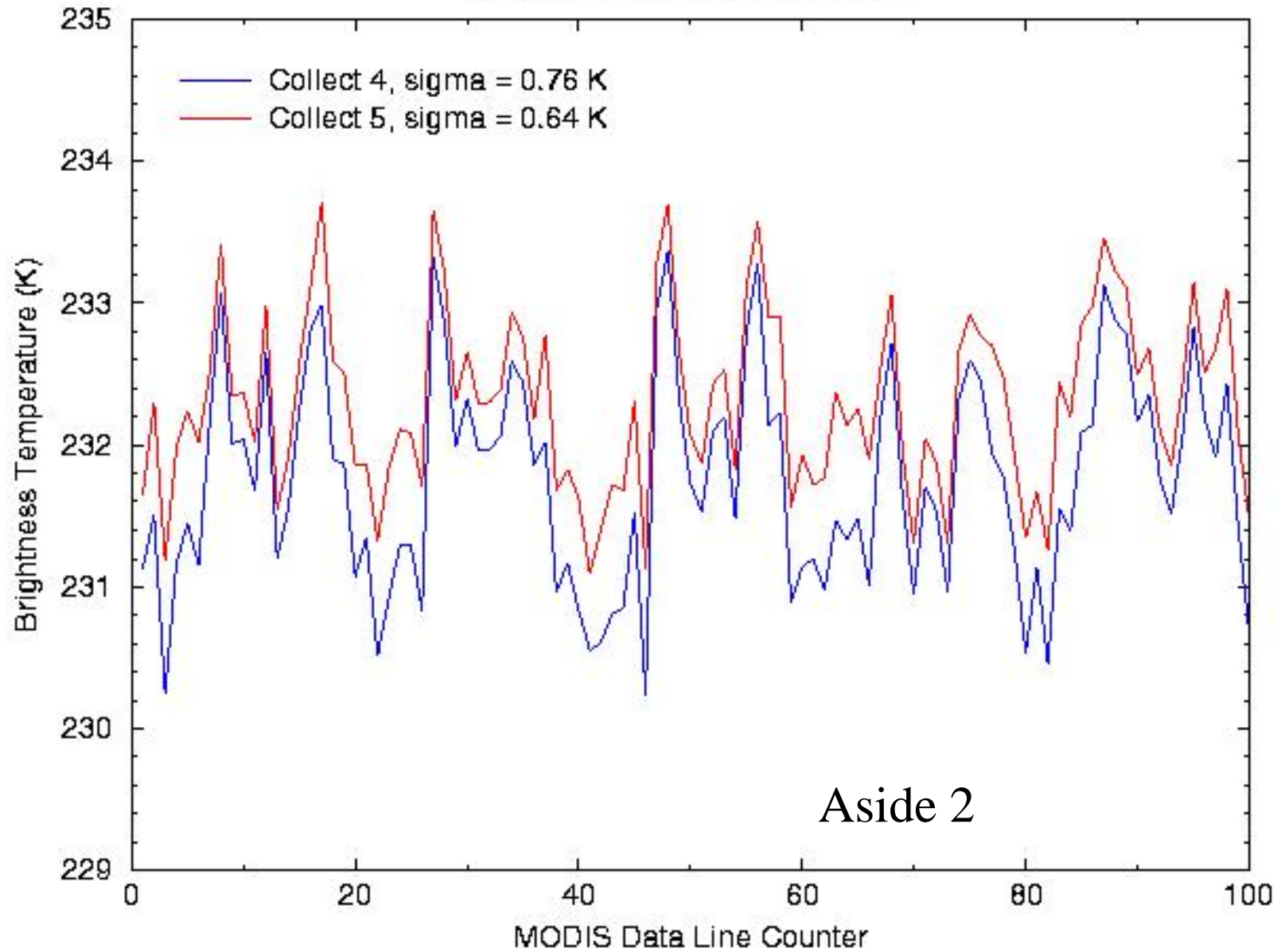
# Terra MODIS Along Track Profile

Day 00136, 1925 UTC, Band 36



# Terra MODIS Along Track Profile

Day 02141, 0240 UTC, Band 36



# Terra MODIS Along Track Profile

Day 02141, 0240 UTC, Band 36

