Status of the GSICS VIS/NIR DCC calibration efforts

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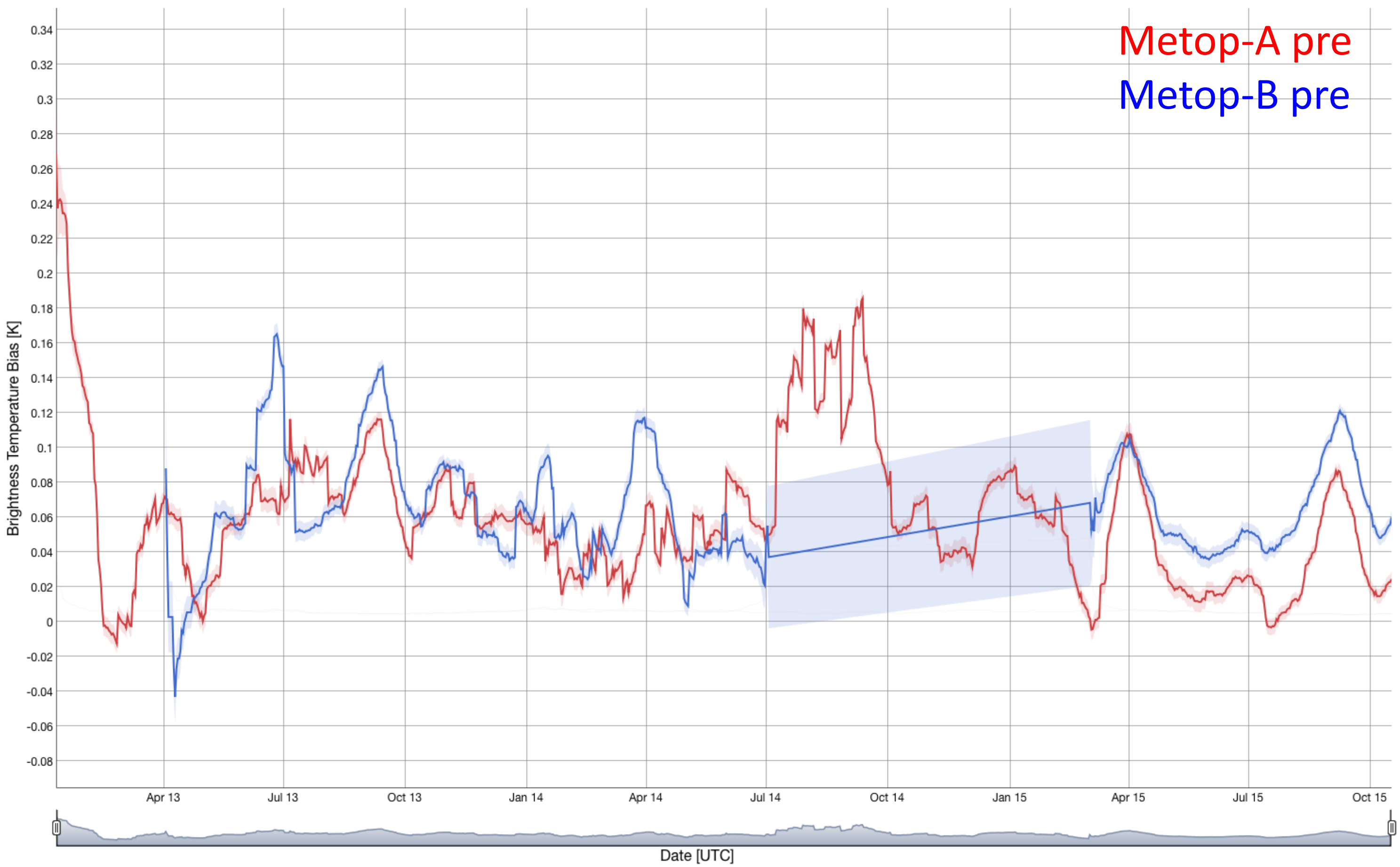
Outline

- GSICS DCC plotting tool
- DCC QC during processing
- DCC update frequency
- Next DCC web meeting topics
- Improvements in MODIS/GEO ray-matching
  - To validate the DCC algorithm to transfer the MODIS calibration reference

GSICS plotting tool

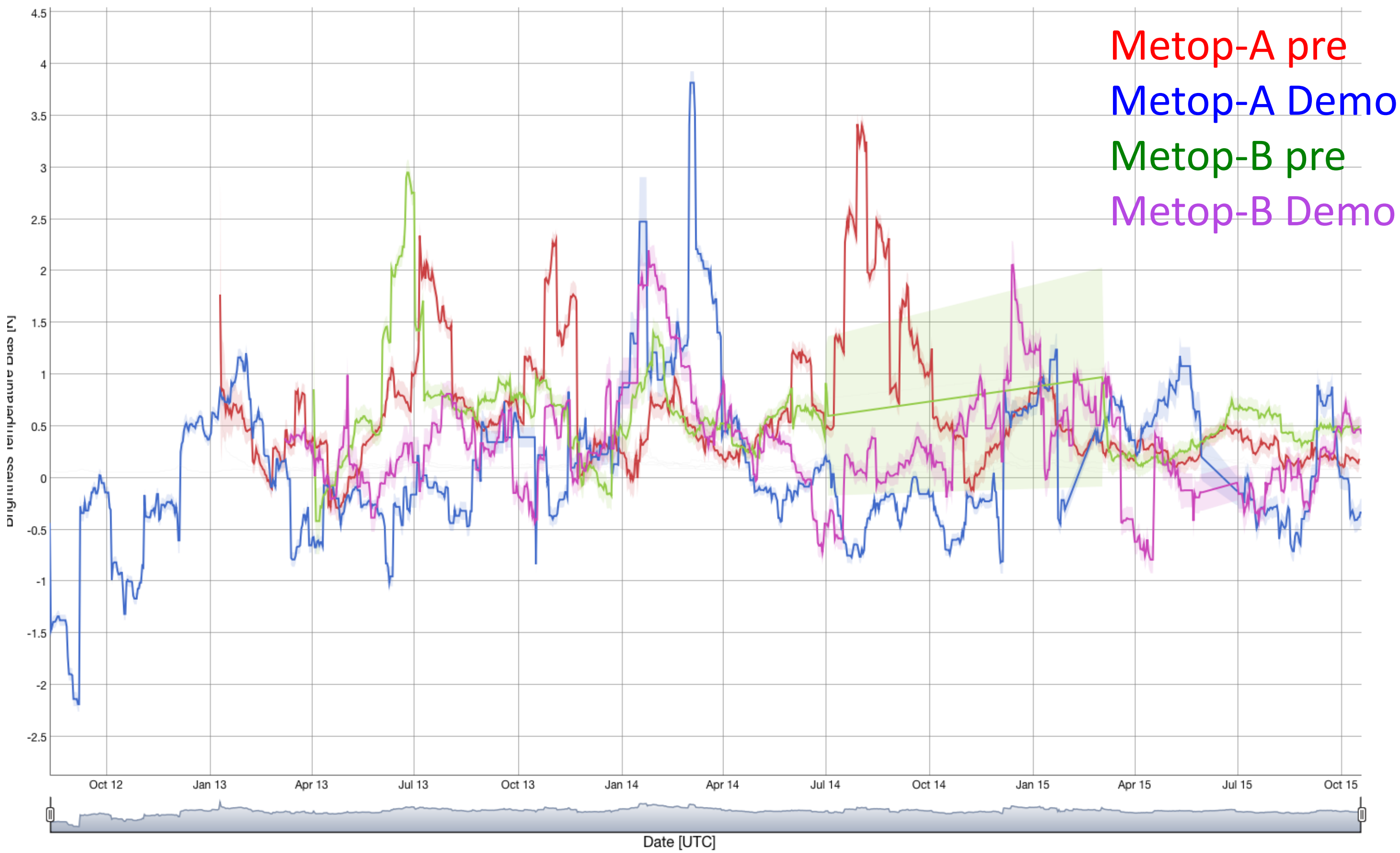
- Plot the gain over time
- Do we also plot the monthly PDFs?
  - For internal QC

Met-10 10.8µm @286K

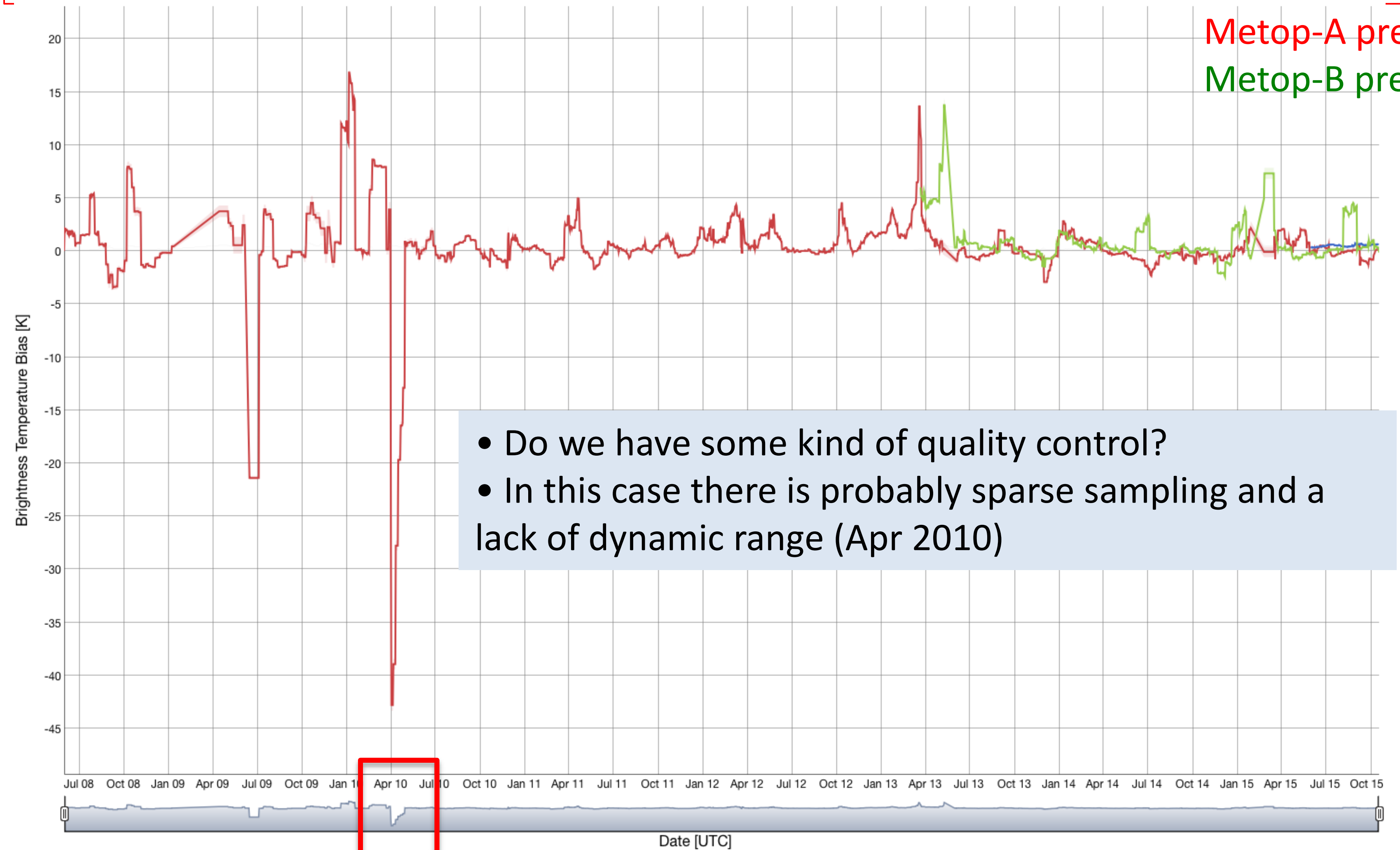


2014-05-19T05:00Z:
MSG3/SEVIRI referenced with MetOpA/IASI [EUMETSAT][RAC][preop][2013/01/10 00:00:00][v01][IR108][286.0K]:0.04 1-sigma +/-:5.86e-3
MSG3/SEVIRI referenced with MetOpB/IASI [EUMETSAT][RAC][preop][2013/01/10 00:00:00][v01][IR108][286.0K]:0.04 1-sigma +/-:5.45e-3

Met-10 10.8µm @205K



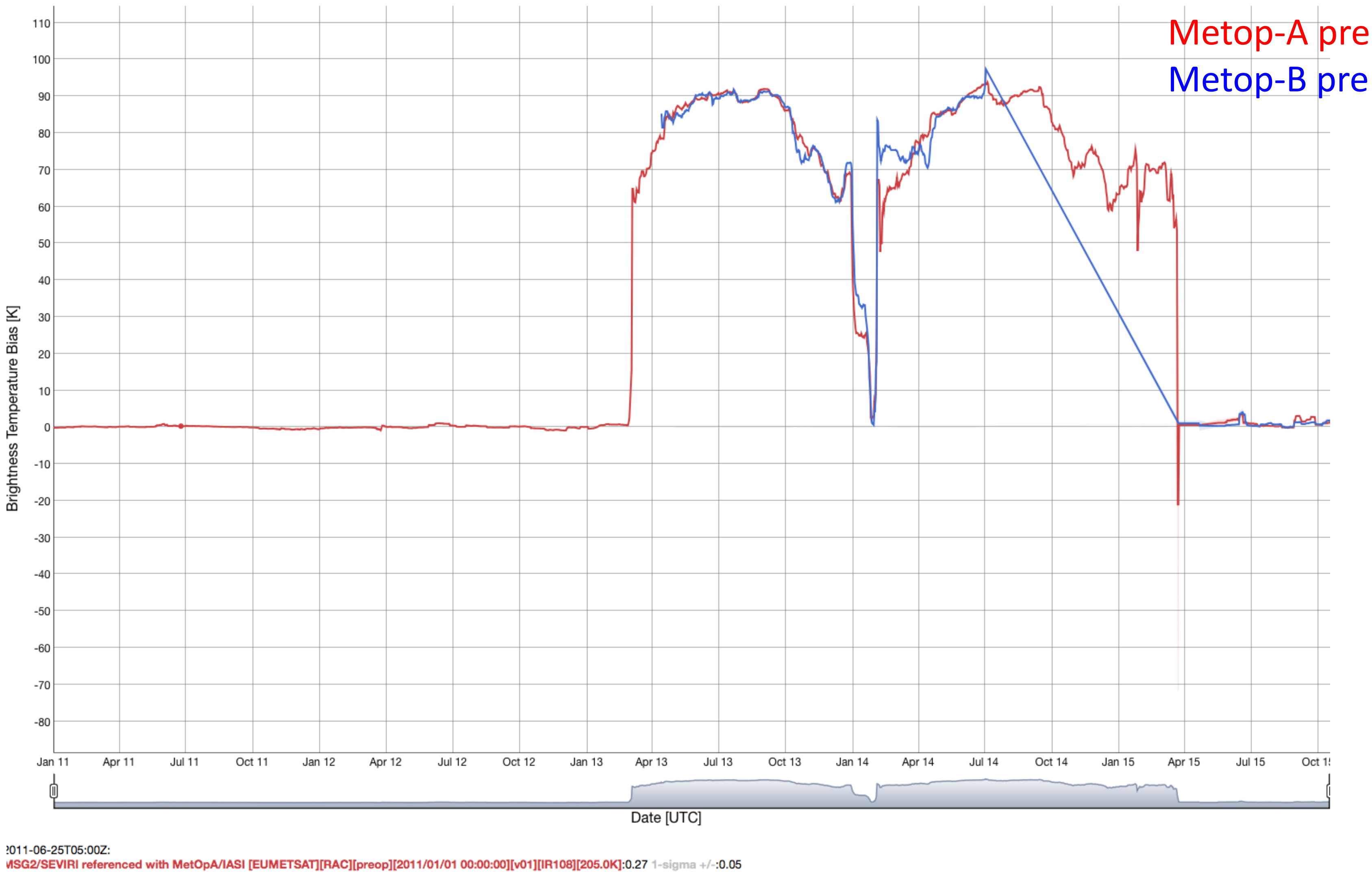
Met-8 10.8µm @205K



- Do we have some kind of quality control?
- In this case there is probably sparse sampling and a lack of dynamic range (Apr 2010)

2008-06-12T05:00Z:
MSG1/SEVIRI referenced with MetOpA/IASI [EUMETSAT][RAC][demo][2008/06/01 00:00:00][v03][IR108][205.0K]:1.71 1-sigma +/-:0.21

Met-9 10.8μm @205K

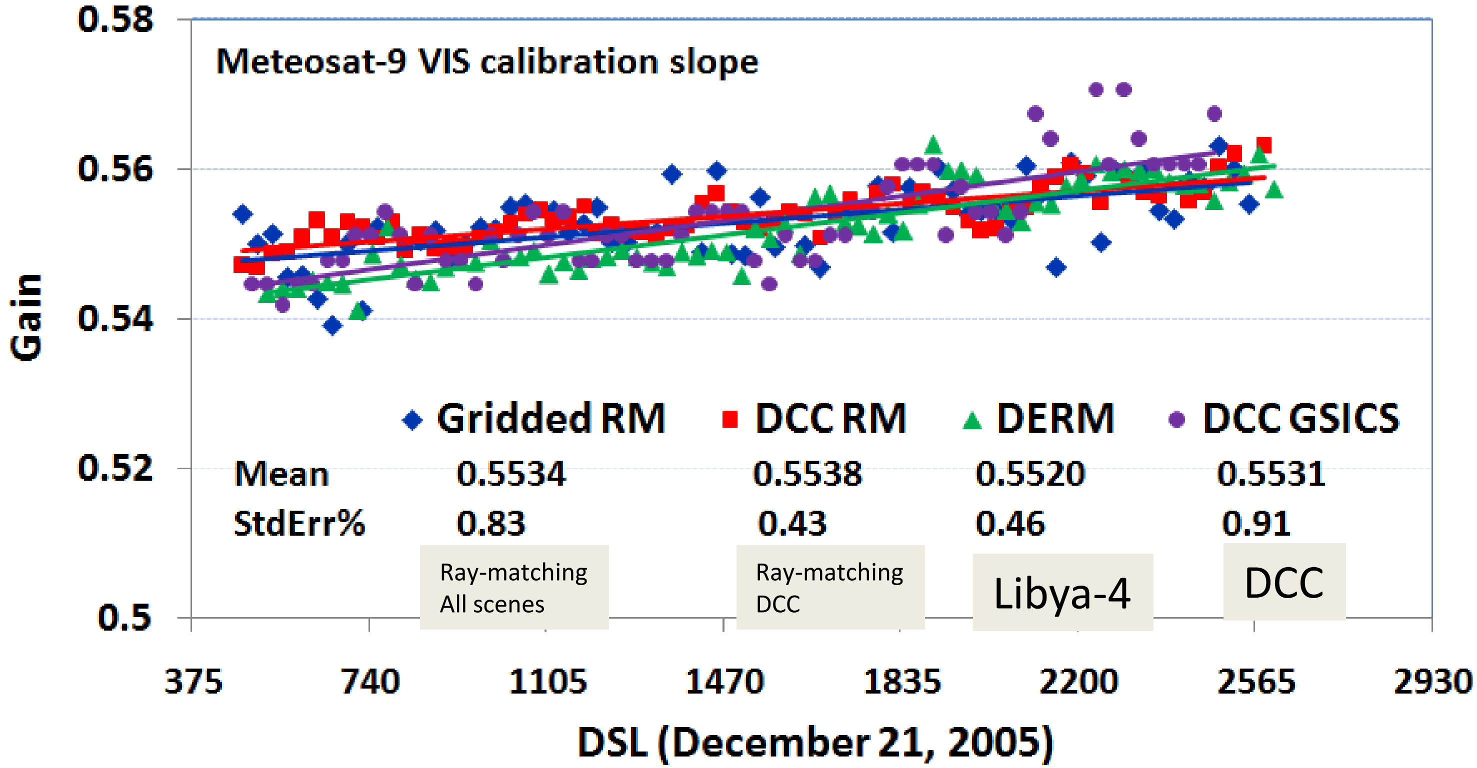


DCC methodology

- The DCC methodology must have some QC
  - Sampling threshold
  - PDF shape, based on PDF statistics
  - 3 sigma outlier
- If insufficient sampling or noisy PDFs then
  - Combine previous month and current month
- If GSICS data product causes artifacts in the users algorithms or exceeds the valid range, which causes their programs to terminate they will not use the calibration coefficients.
  - The dataset can be perfect 99%, but the 1% will upset users
  - Users rely on dataset providers for QC
  - CERES code is 50% exception handling

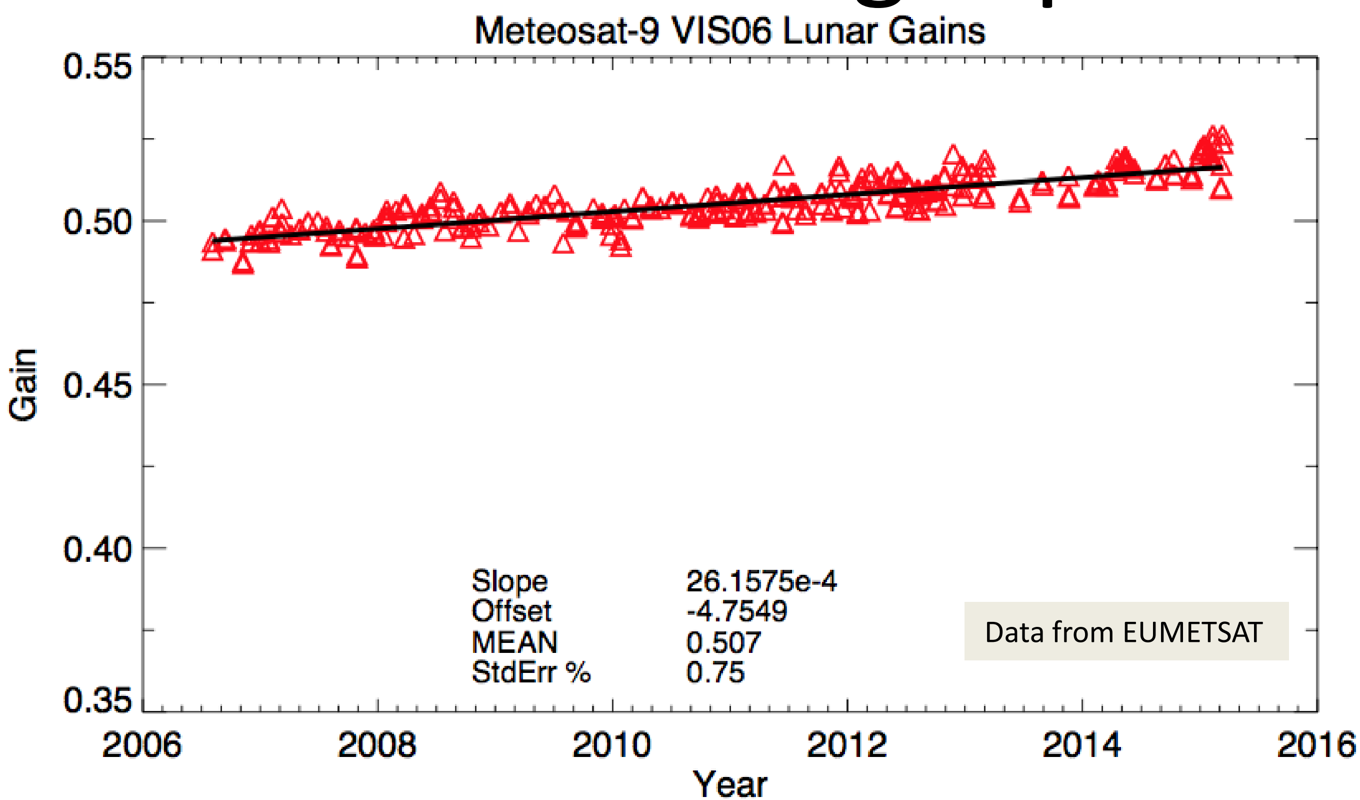
DCC update frequency

Met-9 calibration gains



- All of the calibration gains within 0.2% over the record
- All transferred the Aqua-MODIS calibration succesfully
- There is residual methodology noise and invariant site natural variability
- Use deseasonalization to remove known oscillations
- Even after all know oscillations are removed, noise will remain.
- Best to use a temporal trend to mitigate measurement noise

Next DCC meeting topics



- In this case there is no seasonal cycle, but yet a linear regression makes the most sense
- Do we use the every measurement as the update frequency?
- An instrument anomaly would have to exceed 2*sigma to be detected by this method

NOAA Implementation

Monthly Statistics

Removal of predictable oscillations

Trending fitting

For a single calibration method, we stop at trend fitting

$$R_{pre,t,\,fitting} = a + bt + ct^2$$

Normalized to a common Day1 reflectance

Outlier removal performed with all calibration methods

$$Normalized\_Reflectance_t = \frac{R_{pre,t,observation}}{R_{pre,t=1,\,fitting}}$$

$$R_{pre,t=1,\,fitting} = a + b*1 + c*1^2$$

Combining the Normalized Data

Visible degradation of optics

- We expect the optics to degrade gradually
- We expect no sudden discontinuities
- For satellites with solar diffusers
  - Does GSICS calibrate the visible count level data? Solar diffuser just another calibration method
  - Or is the level 1 data calibration coefficients applied first, similar to the MODIS product

Next DCC meeting topics

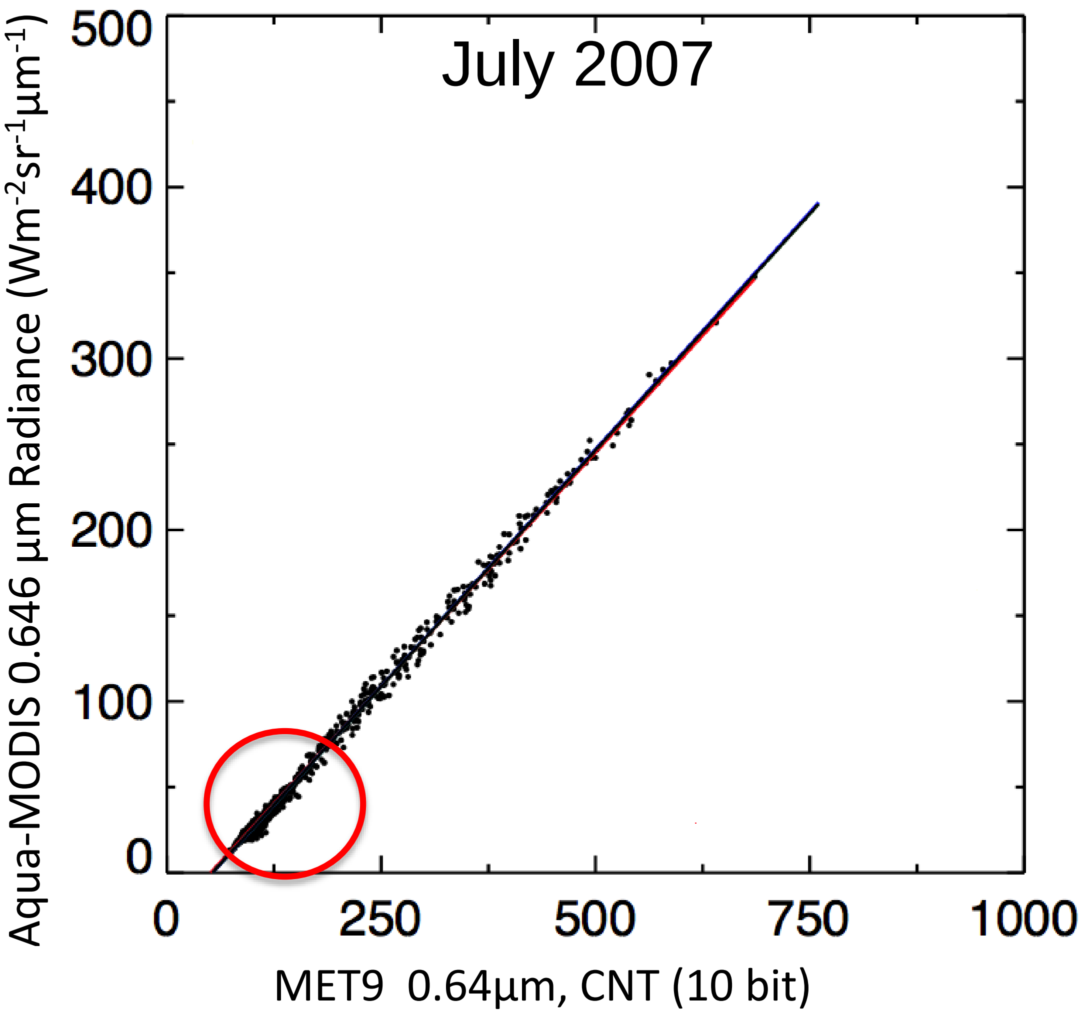
- DCC method applied to other bands
  - There will be enough months of Himawari-8 to perform DCC algorithm for the next web meeting
  - Also reexamine MSG 1.6µm channel
- Seasonal cycle mitigation
  - KMA BRDF model
  - More Lambertian part of BRDF
  - Need to work with the month with the least sampling

DCC algorithm Aqua-MODIS calibration transfer uncertainty

- We have been concentrating on refining the DCC calibration algorithm for stability
- We assume that the long-term Aqua-MODIS PDF mode radiance is equal to the GEO PDF mode radiance observed during the Aqua-MODIS overpass
  - MODIS and GEO would observe the same DCC systems but not under the same angular conditions, rely on the DCC BRDF to remove angular differences
  - Need to determine uncertainty of this assumption
  - What is the natural variability of the DCC invariant target?
  - This method can then characterize DCC as an absolute calibration target
- Use Aqua-MODIS/GEO ray-matched radiance pairs as the truth
  - Use two ray-matching methods to improve the individual algorithms and reduce the overall uncertainty
  - Aqua-MODIS or NPP-VIIRS ray-matching also introduces the MODIS or VIIRS calibration anomalies (scan angle dependencies) into the GEO record

Improvements in MODIS/GEO ray-matching

Graduated Angle Matching (GAM)

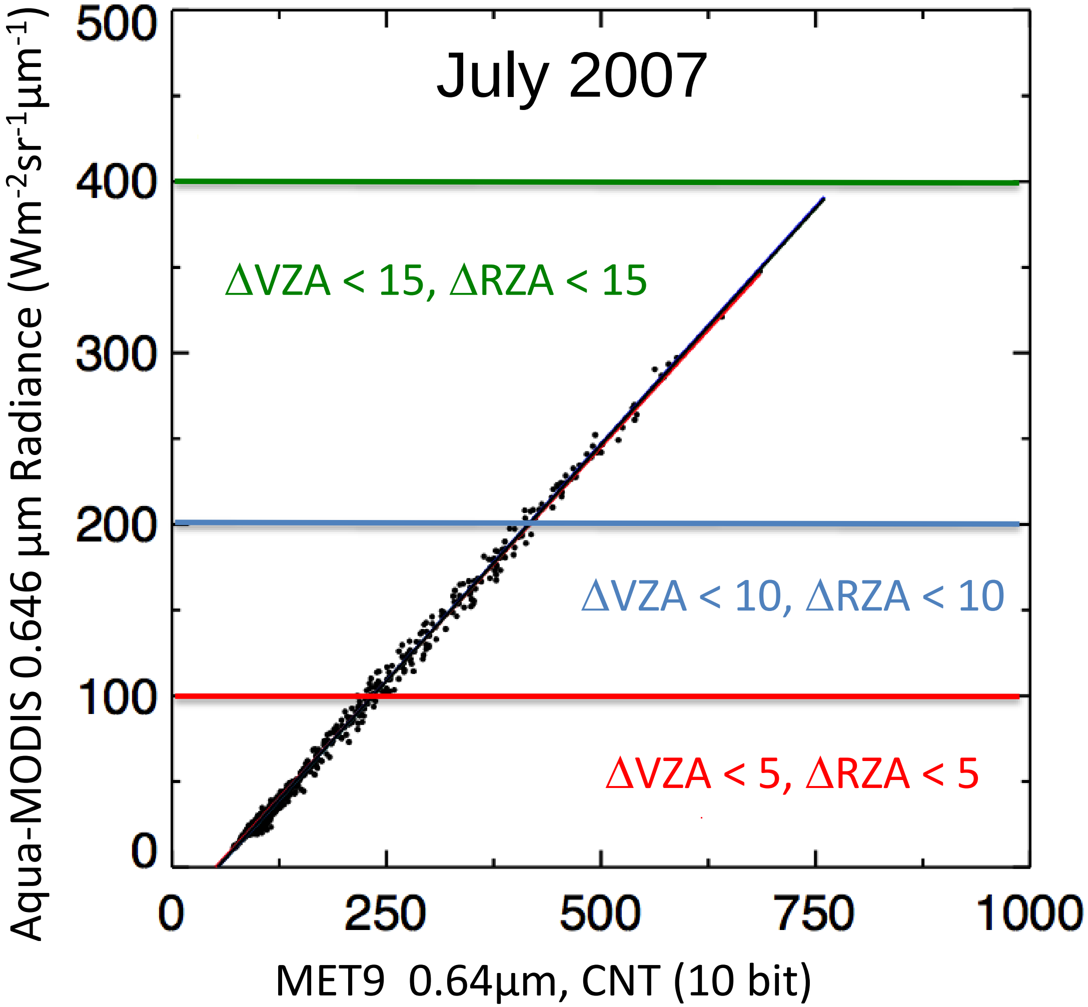


- Baseline ray-matching

ΔSZA< 5° (15 minutes), ΔVZA<15° , ΔRAZ < 15° , ΔSCAT< 15° , no sunglint

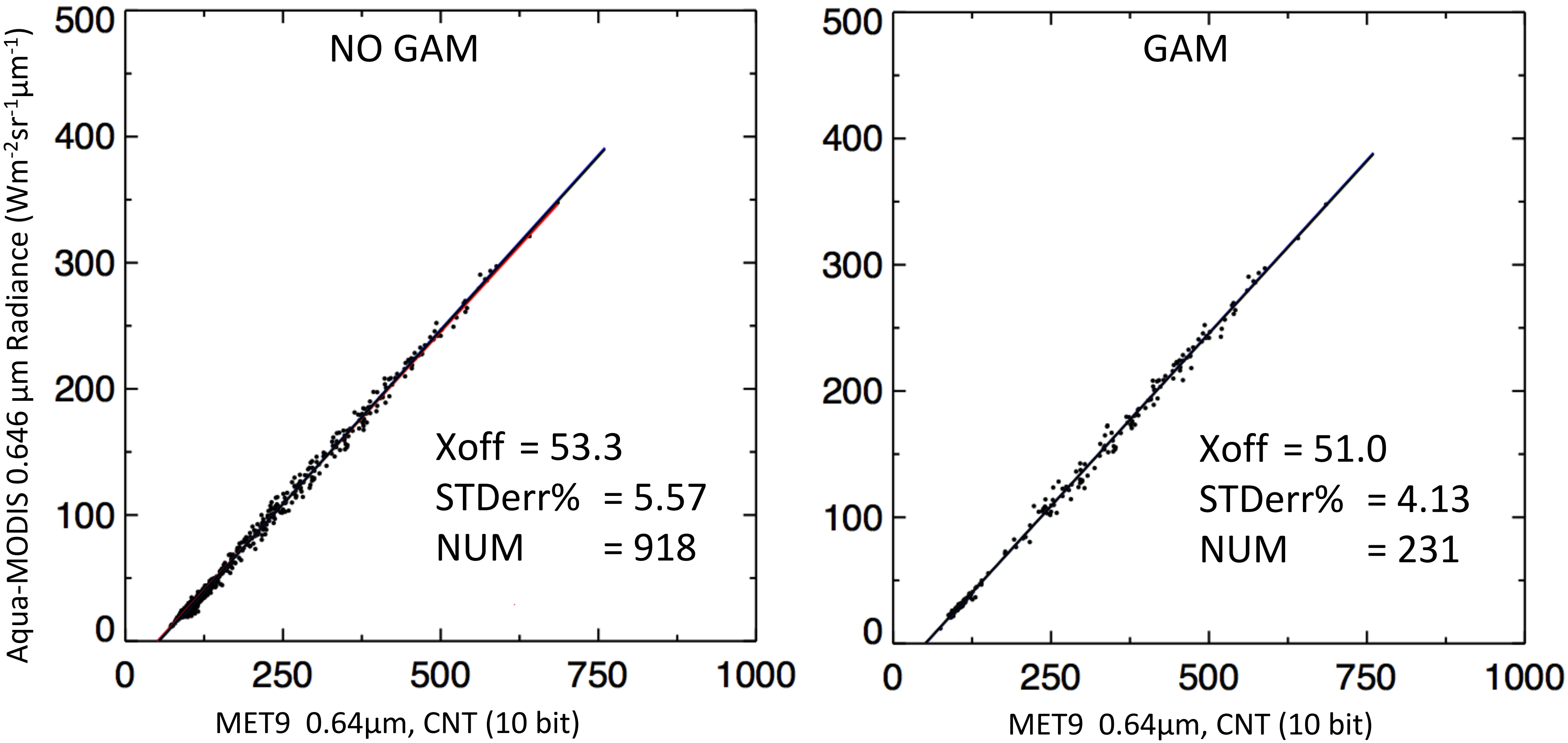
- Note most of the points are in clear-sky (dark radiances) where the conditions are most anisotropic
- The least number of points occur over bright clouds that are most isotropic
- Then a more restrictive angle matching can be applied to the dark radiances, while retaining sufficient dynamic sampling

Graduated Angle Matching (GAM)



- Split the Aqua-radiance domain into 3 sections, increase the angular restriction in the lowest 2 sections

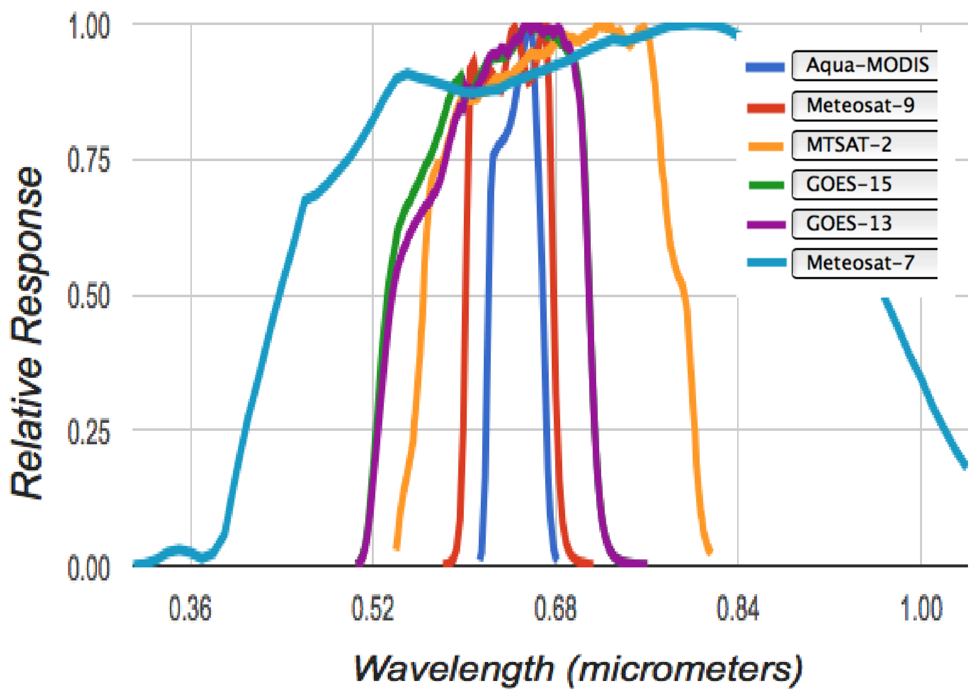
Graduated Angle Matching (GAM)



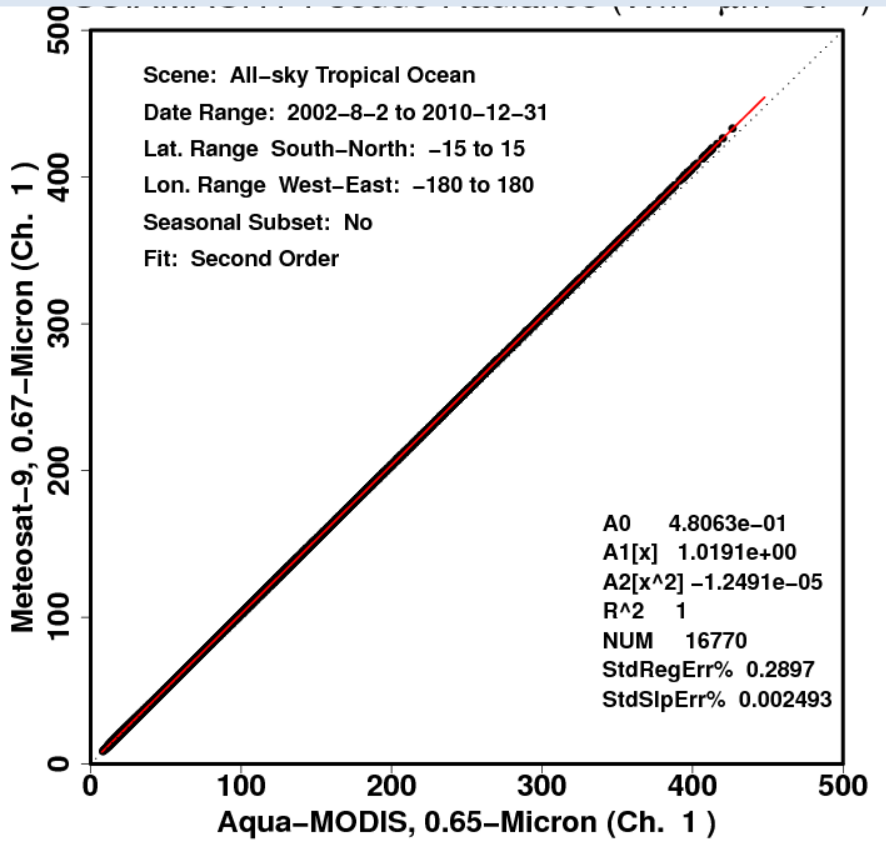
- The X offset or the linear regressed offset is closer to the true space count of 51 using the GAM method

Spectral Band Adjustment Factor (SBAF)

MODIS/GEO spectral responses

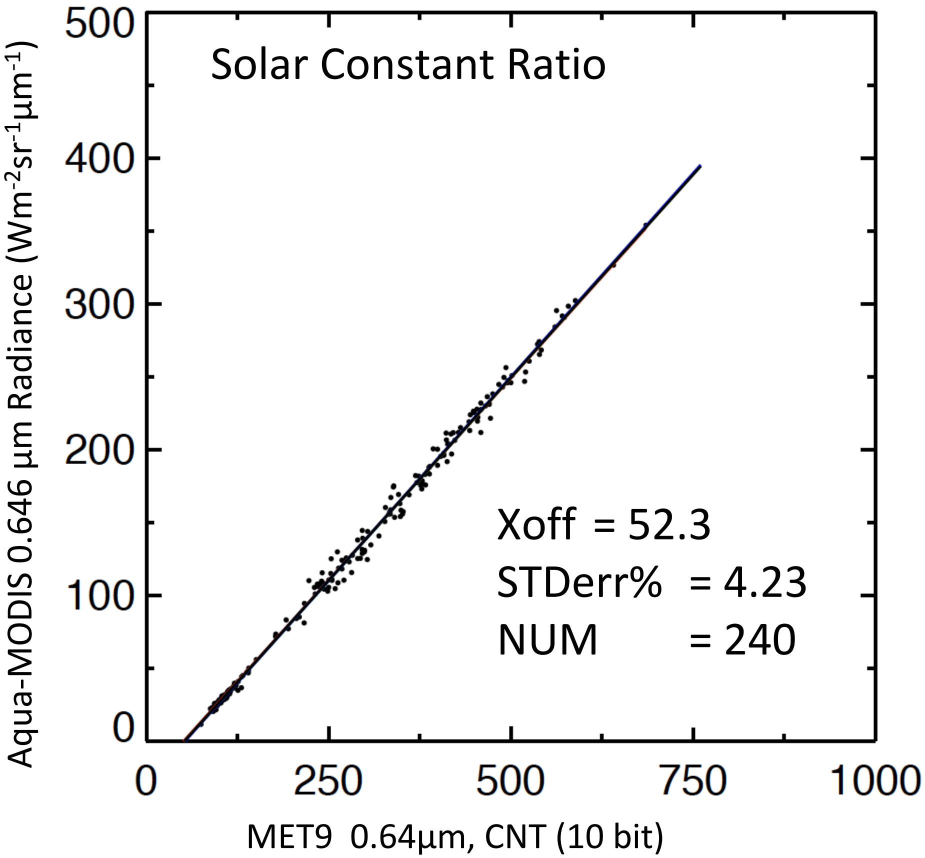


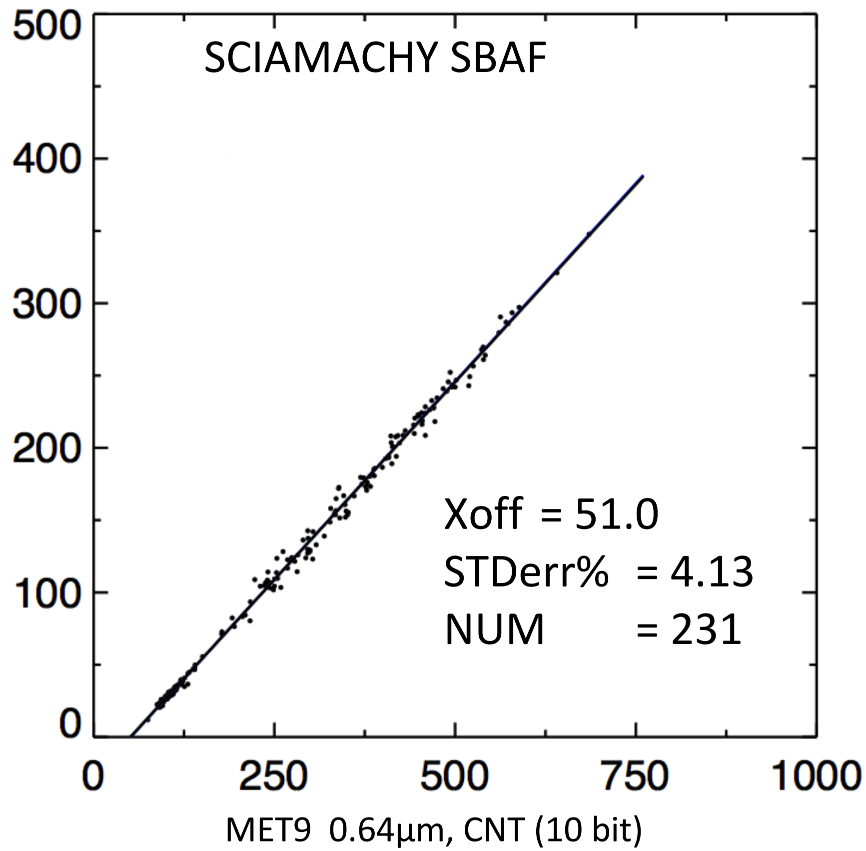
SCIAMACHY Met-9/MODIS SBAF



- Convolve the footprint SCIAMACHY hyper-spectral radiances with the Met-9 and MODIS spectral response functions. Regress the SCIAMACHY pseudo radiances over the ray-matching domain. Apply the SCIAMACHY SBAF to the MODIS radiances.

SBAF Comparison





- Apply the SBAF to the Aqua-MODIS radiances
- The X offset or the linear regressed offset is closer to the true space count of 51 using the SCIAMACHY SBAF

GAM and SCIAMACHY SBAF validation

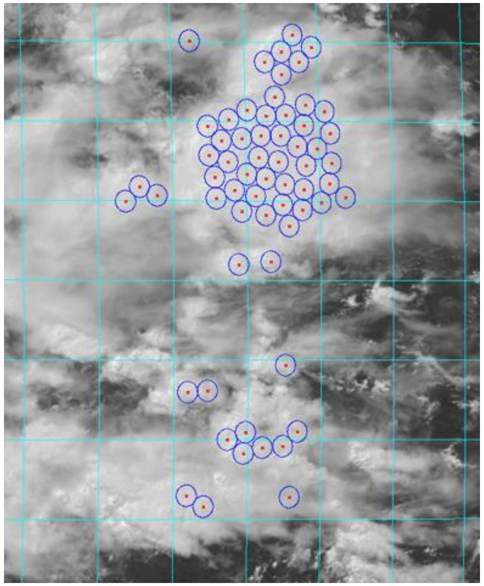
Satellite		GOES-13	GOES-15	Met-7	Met-9	MTSAT-2
Space count	noGAM noSBAF	35.5	33.8	6.07	53.8	-0.46
	GAM noSBAF	33.5	33.1	6.03	53.5	-2.71
	noGAM SBAF	33.0	30.4	4.55	52.6	1.99
	GAM SBAF	30.4	30.1	4.89	52.1	1.75
	published	29	29	4.9	51	2

- The mean timeline GEO space count based on the monthly linear regressions of Aqua-MODIS radiances and GEO count ray-matched pairs.
- The published space count is the operational GEO maintained of the residual or space count.
- Both the application of GAM and the SCIAMACHY SBAF causes the monthly linear regression offsets to become closer to the GEO instrument maintained space count

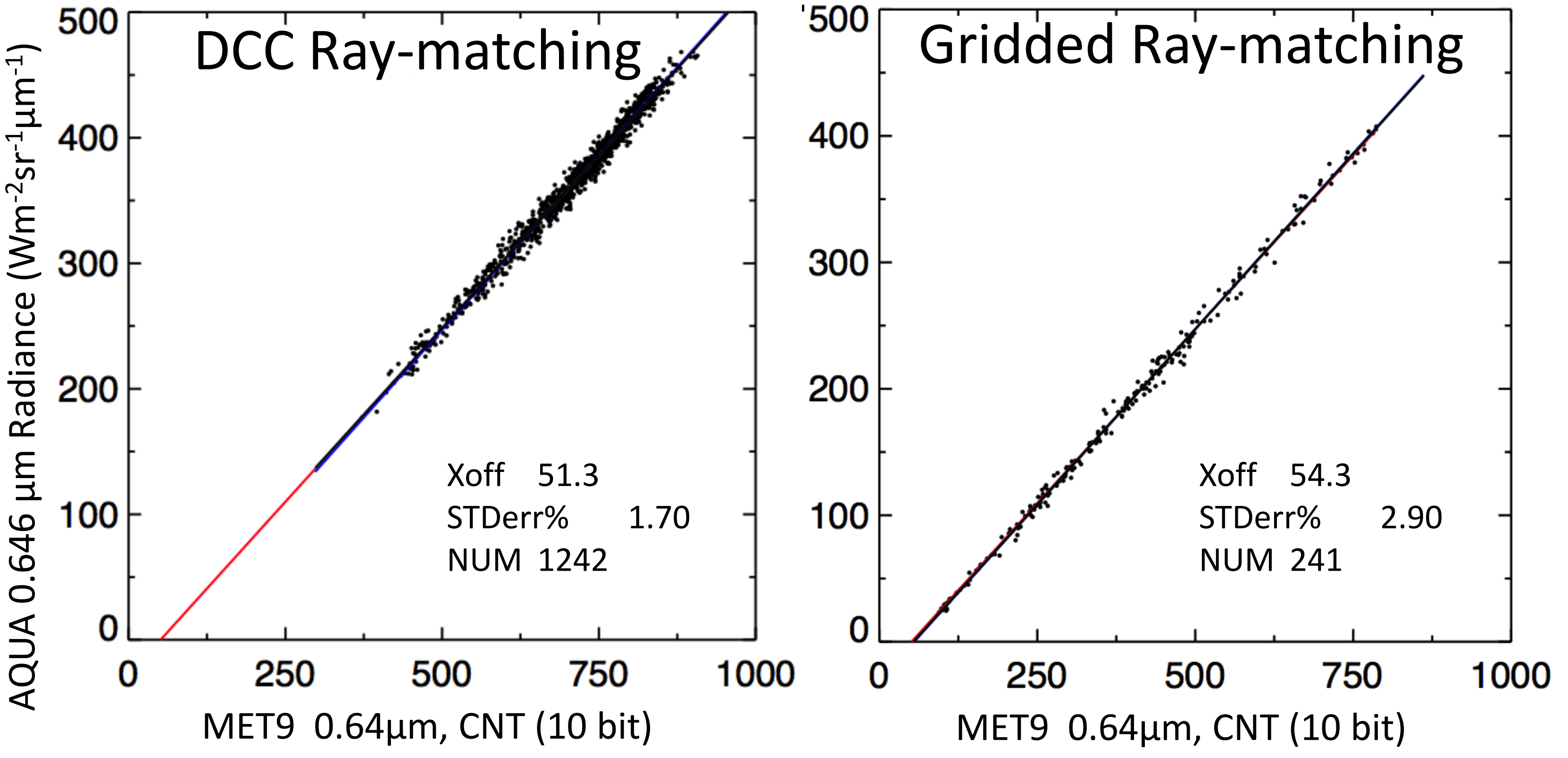
DCC ray-matching algorithm

- Find Aqua equatorial crossings in GEO DCC domain (±40° E/W, ±20° N/S of GEO sub-satellite point)
- Identify the MODIS DCC pixels and predict the GEO angles
- Aggregate MODIS pixel data into 30-km FOV
- Use MODIS pixel lat/lon to locate GEO pixels, and aggregate pixel data into 30-km GEO count and MODIS radiance pairs
- Systematically locate the coldest MODIS pixel centers, by finding the FOV with the coldest temperature and then removing all other DCC identified pixels within the FOV and repeating
- Normalize the cosine SZA, apply SCIAMACHY SBAF factor, perform monthly linear regressions to derive monthly gains

DCC Parameter	Threshold
σVS	<0.2%
σIR	<7.5K
ΔAngle	ΔRZA<25, ΔVZA<15
ΔTime	15 min
Temp	<220 K
Angles	VZA<40, SZA<40
FOV	30-km

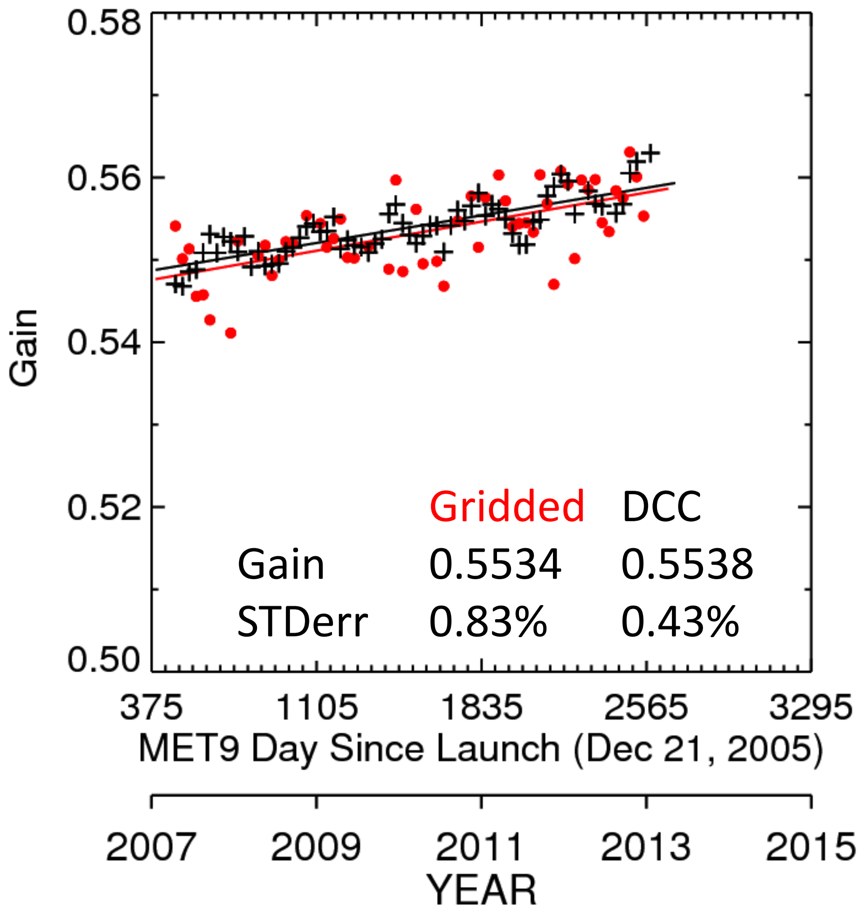


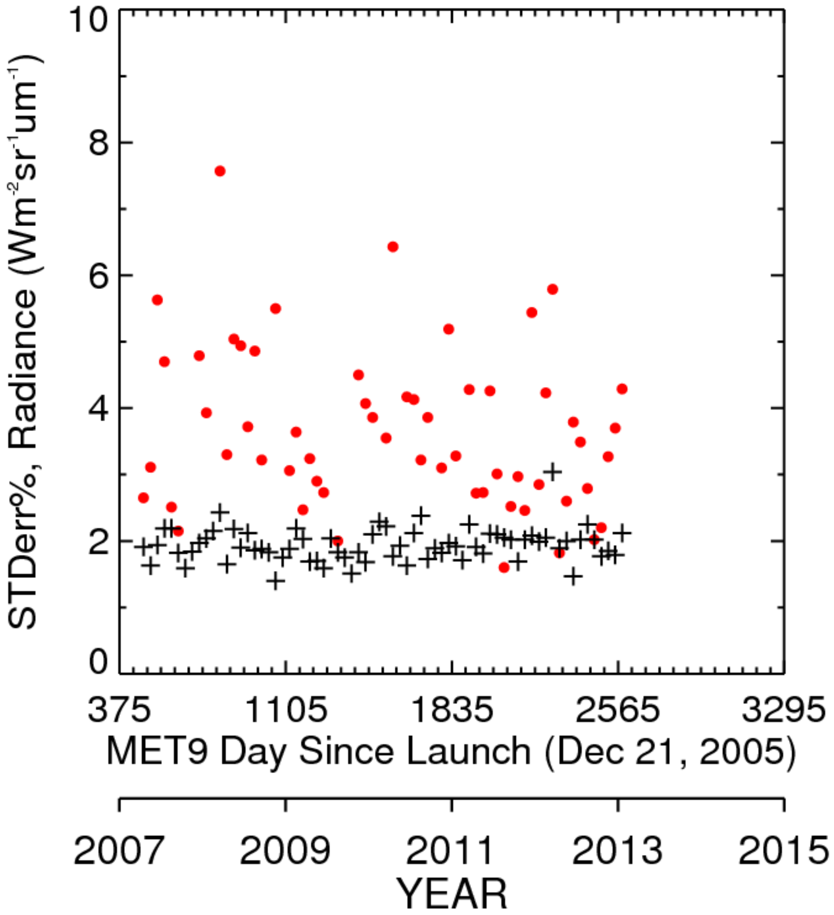
Comparison of DCC and gridded ray-matching, May 2009



- The monthly standard error of the linear regression is smaller for the DCC
- DCC are the most Lambertian Earth targets allowing for the greater angular tolearance, with the least SBAF uncertainty

Comparison of DCC and gridded ray-matching Met-9 2007-2013





- DCC have both the least monthly and temporal standard errors.
- Both methods give a timeline gain within 0.1%

Comparison of DCC and gridded ray-matching algorithm GEO gains

	Gridded Gain	Gridded STDerr	DCC Gain	DCC STDerr	% difference
Met-9	0.5534	0.83%	0.5538	0.43%	0.1%
GOES-15	0.7781	0.86%	0.7760	0.35%	0.3%
GOES-13	0.7857	0.88%	0.7842	0.42%	0.2%
Met-7	0.6127	0.85%	0.6146	0.60%	0.3%
MTSAT-2	0.5838	1.20%	0.5901	0.39%	1.1%

- DCC have the least monthly and temporal standard errors.
- DCC and gridded ray-matching timeline gains agree within 0.3% except for MTSAT-2
- Still investigating MTSAT-2
- In order reduce the GEO calibration gain uncertainty below 2% the SBAF and matching errors must be accounted for.

Conclusions

- Initial disagreement between gridded and DCC ray-matching gains prompted improvements in both procedures
- Both the SCIAMACHY SBAF and GAM gridded ray-matching methodologies were validated by comparing the linear regression offset to the true space count
- Both DCC and gridded ray-matching relies on sufficient monthly sampling during all months of the year. The thresholds were derived using the months with the least DCC and gridded matches
- The GEO ray-matched calibrations will be used to validate the GSICS DCC calibration ability to transfer the Aqua-MODIS reference calibration