Referencing the Deep Convective Cloud (DCC) calibration to Aqua-MODIS over a GEO domain

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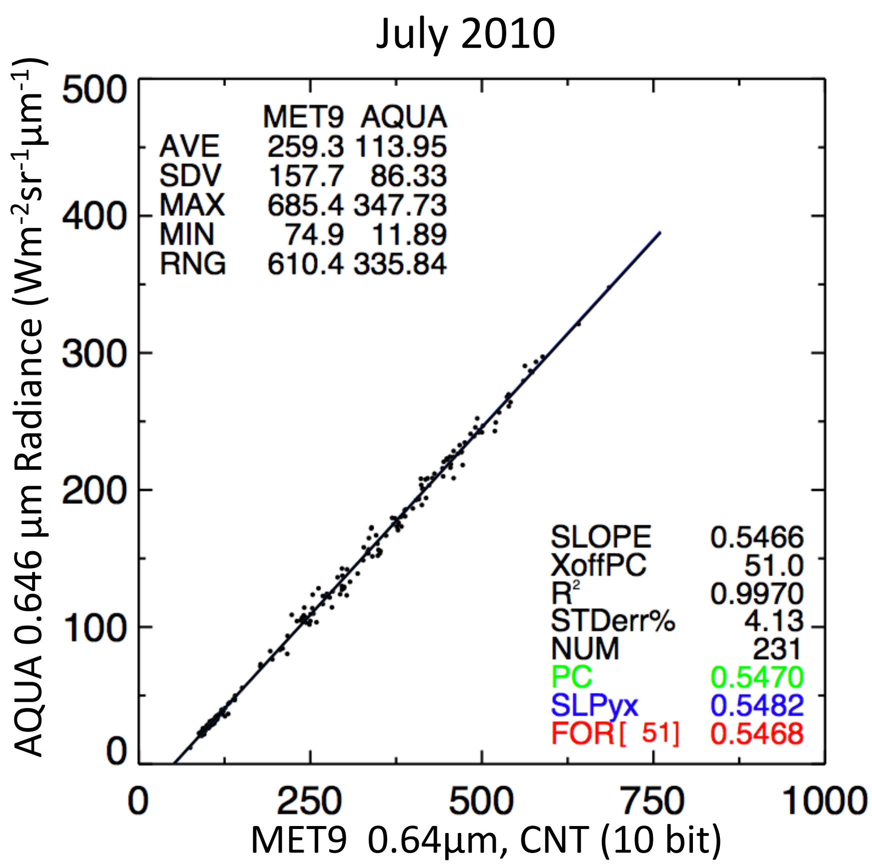
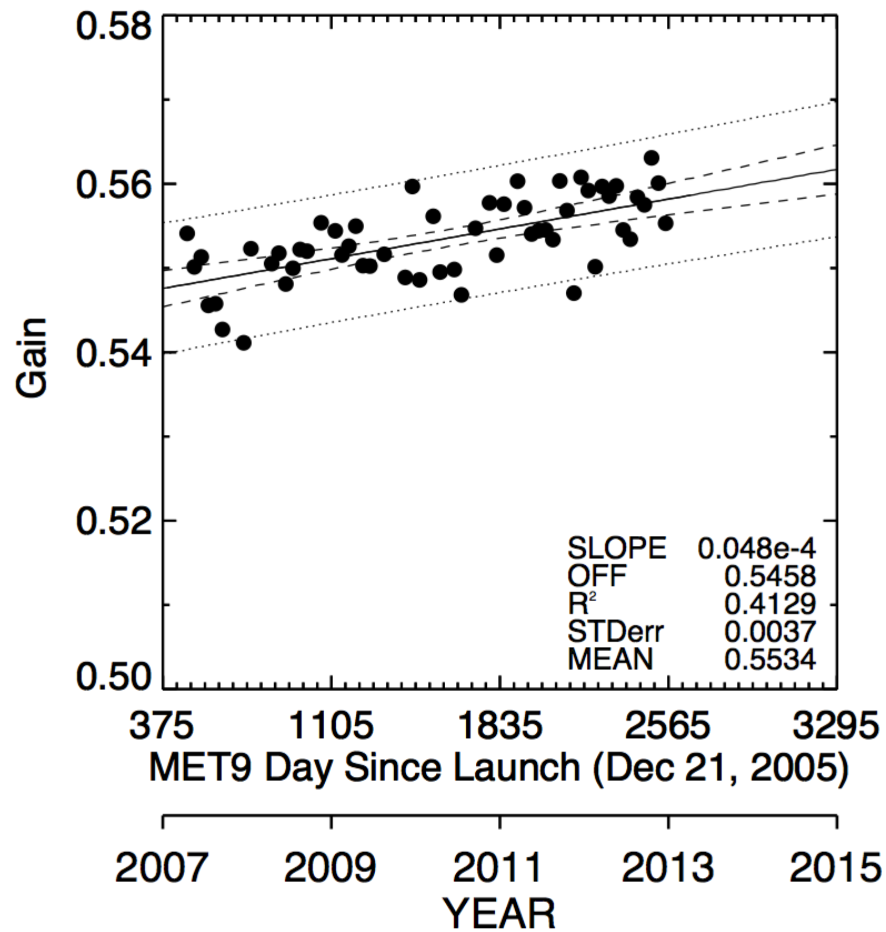
Simple GEO to MODIS Ray-Matching Cross-Calibration Method

- None of the GEO visible sensors have onboard calibration
- Ray-match GEO counts (proportional to radiance) and MODIS radiances within a 0.5° cloudy ocean regions using selection constraints
  - ΔSZA< 5° (15 minutes), ΔVZA<15°, ΔRAZ < 15°, ΔSCAT< 15°, no sunglint
  - Domain ±20° E,W and ± 15° N,S near sub-satellite point to maximize coincident matches
  - Use Aqua-MODIS Collection 6 as reference
  - Use a SCIAMACHY spectral band adjustment factor derived from all SCIA footprints over the same equatorial region
  - Normalize the cosine solar zenith angle
- Perform monthly linear regressions and derive monthly gains
  - Use published offsets
- Compute timeline trends from monthly gains

Gridded Ray-matching





$$Aqua_{radiance}[\cos(SZA_{GEO})/\cos(SZA_{Aqua})]SBAF_{GEO/Aqua} = Gain_{GEO}(CNT - CNT_{space})$$

Improvements

All Ray-matching

- Updated SBAFs
- Applied new timeline trend standard deviation filter

Gridded Ray-Matching

- Locked visible spatial homogeneity (SVS) at 0.7 across all GEOs
- Applied new Graduated Angle Matching (GAM) filter

DCC Ray-Matching

- Updated optimization of various thresholds and filters

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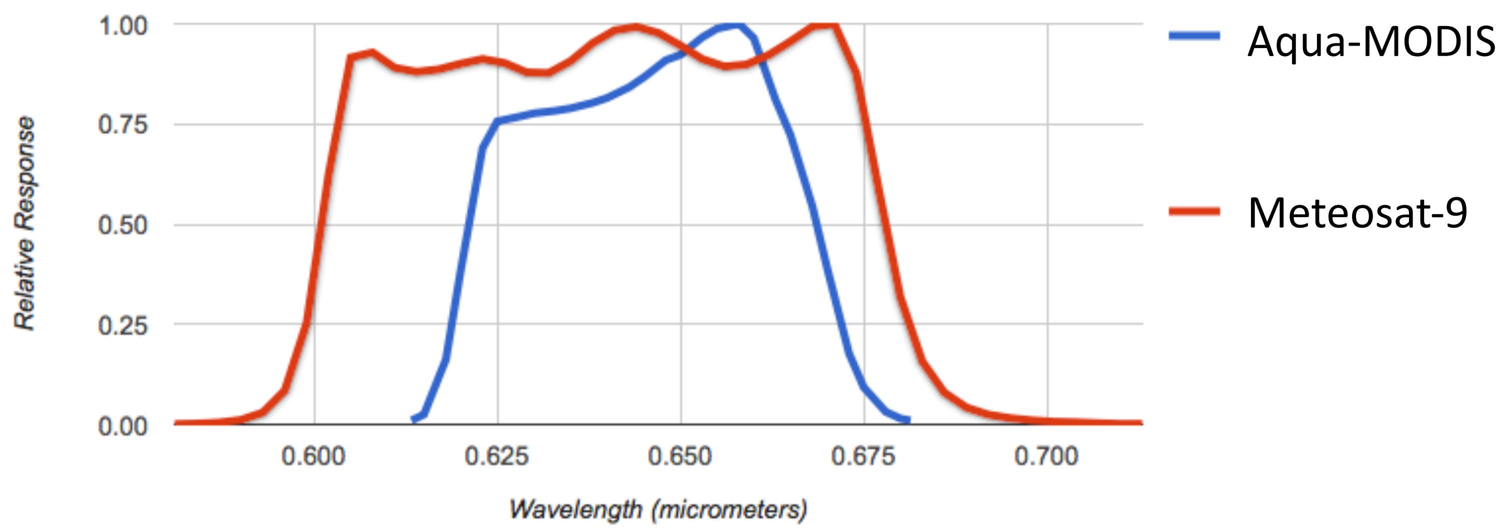
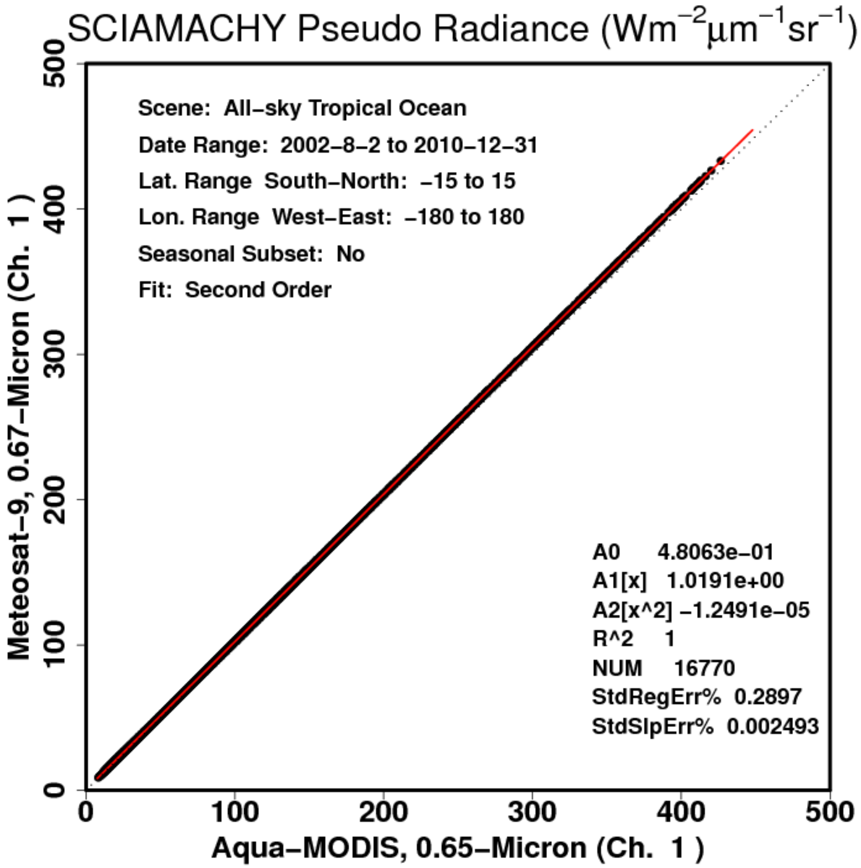
Met-9 and Aqua-MODIS 0.65µm spectral response functions

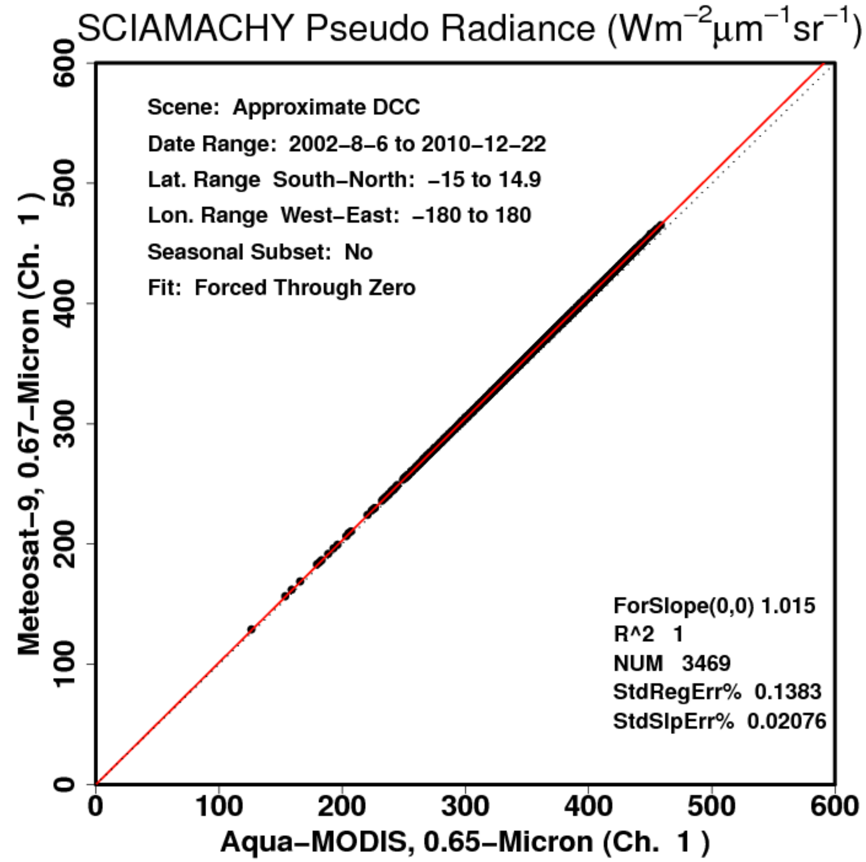


Must account for spectral response differences when inter-calibrating MODIS and Meteosat-9

Use SCIAMACHY hyper-spectral radiances convolved with the spectral response function to derive footprint pseudo radiance pairs over the inter-calibration domain
Then use regress the radiance pairs to derive the SBAF

Updated SBAFs





GRIDDED: Use 2nd order ASTO SBAF for MODIS rad<400, Force Fit DCC SBAF for rad>400

DCC: Use Force Fit DCC SBAF for all values

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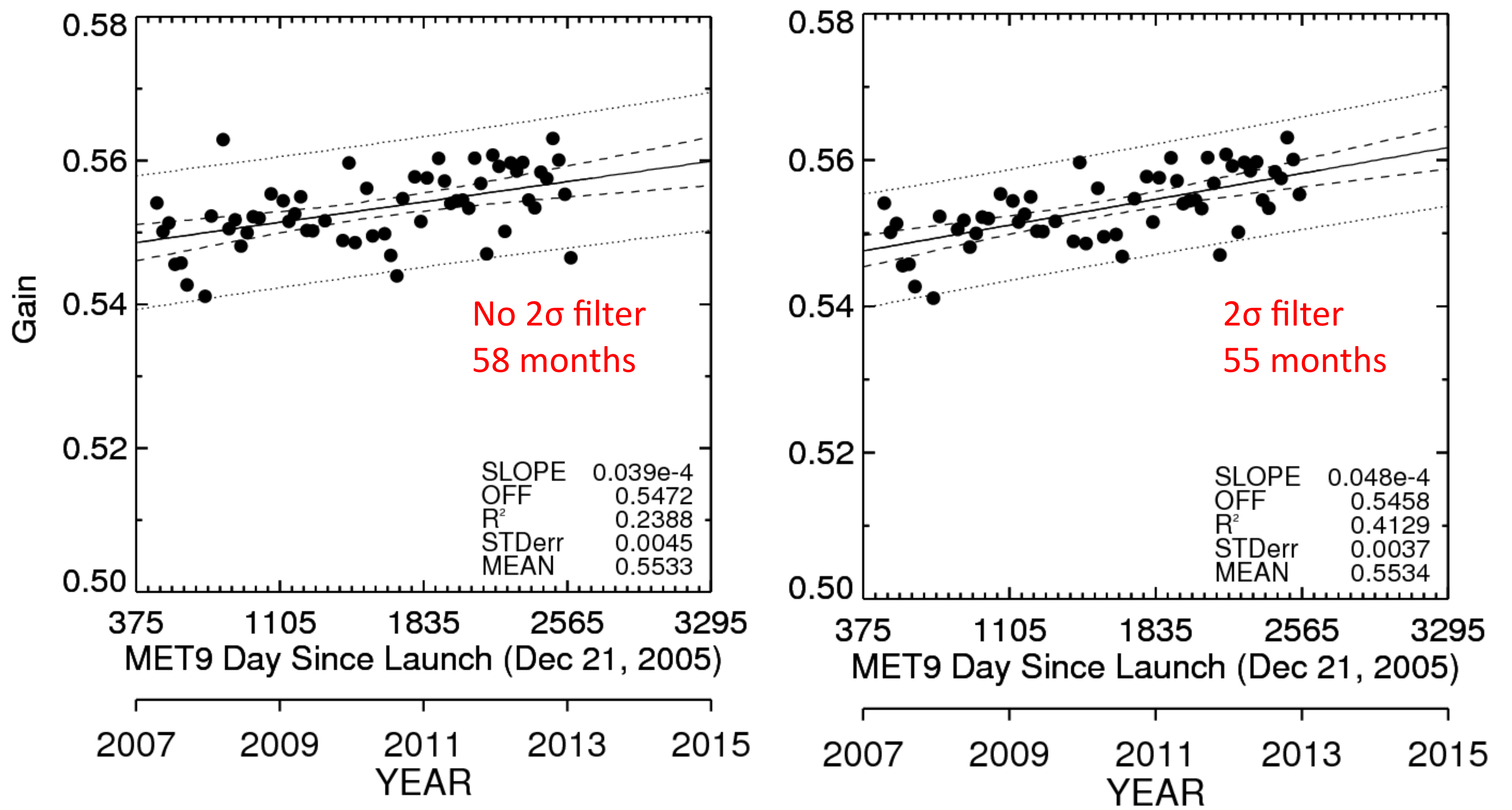
Standard Deviation Filter

Simple filter that removes any outliers that have a gain > 2σ from the original trend



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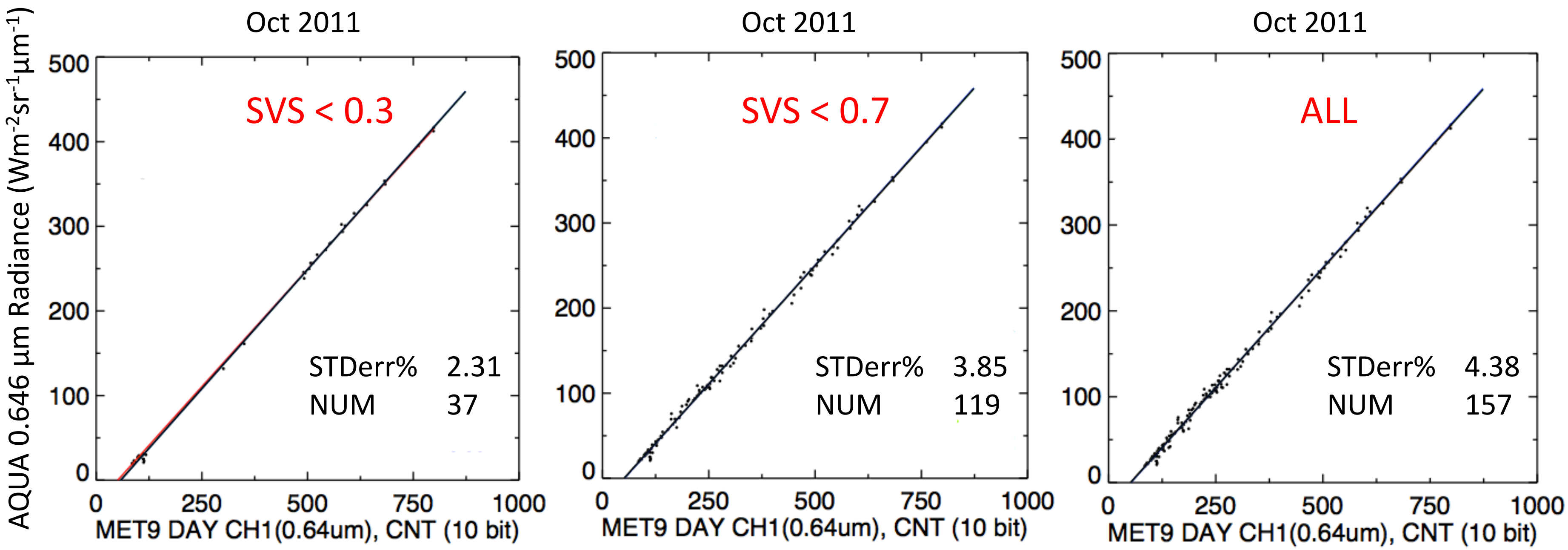
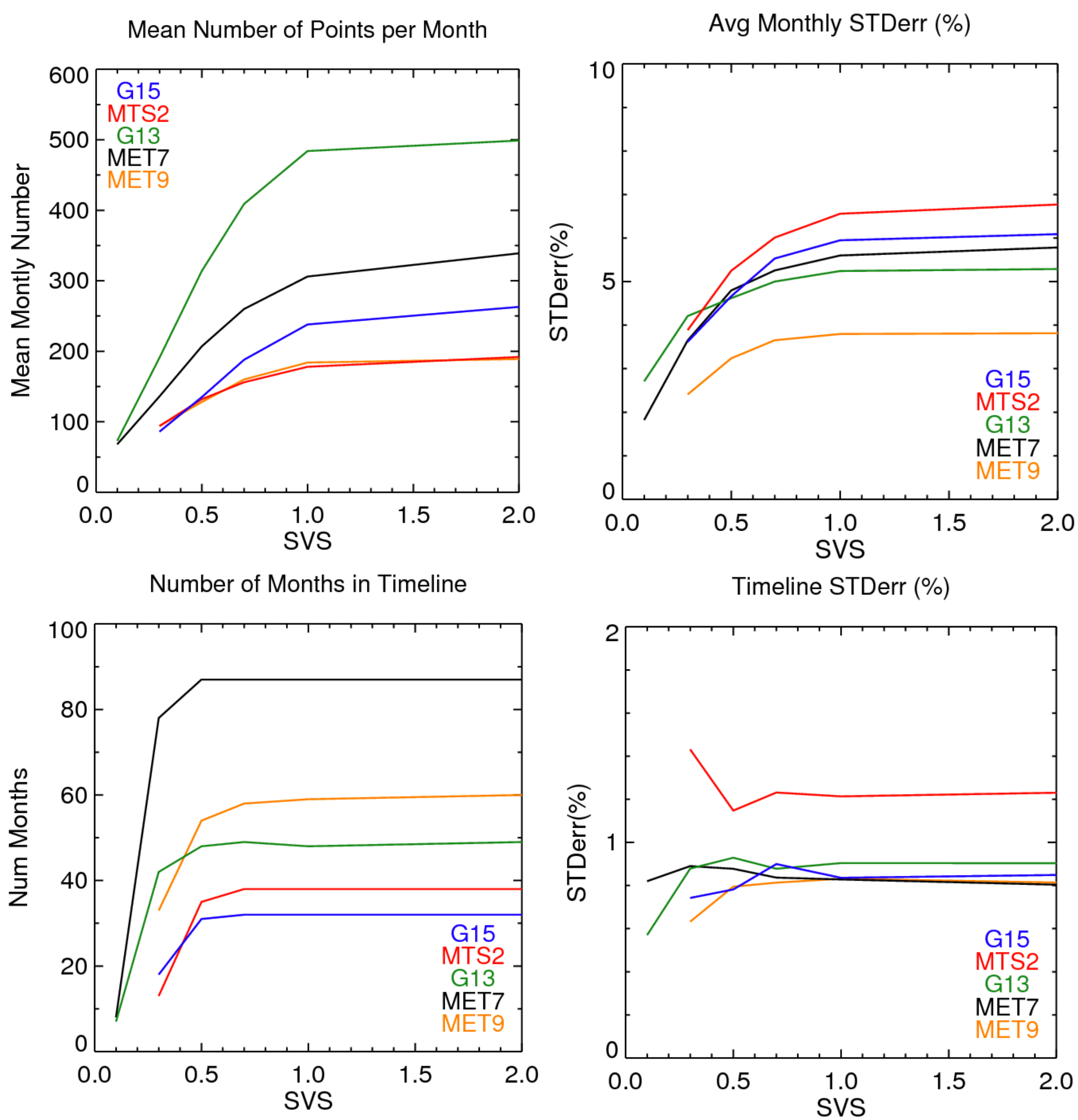
Spatial Homogeneity Testing (SVS)



	SVS < 0.3	SVS < 0.7	All
Mean Monthly Num	226	492	699
Mean Mon STDerr (%)	4.19	5.02	5.39
Number of Months	54	65	66
Timeline STDerr (%)	0.87	0.80	0.83



SVS = Standard deviation / value

Need balance of enough points per month and enough months per timeline, while minimizing STDerr

Found that for all GEOs, SVS did not make a large impact when > 0.7

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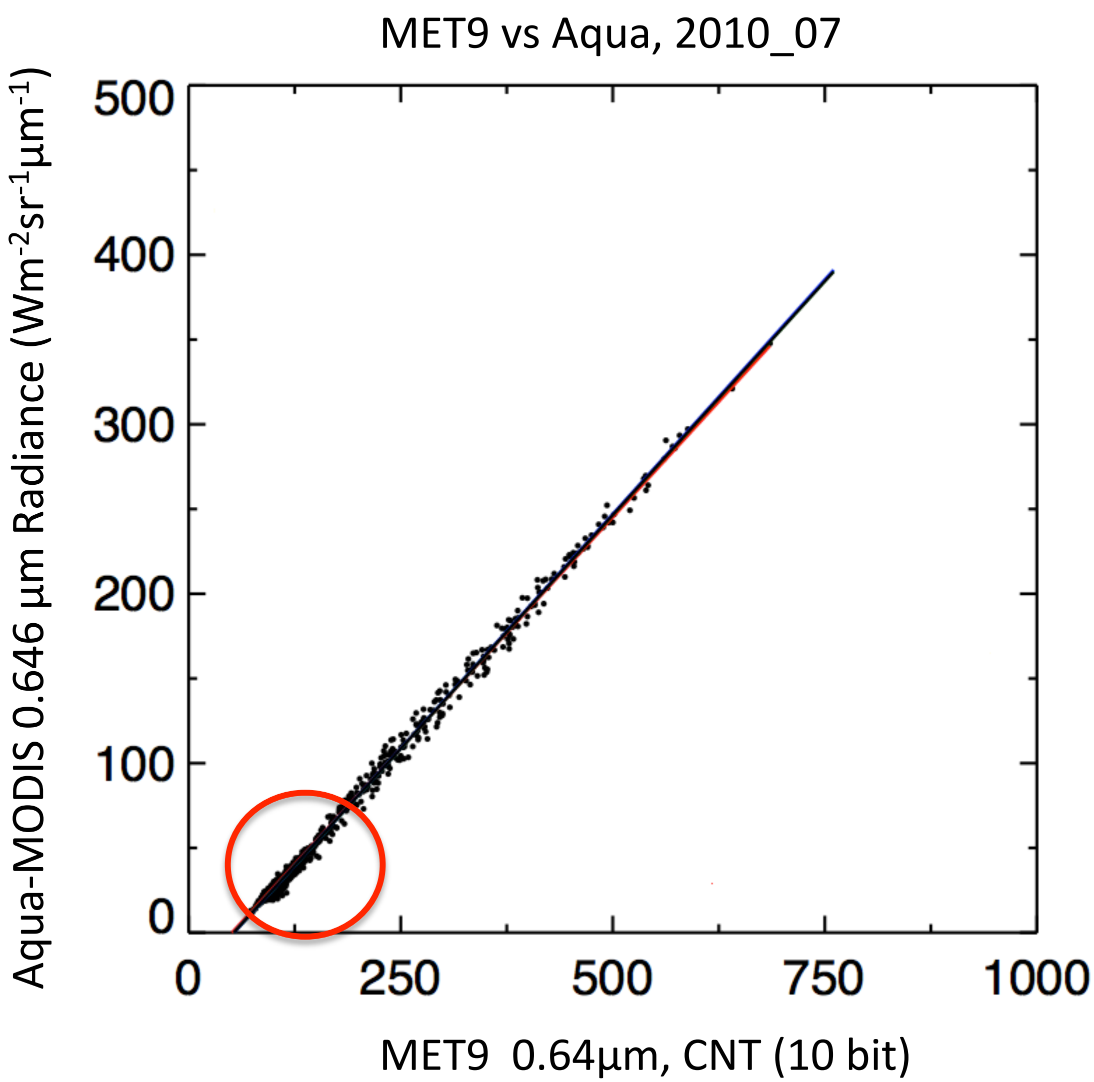
Graduated Angle Matching (GAM)



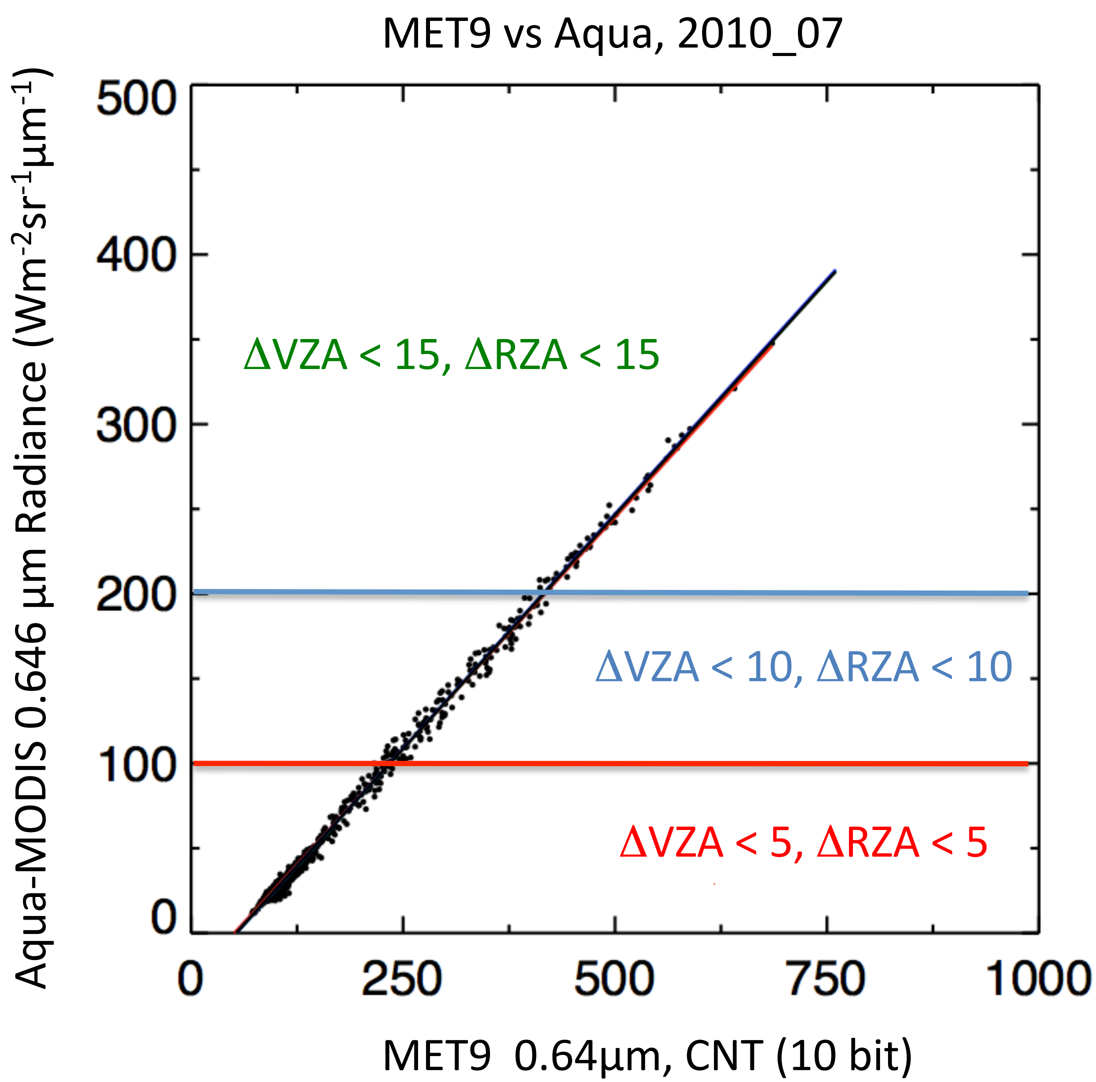
Usual angle matching usually requires
ΔVZA < 15°
ΔRZA < 15°

Note most of the points are in clear-sky (dark radiances) where the conditions are most anisotropic

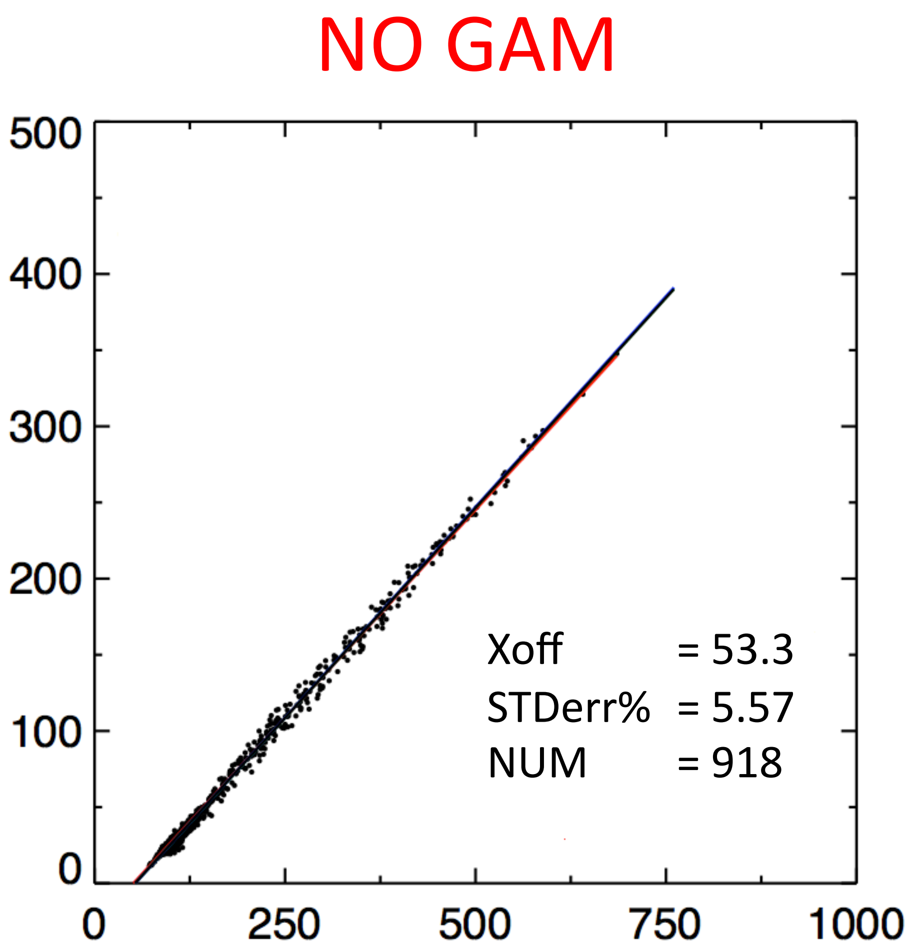
The least number of points occur over bright clouds that are most isotropic

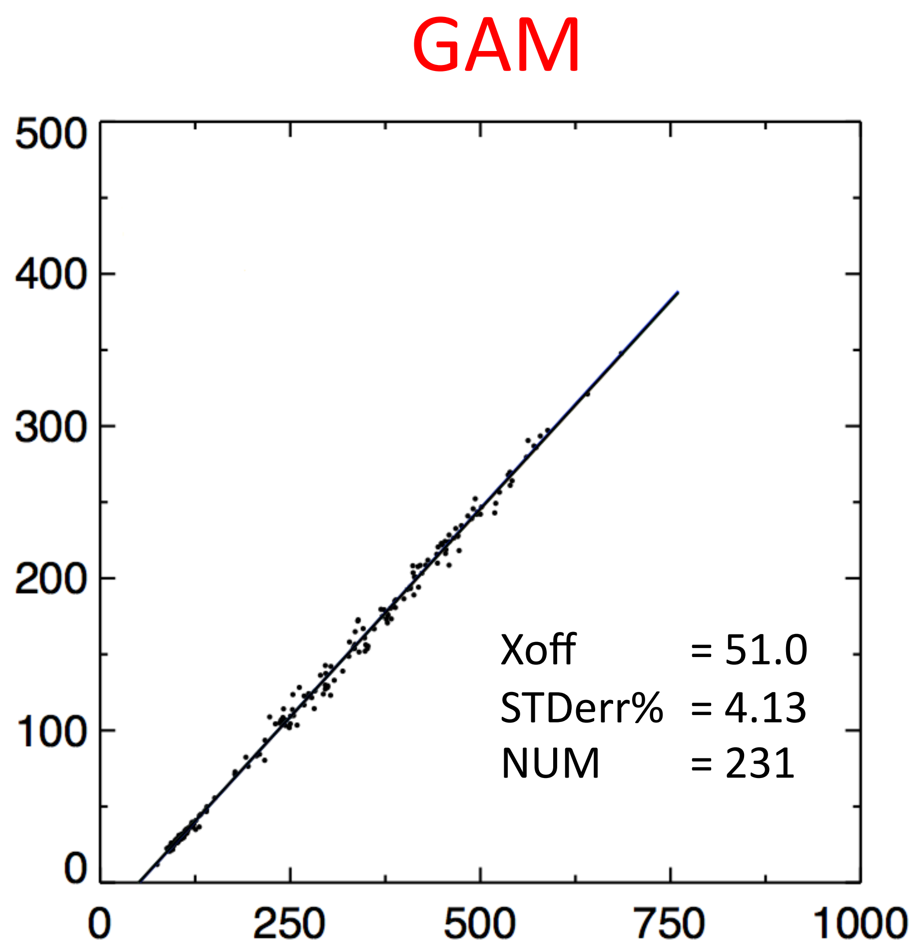
Then a more restrictive angle matching can be applied to the dark radiances, while retaining sufficient sampling

Graduated Angle Matching (GAM)



Graduated Angle Matching (GAM)

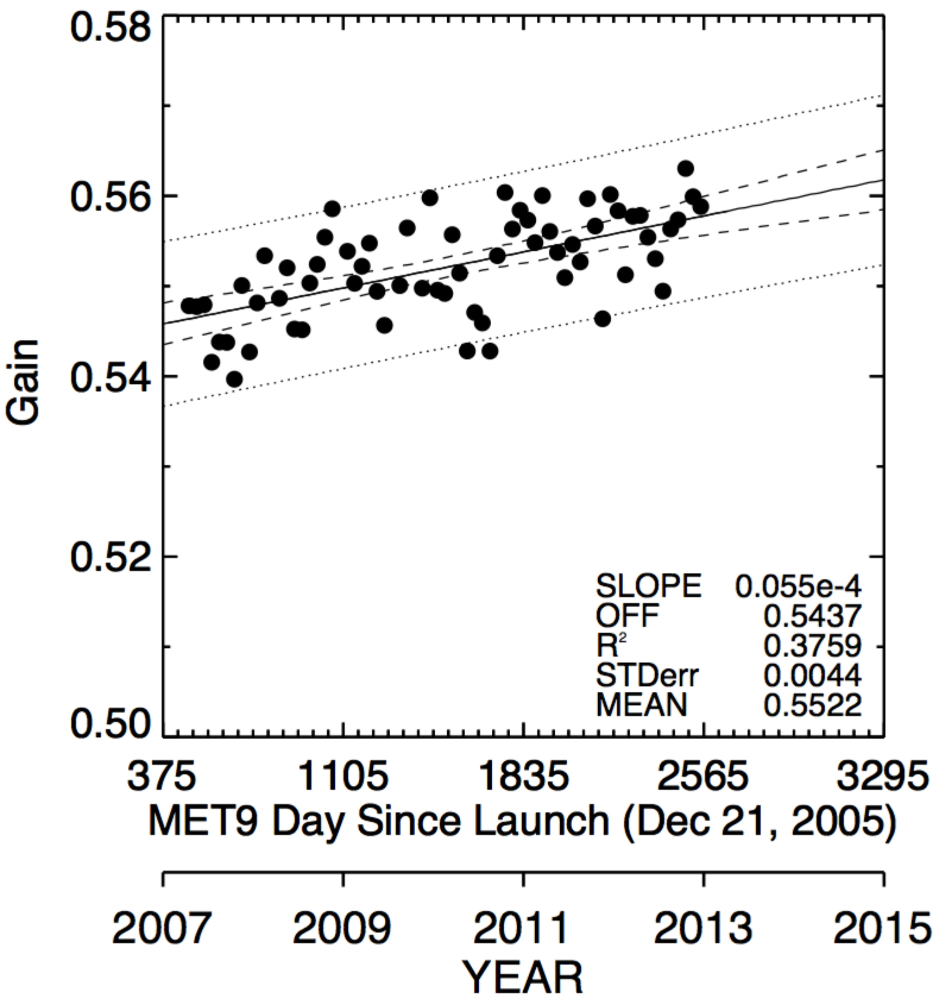




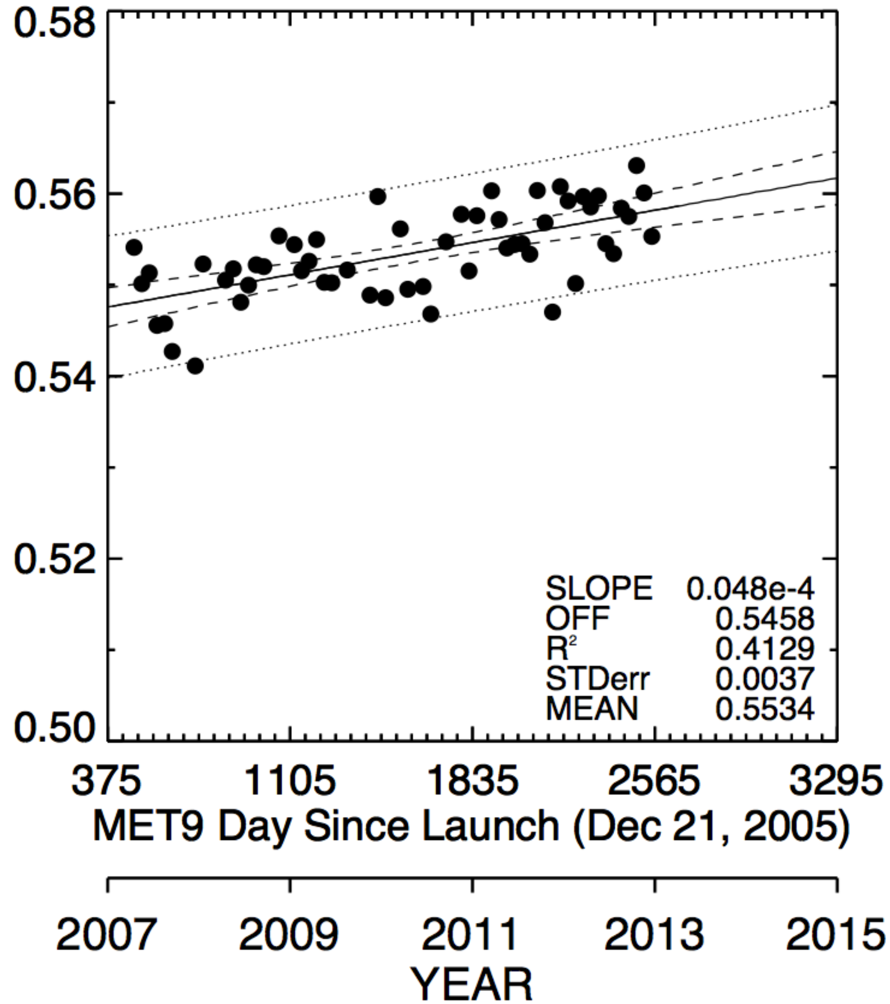
The x offset or space count is closer to the true space count of 51

Graduated Angle Matching (GAM)

NO GAM



GAM



Mean 5-year Met-9 space count

Improvement	Space Count
noGAM noSBAF	53.8
GAM noSBAF	53.5
noGAM SBAF	52.6
GAM SBAF	52.1
true	51

Applying SCIAMACHY SBAFs to the Aqua-MODIS radiances and incorporating GAM when regressing the MODIS and Met-9 radiance pairs causes the linear regression space count averaged over the 5-year Met-9 record to be closer to the true space count.

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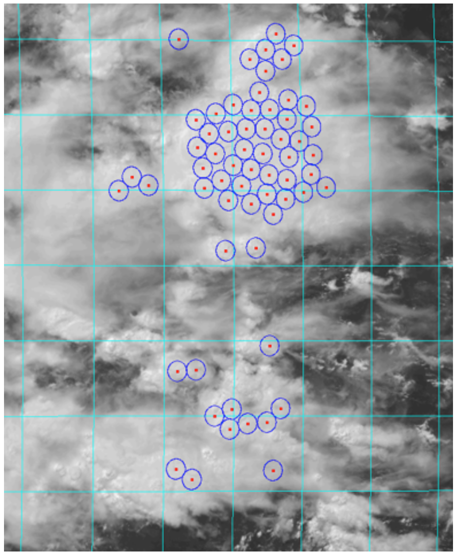
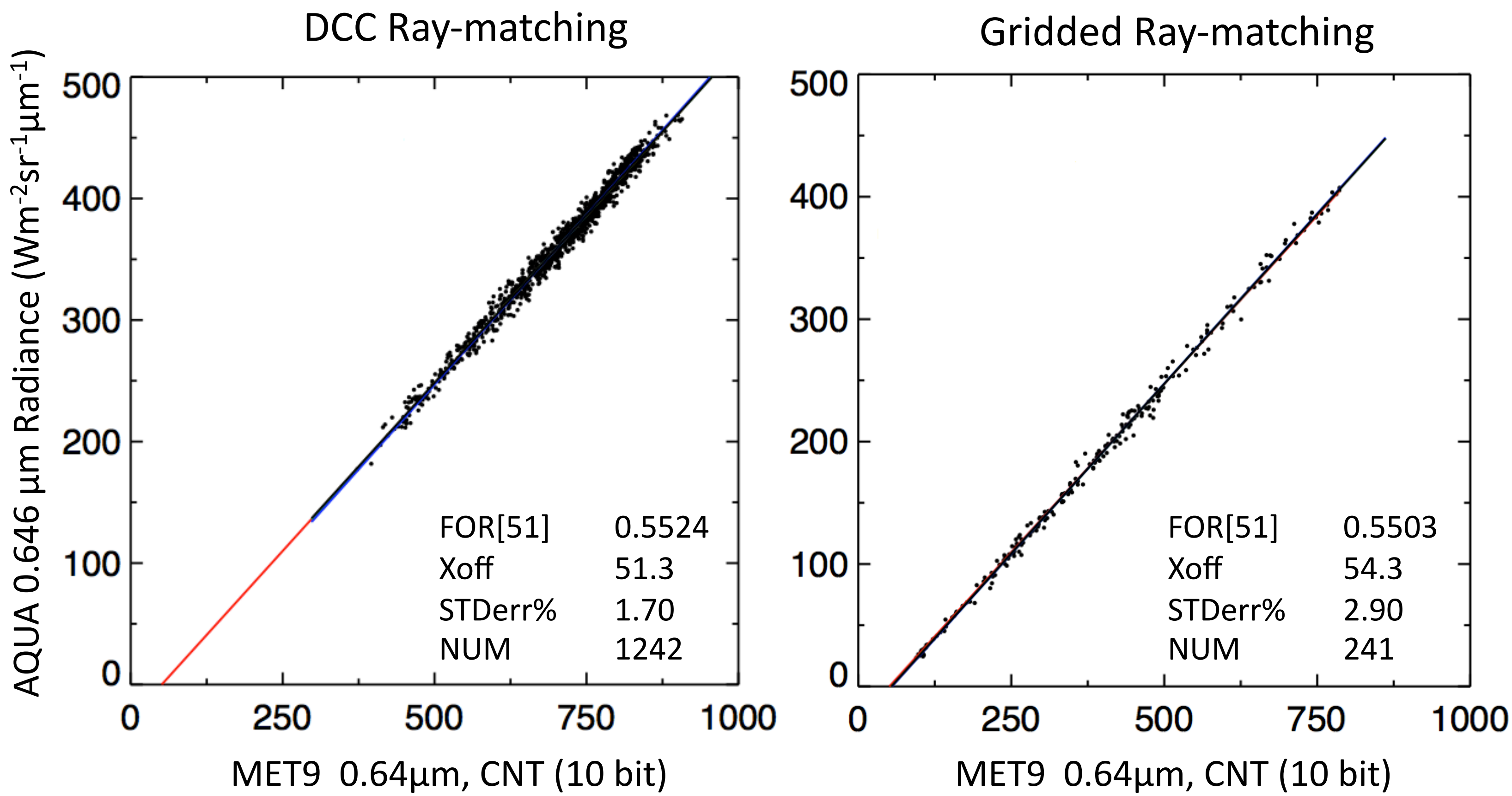
DCC ray-matching

- Find Aqua equatorial crossings in GEO DCC domain (±40° E/W, ±20° N/S of GEO sub-satellite point)
- Identify the MODIS DCC pixels, predict GEO angles at the centers
- Aggregate pixel data into 30-km MODIS FOV, then systematically locate the coldest MODIS FOVs and filter out any overlap
- Use MODIS center lat/lon to locate GEO pixels, and aggregate pixel data into 30-km GEO count and MODIS radiance pairs
- Normalize the cosine SZA, apply SCIAMACHY SBAF factor, perform monthly linear regressions to derive monthly gains
- Compute timeline trends from monthly gains

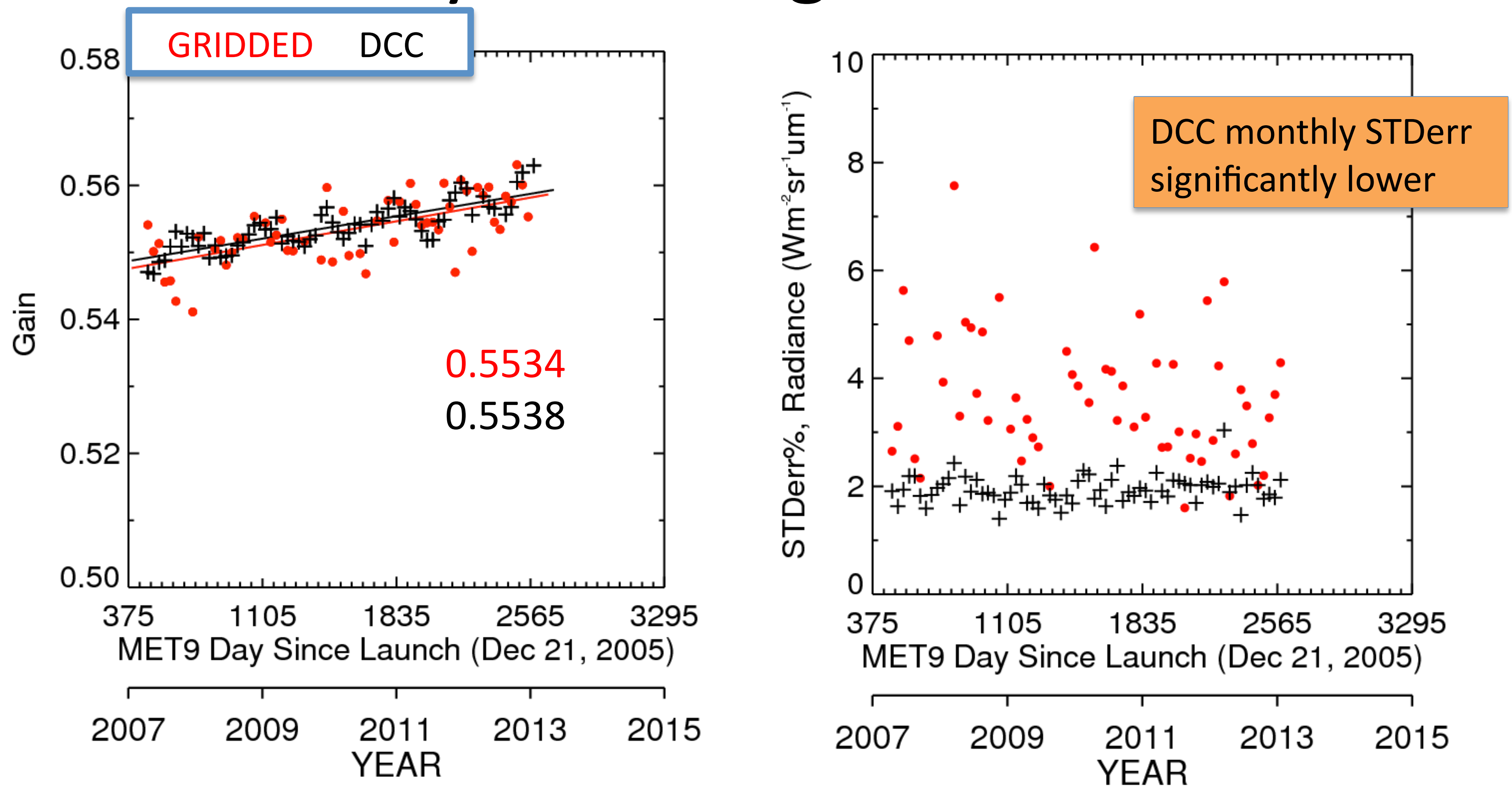
DCC Parameter	Optimum
σVS	<0.2%
σIR	<7.5K
ΔAngle	ΔRZA<25, ΔVZA<15
ΔTime	15 min
Temp	<220 K
Angles	VZA<40, SZA<40
FOV	30-km



Comparison of DCC and Gridded Ray-matching Monthly Regression



Consistency of Calibration Between Ray-matching Methods



DCC ray-matching has the advantage of having a smaller SBAF, and a greater angle matching tolerance, which reduces the monthly stderr.

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

- DCC ray-matching relies on sufficient monthly sampling during all months of the year. The thresholds were derived using the months with the least DCC frequency.

- Validate the gridded and DCC ray-matching procedures with other GEOs