Deriving a geostationary visible sensor calibration reference using DCC targets tied to the Aqua-MODIS band 1 calibration.

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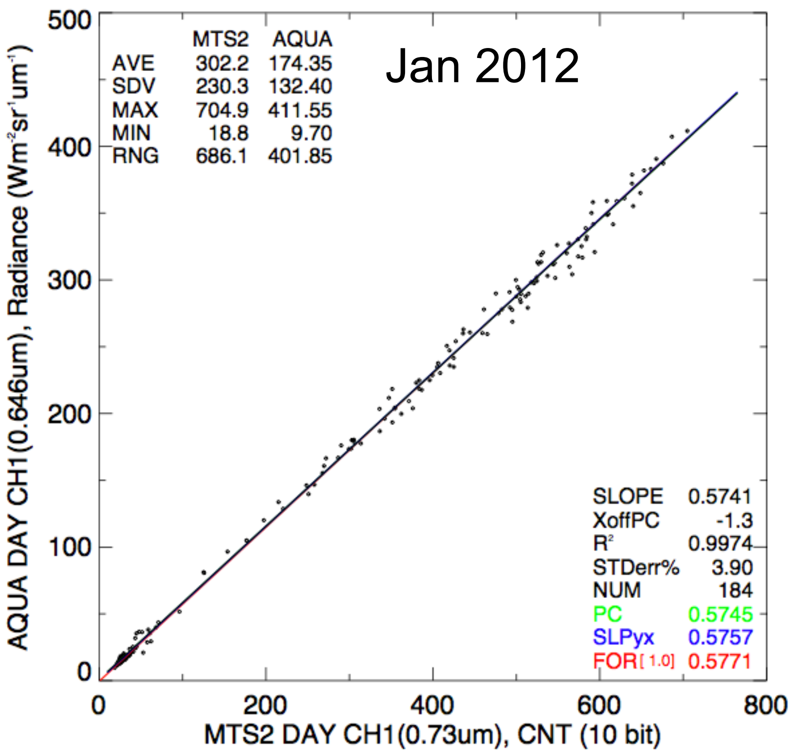
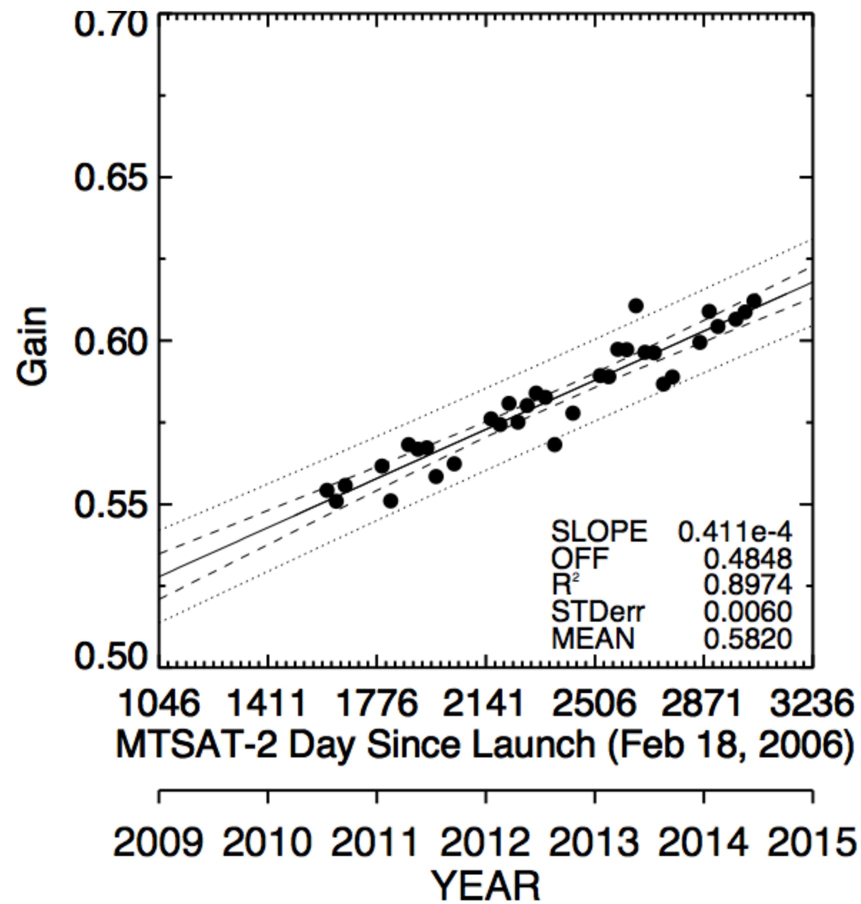
Simple GEO to MODIS Ray-Matching Cross-Calibration Method

- 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<10°, ΔRAZ < 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

Simple MTSAT-2/Aqua-MODIS Ray-Matching





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

Ray-Matching Uncertainty

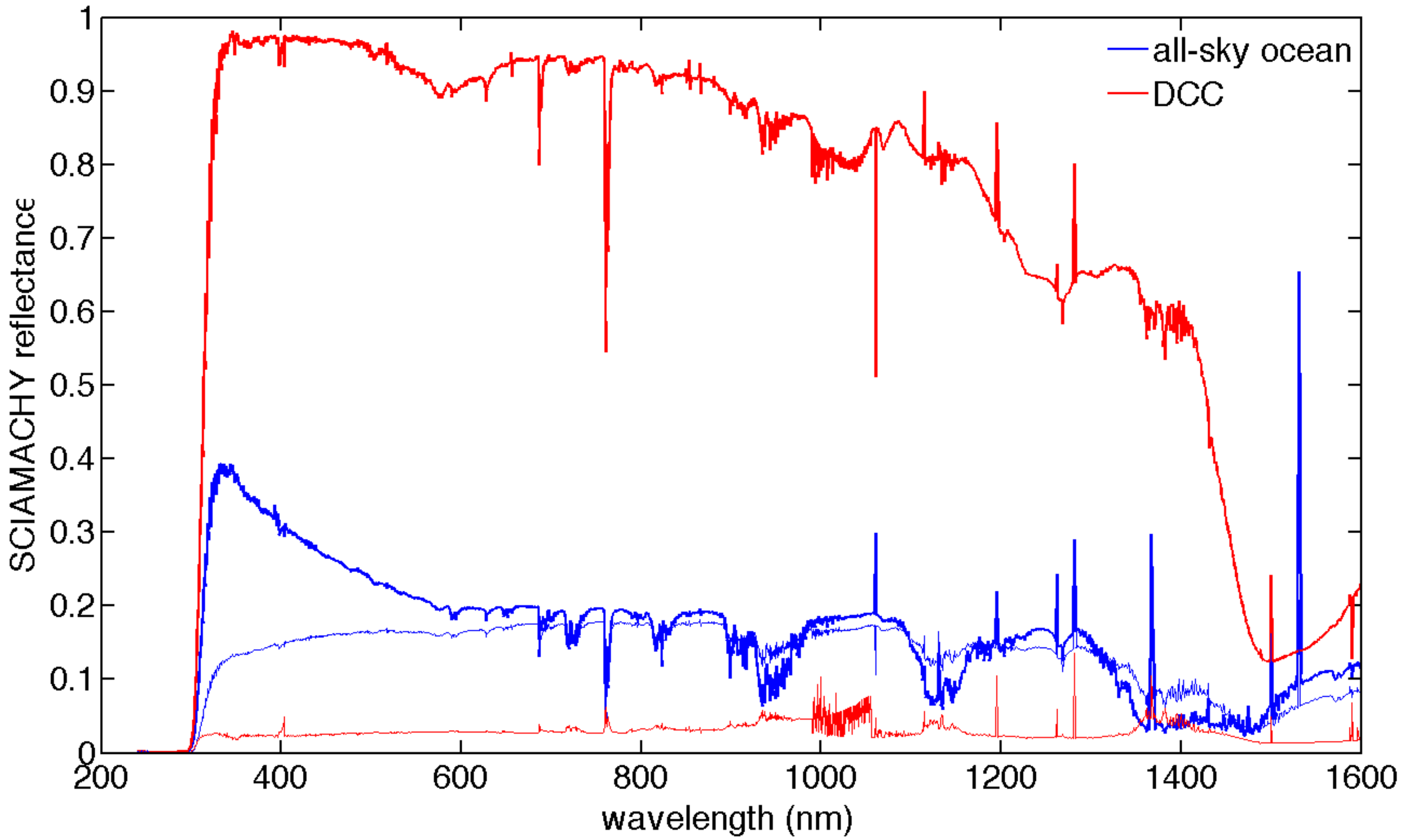
GEO satellite	Aqua-MODIS 0.65µm absolute calibration accuracy	Temporal trend Standard error	MODIS/GEO SBAF uncertainty	Total
MTSAT-2	1.64%	0.60%	1.50%	2.30%
GOES-13	1.64%	0.52%	0.92%	1.95%
Met-9	1.64%	0.48%	0.28%	1.73%

- The long-term calibration uncertainty is shown above

- The earth target that is most Lambertian (less angle matching dependency) and is most spectral flat (less SBAF dependency) are DCC making them ideal as calibration transfer targets

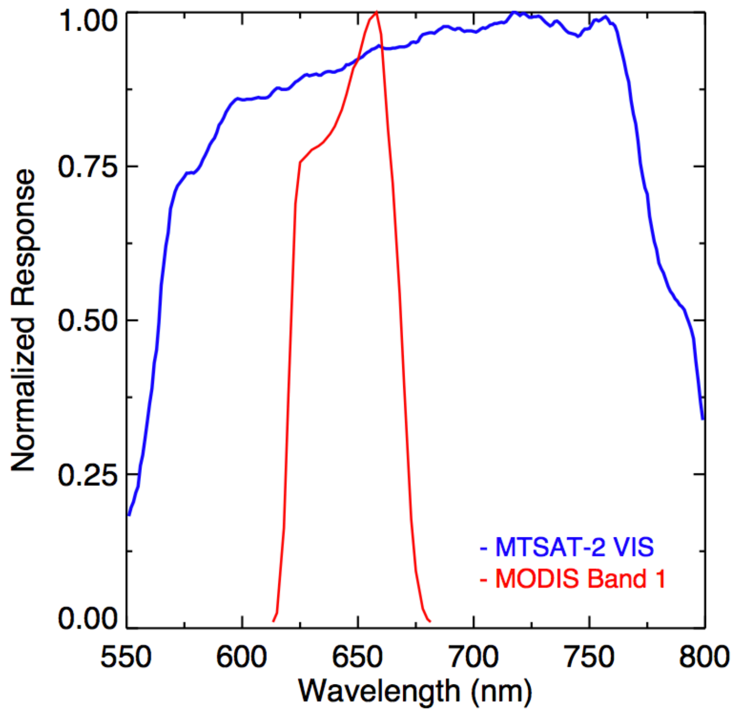
- Uncertainty does not take into account inaccuracies due to band SRF , satellite navigation, imager noise <50km, orbit dependencies, solar spectra, etc.

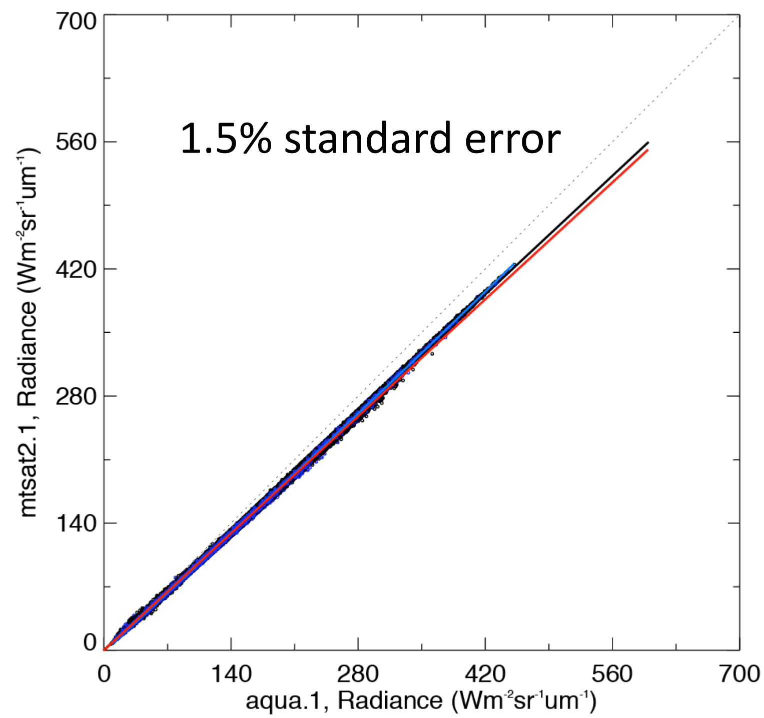
SCIAMACHY spectra



- DCC are the brightest 46 FOV between 2002 and 2012
- The reflectance standard deviation of DCC is <3%

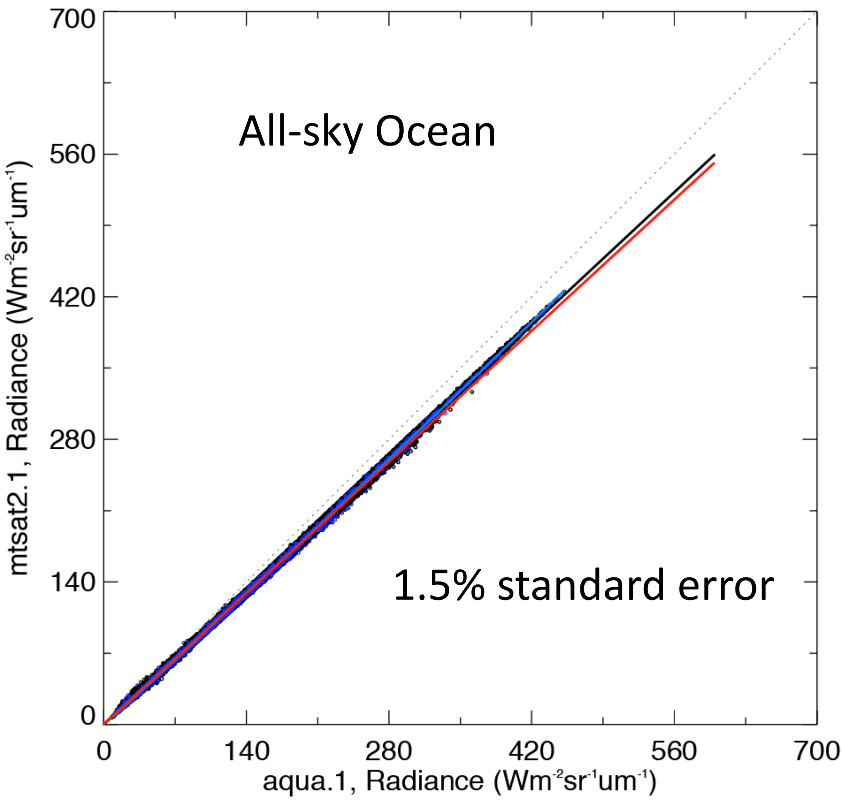
Spectral Band Adjustment Factor

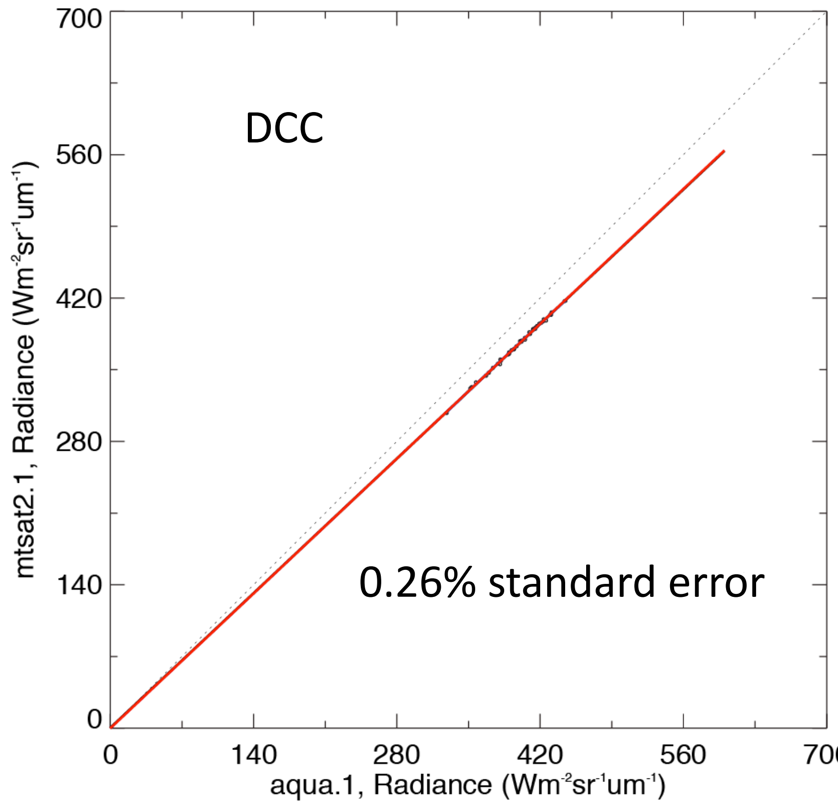


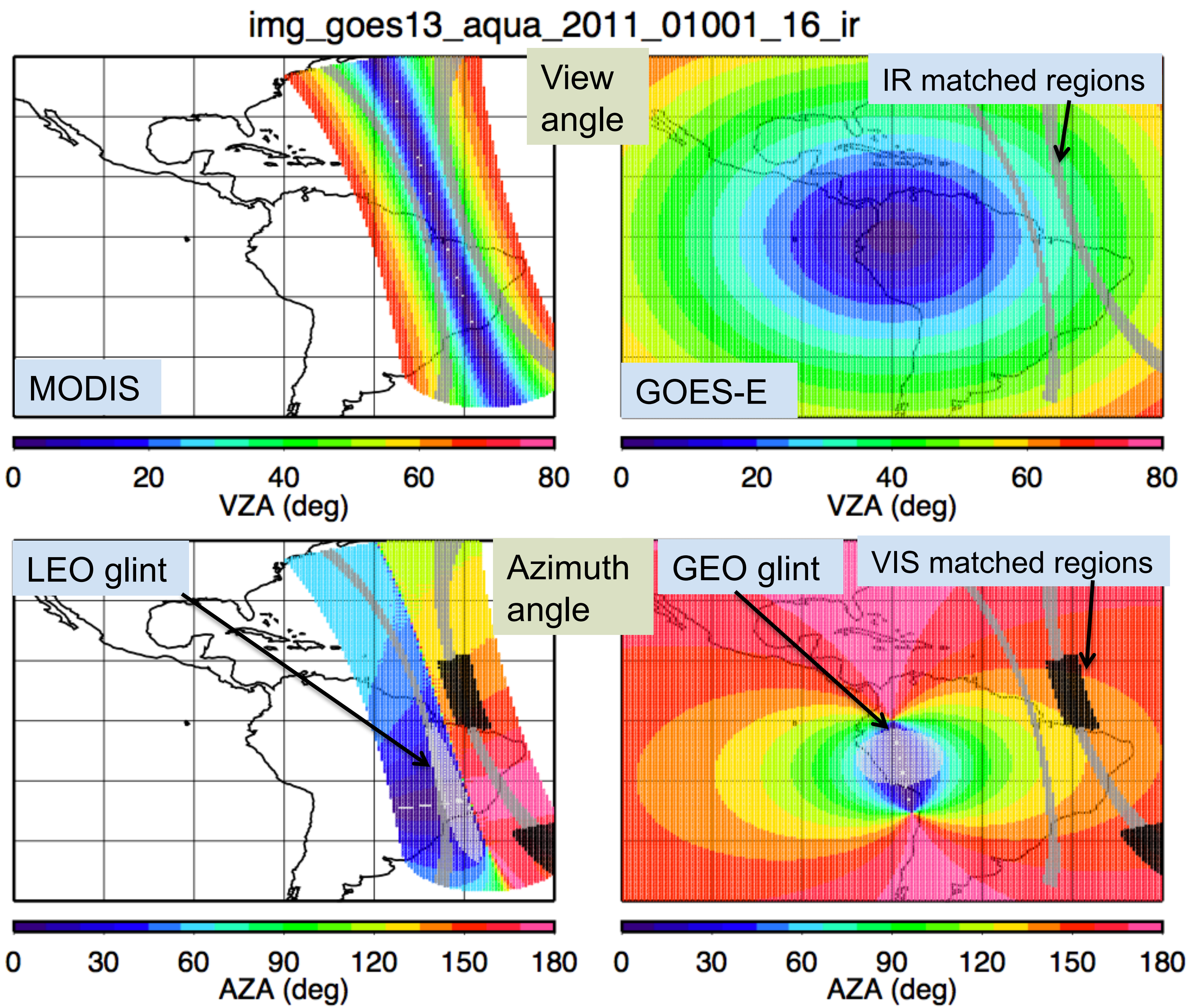


SCIAMACHY footprint pseudo radiance pairs over the MTSAT-2 equatorial cloud ocean domain, 2002-2010

MTSAT-2 SBAF Comparison

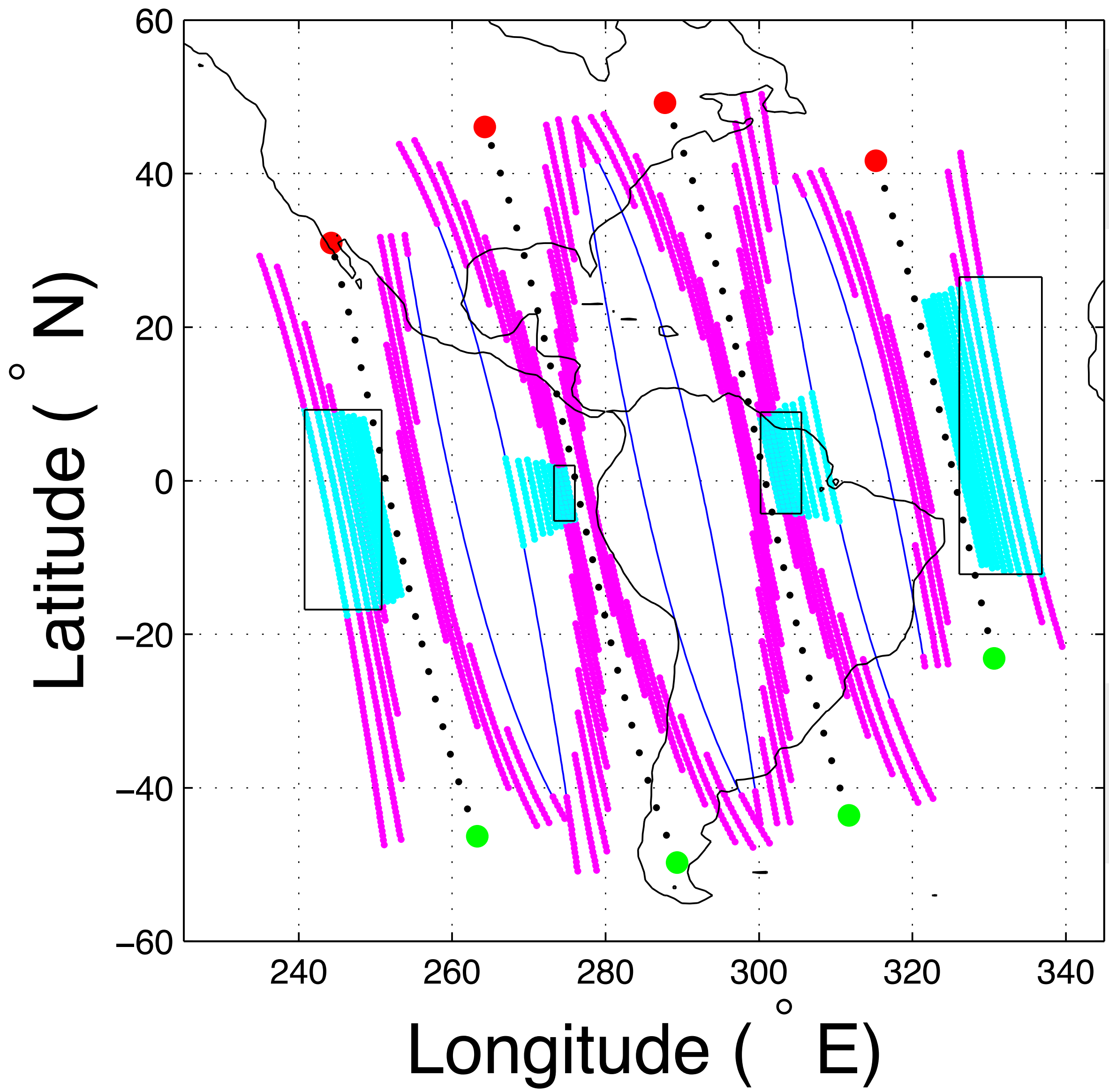





img_goes13_aqua_2011_01001_16_ir
View angle
IR matched regions
MODIS
GOES-E
0
20
40
60
80
VZA (deg)
0
20
40
60
80
VZA (deg)
LEO glint
Azimuth angle
GEO glint
VIS matched regions
0
30
60
90
120
150
180
AZA (deg)
0
30
60
90
120
150
180
AZA (deg)

Predictor Enhancements

Aqua vs. GOES 13. Jan 2, 2011



4 MODIS orbits intersects the GEO domain during the day

The cyan regions are were the only angle matches occur

DCC Ray-Matching

- The challenge of DCC raymatching technique is capturing the angle-matched DCC in the GEO domain
- Will there be enough samples?

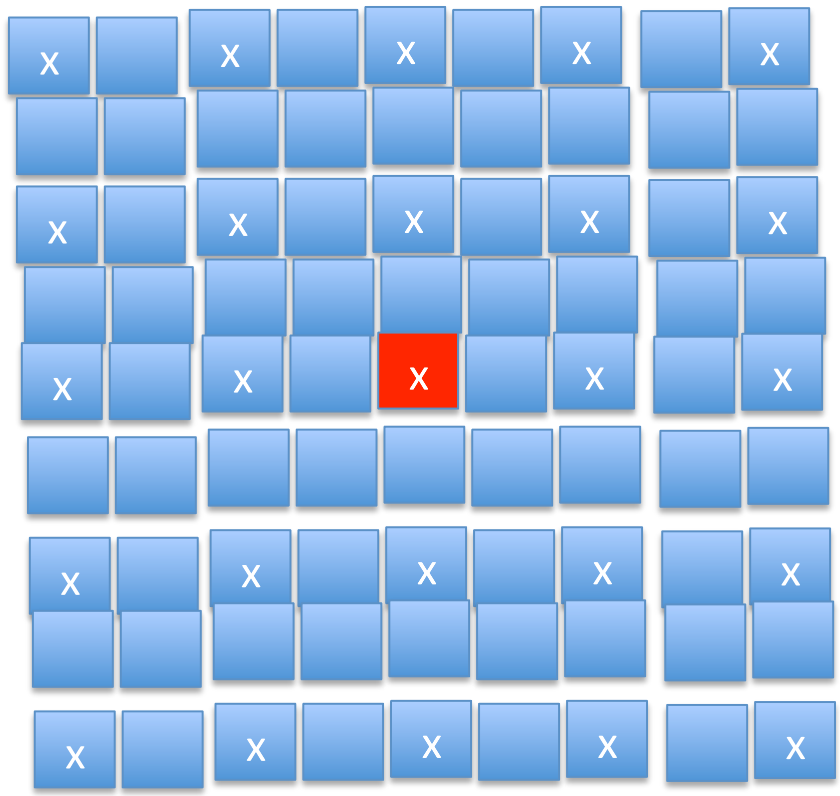
DCC Ray-Matching Procedure

- Find Aqua equatorial crossings in GEO DCC domain (±40° E/W, ±20° N/S of GEO sub-satellite point)
- Predict GEO angles from MODIS pixel and output spatially averaged 0.65um radiance of surrounding region (9x9 km^2, 29x29 km^2) if criteria met:

  - ΔSZA<5°, ΔVZA<10°, ΔRAZ<15°

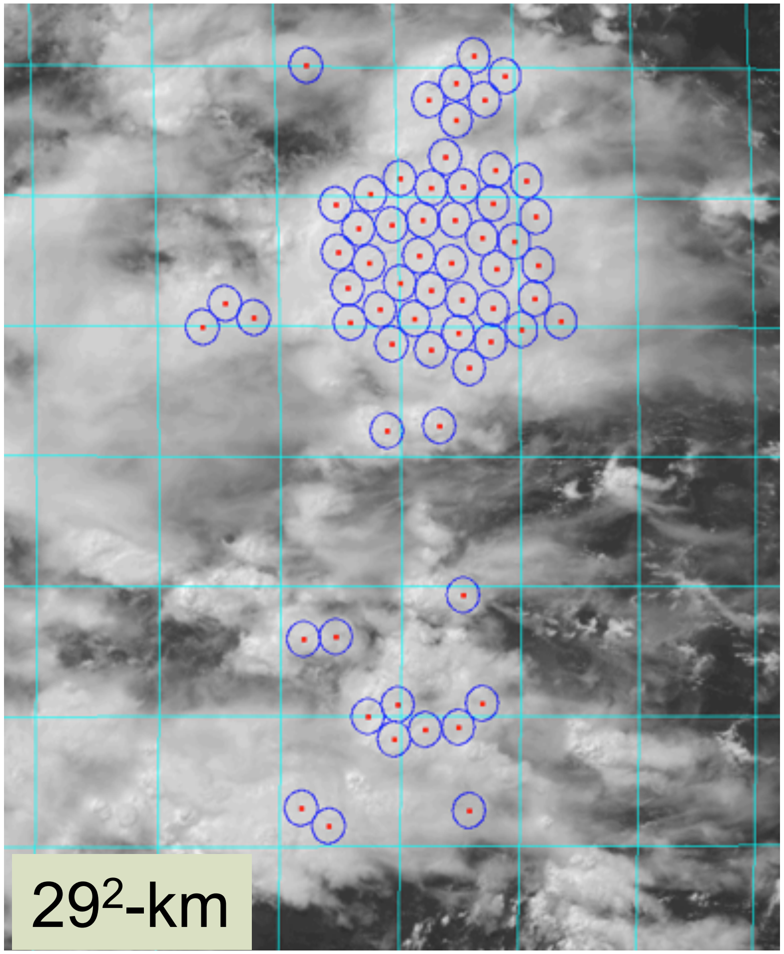
  - Average region 11um T<205K
- Locate coldest regions, filter overlap, aggregate pixel data into monthly files
- Match with available GEO data from McIDAS, spatially average visible radiance same as with MODIS
- Normalize the cosine SZA, apply SHIAMACHY SBAF factor, perform monthly linear regressions to derive monthly gains
- Compute timeline trends from monthly gains

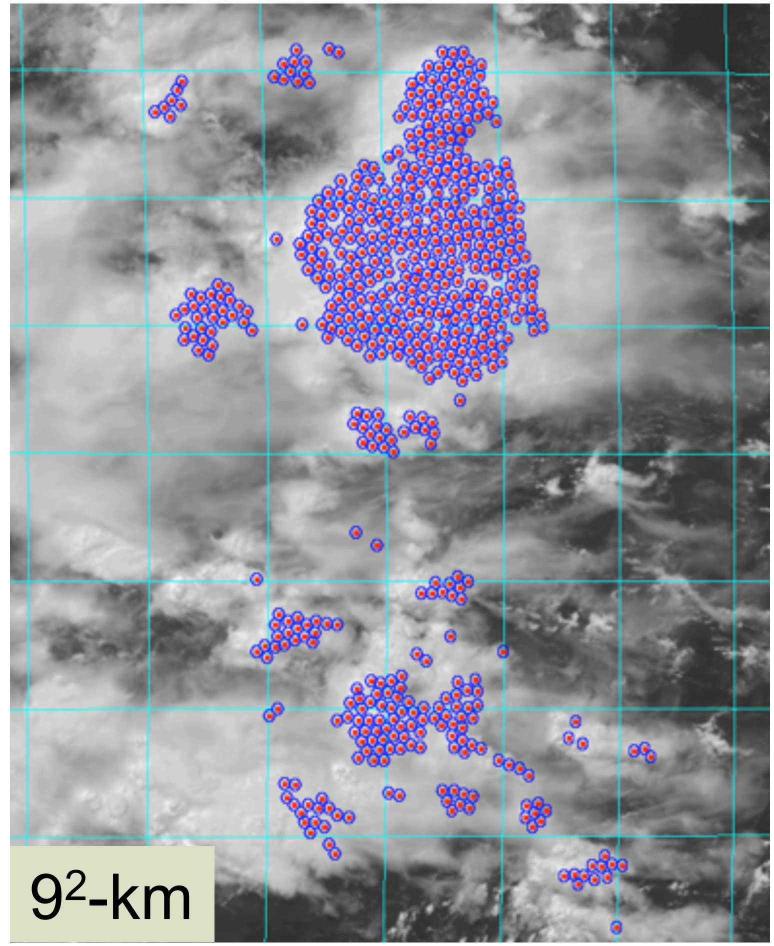
Subsampling & Regional Averaging



5x5 MODIS = 9x9 MTSAT-2

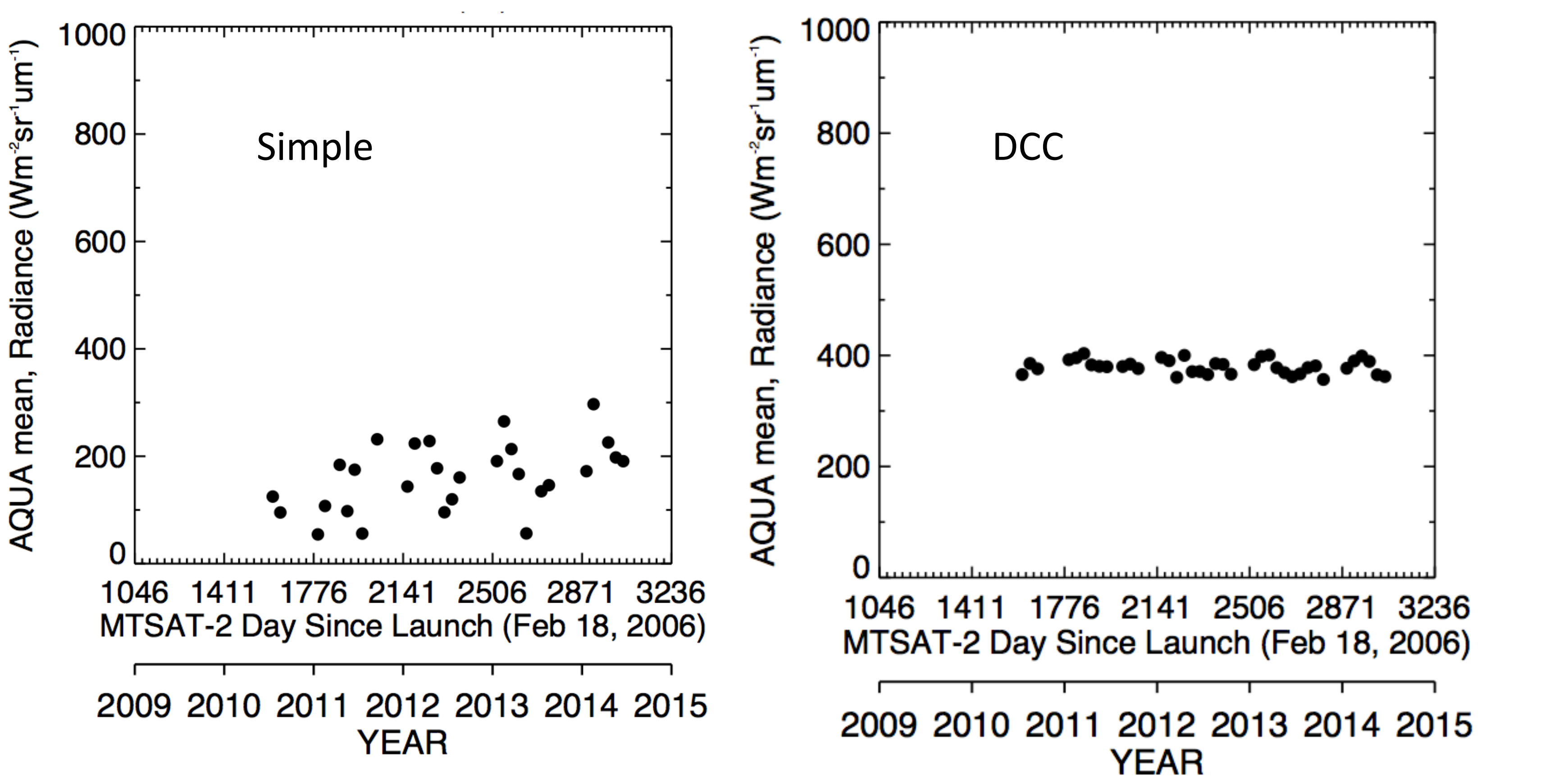
DCC Ray-Matching





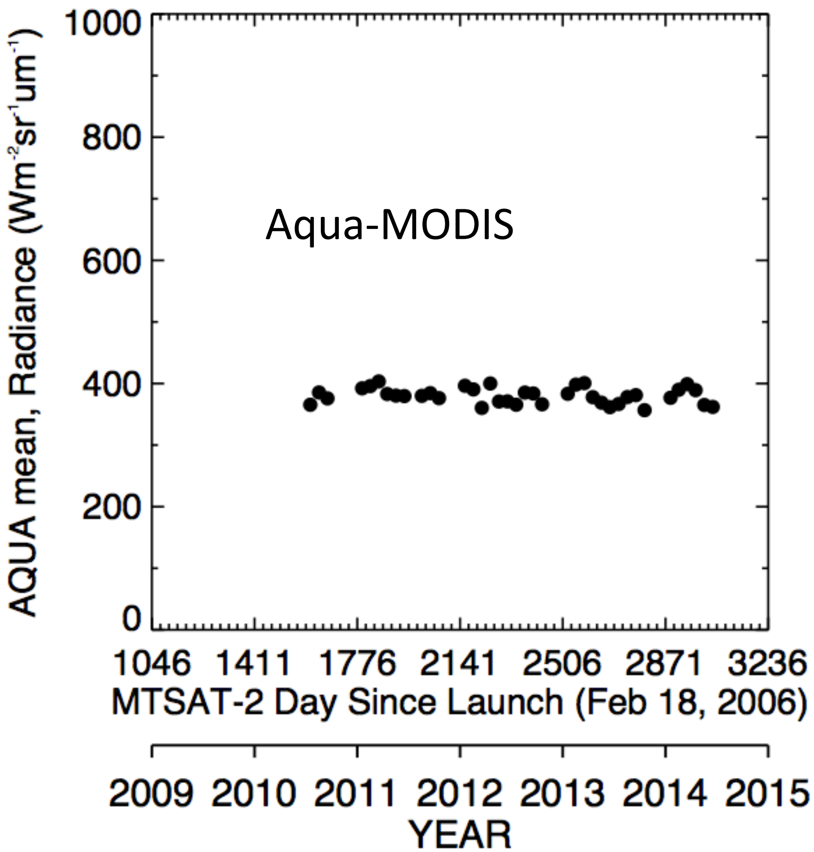
1° lat/lon grid, MTSAT-2, July 20, 2011 2:32 GMT

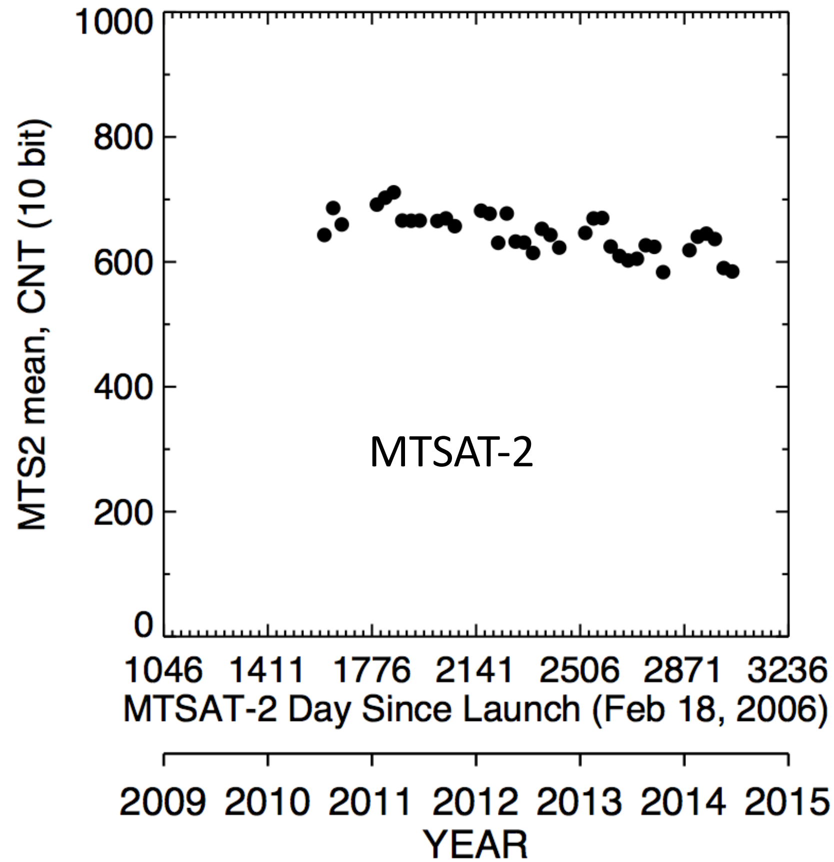
Monthly mean Aqua-MODIS band 1 radiance



The stability of the monthly mean MODIS radiances reveal that DCC are stable targets if analyzed collectively (Must have maintained sun-synch orbit)

Ray-Matching Monthly Mean





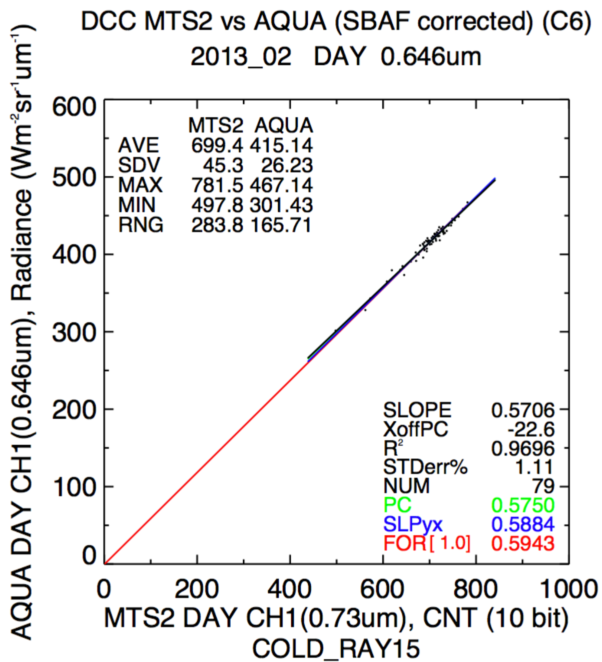
Easily monitor the degradation of the MTSAT-2 monthly mean DCC counts

Dependency test results

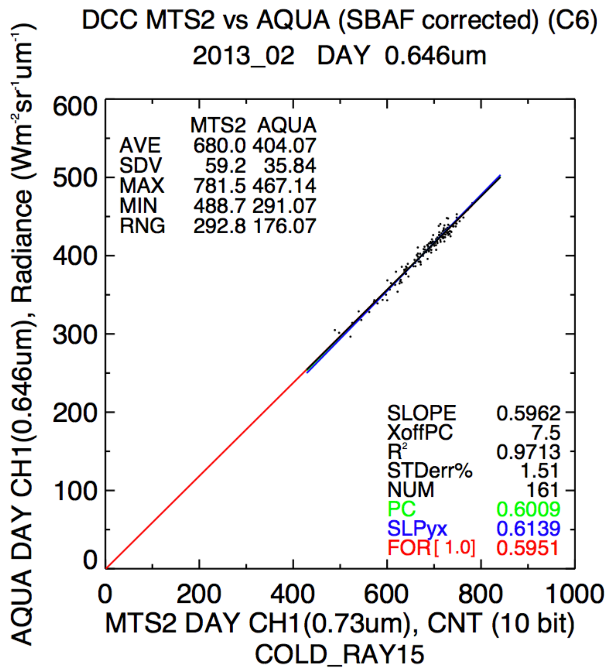
	Range test	optimum	Dependency
σVIS	1.0 to 0.05	0.10	Yes
σIR	5 to 2	5	None
Angle	ΔAZA<15, ΔVZA<10	same	None
Time	15 to 5	15	Slight
Temp	220-200	205	Slight
Lambertian	All angles	VZA<30, SZA<30	Yes
FOV	10 and 30-km	30-km	Yes

Spatial homogeneity dependency

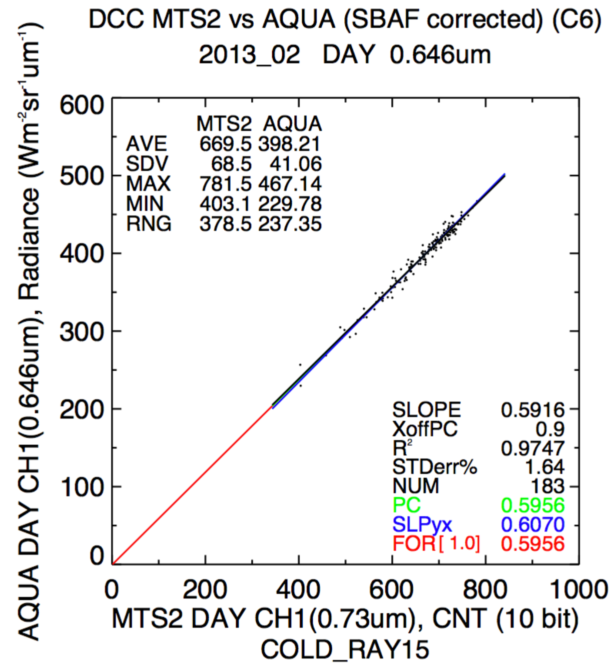
SVS=0.05



SVS=0.1

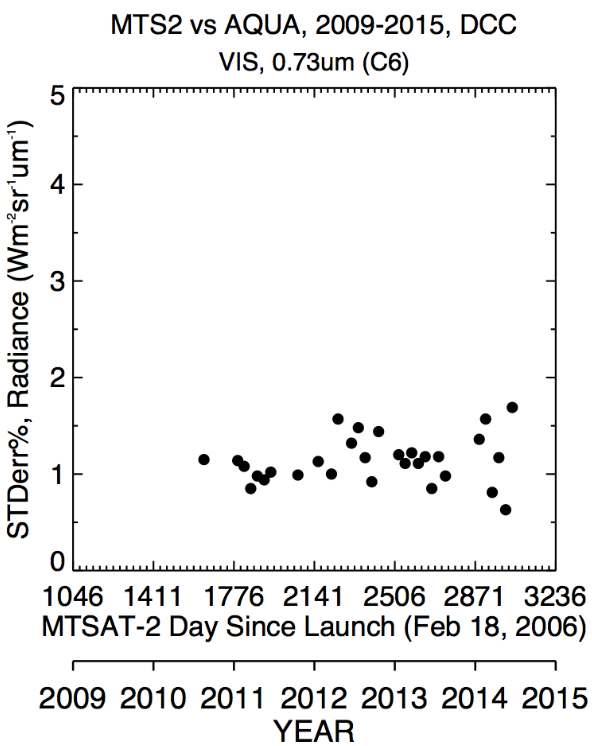


SVS=0.5

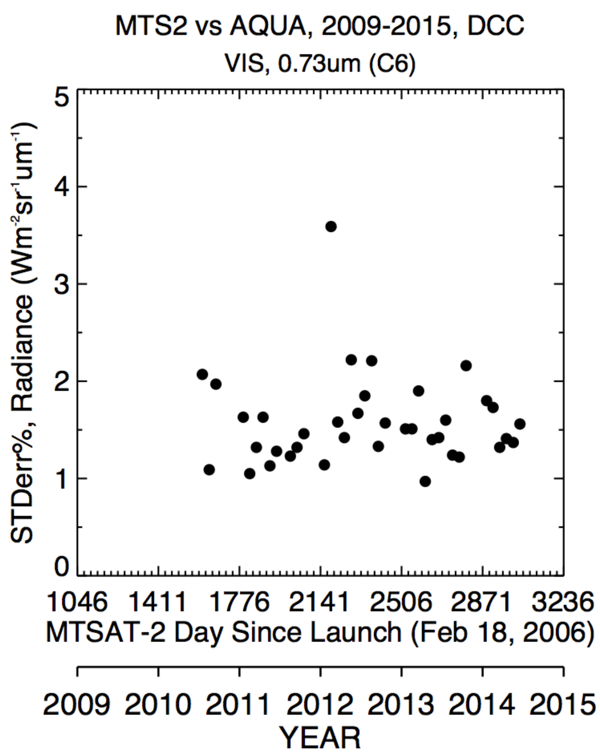


FOV Spatial homogeneity vs monthly standard errors

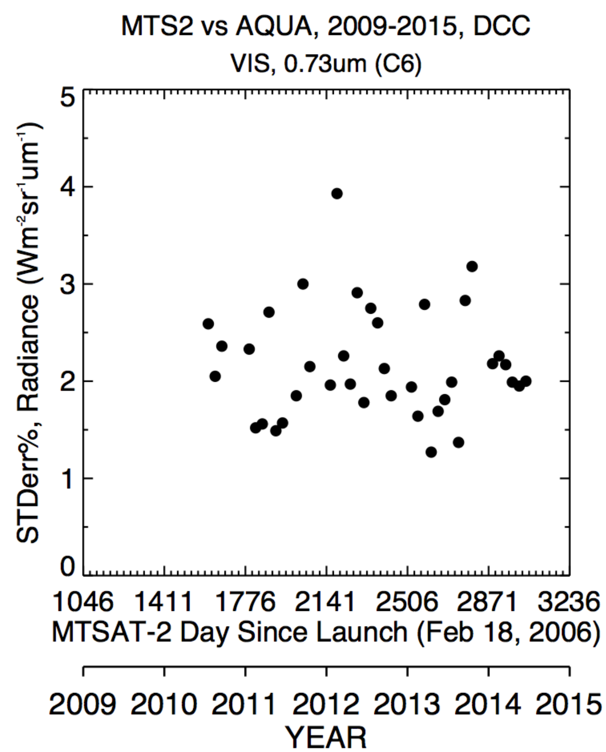
SVS=0.05



SVS=0.1

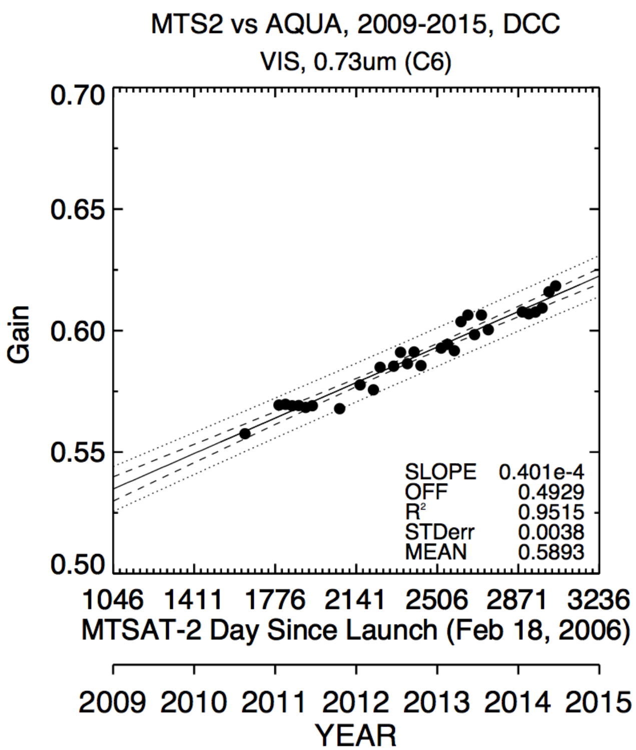


SVS=0.5

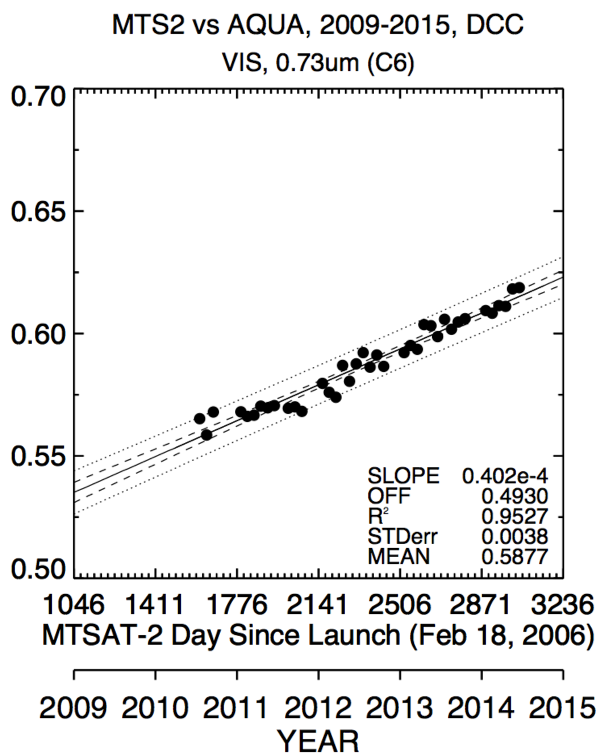


FOV Spatial homogeneity vs timeline temporal standard error

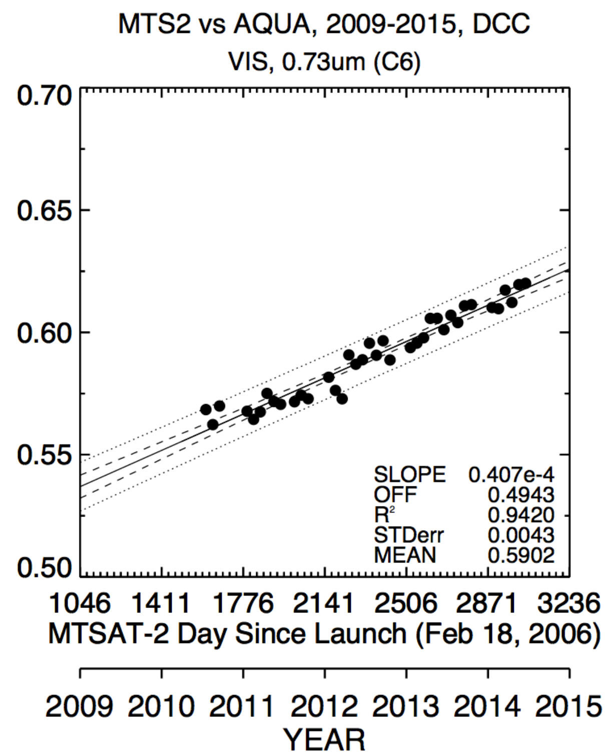
SVS=0.05



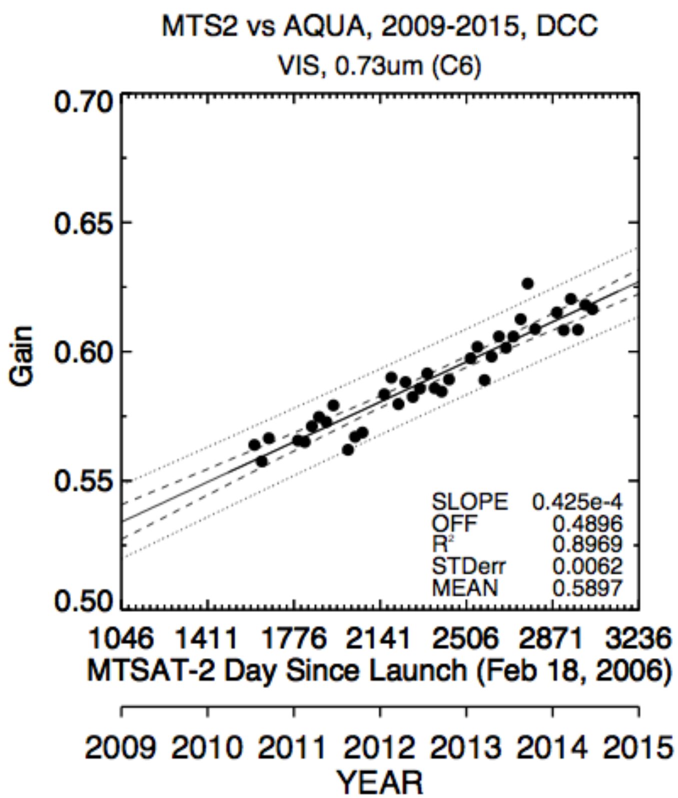
SVS=0.1

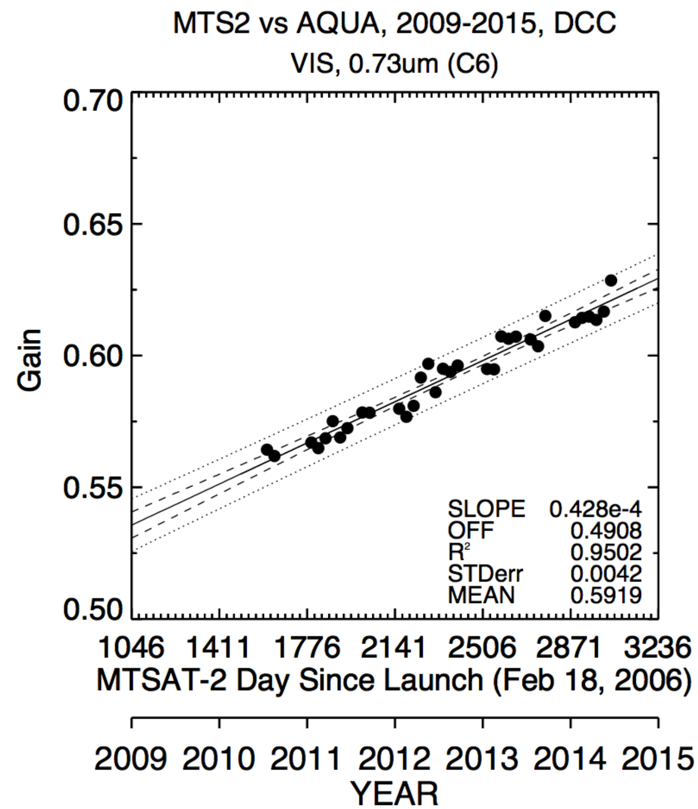


SVS=0.5



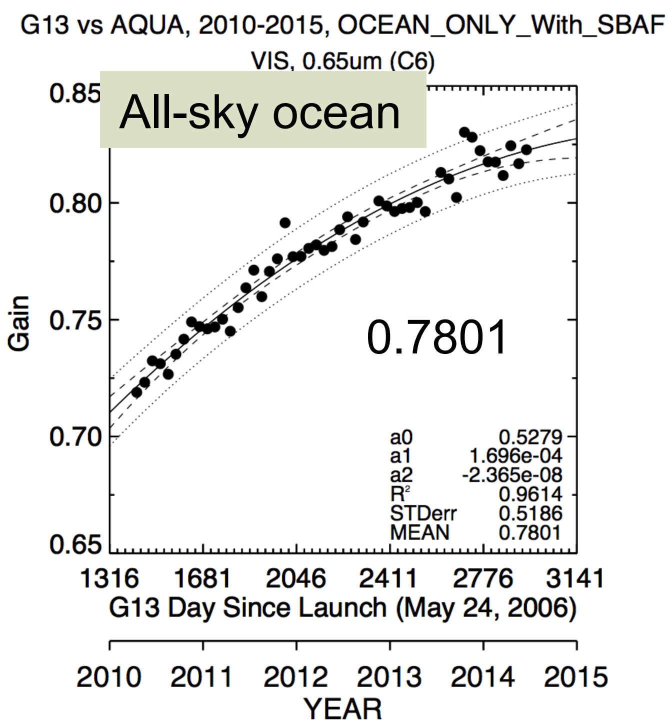
Lambertian

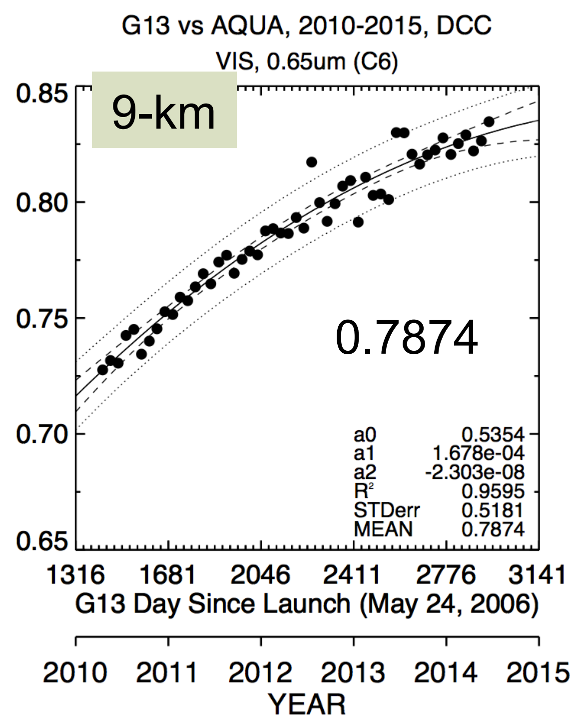


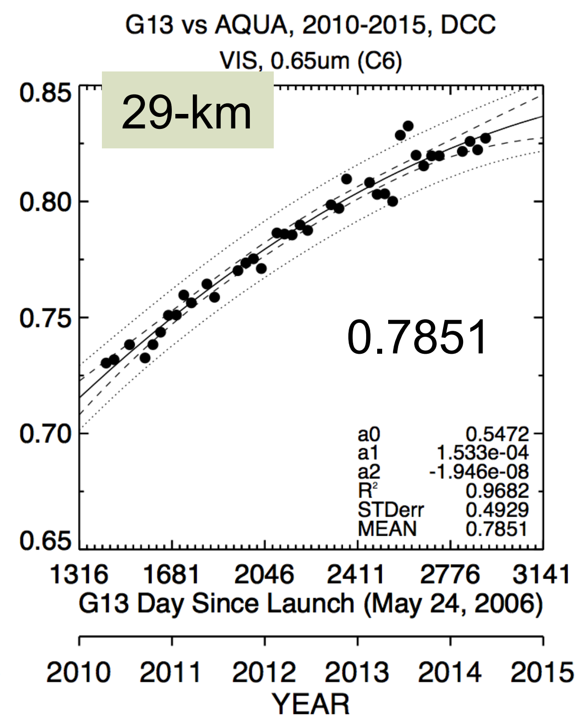


Only a slight reduction in monthly standard errors

Consistency of the calibration between methods







Conclusions

GEO satellite	Aqua-MODIS 0.65µm absolute calibration accuracy	Temporal trend Standard error SIMPLE/DCC	MODIS/GEO SBAF uncertainty SIMPLE/DCC	Total SIMPLE/DCC
MTSAT-2	1.64%	0.60% / 0.38%	1.50% / 0.26%	2.30% / 1.70%
GOES-13	1.64%	0.52% / 0.49%	0.92% / 0.42%	1.95% / 1.76%
Met-9	1.64%	0.48% / 0.25%	0.28% / 0.28%	1.73% / 1.68%

DCC ray-matching can provide improved total calibration uncertainty through lower temporal standard error and lower SBAF uncertainty