GSICS DCC telecon

Oct 26, 2011

NASA-Langley
David Doelling, Dan Morstad, Ben Scarino

Background

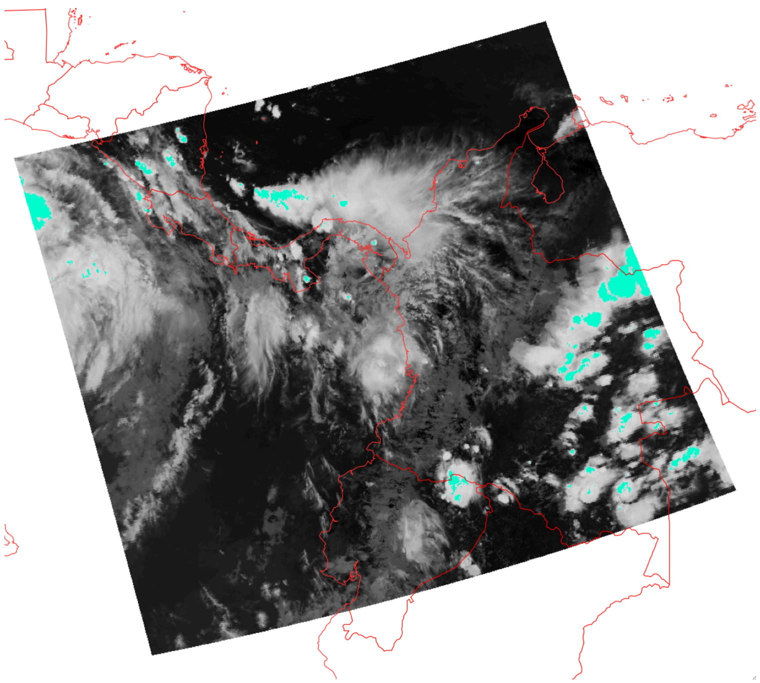
- DCC are bright, tropopause level clouds, solar diffusers, near the equator, offering the brightest earth invariant targets
  - Very little water vapor absorption above tropopause
  - Predictable and nearly Lambertion BRDF, when used as a large ensemble
  - Little inter-annual and seasonal natural variability
  - Found over all GEO domains with slight spatial brightness variations
- Use Aqua-MODIS as calibration reference
  - Aqua-MODIS more stable than Terra-MODIS
  - Use same identification and BRDF for both GEO and Aqua-MODIS to ensure proper calibration transfer
  - Nearly spectrally flat, but use SCIAMACHY pseudo radiance for spectral band adjustment factor

Implementation

- Step #1: Identify DCC pixels on a monthly basis
  - Need to match Aqua-MODIS identified DCC, in order to use as calibration reference, spatial domain, GMT image range, BT thresholds, etc
- Step #2: Convert CNT_{DCC} to overhead sun $CNT_{DCCsz=0°}$
  - Use CERES DCC bidirectional model
- Step #3: Determine mode of $CNT_{DCCsz=0°}$
  - Need to empirically determine count increment
- Step #4: Solve for gain, based on Aqua DCC radiance, which is spectrally adjusted to the GEO SRF
  - Aqua MODIS is the calibration reference
  - Assume a temporal degradation function and solve for the coefficients
  - As with deserts there are natural variations
- Step #5: Derive the calibration uncertainty
  - Based on Aqua-MODIS calibration uncertainty, SBAF correction uncertainty, trend standard error

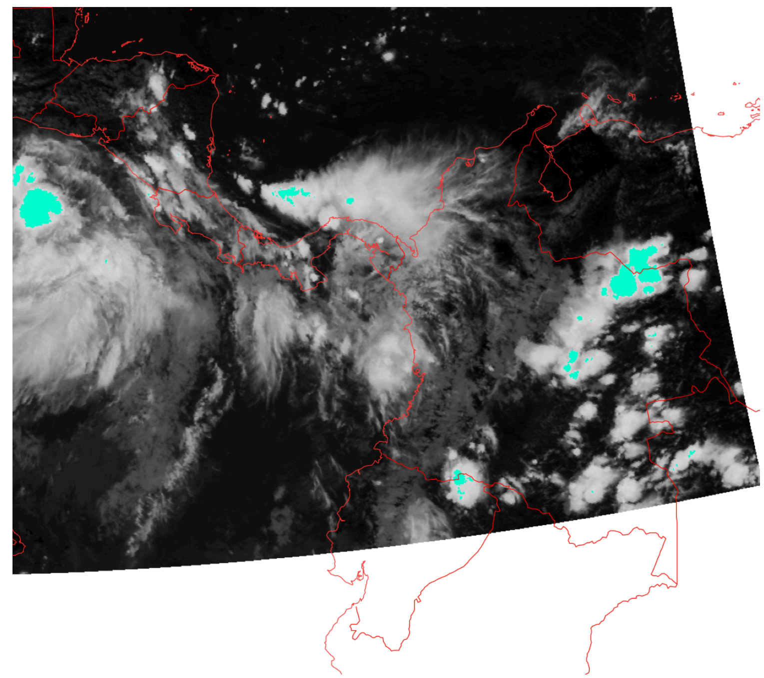
Step 1: Identify DCC

Aqua-MODIS DCC, coincident with GOES-13



T_{MODIS}<205°K in cyan

GOES-13 DCC

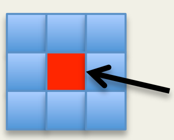


T_{GOES13}<206.5°K in cyan

- Using nearly coincident MODIS and GEO images, domain, and IR thresholds
- Loop through all lines and pixels over DCC domain to capture all DCC pixels

Identify DCC pixels

- Try to match the Aqua identified DCCs in order to use the Aqua MODIS DCC radiance
  - Cycle through the images during the specified GMT range using all days of the month
  - Restrict the pixel selection by spatial domain, 20°N to 20°S and specified longitude, include both ocean and land
  - $BT_{11\mu m}$ < 205°K – (T_{bias})
  - σ $BT_{11\mu m}$ < 1°K
  - σ CNT/CNT < 3%
  - SZA<40°, VZA<40°



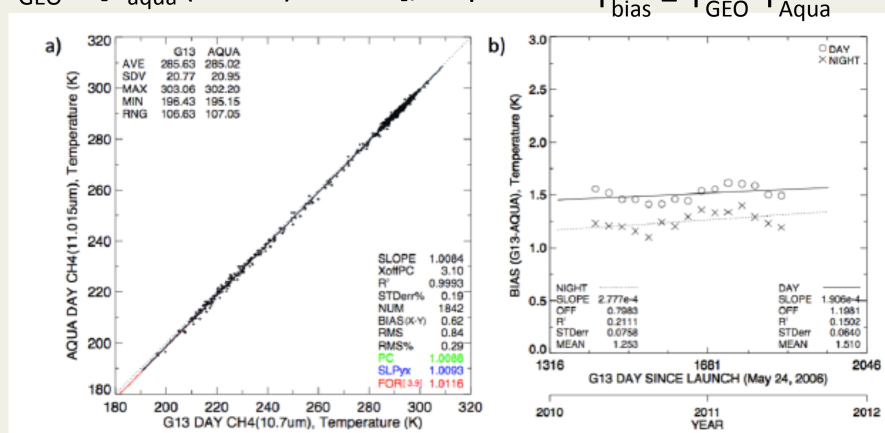
DCC pixel

Standard deviation based on all 9 pixels

T_{Aqua} = slope*T_{GEO}- offset

T_{GEO} = [T_{aqua} (205°K)+offset]/slope

T_{bias} = T_{GEO}-T_{Aqua}



DCC domain selection table

	$long_{SAT}$ (°)	$long_{MIN}$ (°)	$long_{MAX}$ (°)	GMT_{MIN} (hour)	GMT_{MAX} (hour)	$T_{(GEO)}$ (K°)
FY2-D	86	66	106	4:31	8:31	varies
FY2-E	105	85	125	4:31	8:31	varies
GOES-11	-135	-155	-115	20:00	22:30	206.6
GOES-13	-75	-110	-55	17:15	19:45	206.5
MET-7	57	37	77	7:00	9:30	203.6
MET-9	0	-20	20	11:15	13:15	205.4
MTSAT-2	145	125	165	~1:30	~3:30	205.2

Step 2: Convert DCC counts to overhead sun

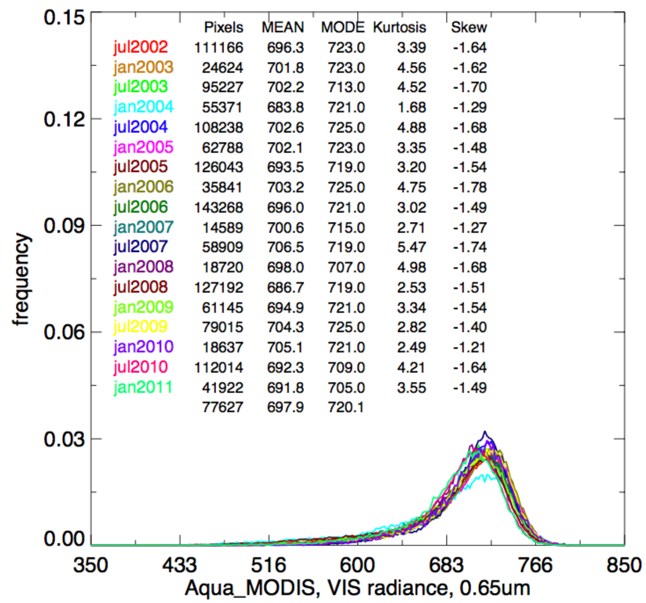
- For each month save the DCC identified pixels
  - CNT, sza, vza, raz, $BT_{11\mu m}$, σ $BT_{11\mu m}$, σ CNT, …
  - Usually 100K to 1000K pixels saved per month
- Convert the DCC counts to overhead sun
  - Use CERES DCC BDRF and albedo sza model (ALB)

$$CNT_{nadir} = CNT_{sz,vz,az}\left[\frac{1.0}{D^2_{earth-sun}(day)*\cos(sz)}\right]\left[\frac{1.0}{BRDF^{DCC}_{sz,vz,az}}\right]\left[\frac{ALB^{DCC}_{sz=0}}{ALB^{DCC}_{sz}}\right]$$

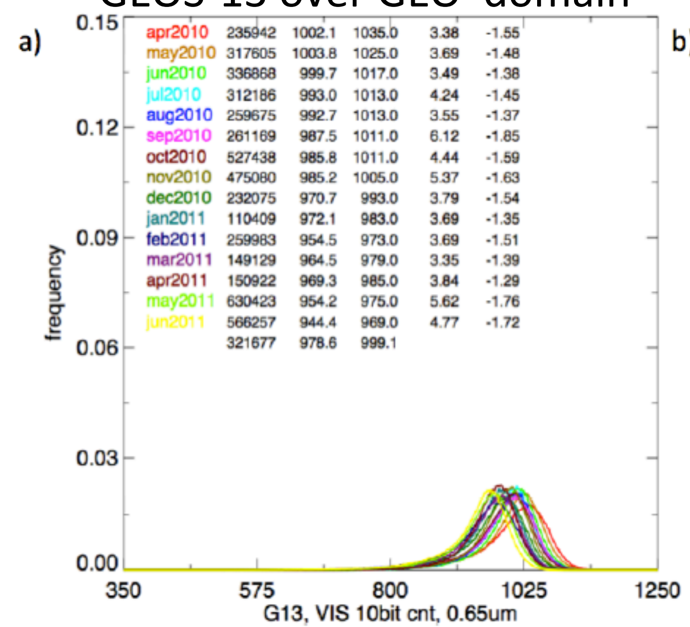
- Set up a frequency histogram using suggested count increment (P_{del})
- Determine mode of histogram using bin with the most counts
- This is the monthly CNT_{nadir}

Step 3: Find mode of DCC nadir radiance over month

Aqua-MODIS over GEO domain

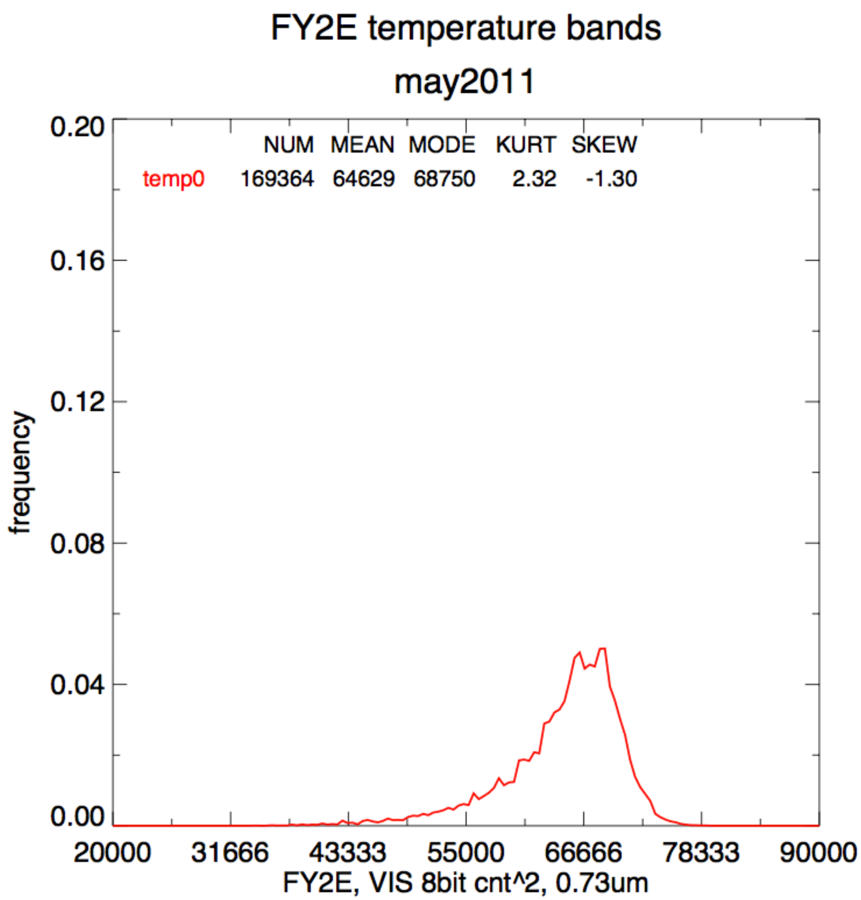


GEOS-13 over GEO domain

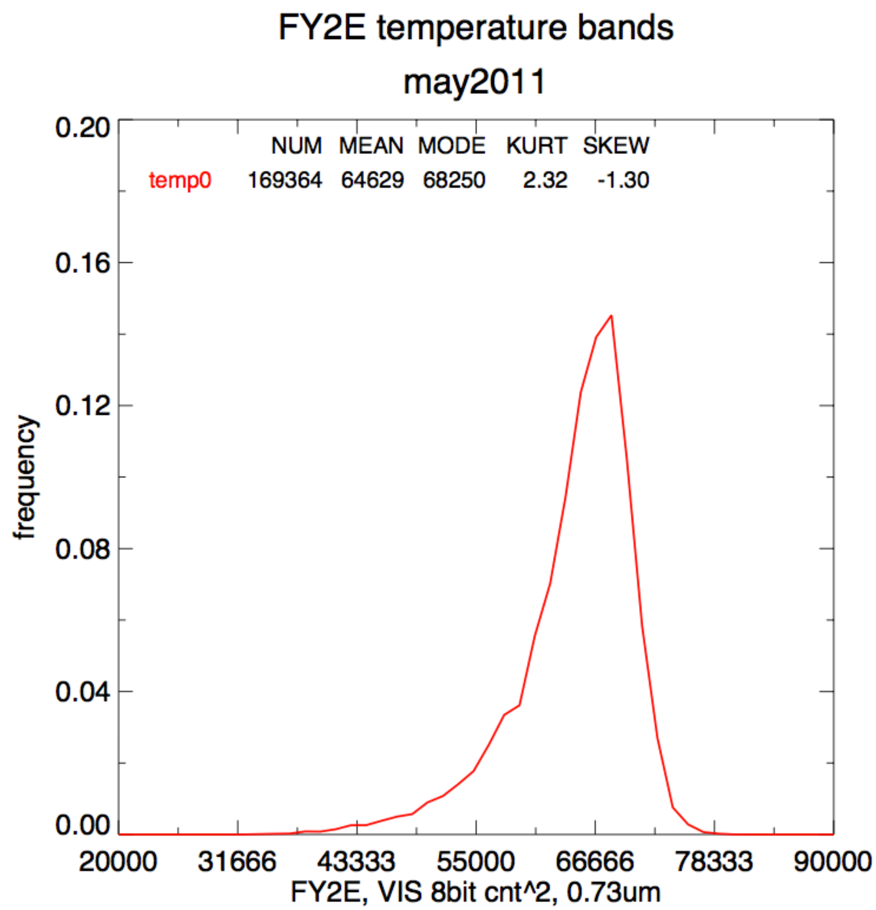


Use CERES BRDF for both GEO and Aqua-MODIS DCC radiances to derive DCC nadir radiance and GEO count (count unit proportional to radiance)

Example of P_{del} increments



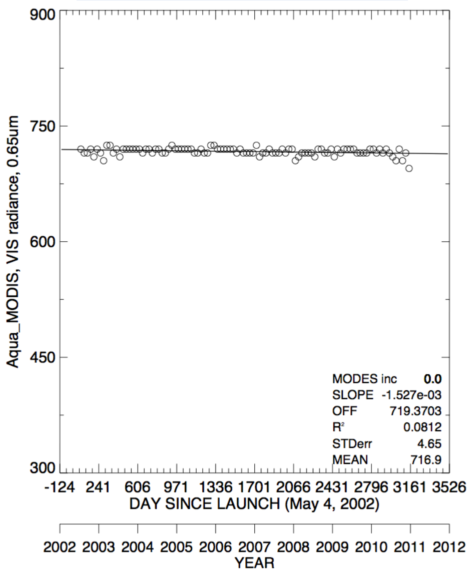
P_{del} too small (500)



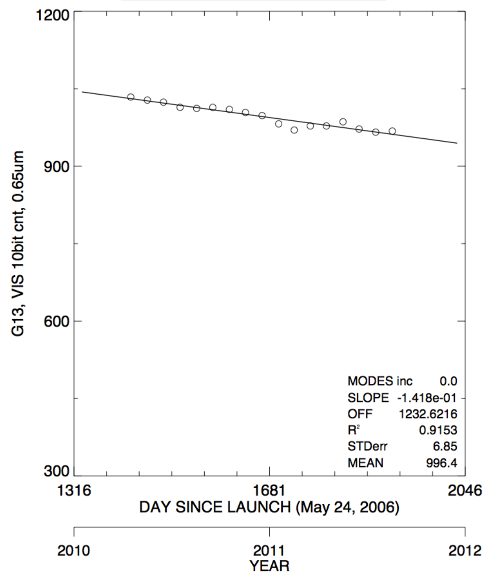
P_{del} =1500

Step 4: Use Aqua DCC radiance to derive GEO gain

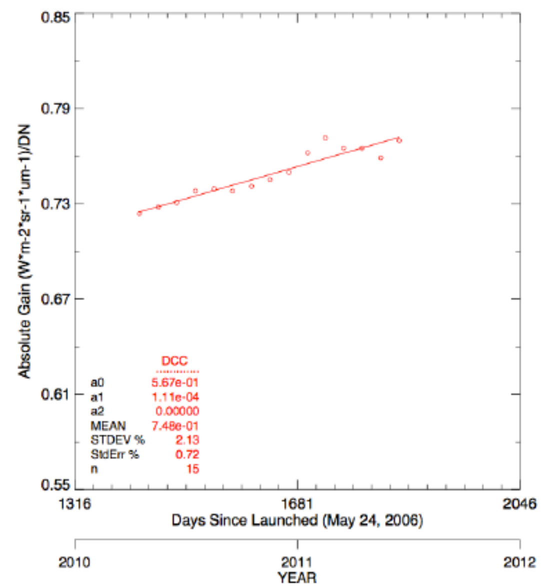
Aqua Rad_{nadir}



G-13 CNT_{nadir}



G-13 gains

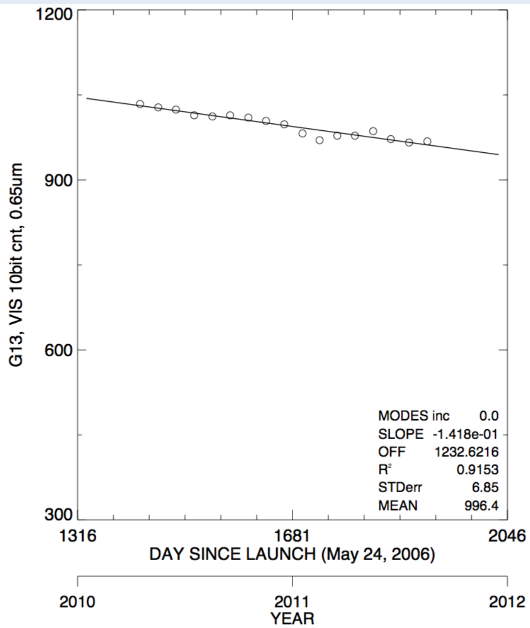


- The gain is factor needed to produce the Aqua DCC radiance with the GEO DCC nadir count

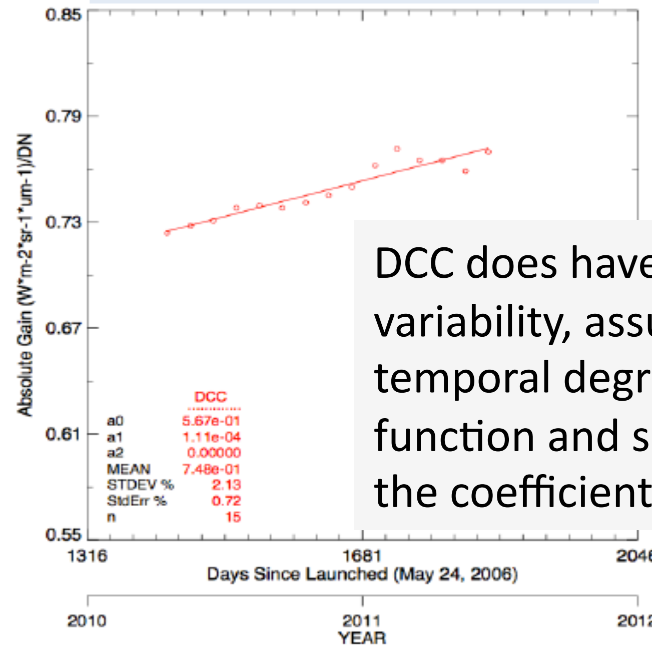
Solve for monthly gain

$$Aqua^{nadir}_{DCCraidance} SBAF_{GEO/Aqua} = GAIN_{GEO}(CNT^{nadir}_{DCC} - CNT_{space})$$

GOES-13 monthly CNT_{nadir}(mode)



GOES-13 Monthly Gains



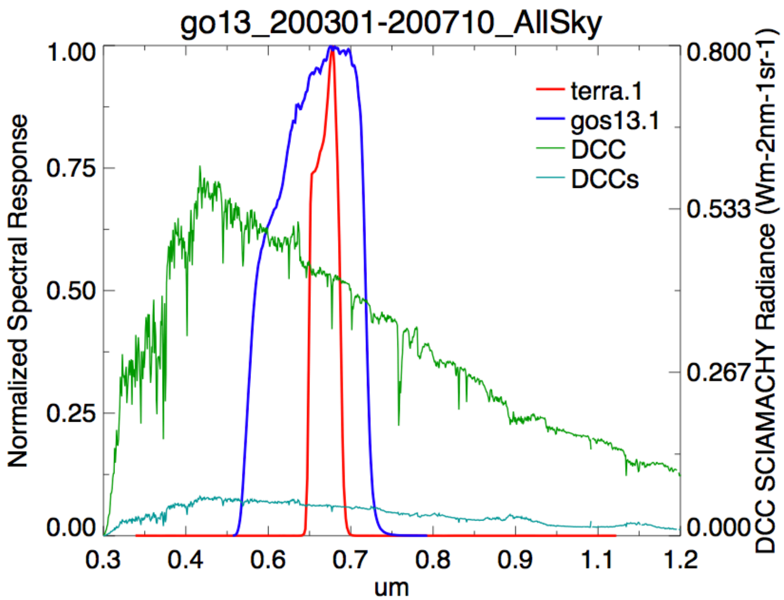
DCC does have natural variability, assume linear temporal degradation function and solve for the coefficients

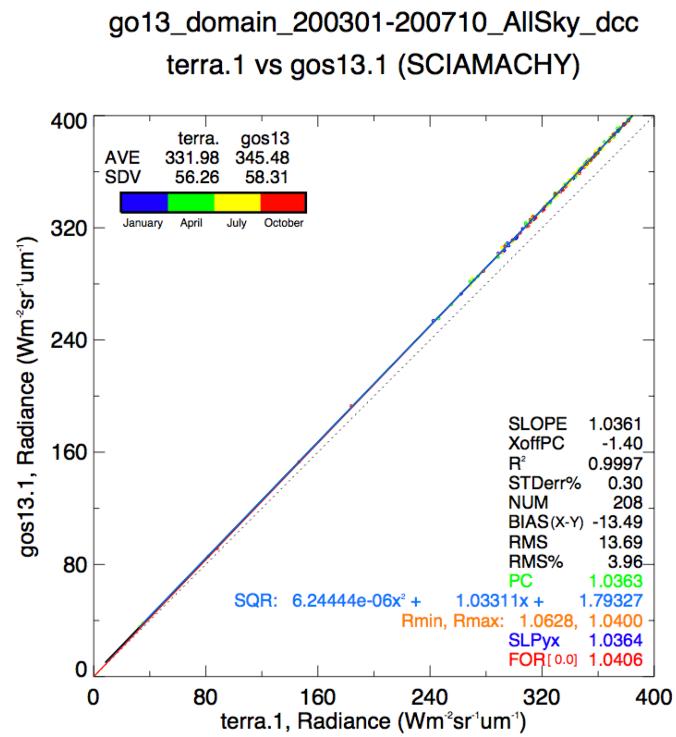
Standard error about degradation function is the uncertainty due to DCC natural variability

To determine reflectance gain

$$GEO_{reflectance} = \frac{Aqua^{nadir}_{DCCraidance} SBAF_{GEO/Aqua}}{SC^{GEO}_{SOLAR(MODIS)}}$$

Use SCIAMACHY to spectrally adjust the Aqua radiance to GEO





- SCIAMACHY is a hyper-spectral imager designed for trace gas studies
- SCIAMACHY calibration is stable against MODIS
- Derive the GEO and Aqua-MODIS pseudo radiance based on convolved SCIAMACHY hyper-spectral radiances and derive the spectral band adjustment factor
- The adjustment factor is nearly linear across the radiance dynamic range

DCC selection table

	Pdel cnts	Aqua DCC radiance $Wm^{-2}sr^{-1}\mu m^{-1}$	Aqua DCC radiance*SBAF $Wm^{-2}sr^{-1}\mu m^{-1}$
FY2-D	1300.	--------	-------
FY2-E	1500.	712.3	609.5
GOES-11	5.	717.5	701.9
GOES-13	2.	716.9	746.0
MET-7	2.	714.8	624.7
MET-9	2.	718.1	730.8
MTSAT-2	5.	713.2	668.7

The Aqua DCC radiance is within 0.8% across all GEOs
The 10-year Aqua DCC monthly radiance trend is between -0.5% to -1.0% across all GEOs and the standard error is between 0.6% and 1.2% validating that both DCC and Aqua are stable

Step 5: Derive GEO gain uncertainty

Aqua-MODIS absolute calibration uncertainty

Based Xiong et al during GSICS 2011 annual meeting 1.64%

DCC Aqua to GEO calibration transfer uncertainty

GOES-13 calibration average gain differences based on various thresholds over 15 months

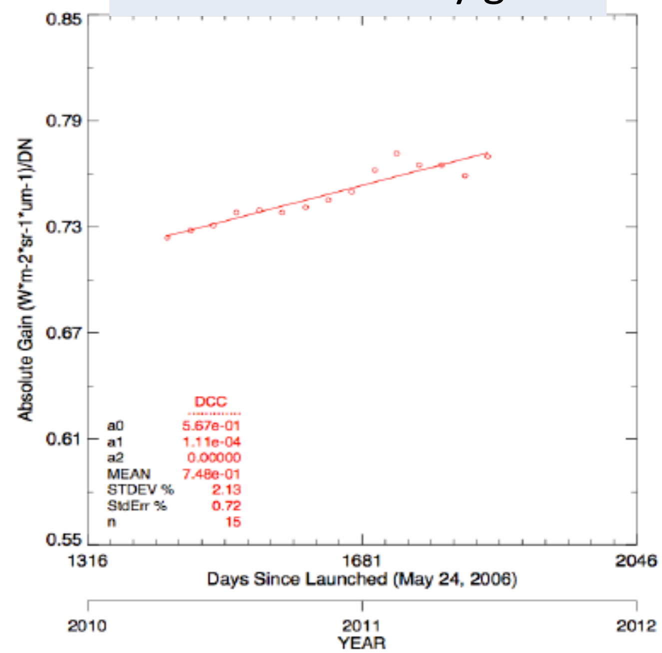
Greatest difference is 1 – (0.7513/0.7488) = 0.33%

GEO	Noon, $T_{205°K}$	Noon, T_{GEO}	1:30PM, $T_{205°K}$	1:30PM, T_{GEO}
GOES-13	0.7500	0.7513	0.7484	0.7492

Derive GEO gain uncertainty

GEO	SBAF standard error (%)	Linear Trend standard error (%)
FY2-D	0.47	1.2
FY2-E	0.86	1.1
GOES-11	0.40	0.9
GOES-13	0.30	0.7
MET-7	0.69	1.0
MET-9	0.08	0.7
MTSAT-2	0.68	0.7

GOES-13 monthly gains



The trend standard error provides the DCC natural variability over the GEO domain

Derive GEO gain uncertainty

GEO (%)	Aqua-MODIS absolute calibration*	DCC Aqua to GEO calibration transfer*	SBAF	Trend	Total Uncertainty
FY2-D	1.64	0.33	0.47	1.2	2.1
FY2-E	1.64	0.33	0.86	1.1	2.2
GOES-11	1.64	0.33	0.40	0.9	1.9
GOES-13	1.64	0.33	0.30	0.7	1.8
MET-7	1.64	0.33	0.69	1.0	2.1
MET-9	1.64	0.33	0.08	0.7	1.8
MTSAT-2	1.64	0.33	0.68	0.7	1.9

*constant for all GEOs

Trend is based on the standard deviation from monthly gains

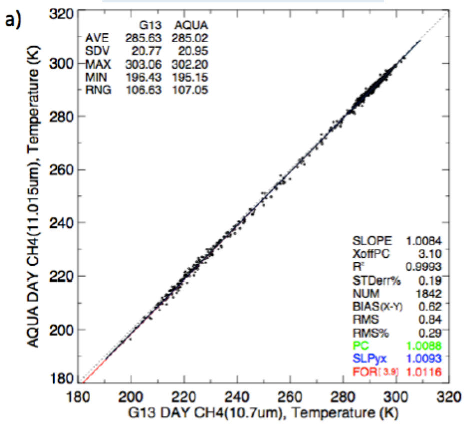
Suggested Way Forward

- Implement outlined procedure as the baseline across all GEO GPRCs
  - Provided a individual GEO plots for validation, which were based on McIDAS images
  - Will provide a wiki page with presentation and requested routines and input data and answer email
  - Decide now on the plots to be used as standard validation across GPRCs
- Have each GEO GPRCs display their DCC results using the baseline version at the annual GSICS meeting
  - Also possible improvements/alternatives on the method

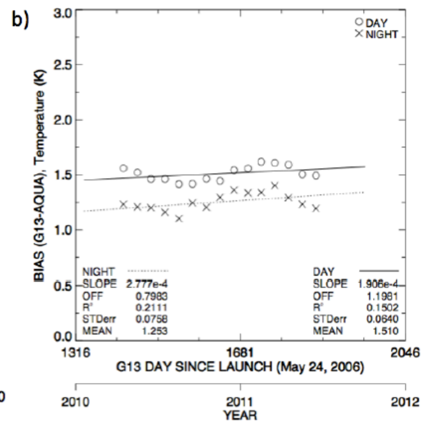
Individual GEO DCC plots for verification

GOES-13

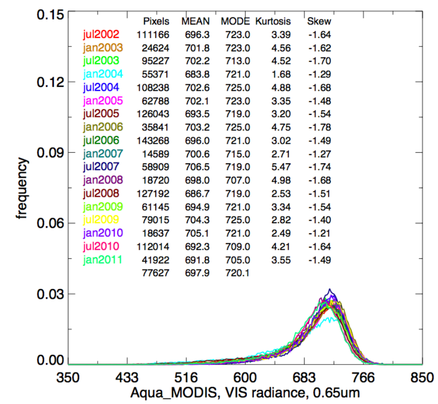
G-13/Aqua BT Jan 2011



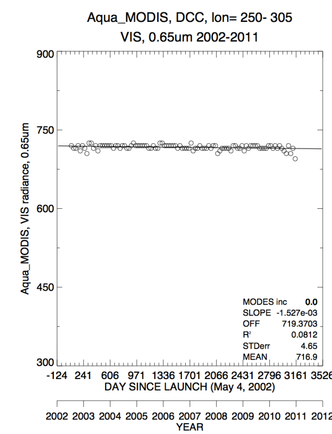
G-13-Aqua BT



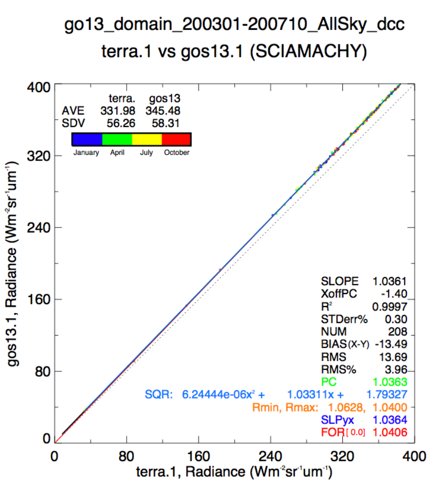
Aqua monthly PDFs



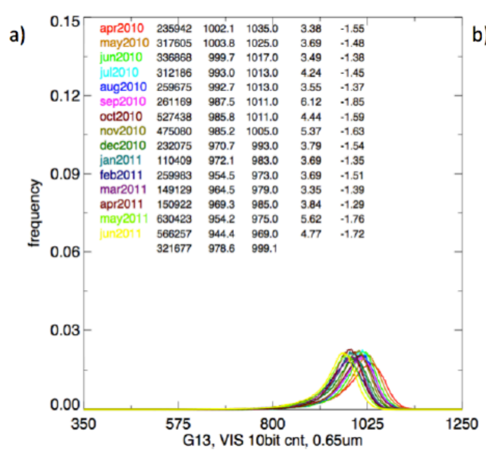
Aqua Rad$_{nadir}$



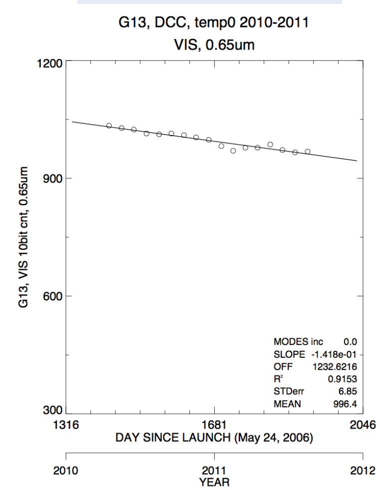
SBAF



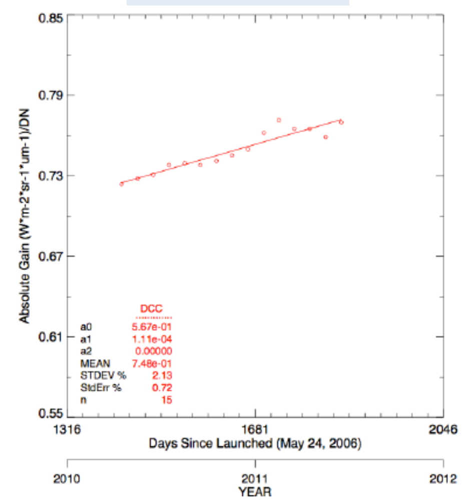
G-13 monthly PDFs



G-13 CNT$_{nadir}$

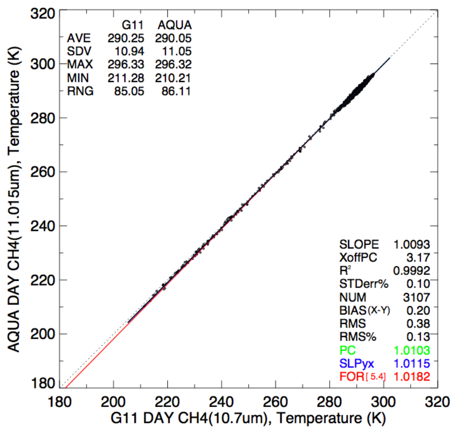


G-13 gains

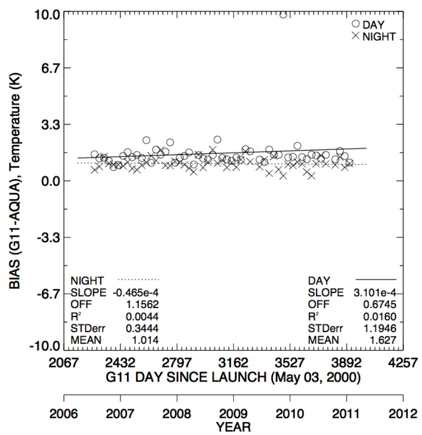


GOES-11

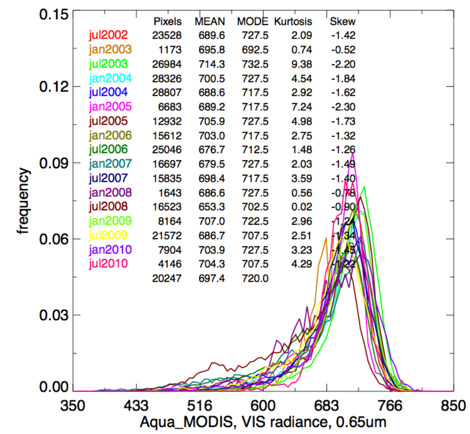
G-11/Aqua BT Jan 2011



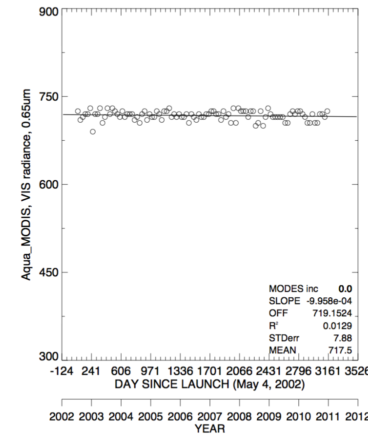
G-11-Aqua BT



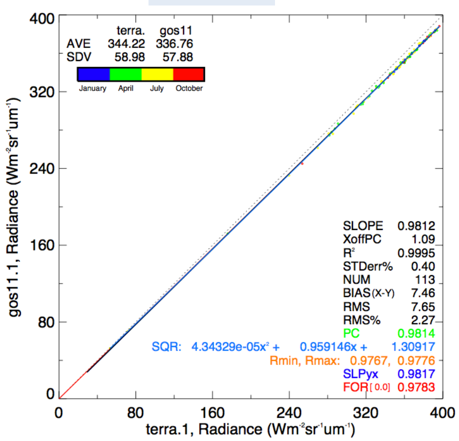
Aqua monthly PDFs



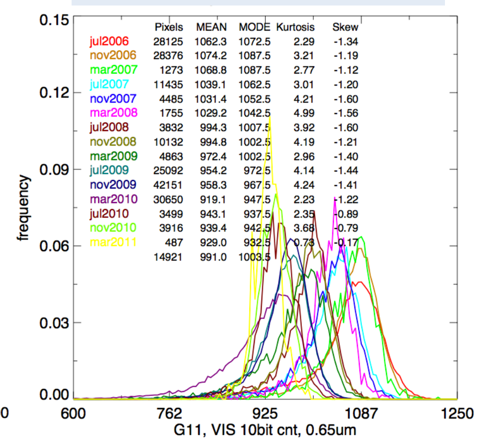
Aqua Rad_{nadir}



SBAF



G-11 monthly PDFs

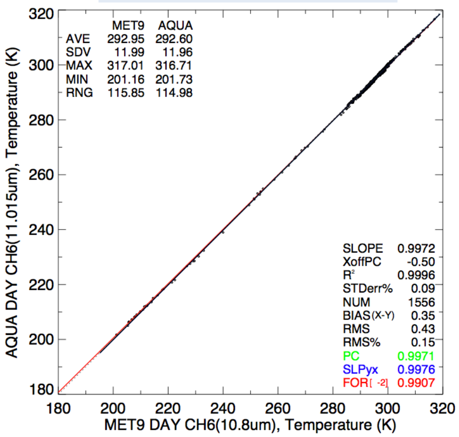


G-11 CNT_{nadir}

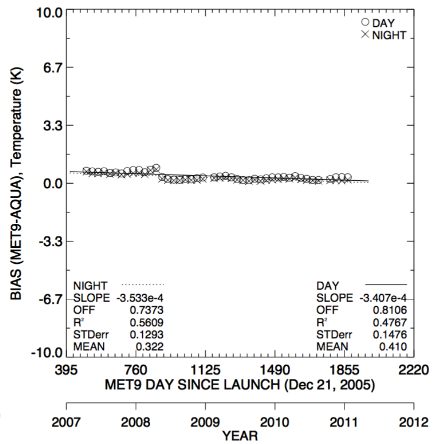
G-11 gains

MET-9

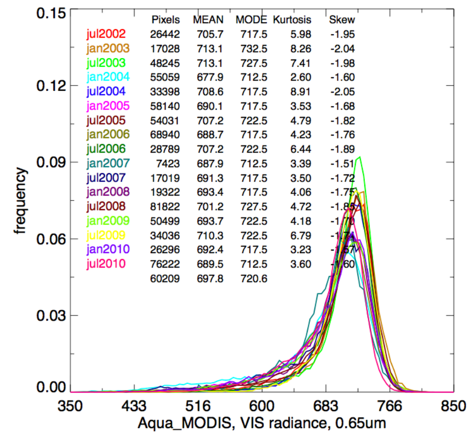
MET9/Aqua BT Jan 2011



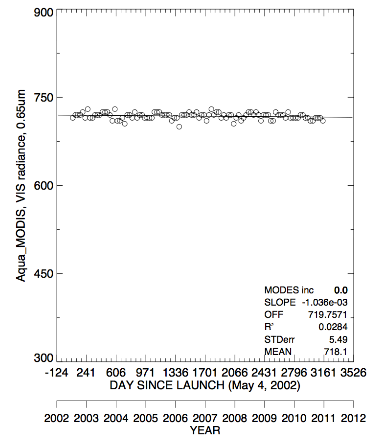
MET9-Aqua BT



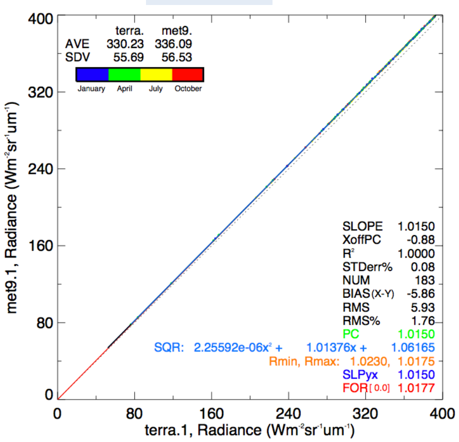
Aqua monthly PDFs



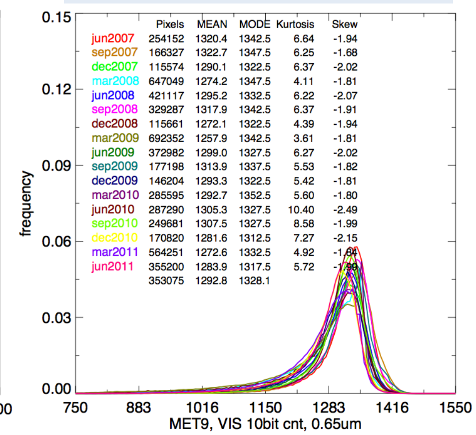
Aqua Rad$_{nadir}$



SBAF



MET9 monthly PDFs

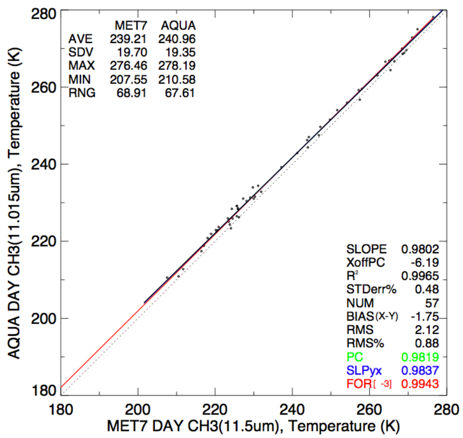


MET9 CNT$_{nadir}$

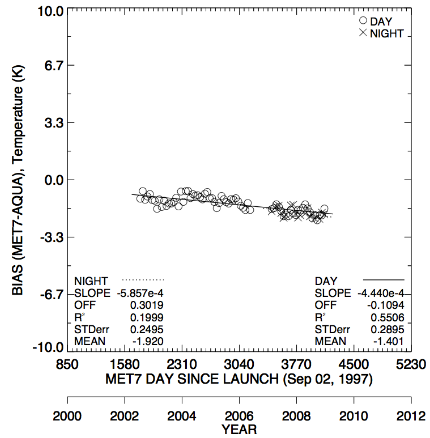
MET9 gains

MET-7

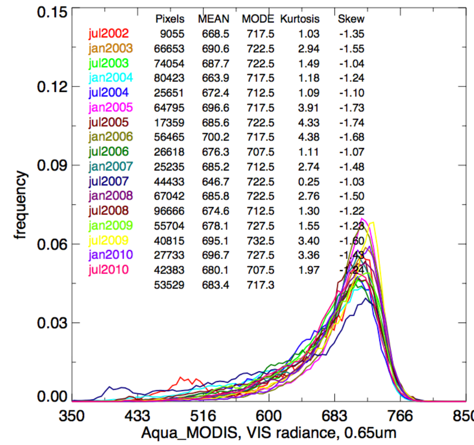
MET7/Aqua BT Jan 2011



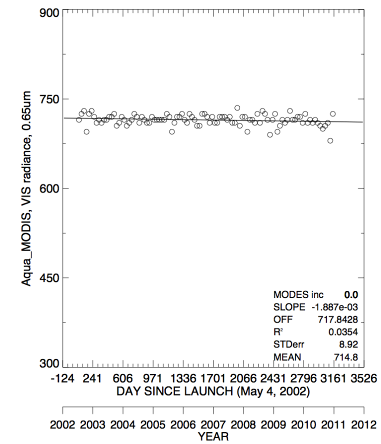
MET7-Aqua BT



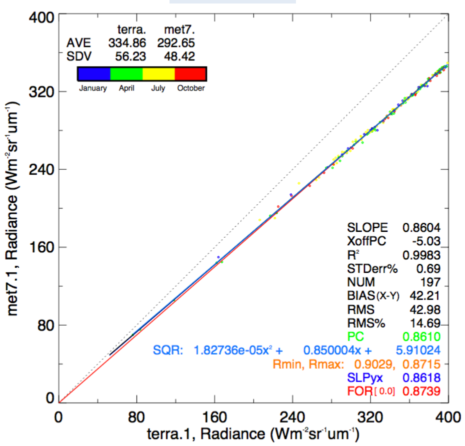
Aqua monthly PDFs



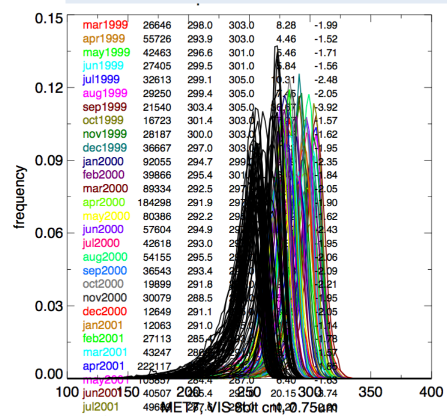
Aqua Rad$_{nadir}$



SBAF



MET7 monthly PDFs

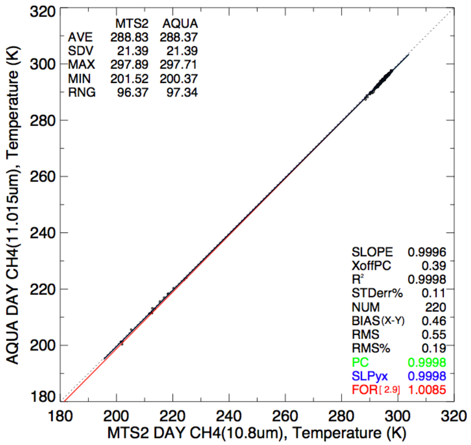


MET7 CNT$_{nadir}$

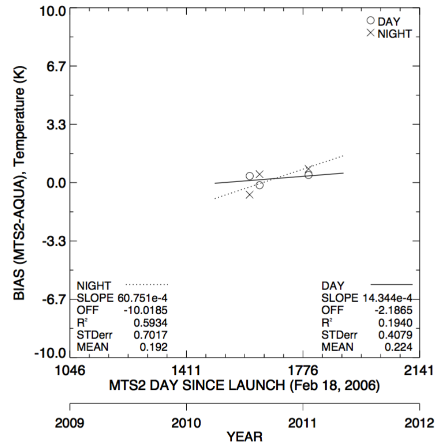
MET7 gains

MTSAT-2

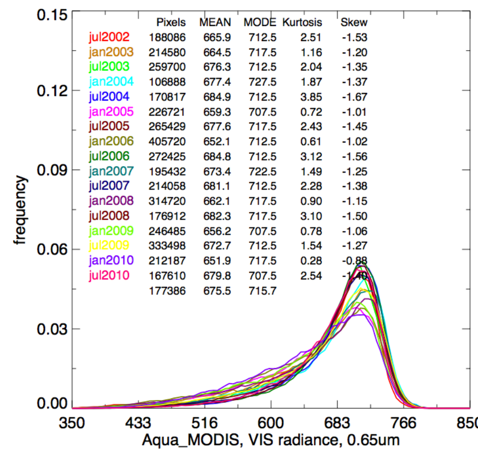
MTS2/Aqua BT Jan 2011



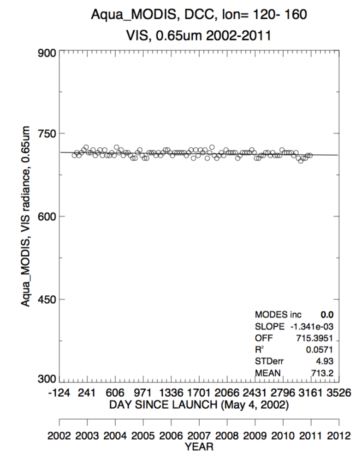
MTS2-Aqua BT



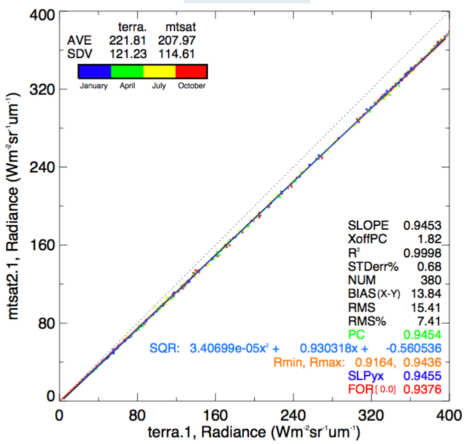
Aqua monthly PDFs



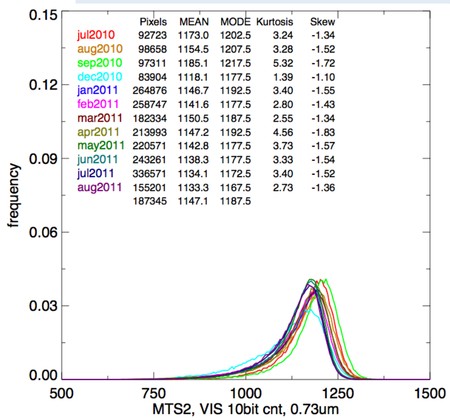
Aqua Rad$_{nadir}$



SBAF



MTS2 monthly PDFs

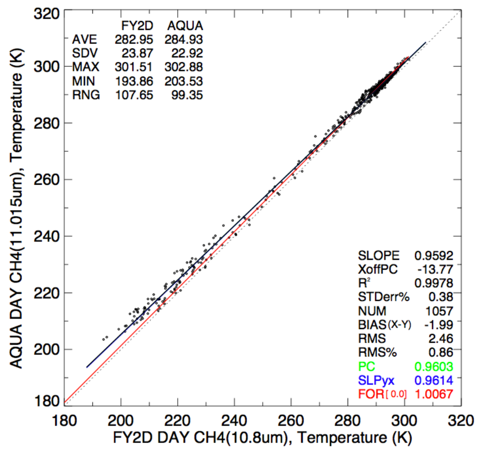


MTS2 CNT$_{nadir}$

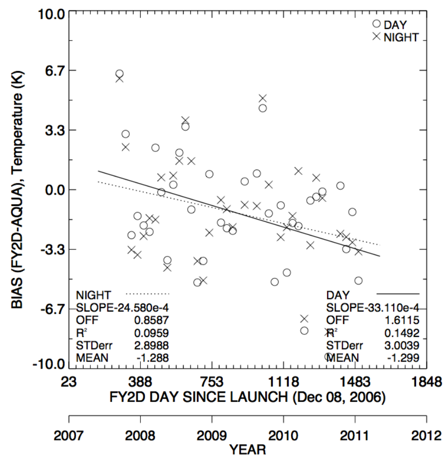
MTS2 gains

FY2-D

FY2D/Aqua BT
Jan 2011



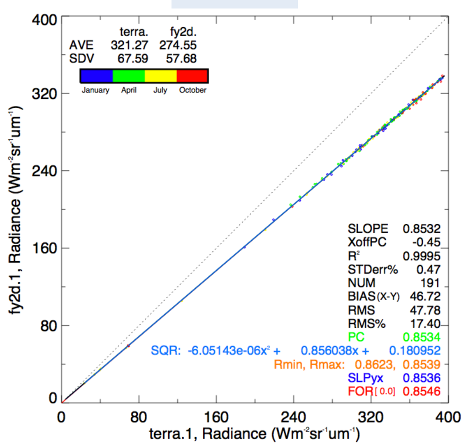
FY2D-Aqua BT



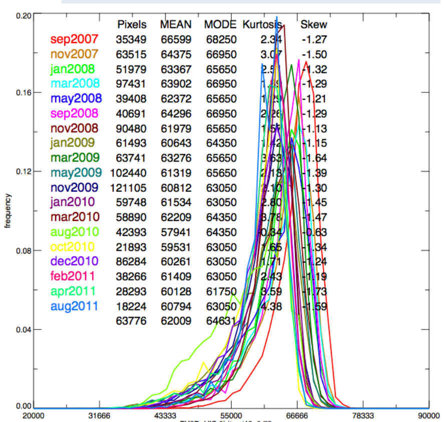
Aqua monthly PDFs

Aqua Rad_{nadir}

SBAF



FY2D monthly PDFs

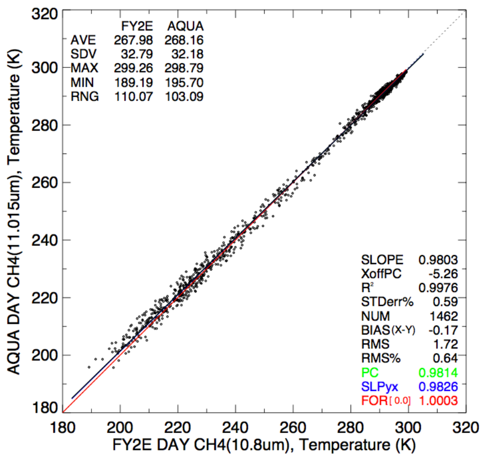


FY2D CNT_{nadir}

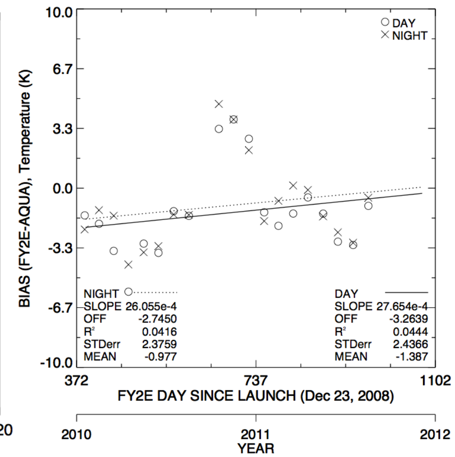
FY2D gains

FY2-E

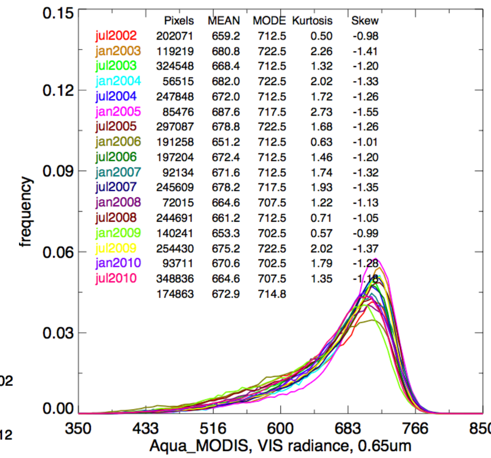
FY2E/Aqua BT Jan 2011



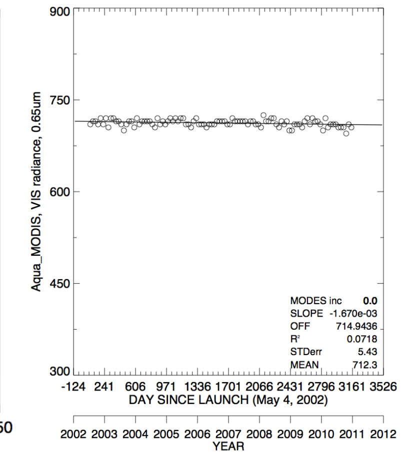
FY2E-Aqua BT



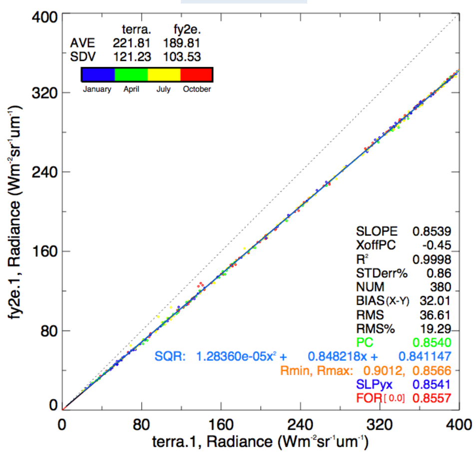
Aqua monthly PDFs



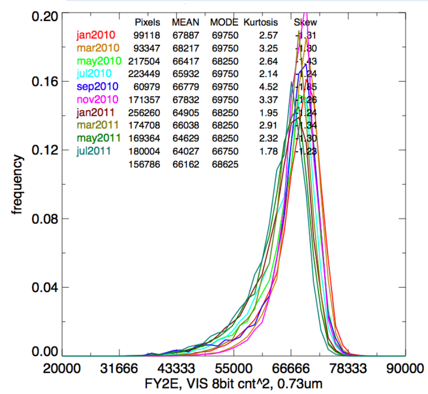
Aqua Rad_{nadir}



SBAF



FY2E monthly PDFs



FY2E CNT_{nadir}

FY2E gains