Calibration of Satellite Imager Channels Using Inter-Satellite Normalization and Deep Convective Cloud Targets

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Calibration Objectives

- Develop timely and accurate calibration equations for meteorological satellites to be able to use any platform to provide consistent retrievals of cloud, surface, and radiative properties

- Need to be accurate for long-term monitoring

- Need to be timely for real-time applications

- No directed funding, everything piecemeal from various grants

Approach

• Develop automated system to normalize all imagers to 1 or 2 other "well-calibrated" reference LEO imagers

1. Determine stability of reference LEO imagers
2. Cross-calibrate every 1-3 months
    a. Use LEO or GEO to reference every 1-3 months
    b. Use LEO or GEO to normalized LEO/GEO
3. Derive degradation equations for each sensor
    a. Predict ahead for real time; project back in time for climate
    b. Use normalization & deep convective cloud albedo techniques
4. Account for spectral differences in channels theoretically

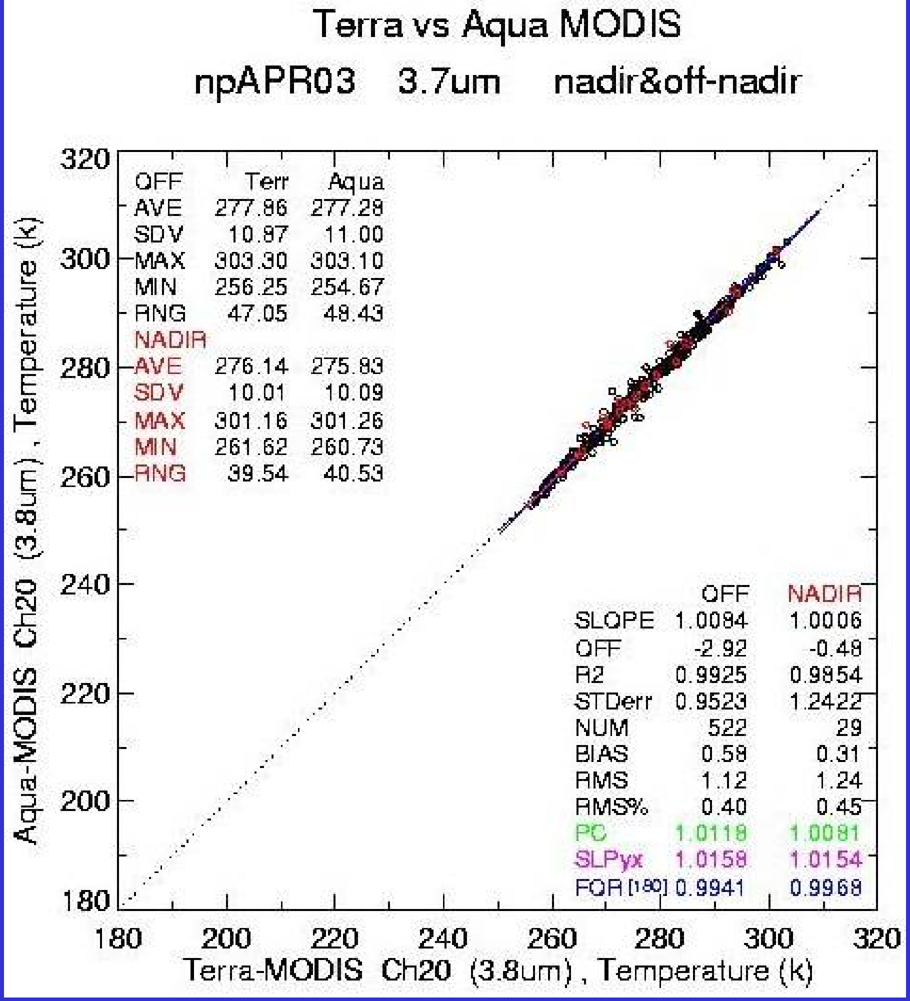
Reference Satellite Stability

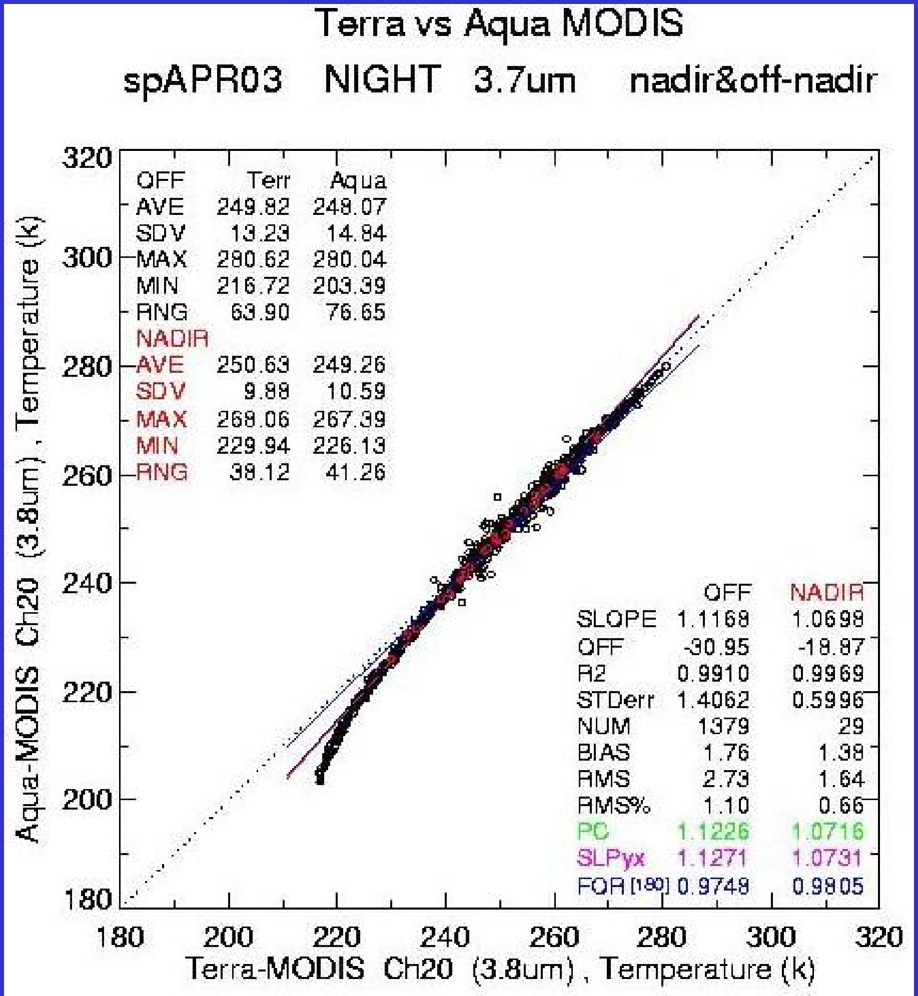
- Reference Imagers
  - *Terra & Aqua* MODIS
  - TRMM VIRS
- Cross-calibration against each other & CERES broadband data
- Deep convective cloud albedos for solar channels

The reference satellite must be understood as well as possible!

Minnis et al., JTech, 2007

Example Reference Checking





Day-night comparisons reveal 0.5K bias and bad cold temps

LEO-to-GEO/LEO Cross-Calibration Method

- Match data & compute average radiance *L* , brightness temperature *T*, or Count *C* within a 0.5° region using following selection constraints

  - ΔSZA < 5°, ΔVZA < 10°, ΔRAA < 15°, Δt < 15 min, no sunglint

- Normalize all solar channels to common solar constants
- Normalize each radiance to a common SZA
- Perform linear regression

$$X_{ref} = a\, Y_{sat} + b$$

$X = L$ or T; $Y = L$, T, or C

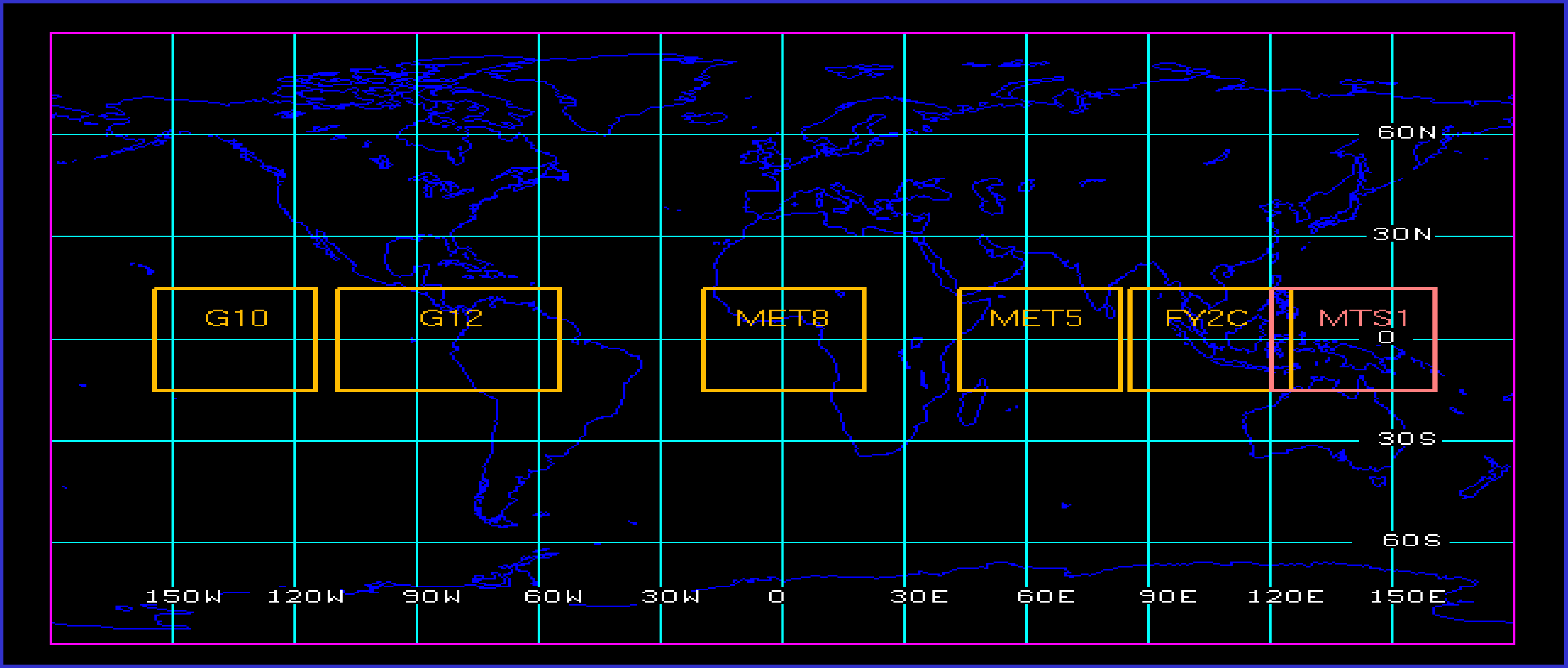
- Compute trends in $a(t)$ and $b(t)$ from sets of coefficients

$$a = c_o + c_1\, DSR + c_2\, DSR^2; \qquad b = d_o + d_1\, DSR + d_2\, DSR^2$$

DSR = days since reference date

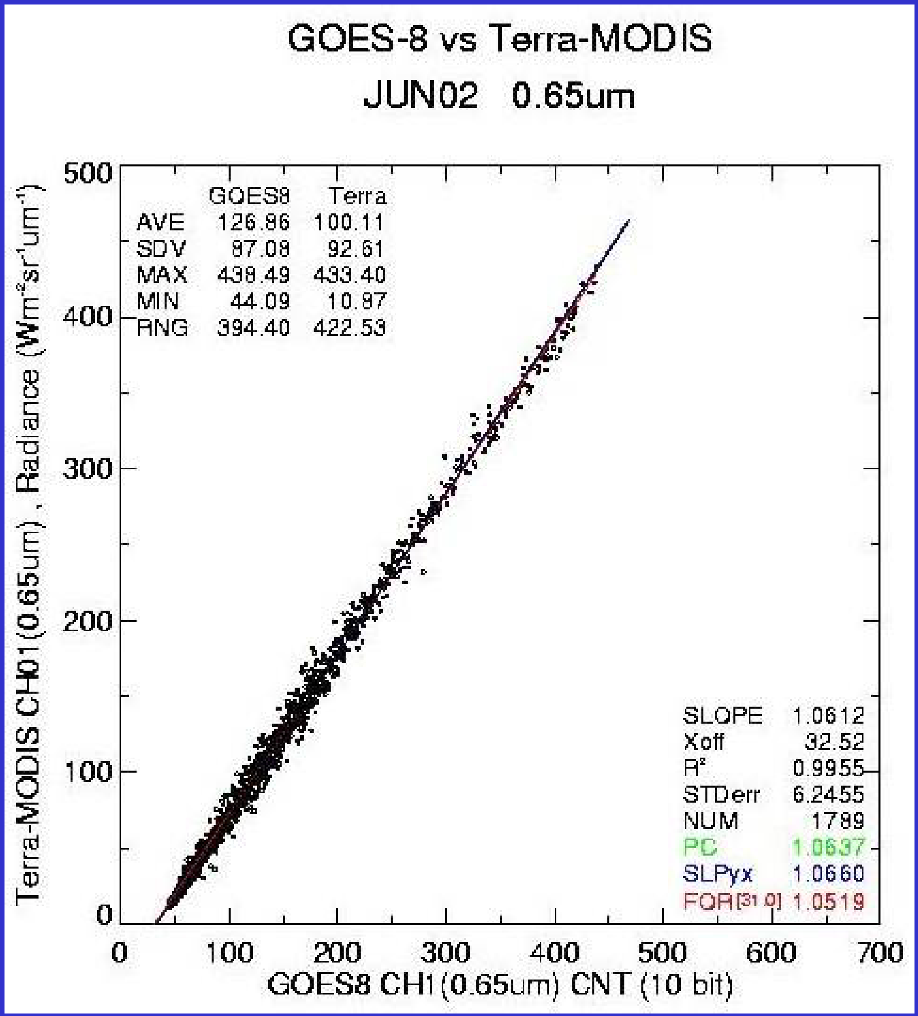
Minnis et al., JTech, 2002

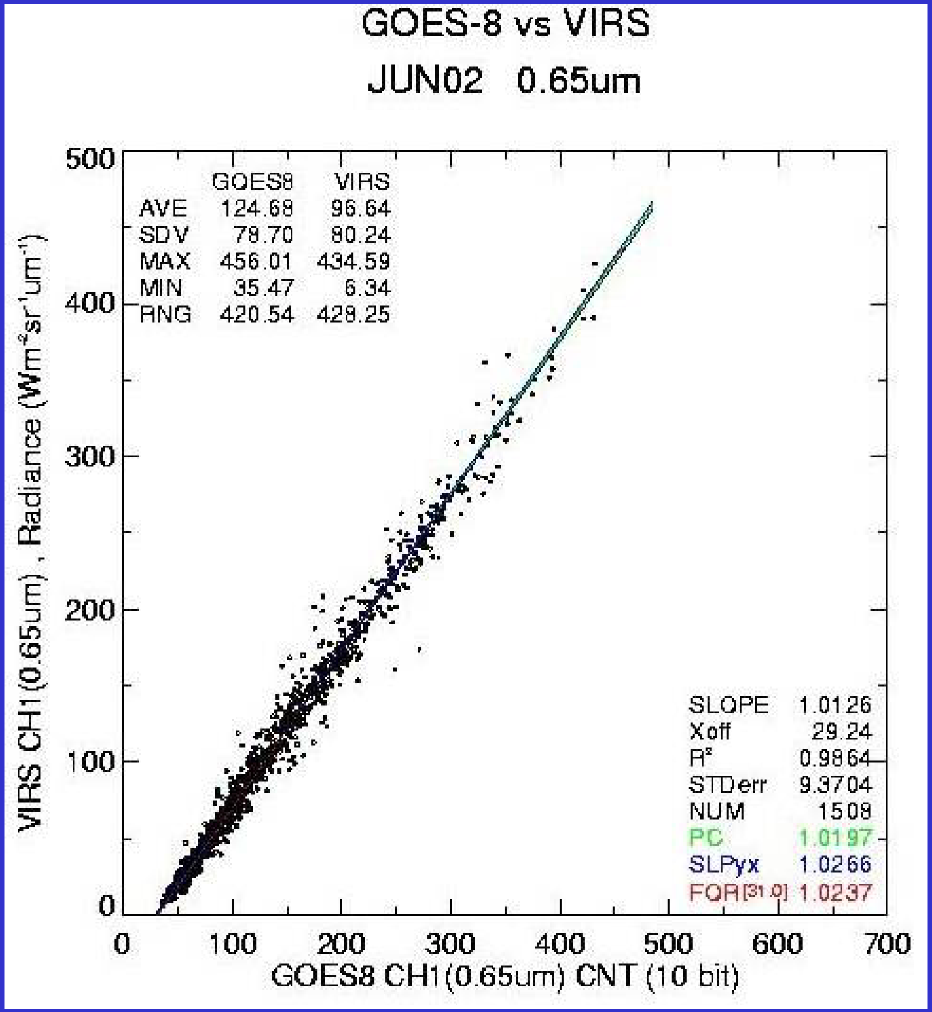
Current LEO-to-GEO Domains & Pairs

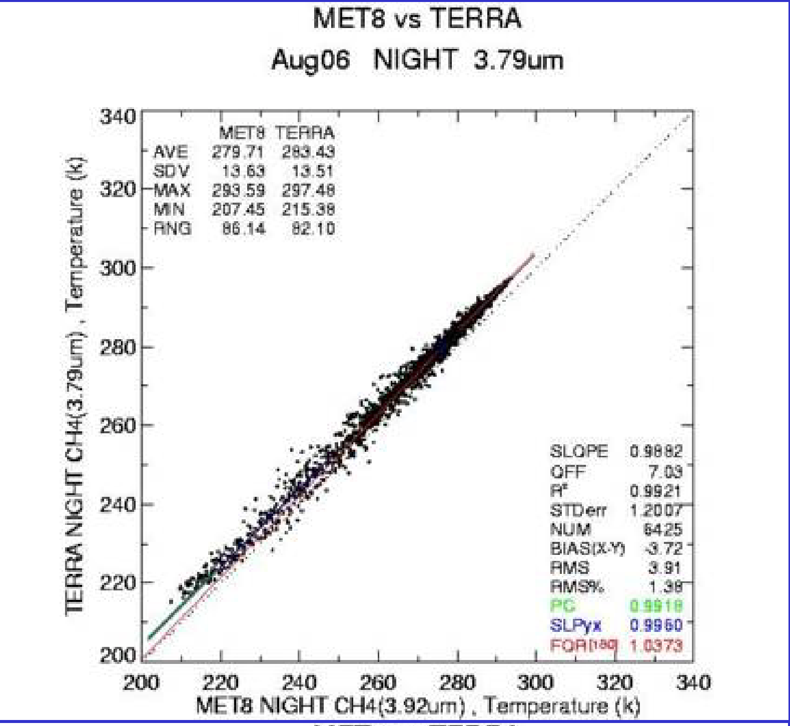


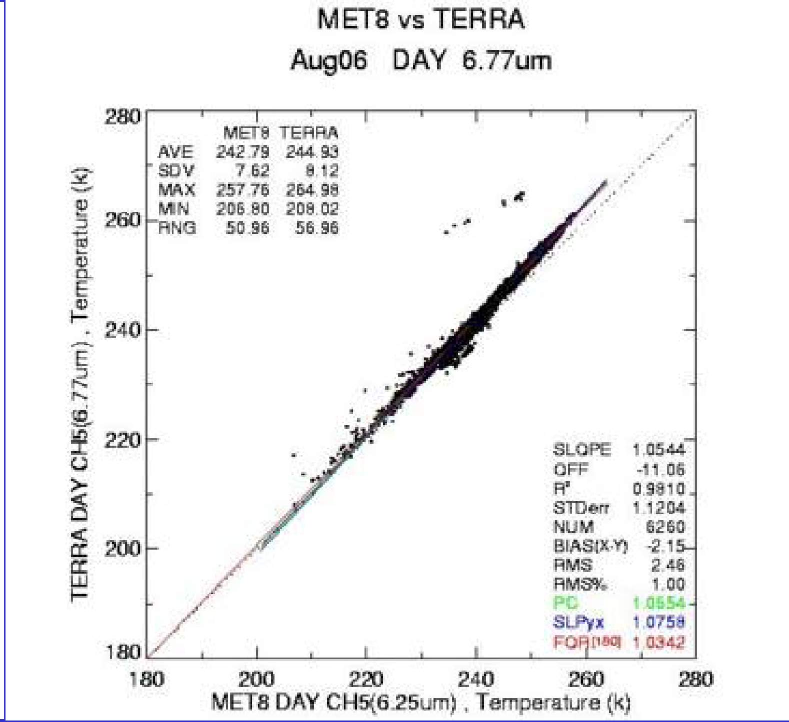
LEO-LEO normalizations use polar data

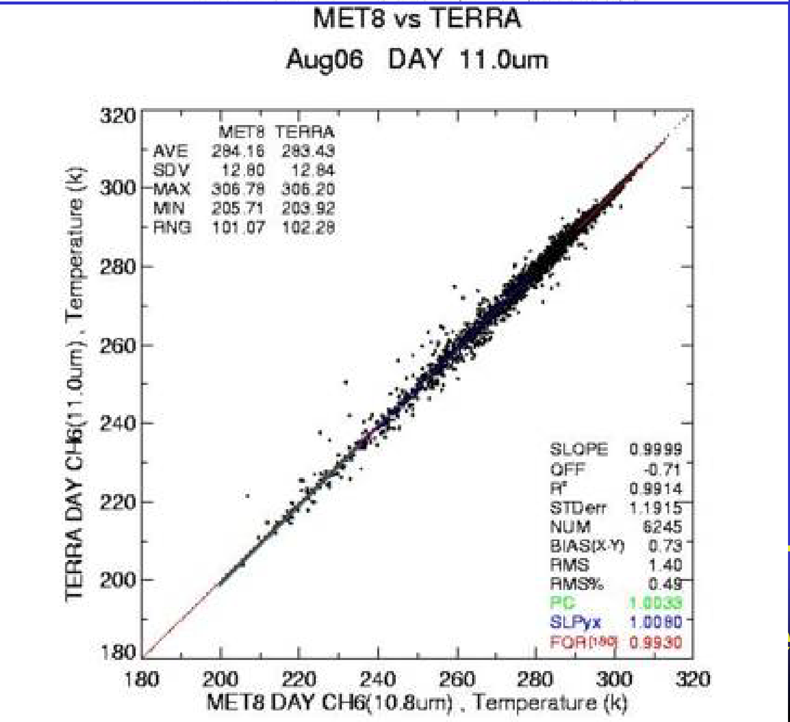
Examples of LEO-to-GEO Normalizations

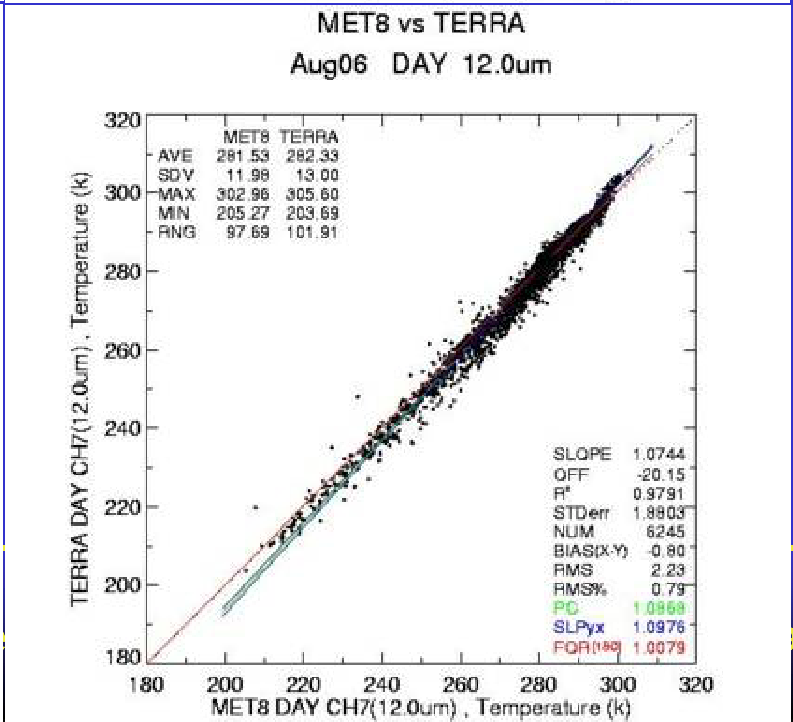












MET-8
Vs
Terra

Aug 2006

anch

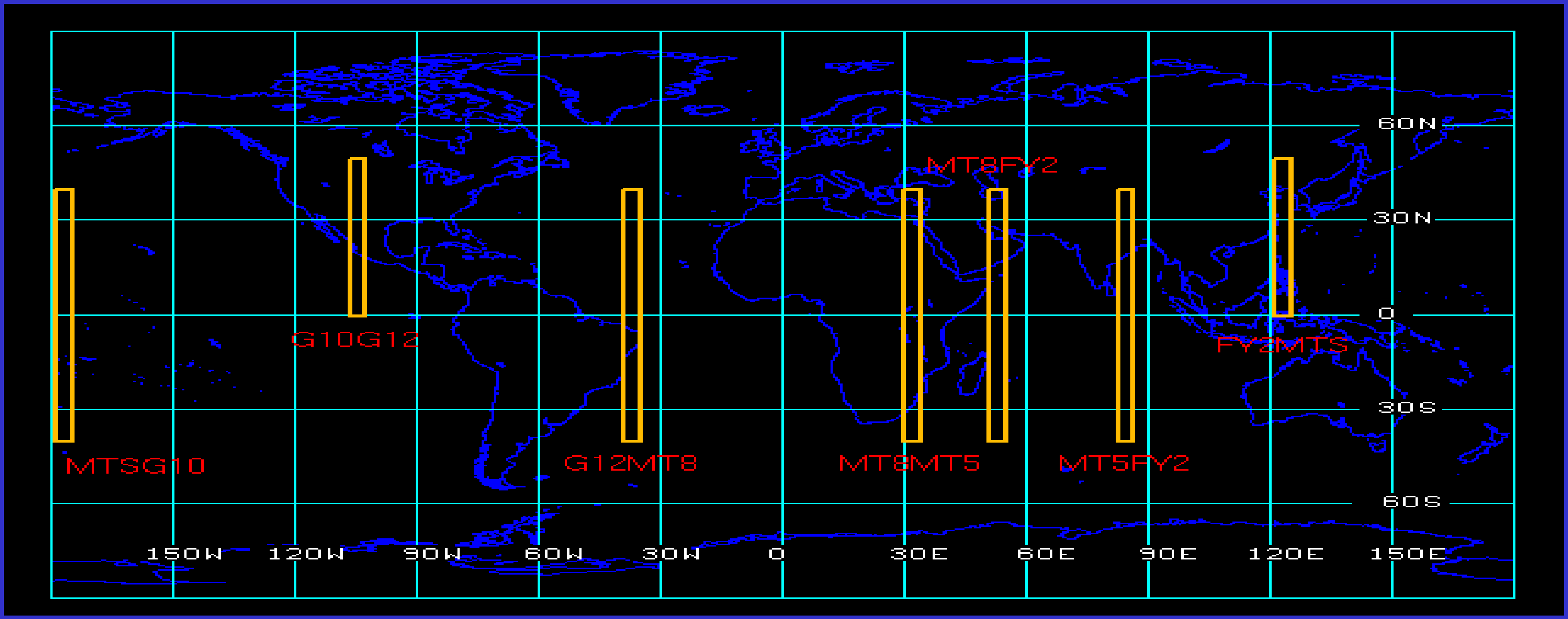
GEO-to-GEO/LEO Cross-Calibration Method

- **GEO-GEO**
  - Match data & compute average radiance *L* , brightness temperature *T*, or Count *C* within each 1.0° region straddling the bisecting longitude at time closest to local noon for solar channels (ensures matched SZA, RAZ, & VZA) and at anytime for IR channels
  - Follow same procedure as LEO-GEO for normalizing

- **GEO-LEO**
  - Follow same procedure as LEO-GEO for normalizing

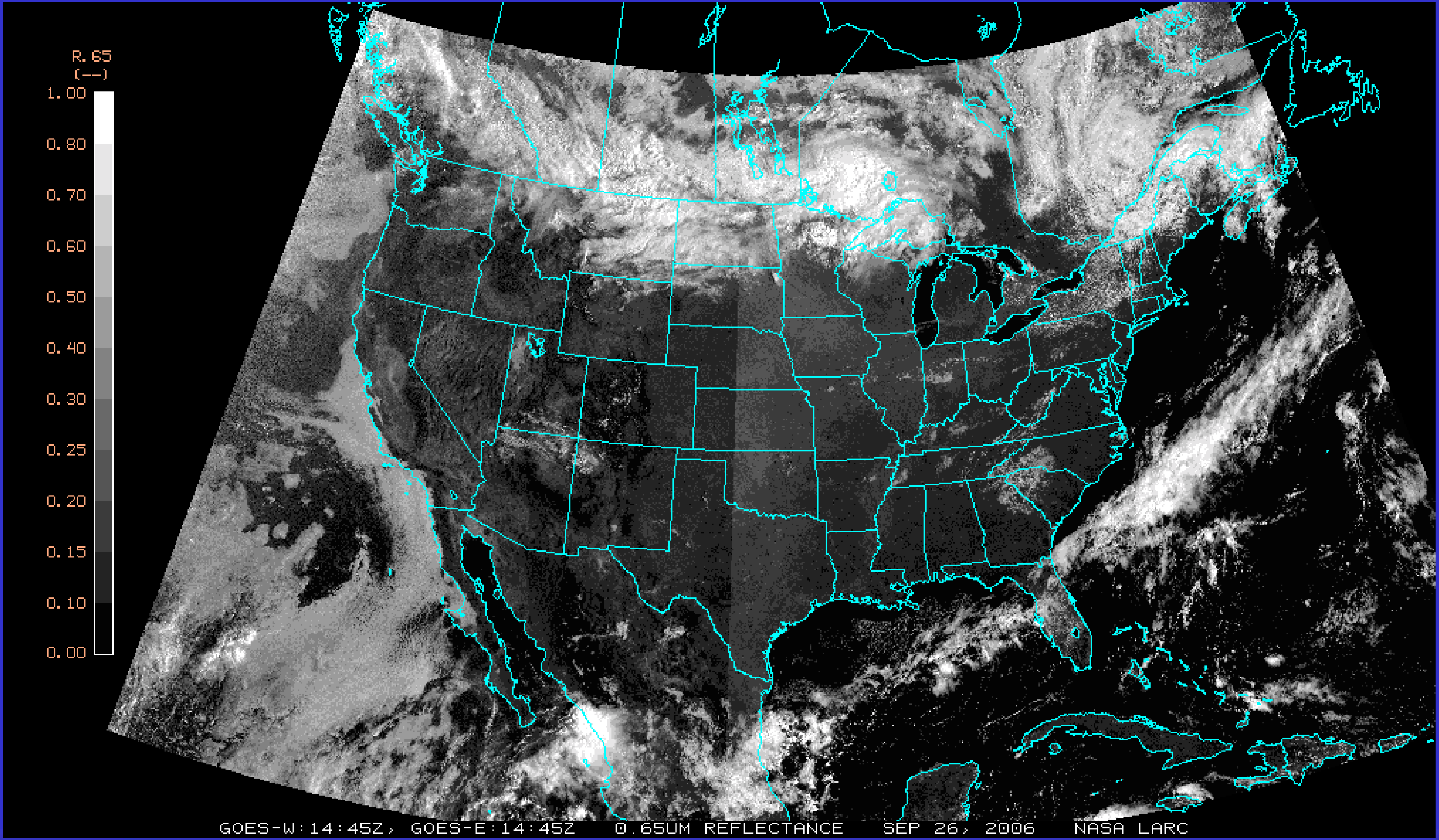
Nguyen et al., JTech, 2007

Current GEO-to-GEO Domains & Pairs



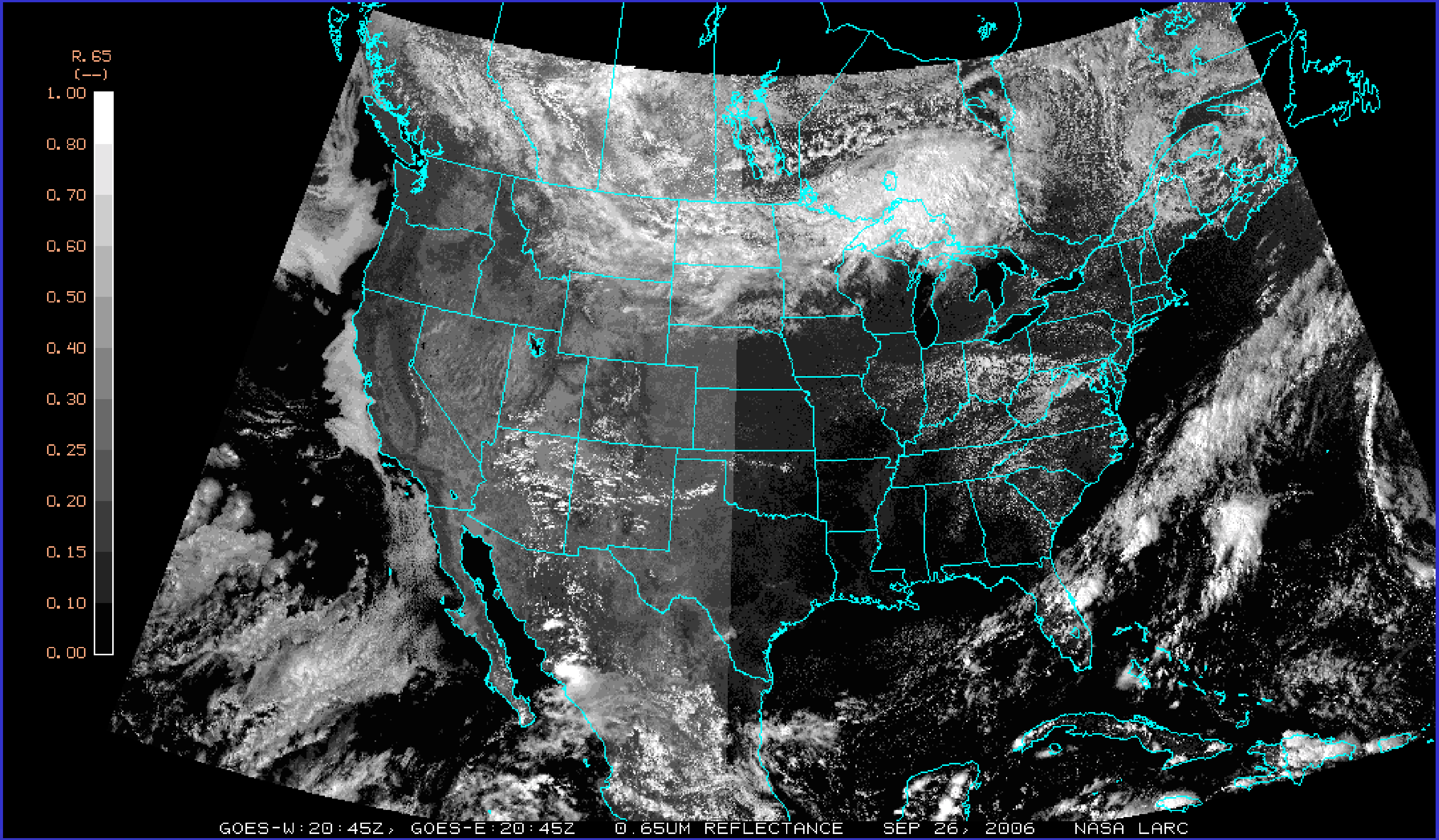
Similar matches were made for defunct satellites

GOES-11/GOES-12 Visible, Sep. 26, 2006



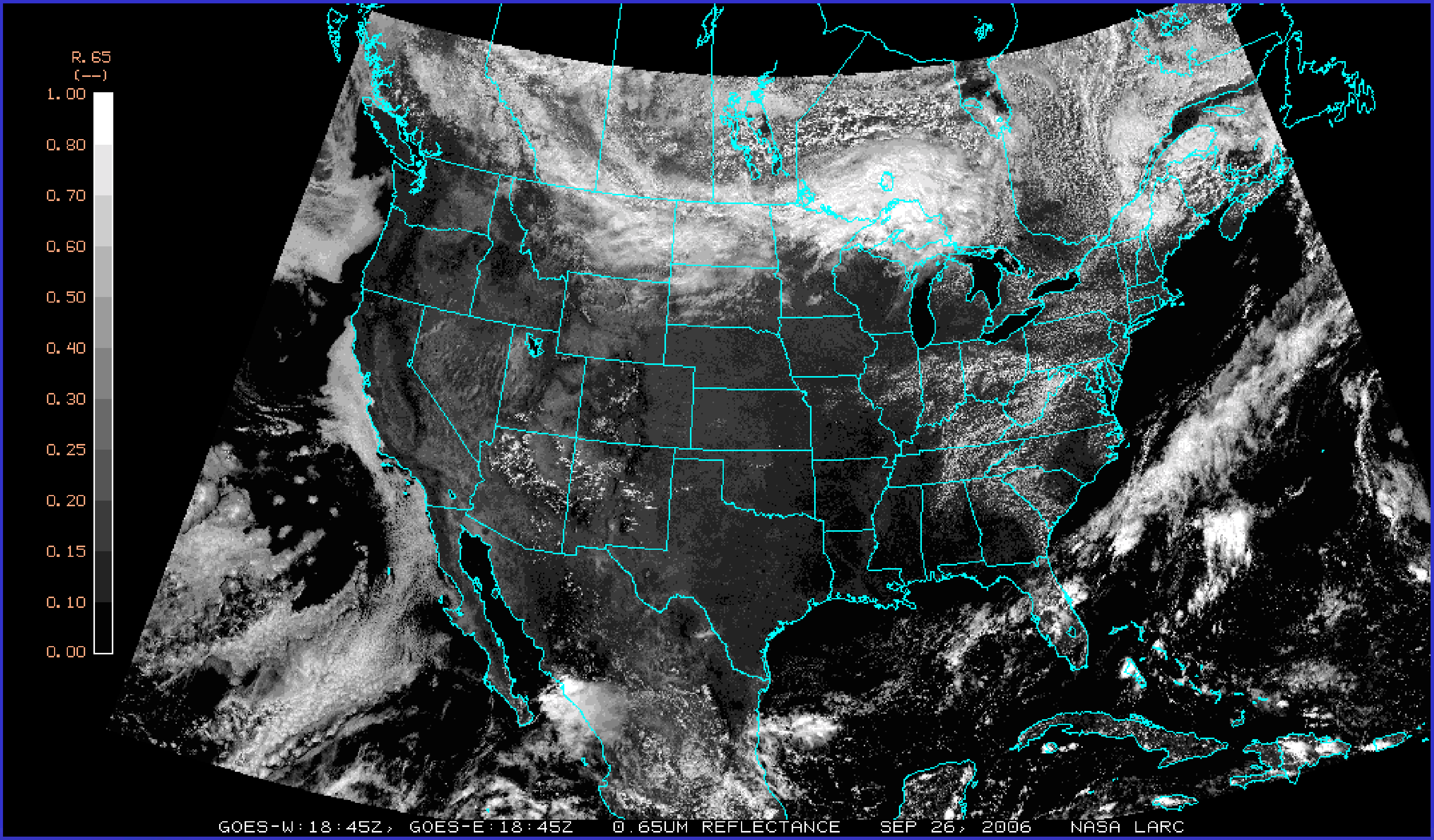
NASA Langley Research Center / Climate Sciences Branch

GOES-11/GOES-12 Visible, 20:45Z, Sep. 26, 2006



NASA Langley Research Center / Climate Sciences Branch

GOES-11/GOES-12 Visible, 18:45Z, Sep. 26, 2006



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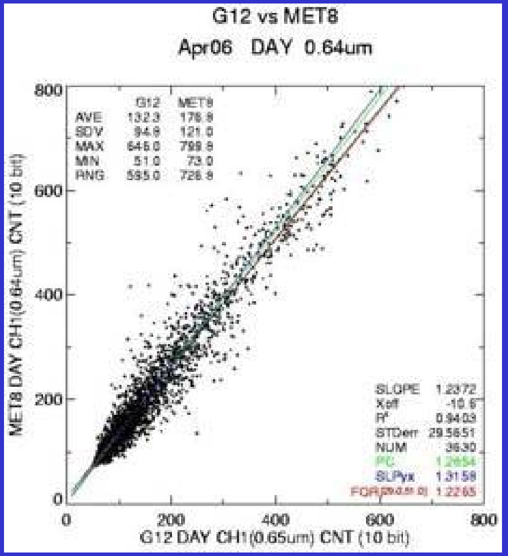
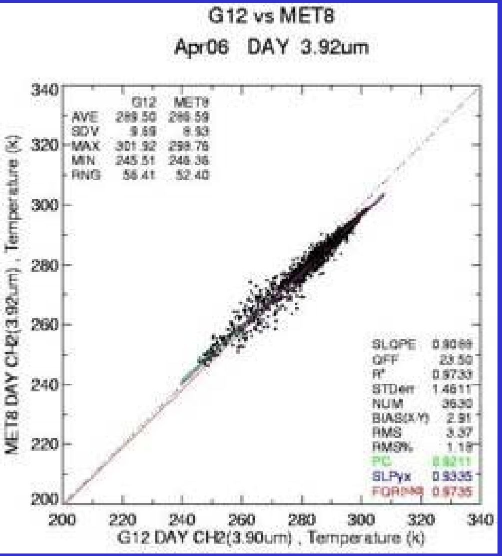
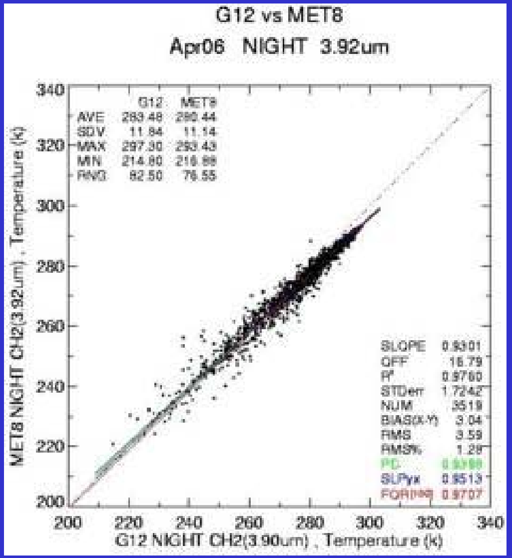
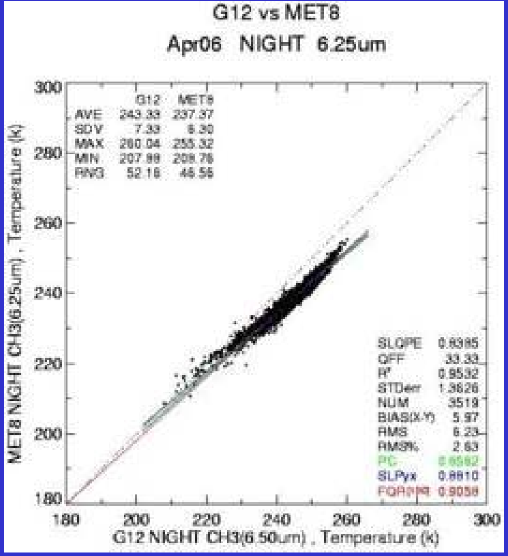
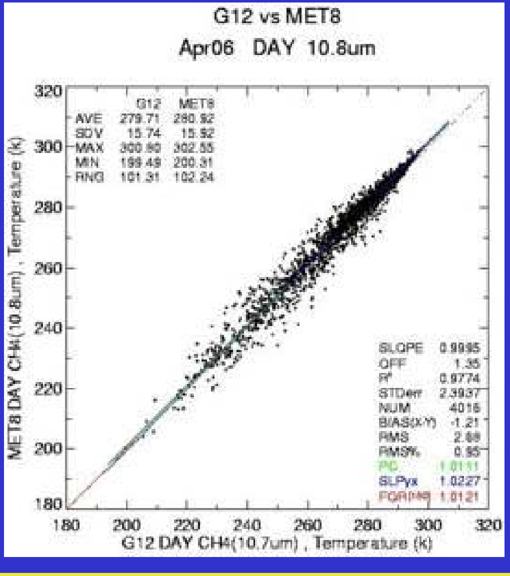
Examples of GEO-to-GEO Normalizations

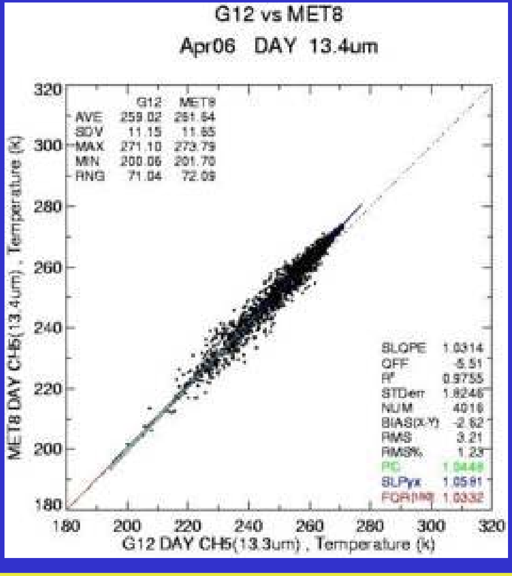












Deep Convective Cloud Technique (DCCT)

- **Assumptions**
  - Mean spectral albedo of deep convective clouds (DCC) is constant over time
  - Change in mean would indicate change in calibration response

- **Approach**
  - Select pixels *i* over ocean between 30°N and 30°S that meet

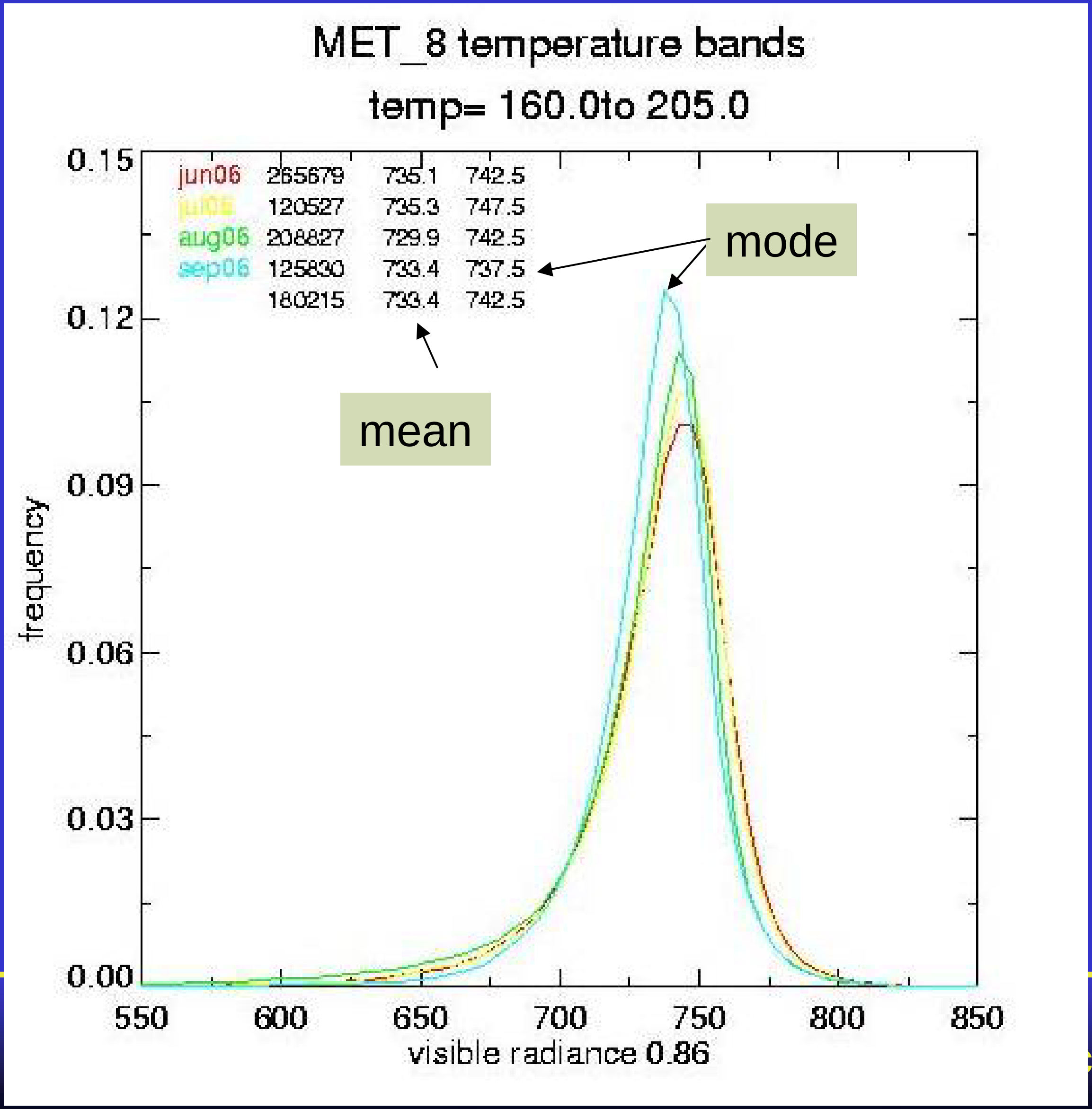
    $T_{11i} < 205.0$ K, $SZA < 40°$, $VZA < 40°$, $10° < RAA < 170°$

    $\sigma(T_{11}) < 1.0$ K, & $\sigma(\rho) < 0.02\ \rho_I$ σ for *i* + 8 surrounding pixels
  - Correct for anisotropy, normalize reflectance to $SZA = 0°$
  - Create histogram, compute mean & mode
  - Compute trends in mean and mode

Minnis et al., JTech, 2007

Doelling et al., JTech, 2007

MET-8 0.86µm DCCT monthly PDFs
June - September 2006



Theoretical Spectral Correction

- **Spectral filter functions vary from imager to imager**
  - Atmospheric scatter and absorption vary with wavelength
  - Surface and cloud reflectance, emissivity vary with wavelength
  - Need to correct intercalibrated radiances

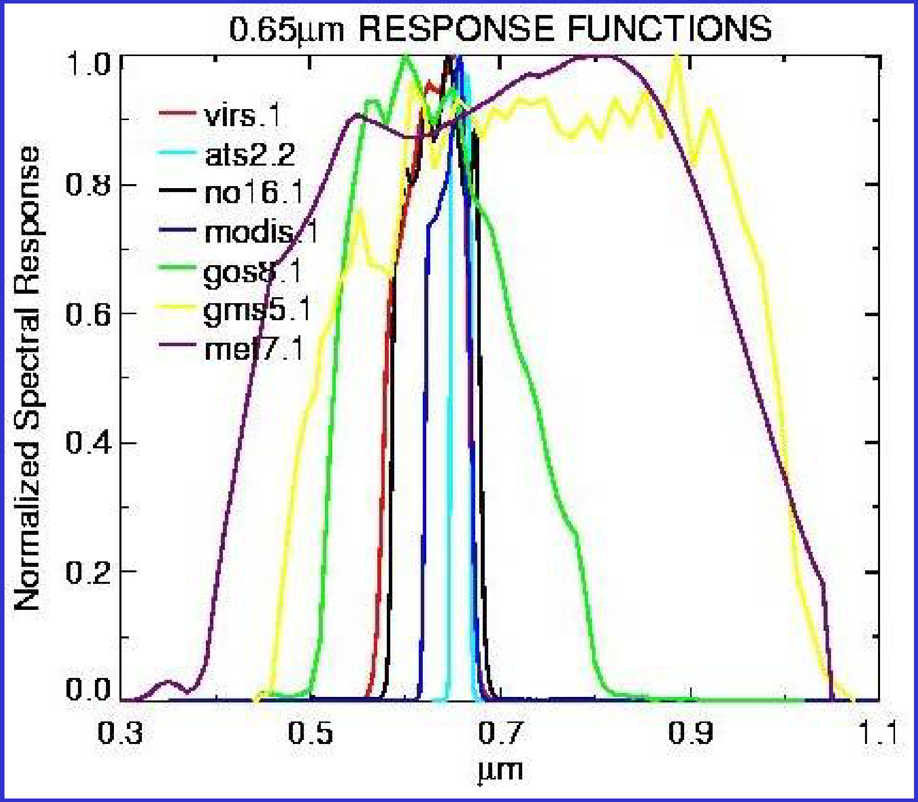
- **Approach**
  - Use radiative transfer models to compute $L_{sat}[L_{ref}(K)]$, K = sfc type

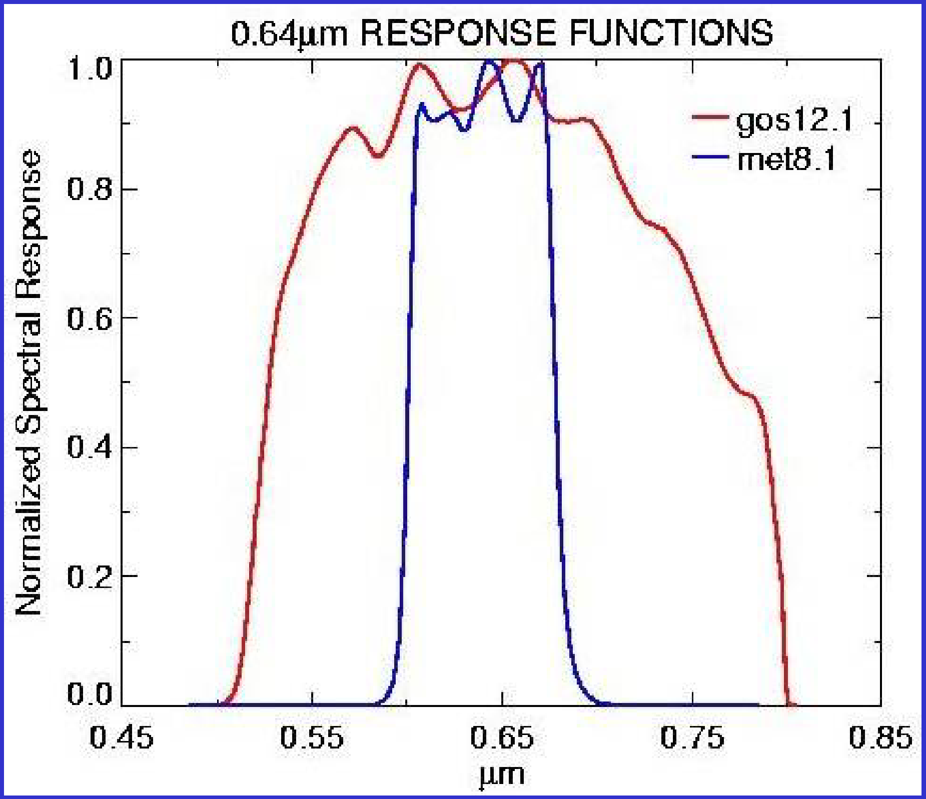
    Compute L_x for range of atmospheres, clouds, & aerosols for all imagers x

    $$L_{sat}(K) = f(L_{ref}(K)) \qquad (1)$$

  - Use SBDART, 3 SZAs, albedo not L, 3 sfc types: ocean, vegetation, sand
  - Given normalized value of L'_{sat} from intercalibration, compute final value as $L_{sat}(K) = f(L'_{sat}(K))$

Visible Channel Spectral Response Functions

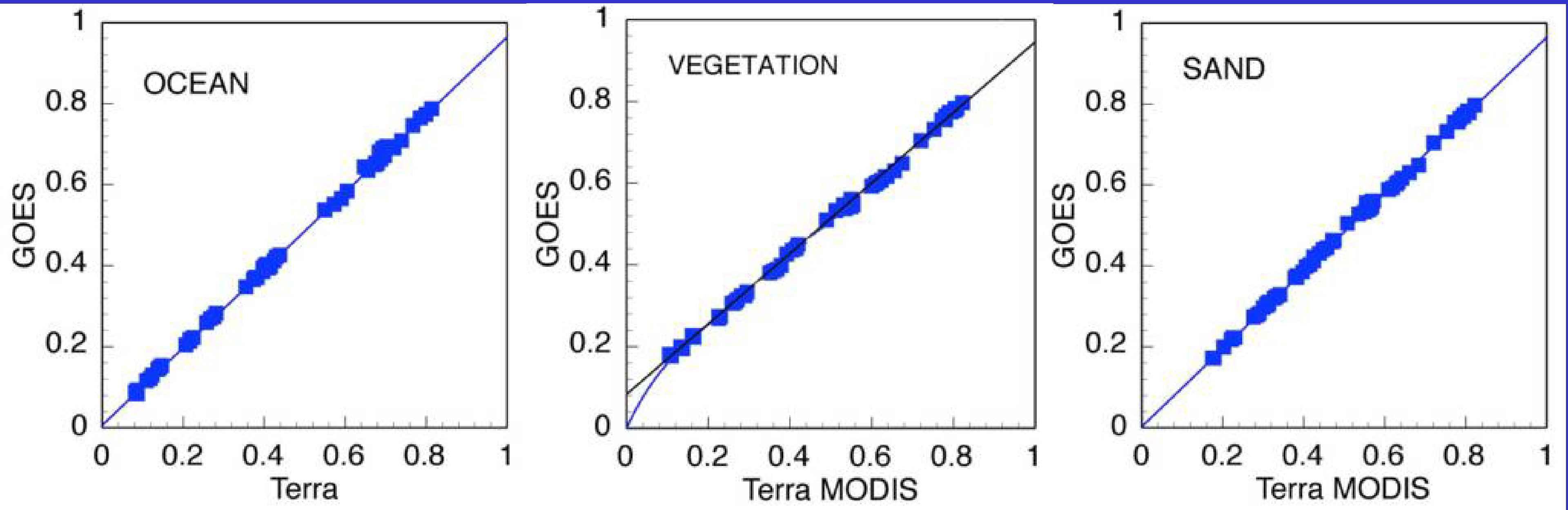




Similar variations seen in other channels!

Examples of Spectral Corrections, MODIS to GOES

0.65 µm



Ocean and sand are very similar, vegetation brighter for GOES

Spectral Corrections to *Terra* MODIS, Ocean only

Satellite	a	b
GOES	0.9584	0.0056
Meteosat-7	$A(\mu_o)$	$B(\mu_o)$
Meteosat-8	0.9741	0.0036
MTSAT-1R	$C(\mu_o)$	$D(\mu_o)$
VIRS	0.9540	0.0109
N14	0.9484	0.0030

- Broadbands have SZA dependence
- SEVIRI closest to MODIS

Nguyen et al., JTech, 2007

Processing

- Ingest data from
  - *UW-SSEC McIDAS (GEOsats)*
  - *NASA LaRC ASDC (TRMM)*
  - *NASA GSFC DAAC (MODIS)*
  - *NOAA SSA (AVHRR)*
- Run matching routines, collect output
- Perform regressions
- Produce & post graphical & numerical output
- Link to webpages (real-time & archival)

Archive Calibration Page

Satellite Cross-Calibrations

	VIRS	Terra_MODIS	Aqua_MODIS	GOES-8	GOES-12	MET-8	NOAA-16	NOAA-17
VIRS	-	VIRS/Terra	VIRS/Aqua	VIRS/GOES-8	VIRS/GOES-12		VIRS/NOAA-16	
Terra-MODIS	Terra/VIRS	Terra4/Terra3	Terra/Aqua	Terra/GOES-8	Terra/GOES-12	Terra/MET-8	Terra/NOAA-16	
Aqua-MODIS	Aqua/VIRS	Aqua/Terra	-		Aqua/GOES-12	Aqua/MET-8		Aqua/NOAA-17
GOES-8	GOES-8/VIRS	GOES-8/Terra		-			GOES-8/NOAA-16	
GOES-12	GOES-12/VIRS	GOES-12/Terra	GOES-12/Aqua		-		GOES-12/NOAA-16	GOES-12/NOAA-17
MET-8		MET-8/Terra	MET-8/Aqua			-		
NOAA-16	NOAA-16/VIRS	NOAA-16/Terra		NOAA-16/GOES-8	NOAA-16/GOES-12		-	NOAA-16/NOAA-17
NOAA-17			NOAA-17/Aqua		NOAA-17/GOES-12		NOAA-17/NOAA-16	-

- MET-8 calibrations *EUMETSAT MTG Prague May04*
- TWPICE calibrations *TWPICE IOP Jan06*
- IR CENTRAL WAVELENGTHS
- NOAA AM/PM combinations:
  o N09/N10 o N10/N11 o N11/N12 o N12/N14 o N14/N15 o N15/N16 o N16/N17
- Other combinations:
  o VIRS/GMS-5 o N-12/N-14 OLD o N-14/N-15 OLD

Deep Convective Calibration

	VIRS	Terra-MODIS	Aqua-MODIS	GOES-8	GOES-12	MET-8	NOAA-09	NOAA-11	NOAA-14	NOAA-16	NOAA-17
Gain	Ver5 0.65 Ver5 0.65 ascii Ver5 1.64 Ver6 0.65 Ver6 0.65 ascii Ver6 1.64	0.65 0.65 ascii 0.47 0.55 1.24 1.64 2.12 1.37	0.65 0.65 ascii 0.47 0.55 1.24 2.12 1.37	1	-	-	1 2	1 2	1 2	1 2	1 2

Satellite Channel Response Functions

- ASCII satellite response functions
- Normalized Response Functions

0.65um	0.86um	1.6um	3.7um	6um	11um	12um
X	X	X	X	X	X	X

- Visible Channel Normalized Response Functions
  NOAA 7-16 GOES 6-11 MET 2-7 GMS 3-5

Archive Individual Pair Calibration SubPage

VIRS vs Terra-MODIS ***(version #4)***

- **Individual Monthly JPEG Plot**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000			1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5	
2001	1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5	
2002	1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5	
2003	1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5	
2004	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5		1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	
2005	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5	1 2 3d 3n 4d 4n 5d 5n 4 5						

CHANNELS STATS MATCHING DATA ASCII

SPECTRAL RESPONSE FUNCTIONS: 0.65 1.6 3.7 11.0 12.0 Central wavelengths Corrk results

- **Timeline JPEG Plot**

	Slope	Yoffset	R2	STDerr	#	Bias	RMS	RMS%	Mave	Vave	SLPpc	SLPyx	SLPfor
0.65um	X	X	X	X	X	X	X	X	X	X	X	X	X
1.6um	X	X	X	X	X	X	X	X	X	X	X	X	X
3.7um	X	X	X	X	X	X	X	X	X	X	X	X	X
11um	X	X	X	X	X	X	X	X	X	X	X	X	X
12um	X	X	X	X	X	X	X	X	X	X	X	X	X

STATS ASCII

RETURN TO MAIN CALIBRATION PAGE

Real-Time Calibration Page, Part 1
(started March 2006)

Latest Calibrations Coefficients

GEO-satellite	MET-8	MET-5	FY2C	MTSAT	GOES-10 GOES-11	GOES-12
AVHRR-satellite	NOAA-15	NOAA-16	NOAA-17	NOAA-18		

GEO to GEO Cross-Calibrations calibration domains

FY2C 0.75um Night Examples problem good
FY2C 3.7um Night Examples problem good

	MET-8	MET-5	FY2C	MTSAT	GOES-10 GOES-11	GOES-12
MET-8	-	MET8/MET5	MET8/FY2C			MET8/GOES12
MET-5	MET5/MET8	-	MET5/FY2C			
FY2C	FY2C/MET8	FY2C/MET5	-	FY2C/MTSAT		
MTSAT			MTSAT/FY2C	-	MTSAT/GOES10 MTSAT/GOES11	
GOES-10 GOES-11				GOES10/MTSAT GOES11/MTSAT	-	GOES10/GOES12 GOES11/GOES12
GOES-12	GOES12/MET8			GOES12/GOES10	GOES12/GOES11	-

GEO to LEO Calibrations calibration domains

	MET-8	MET-5	FY2C	MTSAT	GOES-10 GOES-11	GOES-12
Terra-MODIS	Terra/MET8	Terra/MET5	Terra/FY2C	Terra/MTSAT	Terra/GOES10 Terra/GOES11	Terra/GOES12
Aqua-MODIS	Aqua/MET8	Aqua/MET5	Aqua/FY2C	Aqua/MTSAT	Aqua/GOES10 Aqua/GOES11	Aqua/GOES12
VIRS	VIRS/MET8	VIRS/MET5	VIRS/FY2C	VIRS/MTSAT	VIRS/GOES10 VIRS/GOES11	VIRS/GOES12
NOAA16-AVHRR	NOAA16/MET8					NOAA16/GOES12
NOAA17-AVHRR	NOAA17/MET8					NOAA17/GOES12
NOAA18-AVHRR	NOAA18/MET8					NOAA18/GOES12

Real-Time Calibration Page, Part 2

LEO to LEO Calibrations

	Terra	Aqua	VIRS	NOAA-16	NOAA-17	NOAA-18
Terra-MODIS	-	Terra/Aqua	Terra/VIRS	Terra/NOAA16	Terra/NOAA17	Terra/NOAA18
Aqua-MODIS	Aqua/Terra	-	Aqua/VIRS	Aqua/NOAA16	Aqua/NOAA17	Aqua/NOAA18
VIRS	VIRS/Terra	VIRS/Aqua	-	VIRS/NOAA16	VIRS/NOAA17	VIRS/NOAA18
NOAA16-AVHRR	NOAA16/Terra	NOAA16/Aqua	NOAA16/VIRS	-	NOAA16/NOAA17	NOAA16/NOAA18
NOAA17-AVHRR	NOAA17/Terra	NOAA17/Aqua	NOAA17/VIRS	NOAA17/NOAA16	-	NOAA17/NOAA18
NOAA18-AVHRR	NOAA18/Terra	NOAA18/Aqua	NOAA18/VIRS	NOAA18/NOAA16	NOAA18/NOAA17	-

Deep Convective Calibration

	MET-8	MET-5	FY2C	MTSAT	GOES-11	GOES-12
GEO-gain	0.65 ascii PDF 0.86 ascii PDF 1.64 ascii PDF	0.75 ascii PDF	0.73 ascii PDF	0.73 ascii PDF	0.65 ascii PDF	0.65 ascii PDF

	Terra	Aqua	VIRS	NOAA-16	NOAA-17	NOAA-18
LEO-gain	0.65 ascii PDF 0.47 ascii PDF 0.55 ascii PDF 1.24 ascii PDF 1.64 ascii PDF 2.12 ascii PDF 1.37 ascii PDF	0.65 ascii PDF 0.47 ascii PDF 0.55 ascii PDF 1.24 ascii PDF 1.64 ascii PDF 2.12 ascii PDF 1.37 ascii PDF	0.65 5A ascii 5A PDF 5A 1.64 V6 ascii V6 PDF V6 0.65 V6 ascii V6 PDF V6 Ver6->Ver5A YYYY Ver6->Ver5A DSL Ver6->Ver5A Dec31-03	0.65 ascii PDF 0.85 ascii PDF 1.64 ascii PDF	0.65 ascii PDF 0.85 ascii PDF 1.64 ascii PDF	0.65 ascii PDF 0.85 ascii PDF 1.64 ascii PDF

Individual pair calibration web page

MET-8 vs Aqua-MODIS 9-channel

- **Individual Monthly JPEG Plot**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006				1 2 3 4d 4n 5d 5n 5d 6n 6d 7n 8d 8n 9d 9n	1 2 3 4d 4n 5d 5n 5d 6n 6d 7n 8d 8n 9d 9n	1 2 3 4d 4n 5d 5n 5d 6n 6d 7n 8d 8n 9d 9n	1 2 3 4d 4n 5d 5n 5d 6n 6d 7n 8d 8n 9d 9n	1 2 3 4d 4n 5d 5n 5d 6n 6d 7n 8d 8n 9d 9n	1 2 3 4d 4n 5d 5n 5d 6n 6d 7n 8d 8n 9d 9n			

MONTHLY ASCII FILES

- **VIS Timeline JPEG Plots**

	Slope	Xoffset	R2	STDerr	#	M8ave	Tave	SLPpc	SLPyx	SLPfor
0.64um	X	X	X	X	X	X	X	X	X	X
0.81um	X	X	X	X	X	X	X	X	X	X
1.64um	X	X	X	X	X	X	X	X	X	X

- **IR Timeline JPEG Plots**

	Slope	Yoffset	R2	STDerr	#	Bias	RMS	RMS%	M8ave	Tave	SLPpc	SLPyx	SLPfor
3.92um	X	X	X	X	X	X	X	X	X	X	X	X	X
6.25um	X	X	X	X	X	X	X	X	X	X	X	X	X
10.8um	X	X	X	X	X	X	X	X	X	X	X	X	X
12.0um	X	X	X	X	X	X	X	X	X	X	X	X	X
8.7um	X	X	X	X	X	X	X	X	X	X	X	X	X
13.4um	X	X	X	X	X	X	X	X	X	X	X	X	X

TIME LINE ASCII FILES

- **Spectral Response Functions**

0.65 0.81 1.64 3.92 6.25 10.8 12.0 8.7 13.4 Central wavelengths Corrk results

Individual pair calibration web page

MET8 vs MET5

MET8 vs MET5

- **Individual Monthly JPEG Plot**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006			1 3d 3n 4d 4n	1 3d 3n 4d 4n	1 3d 3n 4d 4n	1 3d 3n 4d 4n	1 3d 3n 4d 4n	1 3d 3n 4d 4n	1 3d 3n 4d 4n			
2007												

MONTHLY ASCII FILES

- **VIS Timeline JPEG Plots**

	Slope	Xoffset	R2	STDerr	#	MET8ave	MET5ave	SLPpc	SLPyx	SLPfor
0.65um	X	X	X	X	X	X	X	X	X	x

- **IR Timeline JPEG Plots**

	Slope	Yoffset	R2	STDerr	#	Bias	RMS	RMS%	MET8ave	MET5ave	SLPpc	SLPyx	SLPfor
6.7um	X	X	X	X	X	X	X	X	X	X	X	X	X
10.8um	X	X	X	X	X	X	X	X	X	X	X	X	X

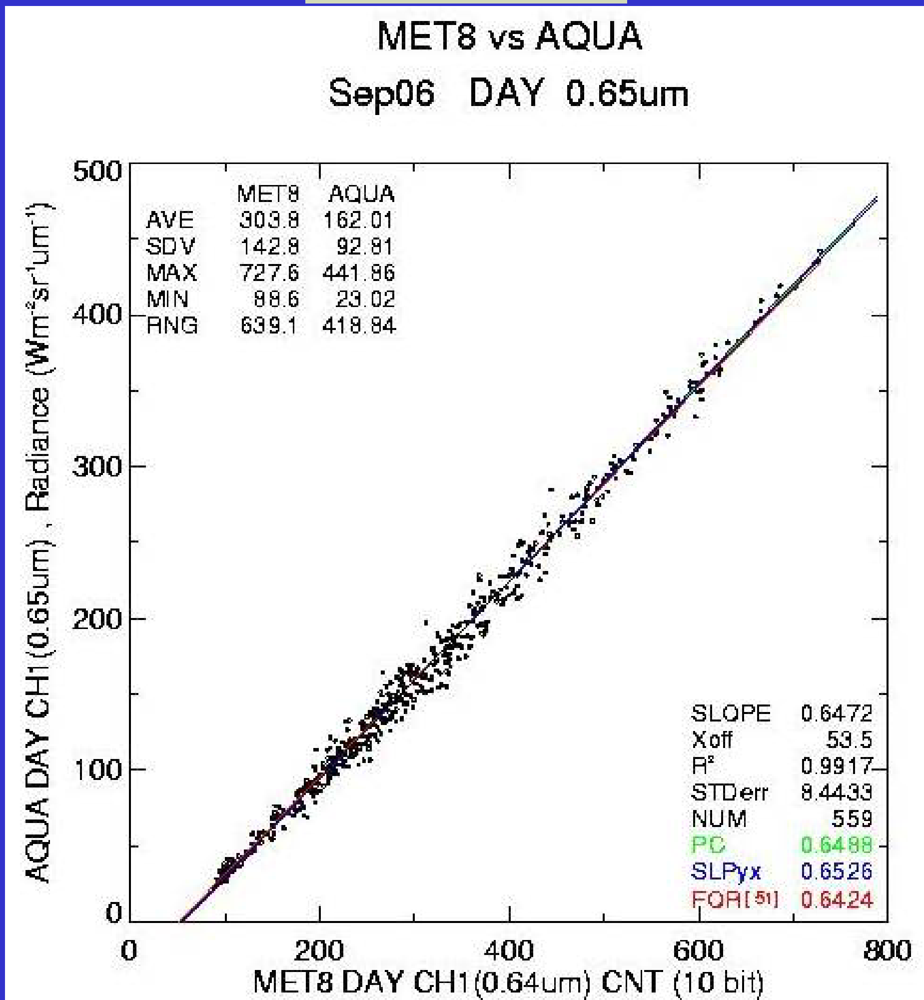
TIME LINE ASCII FILES

- **Spectral Response Functions**
  0.65 6.7 10.8 Central wavelengths Corrk results

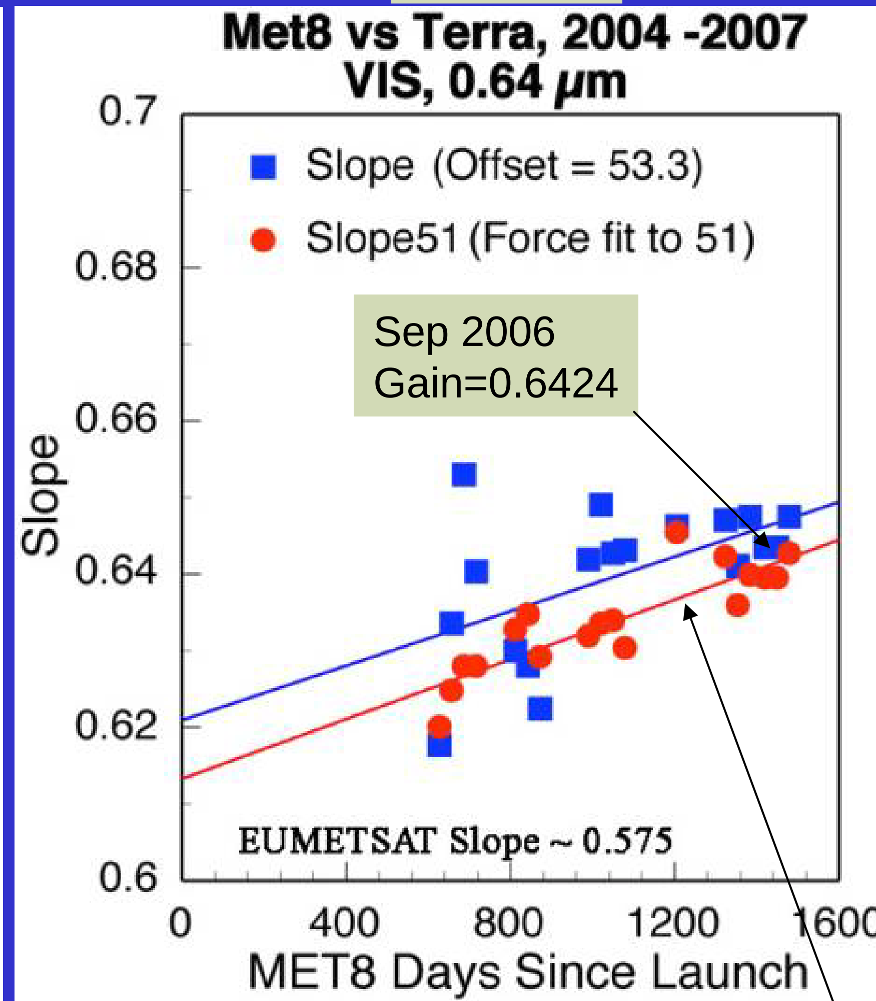
- **ReadMe Files**
  CHANNELdefinitions STATdefinitions MATCHING

MET-8 vs Aqua-MODIS

Monthly Plot



Timeline

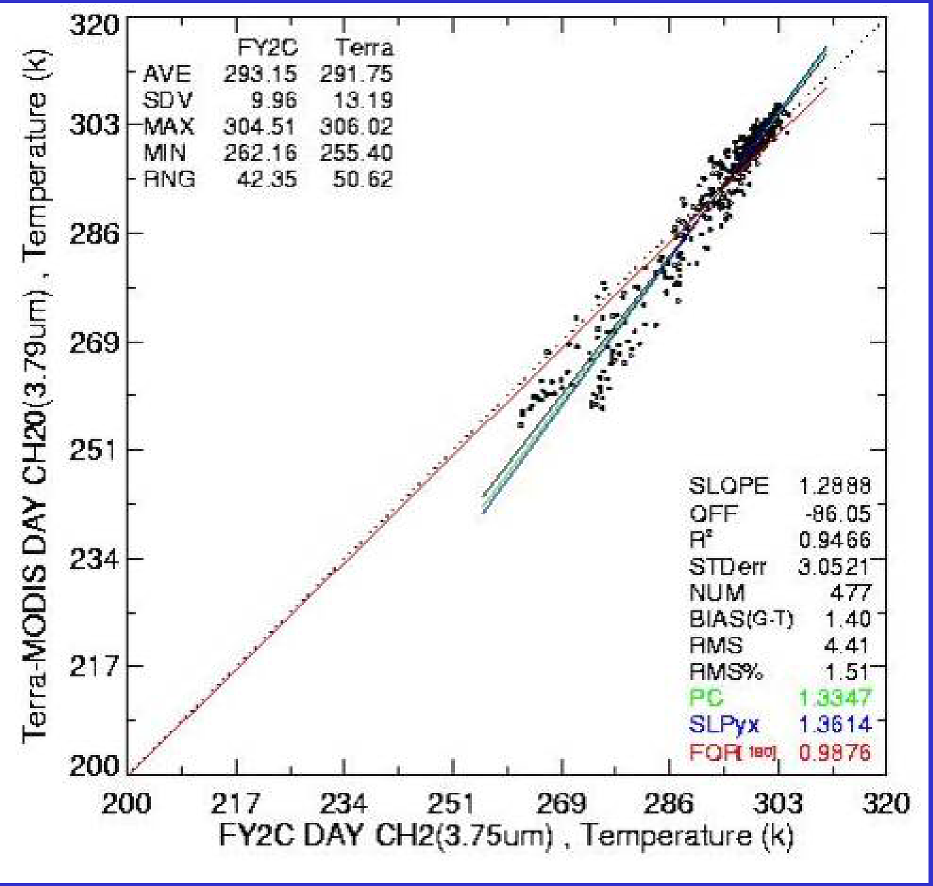


NASA Langley

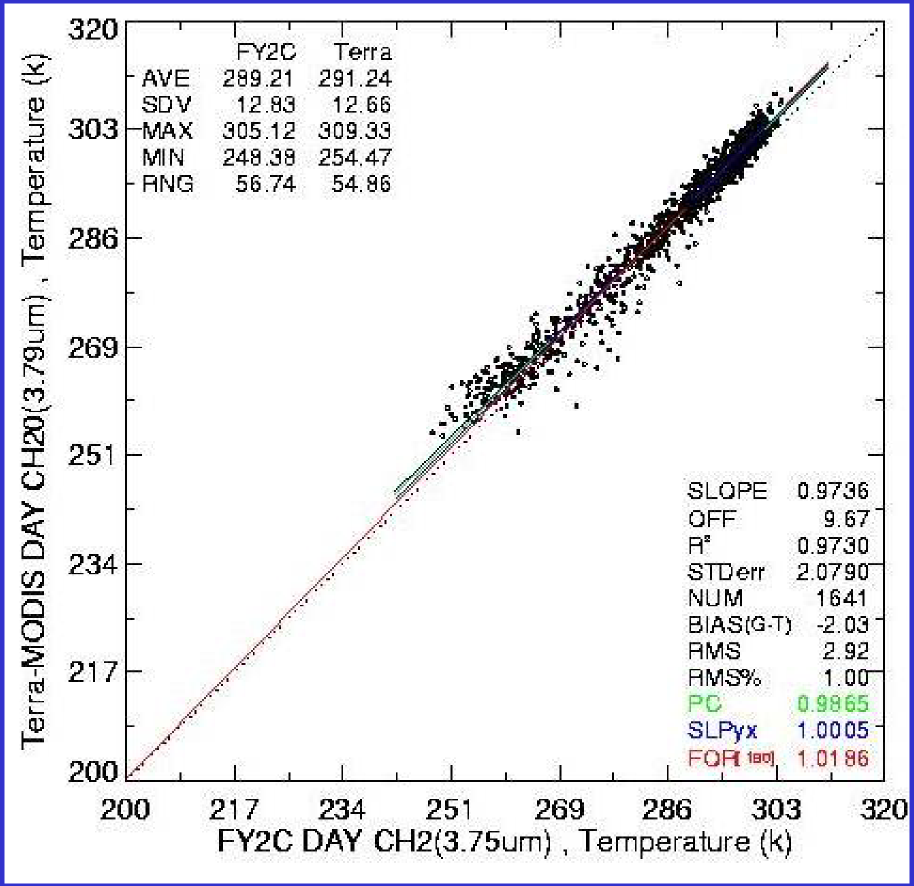
Degradation rate = 365*0.178e-4 = 1%/year

FY2C vs Terra-MODIS, 3.75µm

Before Jan 16, 2006

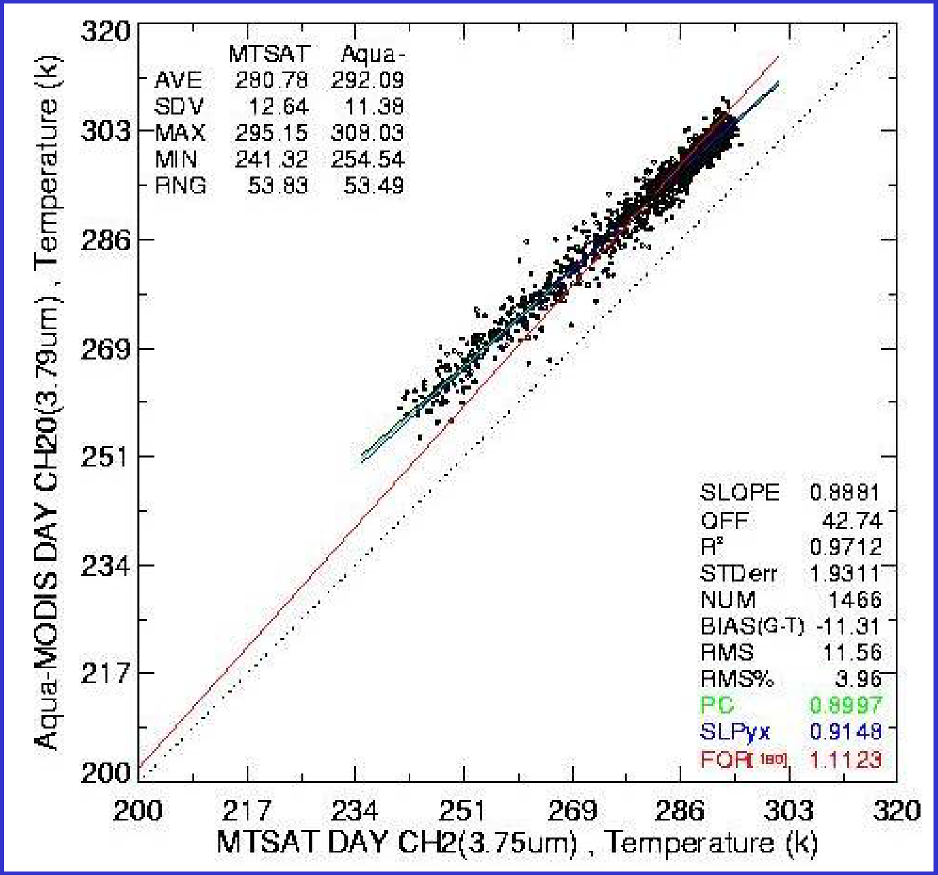


After Jan 17, 2006

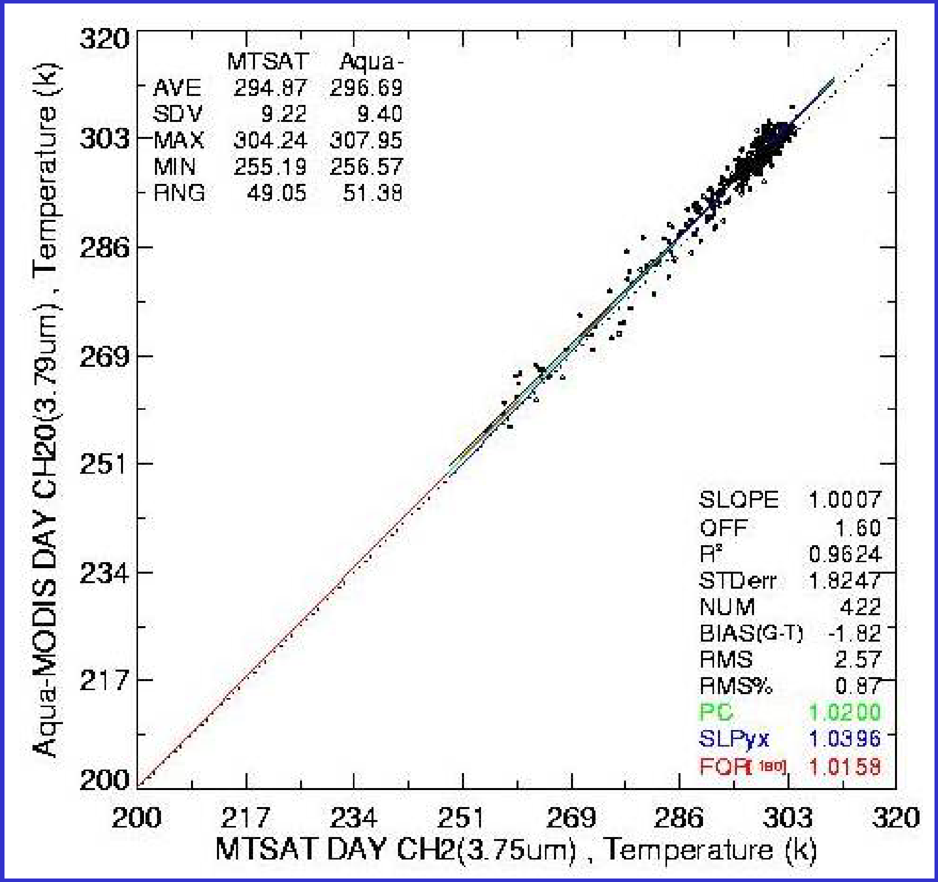


MTSAT vs Aqua-MODIS, 3.75µm

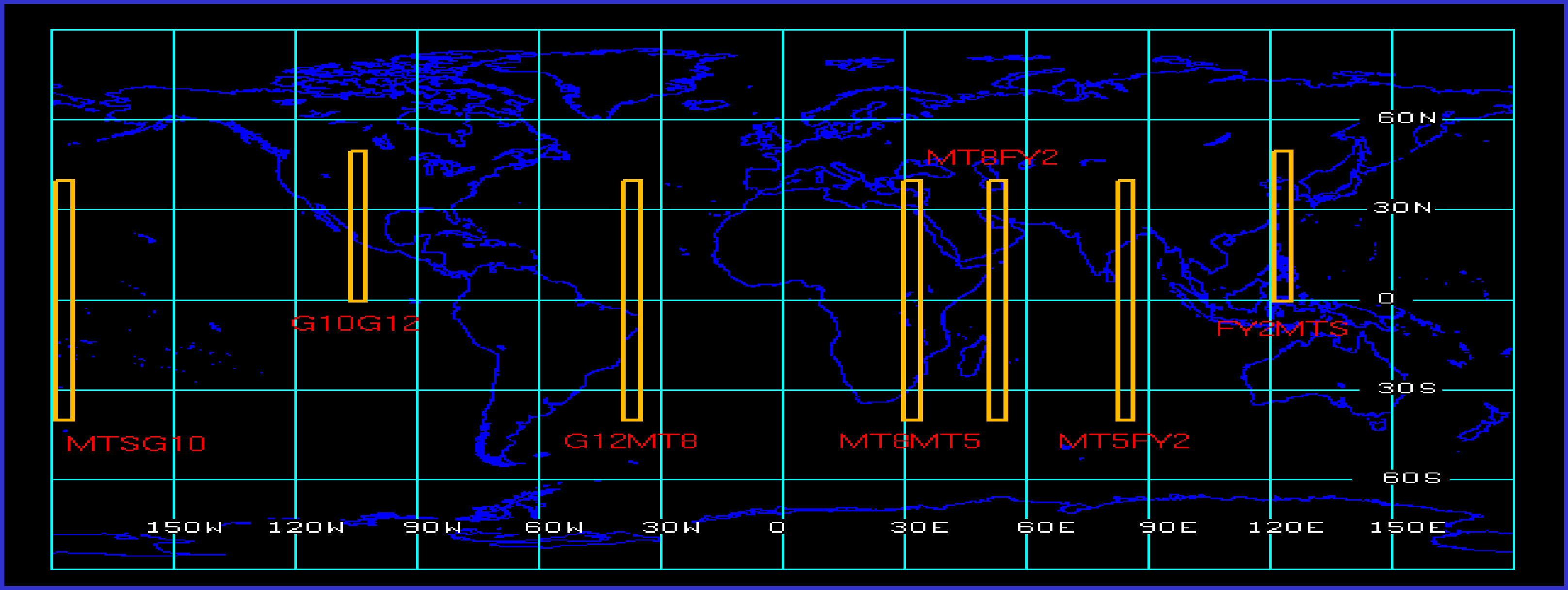
Before Feb 14, 2006



After Feb 15, 2006



GEO to GEO domains and pairs



GEO to GEO Cross-Calibrations calibration domains

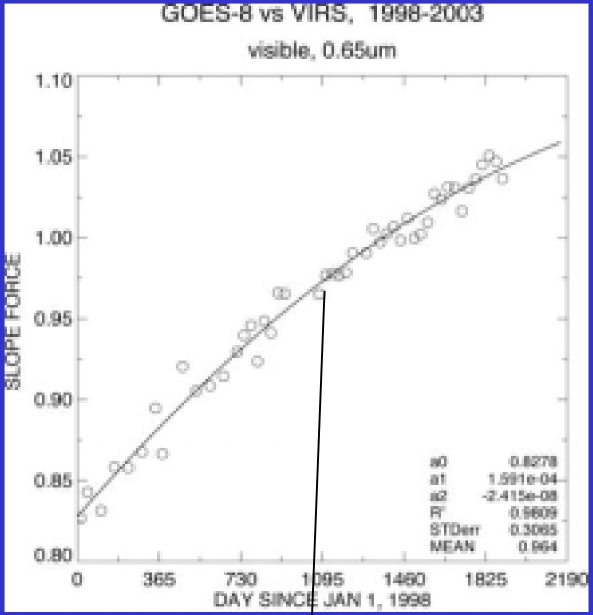
FY2C 0.75um Night Examples problem good

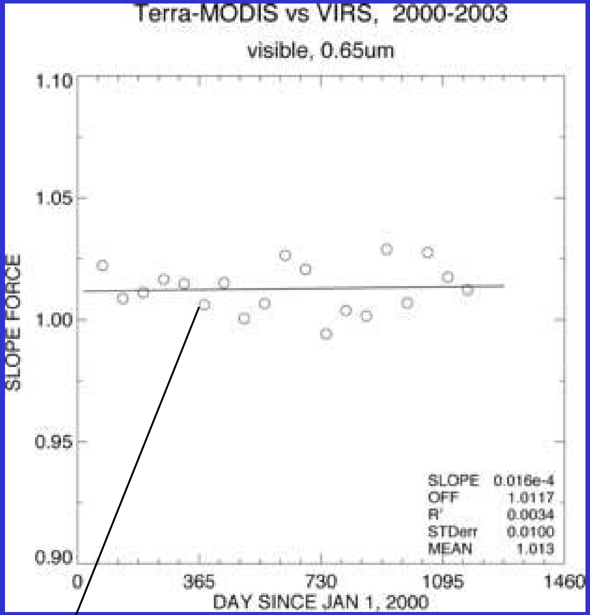
FY2C 3.7um Night Examples problem good

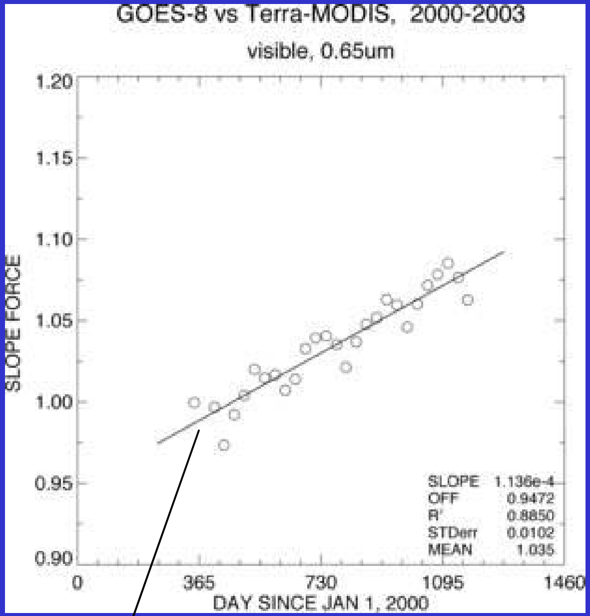
	MET-8	MET-5	FY2C	MTSAT	GOES-10 GOES-11	GOES-12
MET-8	-	MET8/MET5	MET8/FY2C			MET8/GOES12
MET-5	MET5/MET8	-	MET5/FY2C			
FY2C	FY2C/MET8	FY2C/MET5	-	FY2C/MTSAT		
MTSAT			MTSAT/FY2C	-	MTSAT/GOES10 MTSAT/GOES11	
GOES-10 GOES-11				GOES10/MTSAT GOES11/MTSAT	-	GOES10/GOES12 GOES11/GOES12
GOES-12	GOES12/MET8			GOES12/GOES10	GOES12/GOES11	-

3 Way Cross-Calibration Validation

Consistency and Accuracy of GOES-8, VIRS, & TERRA-MODIS Calibration Trends







	VIRS / GOES-8	*	MODIS / VIRS	=	MODIS / GOES-8	From timeline	difference
Jan 2001	0.9730		1.012		.9847	0.9887	0.4%

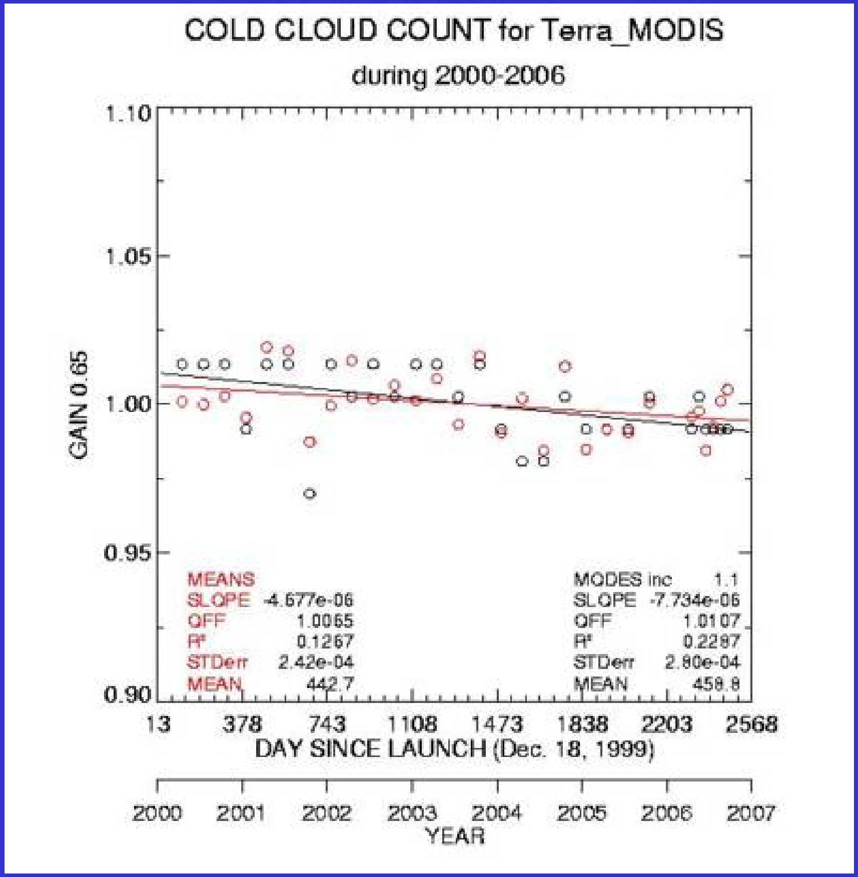
GEO and LEO DCC

Deep Convective Calibration

	MET-8	MET-5	FY2C	MTSAT	GOES-11	GOES-12
GEO-gain	0.65 ascii PDF 0.86 ascii PDF 1.64 ascii PDF	0.75 ascii PDF	0.73 ascii PDF	0.73 ascii PDF	0.65 ascii PDF	0.65 ascii PDF

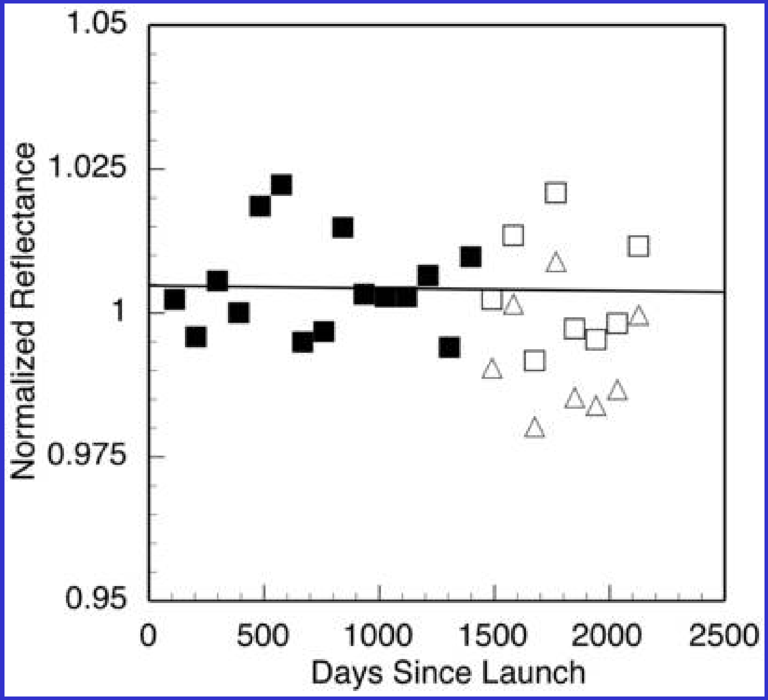
	Terra	Aqua	VIRS	NOAA-16	NOAA-17	NOAA-18
LEO-gain	0.65 ascii PDF 0.47 ascii PDF 0.55 ascii PDF 1.24 ascii PDF 1.64 ascii PDF 2.12 ascii PDF 1.37 ascii PDF	0.65 ascii PDF 0.47 ascii PDF 0.55 ascii PDF 1.24 ascii PDF 1.64 ascii PDF 2.12 ascii PDF 1.37 ascii PDF	0.65 ascii PDF 1.64 ascii PDF Ver6->Ver5A YYYY Ver6->Ver5A DSL Ver6->Ver5A Dec31-03	0.65 ascii PDF 0.85 ascii PDF 1.64 ascii PDF	0.65 ascii PDF 0.85 ascii PDF 1.64 ascii PDF	0.65 ascii PDF 0.85 ascii PDF 1.64 ascii PDF

Terra-MODIS DCC degradation



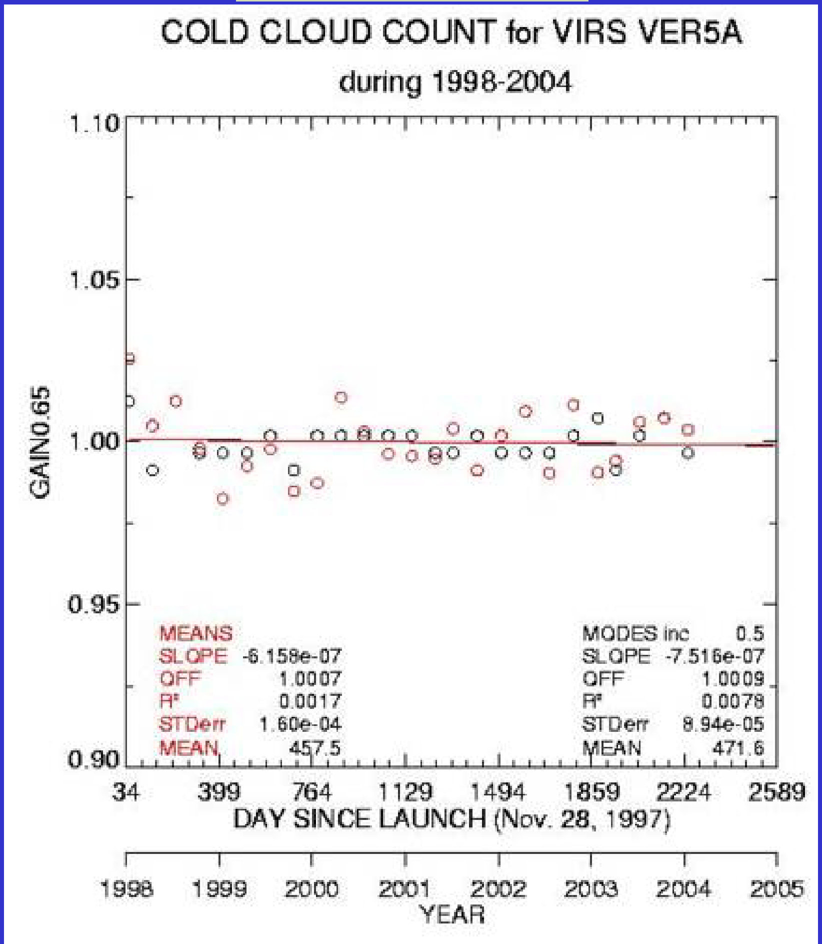
- Apparent trend due to gain jump in late 2003
- Correction needed after day 1419

Open squares corrected for gain change

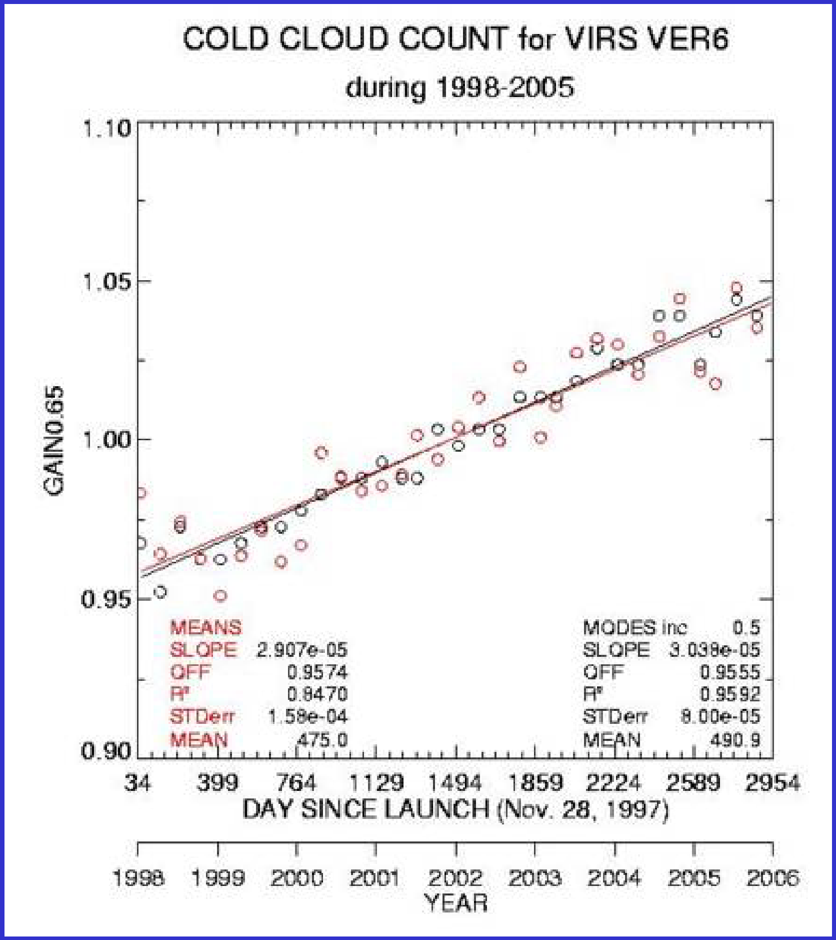


VIRS DCC degradation

Version 5A

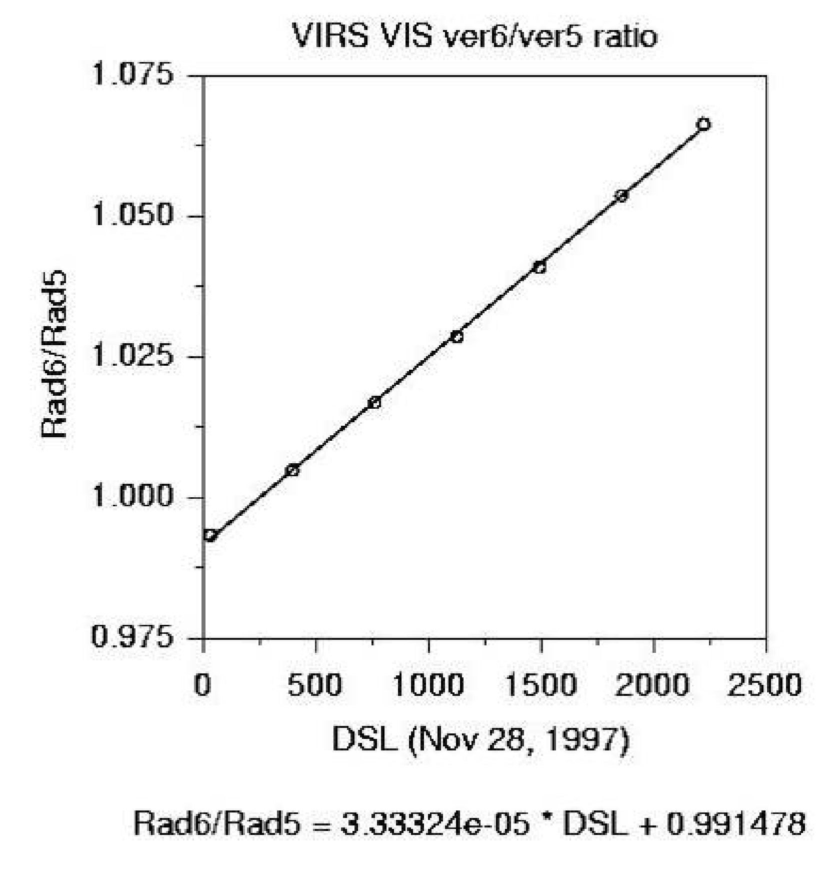


Version 6

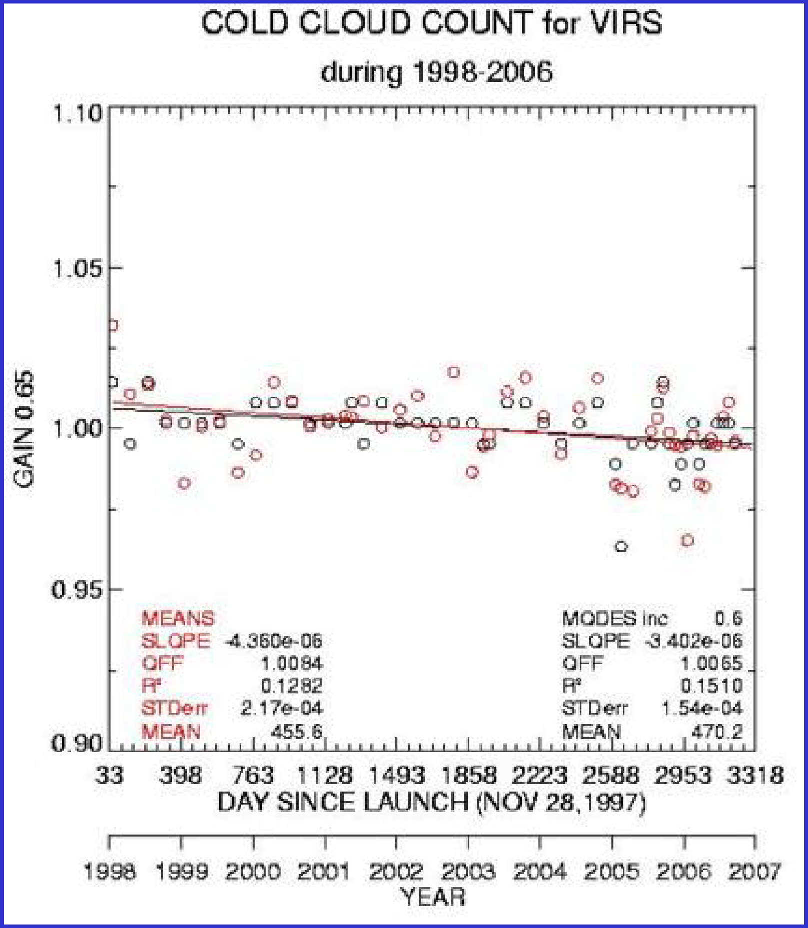


VIRS DCCT degradation correction

VIRS Ver6/Ver5A correction

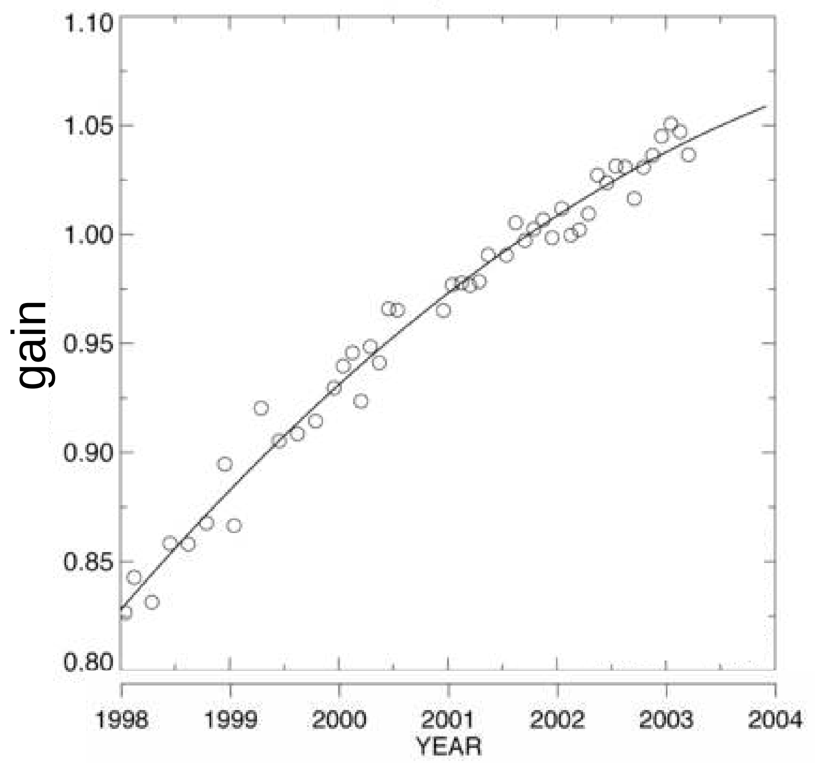


VIRS Ver6 corrected

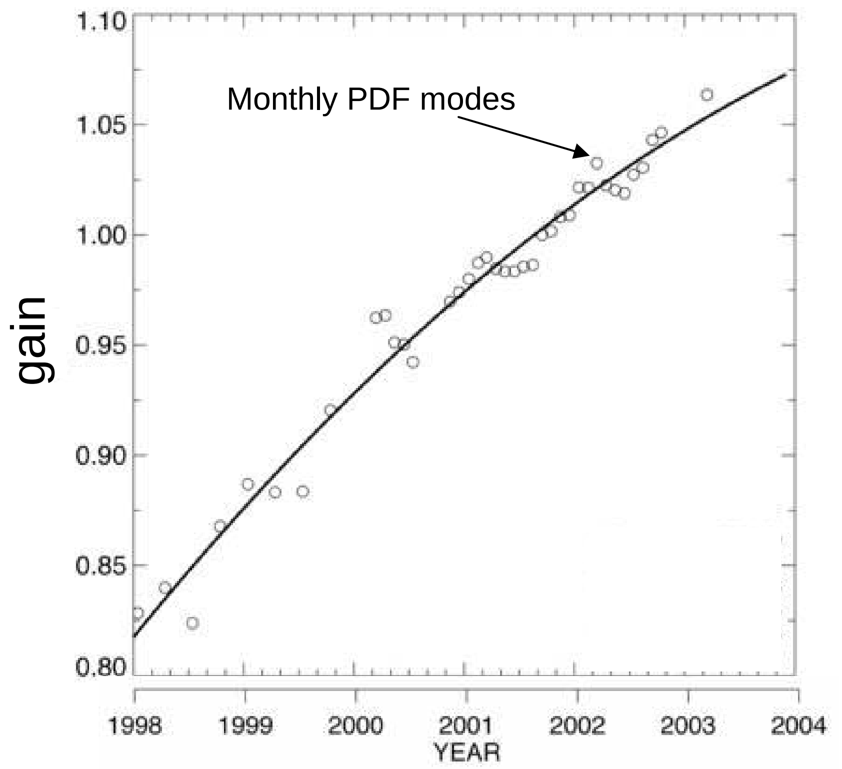


Comparison of LEO-GEO and DCCT Trends

GOES-8 based on VIRS



GOES-8 based on DCCT



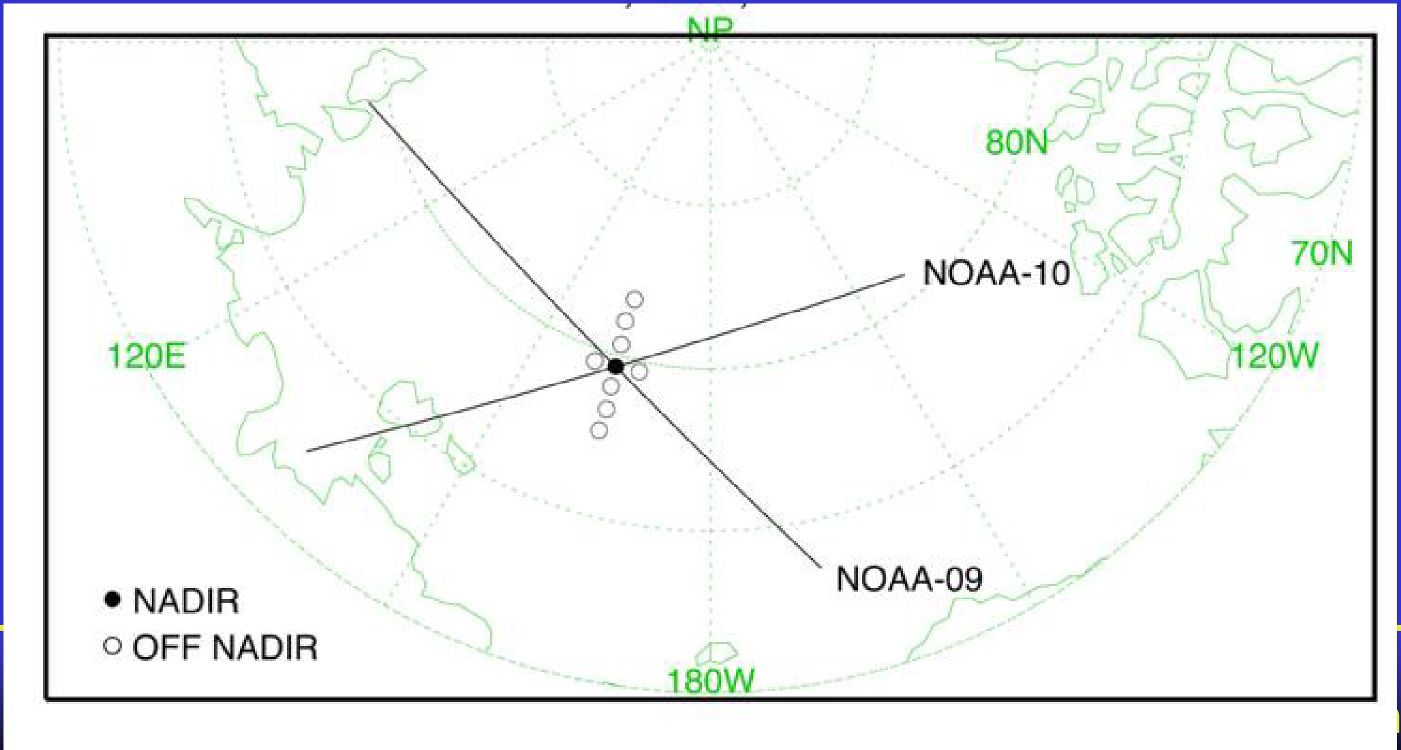
- Curves agree for bulk of period, but differ on extremes
- Need more DCC datapoints

LEO to LEO Technique and Target

Collocate AM/PM Polar orbiters and average pixel radiances into 50km diameter regions at the ground intersect (Nadir method)

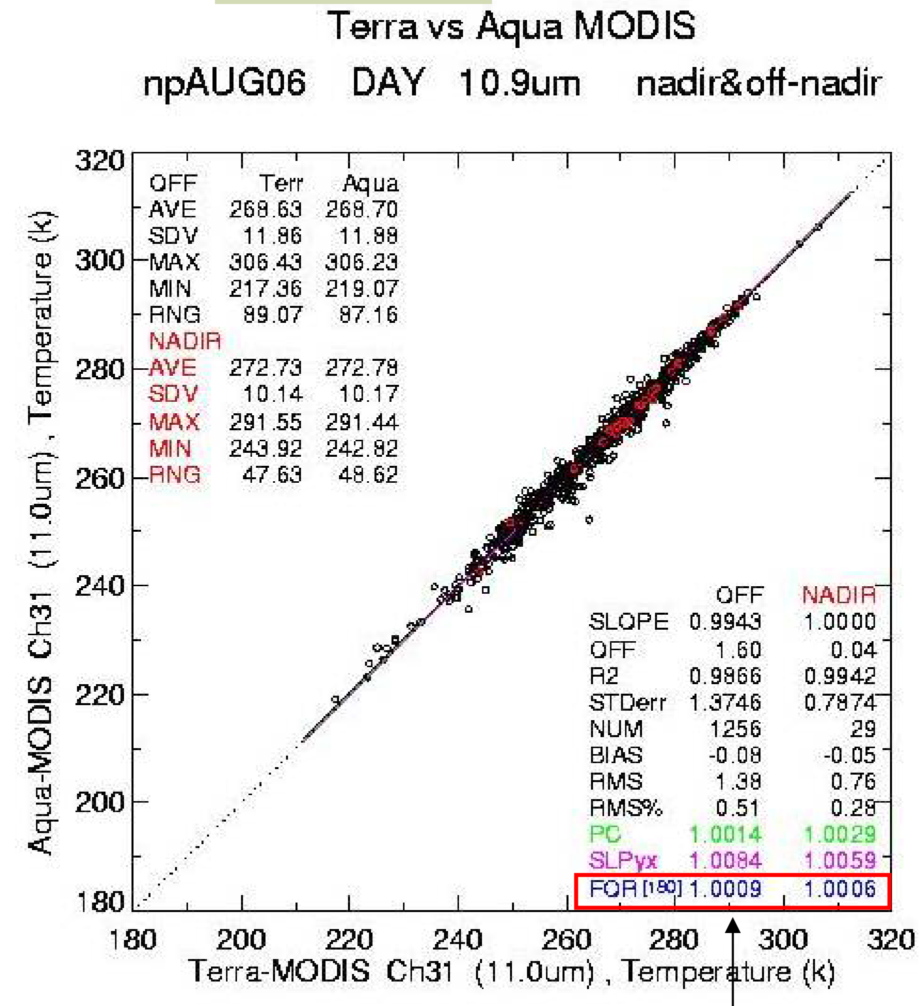
- Limited to polar latitudes (70° Aqua/Terra), (80° NOAA)

Off Nadir method uses 50km region with identical VZA limited to 7.5° VZA - increase the # of samples and dynamic range

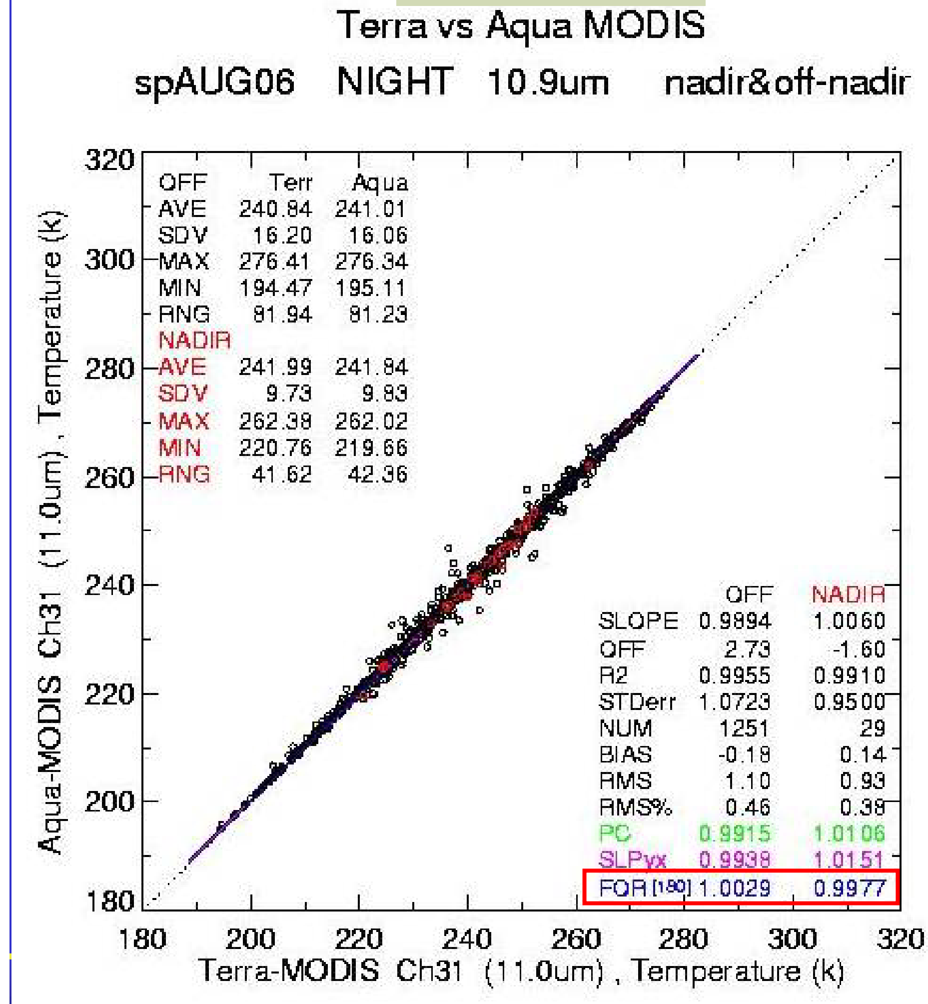


Terra/Aqua MODIS, 10.9µm, Aug 2006

Day, NP

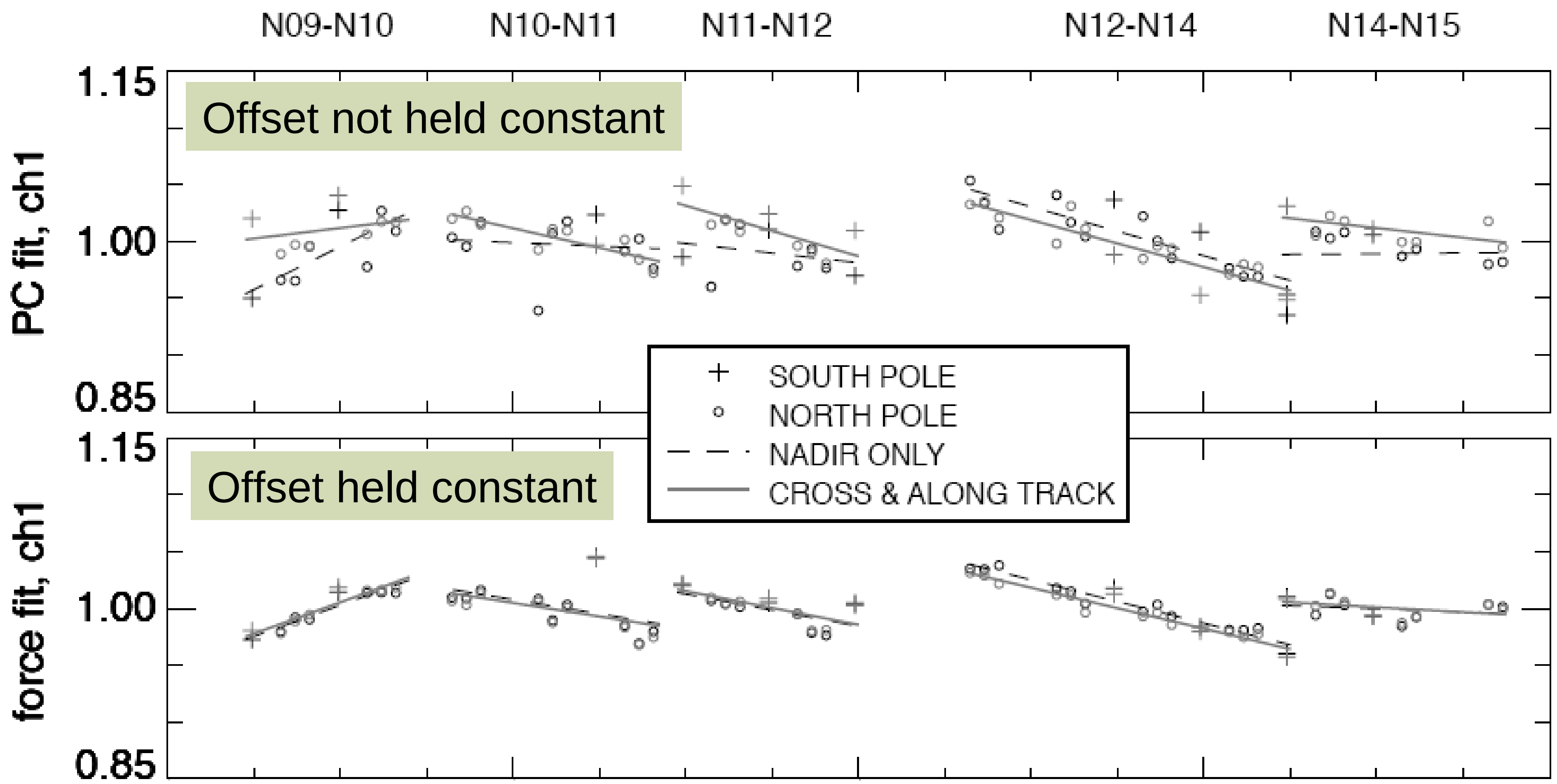


Night, SP

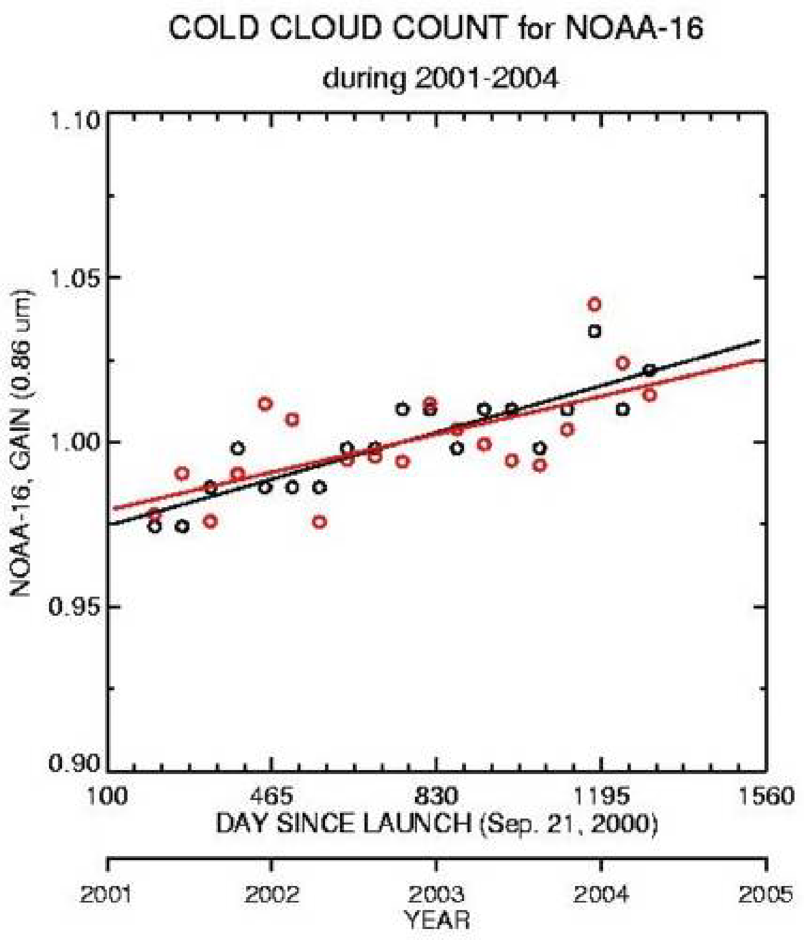


Nadir and off-nadir gains are nearly identical

Calibration can then be transferred back in time given enough overlap - 0.65μm AVHRR



AVHRR DCCT degradation



Conclusions

• Well-calibrated GEO & LEO radiances necessary to produce accurate & cross-platform consistent cloud properties and fluxes

- **Reference imager radiances necessary**
- **Cross-platform normalization can provide accurate calibrations**

• NASA-Langley has developed a prototype end-to-end system linking the calibration of relevant channels on a host of satellites

- **MODIS serves as reference**
- **Multiple approaches ensure redundancy & error checking**
- **Radiative transfer methods used to adjust normalized results**
- **Results to be made public in 2007 (NOAA9-NOAA18 + GEOs)**

For references: http://www-pm.larc.nasa/calibration/calib-ref.html

Future Work

- Collaborate with calibration community
- Construct user-friendly web page
- Complete documentation & error analyses
- Continue real-time processing with QC
- Develop & test complete set of K-dependent normalization corrections
- Revise historical & real-time results as needed
- Add new satellites as needed
- Secure funding to complete the system