GEO Visible Calibration Strategy Using MODIS as Reference

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Overview

- Inter-Calibration Methods
- VIS calibration results under legacy system
- Demo New Calibration Server and Website
- New VIS calibration trends from MODIS

Inter-Calibration Methods

Technique 1: LEO-GEO (ex: MODIS-GOES12)

- Co-locate GEO & Polar pixels and average to 0.5° regions using 30° x 20° grid box near GEO subsatellite point
- Match solar, viewing and azimuth angles and time:

  SZA < 5° VZA < 10° RAZ < 15° Time < 15min no glint

Technique 2: GEO-GEO (ex: GOES12-GOES10)

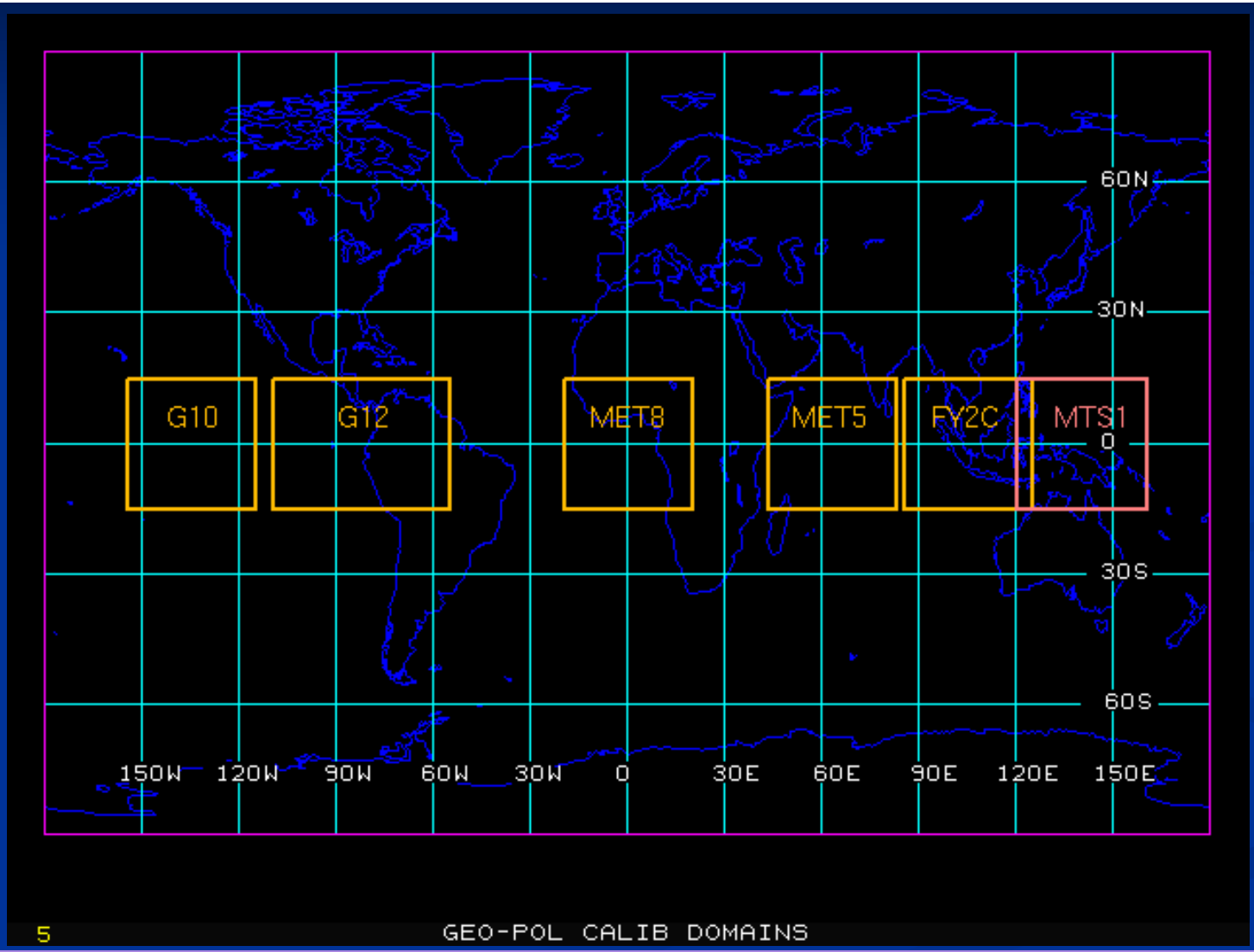
- Match pixels from 0.5 or 1° regions straddling the bisecting longitude at solar noon
- Ensures matched SZA and VZA
- Match image time within 15 minutes

Normalize all solar channels to common solar constants

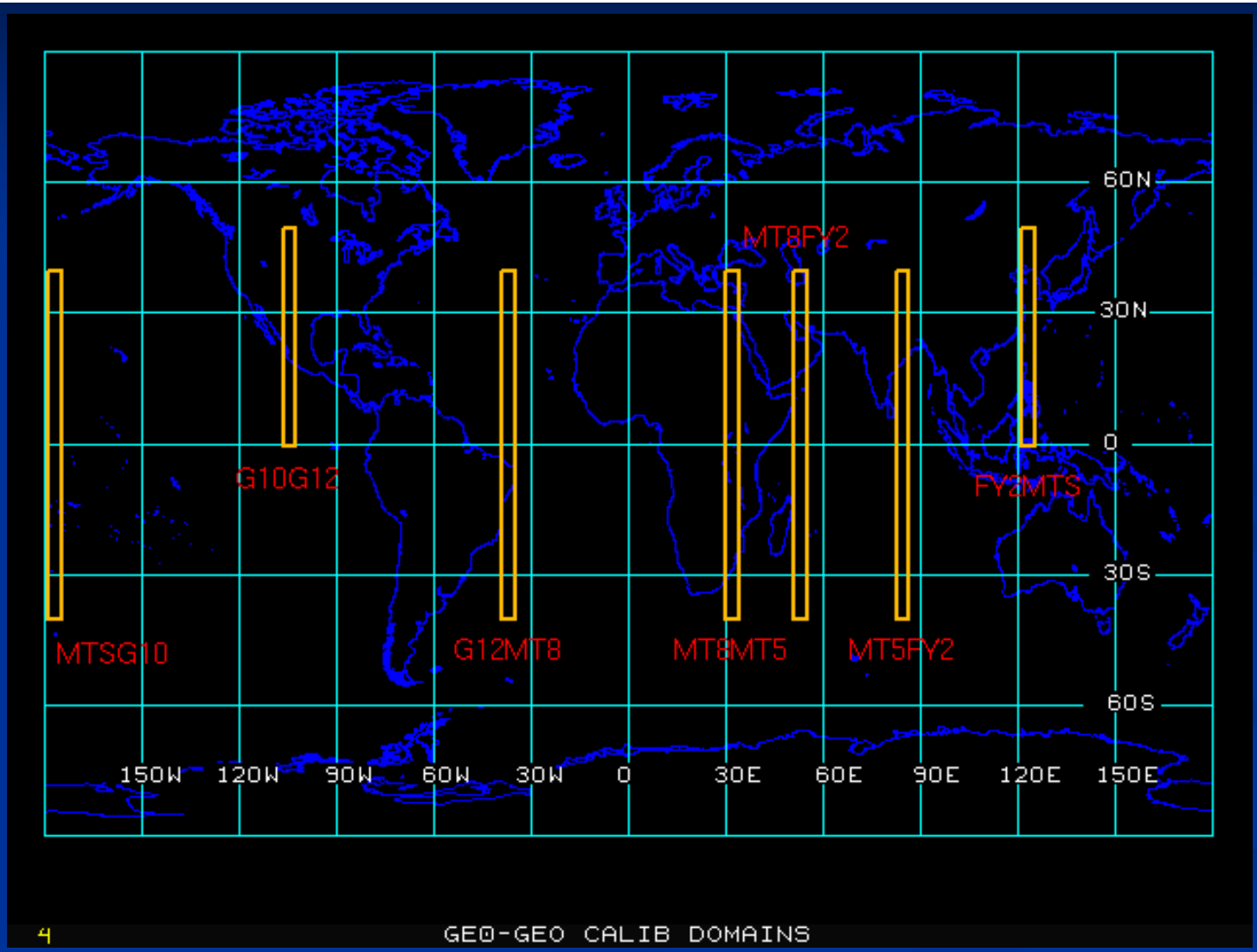
Normalize each radiance to a common SZA

Perform linear regression

Satellite Calibration Regions LEO-GEO



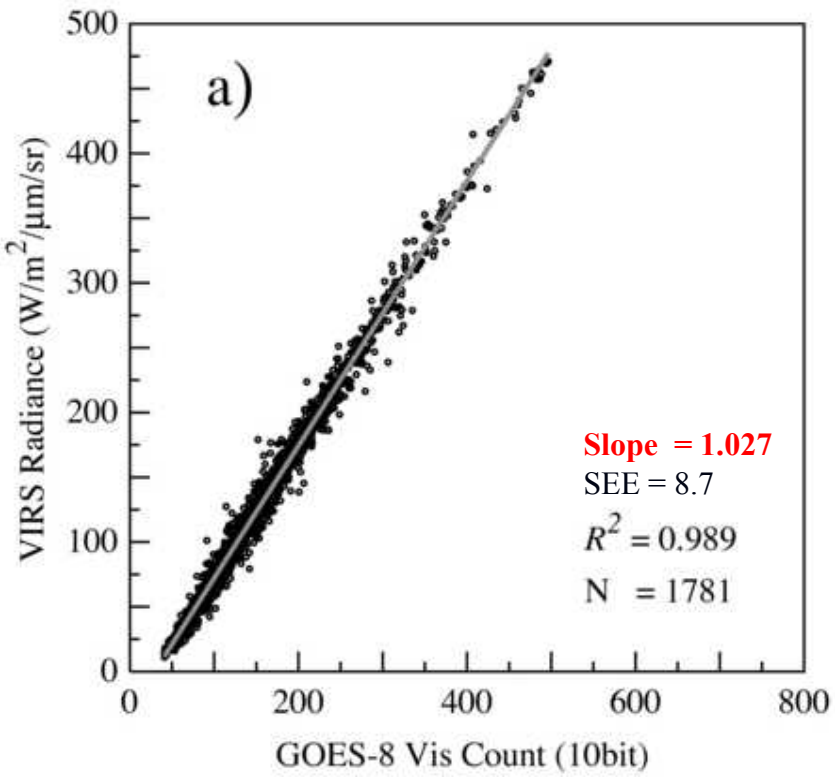
Satellite Calibration Regions GEO-GEO



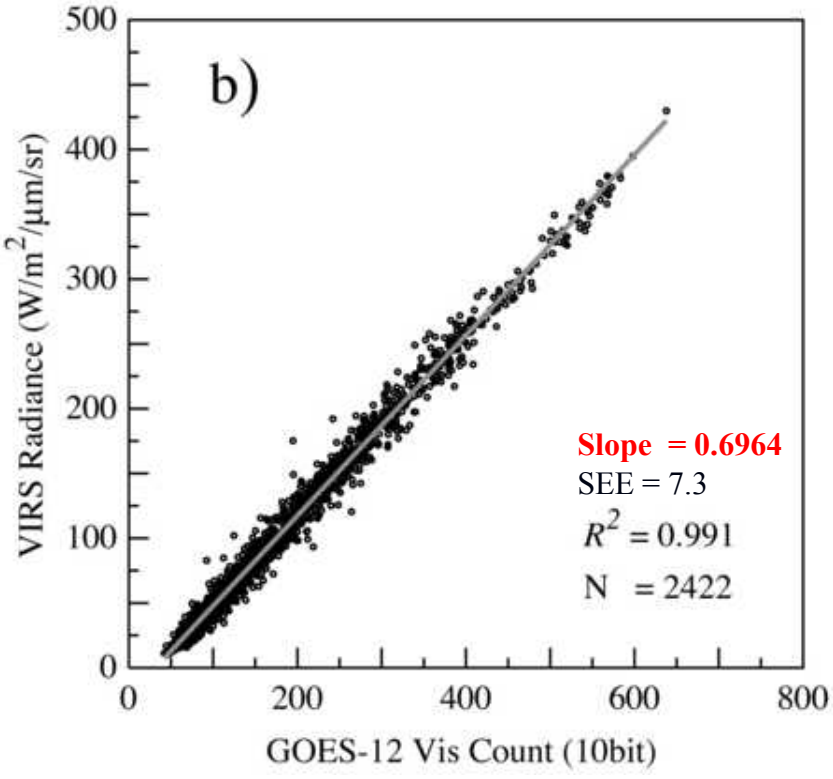
GOES Calibration using VIRS

Use LEO-GEO technique to directly calibrate GOES-8 & GOES-12 with VIRS

GOES-8 Oct 2002

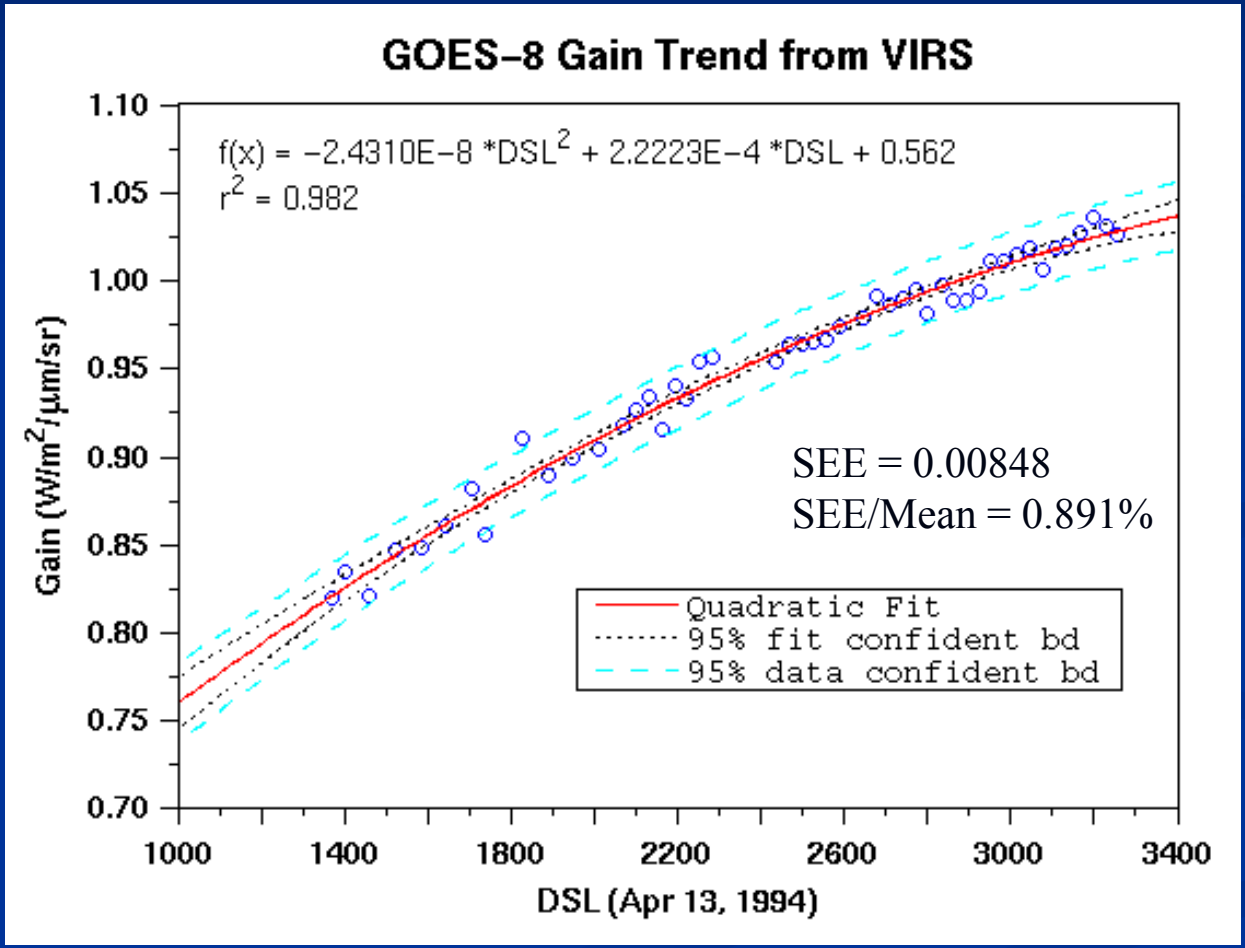


GOES-12 Feb 2004



Time Series of GOES-8 Slope Trend

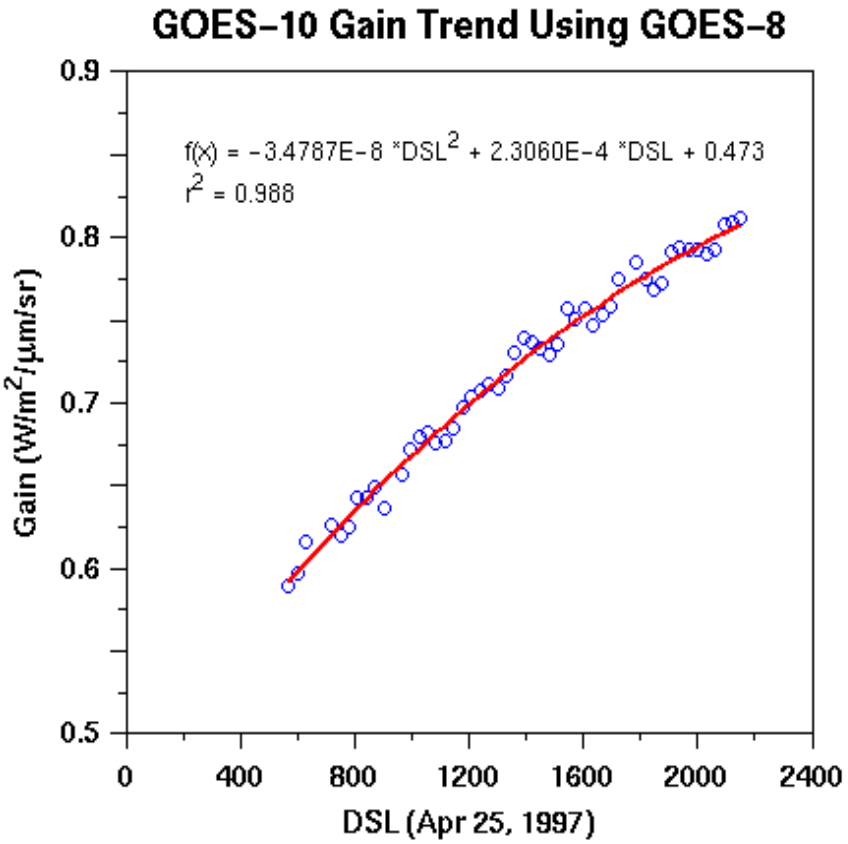
GOES-8 Gain Trend Jan 1998 - Mar 2003



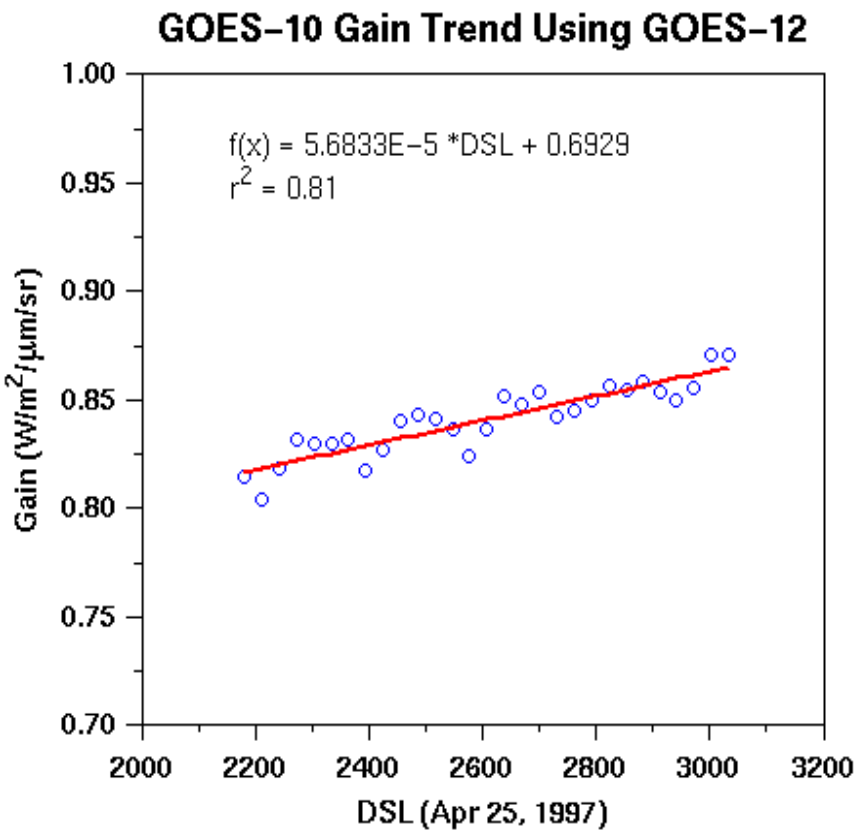
GOES-10 Calibration Using G8 & G12

Use GEO-GEO technique to transfer VIRS calibrated GOES-8 & GOES-12 to GOES-10

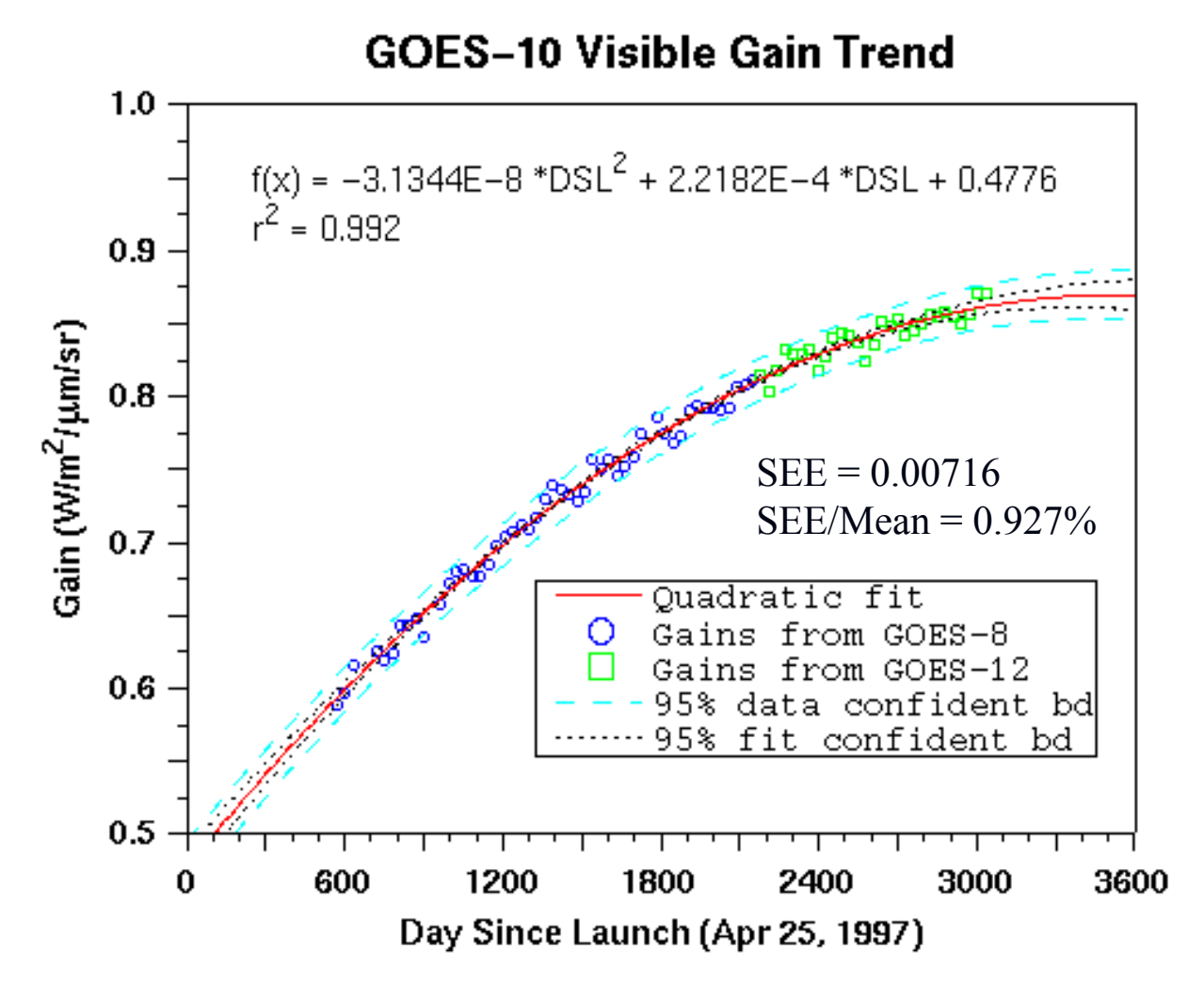
Nov 1998 - Mar 2003



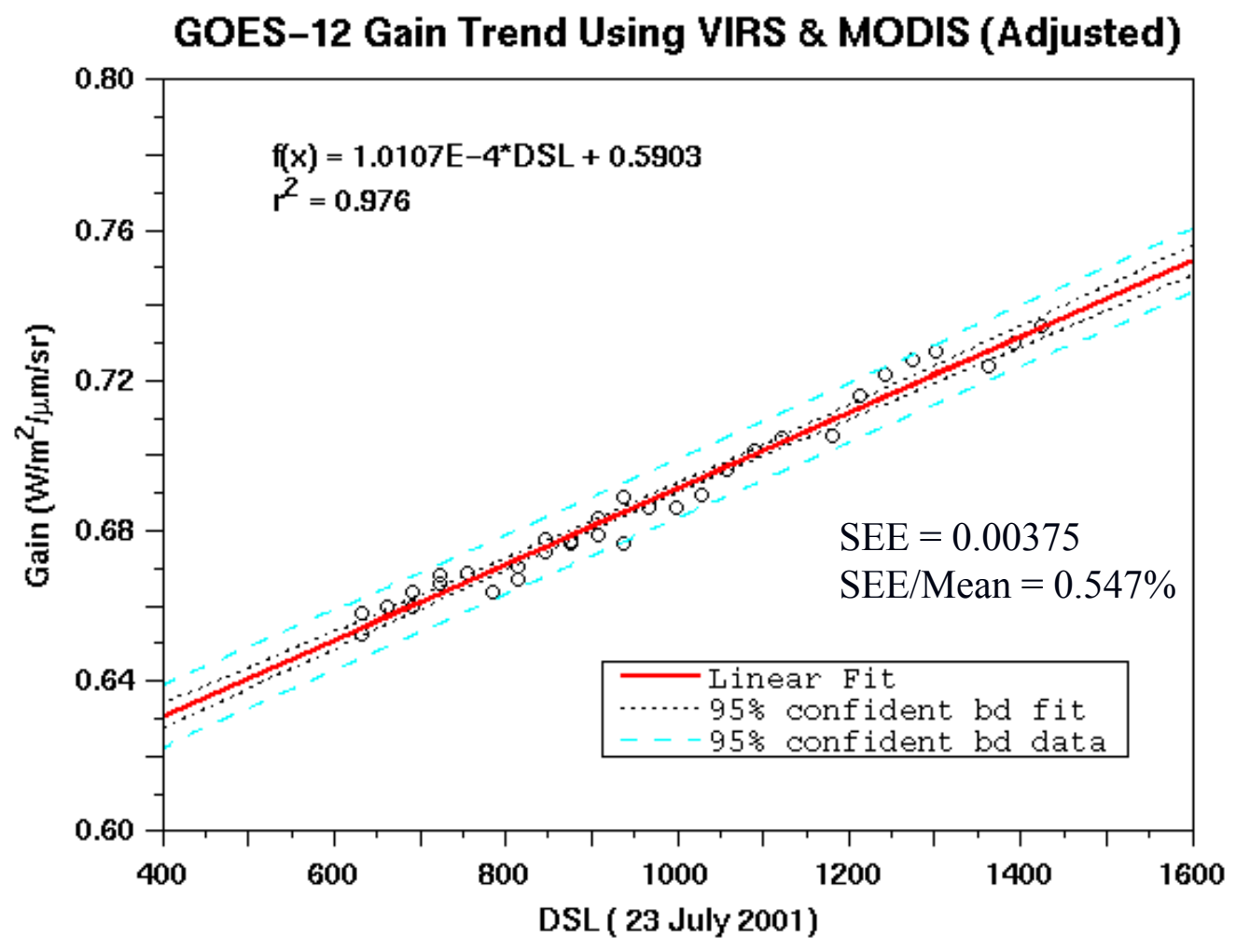
Apr 2003 - Aug 2005



Time Series of GOES-10 Slope Trend



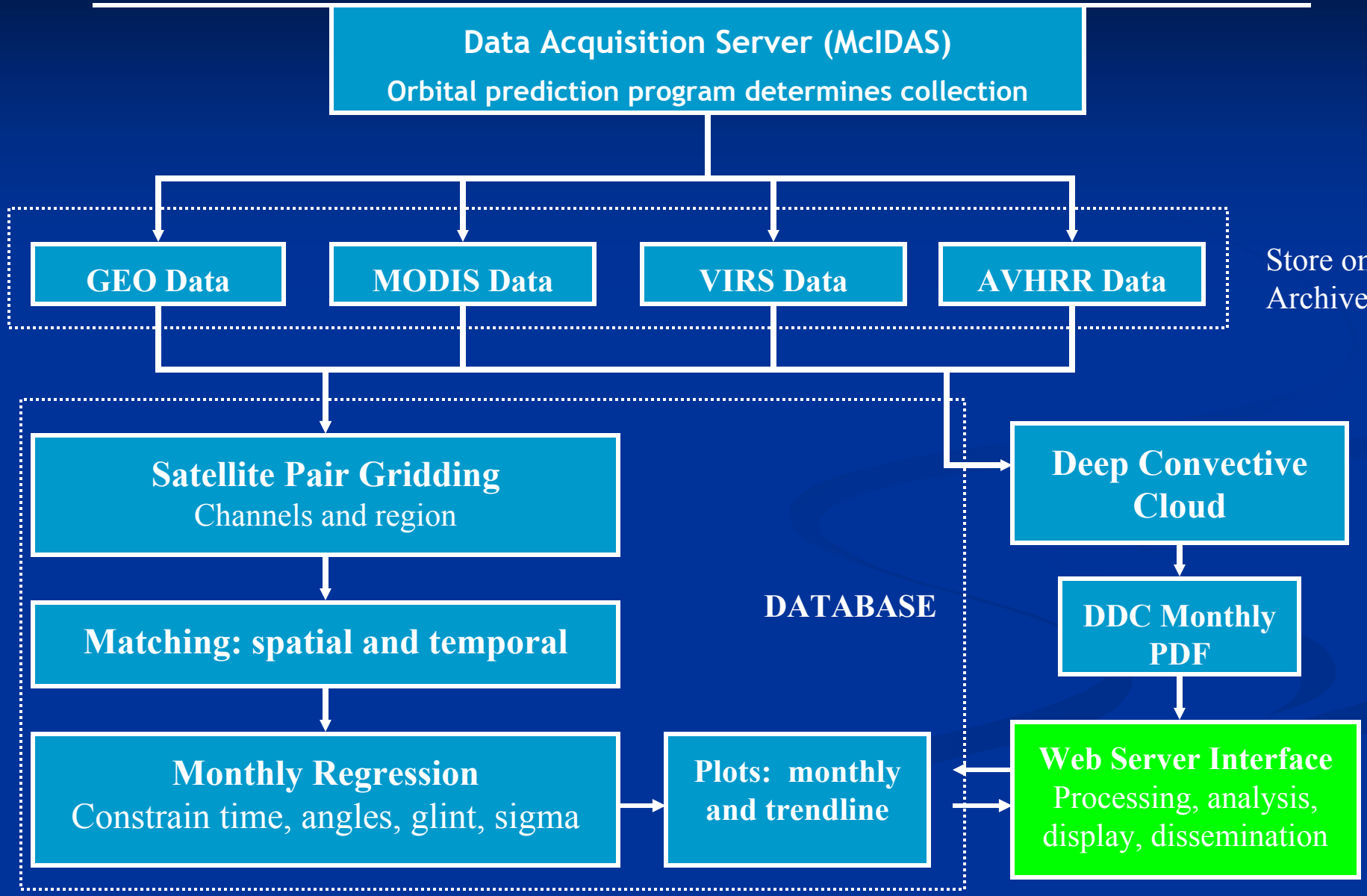
GOES-12 Slope Trends



Motivation for Calibration Server and Website

- Dissemination of post-launch calibration equations in timely manner
  - For public and in-house use (GEO cloud retrieval algorithm)
- Traceability
  - Utilize database to track and control datasets and algorithms
  - Version control for publishing post-launched calibration equations
  - Results are reproducible via cloning dataset and algorithms
- Analysis of Calibration Results
  - Allows side-by-side comparison of monthly and trend differences in reference calibration source (TERRA-AQUA, VIRS, DDC, etc)
  - Results are controlled under “research” and “published” versions
  - Allows tweaking of algorithms under predefined parameter list
- Automation: Processing and Re-processing of Calibration Data
  - Calibration performed under controlled Web environment
  - More automated and less tedious; time serie trends, monthly plots, calibration equations are updated automatically in one process
  - Plots are generated on demand, calibration equations published on website are pulled from database

NASA-Langley Calibration System Flowchart



Demo

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NASA Fact

NASA's Environmental Research Aircraft and Sensor Technology

Satellite Calibration Page

NASA Langley Satellite Calibration Page

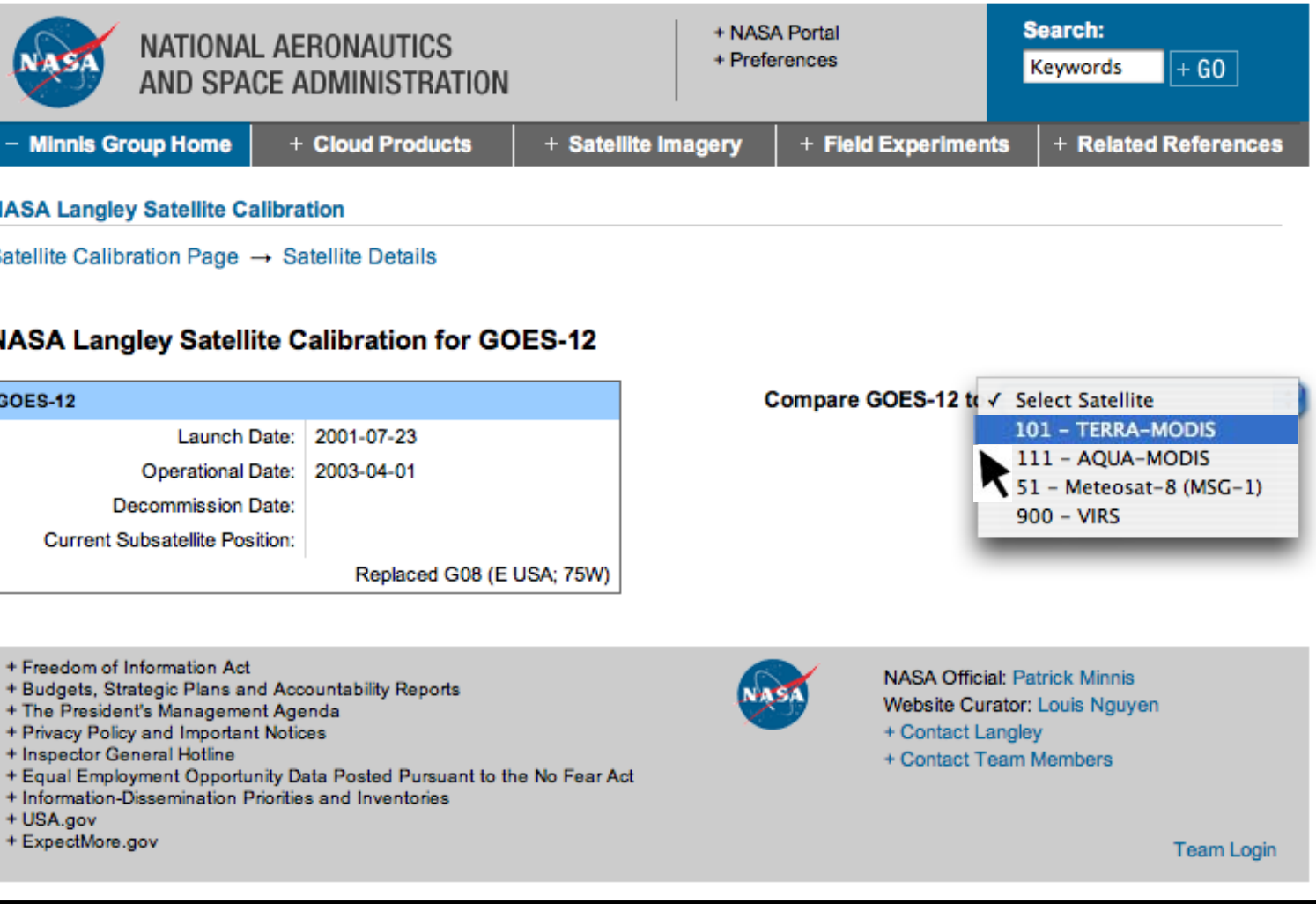
Post Launch Calibration Equations

Satellite	Go	dg1	dg2	Co	Reference Date	Operation Date
GOES-12	0.635	7.7950e-04	0	29	Jul 23, 2001	Apr 01, 2003
GOES-11	0.4696	1.2110e-04	0	29	May 03, 2001	Jun 21, 2006
GOES-10 (pre Jan'04)	0.4776	2.2182e-04	0	29	Apr 25, 1997	Apr 27, 1998
GOES-10 (post Jan'04)	0.7194	5.3200e-05	0	29	Apr 25, 1997	Apr 27, 1998
GOES-9 (yr96-98)	0.5375	1.2344e-04	0	29	May 23, 1995	Jan 11, 1996
GOES-9 (yr03-05)	0.4193	9.7950e-05	0	29	May 23, 1995	Jan 11, 1996
GOES-8	0.562	2.2223e-04	-2.431e-08	29	Apr 13, 1994	Jun 01, 1995
Meteosat-7	1.989	4.7010e-04	-8.259e-08	4.9	Sep 02, 1997	Jun 03, 1998
Meteosat-8 (MSG-1)	0.6369	-6.9000e-06	0	51	Aug 28, 2002	Dec 12, 2002
Meteosat-9 (MSG-2)	0.5328	0.0000e+00	0	51	Dec 21, 2005	Apr 11, 2007
FY-2C	0.0079	1.9000e-05	0	1	Oct 19, 2004	Jul 01, 2005
MTSAT-1R	0.0098	-6.0000e-07	0	0	Feb 26, 1995	Jun 28, 2005

Publications

Minnis, P.; Young, D. F., and Harrison, E. F.: **Examination of the relationship between infrared window radiance and the total outgoing longwave flux using satellite data.** *J. Climate, 4, 1114-1133, 1991.*

Minnis, P., L. Nguyen, D.R. Doelling, D.F. Young, W.F. Miller, D.P. Kratz: **Rapid Calibration of Operational and Research Meteorological Satellite Imagers. Part I: Evaluation of Research Satellite Visible Channels as References.** *J. Atmos. Oceanic Technol.*, **19**,1233-1249, 2002.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Satellite Calibration Page → Satellite Details
NASA Langley Satellite Calibration for GOES-12
GOES-12
Launch Date: 2001-07-23
Operational Date: 2003-04-01
Decommission Date:
Current Subsatellite Position:
Replaced G08 (E USA; 75W)
Compare GOES-12 t
✓ Select Satellite
101 - TERRA-MODIS
111 - AQUA-MODIS
51 - Meteosat-8 (MSG-1)
900 - VIRS
+ Freedom of Information Act
+ Budgets, Strategic Plans and Accountability Reports
+ The President's Management Agenda
+ Privacy Policy and Important Notices
+ Inspector General Hotline
+ Equal Employment Opportunity Data Posted Pursuant to the No Fear Act
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NASA Langley Satellite Calibration

NASA Langley Satellite Calibration for GOES-12

GOES-12	
Launch:	2001-07-23
Operational:	2003-04-01
Decommission:	
Cur Subsat Pos:	
Replaced G08 (E USA; 75W)	

Compare GOES-12 to: 101 – TERRA-MODIS

Monthly Plots

Visible Timeline plots (0.65 µm)

Slope	SLPfor	Xoffset	R2	STDerr	Nbr	G12ave	Tave	SLPpc	SLPyx

Infrared Timeline plots

3.9 µm	slp	Lave	SLPpc	SLPyx	SLPfor	yoff	r2	std	num	bias	rms	rmsp	Gave
6.5 µm	slp	Lave	SLPpc	SLPyx	SLPfor	yoff	r2	std	num	bias	rms	rmsp	Gave
10.7 µm	slp	Lave	SLPpc	SLPyx	SLPfor	yoff	r2	std	num	bias	rms	rmsp	Gave
13.4 µm	slp	Lave	SLPpc	SLPyx	SLPfor	yoff	r2	std	num	bias	rms	rmsp	Gave

Spectral Response Functions

0.65	3.9	6.5	10.7	13.4

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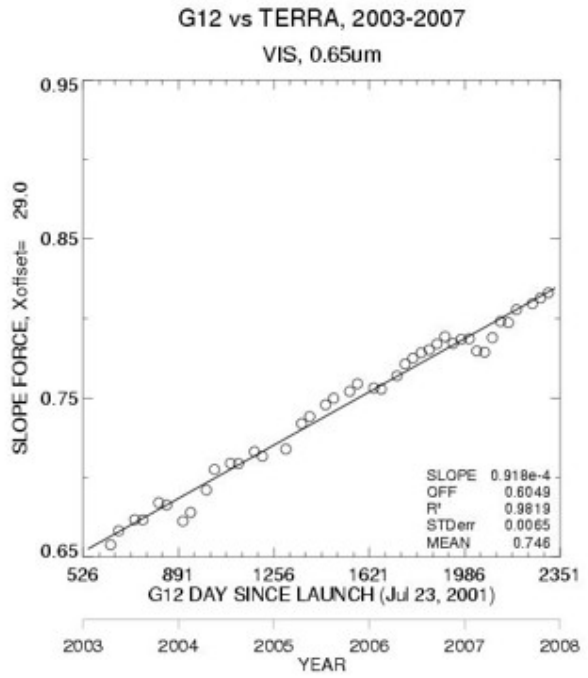
Lock



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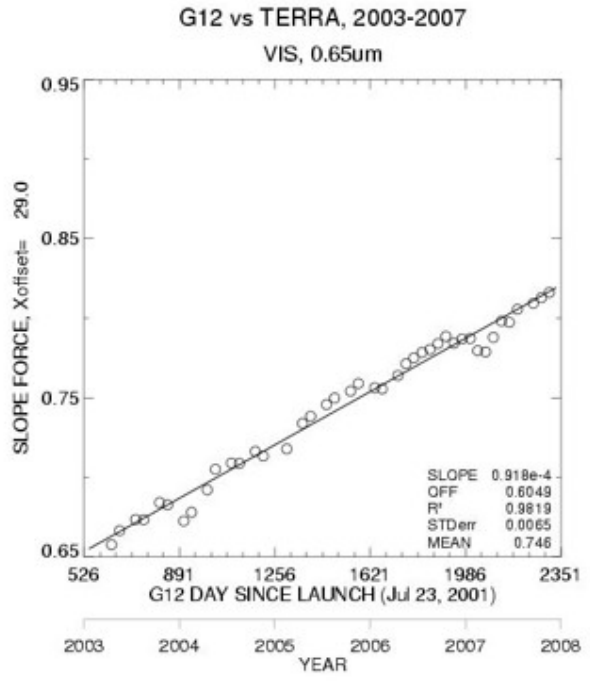

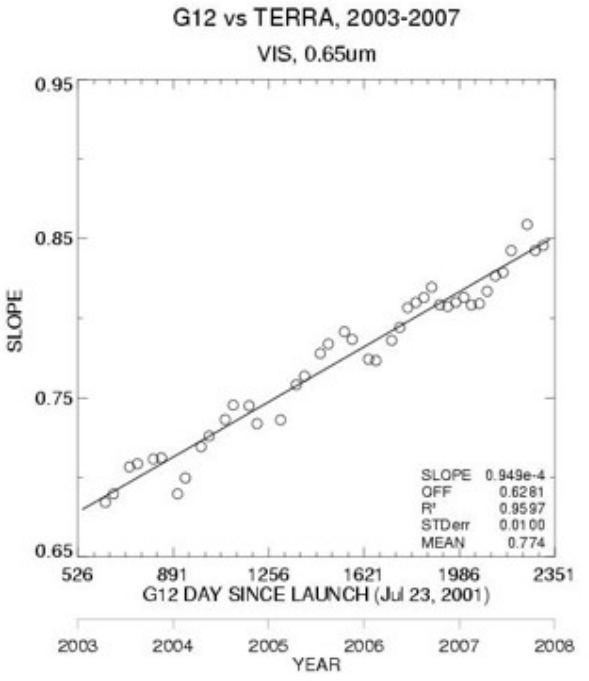

GOES-12	
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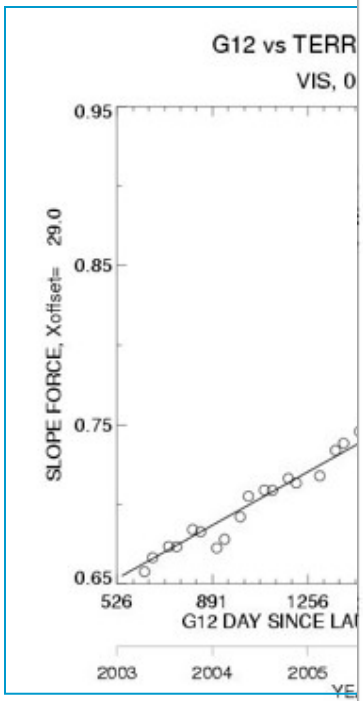
Replaced G08 (E USA; 75W)	

Compare GOES-12 to: 101 – TERRA-MODIS

Monthly Plots

Visible Timeline plots (0.65 µm)

Lock



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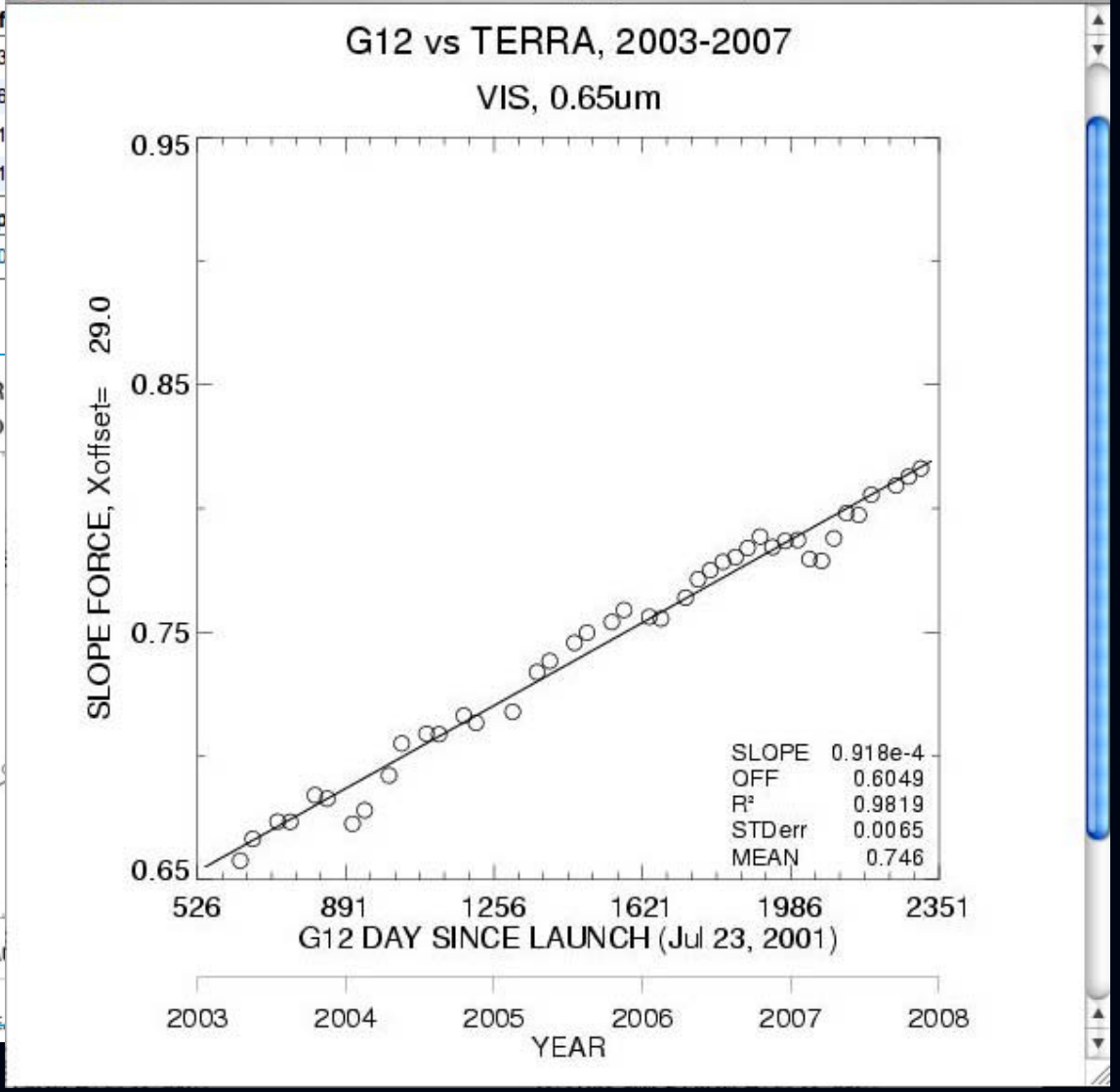

NASA Langley Satellite Calibration

NASA Langley Satellite Calibration for GOES-12

GOES-12	
Launch:	2001-07-23
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Compare GOES-12 to: 101 – TERRA-MODIS

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13.4 µm	slp	Lave	SLPpc	SLPyx	SLPfor	yoff	r2	std	num	bias	rms	rmsp	Gave

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Compare GOES-12 to: 101 – TERRA–MODIS

Summary Plots

2007 | 2006 | 2005 | 2004 | 2003

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 2d 2n	1 2d 2n	1 2d 2n	1 2d 2n	1 2d 2n 3d	1 2d 2n 3d	1 2d 2n 3d		1 2d 2n 3d	1 2d 2n 3d	1 2d 2n 3d	
n 4d	3d 3n 4d	3d 3n 4d	3d 3n 4d	3n 4d 4n	3n 4d 4n	3n 4d 4n		3n 4d 4n	3n 4d 4n	3n 4d 4n	
d 5n	4n 5d 5n	4n 5d 5n	4n 5d 5n	5d 5n	5d 5n	5d 5n		5d 5n	5d 5n	5d 5n	

NASA Langley Satellite Calibration for GOES-12

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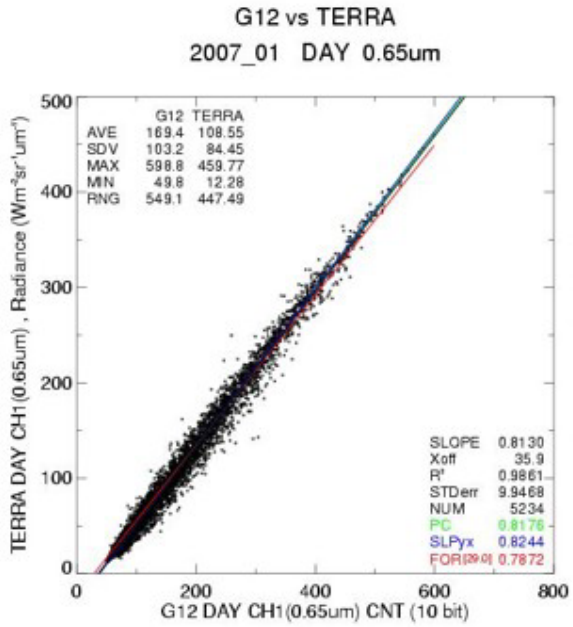
Compare GOES-12 to: 101 – TERRA-MODIS

Summary Plots

2007 | 2006 | 2005 | 2004 | 2003

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 2d 2n	1 2d 2n	1 2d 2n	1 2d 2n	1 2d 2n 3d	1 2d 2n 3d	1 2d 2n 3d		1 2d 2n 3d	1 2d 2n 3d	1 2d 2n 3d	
3d 3n 4d	3d 3n 4d	3d 3n 4d	3d 3n 4d	3n 4d 4n	3n 4d 4n	3n 4d 4n		3n 4d 4n	3n 4d 4n	4n	
4n 5d 5n	4n 5d 5n	4n 5d 5n	4n 5d 5n	5d 5n	5d 5n	5d 5n		5d 5n	5d 5n		

Lock



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Compare GOES-12 to: 101 - TERRA-MODIS

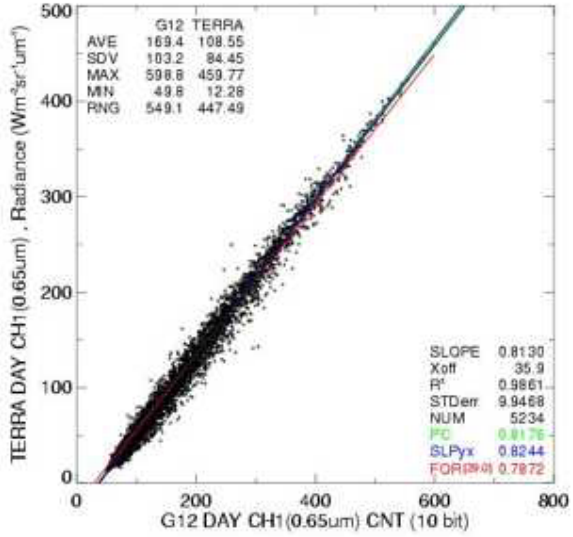
Summary Plots

2007 | 2006 | 2005 | 2004 | 2003

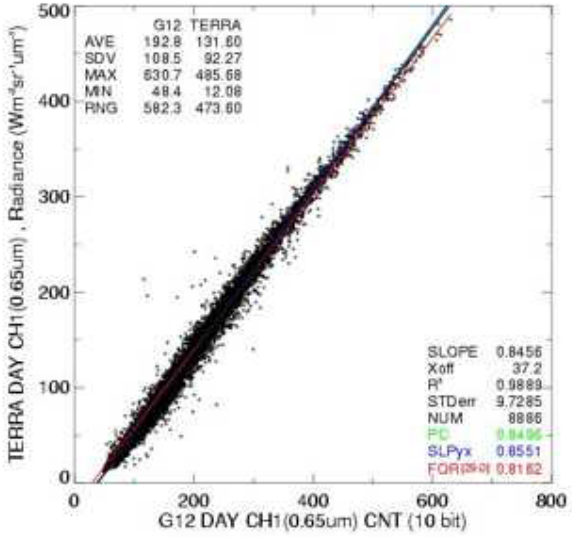
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 2d 2n	1 2d 2n	1 2d 2n	1 2d 2n	1 2d 2n 3d	1 2d 2n 3d	1 2d 2n 3d		1 2d 2n 3d	1 2d 2n 3d	1 2d 2n 3d	
3d 3n 4d	3d 3n 4d	3d 3n 4d	3d 3n 4d	3n 4d 4n	3n 4d 4n	3n 4d 4n		3n 4d 4n	3n 4d 4n	3n 4d 4n	
4n 5d 5n	4n 5d 5n	4n 5d 5n	4n 5d 5n	5d 5n	5d 5n	5d 5n		5d 5n	5d 5n	5d 5n	

Unlock Lock

G12 vs TERRA
2007_01 DAY 0.65um



G12 vs TERRA
2007_11 DAY 0.65um



NASA Langley Satellite Calibration for GOES-12

GOES-12	
Launch:	2001-07-23
Operational:	2003-04-01
Decommission:	
Cur Subsat Pos:	
Replaced G08 (E USA; 75W)	

Compare GOES-12 t

Select Satellite
101 - TERRA-MODIS
✓ 111 - AQUA-MODIS
1 - Meteosat-8 (MSG-1)
00 - VIRS

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Compare GOES-12 to: 111 – AQUA-MODIS

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Visible Timeline plots (0.65 μm)

Slope	SLPfor	Xoffset	R2	STDerr	Nbr	G12ave	Tave	SLPpc	SLPyx

Infrared Time plots

3.9 μm	slp	Lave	SLPpc	SLPyx	SLPfor	yoff	r2	std	num	bias	rms	rmsp	Gave
6.5 μm	slp	Lave	SLPpc	SLPyx	SLPfor	yoff	r2	std	num	bias	rms	rmsp	Gave
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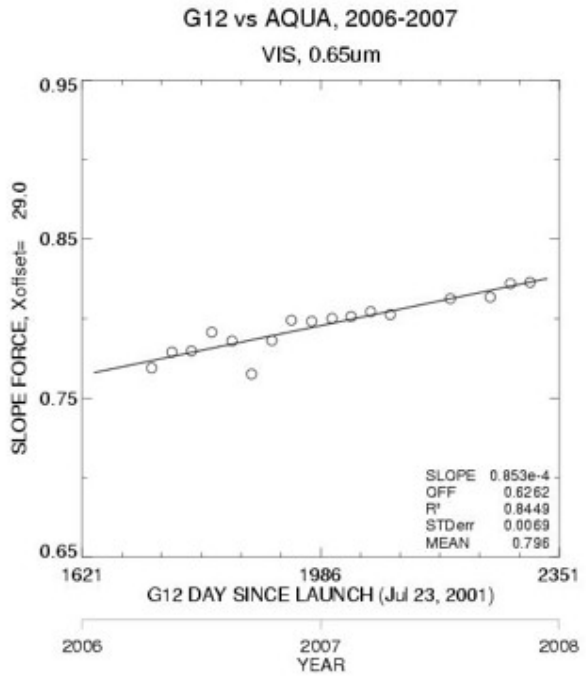

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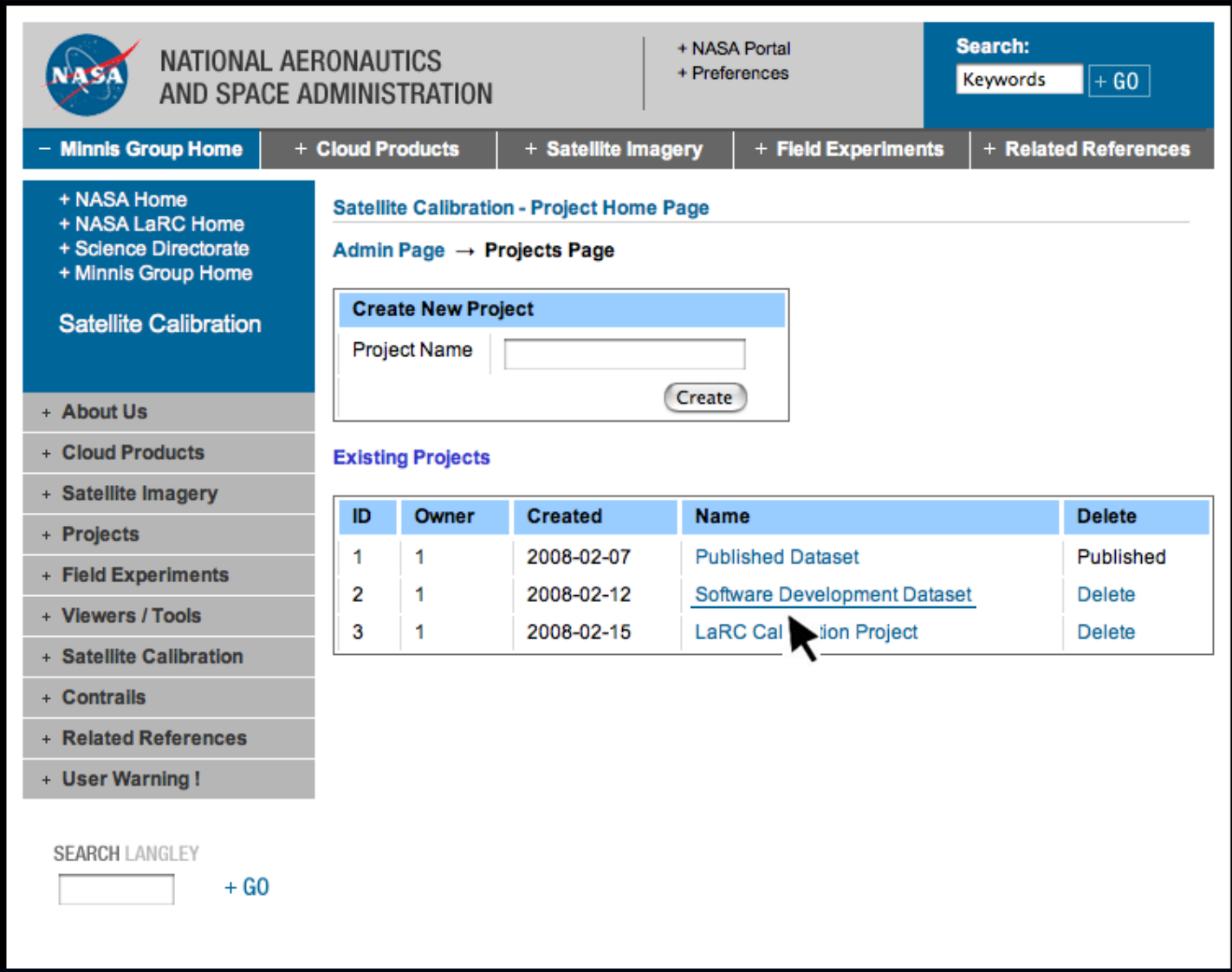
Satellite Calibration Admin Home

- Viewer - View the published results
- Projects - Create or work with a project
- Data - Clone or Synthesize a dataset for use in a project
- Import - Import monthly numbers
- Load Test - Load Dave's things (careful...)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Project Name
Create
Existing Projects
ID
Owner
Created
Name
Delete
1
1
2008-02-07
Published Dataset
Published
2
1
2008-02-12
Software Development Dataset
Delete
3
1
2008-02-15
LaRC Cal ion Project
Delete

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Project Functions

- Build Monthly Scatter Plots
- Build Trendline Plots
- View Results

Plot Control / IDL

- Plot Controls - View/Edit IDL Plot Variables
- Monthly Plot Edit - View/Edit IDL Scatter Plot Program
- Trendline Edit - View/Edit IDL Trendline Program
- Logs - View IDL Logs

Project: Software Development Dataset

ID	2
Workspace:	/Library/WebServer/htdocs/site//calib-work/dataset-2
Owner	1
Created On	2008-02-12
Dataset	INIT

Notes:

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Admin Page → Projects Page → Project Details → Select Monthly Scatter Plot

Select Month to build: Software Development Dataset

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003				Build	Build		Build	Build		Build	Build	
2004	Build	Build		Build	Build		Build	Build		Build	Build	
2005	Build	Build		Build	Build		Build	Build		Build	Build	
2006	Build	Build		Build	Build	Build	Build	Build	Build	Build	Build	Build
2007	Build	Build	Build	Build	Build	Build	Build		Build	Build	Build	

Build

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- Plot Controls - View/Edit IDL Plot Variables
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Project: Software Development Dataset

ID	2
Workspace:	/Library/WebServer/htdocs/site//calib-work/dataset-2
Owner	1
Created On	2008-02-12
Dataset	INIT

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Admin Page → Projects Page → Project Details → Build Trendlines (Select Months)

Select Months to Include For Project: Software Develop Dataset

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003				☐								
2004	☑	☑										
2006				☑	☑	☑			☑			
2007	☑	☑	☑	☑		☑			☑			

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Project Functions

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Plot Control / IDL

- Plot Controls - View/Edit IDL Plot Variables
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Project: Software Development Dataset

ID	2
Workspace:	/Library/WebServer/htdocs/site//calib-work/dataset-2
Owner	1
Created On	2008-02-12
Dataset	INIT

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Admin Page → Projects Page → Projects Details → View/Edit IDL Plot Variabls

Plot Control Variables

Pick a satellite pair to change their plot control variables:

Pick Satellite Pair ----------

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Plot Control Variables for satellites: GOES-12 / TERR MODIS

Pick a satellite pair to change their plot control variables:

GOES-12 vs TERRA-MODIS

IDL Plot Settings

Plot Variables Applied Across All Channels			
mSTAT: 9	mCH: 5	mVIS: 1	Num0: 100

	SLP	YOFF	R2	STD	NUM	BIAS	RMS	RMSP	GEO	LEO
Channel Number 1										
YMin	0.65	10	0.9	0	0	0	0	0	0	0
YMax	0.95	50	1	50	10000	0	0	0	300	200
YTick	3	4	5	5	5	0	0	0	3	4
Channel Number 2										
YMin	0.7	-50	0.9	0	0	-10	0	0	270	270
YMax	1.1	100	1	10	10000	5	10	5	320	320
YTick	4	3	5	5	5	5	5	5	5	5
Channel Number 3										

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- Plot Controls - View/Edit IDL Plot Variables
- Monthly Plot Edit - View/Edit IDL Scatter Plot Program
- Trendline Edit - Vie dit IDL Trendline Program
- Logs - View IDL Logs

Project: Software Development Dataset

ID	2
Workspace:	/Library/WebServer/htdocs/site//calib-work/dataset-2
Owner	1
Created On	2008-02-12
Dataset	INIT

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IDL Program (GMplt.pro): "/Library/WebServer/htdc site//calib-work/dataset-2/GMplt.pro"

```
; FOR GEO to LEO comparisons -> MET8/TERRA 9 channel comparison
; plots the individual monthly channel plots
; this is a test

function strtrm0, x
return, strtrim(string(x),1)+', '
end

; 2008-02-07 - tlc - changed the invocation to allow passed in params
;-------------------------------------------------------------------
; GMplt, ileo, igeo, yyyymm, syspath, inputfilename
;

pro GMplt, ileo, igeo, yyyymm, syspath, inputfilename, mmcol0

print, 'Revised routine entered'
print, 'Entering the GMplt routine.'
print, 'System Path=[',syspath,']'

iyyyymm = 1

asat = strarr(2)

isymtyp = 8   ; 1=+, 2=*, 3=. 4=Diamond, 5=triangle, 6=square, 7=X, 8=circle
symsiz = 0.2

; 2008-02-07 - tlc - changed this programming to allow passed in values
;-------------------------------------------------------------------

;for ileo = 1,2 do begin  ; 1=terra, 2=aqua
leo_sat_names = [ '?','TERRA', 'AQUA' ]
```

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- Trendline Edit - View/Edit IDL Trendline Program
- Logs - View IDL ...gs

Project: Software Development Dataset

ID	2
Workspace:	/Library/WebServer/htdocs/site//calib-work/dataset-2
Owner	1
Created On	2008-02-12
Dataset	INIT

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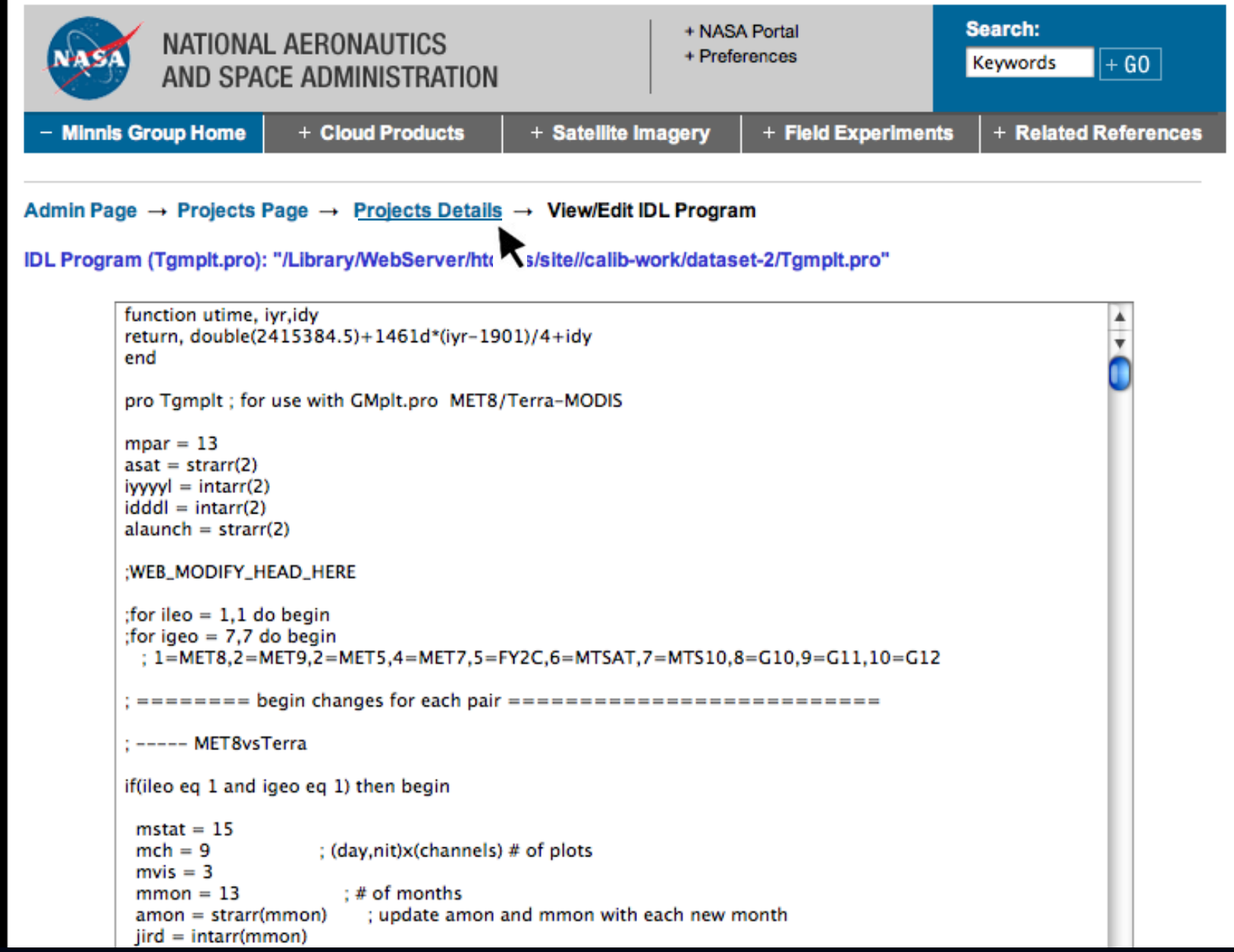
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IDL Program (Tgmplt.pro): "/Library/WebServer/ht s/site//calib-work/dataset-2/Tgmplt.pro"
function utime, iyr,idy
return, double(2415384.5)+1461d*(iyr-1901)/4+idy
end
pro Tgmplt ; for use with GMplt.pro MET8/Terra-MODIS
mpar = 13
asat = strarr(2)
iyyyyl = intarr(2)
idddl = intarr(2)
alaunch = strarr(2)
;WEB_MODIFY_HEAD_HERE
;for ileo = 1,1 do begin
;for igeo = 7,7 do begin
; 1=MET8,2=MET9,2=MET5,4=MET7,5=FY2C,6=MTSAT,7=MTS10,8=G10,9=G11,10=G12
; ======== begin changes for each pair ==========
; ----- MET8vsTerra
if(ileo eq 1 and igeo eq 1) then begin
mstat = 15
mch = 9 ; (day,nit)x(channels) # of plots
mvis = 3
mmon = 13 ; # of months
amon = strarr(mmon) ; update amon and mmon with each new month
jird = intarr(mmon)

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End of DEMO

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- Plot Controls - View/Edit IDL Plot Variables
- Monthly Plot Edit - View/Edit IDL Scatter Plot Program
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- Logs - View IDL Logs

Project: Software Development Dataset

ID	2
Workspace:	/Library/WebServer/htdocs/site/calib-work/dataset-2
Owner	1
Created On	2008-02-12
Dataset	INIT

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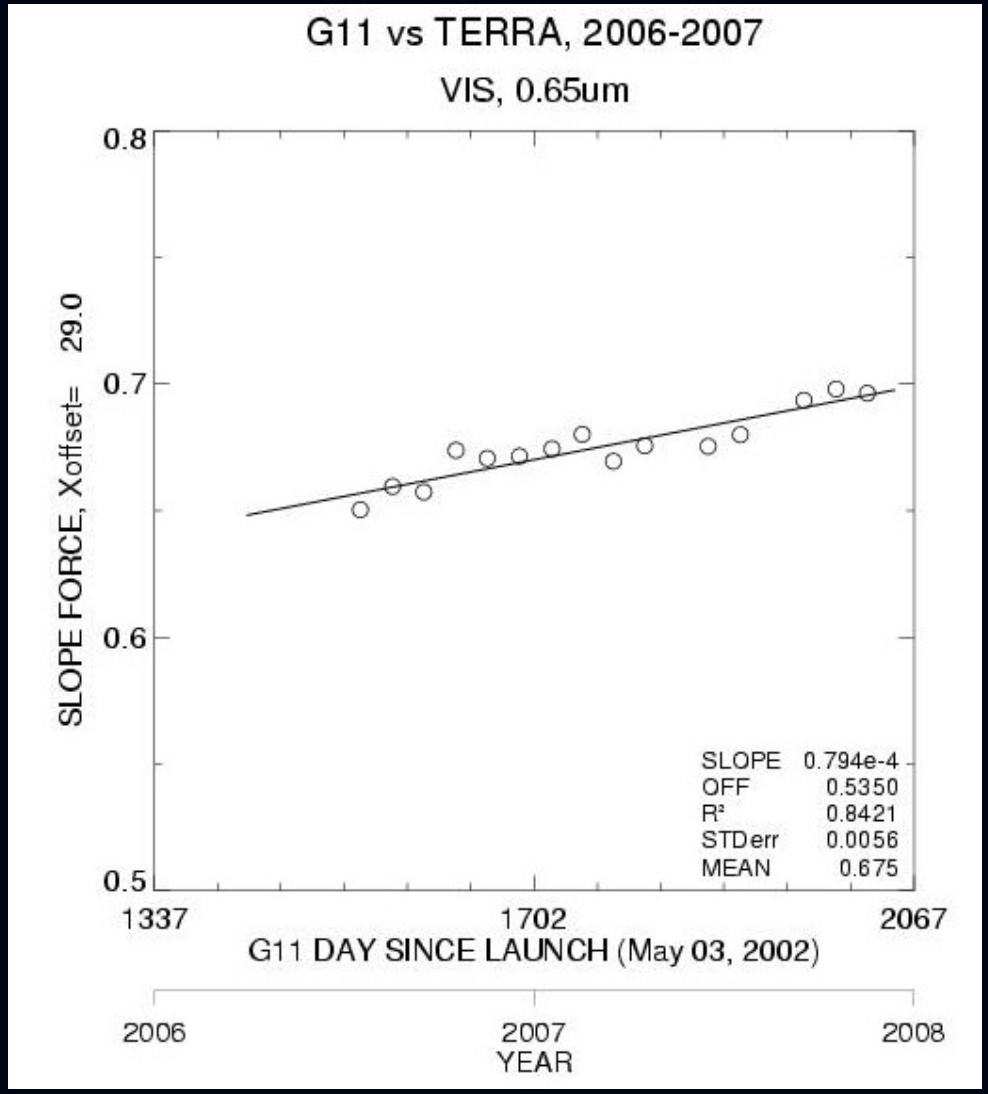
GOES-12	0.635	7.7950e-04	0	29	Jul 23, 2001	Apr 01, 2003
GOES-11	0.4696	1.2110e-04	0	29	May 03, 2001	Jun 21, 2006
GOES-10 Jan'04)	0.4776	2.2182e-04	0	29	Apr 25, 1997	Apr 27, 1998
GOES-10 (post Jan'04)	0.7194	5.3200e-05	0	29	Apr 25, 1997	Apr 27, 1998
GOES-9 (yr96-98)	0.5375	1.2344e-04	0	29	May 23, 1995	Jan 11, 1996
GOES-9 (yr03-05)	0.4193	9.7950e-05	0	29	May 23, 1995	Jan 11, 1996
GOES-8	0.562	2.2223e-04	-2.431e-08	29	Apr 13, 1994	Jun 01, 1995
Meteosat-7	1.989	4.7010e-04	-8.259e-08	4.9	Sep 02, 1997	Jun 03, 1998
Meteosat-8 (MSG-1)	0.6369	-6.9000e-06	0	51	Aug 28, 2002	Dec 12, 2002
Meteosat-9 (MSG-2)	0.5328	0.0000e+00	0	51	Dec 21, 2005	Apr 11, 2007
FY-2C	0.0079	1.9000e-05	0	1	Oct 19, 2004	Jul 01, 2005
MTSAT-1R	0.0098	-6.0000e-07	0	0	Feb 26, 1995	Jun 28, 2005

Publications

Minnis, P.; Young, D. F., and Harrison, E. F.: **Examination of the relationship between infrared window radiance and the total outgoing longwave flux using satellite data.** *J. Climate, 4, 1114-1133, 1991.*

Minnis, P., L. Nguyen, D.R. Doelling, D.F. Young, W.F. Miller, D.P. Kratz: **Rapid Calibration of Operational and Research Meteorological Satellite Imagers. Part I: Evaluation of Research Satellite Visible Channels as References.** *J. Atmos. Oceanic Technol.*, **19**,1233-1249, 2002.

GOES-11 Visible Gain Trend



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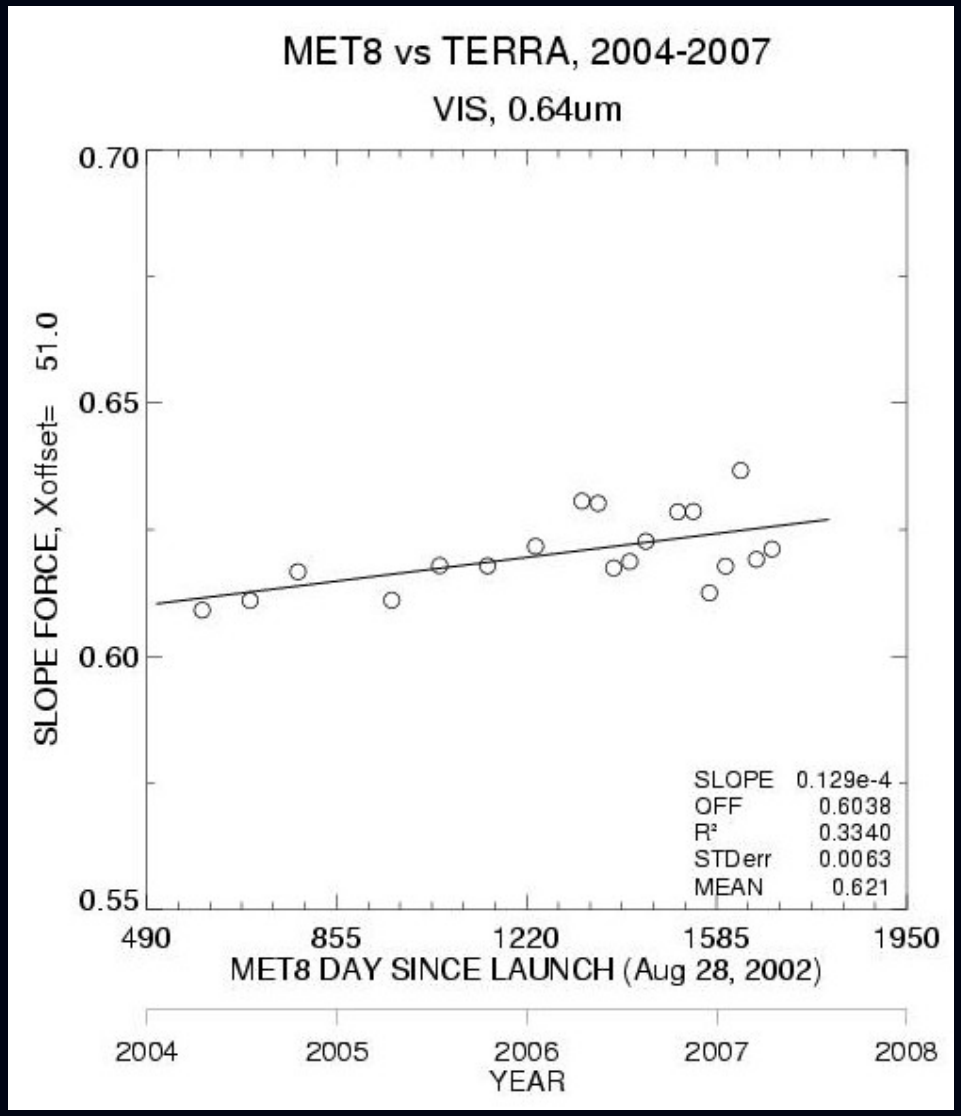
Meteosat-8 Visible Gain Trend



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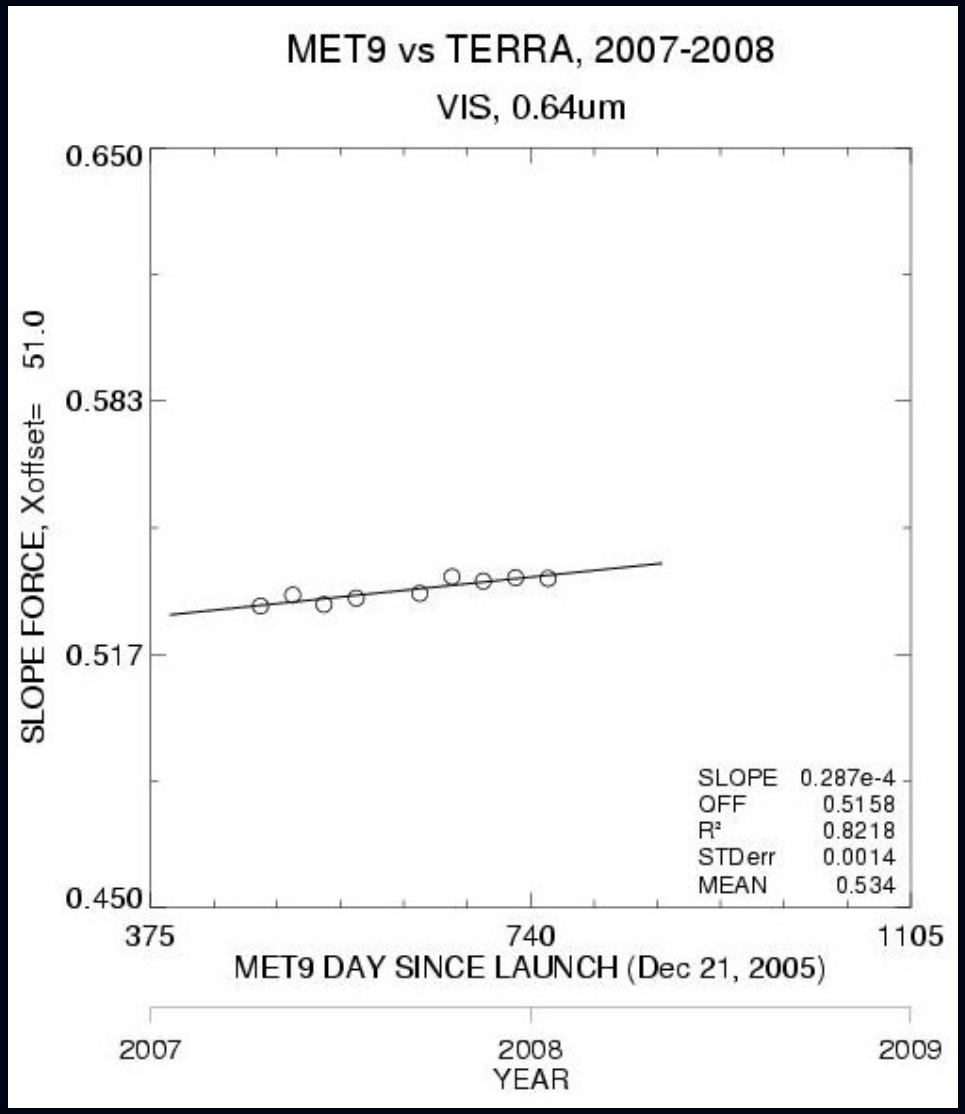
Meteosat-9 Visible Gain Trend



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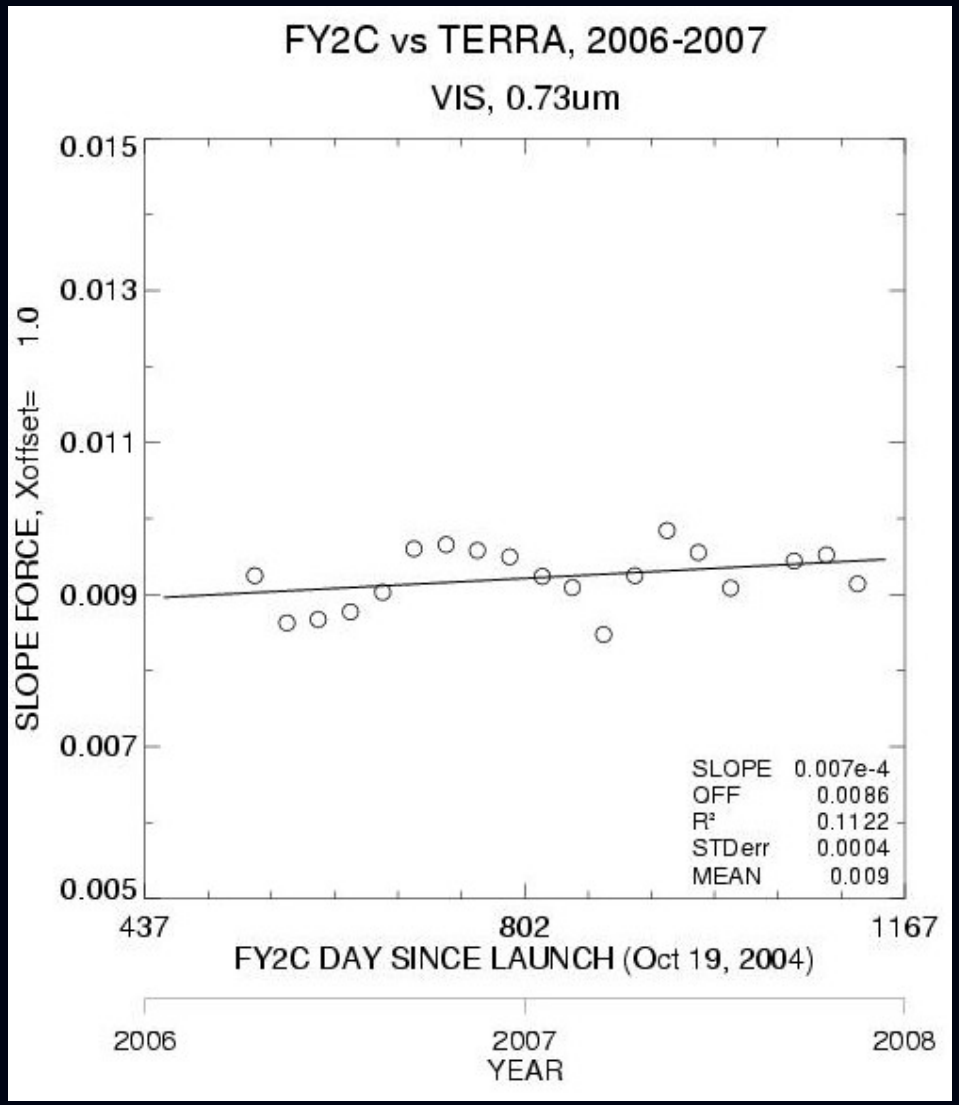
FY-2C Visible Gain Trend



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Post Launch Calibration Equations

Satellite	Go	dg1	dg2	Co	Reference Date	Operation Date
GOES-12	0.635	7.7950e-04	0	29	Jul 23, 2001	Apr 01, 2003
GOES-11	0.4696	1.2110e-04	0	29	May 03, 2001	Jun 21, 2006
GOES-10 (pre Jan'04)	0.4776	2.2182e-04	0	29	Apr 25, 1997	Apr 27, 1998
GOES-10 (post Jan'04)	0.7194	5.3200e-05	0	29	Apr 25, 1997	Apr 27, 1998
GOES-9 (yr96-98)	0.5375	1.2344e-04	0	29	May 23, 1995	Jan 11, 1996
GOES-9 (yr03-05)	0.4193	9.7950e-05	0	29	May 23, 1995	Jan 11, 1996
GOES-8	0.562	2.2223e-04	-2.431e-08	29	Apr 13, 1994	Jun 01, 1995
Meteosat-7	1.989	4.7010e-04	-8.259e-08	4.9	Sep 02, 1997	Jun 03, 1998
Meteosat-8 (MSG-1)	0.6369	-6.9000e-06	0	51	Aug 28, 2002	Dec 12, 2002
Meteosat-9 (MSG-2)	0.5328	0.0000e+00	0	51	Dec 21, 2005	Apr 11, 2007
FY-2C	0.0079	1.9000e-05	0	1	Oct 19, 2004	Jul 01, 2005
MTSAT-1R	0.0098	-6.0000e-07	0	0	Feb 26, 1995	Jun 28, 2005

Publications

Minnis, P.; Young, D. F., and Harrison, E. F.: **Examination of the relationship between infrared window radiance and the total outgoing longwave flux using satellite data.** *J. Climate, 4, 1114-1133, 1991.*

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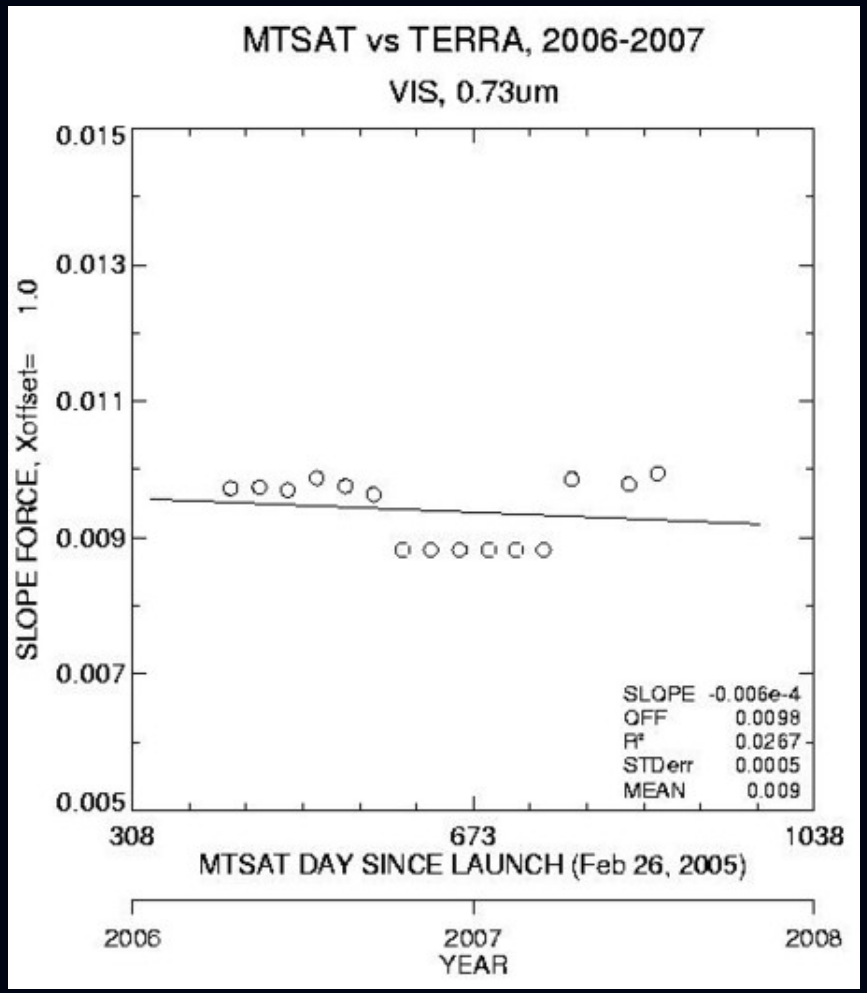
MTSAT-1R Visible Gain Trend

8-bit^2 data



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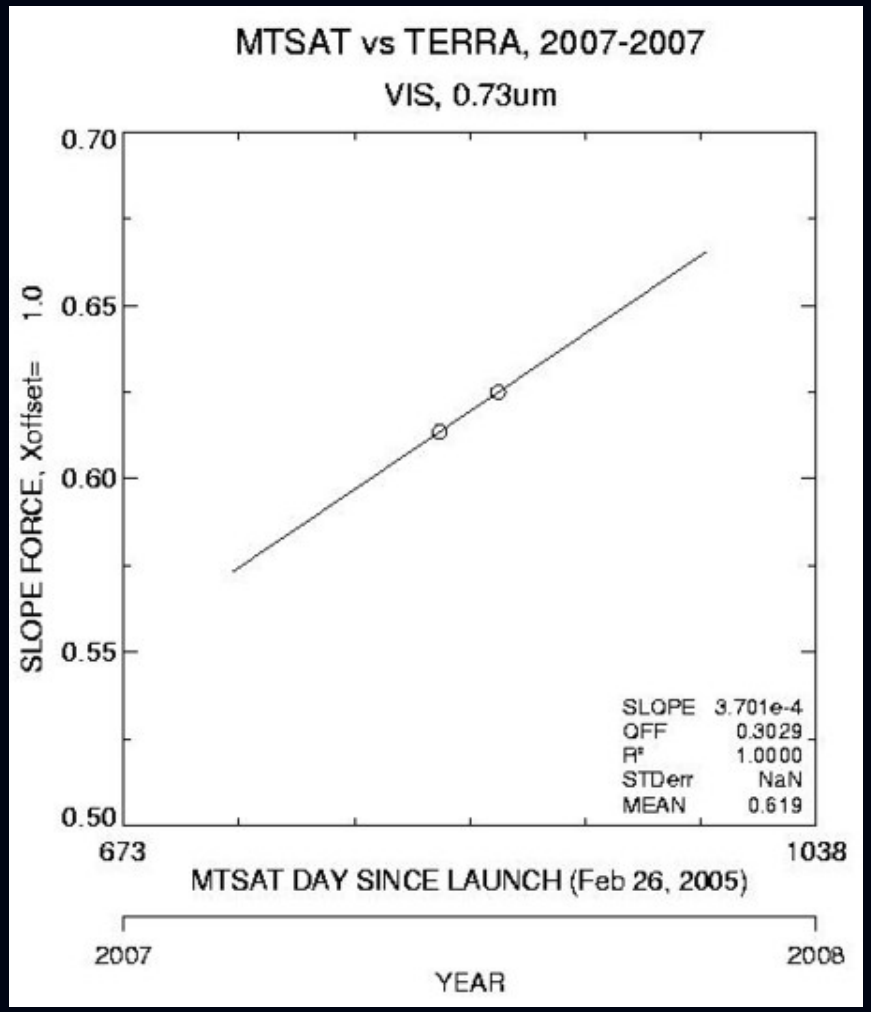

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