GEO Visible Calibration Strategy Using MODIS as Reference

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Douglas A. Spangenberg
Space Systems and Applications, Inc
Hampton, Virginia, USA
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

VIRS Radiance (W/m²/µm/sr)

VIRS Radiance (W/m²/µm/sr)

GOES-12 Feb 2004

Slope = 1.027
SEE = 8.7
$R^2 = 0.989$
N = 1781

Slope = 0.6964
SEE = 7.3
$R^2 = 0.991$
N = 2422
Time Series of GOES-8 Slope Trend

GOES-8 Gain Trend Jan 1998 - Mar 2003

\[ f(x) = -2.4310E-8 * DSL^2 + 2.2223E-4 * DSL + 0.562 \]

\[ r^2 = 0.982 \]

SEE = 0.00848
SEE/Mean = 0.891%
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

GOES-10 Gain Trend Using GOES-8

\[ f(x) = -3.4767 \times 10^{-8} \times DSL^2 + 2.3060 \times 10^{-4} \times DSL + 0.473 \]

\[ r^2 = 0.988 \]

Apr 2003 - Aug 2005

GOES-10 Gain Trend Using GOES-12

\[ f(x) = 5.6833 \times 10^{-5} \times DSL + 0.6923 \]

\[ r^2 = 0.81 \]
**Time Series of GOES-10 Slope Trend**

**GOES-10 Visible Gain Trend**

$$f(x) = -3.1344E-8 \cdot DSL^2 + 2.2182E-4 \cdot DSL + 0.4776$$

$$r^2 = 0.992$$

SEE = 0.00716

SEE/Mean = 0.927%
GOES-12 Slope Trends

GOES-12 Gain Trend Using VIRS & MODIS (Adjusted)

\[ f(x) = 1.0107E-4 \times \text{DSL} + 0.5903 \]
\[ r^2 = 0.976 \]

SEE = 0.00375
SEE/Mean = 0.547%
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

Data Acquisition Server (McIDAS)
Orbital prediction program determines collection

GEO Data
MODIS Data
VIRS Data
AVHRR Data

Satellite Pair Gridding
Channels and region

Matching: spatial and temporal

Monthly Regression
Constrain time, angles, glint, sigma

Deep Convective Cloud

DATABASE

Plots: monthly and trendline

Web Server Interface
Processing, analysis, display, dissemination

Store on Archive

DDC Monthly PDF
Demo
Satellite Calibration Page

NASA Langley Satellite Calibration Page

Post Launch Calibration Equations

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<th>Go</th>
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Publications


### NASA Langley Satellite Calibration for GOES-12

**GOES-12**

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<td>Decommission Date</td>
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<td>Current Subsatellite Position</td>
<td>Replaced G08 (E USA; 75W)</td>
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**Compare GOES-12 to**

- **TERRA-MODIS**
- **AQUA-MODIS**
- **Meteosat-8 (MSG-1)**
- **VIRS**

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**NASA Official:** Patrick Minnis

**Website Curator:** Louis Nguyen

**Contact:**
- Langley
- Team Members

**More:**
- 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
- Information-Dissemination Priorities and Inventories
- USA.gov
- ExpectMore.gov

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Team Login
NASA Langley Satellite Calibration

Satellite Calibration Page → Satellite Details → GOES-12 compared to TERRA-MODIS

### NASA Langley Satellite Calibration for GOES-12

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**Visible Timeline plots (0.65 μm)**

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**Infrared Time plots**

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NASA Langley Satellite Calibration

Satellite Calibration Page → Satellite Details → GOES-12 compared to AQUA-MODIS

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## NASA Langley Satellite Calibration

**GOES-12**

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

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Satellite Calibration

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...)
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 |
| Workspoc | /Library/WebsServer/htdocs/site/calib-work/dataset-2 |
| Owner | 1 |
| Created On | 2008-02-12 |

Notes:
This is a test project.
Notes should be placed here.
### Admin Page → Projects Page → Project Details → Select Monthly Scatter Plot

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Select Months to include for Project: Software Development Dataset

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[Build]
IDL Program (GMplt.pro): 

```
; FOR GEO to LEO comparisons --> MET8/TERRA 9 channel comparison
; plots the individual monthly channel plots
; this is a test
function strtrim0, 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,"]'

iiyyyymm = 1
asat = strarr(2)
isspace = 8  ; 1=+, 2=*, 3=.  4=Diamond, 5=triangle, 6=square, 7=X, 8=circle
symssiz = 0.2

; 2008-02-07 - tlc - changed this programming to allow passed in values
------------------------------------------------------------------------------------------------------------------------------------
;for ileo = 1,2 do begin ; 1=terra, 2=aqua
ileo, sat_names = [ "TERRA", "AQUA"]
```
Admin Page → Projects Page → Project Details

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

Project: Software Development Dataset

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<td>This is a test project. Notes should be placed here.</td>
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</table>

Dataset: INIT
Admin Page → Projects Page → Projects Details → View/Edit IDL Program

IDL Program (Tgmplt.pro): 
```
function utime, lyr, idy
return, double(2415384.5)+1461d*(lyr-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
mmom = 13 ; # of months
amon = strarr(mmom) ; update amon and mmom with each new month
jird = intarr(mmom)
```
Let’s go straight to the VIS Calibration Results
NASA Langley Satellite Calibration Page

Post Launch Calibration Equations

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Go</th>
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Publications


GOES-11 Visible Gain Trend

G11 vs TERRA, 2006-2007

VIS, 0.65μm

SLOPE FORCE, Xoffset= 20.0

G11 DAY SINCE LAUNCH (May 03, 2002)

YEAR

2006  2007  2008

1337  1702  2067

SLOPE  0.794e-4
OFF     0.5350
R²      0.8421
STDerr  0.0058
MEAN    0.675
Satellite Calibration Page

NASA Langley Satellite Calibration Page

Post Launch Calibration Equations

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Publications


Meteosat-8 Visible Gain Trend

MET8 vs TERRA, 2004-2007
VIS, 0.64um

SLOPE FORCE, Xoffset= 51.0

MET8 DAY SINCE LAUNCH (Aug 28, 2002)

2004 2005 2006 2007 2008

YEAR

SLOPE 0.129e-4
OFF 0.8038
R² 0.3340
STDerr 0.0063
MEAN 0.621
Satellite Calibration Page

NASA Langley Satellite Calibration Page

Post Launch Calibration Equations

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Publications


Meteosat-9 Visible Gain Trend

MET9 vs TERRA, 2007-2008
VIS, 0.64\textmu m

SLOPE FORCE, X_offset = 51.0

SLOPE: 0.287e-4
OFF: 0.5158
R^2: 0.8218
STDerr: 0.0014
MEAN: 0.534

MET9 DAY SINCE LAUNCH (Dec 21, 2005)
2007  2008  2009
YEAR
NASA Langley Satellite Calibration Page

Post Launch Calibration Equations

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Publications


FY-2C Visible Gain Trend

FY2C vs TERRA, 2006-2007

VIS, 0.73um

SLOPE FORCE, Xcfixset= 1.0

FY2C DAY SINCE LAUNCH (Oct 19, 2004)

2006  2007  2008

YEAR

SLOPE 0.007e-4
OFF 0.0086
R^2 0.1122
STDerr 0.0004
MEAN 0.009
Satellite Calibration Page

NASA Langley Satellite Calibration Page

Post Launch Calibration Equations

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Publications


MTSAT-1R Visible Gain Trend

8-bit data

MTSAT vs TERRA, 2006-2007
VIS, 0.73μm

MTSAT DAY SINCE LAUNCH (Feb 26, 2005)

SLOPE = 0.0066-4
OFF = 0.0095
FP = 0.0227
STDerr = 0.0005
MEAN = 0.009

10-bit data

MTSAT vs TERRA, 2007-2007
VIS, 0.73μm

MTSAT DAY SINCE LAUNCH (Feb 26, 2005)

SLOPE = 3.701e-4
OFF = 0.3029
FP = 1.0000
STDerr = NaN
MEAN = 0.619
# NASA Langley Satellite Calibration Page

## Post Launch Calibration Equations

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<tr>
<th>Satellite</th>
<th>Go</th>
<th>dg1</th>
<th>dg2</th>
<th>Co</th>
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<td>GOES-12</td>
<td>0.635</td>
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## Publications
