GSICS GEO-LEO Inter-Calibration at NOAA

X. Wu, 29 Jan 2009

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- Algorithm
- Operation
- Performance Monitoring
- Anomaly Diagnosis
- Visible Calibration

Algorithm

- Version 0 (May 2007)
  - Test for GOES-AIRS, not operational.
- Version 1.0 (October 2007)
  - Separate subsetting (orbit prediction) from collocation.
- Version 1.1 (December 2007)
  - Improved selection
- Version 1.2 (January 2008)
  - Improved selection
- Version 1.3 (March 2008)
  - Output in NetCDF (instead of binary)
- **Version 2.0 (May 2008)**
  - JMA gap filling algorithm
  - Separate selection from collocation
- Version 2.0.1 (August 2008)
  - Adopted the code for GOES-IASI in IDL
- Version 2.1 (February 2009)
  - Modularization for GEO-AIRS/IASI

Algorithm

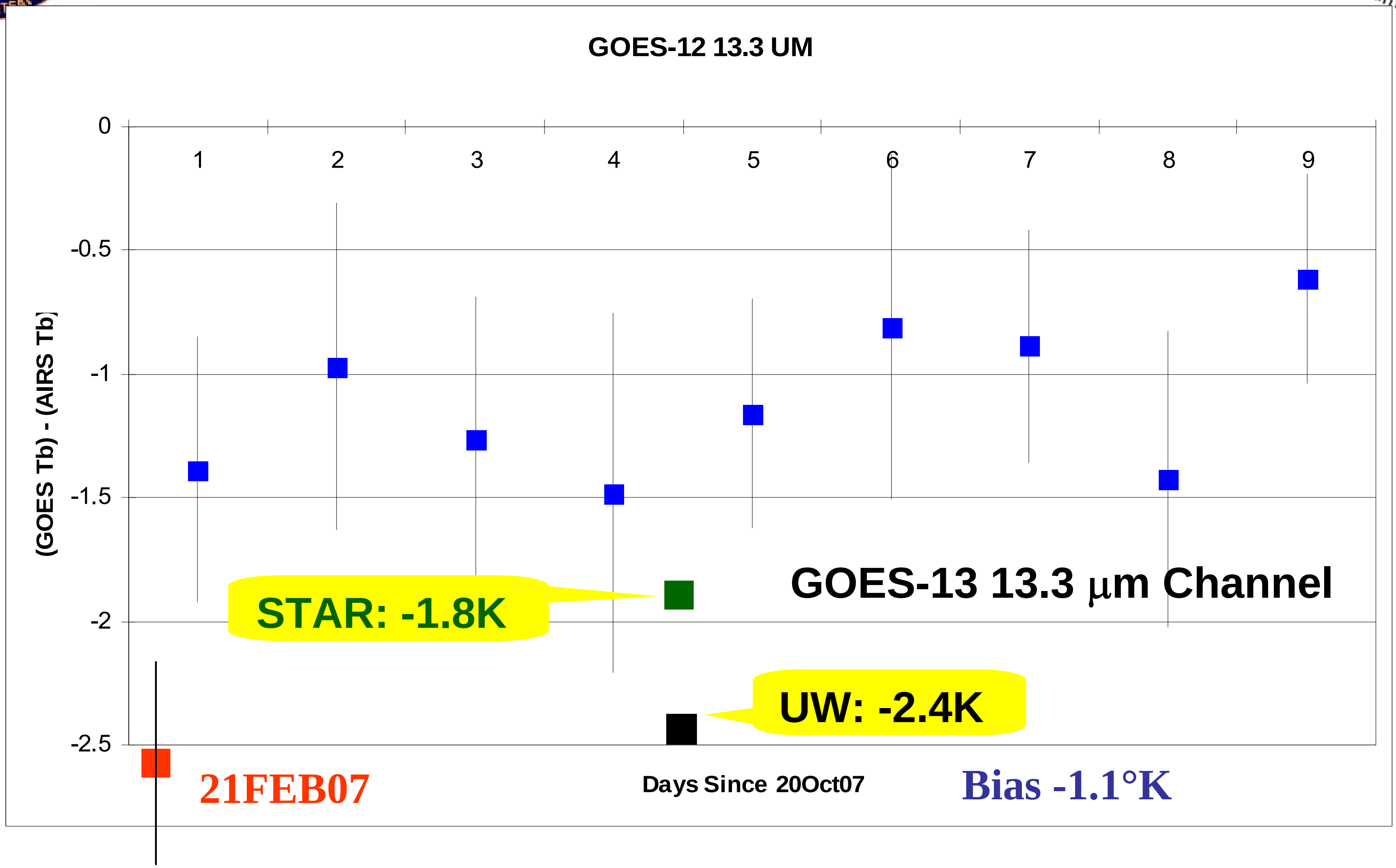
- No major change since May 2008
  - Data back-processed
- ATBD is incomplete
  - JMA gap filling algorithm to be finalized
- Hierarchical Structure for ATBD
  - Convenient to describe what it is
  - Extremely useful to compare with others
  - How much about “why” for certain steps or threshold values?
    - None – less than “Theoretical Basis”
    - Too much – no longer concise

Operation

- Version 2.0, GOES-AIRS, since January 2007
- Version 2.0.1, GOES-IASI, June 2007 to November 2008
- Version 2.1 will be tested for compatibility with 2.0 for GOES-AIRS and Version 2.0.1 for GOES-IASI
- Version 2.1 will be used to inter-calibrate MTSAT-1R, FY2C, METEOSAT-7/8/9 with AIRS/IASI since August 2008.
- Version 2.1 will replace 2.0 for GOES-AIRS/IASI.
- Version 2.0 or equivalent is used for
  - GOES-AIRS since Jan 2007
  - GOES-IASI since Jun 2007
  - GEO-AIRS/IASI since Aug 2008

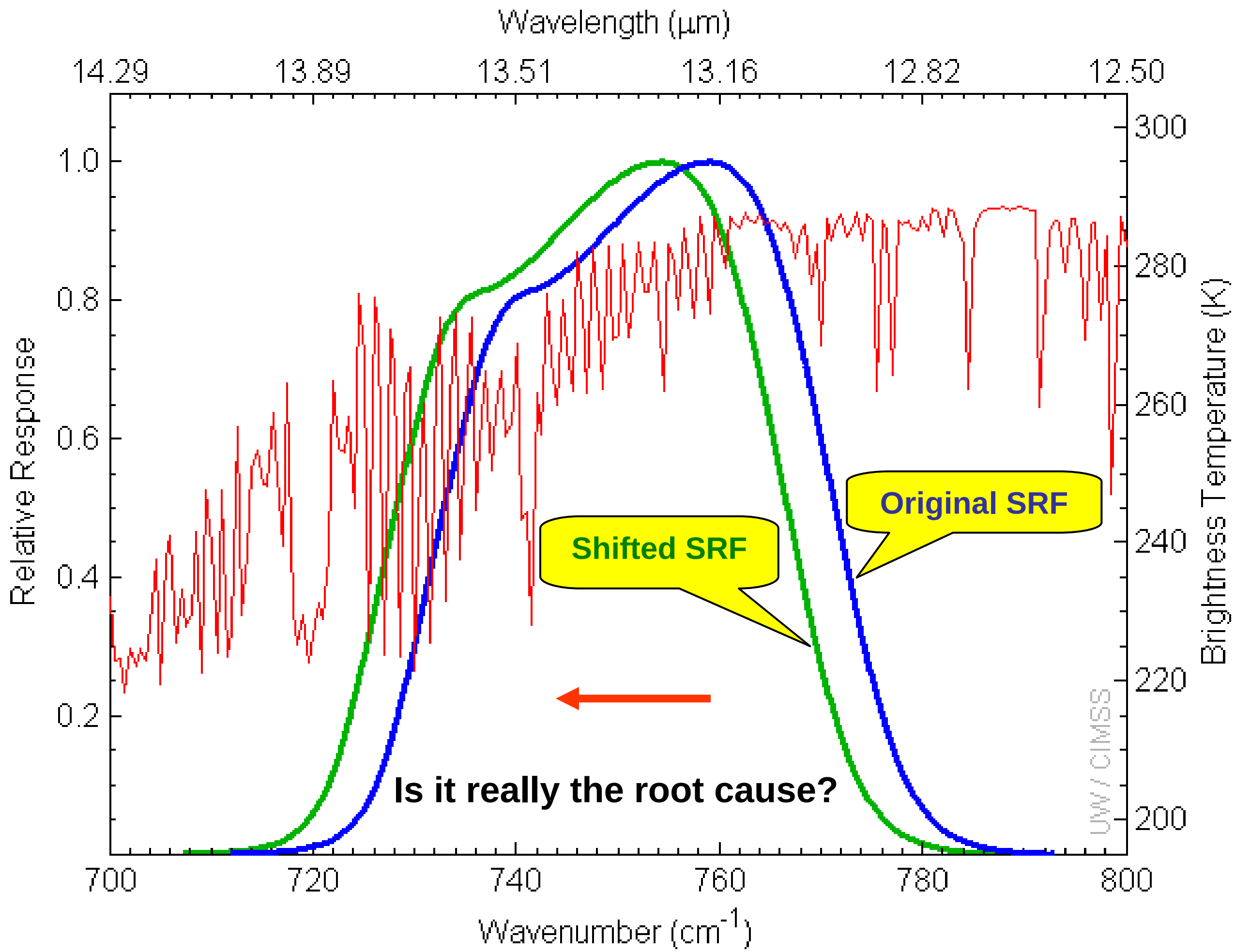
Performance Monitoring

- Effects of METEOSAT-9 and GOES-12 decontamination
- Monitoring GOES-12 contamination
- Effects of IASI decontamination
- IASI recovery

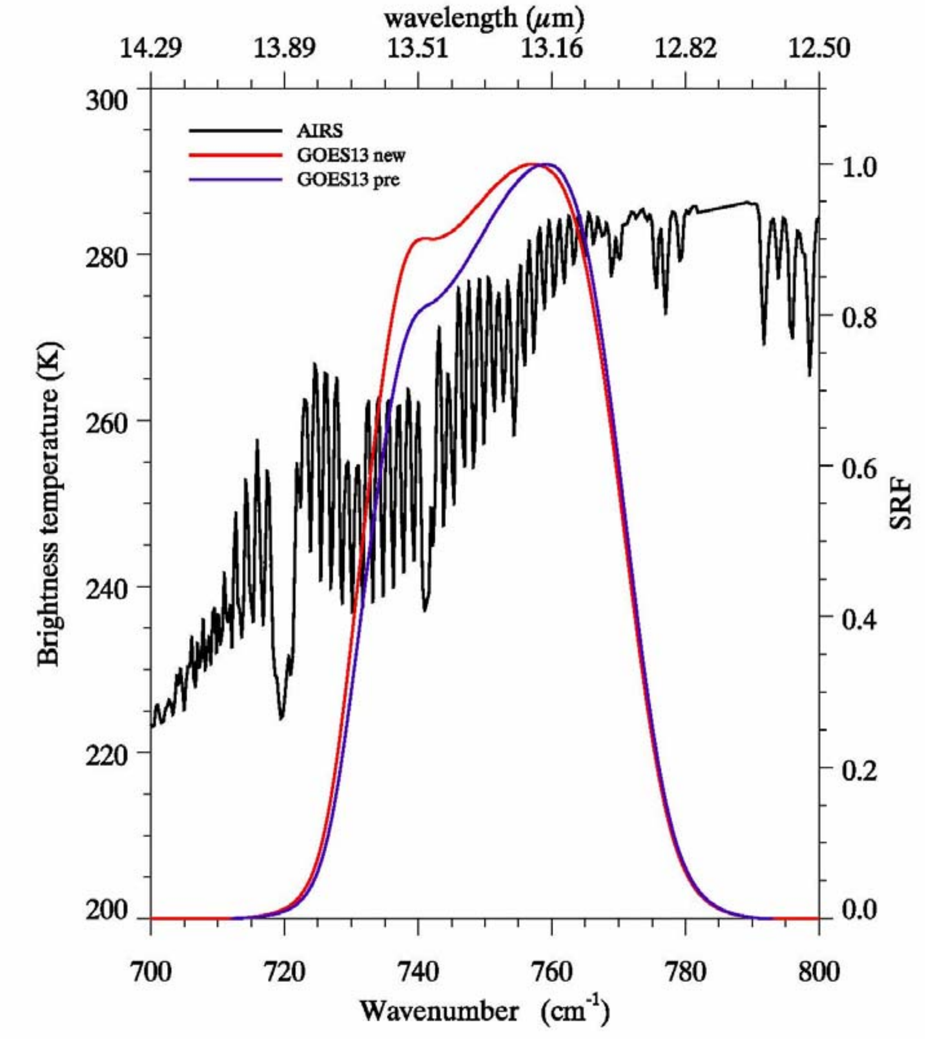


Difference may be due to the methods used. Insufficient data in general.

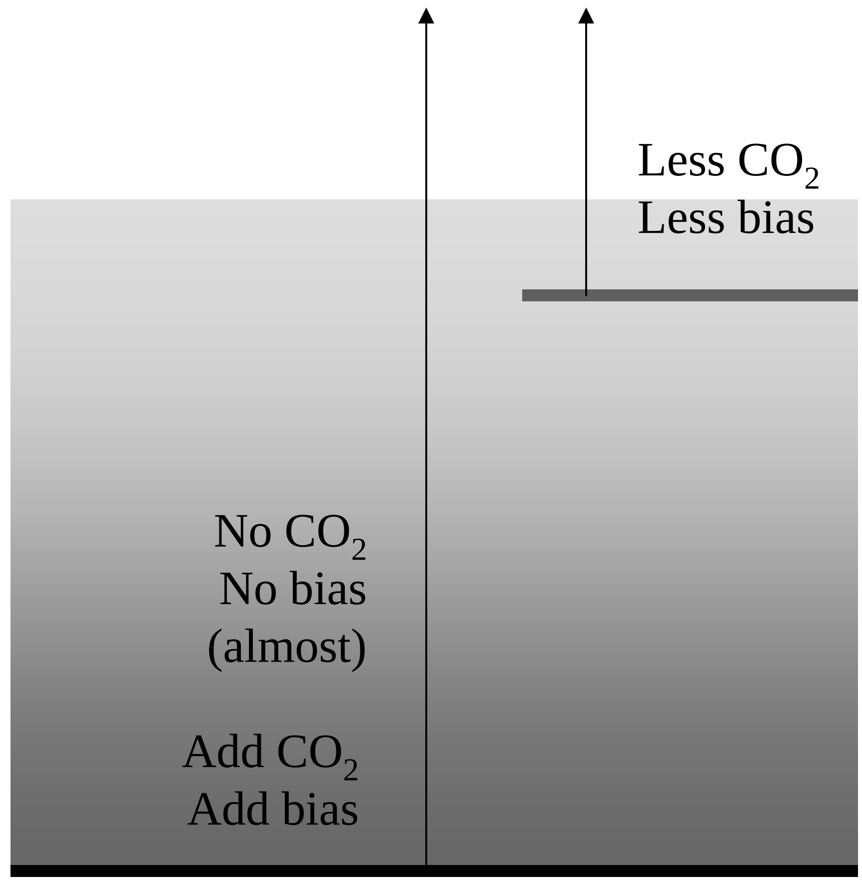
Solution: Shift SRF by ~4.7 cm^{-1}



Updated SRF with effective shift of ~-1 cm^{-1}



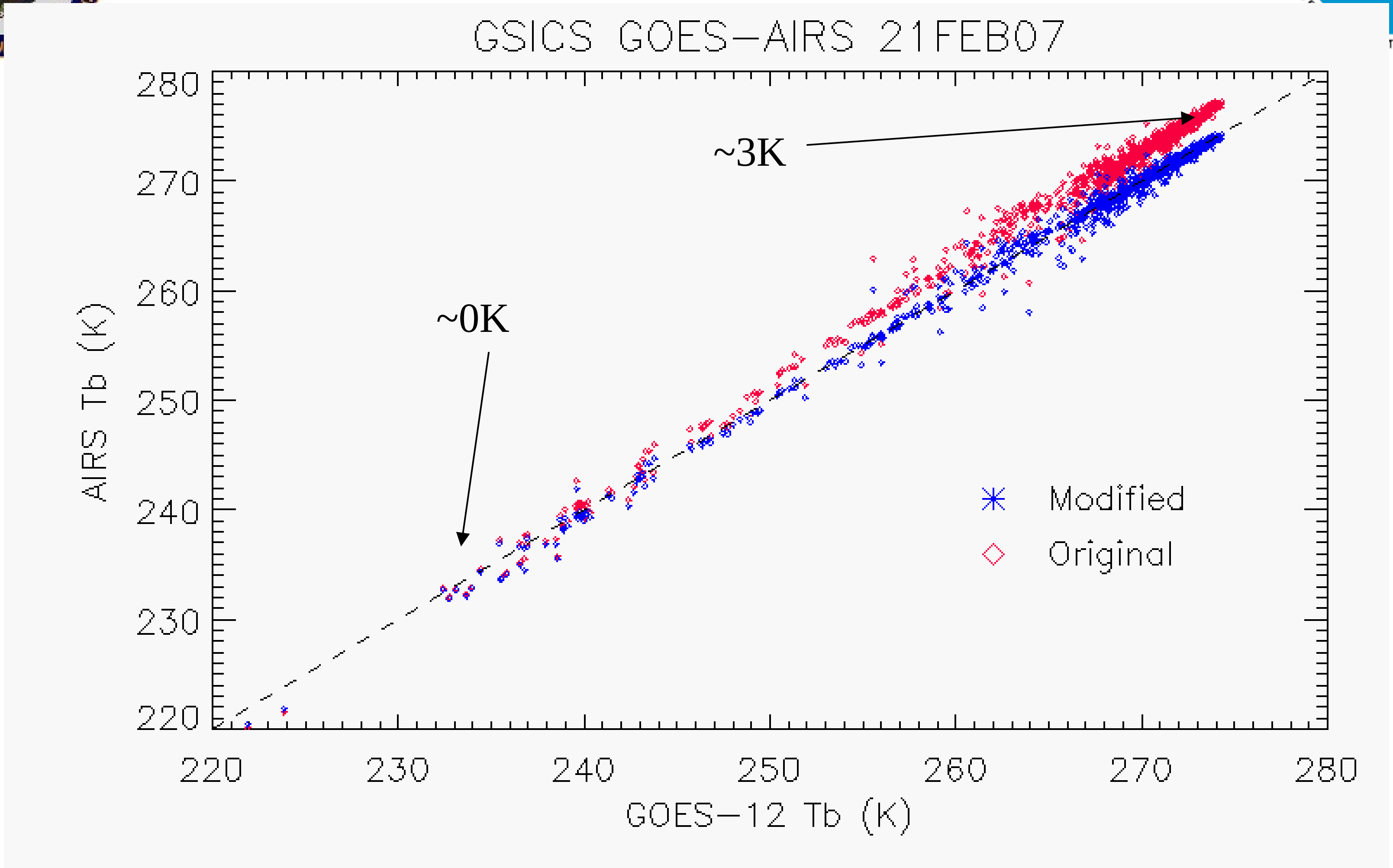
Satellite Instrument with incorrect SRF

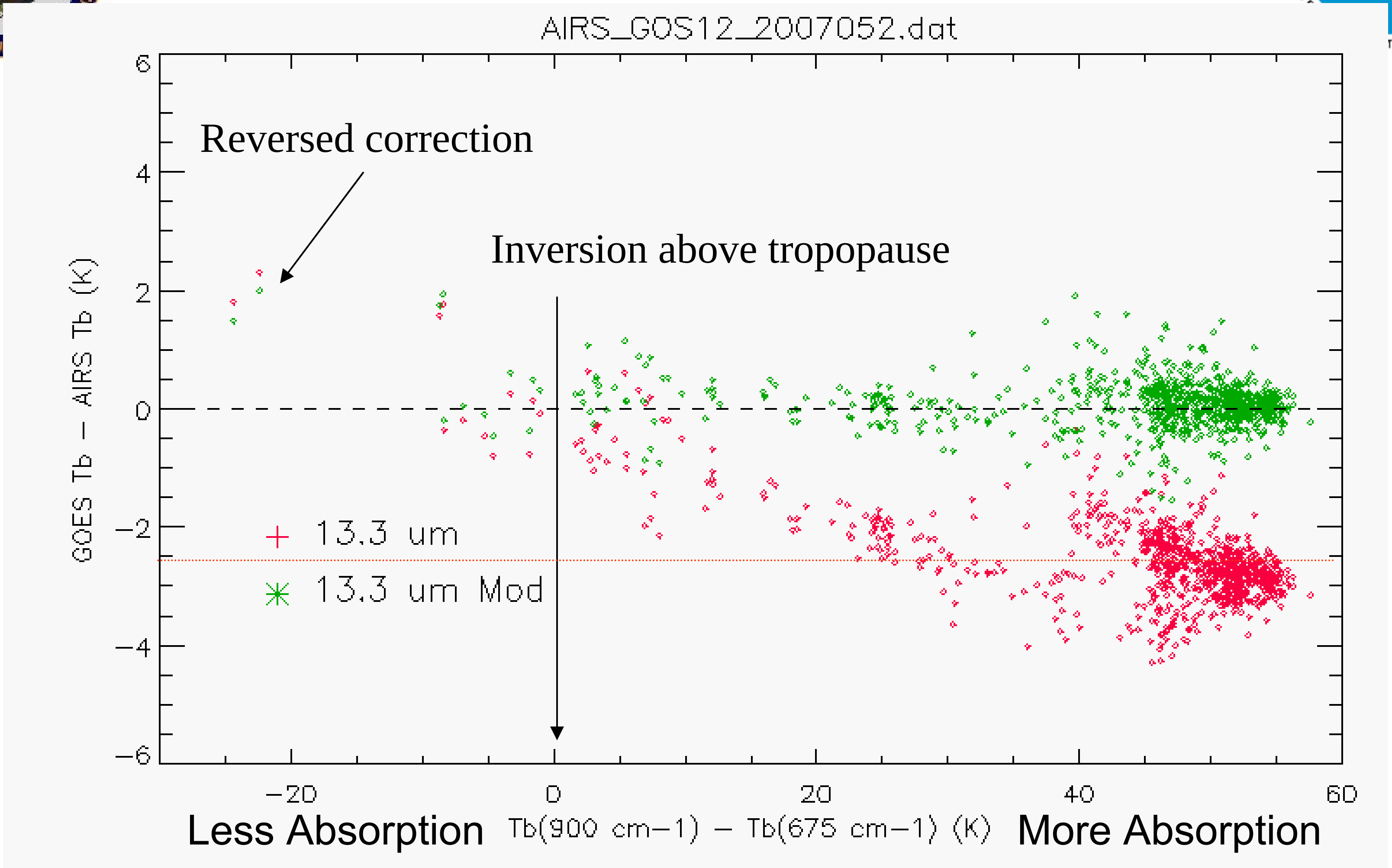


Colder

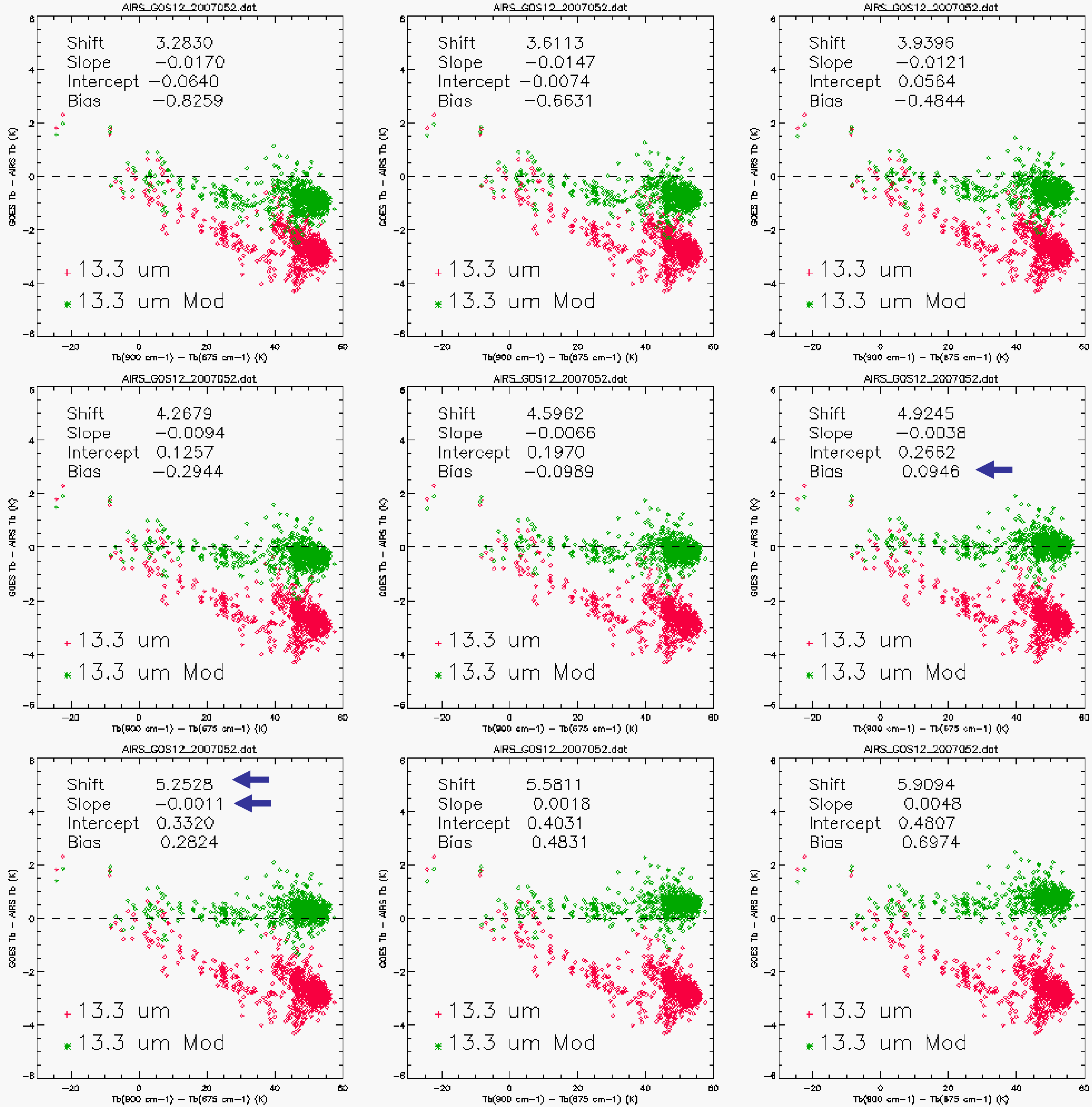
Warmer

Would the bias for warmer scenes be larger than that for colder scenes?

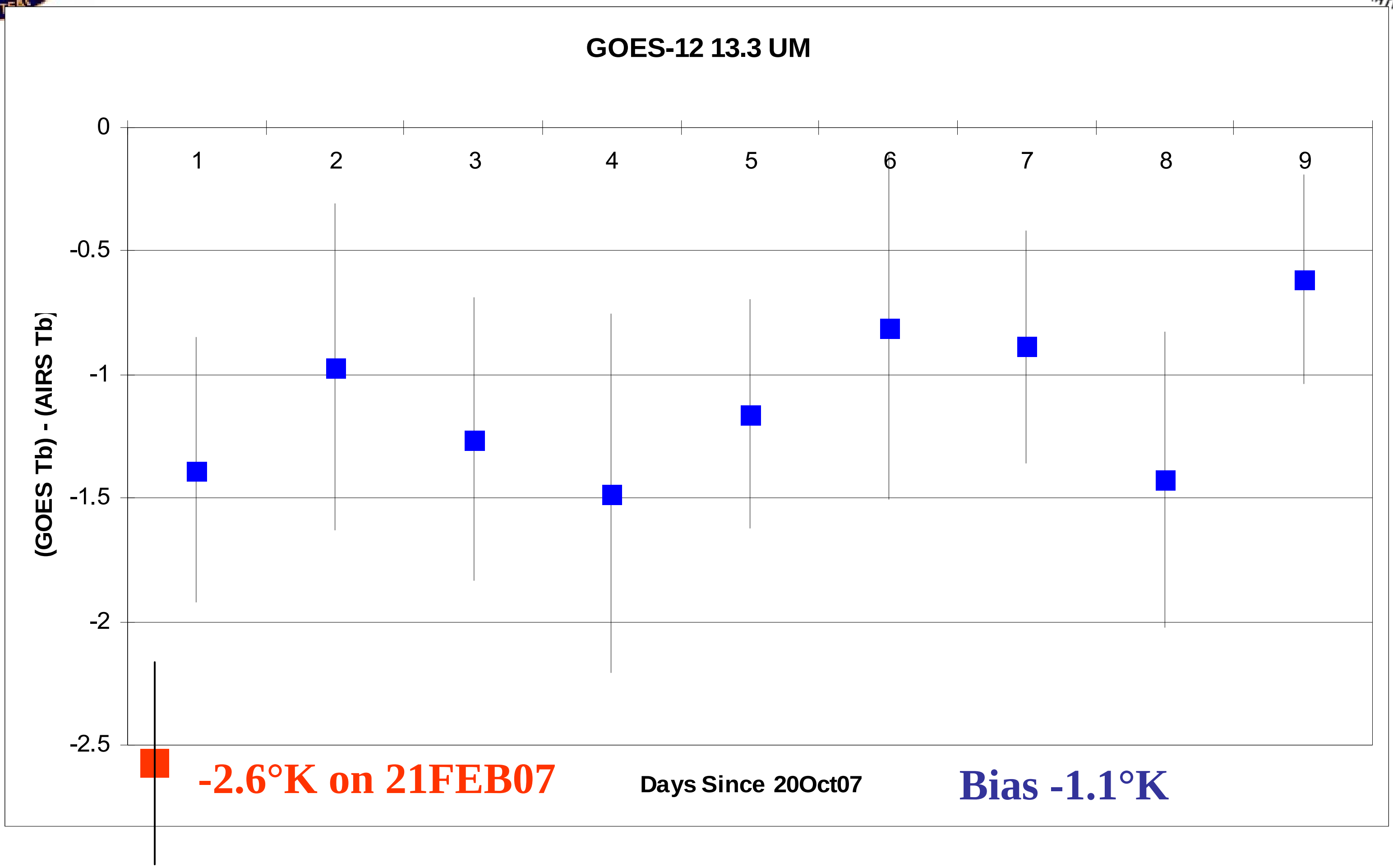

GSICS GOES–AIRS 21FEB07
~3K
~0K
AIRS Tb (K)
GOES–12 Tb (K)
280
270
260
250
240
230
220
220
230
240
250
260
270
280
Modified
Original



Adding a constant under-corrects warm scenes and over-corrects cold scenes



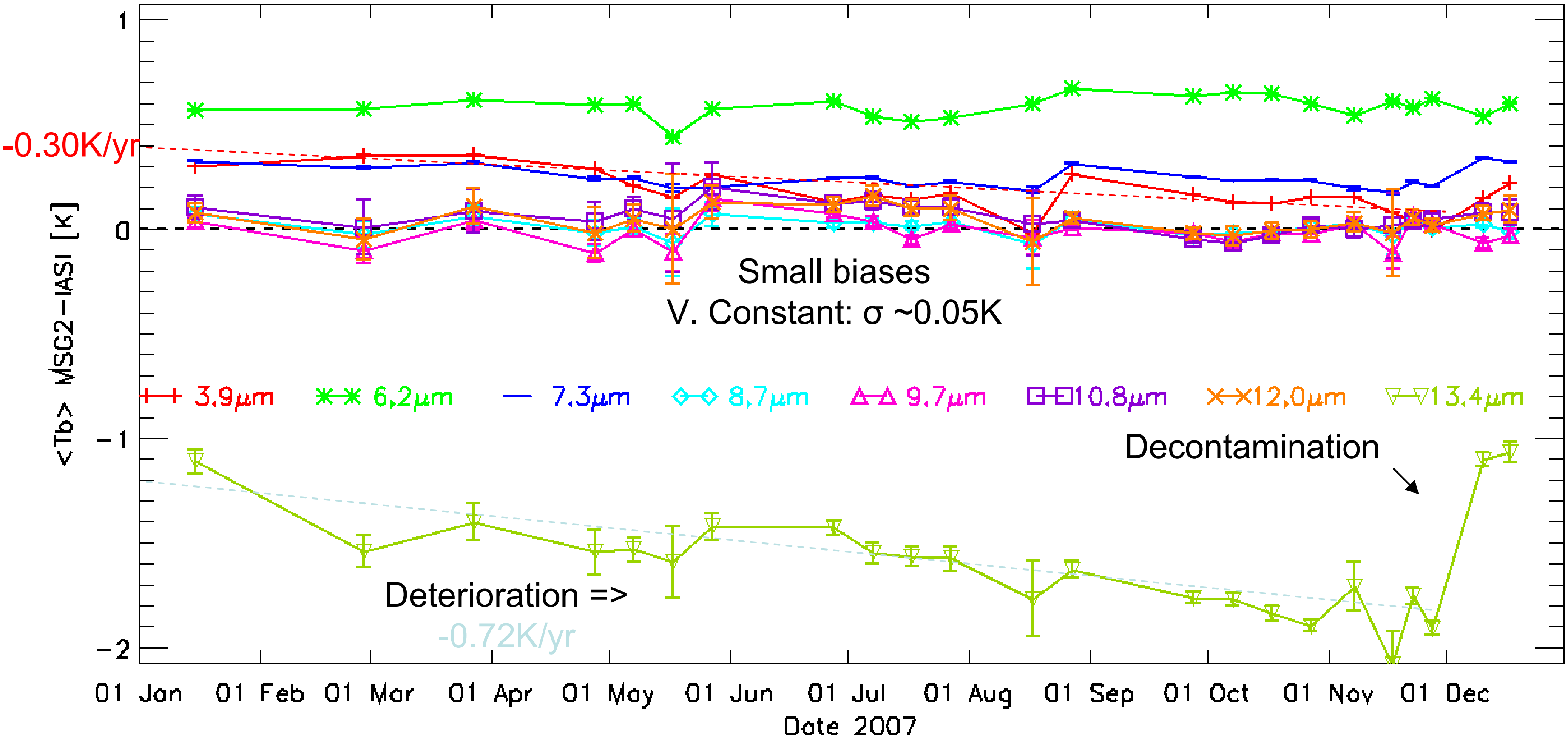
AIRS_GOS12_2007052.dat
Shift 3.2830
Slope −0.0170
Intercept −0.0640
Bias −0.8259
13.3 um
13.3 um Mod
GOES Tb − AIRS Tb (K)
Tb(900 cm−1) − Tb(675 cm−1) (K)
AIRS_GOS12_2007052.dat
Shift 3.6113
Slope −0.0147
Intercept −0.0074
Bias −0.6631
13.3 um
13.3 um Mod
AIRS_GOS12_2007052.dat
Shift 3.9396
Slope −0.0121
Intercept 0.0564
Bias −0.4844
13.3 um
13.3 um Mod
AIRS_GOS12_2007052.dat
Shift 4.2679
Slope −0.0094
Intercept 0.1257
Bias −0.2944
13.3 um
13.3 um Mod
AIRS_GOS12_2007052.dat
Shift 4.5962
Slope −0.0066
Intercept 0.1970
Bias −0.0989
13.3 um
13.3 um Mod
AIRS_GOS12_2007052.dat
Shift 4.9245
Slope −0.0038
Intercept 0.2662
Bias 0.0946
13.3 um
13.3 um Mod
AIRS_GOS12_2007052.dat
Shift 5.2528
Slope −0.0011
Intercept 0.3320
Bias 0.2824
13.3 um
13.3 um Mod
AIRS_GOS12_2007052.dat
Shift 5.5811
Slope 0.0018
Intercept 0.4031
Bias 0.4831
13.3 um
13.3 um Mod
AIRS_GOS12_2007052.dat
Shift 5.9094
Slope 0.0048
Intercept 0.4807
Bias 0.6974
13.3 um
13.3 um Mod



Now what about this outlier?

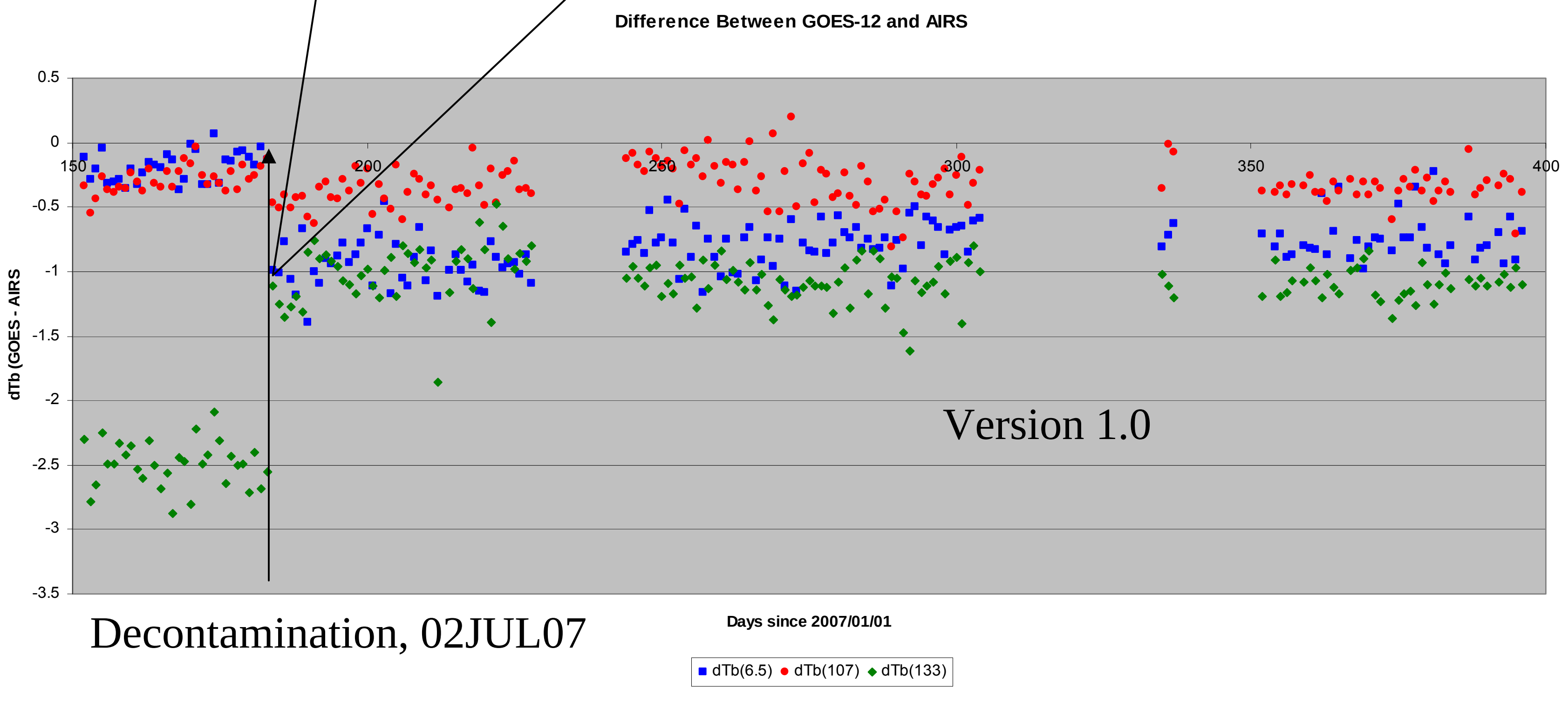
It's not, in fact it's a clue to trace down a cause for SRF error

SEVIRI on Meteosat-9 – IASI on Metop



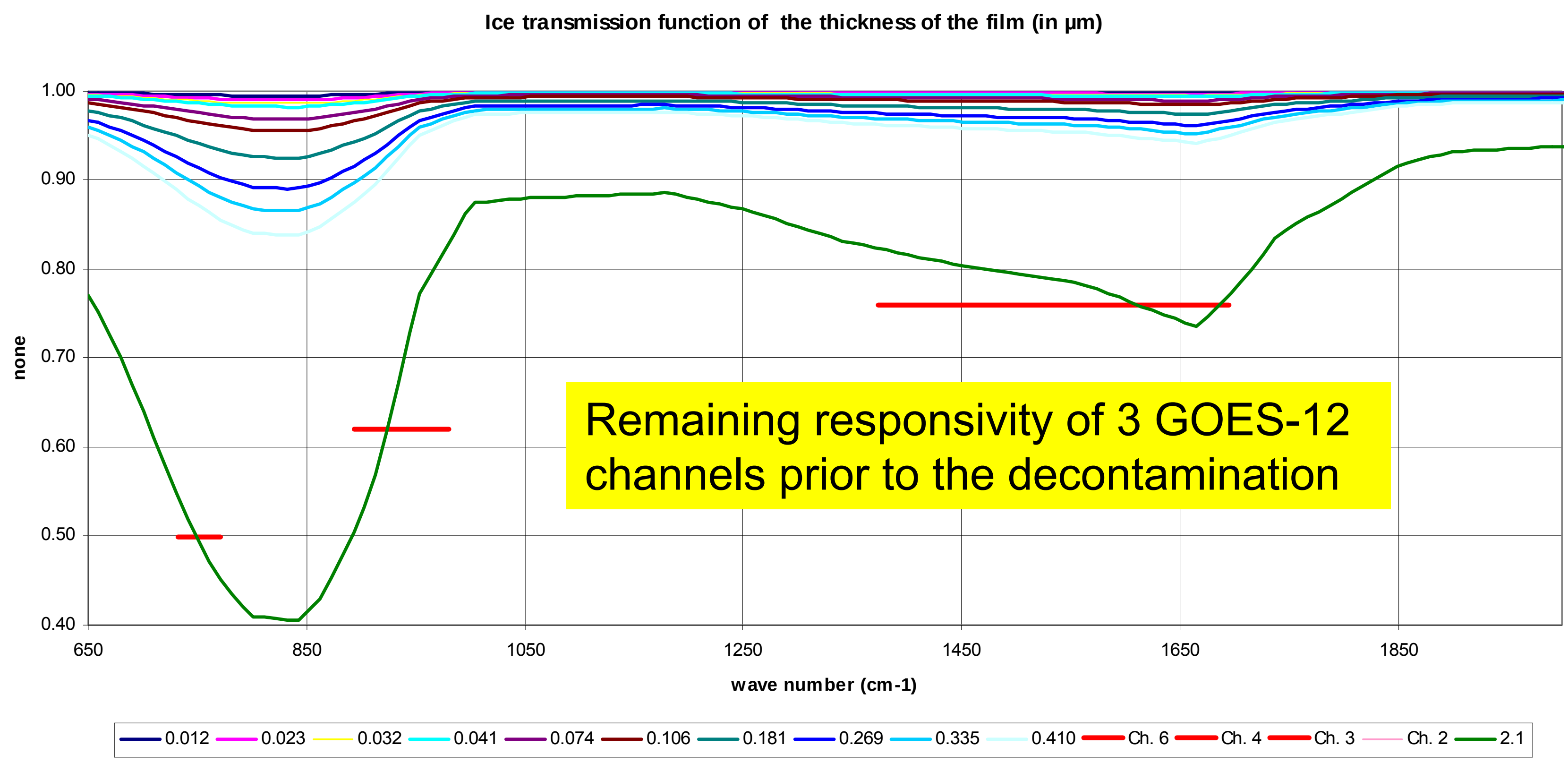
Time series of brightness temperature differences between MSG2-IASI for typical clear-sky radiances. Each MSG infrared channel is shown in a different color, with different symbols, following the legend. Error bars represent statistical uncertainty on each mean bias (may be very small).

Why did the 13.3μm and the 6.5 μm channels respond differently to the decontamination



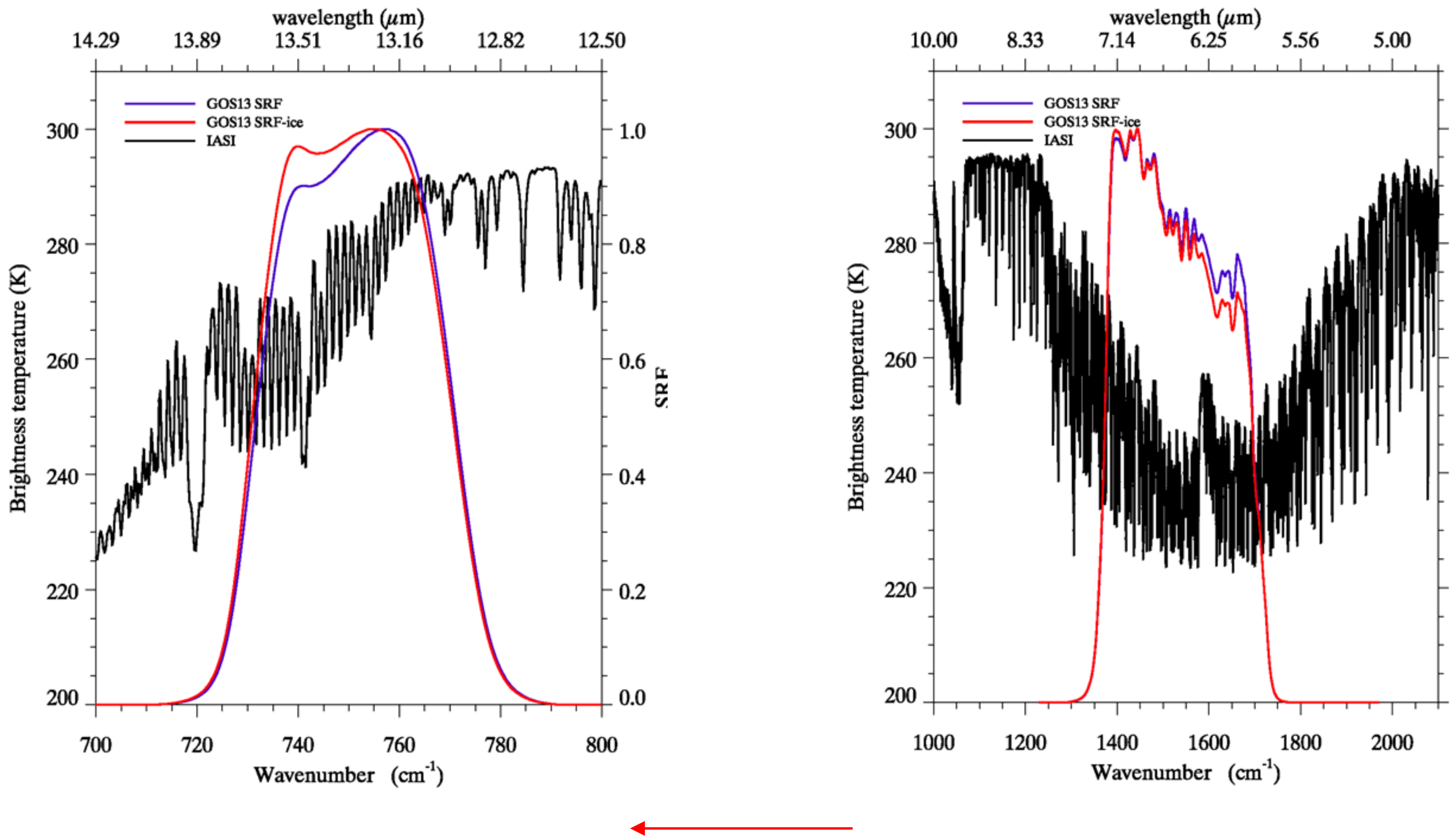
Decontamination, 02JUL07

Spectral transmission of H_2O Ice with various thickness



Diagnosis for METEOSAT-9: ~1μm

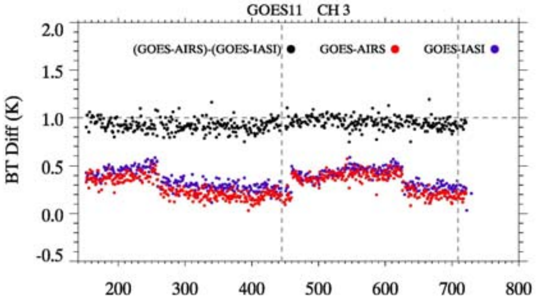
From CNES, verified by IASI data

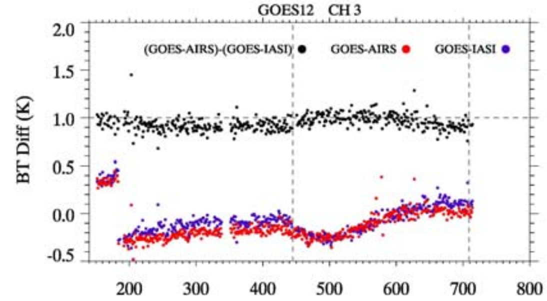


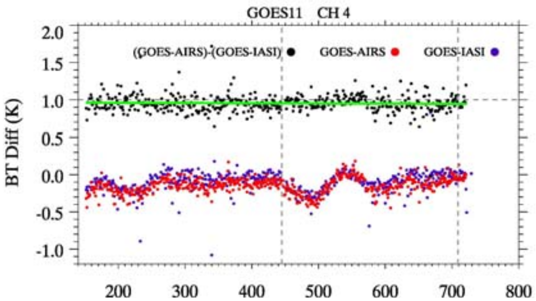
Effective shift of SRF assuming 2.1 μm ice

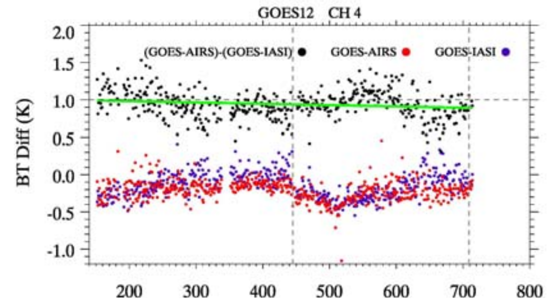
Performance Monitoring

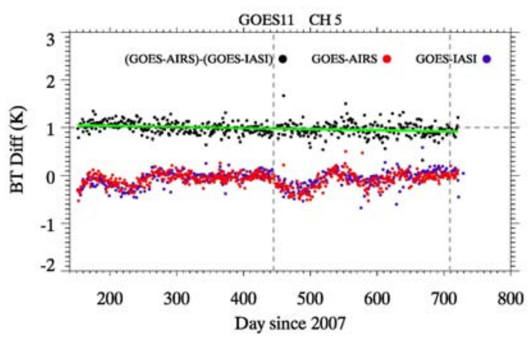
- Effects of METEOSAT-9 and GOES-12 decontamination
- Monitoring contamination
- Effects of IASI decontamination
- IASI recovery

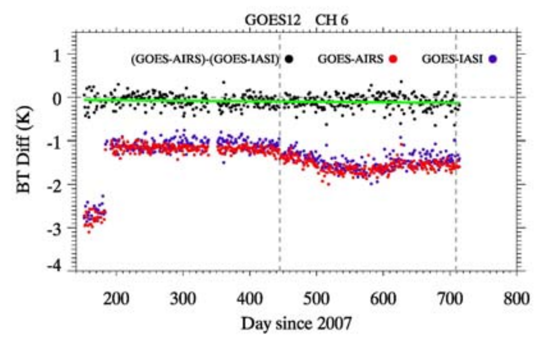

GOES11 CH 3
(GOES-AIRS)-(GOES-IASI)
GOES-AIRS
GOES-IASI
BT Diff (K)


GOES12 CH 3
(GOES-AIRS)-(GOES-IASI)
GOES-AIRS
GOES-IASI
BT Diff (K)


GOES11 CH 4
(GOES-AIRS)-(GOES-IASI)
GOES-AIRS
GOES-IASI
BT Diff (K)


GOES12 CH 4
(GOES-AIRS)-(GOES-IASI)
GOES-AIRS
GOES-IASI
BT Diff (K)

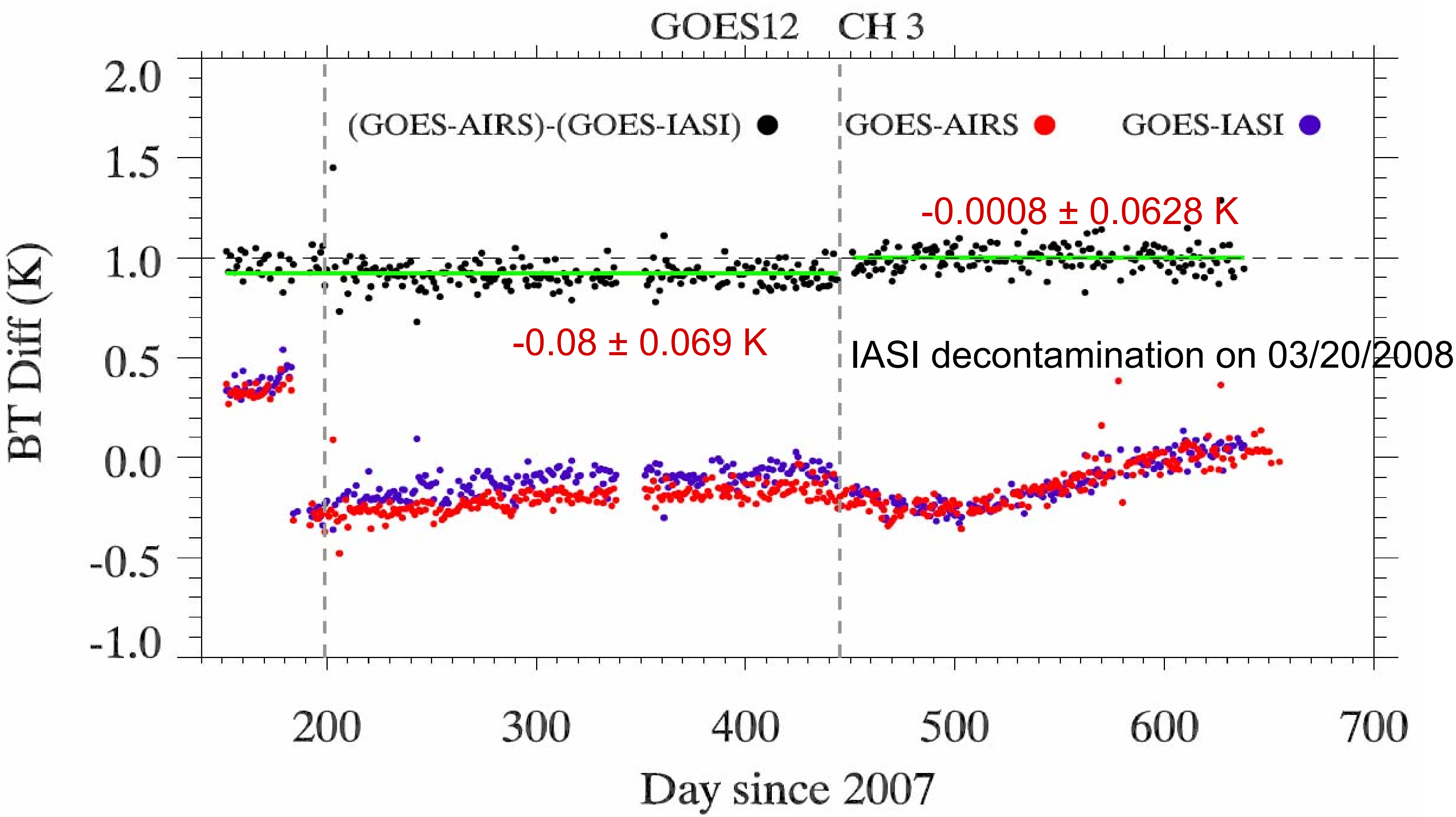

GOES11 CH 5
(GOES-AIRS)-(GOES-IASI)
GOES-AIRS
GOES-IASI
BT Diff (K)
Day since 2007


GOES12 CH 6
(GOES-AIRS)-(GOES-IASI)
GOES-AIRS
GOES-IASI
BT Diff (K)
Day since 2007

Performance Monitoring

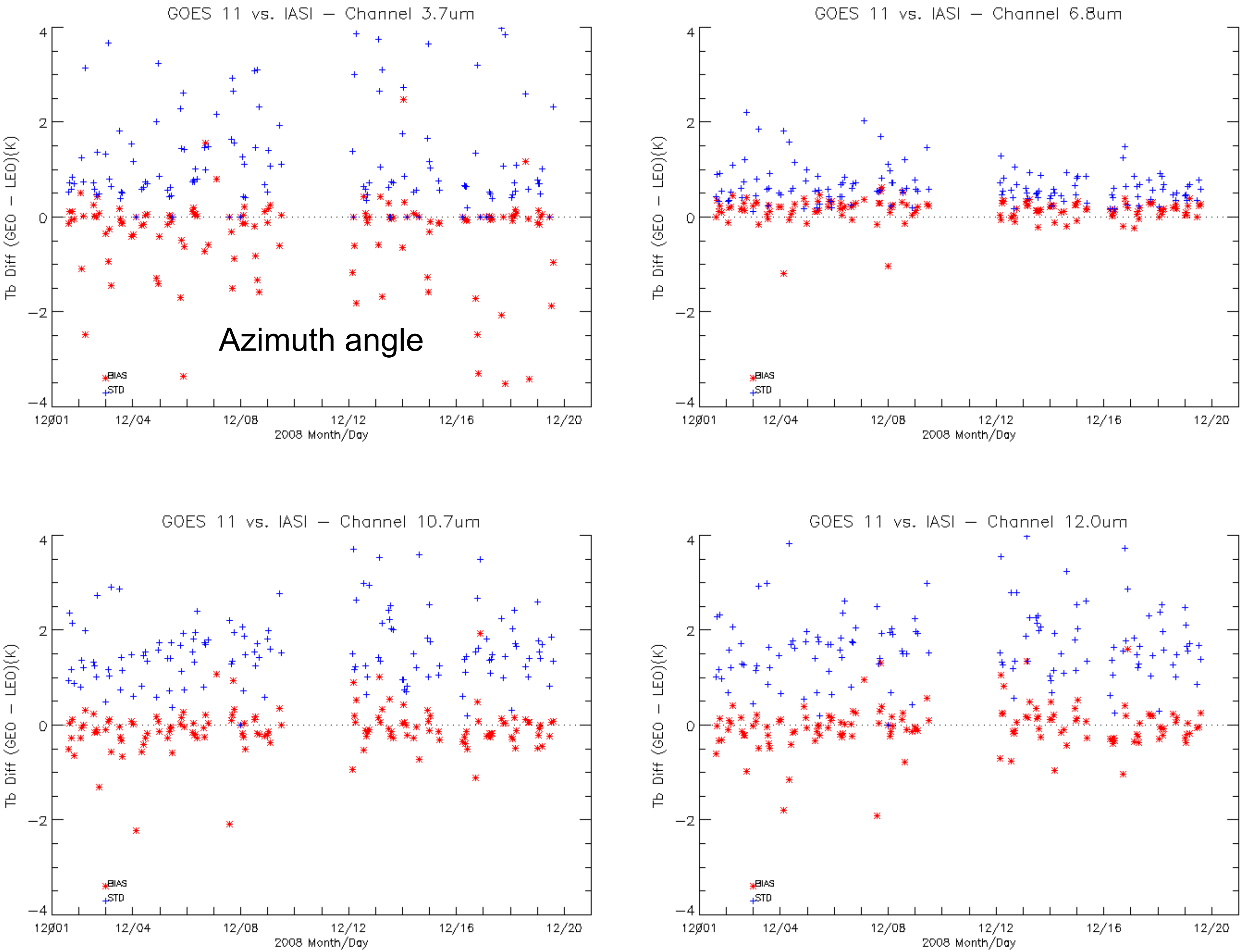
- Effects of METEOSAT-9 and GOES-12 decontamination
- Monitoring contamination
- Effects of IASI decontamination
- IASI recovery

IASI Decontamination Effects: GOES12: 6.5 µm channel

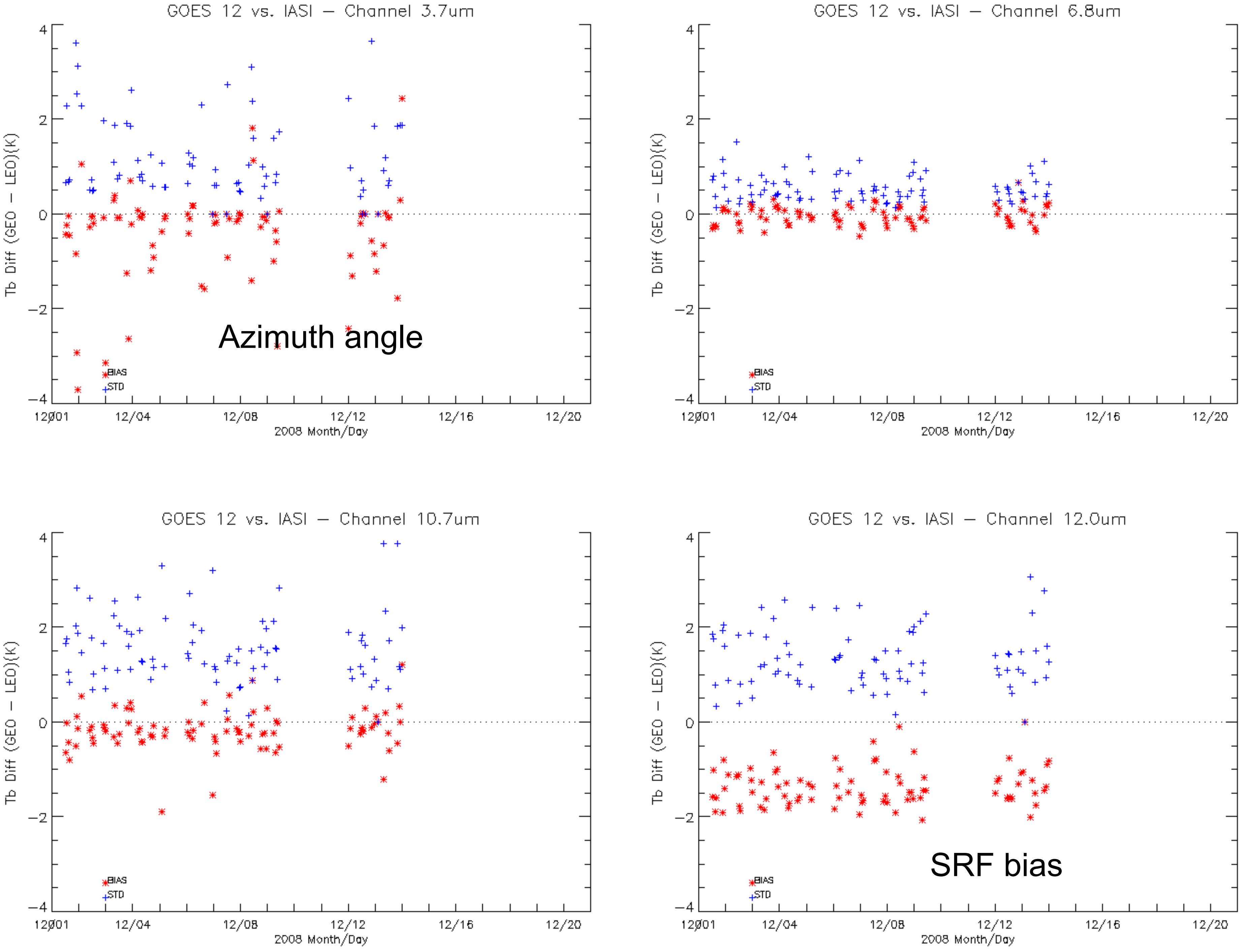


Performance Monitoring

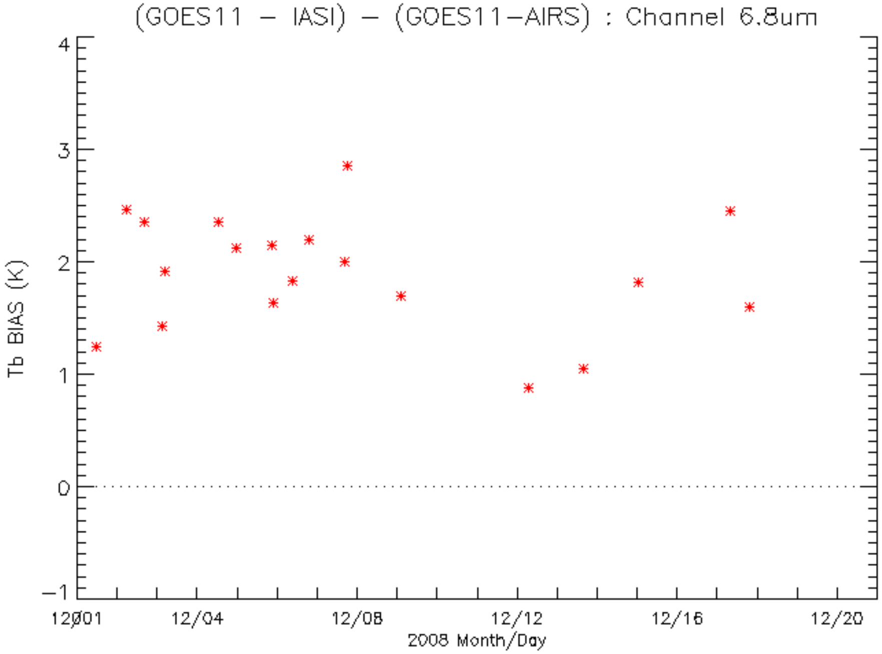
- Effects of METEOSAT-9 and GOES-12 decontamination
- Monitoring contamination
- Effects of IASI decontamination
- IASI recovery
  - Preliminary results, for discussion only

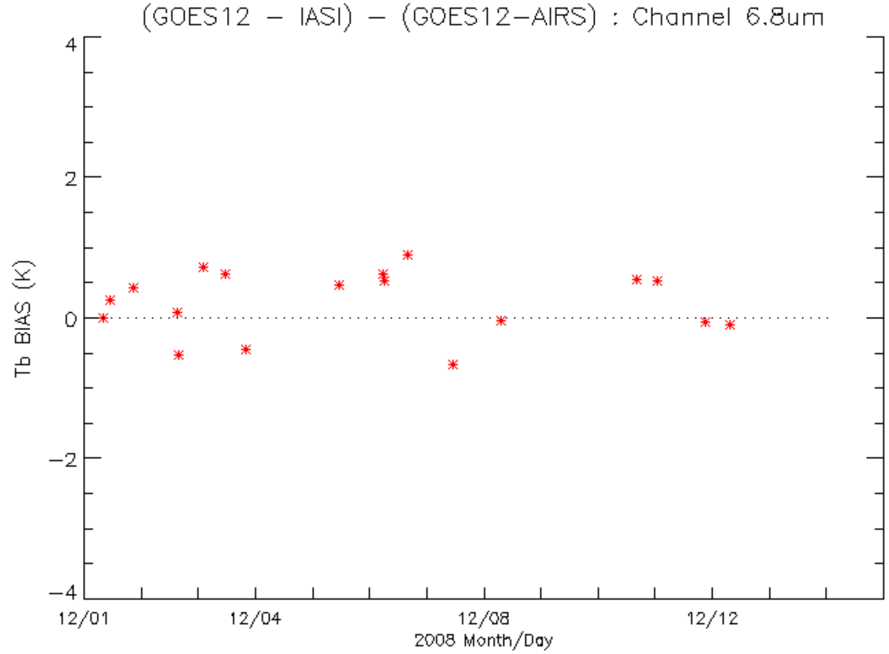


GOES 11 vs. IASI – Channel 3.7um
Azimuth angle
GOES 11 vs. IASI – Channel 6.8um
GOES 11 vs. IASI – Channel 10.7um
GOES 11 vs. IASI – Channel 12.0um
Tb Diff (GEO – LEO)(K)
2008 Month/Day
12/01
12/04
12/08
12/12
12/16
12/20
4
2
0
–2
–4
BIAS
STD



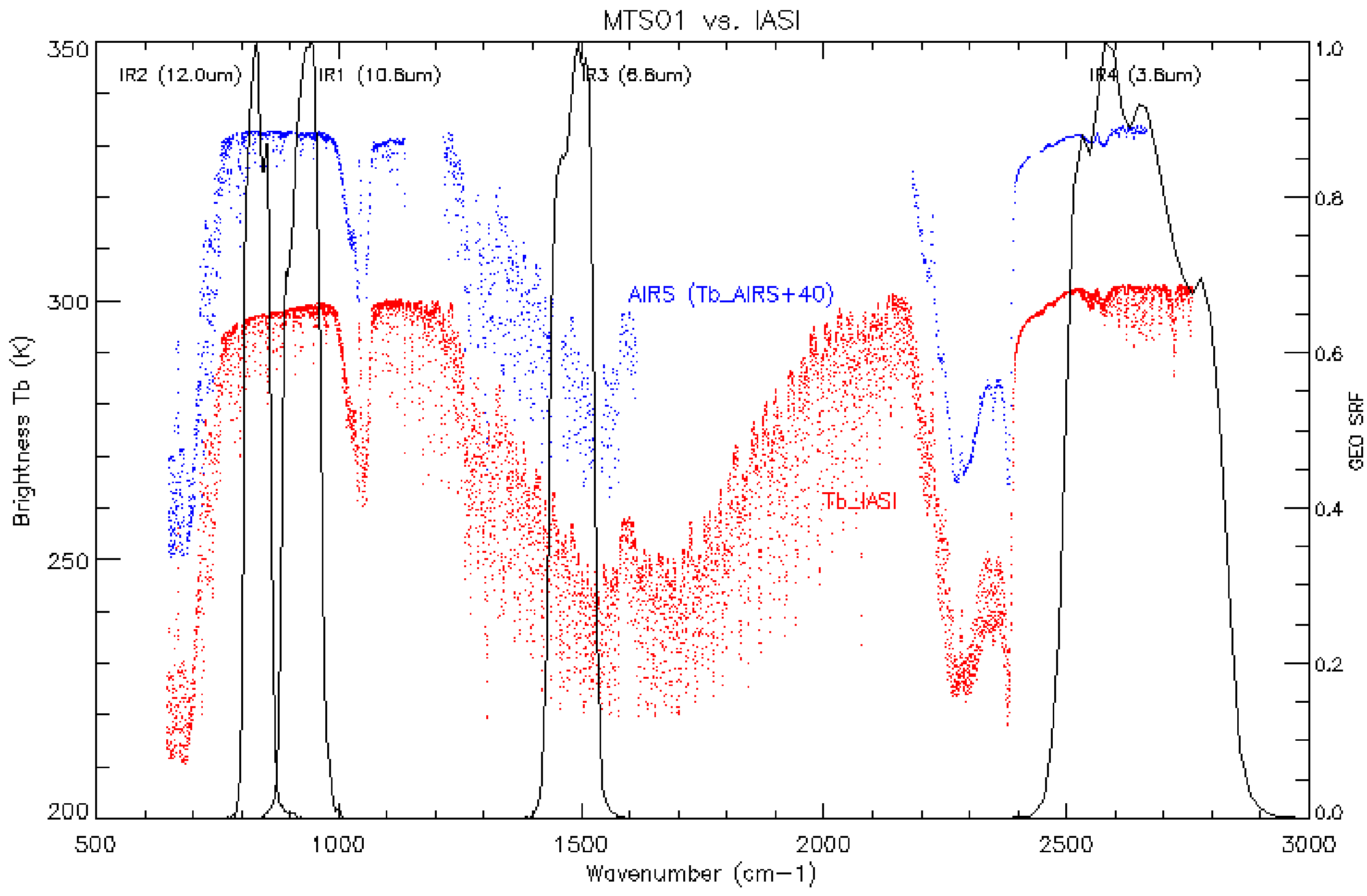
GOES 12 vs. IASI – Channel 3.7um
Azimuth angle
GOES 12 vs. IASI – Channel 6.8um
GOES 12 vs. IASI – Channel 10.7um
GOES 12 vs. IASI – Channel 12.0um
SRF bias
Tb Diff (GEO – LEO)(K)
2008 Month/Day
BIAS
STD



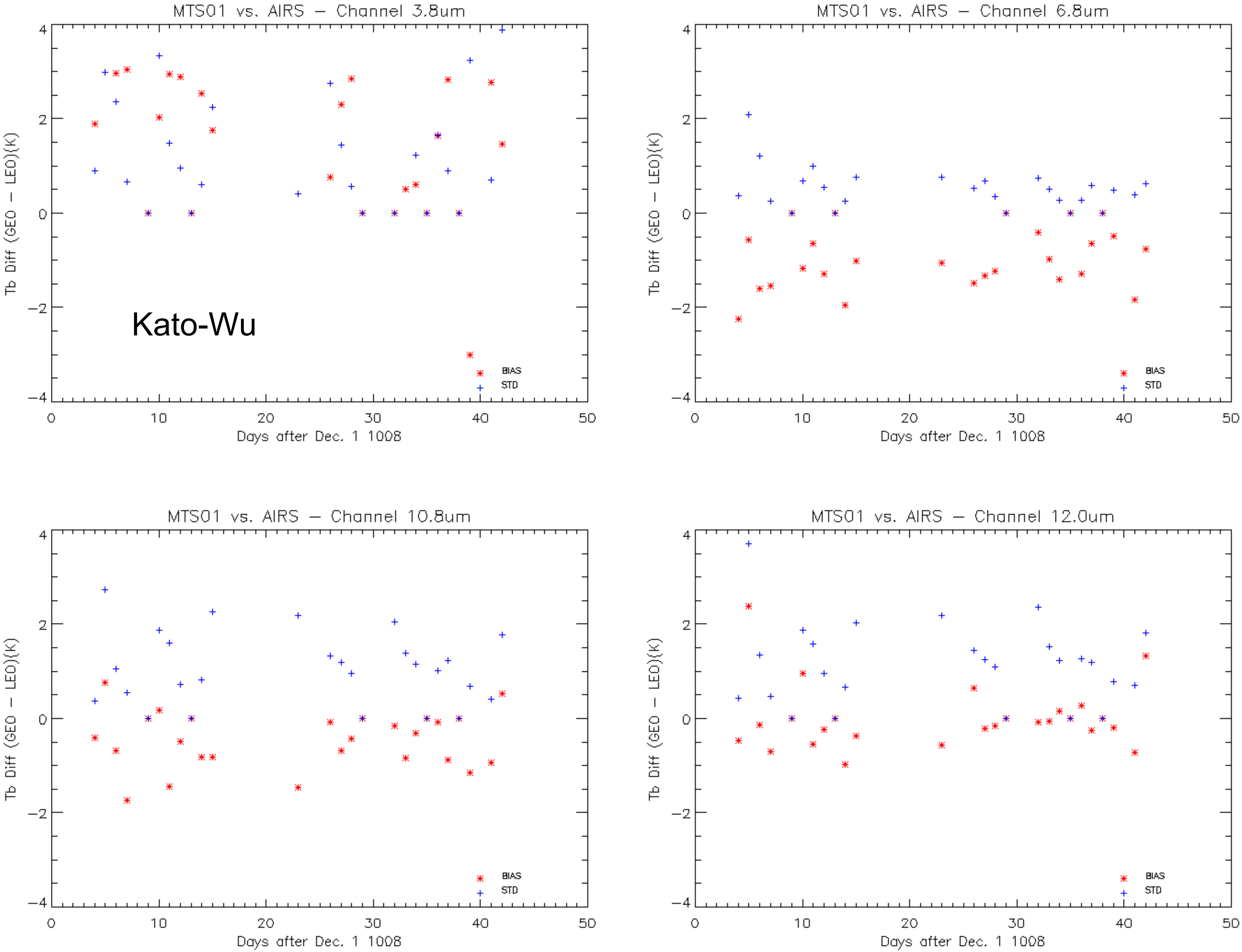


GOES-11 – AIRS in transition V2.0 to V2.1

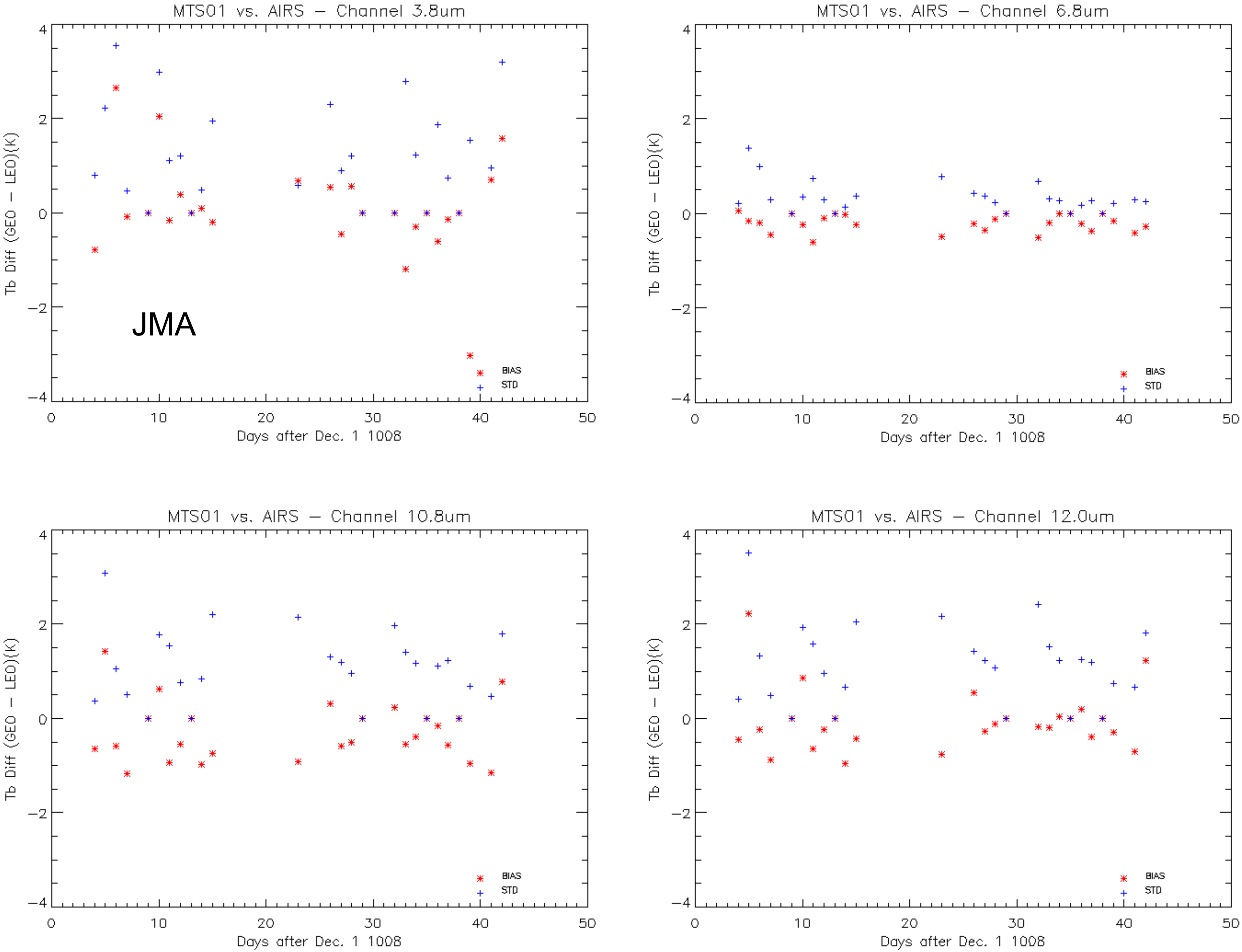
MTSAT-1R

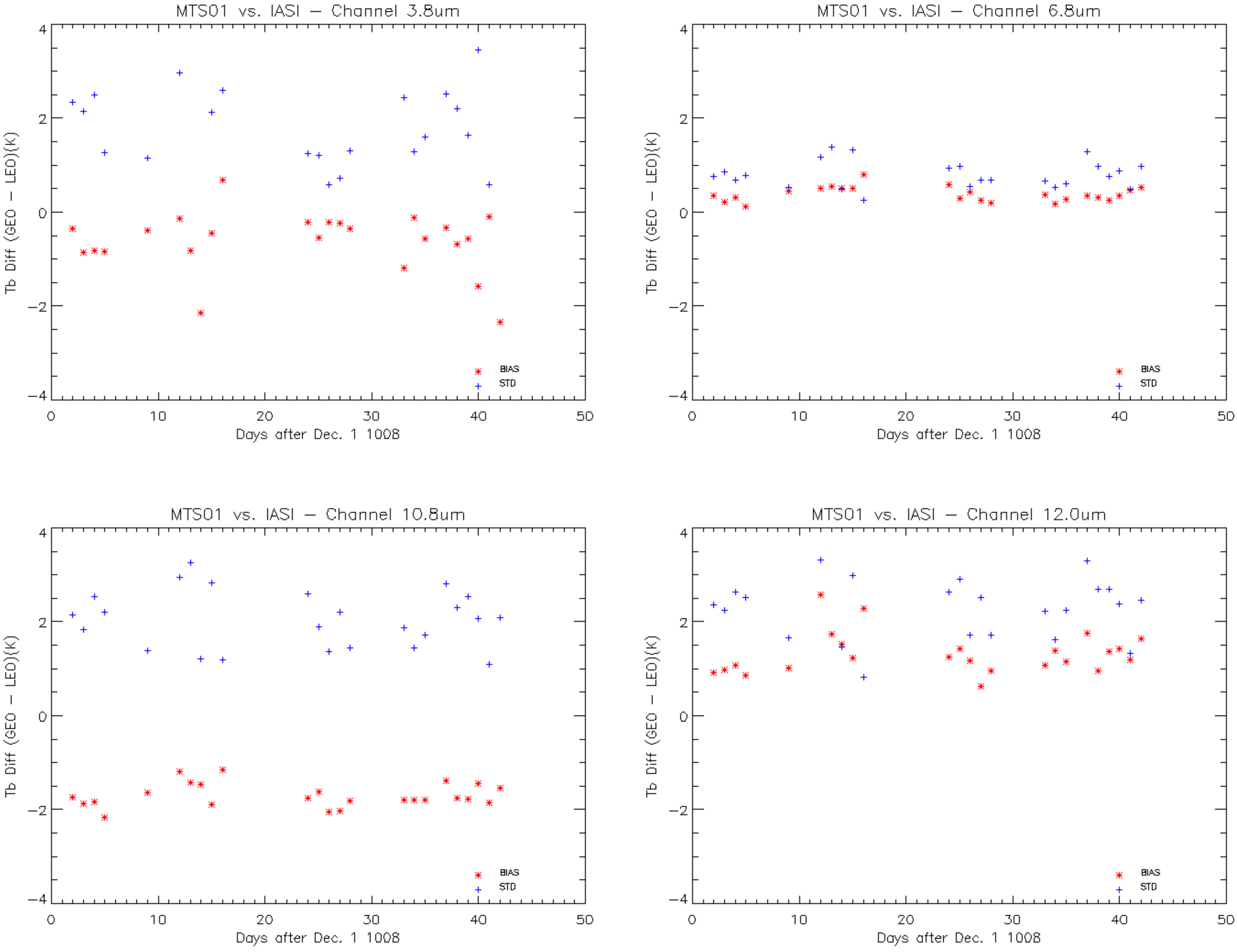


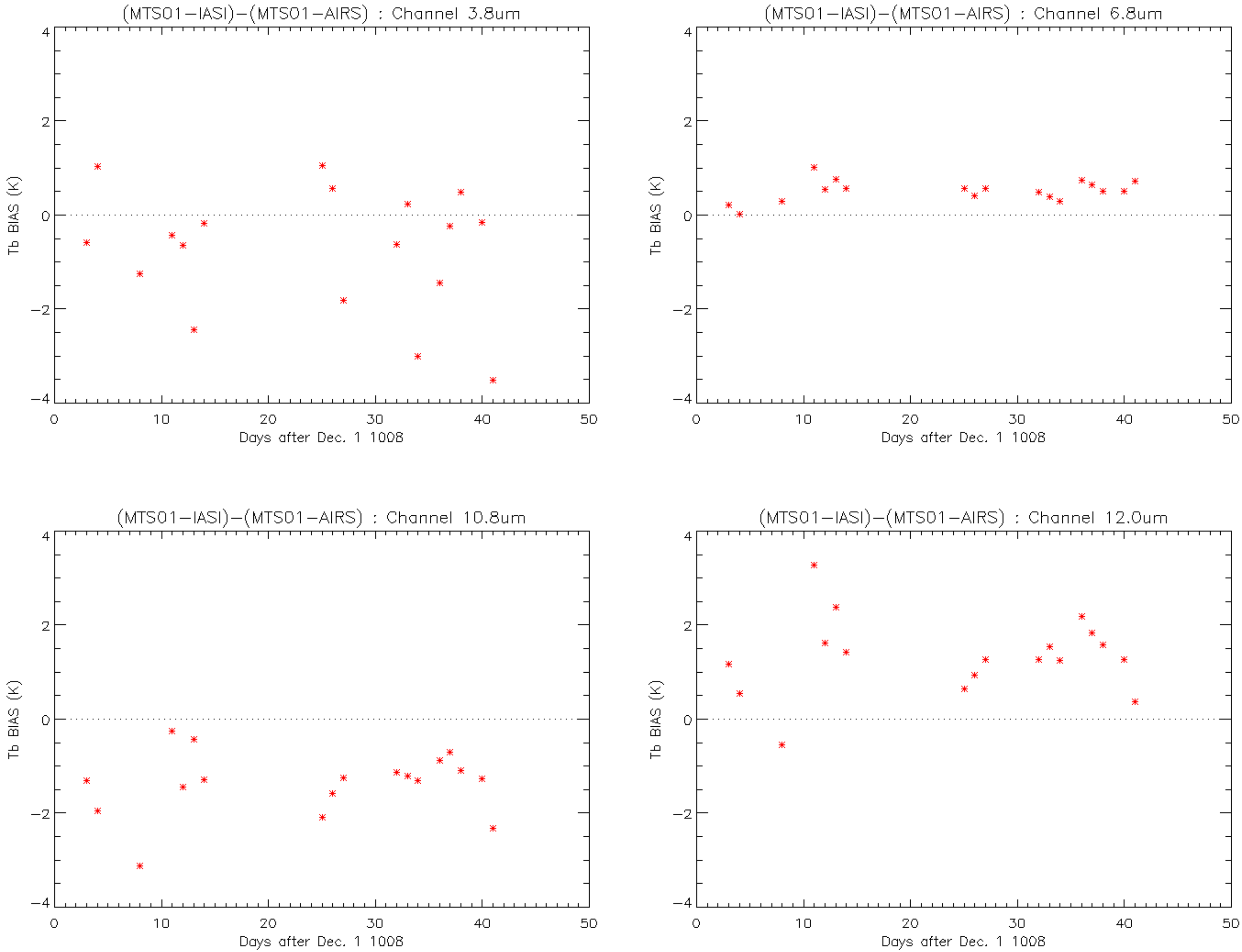
MTS01 vs. IASI
IR2 (12.0um)
IR1 (10.8um)
IR3 (6.8um)
IR4 (3.8um)
AIRS (Tb_AIRS+40)
Tb_IASI
Brightness Tb (K)
GEO SRF
Wavenumber (cm−1)
350
300
250
200
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000



MTS01 vs. AIRS – Channel 3.8um
MTS01 vs. AIRS – Channel 6.8um
MTS01 vs. AIRS – Channel 10.8um
MTS01 vs. AIRS – Channel 12.0um
Tb Diff (GEO – LEO)(K)
Days after Dec. 1 1008
Kato-Wu
BIAS
STD


MTS01 vs. AIRS – Channel 3.8um
Tb Diff (GEO – LEO)(K)
Days after Dec. 1 1008
JMA
BIAS
STD
MTS01 vs. AIRS – Channel 6.8um
Tb Diff (GEO – LEO)(K)
Days after Dec. 1 1008
BIAS
STD
MTS01 vs. AIRS – Channel 10.8um
Tb Diff (GEO – LEO)(K)
Days after Dec. 1 1008
BIAS
STD
MTS01 vs. AIRS – Channel 12.0um
Tb Diff (GEO – LEO)(K)
Days after Dec. 1 1008
BIAS
STD

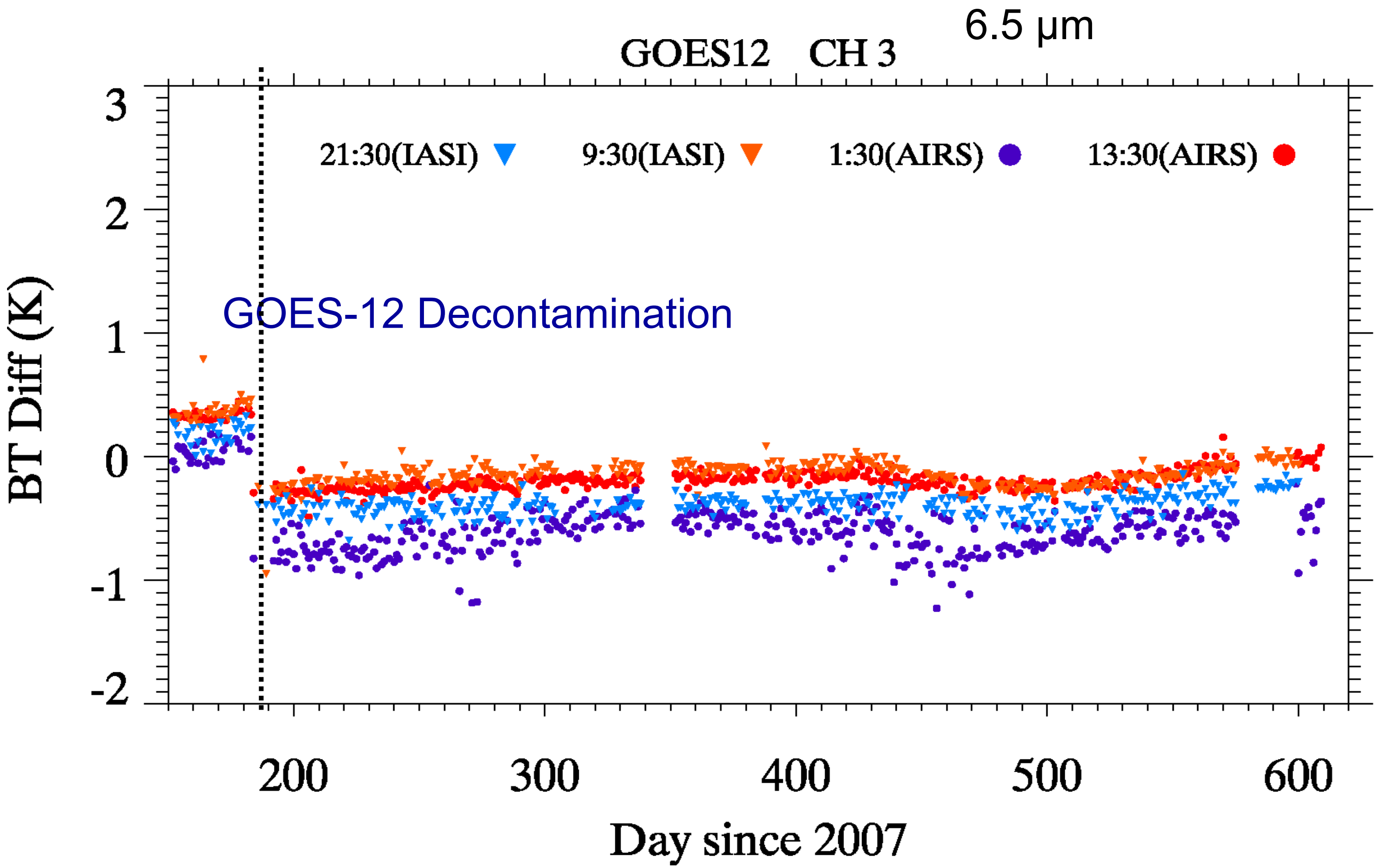

MTS01 vs. IASI – Channel 3.8um
MTS01 vs. IASI – Channel 6.8um
MTS01 vs. IASI – Channel 10.8um
MTS01 vs. IASI – Channel 12.0um
Tb Diff (GEO – LEO)(K)
Days after Dec. 1 1008
BIAS
STD

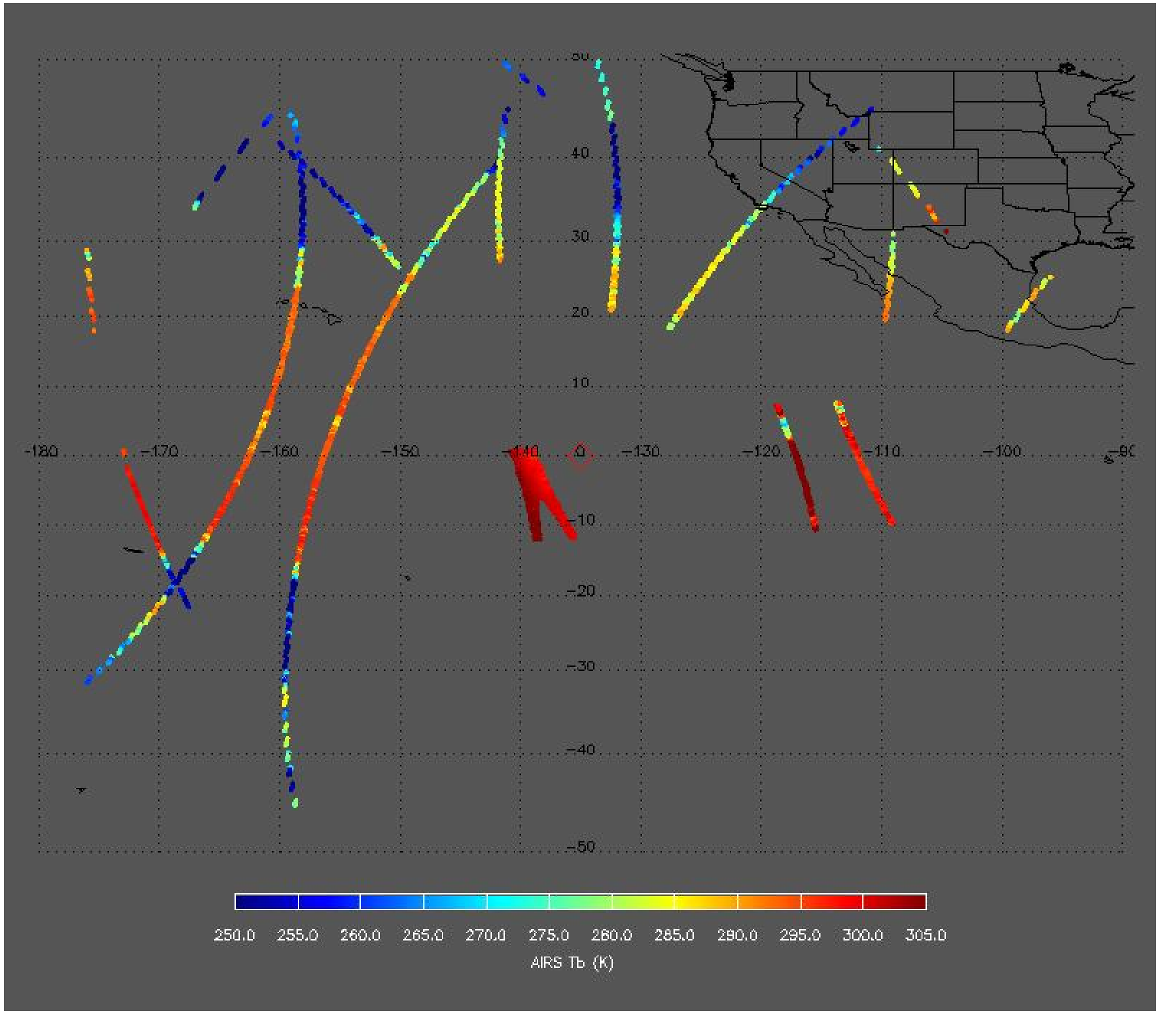

(MTS01−IASI)−(MTS01−AIRS) : Channel 3.8um
(MTS01−IASI)−(MTS01−AIRS) : Channel 6.8um
(MTS01−IASI)−(MTS01−AIRS) : Channel 10.8um
(MTS01−IASI)−(MTS01−AIRS) : Channel 12.0um
Tb BIAS (K)
Days after Dec. 1 1008
4
2
0
−2
−4
0
10
20
30
40
50

Anomaly Diagnosis

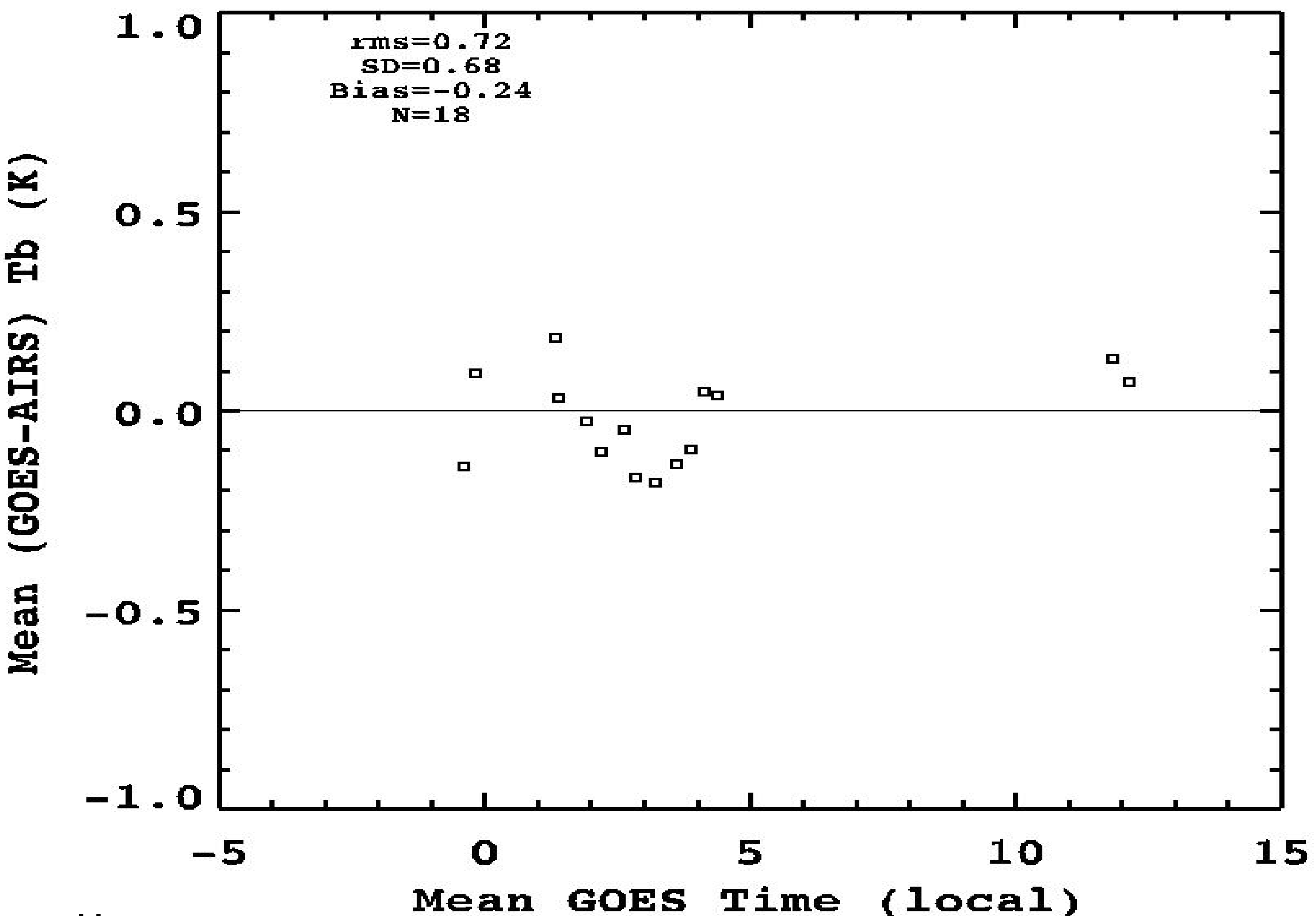
- GOES-11 patch change
- GOES-12/13 SRF error, pre-launch and post-launch
- GOES and MTSAT midnight blackbody calibration anomaly

Diurnal Variation of Bias




250.0 255.0 260.0 265.0 270.0 275.0 280.0 285.0 290.0 295.0 300.0 305.0
AIRS Tb (K)

GOES-11-AIRS February 23-29, 2008. Channel 3.9 microns



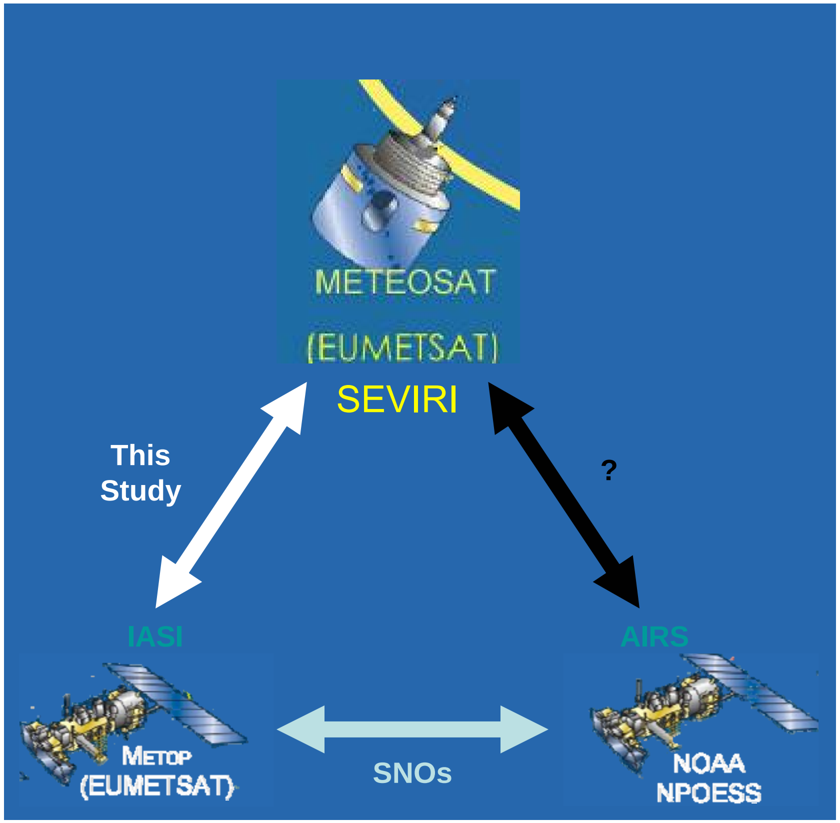
Constraints used here:

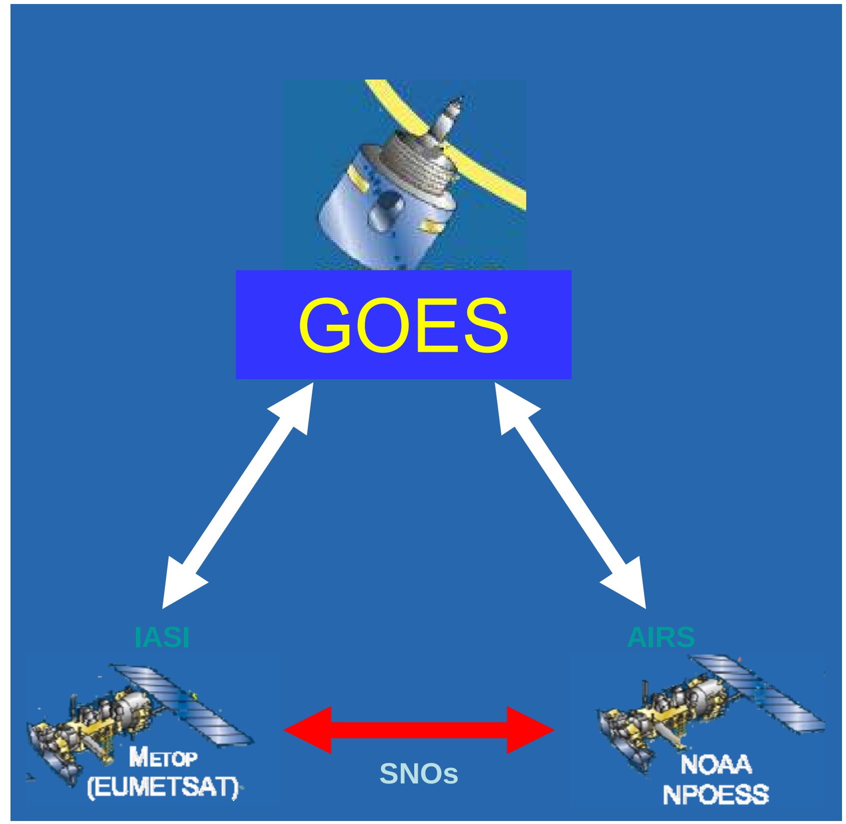
GEO-LEO Azi. Within 25 degrees of each other, this constrain during day time only

Relative path difference <= 0.01. In addition during day time zenith angle difference restricted to 0.3 deg.

Env stdv/Env mean <= 0.01

FOV stdv/FOV mean <= 0.01

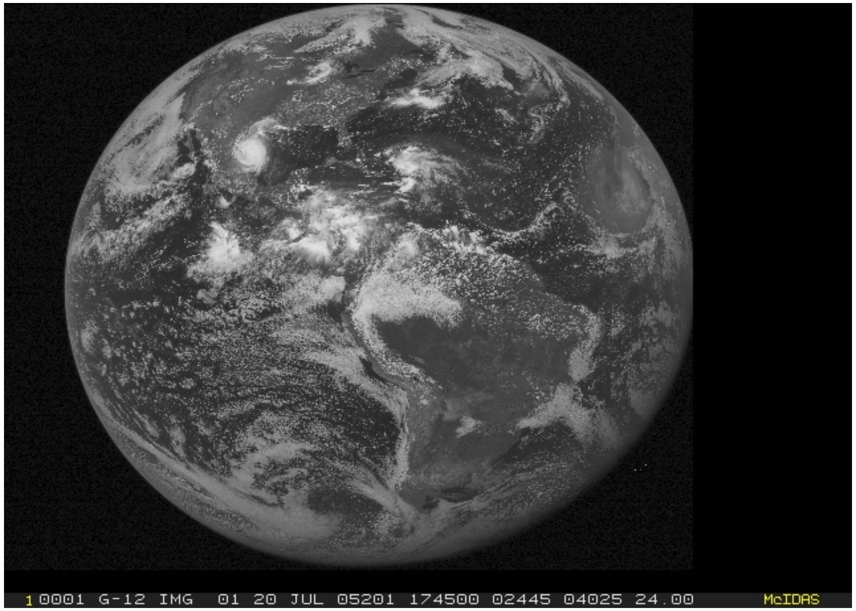

METEOSAT
(EUMETSAT)
SEVIRI
This Study
?
IASI
AIRS
METOP
(EUMETSAT)
SNOs
NOAA
NPOESS

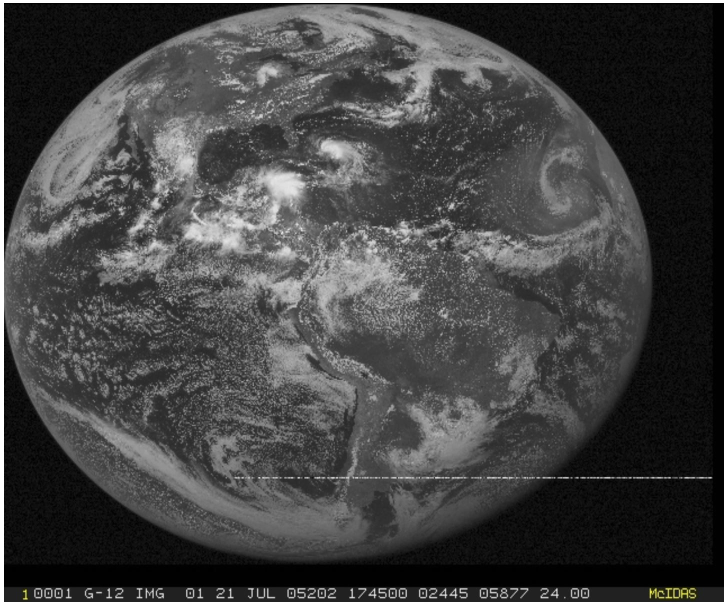

GOES
IASI
AIRS
METOP
(EUMETSAT)
SNOs
NOAA
NPOESS

Visible Calibration

- Many methods
- Emphasize DCC

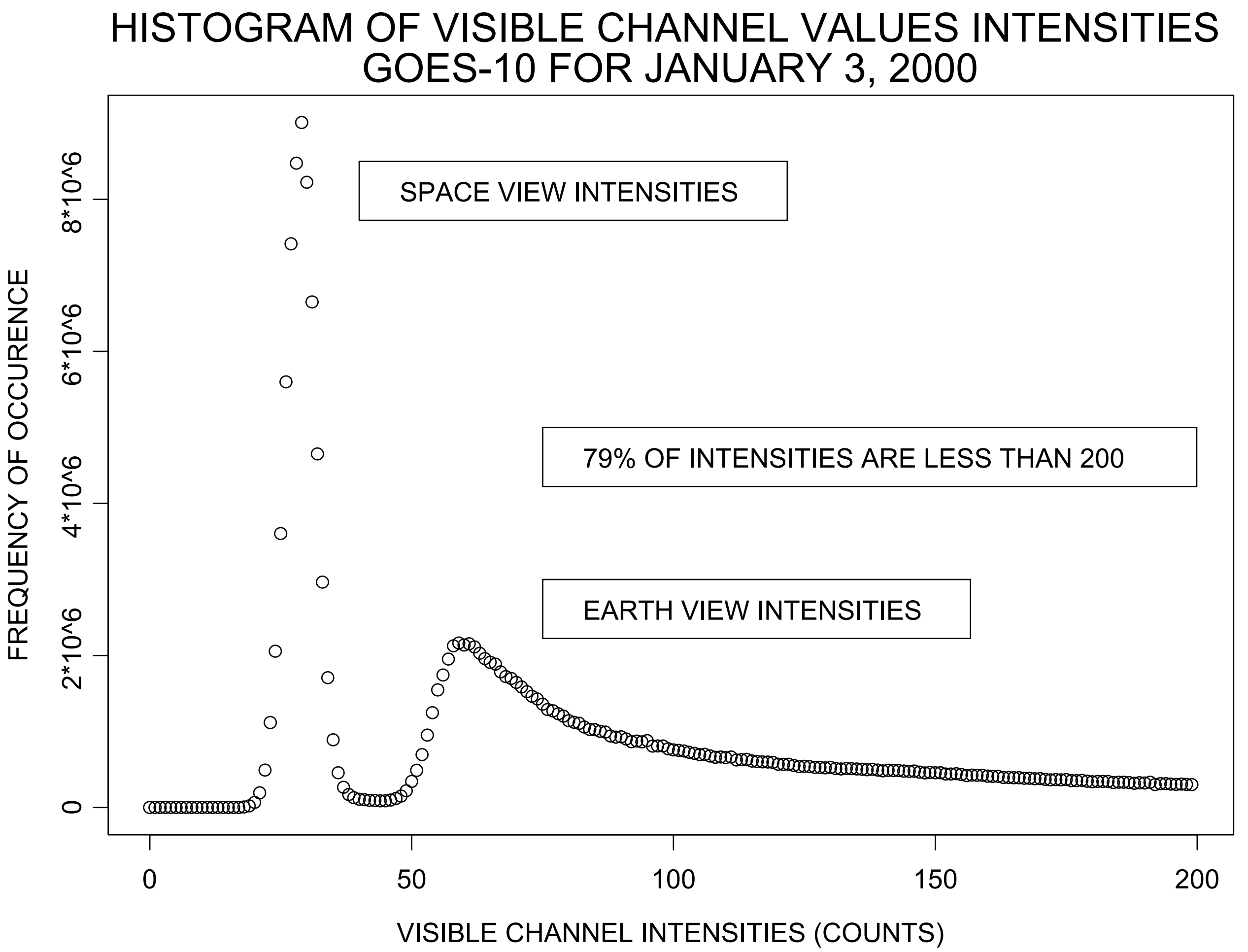
EDF



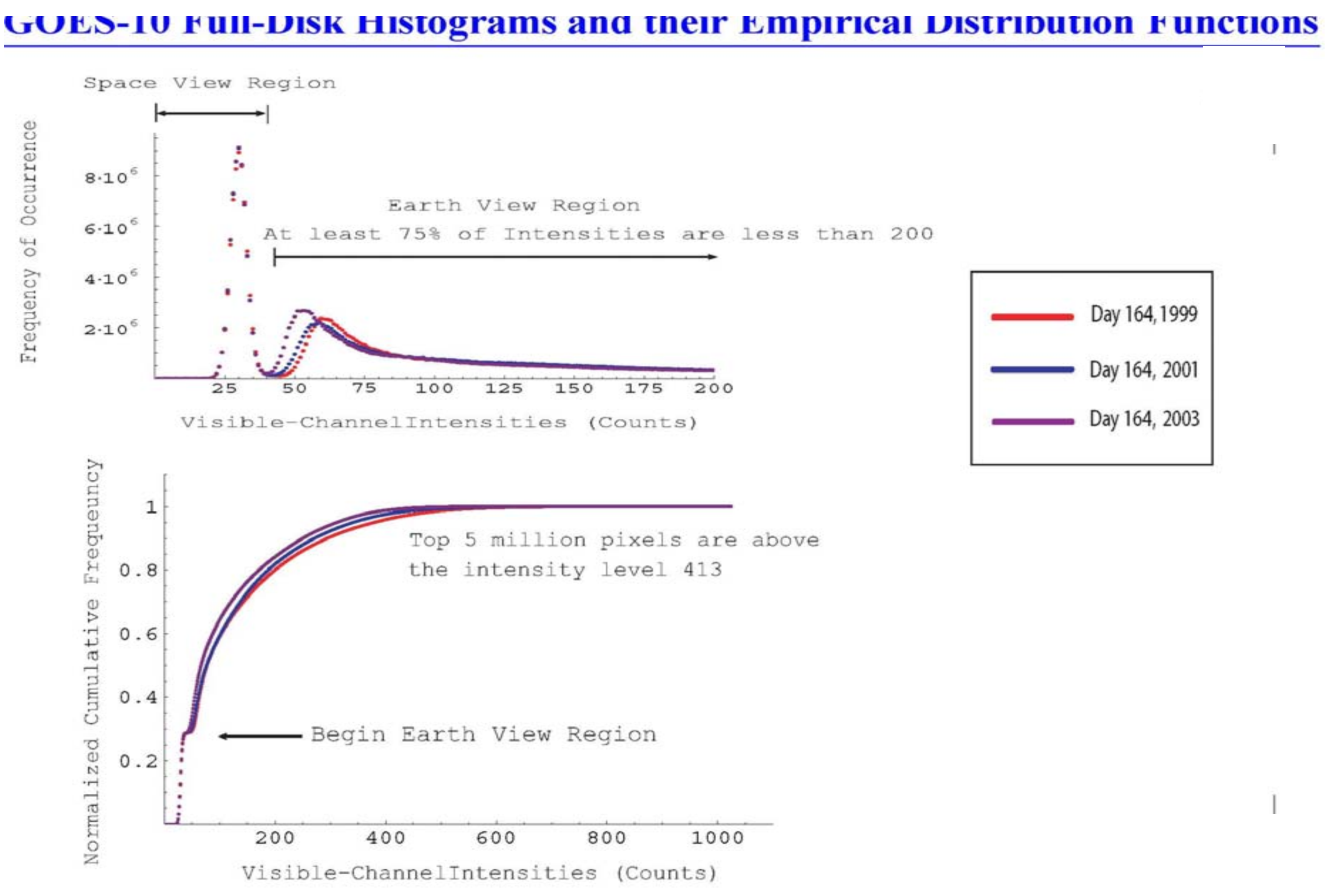


Statistical distribution of brightness is stable over time

EDF

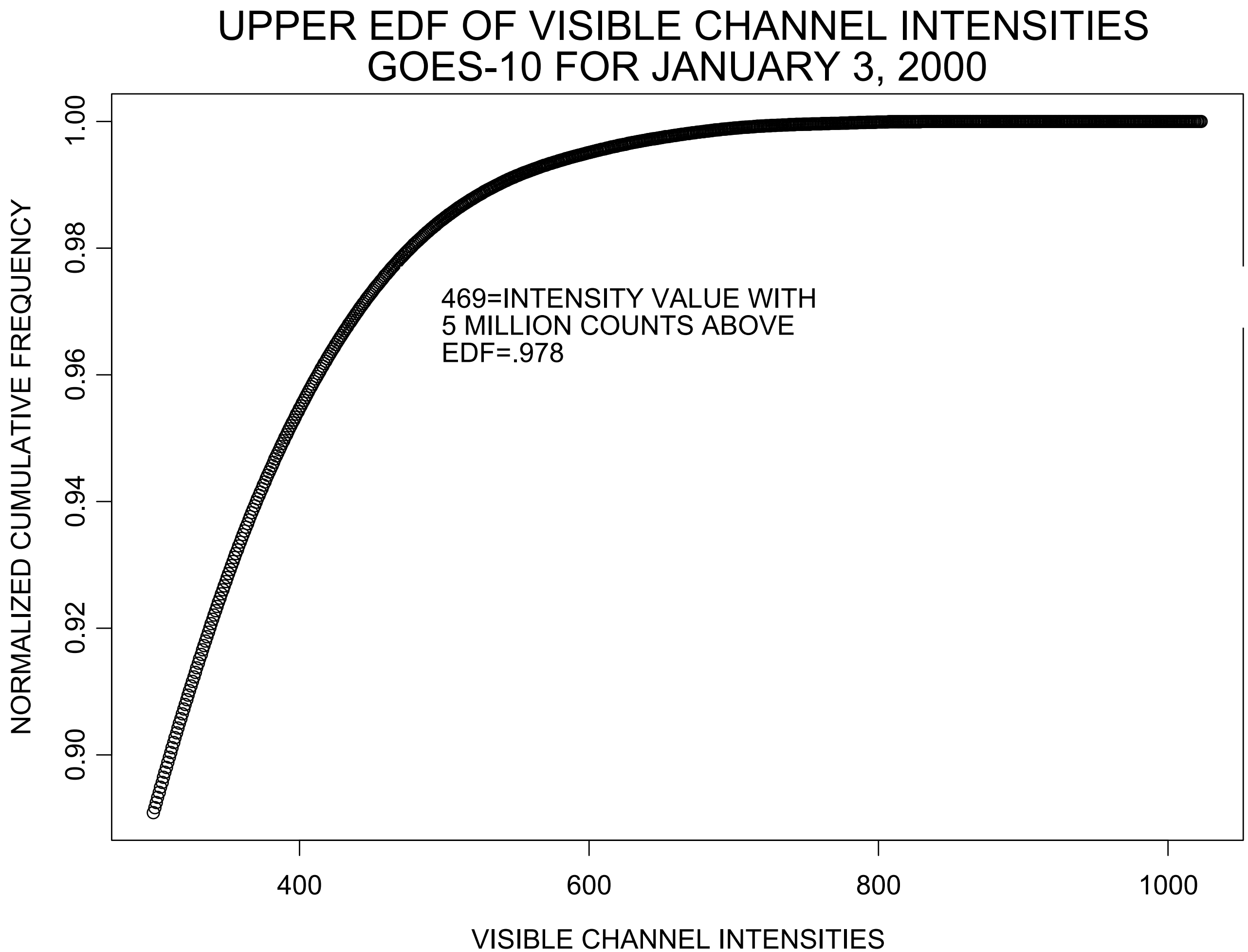

HISTOGRAM OF VISIBLE CHANNEL VALUES INTENSITIES
GOES-10 FOR JANUARY 3, 2000
SPACE VIEW INTENSITIES
79% OF INTENSITIES ARE LESS THAN 200
EARTH VIEW INTENSITIES
FREQUENCY OF OCCURENCE
0
2*10^6
4*10^6
6*10^6
8*10^6
0
50
100
150
200
VISIBLE CHANNEL INTENSITIES (COUNTS)

EDF



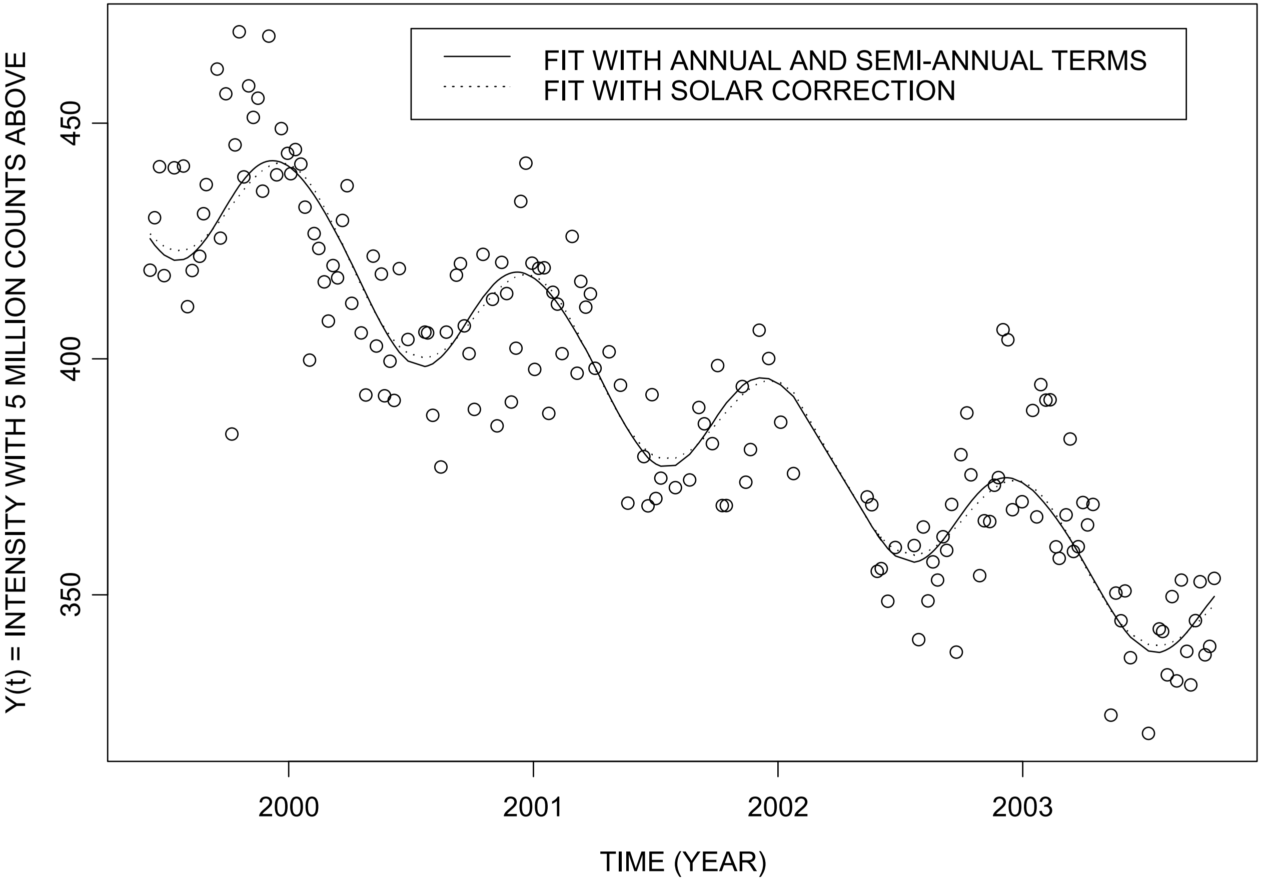
GOES-10 Full-Disk Histograms and their Empirical Distribution Functions
Space View Region
Frequency of Occurrence
8·10^6
6·10^6
4·10^6
2·10^6
Earth View Region
At least 75% of Intensities are less than 200
25
50
75
100
125
150
175
200
Visible-ChannelIntensities (Counts)
Day 164, 1999
Day 164, 2001
Day 164, 2003
Normalized Cumulative Frequeuncy
1
0.8
0.6
0.4
0.2
Top 5 million pixels are above
the intensity level 413
Begin Earth View Region
200
400
600
800
1000
Visible-ChannelIntensities (Counts)

EDF


UPPER EDF OF VISIBLE CHANNEL INTENSITIES
GOES-10 FOR JANUARY 3, 2000
NORMALIZED CUMULATIVE FREQUENCY
0.90
0.92
0.94
0.96
0.98
1.00
469=INTENSITY VALUE WITH
5 MILLION COUNTS ABOVE
EDF=.978
400
600
800
1000
VISIBLE CHANNEL INTENSITIES

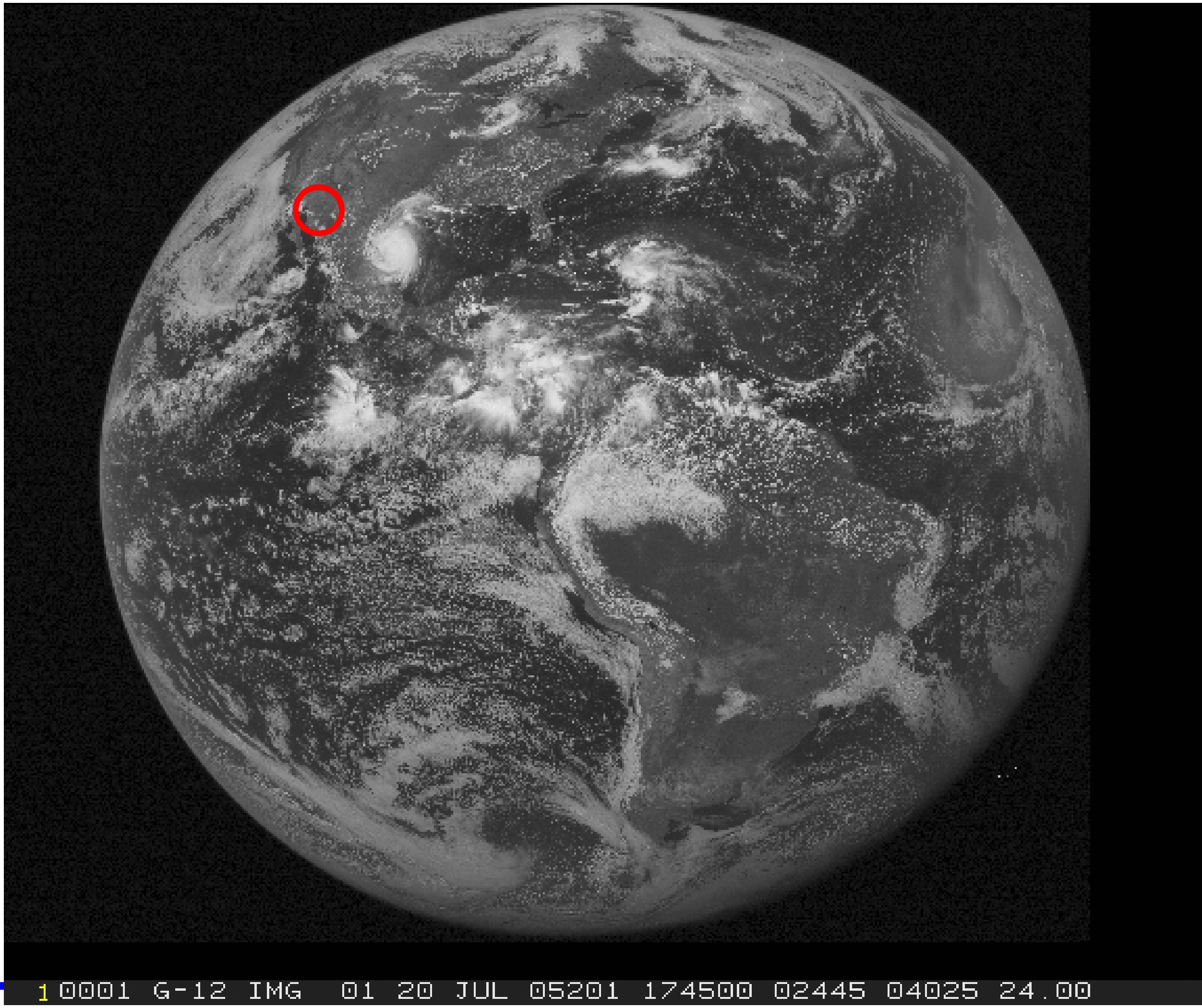
EDF

PLOT OF INTENSITIES WITH 5 MILLION COUNTS ABOVE
FOR GOES-10

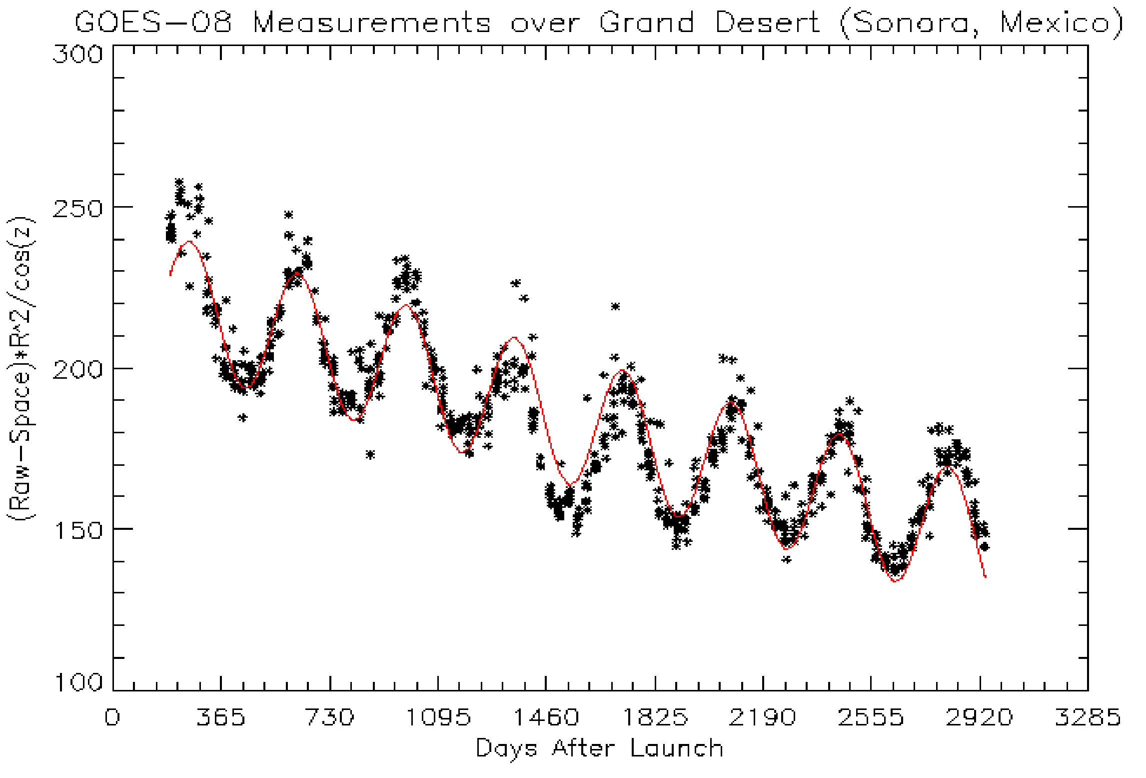


Desert

- Desert reflectance is stable
- No good target with favorable viewing geometry
- Useful for redundancy

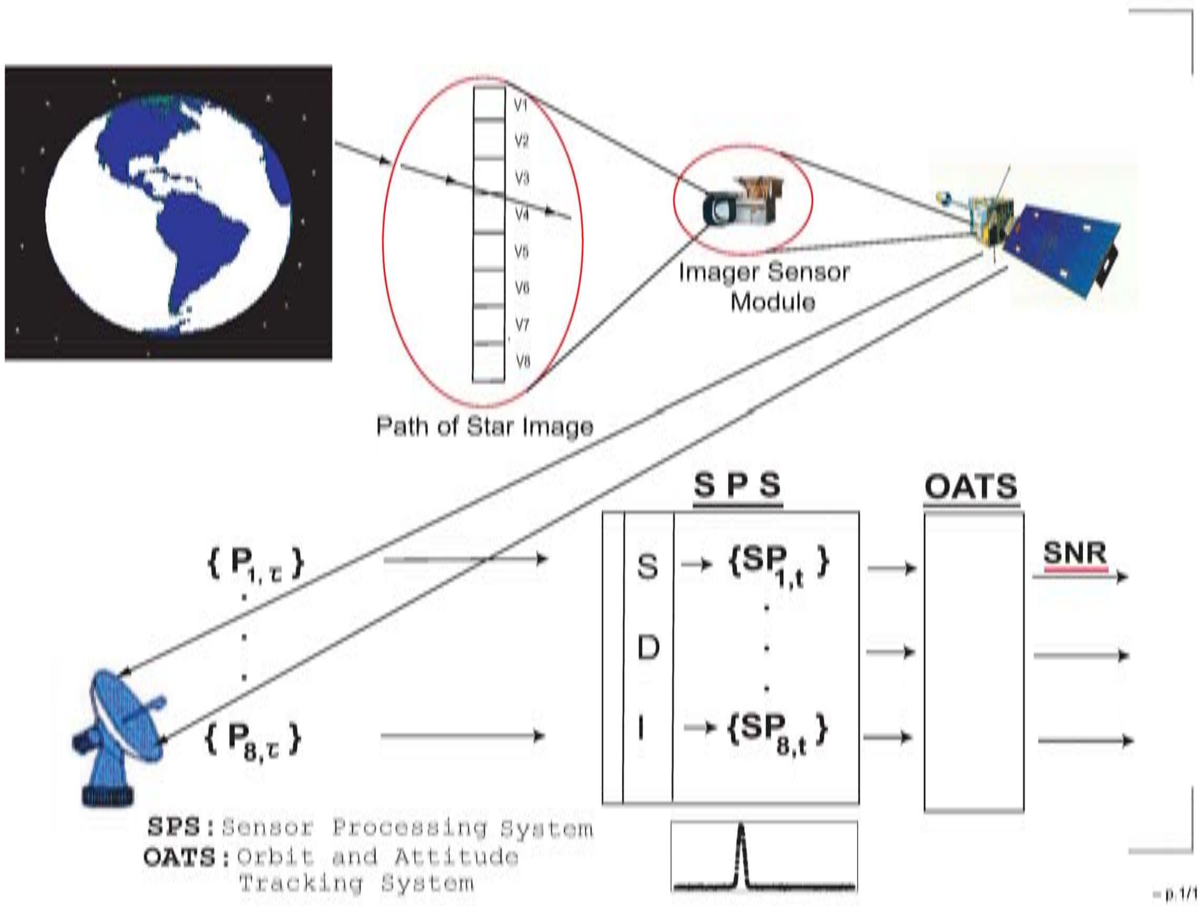


Desert

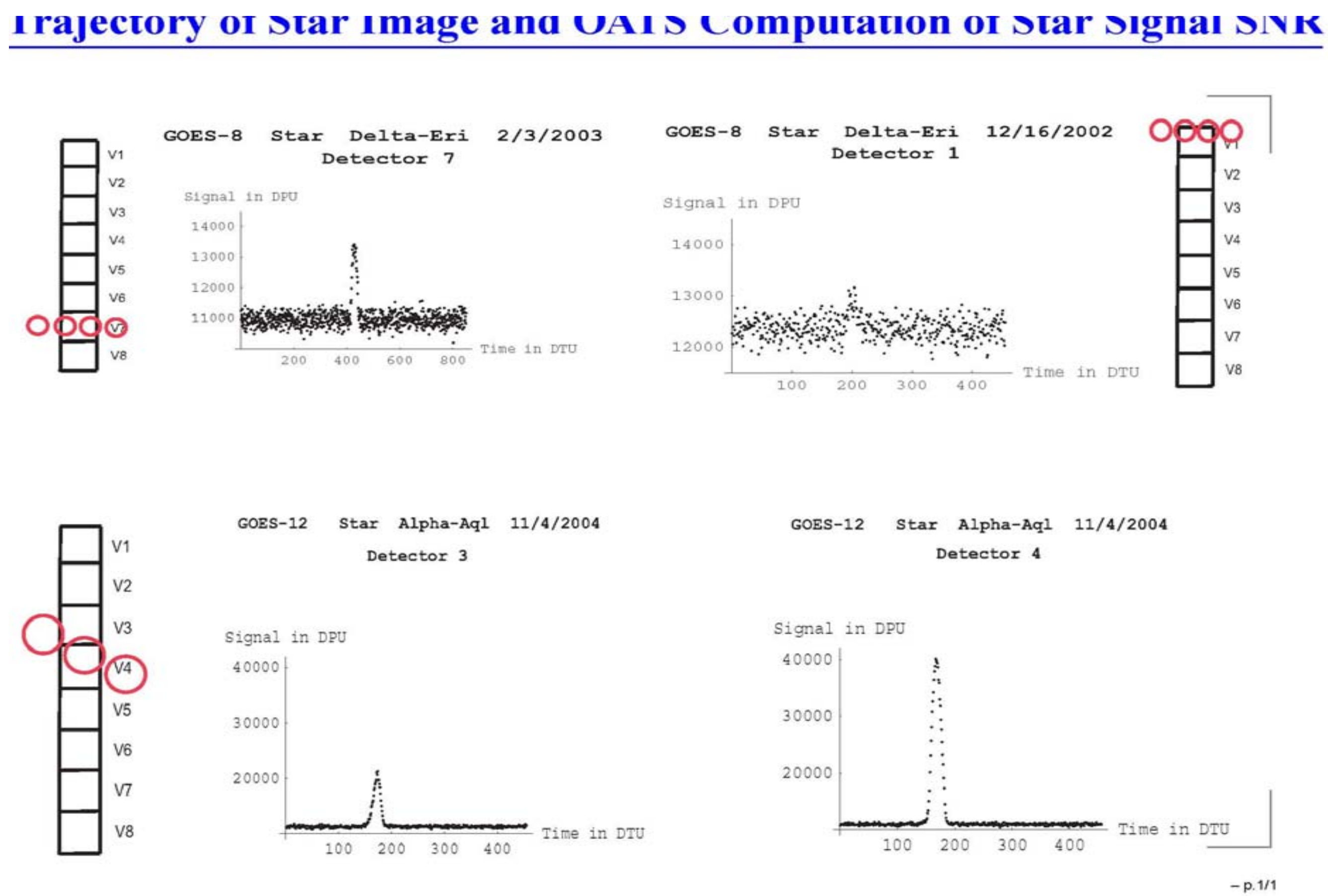

GOES-08 Measurements over Grand Desert (Sonora, Mexico)
(Raw-Space)*R^2/cos(z)
Days After Launch
300
250
200
150
100
0
365
730
1095
1460
1825
2190
2555
2920
3285

Star

Radiation from stars is stable

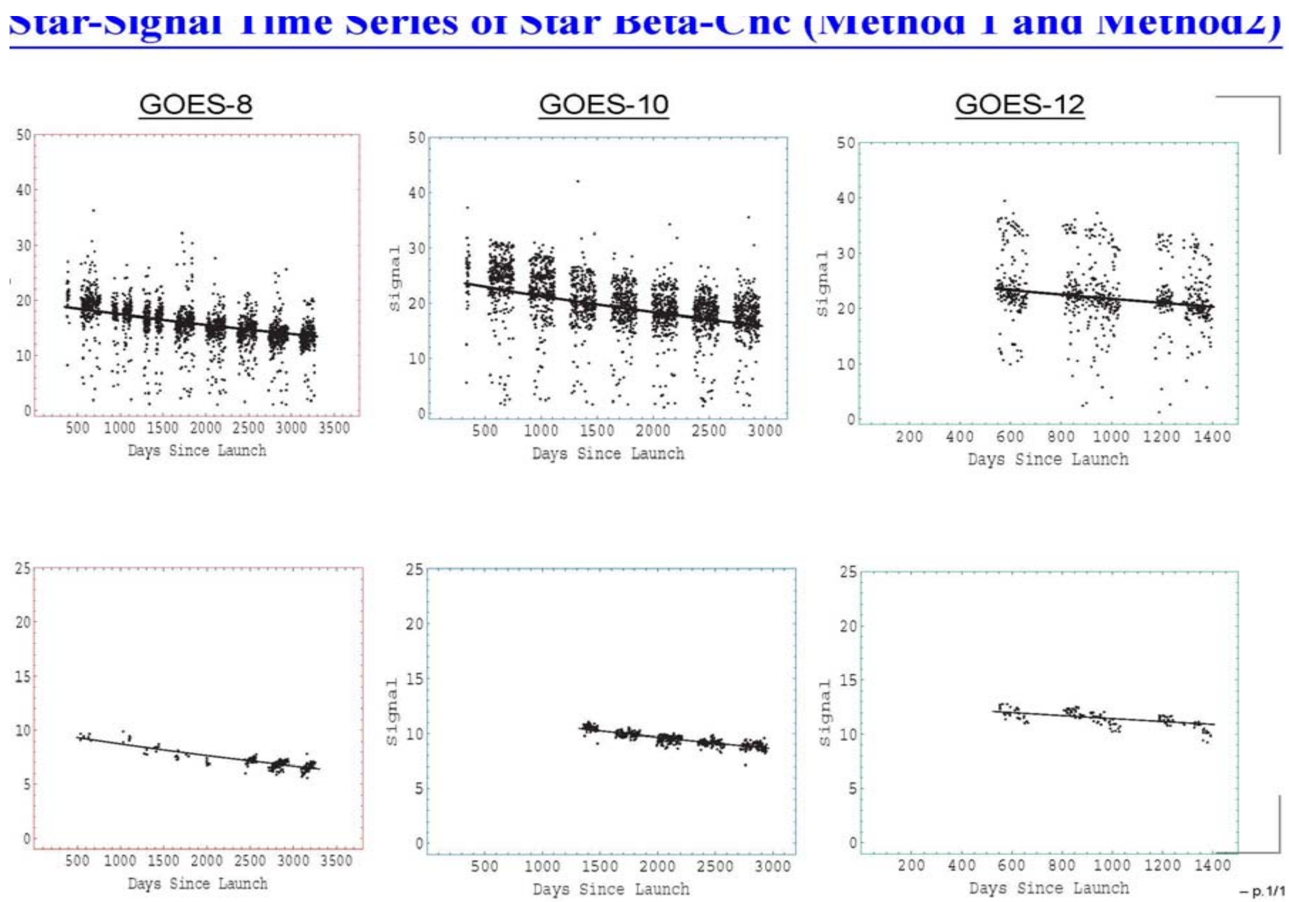


Star



Trajectory of Star Image and OATS Computation of Star Signal SNR
GOES-8 Star Delta-Eri 2/3/2003
Detector 7
Signal in DPU
14000
13000
12000
11000
200 400 600 800
Time in DTU
V1
V2
V3
V4
V5
V6
V7
V8
GOES-8 Star Delta-Eri 12/16/2002
Detector 1
Signal in DPU
14000
13000
12000
100 200 300 400
Time in DTU
V1
V2
V3
V4
V5
V6
V7
V8
GOES-12 Star Alpha-Aql 11/4/2004
Detector 3
Signal in DPU
40000
30000
20000
100 200 300 400
Time in DTU
V1
V2
V3
V4
V5
V6
V7
V8
GOES-12 Star Alpha-Aql 11/4/2004
Detector 4
Signal in DPU
40000
30000
20000
100 200 300 400
Time in DTU
– p.1/1

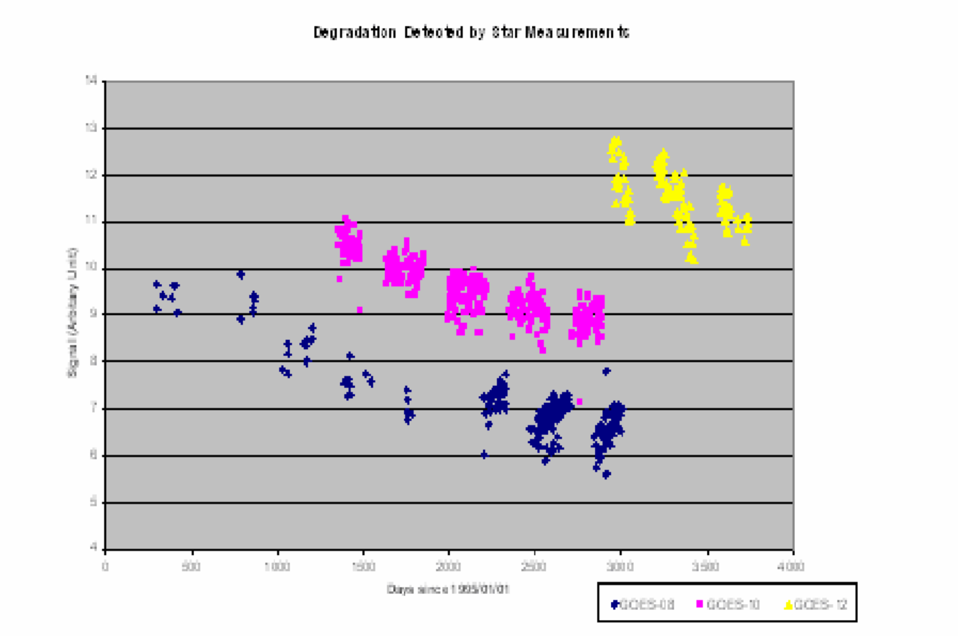
Star

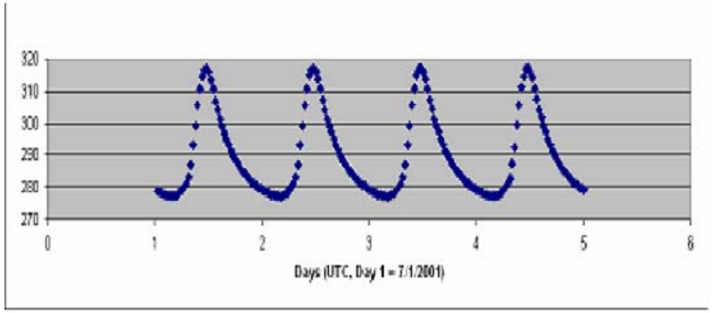

Star-Signal Time Series of Star Beta-Cnc (Method 1 and Method2)
GOES-8
GOES-10
GOES-12
Signal
Days Since Launch
– p.1/1

Star

Difficulties:

- **Interruption of observations**
- **Intra-annual variation in addition to inter-annual degradation**



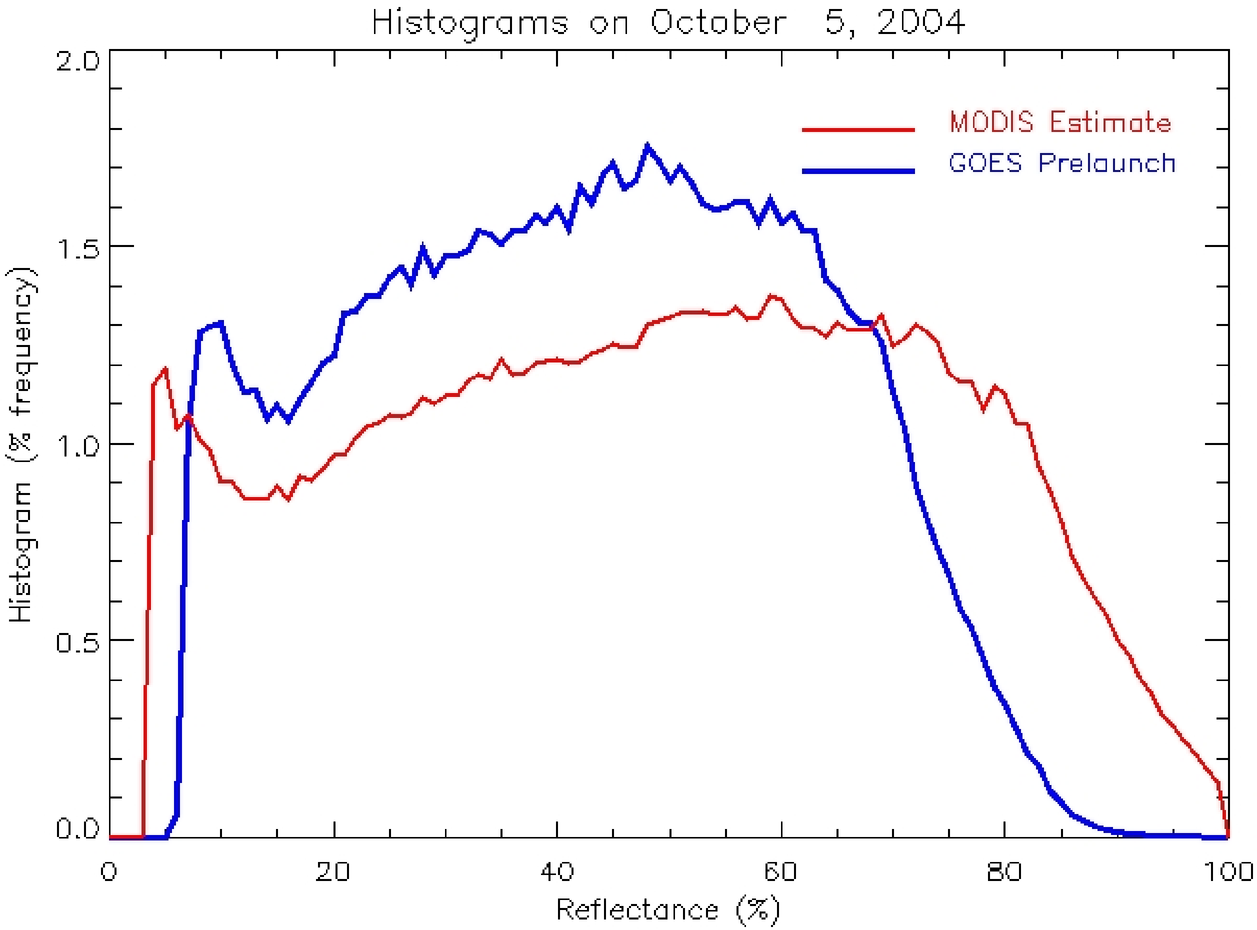


MODIS

- **MODIS is perfectly calibrated**
- **Match data are available that are:**

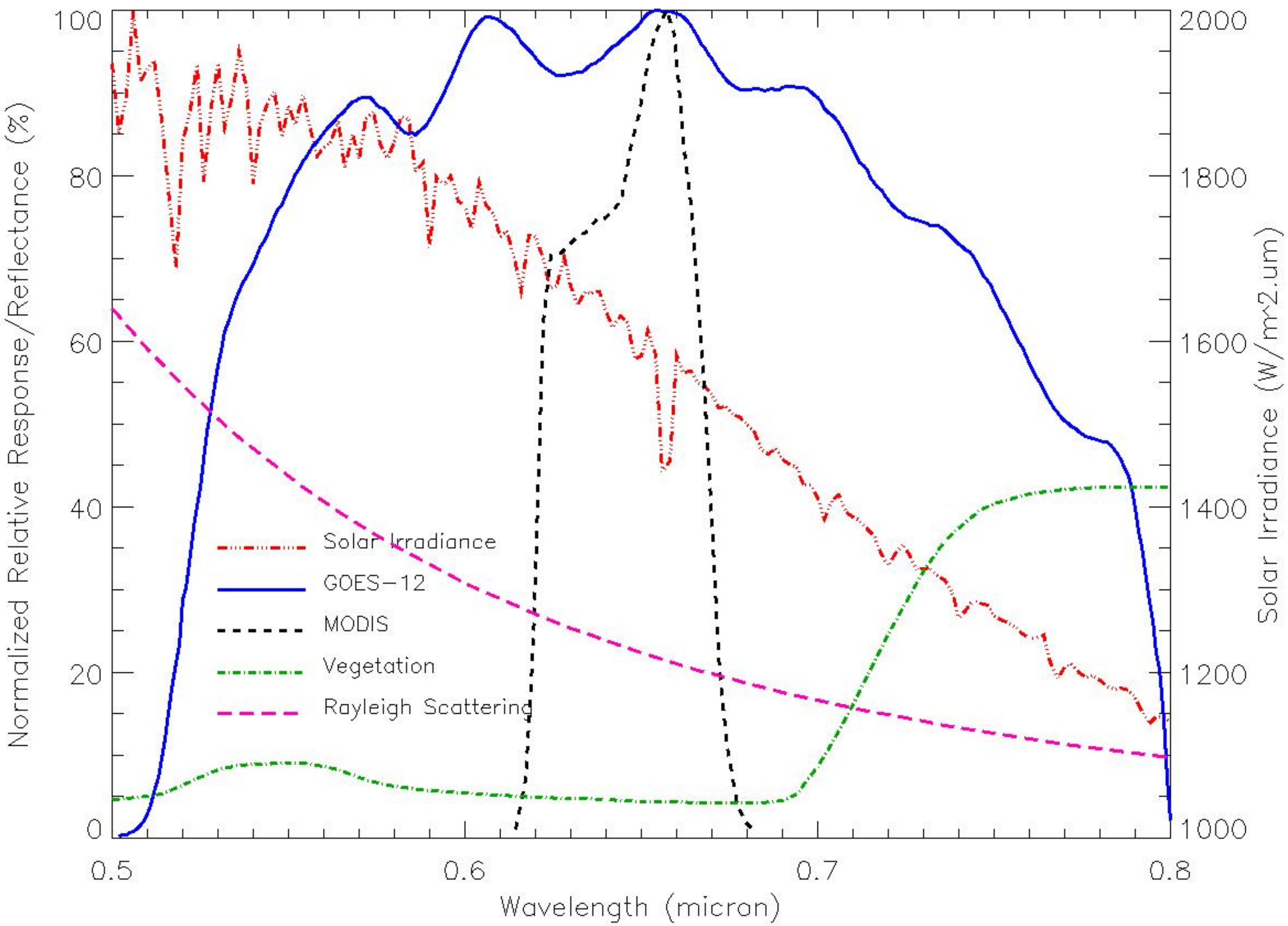
Co-located in space	Operational Navigation
Concurrent in time	Within 10 minutes
Identical spatial and spectral coverage	MODIS Ch. 1 @ 1KM
Identical view geometry	Within ~8° from nadir

MODIS

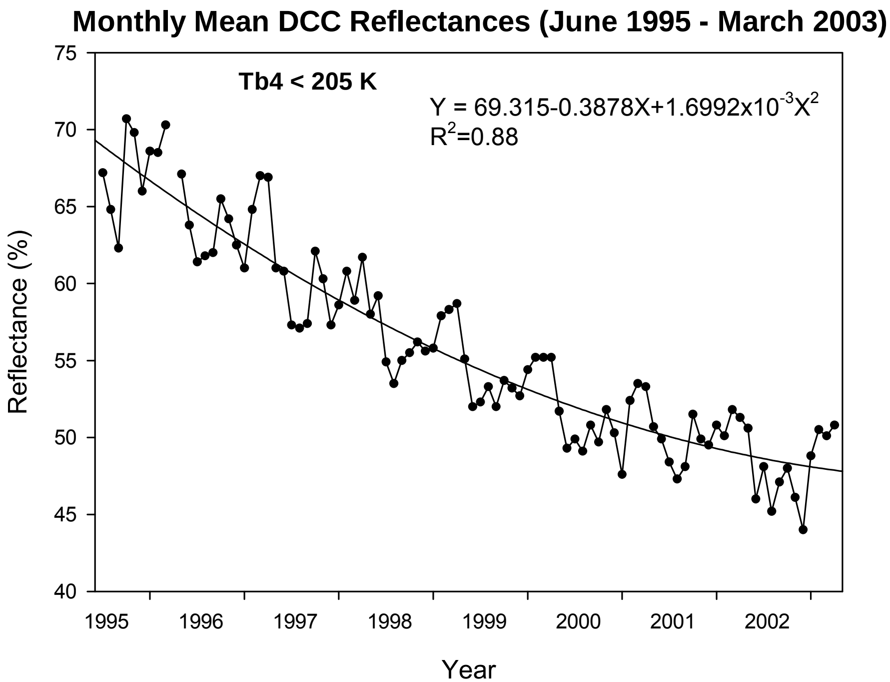


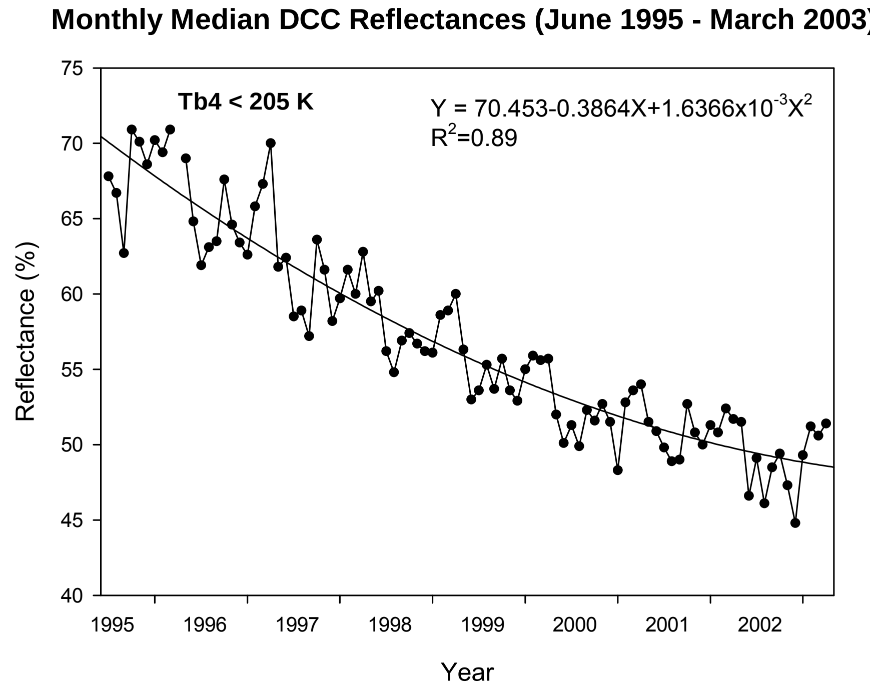
Histograms on October 5, 2004
MODIS Estimate
GOES Prelaunch
Histogram (% frequency)
Reflectance (%)
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100

MODIS



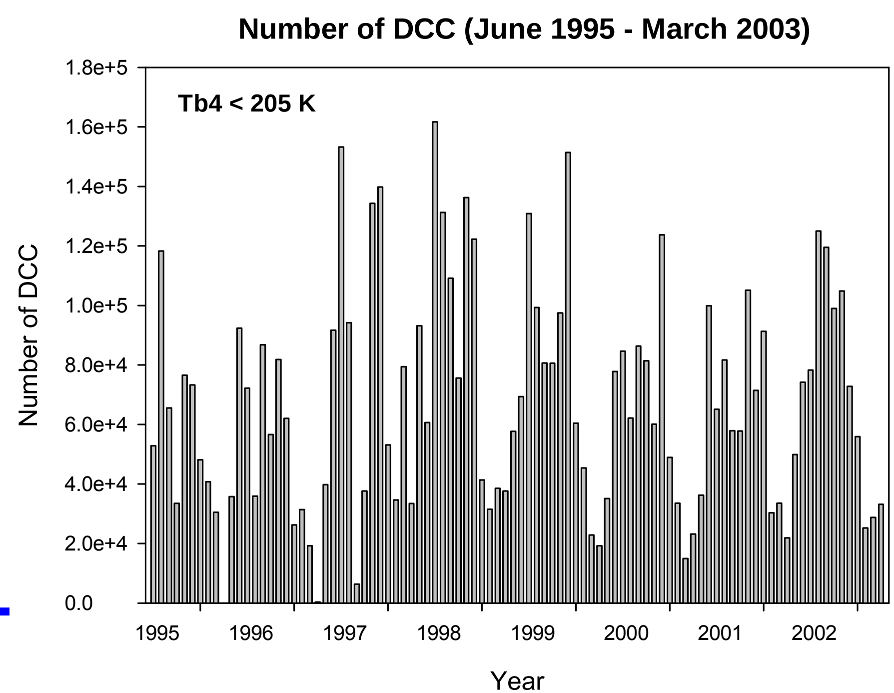
Normalized Relative Response/Reflectance (%)
Solar Irradiance (W/m^2.um)
Wavelength (micron)
Solar Irradiance
GOES−12
MODIS
Vegetation
Rayleigh Scattering
0
20
40
60
80
100
1000
1200
1400
1600
1800
2000
0.5
0.6
0.7
0.8

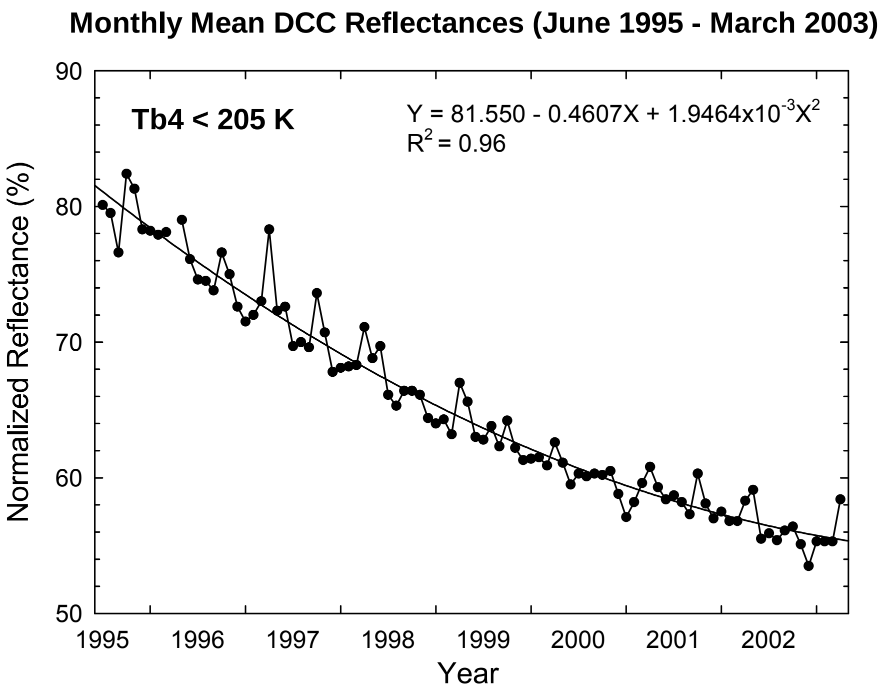


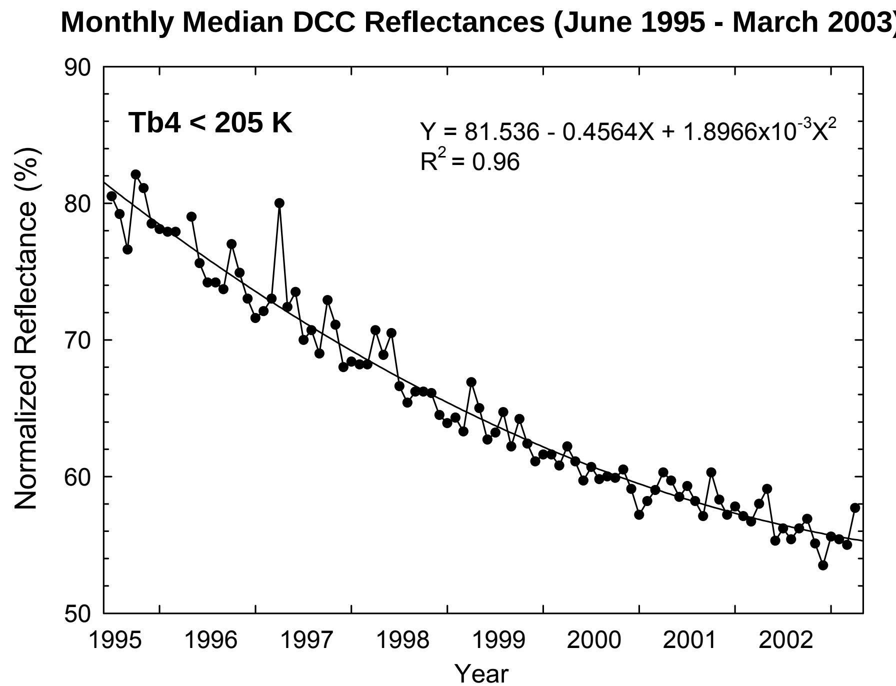


- Tb4 < 205 K
- STD(Tb4) < 1 K
- STD(VIS) < 2%

No ADM

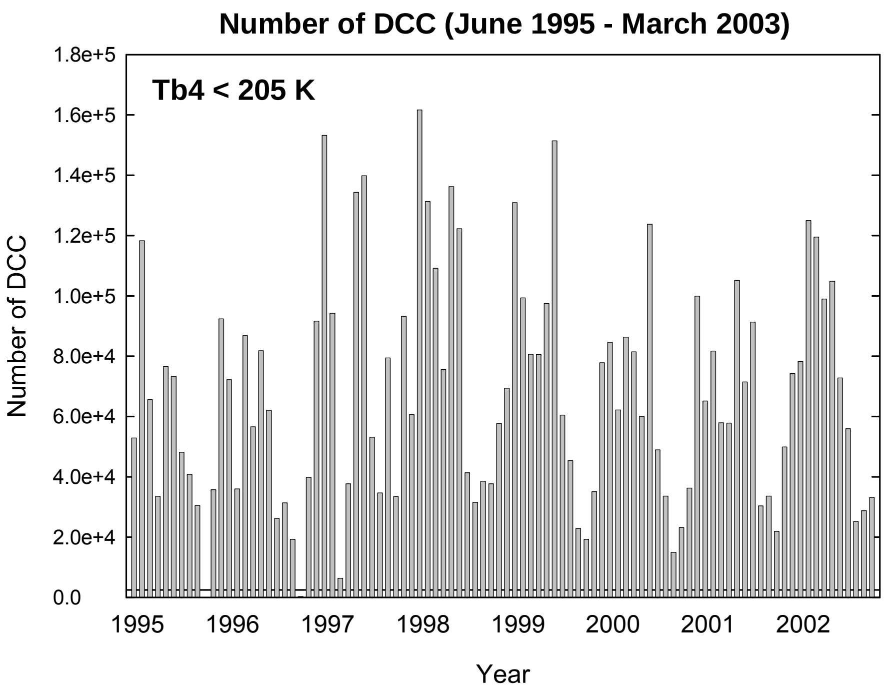






- Tb4 < 205 K
- STD(Tb4) < 1 K
- STD(VIS) < 2%

ADM



Summary

- Algorithm – stable
- Operation – started
- Performance Monitoring – GSICS is a
- Anomaly Diagnosis – good tool
- Visible Calibration