The effect of C0=0 for VIIRS SDR RSB Calibration

VIIRS/SDR Team

2 April 2014

Executive Summary (1)

As of March 31, 2014:

Based on comparisons of before and after setting C0=0 (with C2 refit), the VIIRS SDR team found the following using a sample MOBY ocean scene [Appendix A]:

1. For ocean color bands (M1-M7), the effect of setting C0=0 is relatively small (well within 1% difference)
2. For M8-M11, and I1-I3 at Ltyp, the difference is also well within 1%, although larger percent differences are observed at extremely low radiances

Executive Summary (2)

Comparisons between I2/M7:

1. NOAA/STAR performed an independent analysis of I2/M7 before and after C0=0, which was presented at the VIIRS SDR Maturity Review [December, 2013 – Appendix B]
2. The Aerospace presented similar results for I2/M7 consistency at the VIIRS SDR Team Telecons last year; also summarized at the VIIRS SDR Maturity Review [December, 2013 – Appendix C]
3. NASA VCST supported an early analysis of I2/M7
4. Preliminary results of VIIRS & MODIS comparisons before and after C0=0 [Appendix D]. However, note that MODIS has higher polarization sensitivity than VIIRS.

Executive Summary (3)

Comparisons between I3/M10:

1. NOAA/STAR performed a preliminary study of I3/M10, however, note I3/M10 have different spectral response functions [Appendix E]
2. Both The Aerospace and NASA VCST also performed preliminary studies

Experiments with RSBAutoCal to Compare Radiometric Calibration with Different Values of the c Coefficients (Including c0 = 0)

APPENDIX A

Experiments with RSBAutoCal to Compare Radiometric Calibration with Different Values of the c Coefficients (Including $c_0 = 0$)

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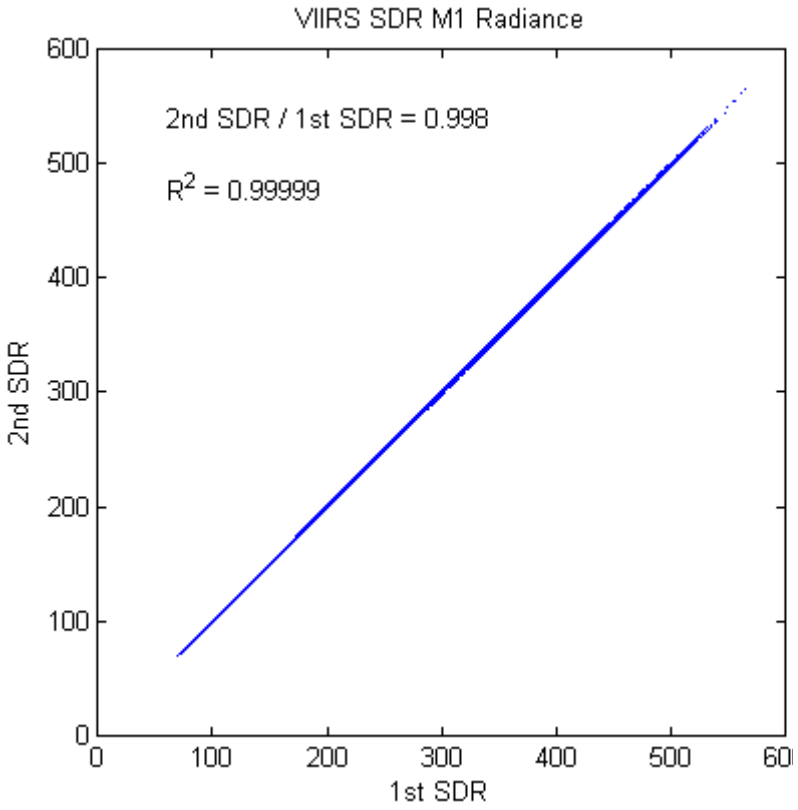
[1]*CICS/ESSIC, University of Maryland, College Park*

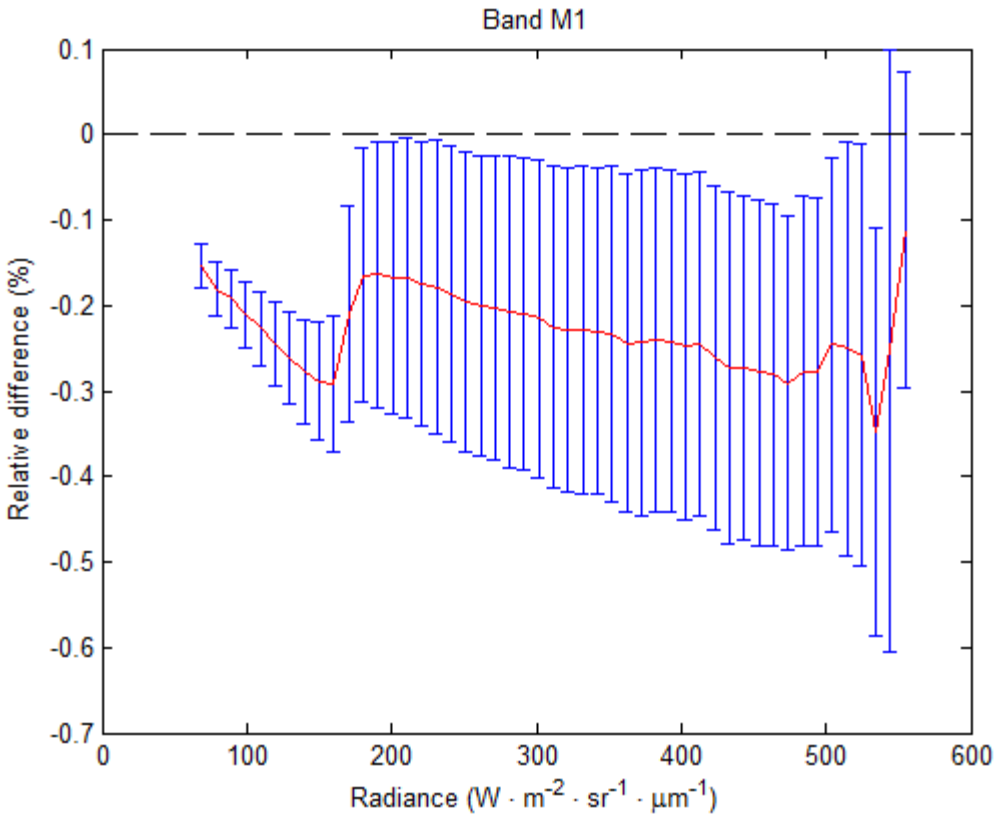
[2]*NOAA NESDIS STAR*

Using RSBAutoCal for LUT Comparison

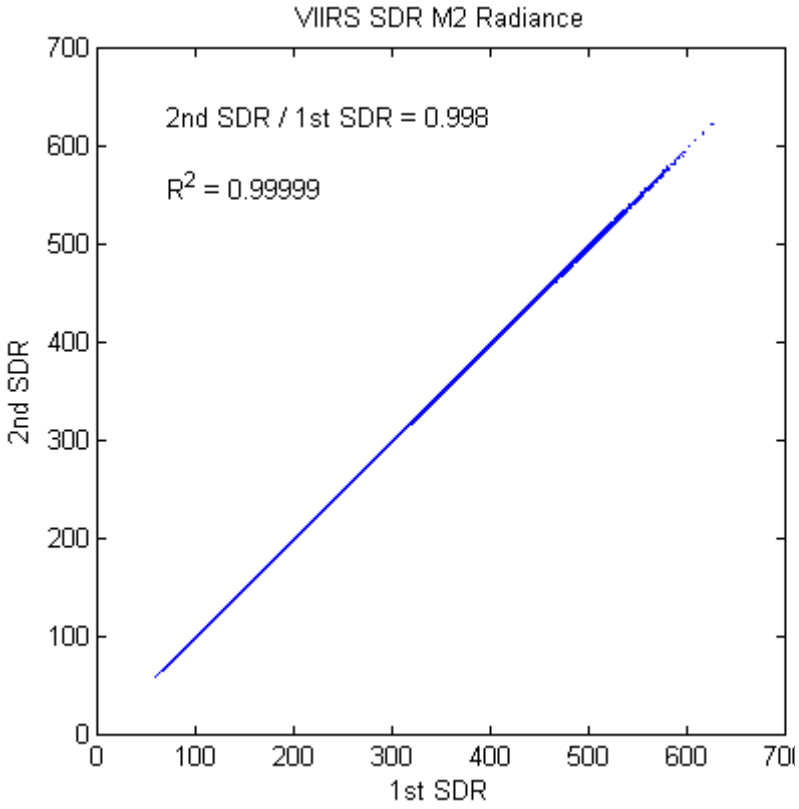
- Used RSBAutoCal code from Aerospace installed in the then-current version of ADL with the nominal RHW filter parameters: smoothing applied
- Processed OBC IP files from the time period between July and December 2013
  - only RSB calibration (no DNB)
- Calculated F factors for two cases:
  - current c_0 and c_2 values
  - $c_0 = 0$ and c_2 from a refit of the pre-launch test data by Aerospace
- Produced SDR for an ocean scene granule around Hawaii (2013-08-30 23-57 UTC) using the appropriate VIIRS-RSBAUTOCAL-HISTORY-AUX files generated by ADL

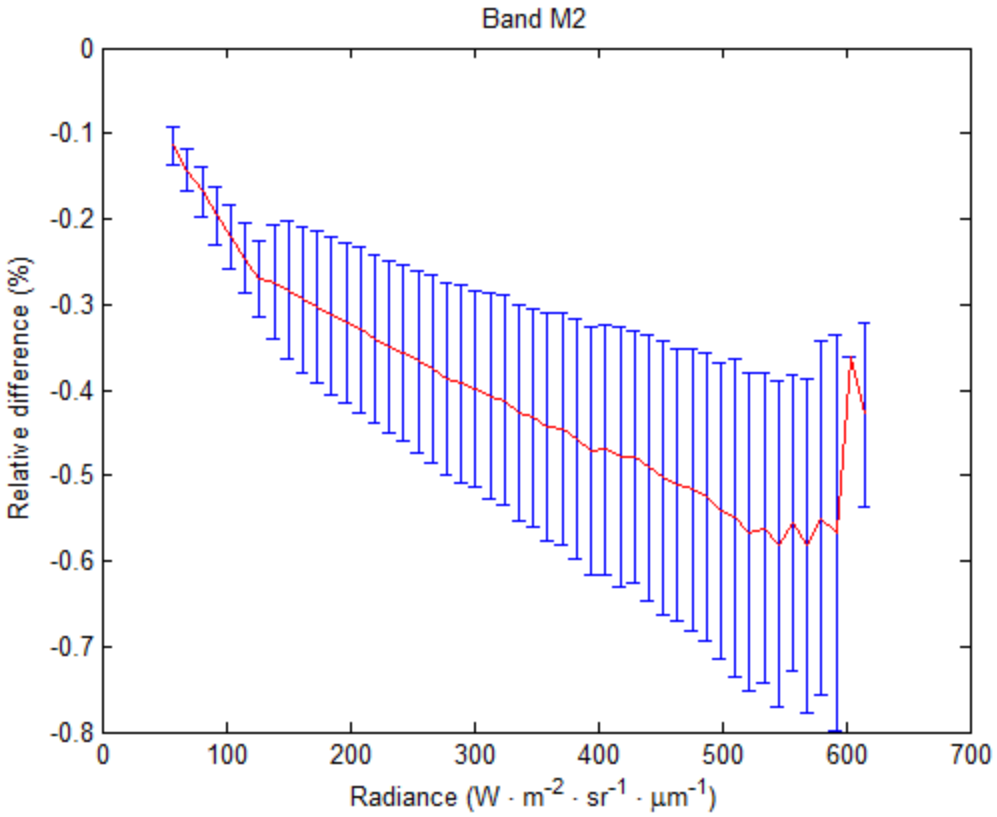
M1


VIIRS SDR M1 Radiance
2nd SDR / 1st SDR = 0.998
R2 = 0.99999
2nd SDR
1st SDR
0
100
200
300
400
500
600

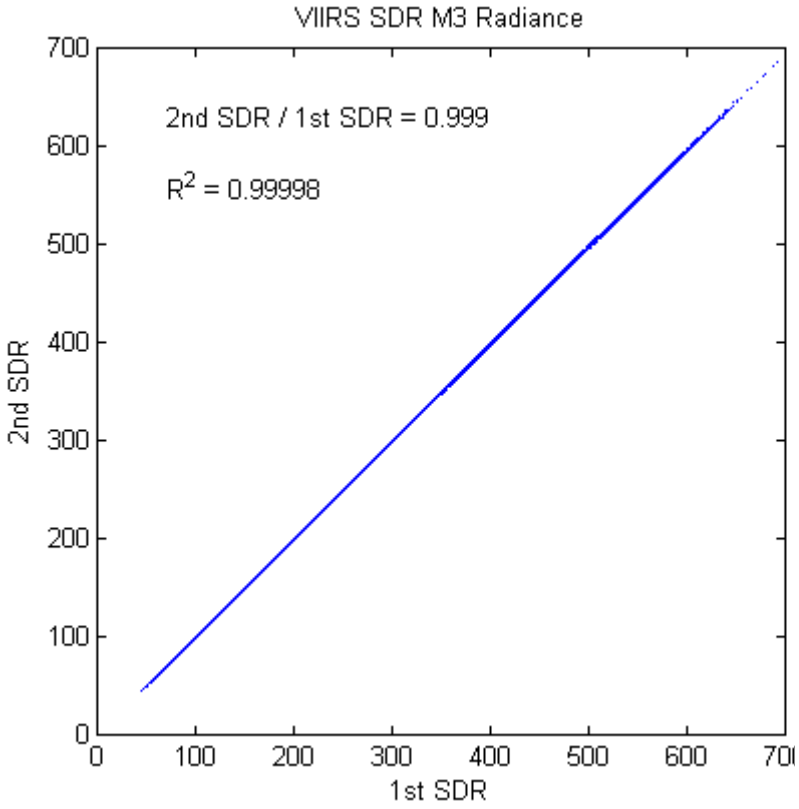

Band M1
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0
100
200
300
400
500
600

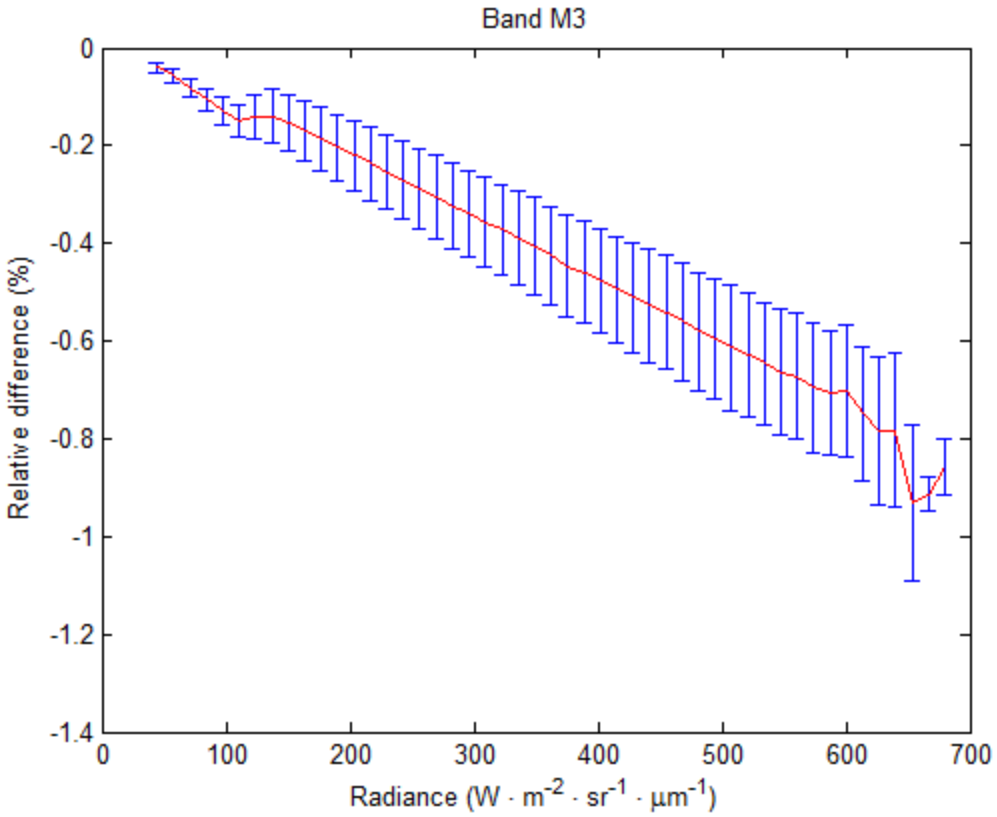
M2


VIIRS SDR M2 Radiance
2nd SDR / 1st SDR = 0.998
R2 = 0.99999
2nd SDR
1st SDR
0
100
200
300
400
500
600
700

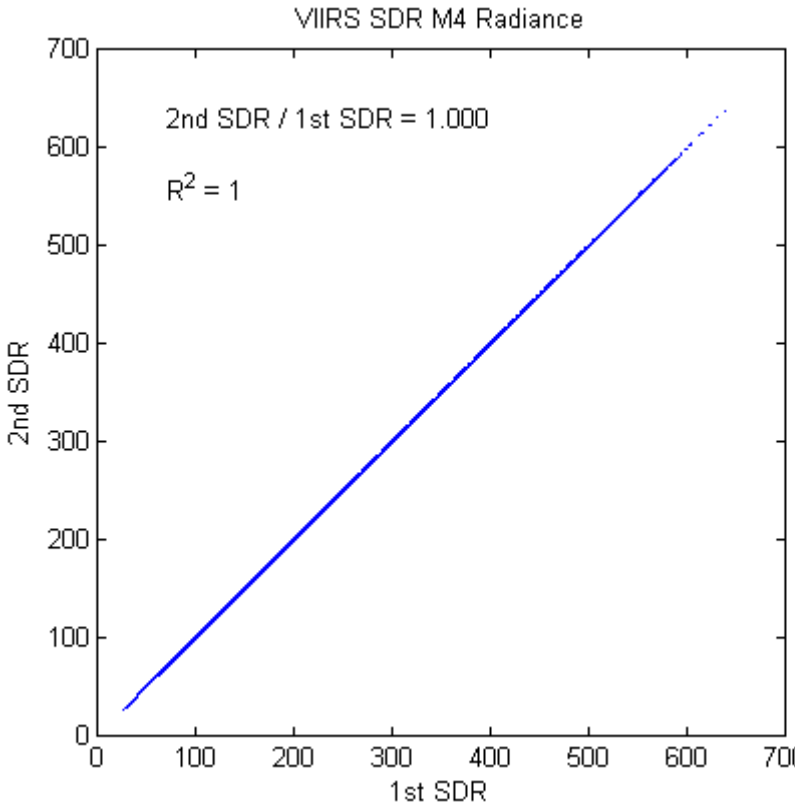

Band M2
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
0
100
200
300
400
500
600
700

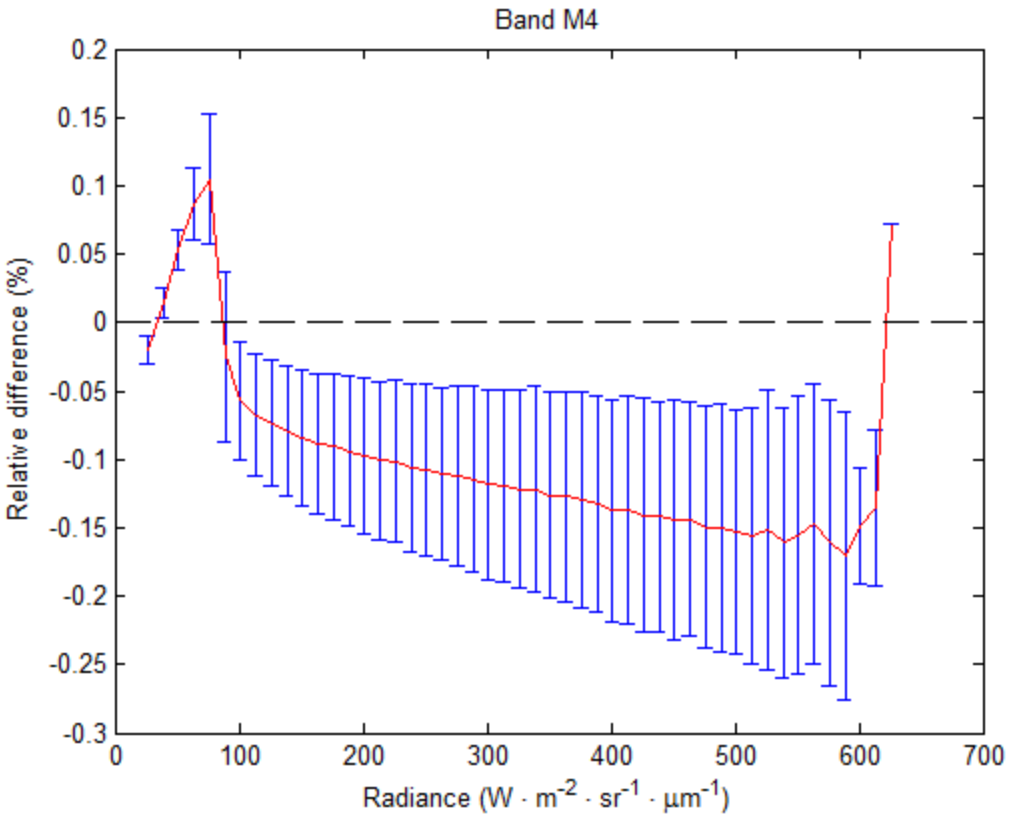
M3


VIIRS SDR M3 Radiance
2nd SDR / 1st SDR = 0.999
R2 = 0.99998
2nd SDR
1st SDR
0
100
200
300
400
500
600
700

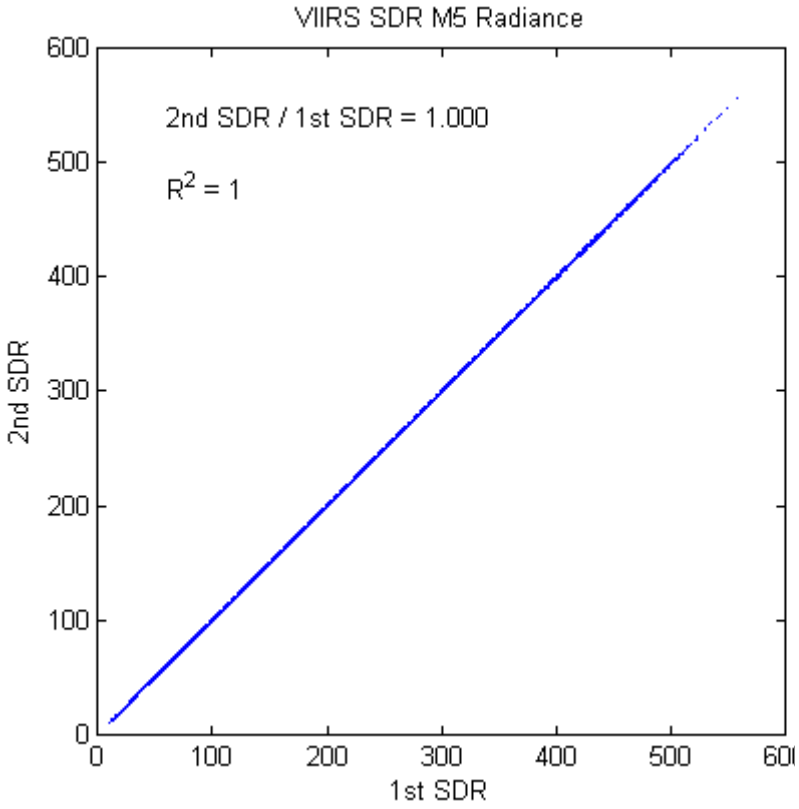

Band M3
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
0
100
200
300
400
500
600
700

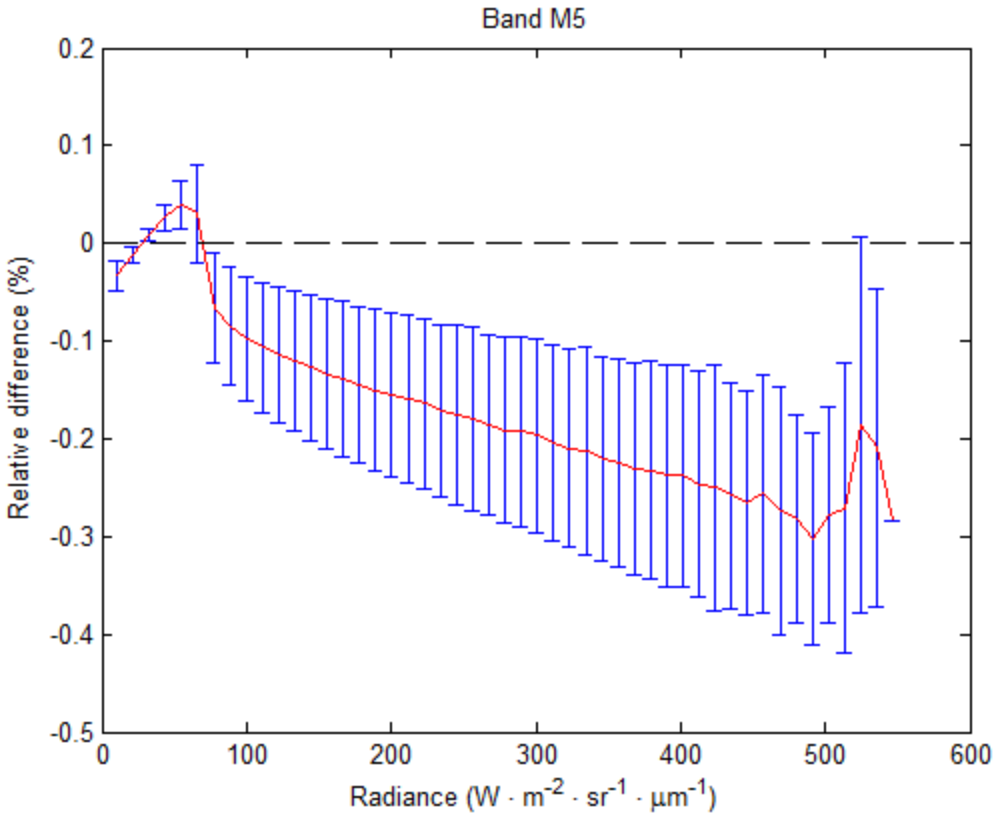
M4


VIIRS SDR M4 Radiance
2nd SDR / 1st SDR = 1.000
R^2 = 1
2nd SDR
1st SDR
0
100
200
300
400
500
600
700

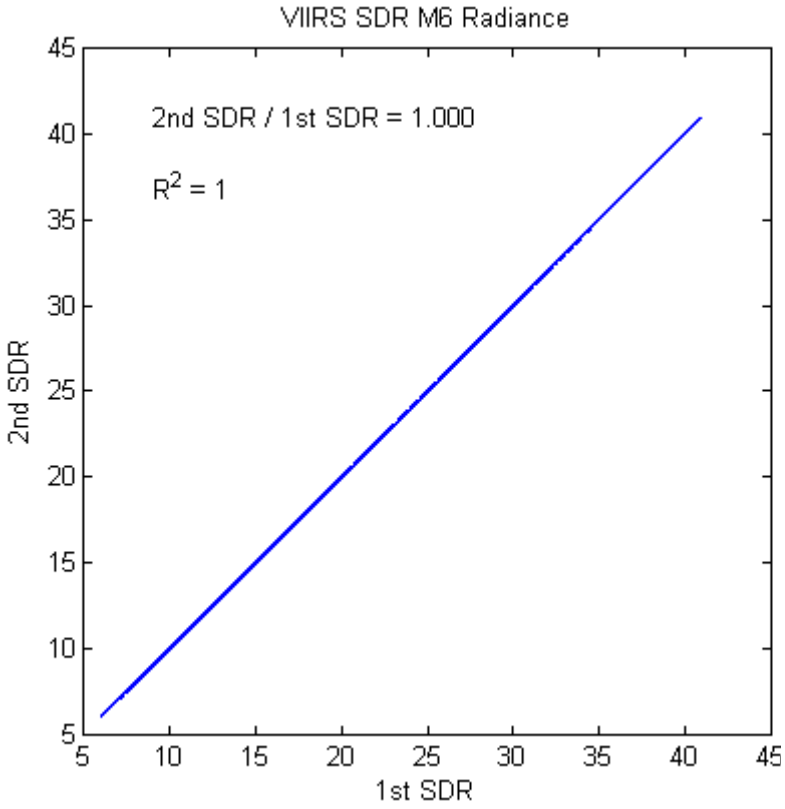

Band M4
Relative difference (%)
Radiance (W · m^{-2} · sr^{-1} · µm^{-1})
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
0
100
200
300
400
500
600
700

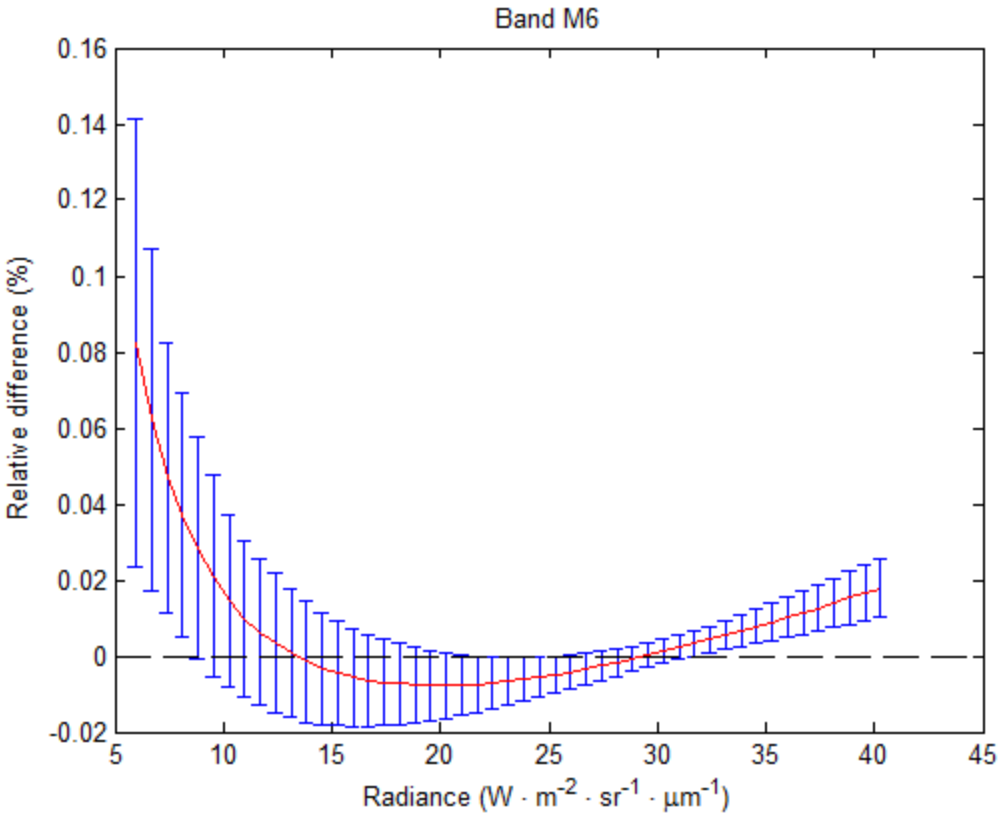
M5


VIIRS SDR M5 Radiance
2nd SDR / 1st SDR = 1.000
R2 = 1
2nd SDR
1st SDR
0
100
200
300
400
500
600

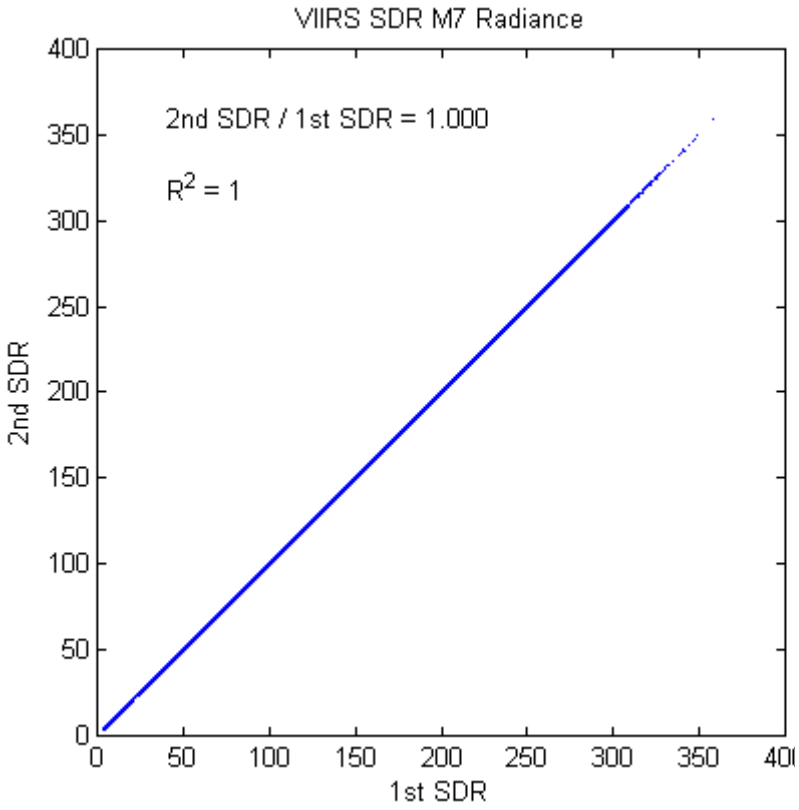

Band M5
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
100
200
300
400
500
600

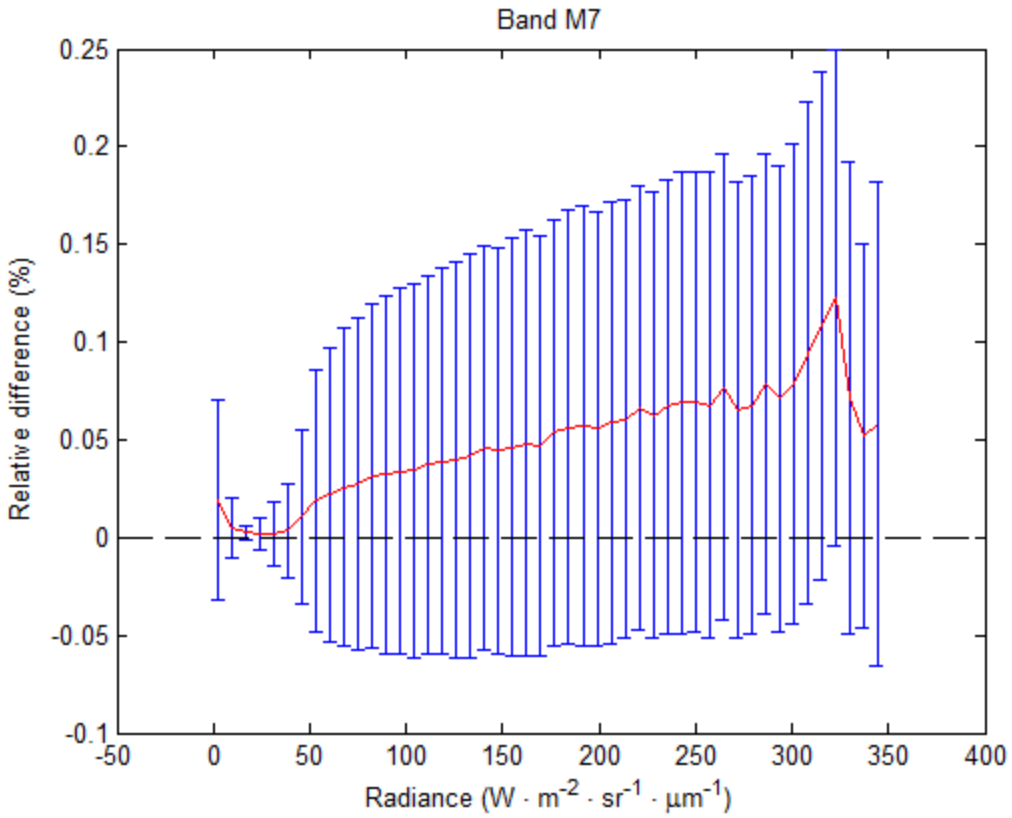
M6


VIIRS SDR M6 Radiance
2nd SDR / 1st SDR = 1.000
R2 = 1
2nd SDR
1st SDR
5
10
15
20
25
30
35
40
45

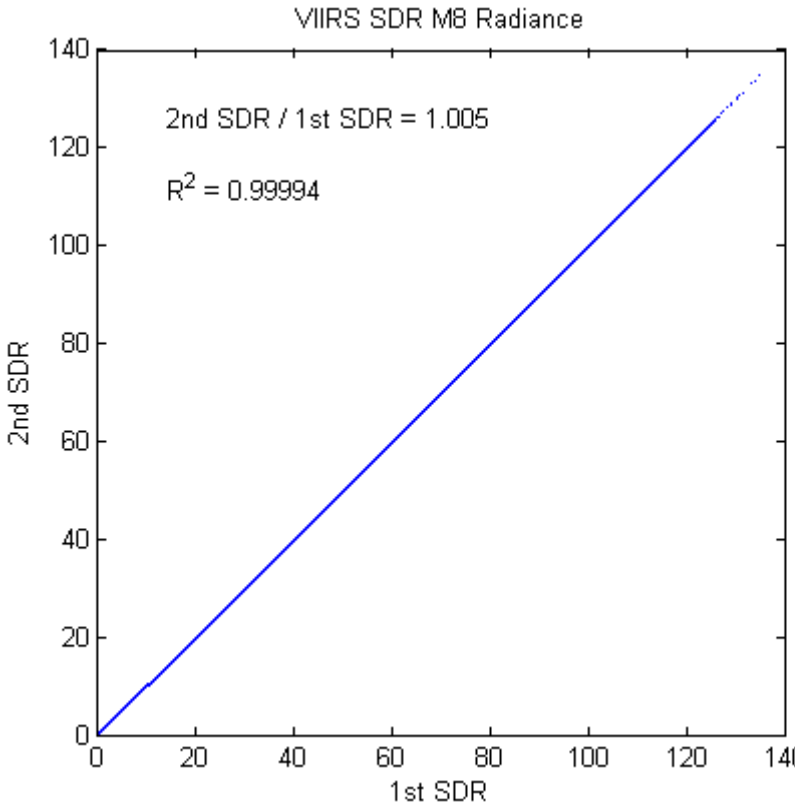

Band M6
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
5
10
15
20
25
30
35
40
45

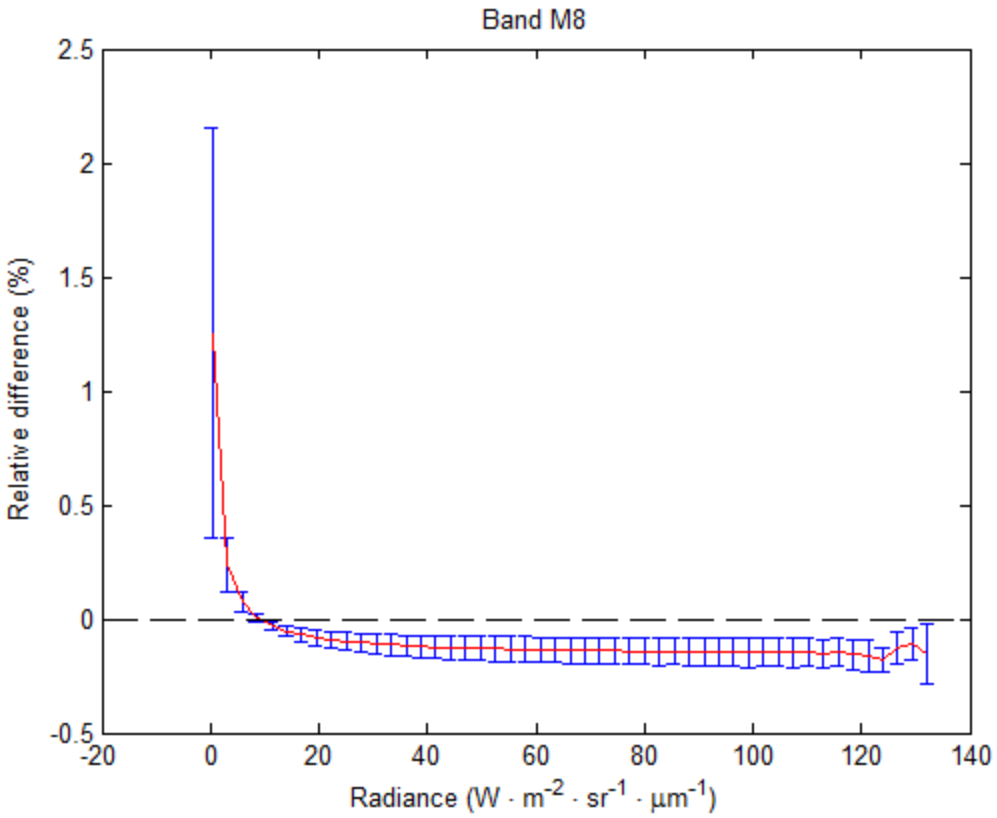
M7


VIIRS SDR M7 Radiance
2nd SDR / 1st SDR = 1.000
R2 = 1
2nd SDR
1st SDR
0
50
100
150
200
250
300
350
400

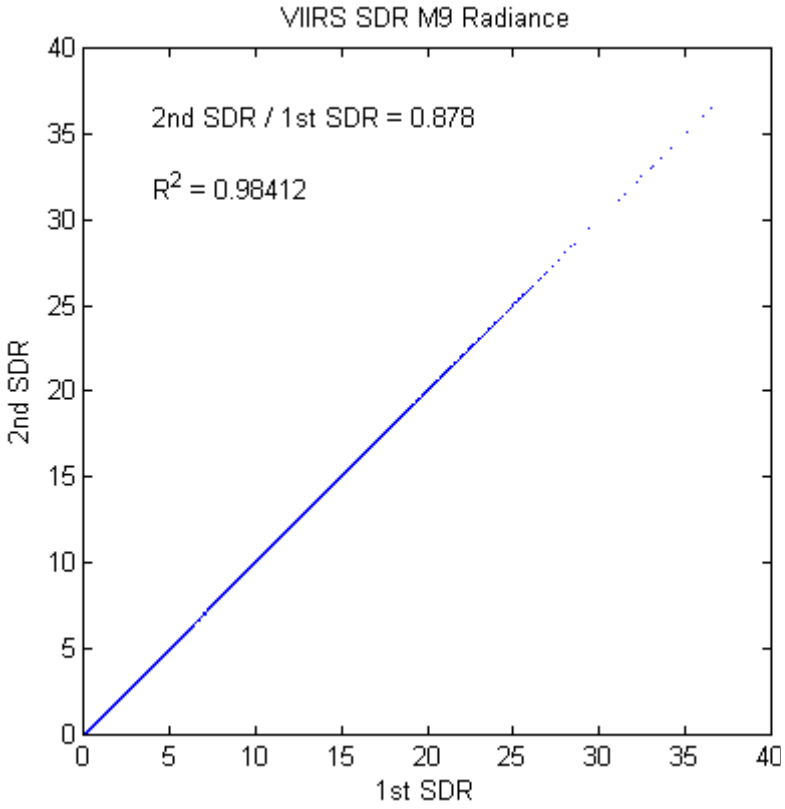

Band M7
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-50
0
50
100
150
200
250
300
350
400

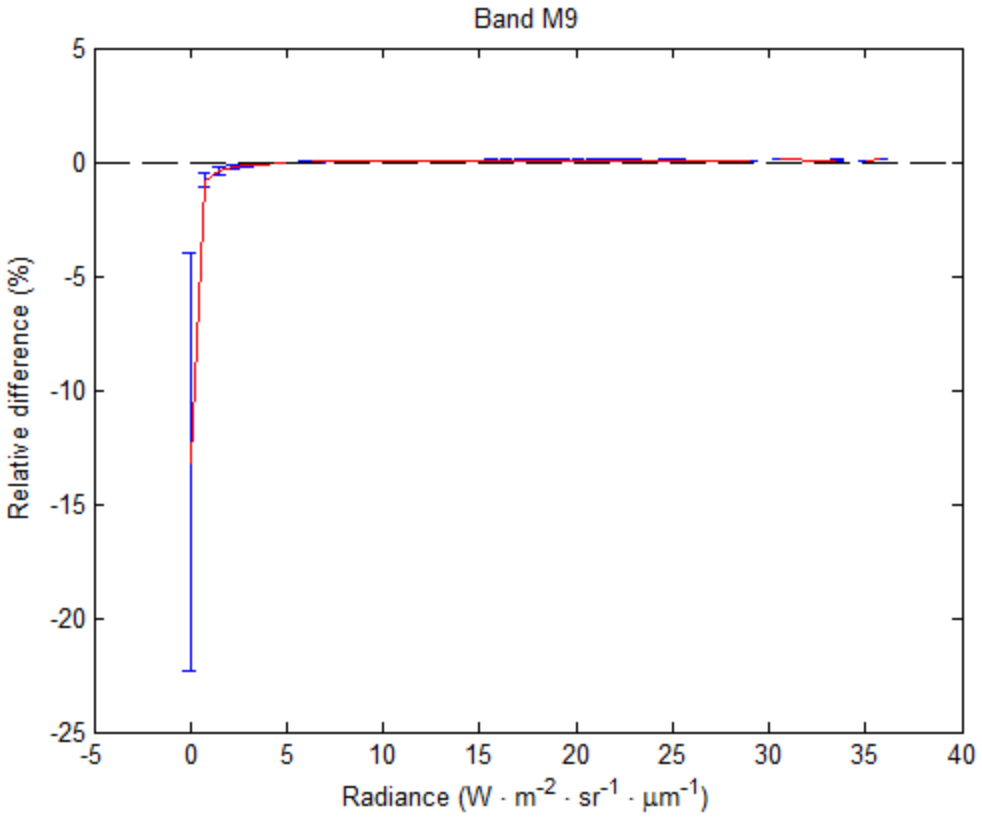
M8


VIIRS SDR M8 Radiance
2nd SDR / 1st SDR = 1.005
R2 = 0.99994
2nd SDR
1st SDR
0
20
40
60
80
100
120
140

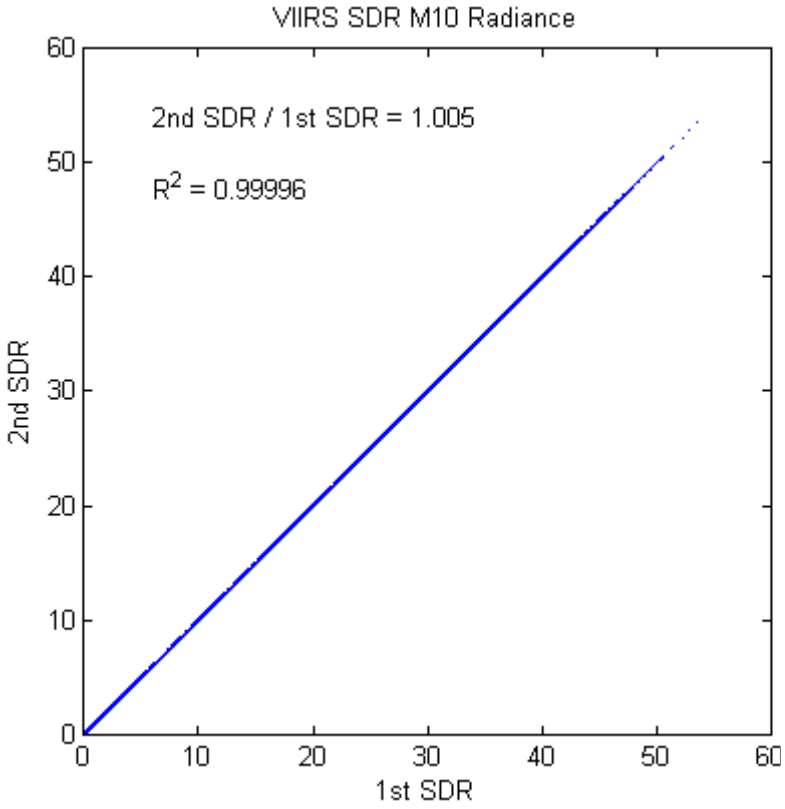

Band M8
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
2.5
2
1.5
1
0.5
0
-0.5
-20
0
20
40
60
80
100
120
140

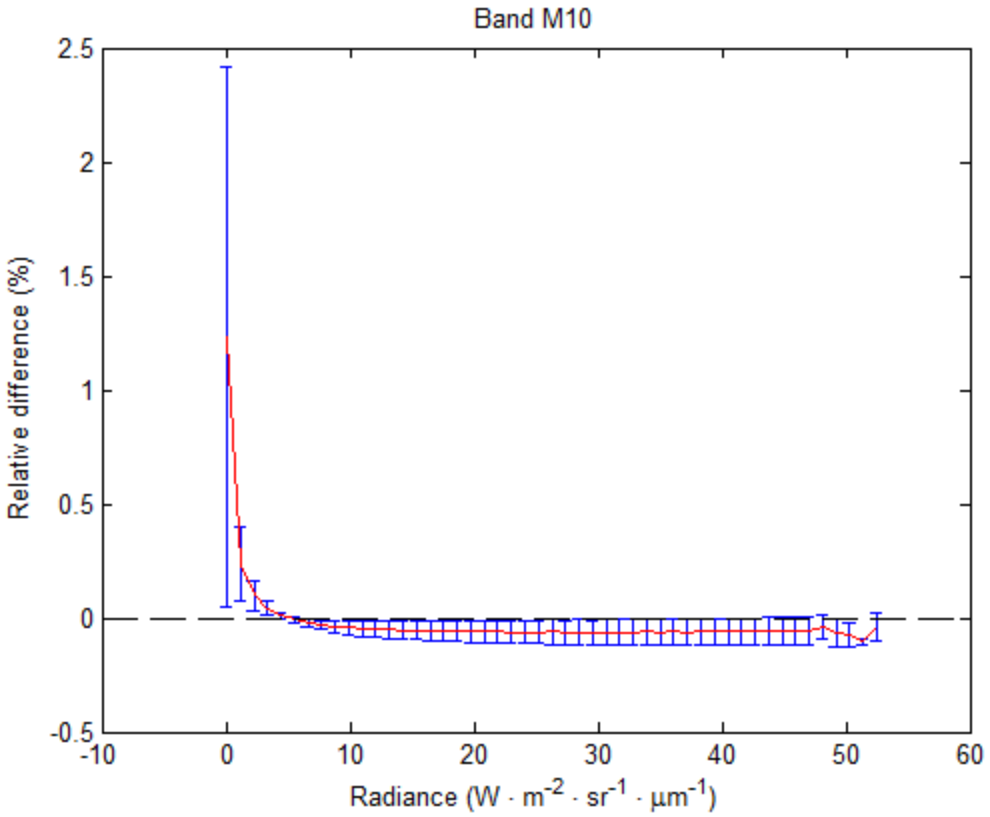
M9


VIIRS SDR M9 Radiance
2nd SDR / 1st SDR = 0.878
R2 = 0.98412
2nd SDR
1st SDR
0
5
10
15
20
25
30
35
40

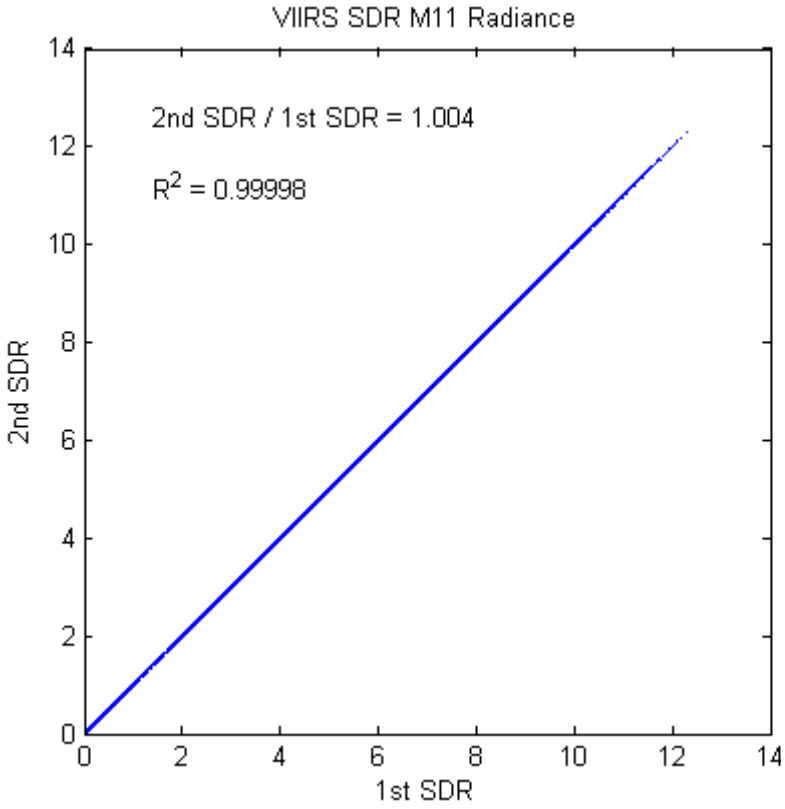

Band M9
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
5
0
-5
-10
-15
-20
-25
-5
0
5
10
15
20
25
30
35
40

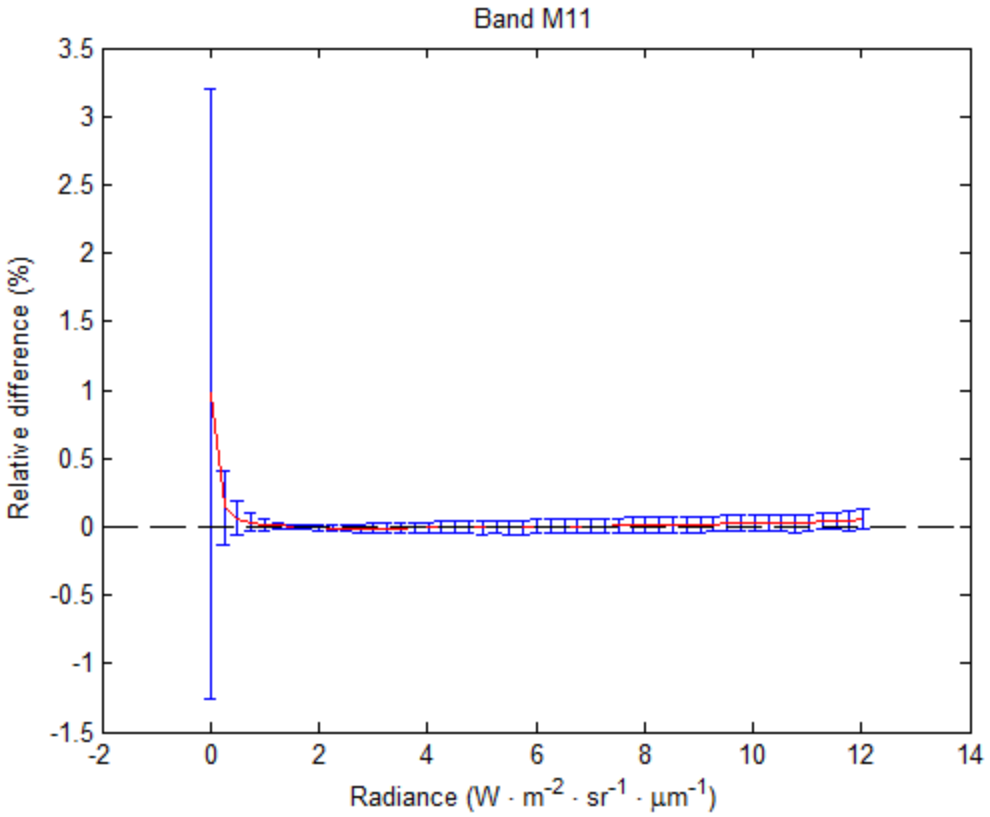
M10


VIIRS SDR M10 Radiance
2nd SDR / 1st SDR = 1.005
R2 = 0.99996
2nd SDR
1st SDR
0
10
20
30
40
50
60

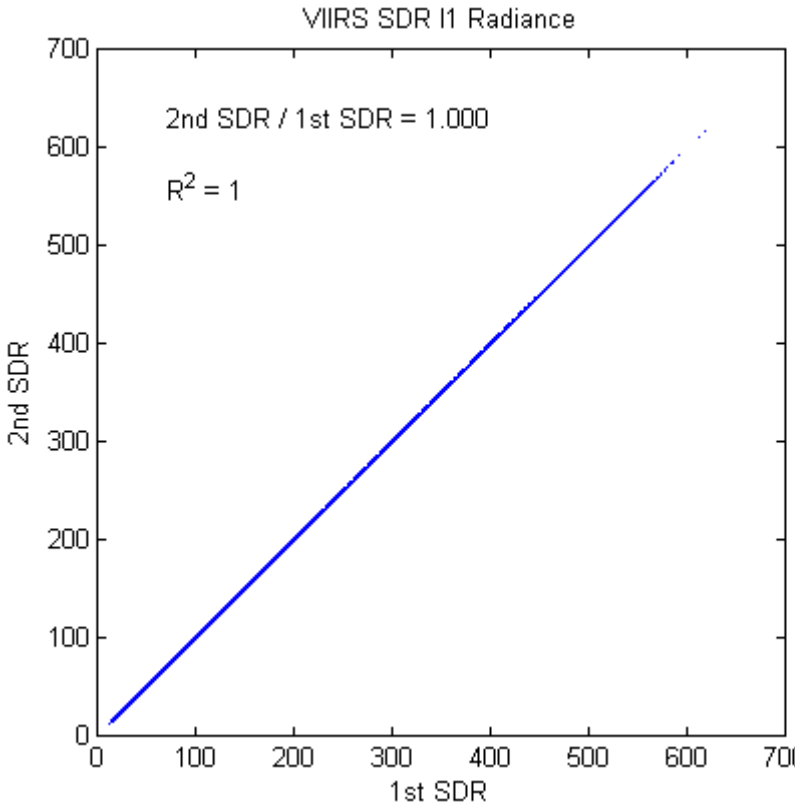

Band M10
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
2.5
2
1.5
1
0.5
0
-0.5
-10
0
10
20
30
40
50
60

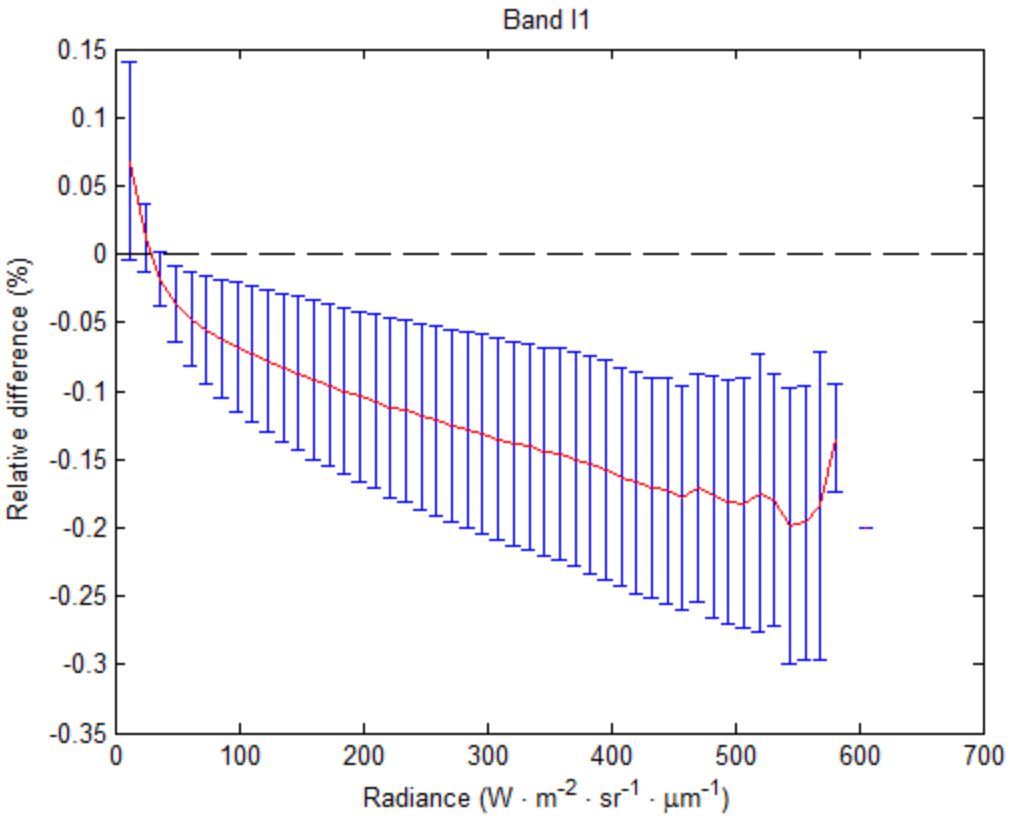
M11


VIIRS SDR M11 Radiance
2nd SDR / 1st SDR = 1.004
R2 = 0.99998
2nd SDR
1st SDR
0
2
4
6
8
10
12
14

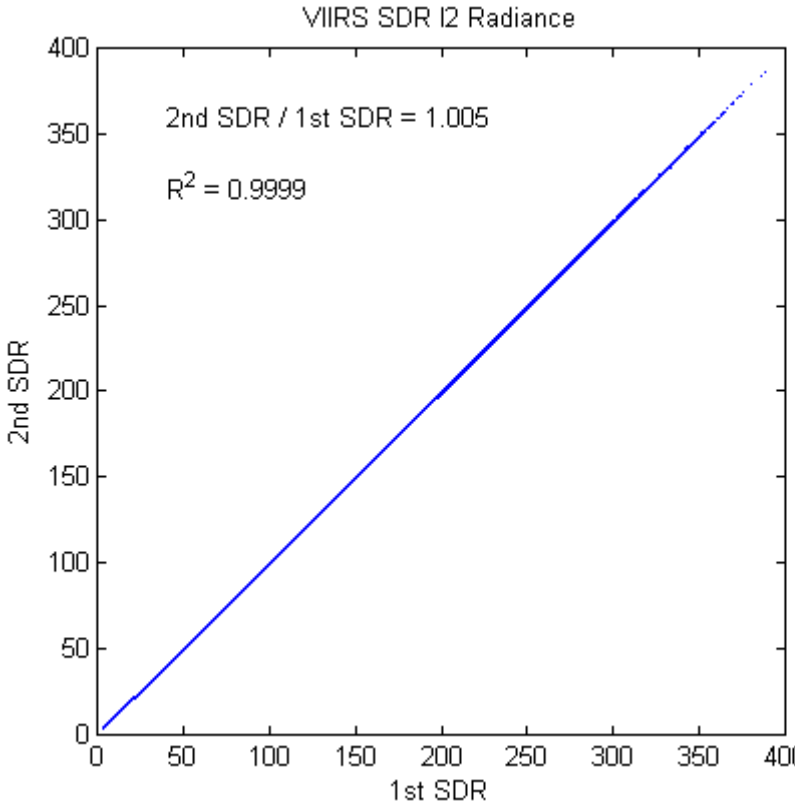

Band M11
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
2
4
6
8
10
12
14

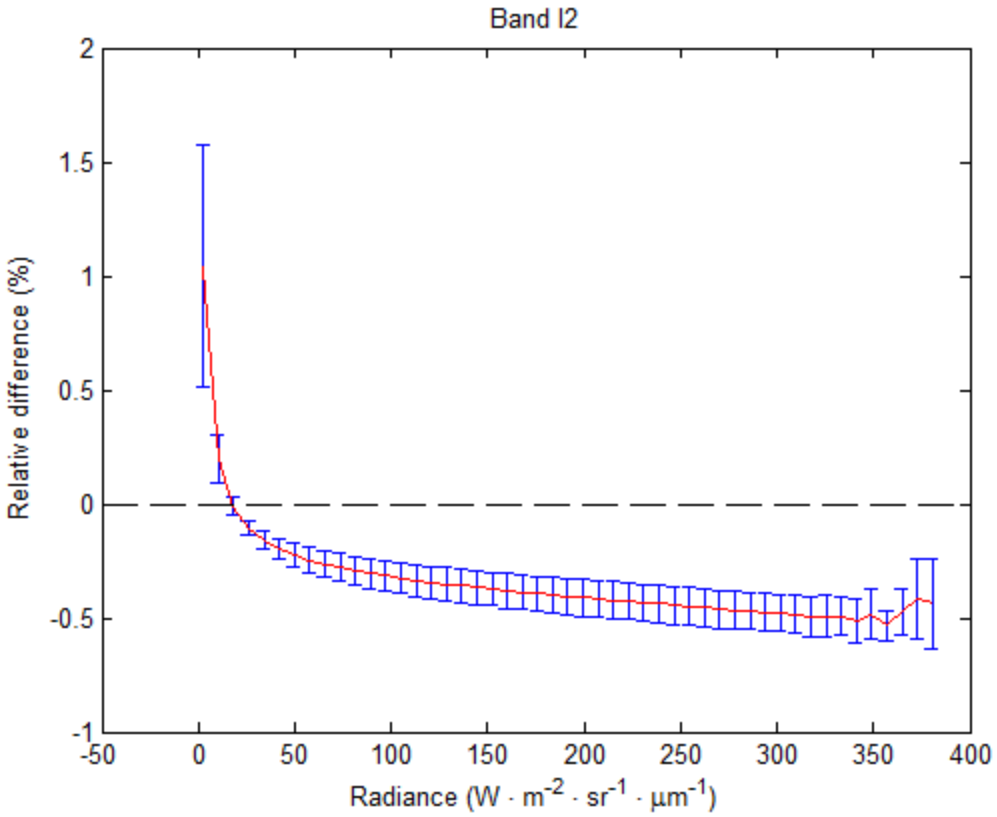
I1


VIIRS SDR I1 Radiance
2nd SDR / 1st SDR = 1.000
R2 = 1
2nd SDR
1st SDR
0
100
200
300
400
500
600
700

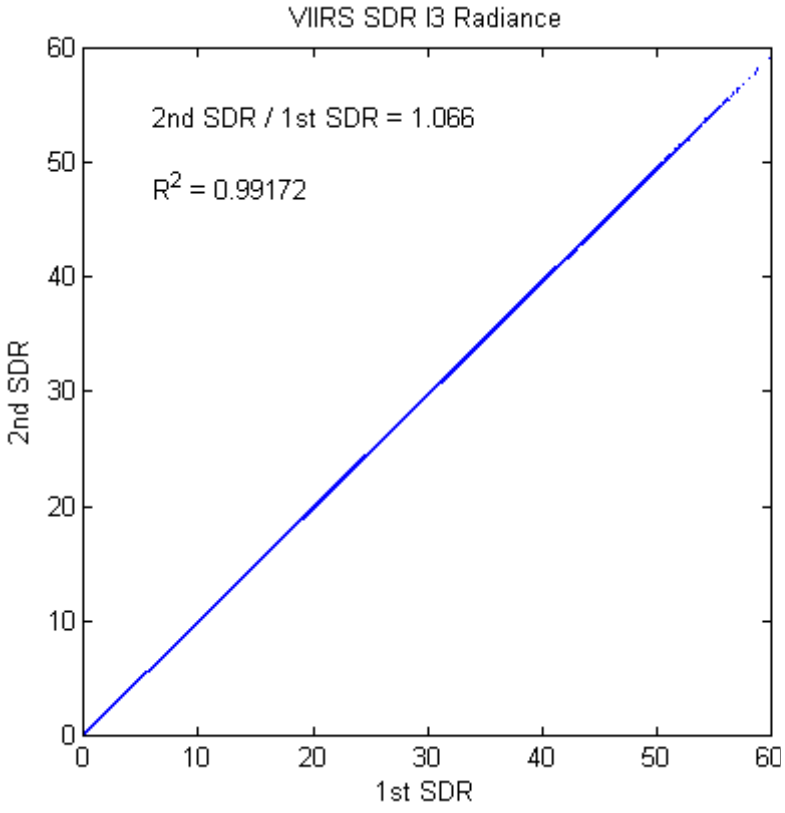

Band I1
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
0
100
200
300
400
500
600
700

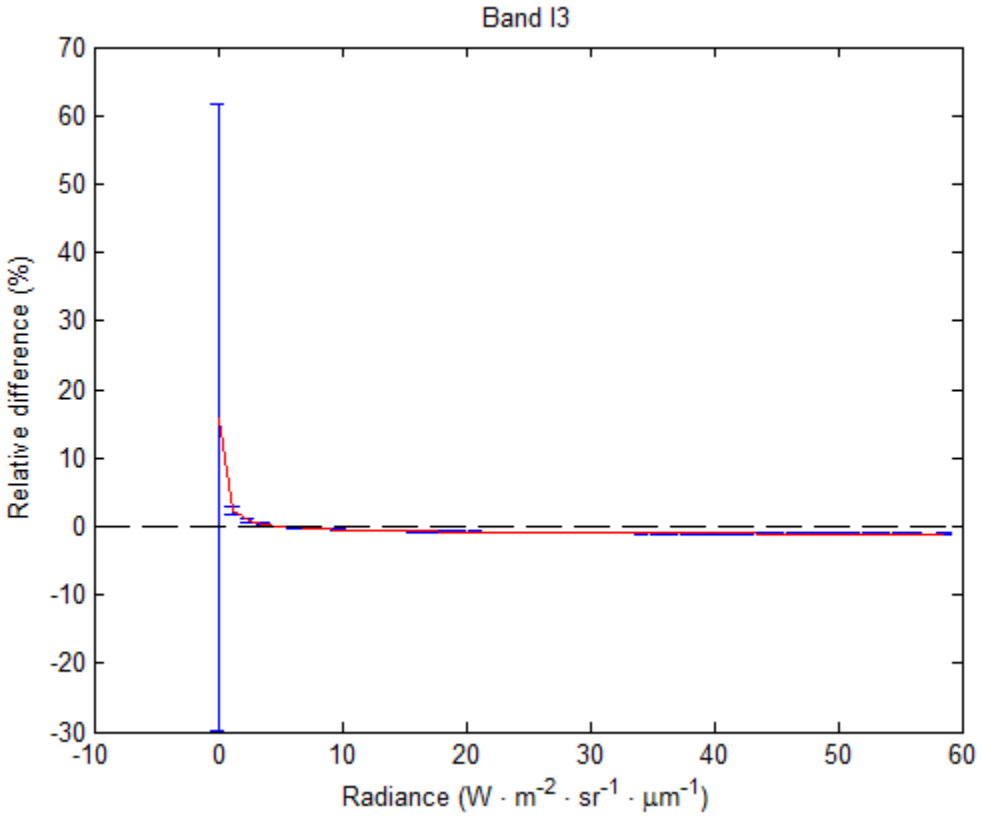
I2


VIIRS SDR I2 Radiance
2nd SDR / 1st SDR = 1.005
R2 = 0.9999
2nd SDR
1st SDR
0
50
100
150
200
250
300
350
400


Band I2
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
2
1.5
1
0.5
0
-0.5
-1
-50
0
50
100
150
200
250
300
350
400

I3


VIIRS SDR I3 Radiance
2nd SDR / 1st SDR = 1.066
R2 = 0.99172
2nd SDR
1st SDR
0
10
20
30
40
50
60


Band I3
Relative difference (%)
Radiance (W · m-2 · sr-1 · µm-1)
70
60
50
40
30
20
10
0
-10
-20
-30
-10
0
10
20
30
40
50
60

VIIRS RSB Validation:
AutoCal and Inter-comparison Update

APPENDIX B

VIIRS RSB Validation: AutoCal and Inter-comparison Update

Slawomir Blonski
VIIRS SDR Cal/Val Team

Suomi NPP SDR Product Review
NOAA Center for Weather and Climate Prediction (NCWCP)
5830 University Research Park, College Park, Maryland
December 18-20, 2013

Outline

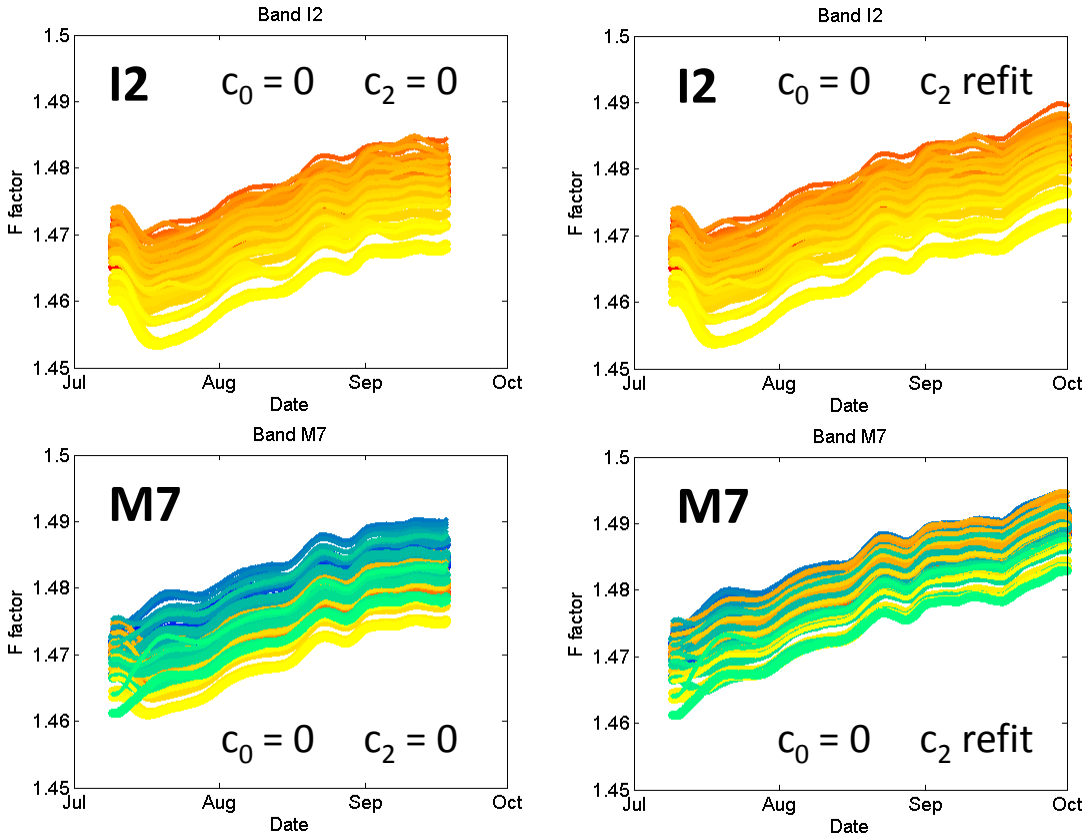
- …
  - Demonstrating use of the RSBAutoCal to improve radiometric consistency between the bands I2 and M7

Improving I2/M7 Consistency

- RSBAutoCal was used in optimizing values of the c coefficients to improve consistency between radiance measurements in bands I2 and M7
- Imaging band I2 pixels were aggregated to the M7 band pixel size (2x2 averaging)
- RSBAutoCal calculated F factors for two cases:
  1. $c_0 = 0$ and $c_2 = 0$
  2. $c_0 = 0$ and c_2 from refit of pre-launch

test data

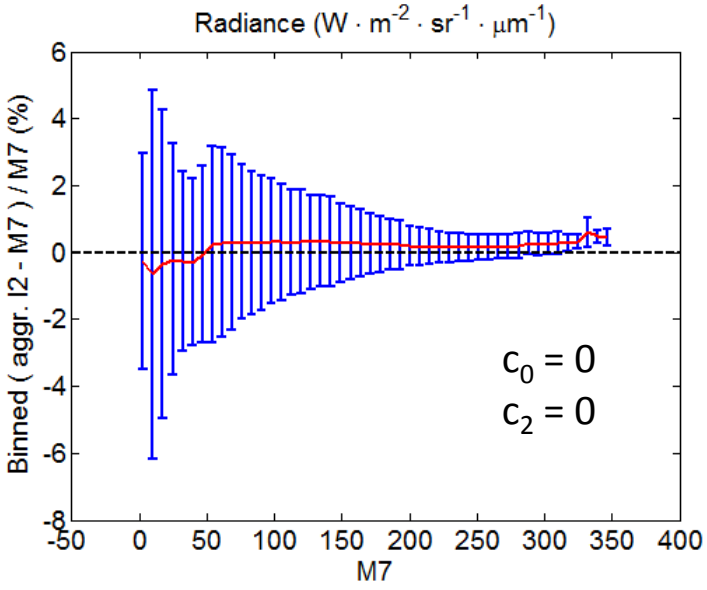
- Produced SDR for selected granules using the appropriate calibration history files generated by ADL

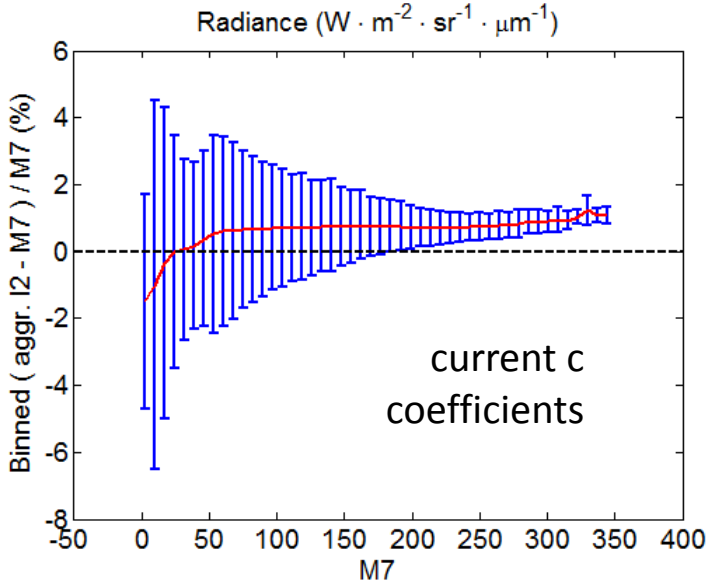


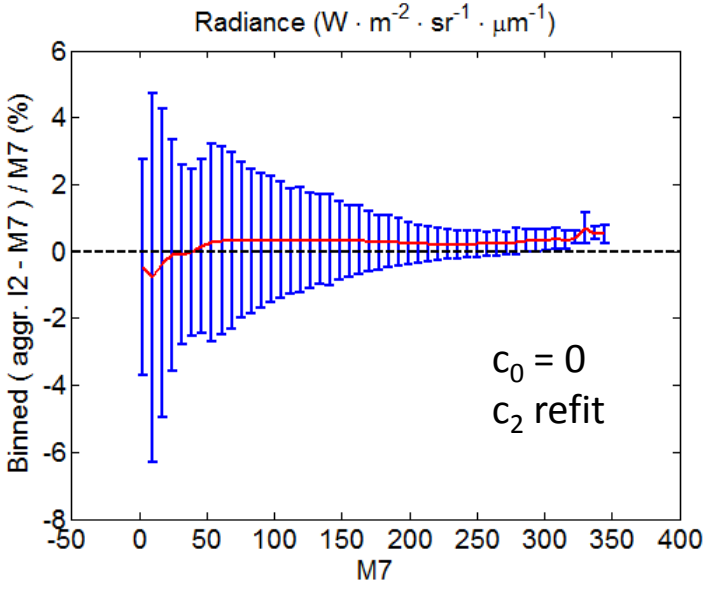
Transient F factor changes until August

Granule 2013-08-30 23-57 UTC

Improved I2/M7 Consistency







- Ocean scene around Hawaii (2013-08-30 23-57 UTC)
- Comparison of I2 and M7 radiance values for all pixels in the granule
- Setting c_0 to zero reduces I2/M7 differences at low (ocean) and high (clouds) radiance
  - At the low end of the M7 high-gain radiance range, $c_2 = 0$ is a little better in improving agreement between I2 and M7
  - At the high end of the high-gain range, the c_2 refit is clearly better
  - In the low-gain range, $c_2 = 0$ seems slightly better

Summary

- …
- Using the RSBAutoCal, consistency between the radiometric measurements in bands I2 and M7 can be improved by removing the free term (c_0) from the calibration equation
- …

VIIRS RSB Performance and Uncertainty Estimates

APPENDIX C

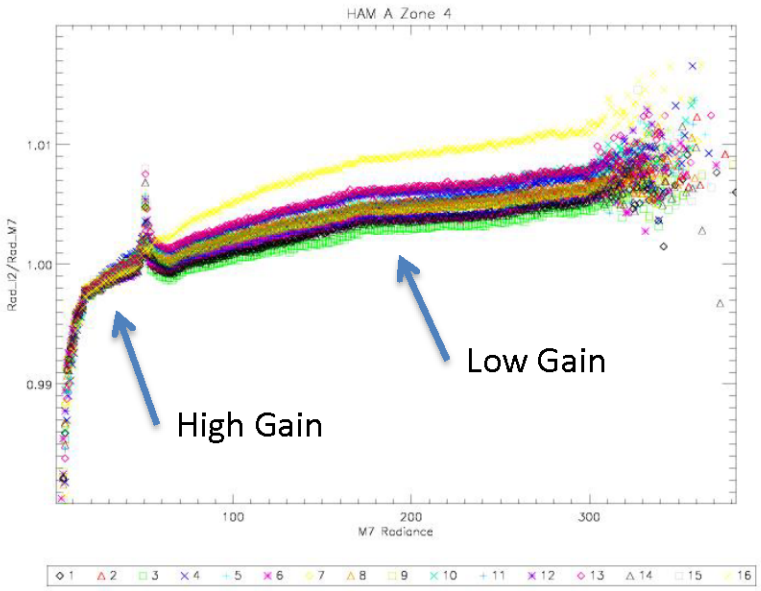
VIIRS Reflective Solar Band (RSB) Performance and Uncertainty Estimates

Dr. Frank J. De Luccia
The Aerospace Corporation
- Reporting on behalf of entire VIIRS SDR Calibration/Validation team -

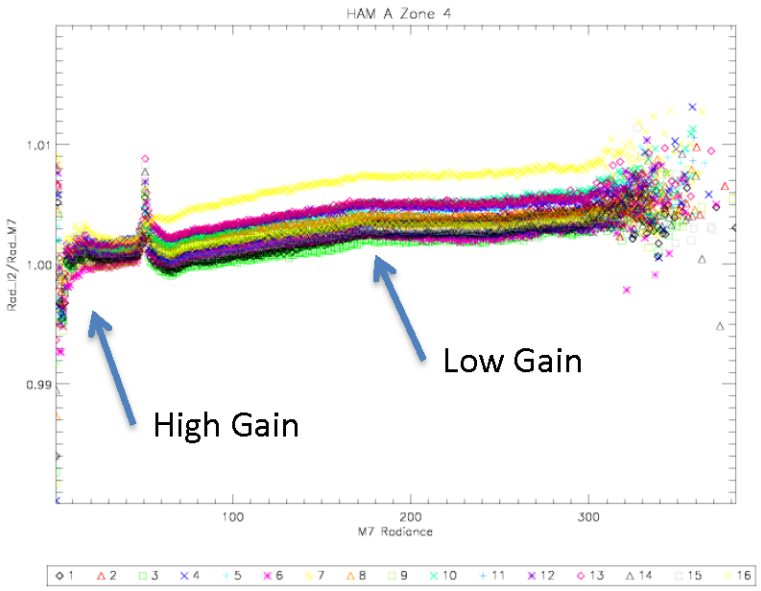
Suomi NPP SDR Product Review
NOAA Center for Weather and Climate Prediction (NCWCP)
5830 University Research Park, College Park, Maryland
December 18-20, 2013

Mitigation of I2/M7 Discrepancy

I2/M7 Radiance Ratio vs M7 Radiance
with Baseline Calibration Coefficients



I2/M7 Radiance Ratio vs M7 Radiance
with c0=0 c2=Refit Calibration Coefficients



- c0/c1 and c2/c1 calibration coefficient ratios were the key derived parameters from pre-launch RSB response characterization
- c0 does not arise in the derivation of the radiance retrieval equation, but is added post hoc to compensate for potential errors in other model parameters
- It was found in pre-launch data analysis that for most detectors in many RSB, c0/c1 = 0 to within 2-sigma measurement uncertainty
- c2/c1 was derived pre-launch for all bands setting c0 = 0
- Use of the c0 = 0, c2 = refit calibration coefficients substantially improves consistency between I2 and M7, as shown above
- This finding is strong evidence that the c0 = 0, c2 = refit calibration coefficients would reduce radiometric uncertainty in ALL RSB if used to update the calibration coefficient LUT, as predicted pre-launch

Improvements in Work or Under Investigation

- Updated screen transmission and SD BRDF related LUTs are in work
  - Provide better behaved SD degradation factor (H) time series
  - Improve radiometric uncertainty and stability
- Improved calibration coefficients with c0 = 0 constraint available and under investigation
  - Known to mitigate I2/M2 discrepancy
  - Expected to mitigate or eliminate M11 uncertainty non-compliance
  - Expected to mitigate striping
- RSBAutoCal input parameters are being tuned for optimal automated RSB calibration performance

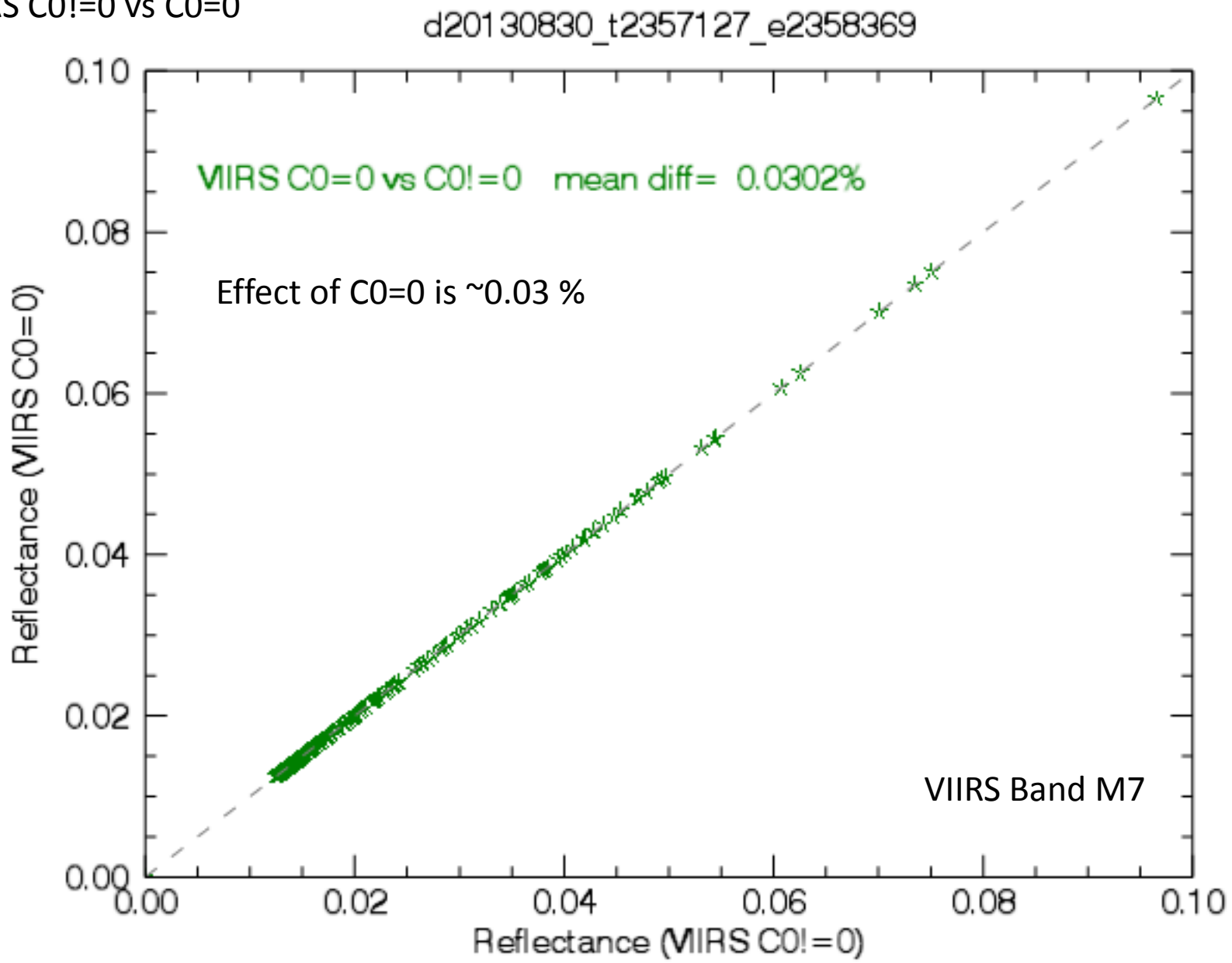
Summary

- IDPS RSB data products generally perform very well
- Performance will improve when calibration is fully automated
  - Greater radiometric stability
  - Robustness to data gaps and trend changes
- Additional data product improvements are in work that will enhance uncertainty, stability and uniformity performance
  - Application of c0 = 0 coefficients developed pre-launch will reduce I2/M7 discrepancy
  - Improved screen transmission and SD BRDF related LUTs
- Additional characterization needed to address remaining instrument artifacts that limit uniformity and radiometric stability
  - Striping
  - Spurious temporal modulations in calibration

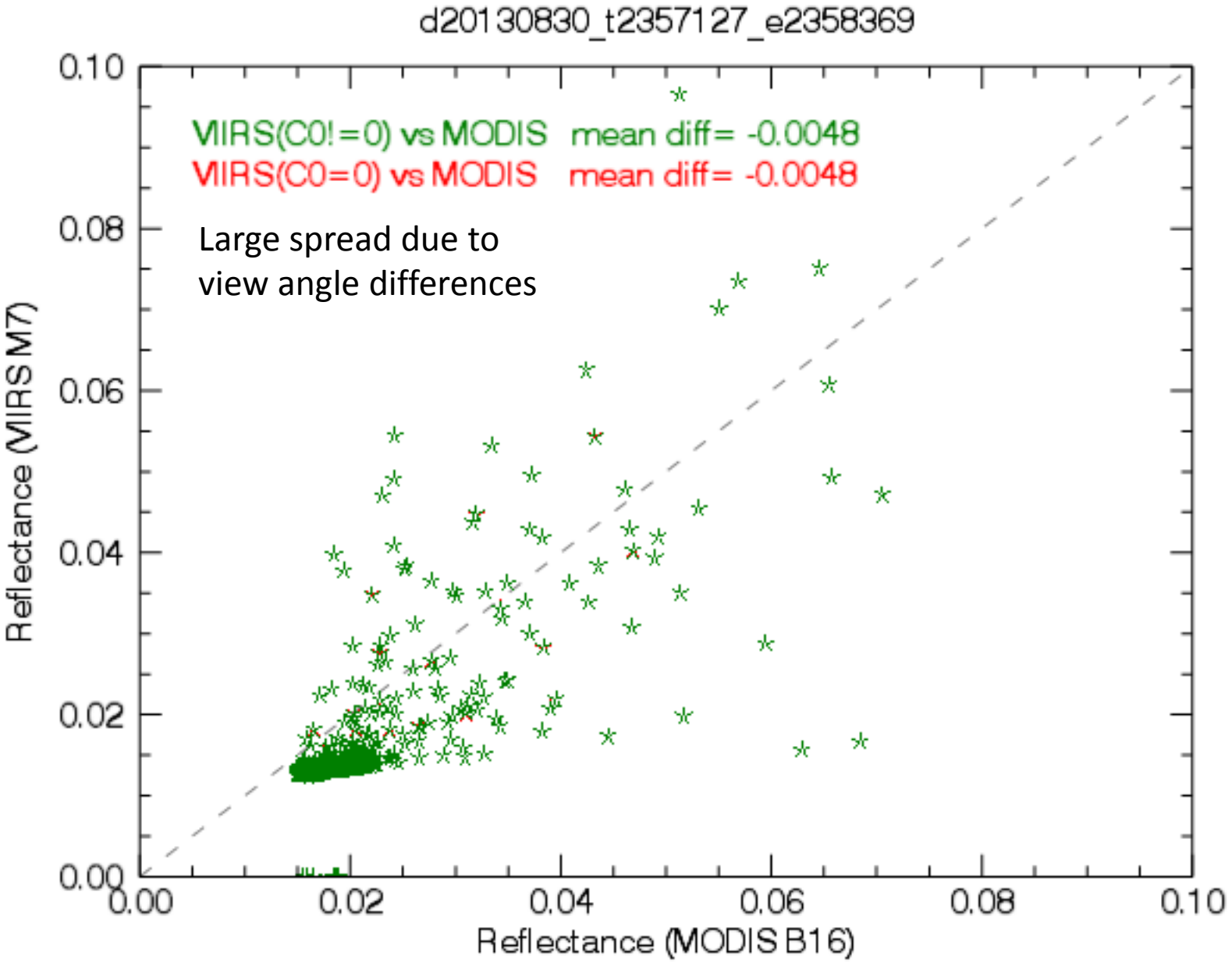
VIIRS & MODIS Comparisons

APPENDIX D

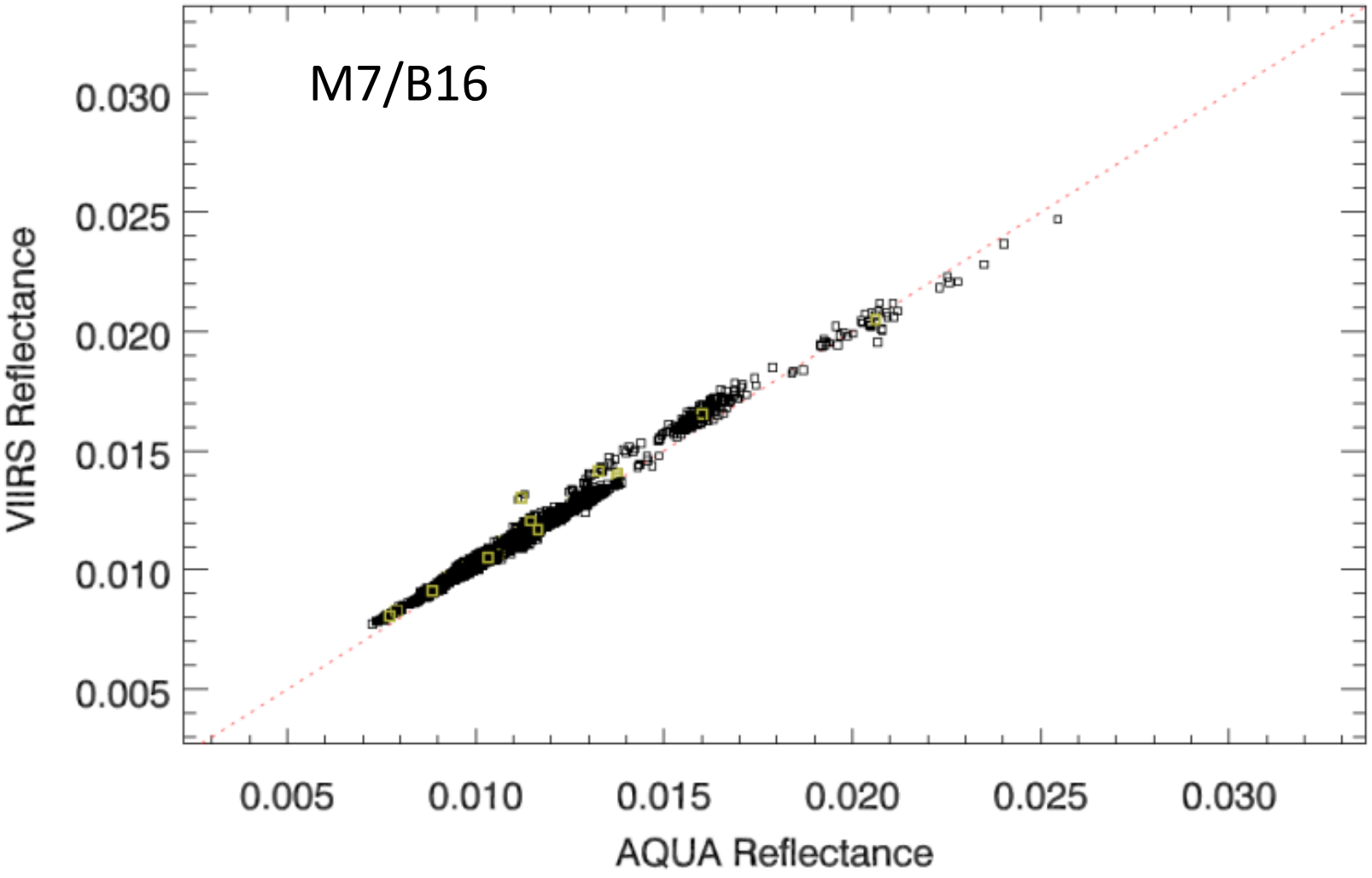
VIIRS C0!=0 vs C0=0



MODIS vs VIIRS



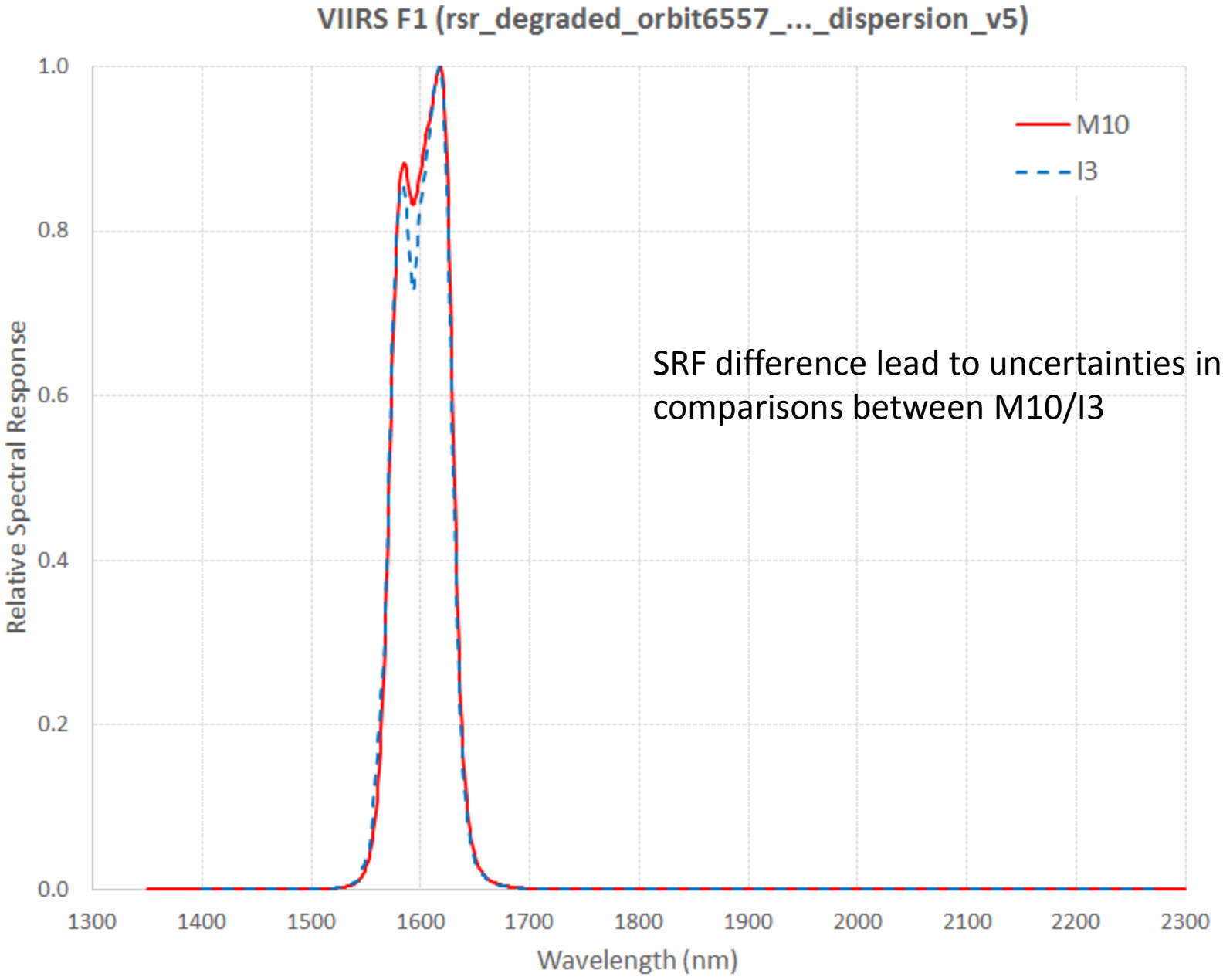
VIIRS & MODIS at Low Latitude SNOs Over Ocean



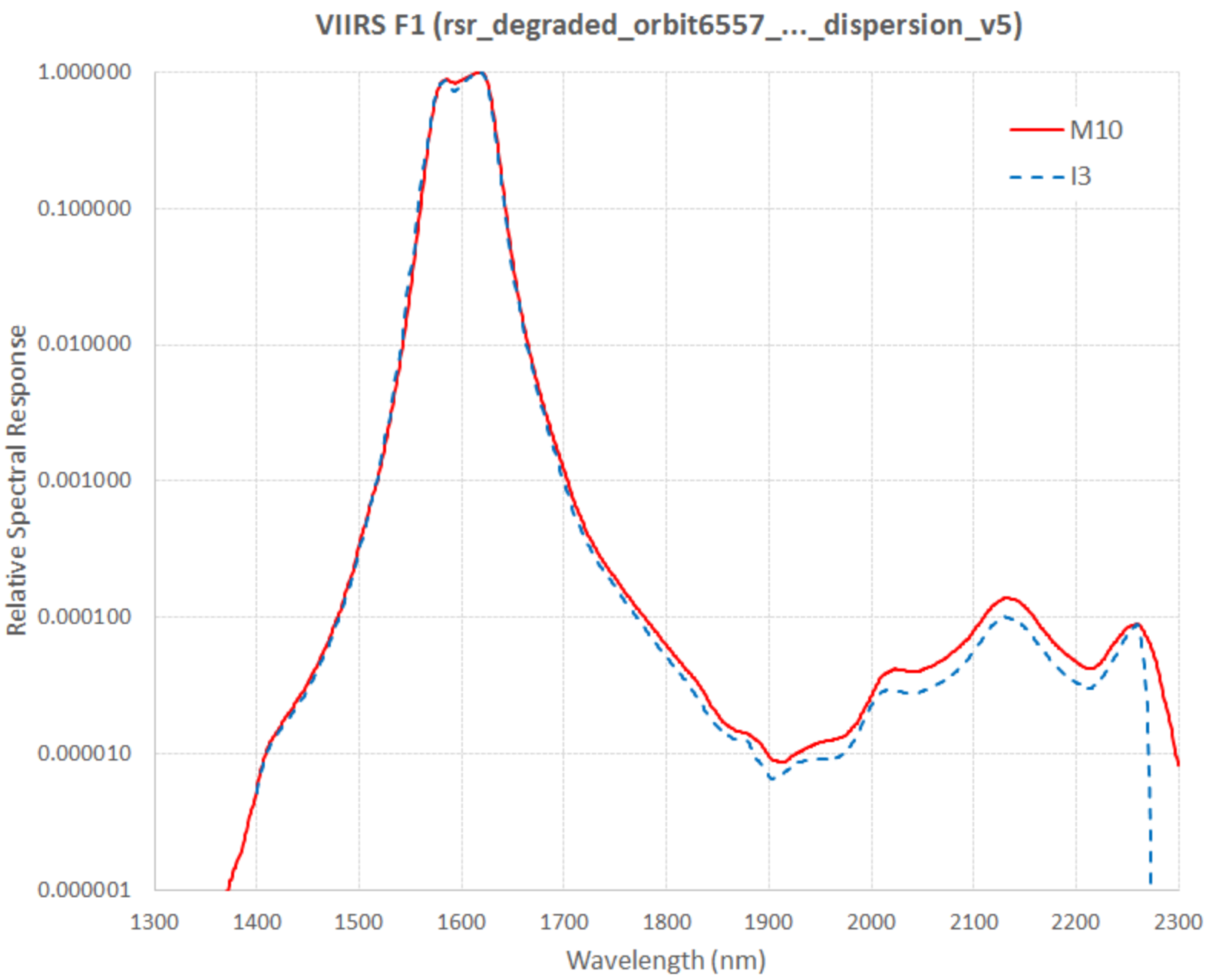
- VIIRS VNIR bands (M1-M7) indicate the observed radiometric bias to be within 2% relative to MODIS.

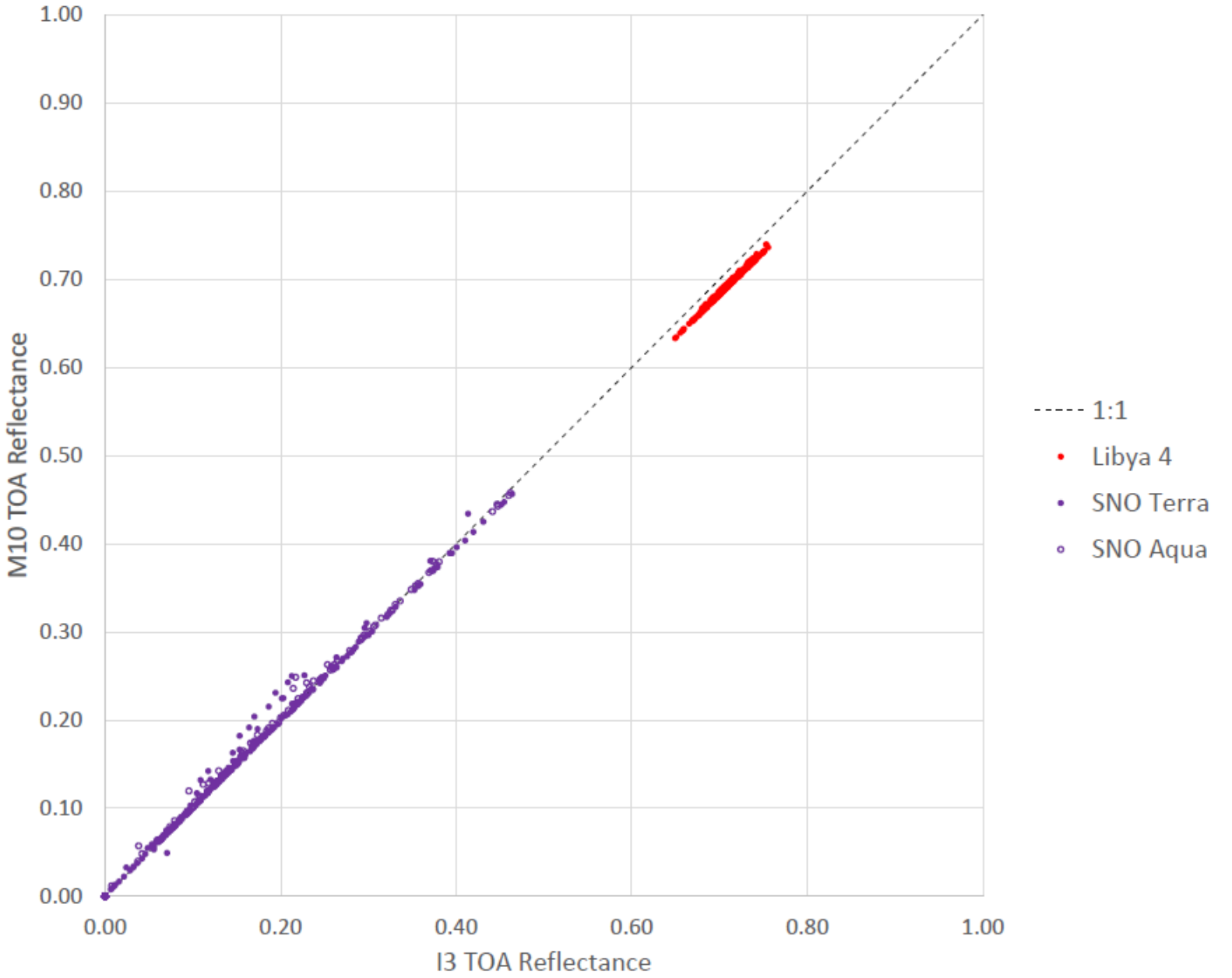
I3/M10 Comparisons

APPENDIX E

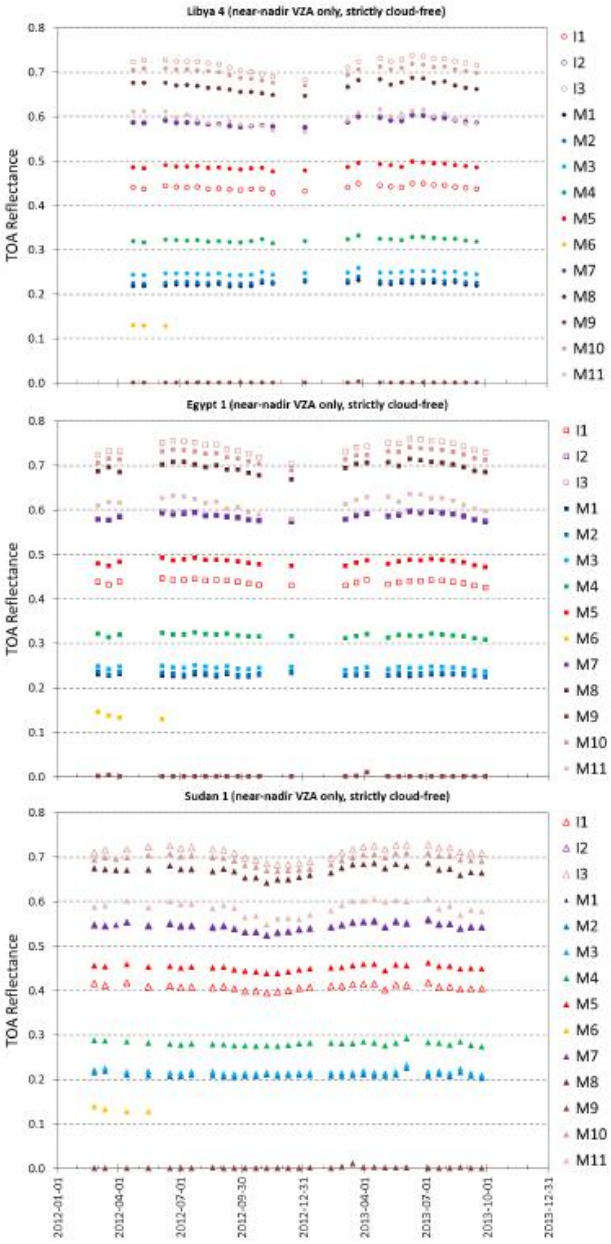


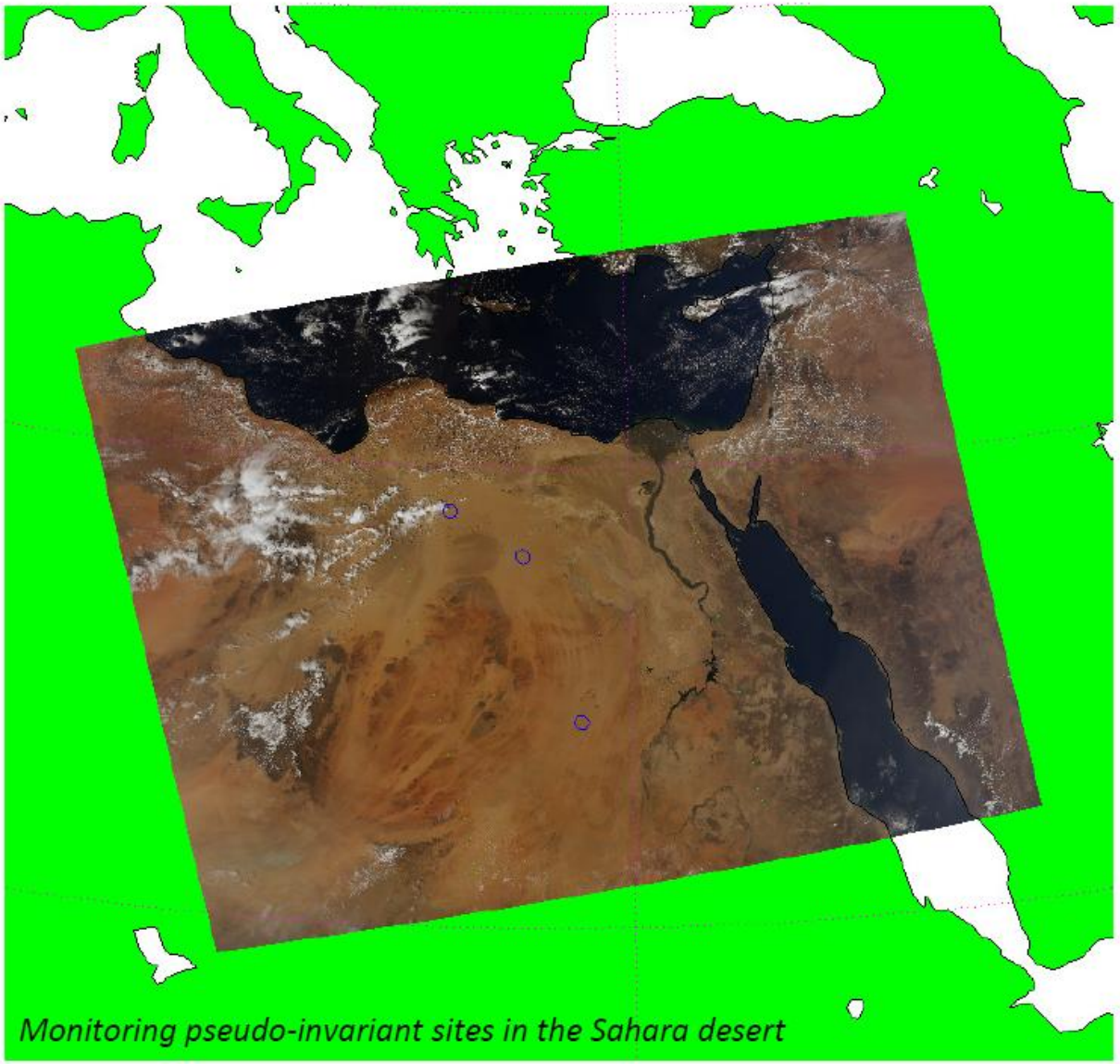
SRF difference lead to uncertainties in comparisons between M10/I3


VIIRS F1 (rsr_degraded_orbit6557_..._dispersion_v5)
1.000000
0.100000
0.010000
0.001000
0.000100
0.000010
0.000001
Relative Spectral Response
M10
I3
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
Wavelength (nm)


1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
M10 TOA Reflectance
0.00
0.20
0.40
0.60
0.80
1.00
I3 TOA Reflectance
1:1
Libya 4
SNO Terra
SNO Aqua

Radiometric Stability of Data Products





Monitoring pseudo-invariant sites in the Sahara desert

Bands M5, M4, M2 are shown as RGB