



VIIRS Radiometric Calibration for Reflective Solar Bands: Antarctic Dome C Site and Simultaneous Nadir Overpass Observations

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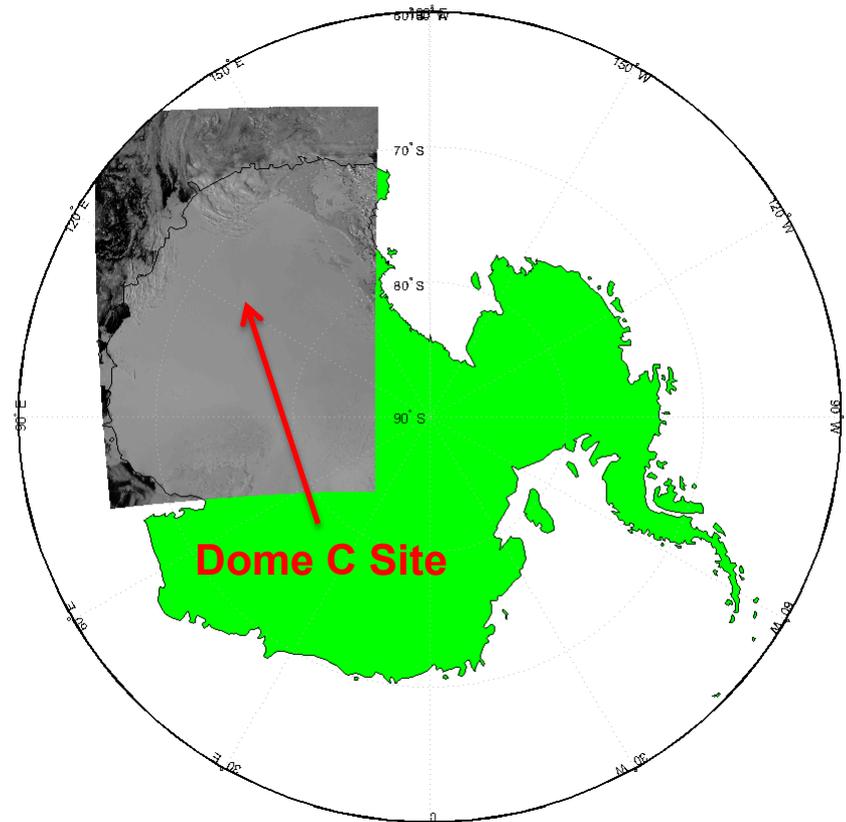
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Antarctic Dome C Observations

- The Dome C measurements were carried out to confirm that a faster-than-expected degradation of the VIIRS radiometric response occurs for selected spectral bands in the visible and near-infrared region, with other bands remaining stable
- The Antarctic Dome C site is located in a high polar plateau region with the mean elevation of 3.2 km above sea level:
 - the site's characteristics make it very suitable for radiometric calibration and validation of satellite sensors as one of the CEOS LANDNET sites
- Because of its broad imaging swath, VIIRS acquires Dome C imagery several times per day:
 - To reduce effects of changing scattering angles, only a small subset of these images was selected for the presented analysis by excluding datasets with the solar zenith angle larger than 75° or with the satellite view zenith angle larger than 15° (at the Dome C site)

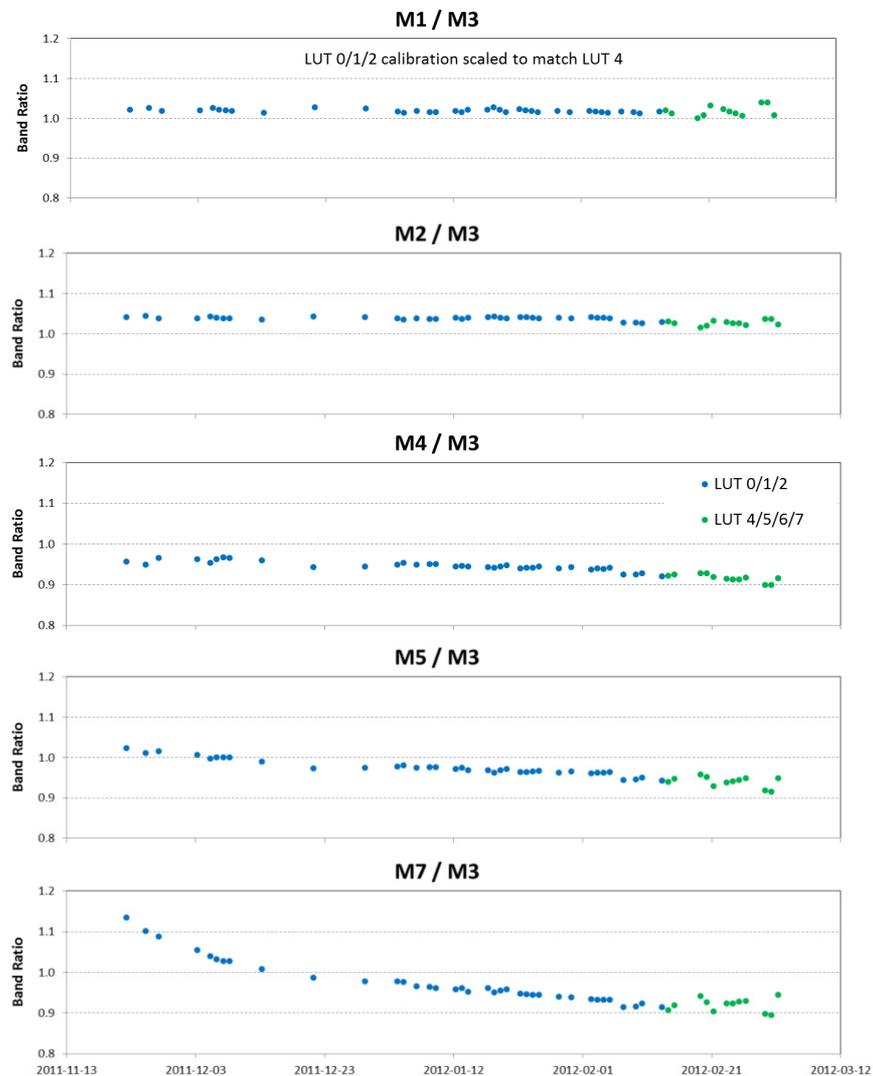


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Monitoring VIIRS Sensitivity Degradation

- To further account for the solar zenith angle variability, the analysis is based on TOA (top-of-atmosphere) reflectance
- To mitigate bidirectional reflectance effects even more, band ratios were calculated between the bands M1, M2, M4 to M7, and the band M3, which was the most stable
- The bands at the shorter wavelengths, M1 with the nominal center wavelength of 412 nm, M2 (445 nm), and M3 (488 nm), are shown to be stable
- Bands M4 (555 nm) and M5 (672 nm) are moderately affected by the sensitivity degradation: their radiometric response decreased by approximately 5% and 10%, respectively, over the period of the first three months of the mission
- The largest decline occurred for the near-infrared band M7 (865 nm): around 20%
- Regular updates of the calibration coefficient lookup table (LUT) have stabilized VIIRS radiometric calibration starting with the LUT no. 4





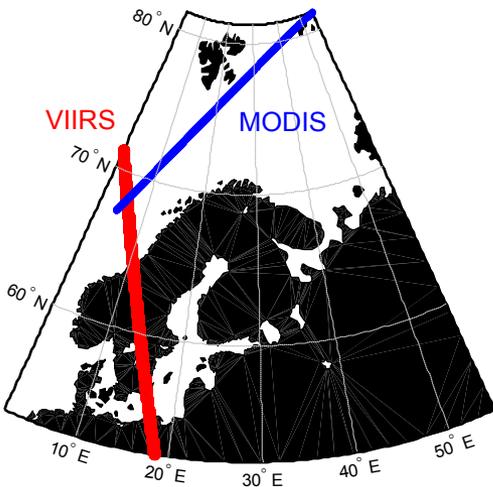
VIIRS – MODIS SNO Prediction and Analysis

- Based on information from the NOAA / STAR / NCC SNO (simultaneous nadir overpass) prediction website, <https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions>, included all SNO datasets acquired by Suomi NPP VIIRS and by MODIS from both Aqua and Terra during six months since mid-February 2012
- The SNOs occur over snow-covered Antarctica (some at the Dome C site), providing bright surfaces in the VisNIR bands, as well as over northern Alaska, Canada, Greenland, Scandinavia, Siberia, and ocean (both dark and bright scenes)

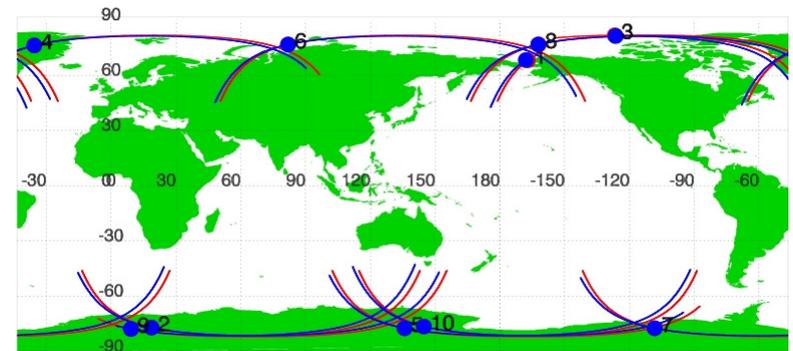
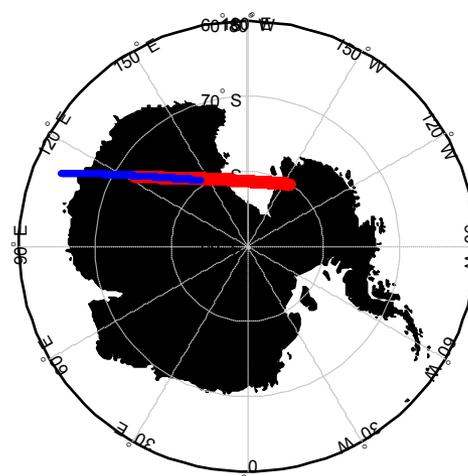
Table of predicted SNOs for the next 14.0 days since TLE Epoch: 2/11/2012

Index	Date (AQUA)	Time (AQUA)	AQUA Lat,Lon	Date (NPP)	Time (NPP)	NPP Lat,Lon	Distance(km)	Time Diff (sec)
1	02/12/2012	14:07:39	68.18,-167.05	02/12/2012	14:06:26	68.31,-168.01	42.15	73
2	02/12/2012	14:54:19	-76.97, 18.64	02/12/2012	14:54:19	-76.97, 18.68	1.08	0
3	02/12/2012	15:41:09	81.79,-126.79	02/12/2012	15:42:22	81.33,-126.43	50.45	73
4	02/15/2012	06:21:38	76.25, -35.59	02/15/2012	06:20:45	76.25, -35.60	0.21	53
5	02/15/2012	07:10:43	-77.31, 135.83	02/15/2012	07:11:07	-77.32, 135.89	1.70	24
6	02/17/2012	22:37:58	76.73, 81.90	02/17/2012	22:37:29	76.73, 81.94	1.10	29
7	02/17/2012	23:27:13	-77.31,-108.29	02/17/2012	23:28:02	-77.30,-108.40	2.89	49
8	02/20/2012	14:54:28	76.76,-162.13	02/20/2012	14:54:24	76.75,-162.23	2.77	4
9	02/20/2012	15:43:35	-77.71, 9.21	02/20/2012	15:44:48	-77.70, 9.18	0.76	73
10	02/23/2012	06:21:41	-76.37, 144.76	02/23/2012	06:20:44	-76.37, 144.78	0.54	57

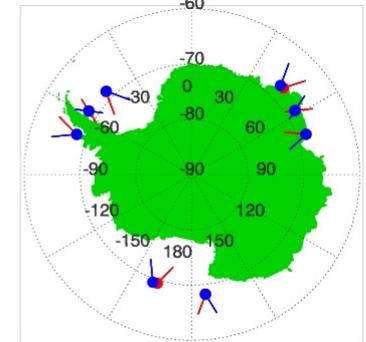
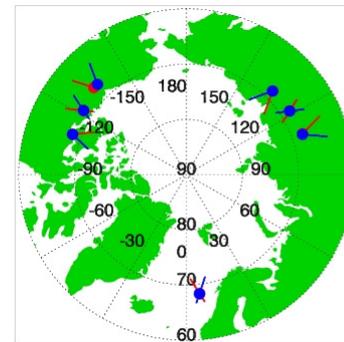
Suomi NPP and Terra SNO Example



Suomi NPP and Aqua SNO Example

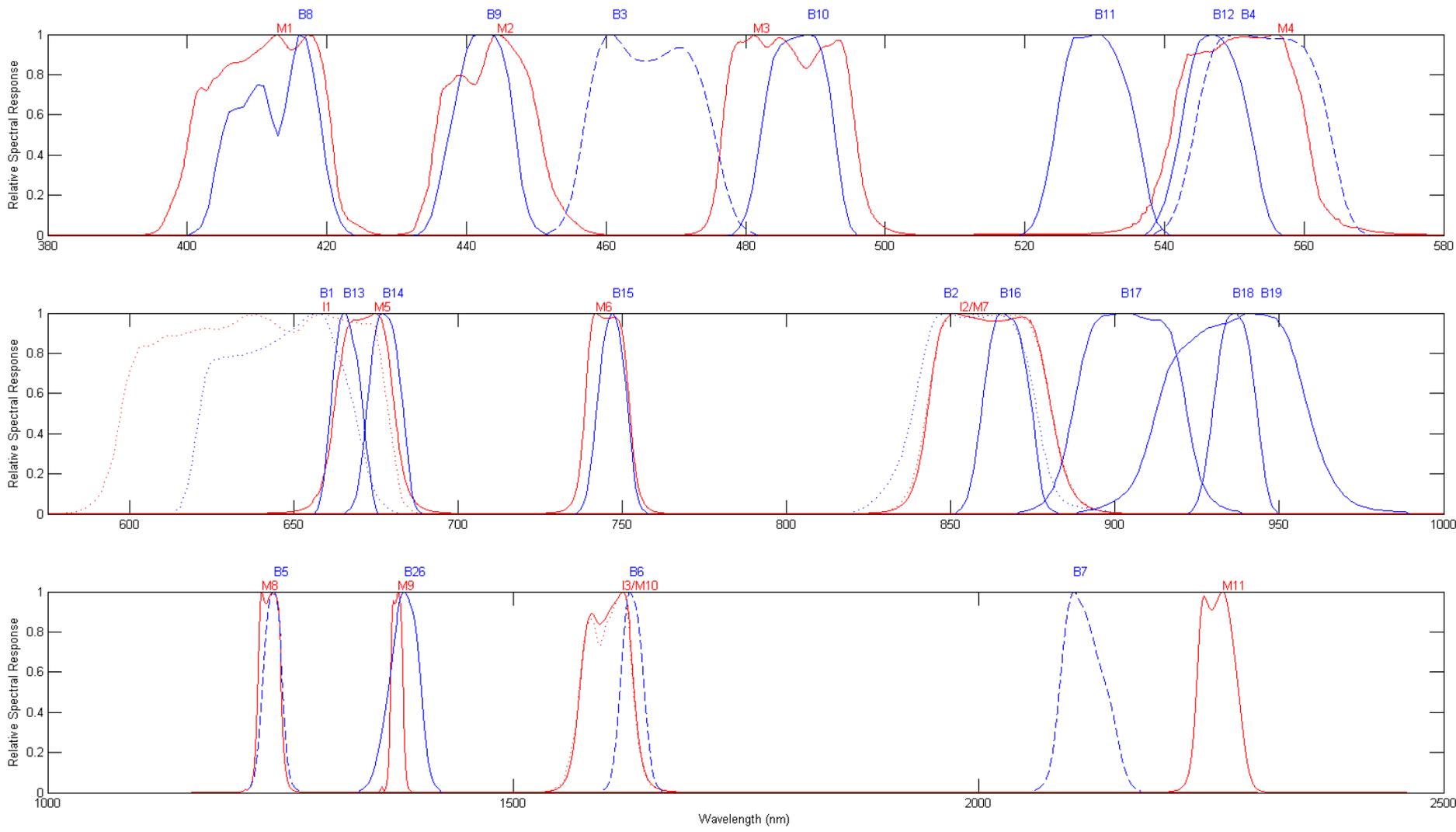


Red line: AQUA Blue line: NPP TLE Epoch: 2012/2/11



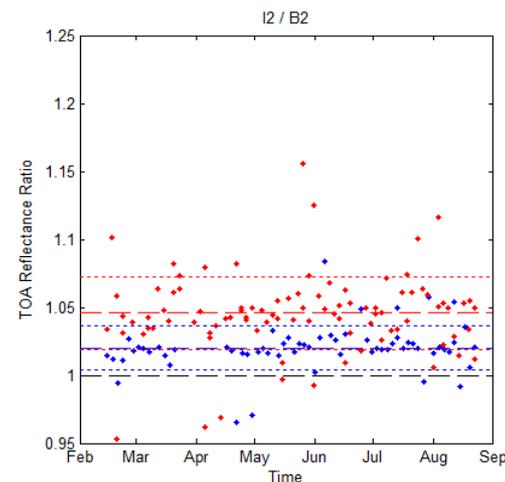
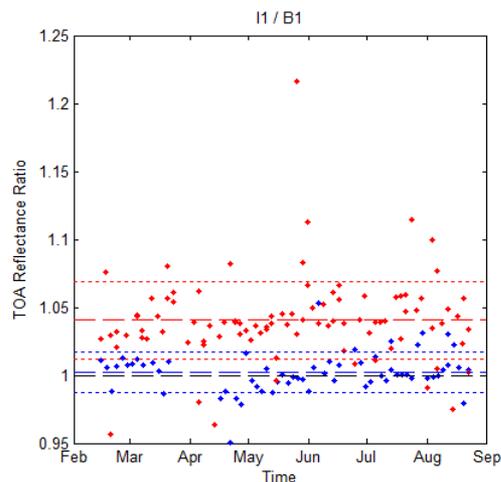
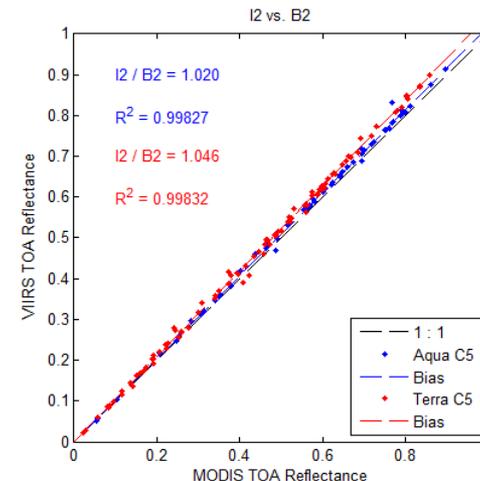
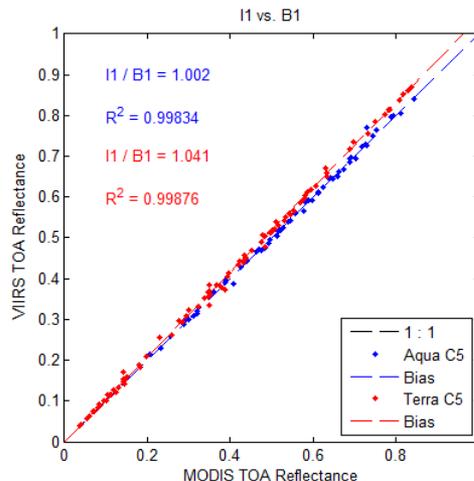


Spectral Response Comparison



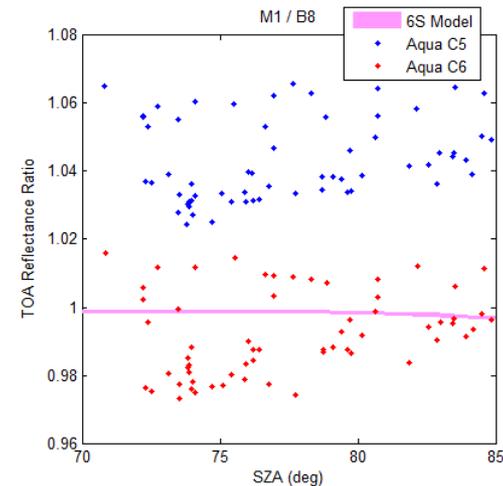
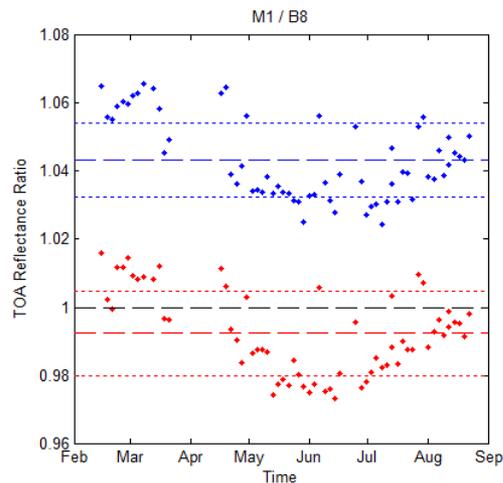
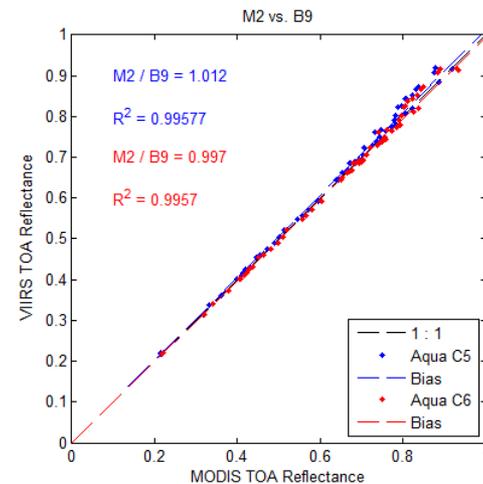
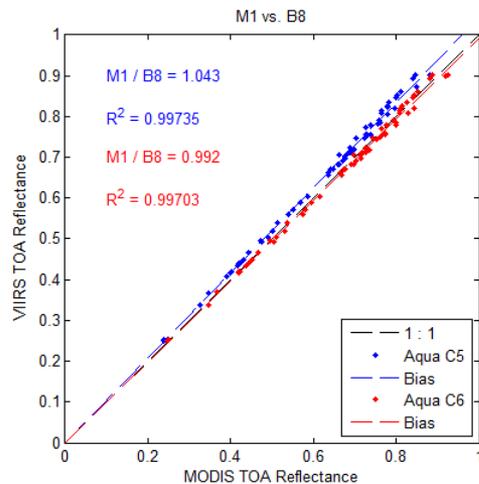
Aqua vs. Terra in VIIRS – MODIS SNO Data

- Compared TOA reflectance measured by VIIRS and MODIS during the SNO events between Suomi NPP and either Aqua or Terra
- For the terrestrial ecology bands (used in NDVI calculations: VIIRS bands I1 and I2, MODIS bands 1 and 2):
 - There is no bias when comparing NPP VIIRS band I1 with Aqua MODIS band 1
 - There is only small bias (~2%) between VIIRS band I2 and Aqua MODIS band 2
- When VIIRS is compared with Terra MODIS, the biases are larger (~4%):
 - There are clearly biases between MODIS bands 1 and 2 measurements from Aqua and Terra (similar biases occur for other bands as well)
- Collection 5 MODIS Level 1B data were used for the Aqua vs. Terra comparison because Collection 6 products are not yet available for Terra MODIS



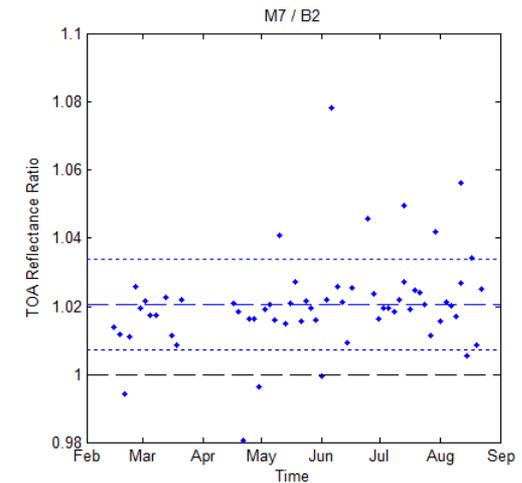
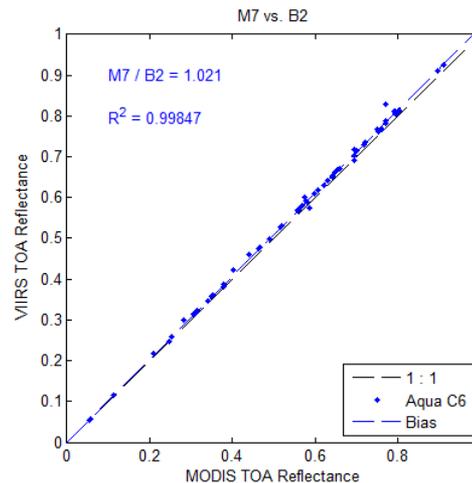
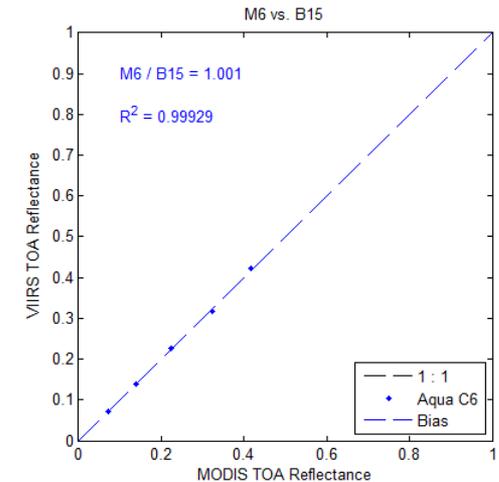
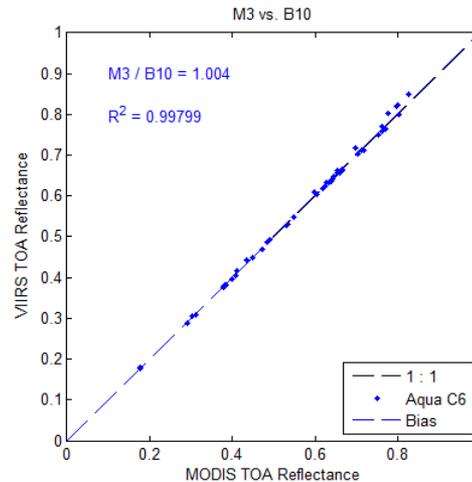
MODIS Collection 5 vs. Collection 6

- Aqua MODIS radiometric calibration has been recently improved in production of Collection 6 datasets
- The largest change has occurred for bands 8 and 9 that are comparable with VIIRS bands M1 and M2, respectively
- When, instead of Collection 5 data, Aqua MODIS Collection 6 data are used in SNO comparisons with VIIRS :
 - M1 bias is reduced from +4% to -1%
 - M2 bias is reduced from 1% to near zero
- Observed temporal variation of the M1 bias may be due to VIIRS polarization sensitivity (will investigate)
- 6Sv radiative transfer modeling conducted for VIIRS band M1 (including out-of-band response) and for MODIS band 8 (using a snow surface reflectance and a range of atmospheric conditions) agrees better with the Collection 6 data



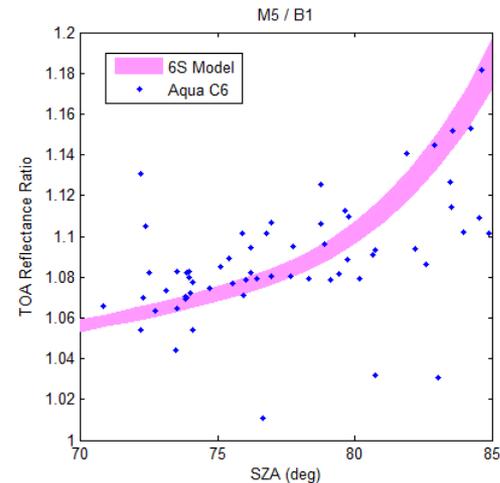
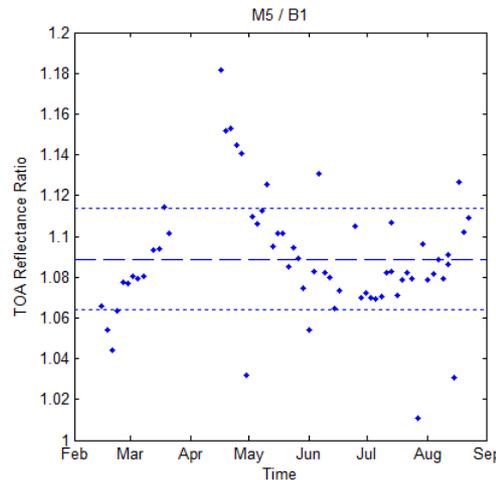
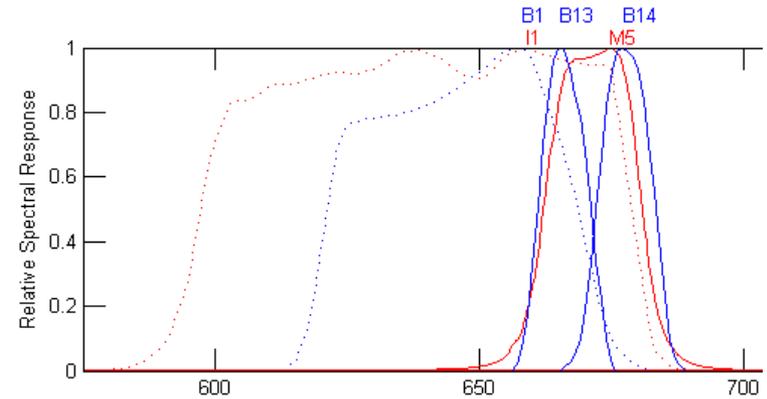
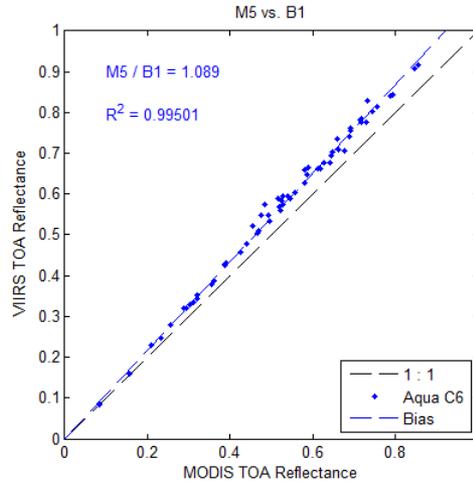
SNO Comparisons for Other VisNIR Bands

- VIIRS band M3 measurements agree very well with Aqua MODIS band 10 Collection 6 data: no bias is observed
- VIIRS band M6 and MODIS band 15 data are often saturated in SNO observations:
 - A few data points collected during the last six months show no bias (with large uncertainty)
- VIIRS band M7 shows 2% bias versus Aqua MODIS band 2 (similarly to band I2 which has almost the same spectral response)
 - Bands M7 and I2 are the most affected by the VIIRS telescope throughput degradation, but the bias remains stable (within uncertainty of the SNO measurements) thanks to weekly updates of the radiometric calibration coefficients



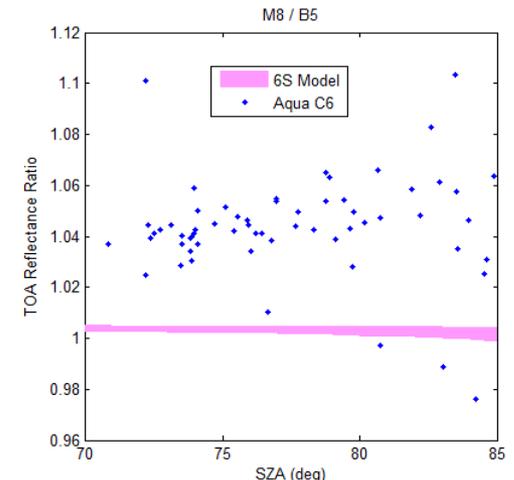
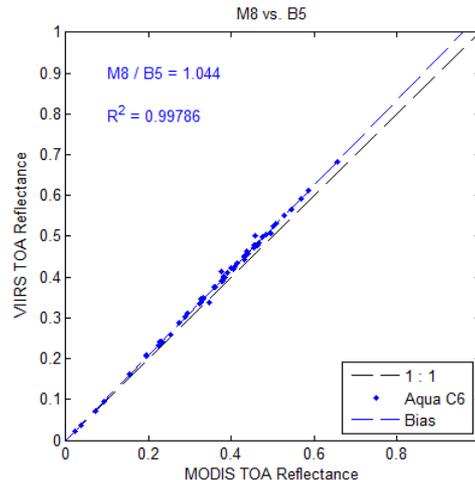
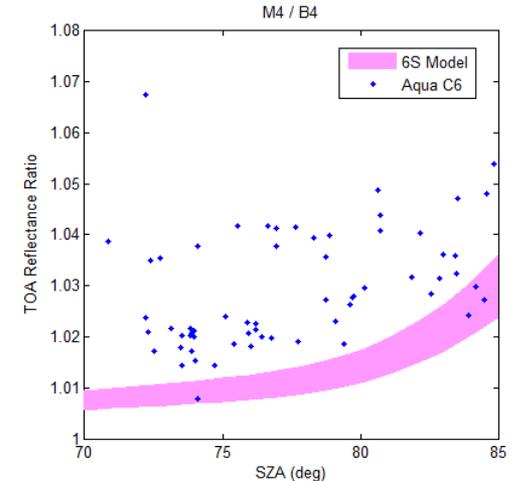
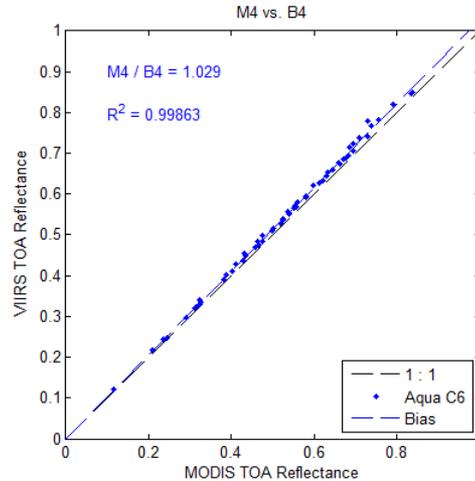
VIIRS band M5 vs. MODIS band 1

- In SNO observations, there is a large bias (~9%) between VIIRS band M5 and MODIS band 1
- Spectral responses of MODIS band 1 and VIIRS band M5 are quite different (unlike for band I1 which shows no bias from MODIS band 1)
- Although the average bias is ~9%, the bias changes with time between 5-6% and ~18%
- The temporal dependence is correlated with the solar zenith angle (SZA) changes
- 6Sv radiative transfer modeling (using a snow surface reflectance and a range of atmospheric conditions) predicts a very similar SZA dependence for the SNO observations



VIIRS Bands with Larger Biases

- In SNO observations, there is a bias of ~3% between VIIRS band M4 and MODIS band 4
- Dependence of this bias on the solar illumination conditions (atmospheric path) can be partially explained by the 6Sv radiative transfer modeling, but the magnitude of the bias cannot
- Origins of the M4 bias need to be further investigated
- There is also a bias of ~4% between VIIRS band M8 and MODIS band 5
- 6Sv modeling predicts only a very small bias in this case
- Uncertainty of radiometric calibration for these SWIR bands is higher than for the VisNIR bands both for VIIRS and for MODIS





Summary

- Measurements acquired by VIIRS at the Dome C pseudo-invariant calibration site in Antarctica has confirmed that a faster-than-expected degradation of the radiometric response occurs for selected spectral bands in the visible and near-infrared region, with other bands remaining stable
 - Demonstrates usefulness of the Dome C site for future monitoring of the VIIRS radiometric stability
- SNO comparisons with MODIS have shown that the implemented regular updates of the radiometric calibration coefficients have stabilized the VIIRS radiometric calibration and that biases between the Suomi NPP VIIRS and Aqua MODIS measurements in reflective solar bands are small:

VIIRS Band	MODIS Band	SNO Bias	R ²
I1	1	0	0.998
I2	2	2%	0.998
M1	8	-1%	0.997
M2	9	0	0.996
M3	10	0	0.998
M4	4	3%	0.999
M5	1	9%	0.995
M6	15	0	0.999
M7	2	2%	0.998
M8	5	4%	0.998