Monitoring Stability of VIIRS Radiometric Response

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NOAA / NESDIS / STAR

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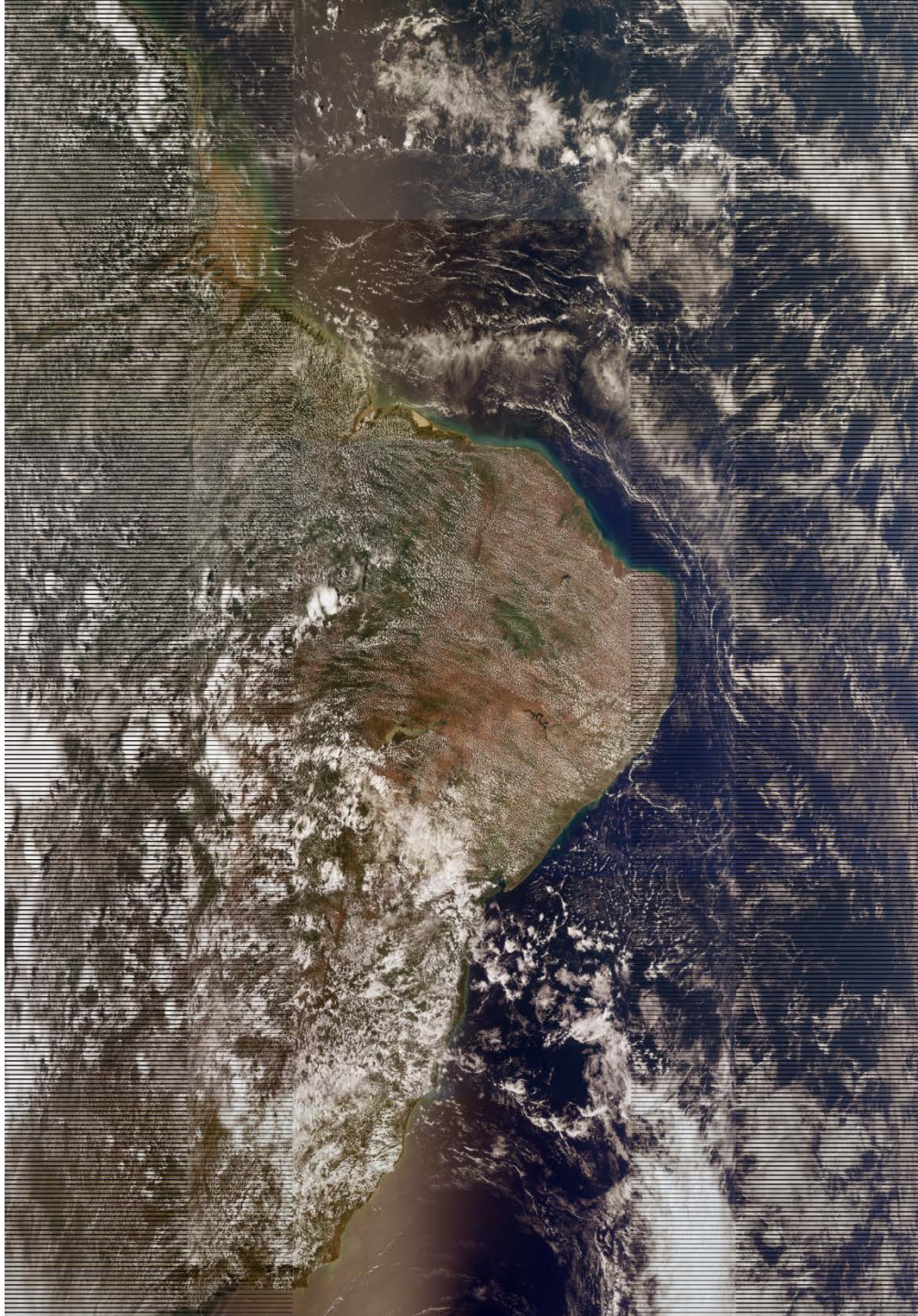
First Image from Suomi NPP VIIRS

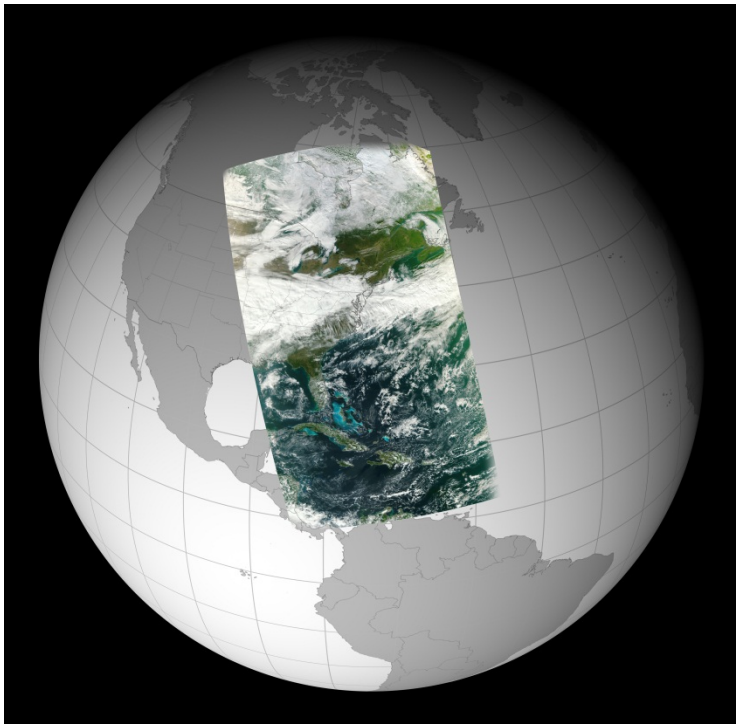
- Opening of the VIIRS nadir door on November 21, 2011
- Global observations of land, ocean, and atmosphere with high (~daily) temporal resolution
- Builds on a long heritage of operational and research earth observing imaging radiometers with moderate resolution:
  - **AVHRR** (Advanced Very High Resolution Radiometer) on NOAA and MetOp satellites, with 5 (6) bands, since 1979
  - **MODIS** (Moderate-Resolution Imaging Spectroradiometer) on EOS Terra and Aqua, with 36 bands, since 1999
  - **SeaWiFS** (Sea-viewing Wide Field-of-view Sensor), since 1997
  - **OLS** (Operational Linescan System) on DMSP, since 1972
- Characteristics:
  - Multispectral scanning radiometer
  - 22 bands between 400 nm and 12 µm:
    - 5 Imaging, 375-m bands
    - 16 Moderate-resolution, 750-m bands
    - 1 broadband Day/Night, 750-m band
  - 12-bit quantization
  - 3000 km swath width



Bands M5, M4, M2 shown as RGB

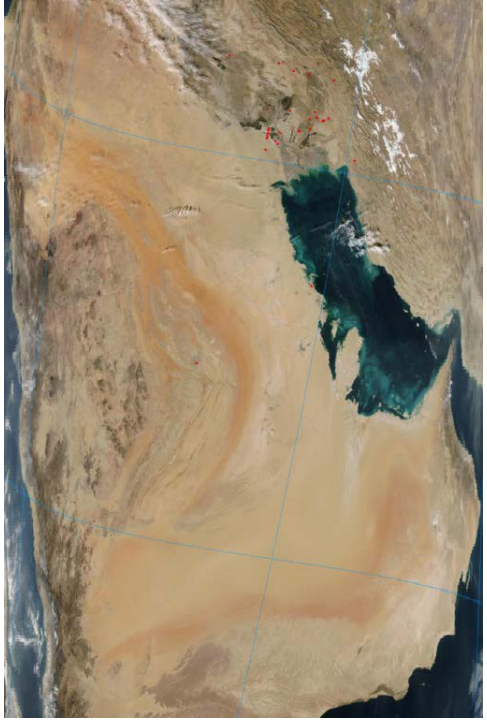
VIIRS Novel Spatial Sampling Characteristics

Three pixel aggregation zones reduce GSD growth as a function of scan angle and allow for extended swath width

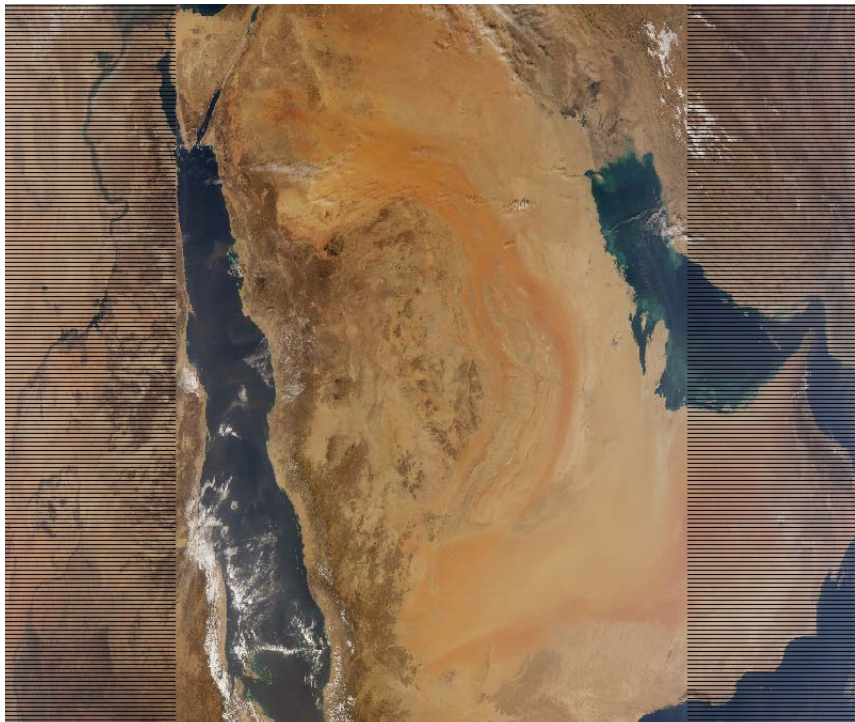


Extent of a multi-granule, single-swath image from VIIRS (courtesy of NASA and University of Wisconsin - Madison)

MODIS



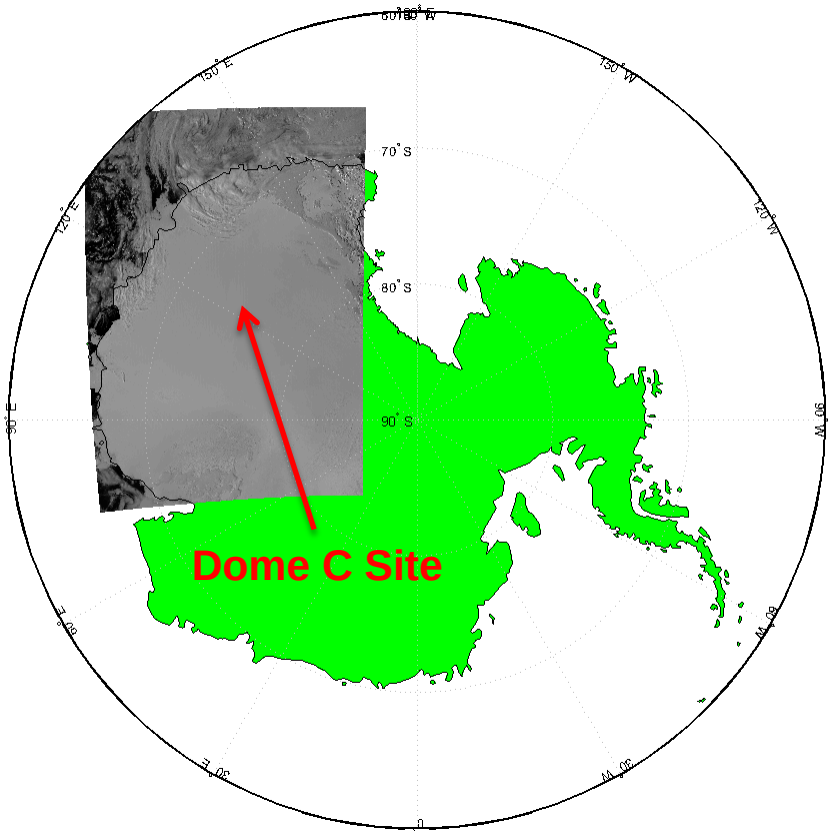
VIIRS



Bands M5, M4, M2 shown as RGB

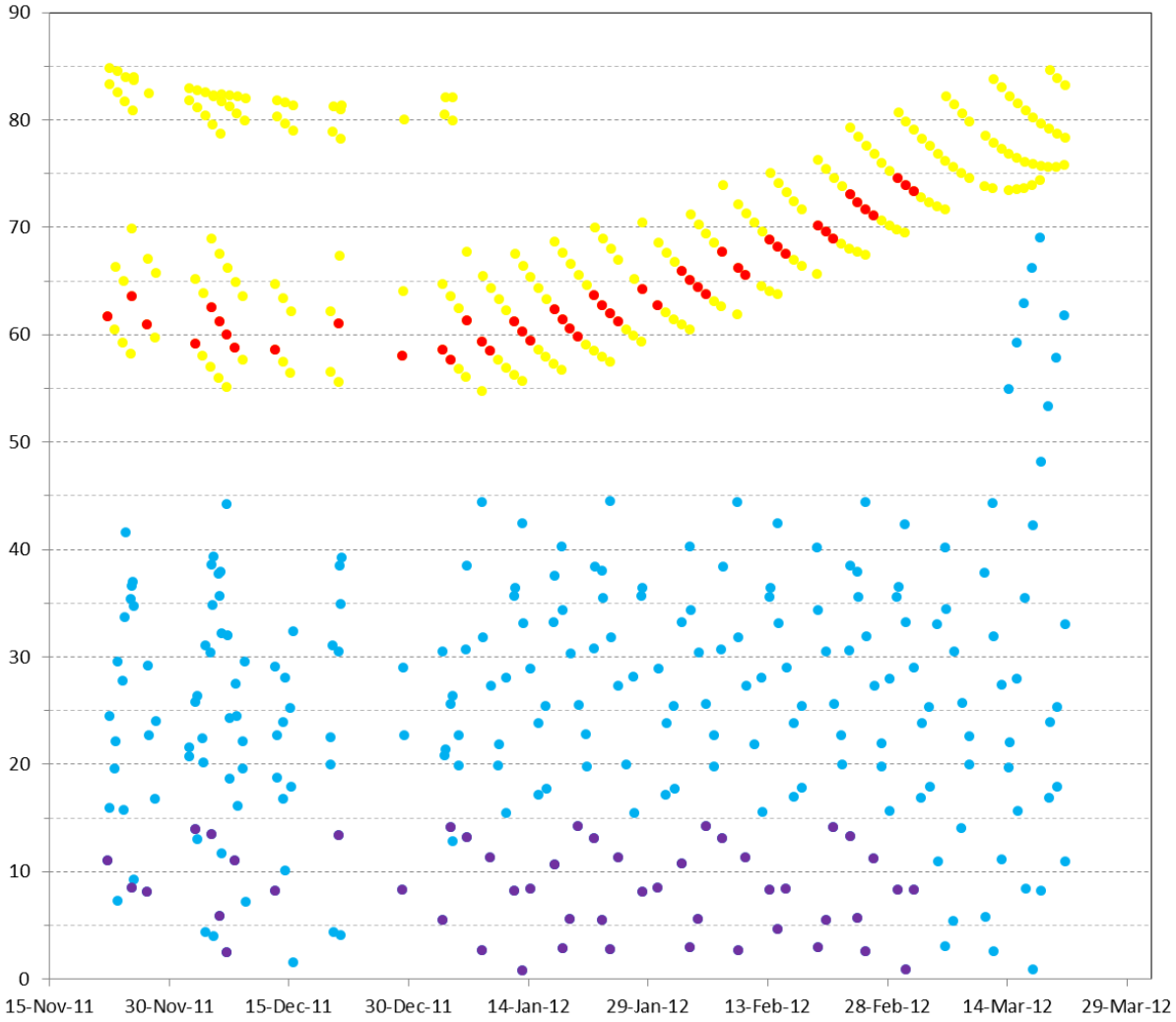
Antarctic Dome C Observations

- The Antarctic Dome C site is located in the High Polar Plateau Region at 75°06'S, 123°21'E with mean elevation of 3.2 km above sea level
- The site has the following characteristics that make it very suitable for radiometric calibration and validation of satellite sensors:
  - o Surface is flat and covered with uniformly distributed, permanent snow
  - o Temperatures are extremely cold and stable, except for seasonal variability
  - o Skies are clear most of the time, with more than 75% of days being cloud free
  - o Atmosphere above the site has low water vapor and aerosol loading, thus atmospheric effects are small
- **TOA (top-of-atmosphere) reflectance measured by VIIRS at the Dome C site was averaged over a 48×48-pixel area to reduce effects of radiometric response non-uniformity (striping)**
- **To mitigate BRDF effects, band ratios were calculated between the bands M1, M2, M4 to M7, and the band M3**



An example of a 4-granule VIIRS image that includes the Dome C site in Antarctica (band M5)

Data Quality Assurance Without Corrections

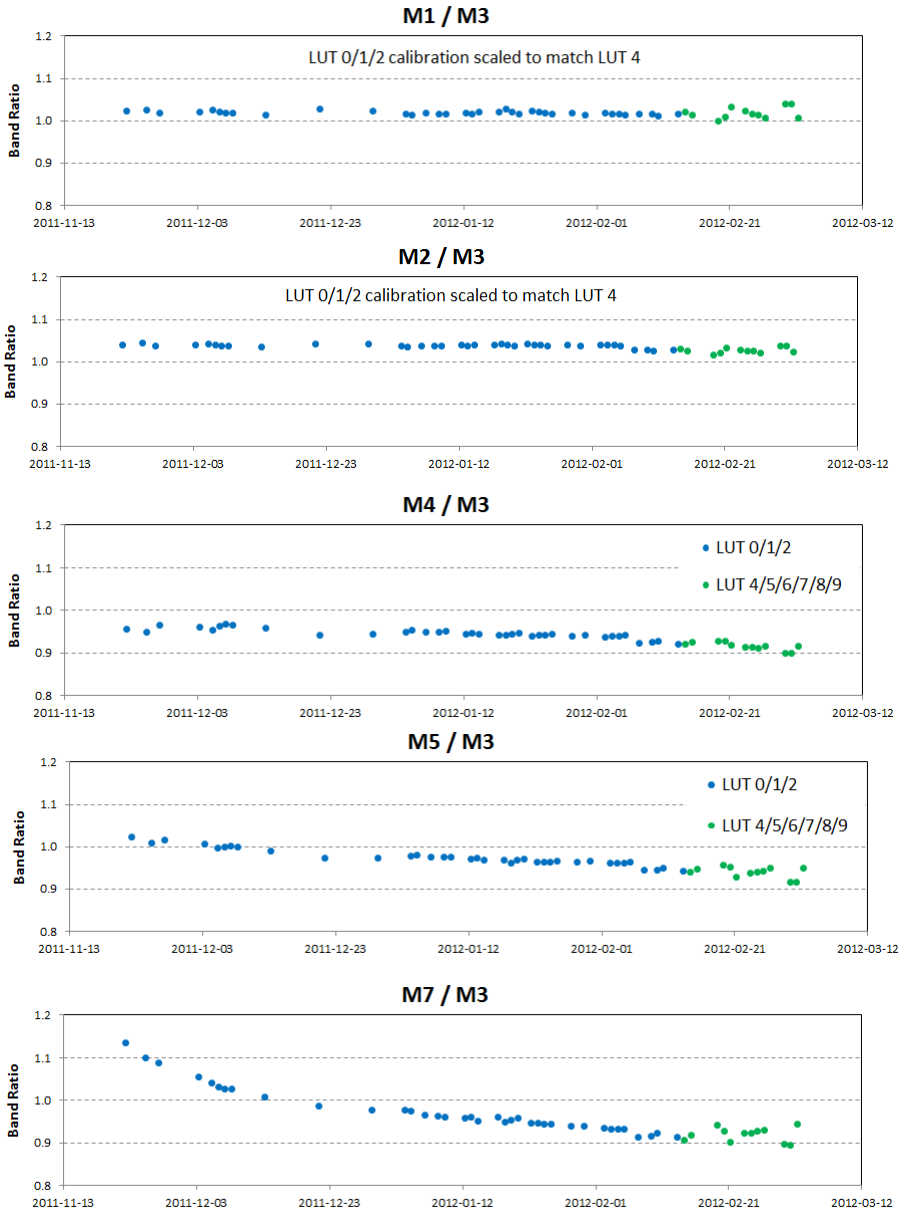


Restricted solar zenith angles and satellite viewing angles:

- Data points with solar zenith angle larger than 75° or satellite zenith angle larger than 15° were excluded from the analysis (yellow and blue dots)
- Only points shown as red and magenta dots were included

Monitoring VIIRS Sensitivity Degradation

- Antarctic Dome C data have shown that VIIRS Earth View (EV) measurements changed with time similarly to the onboard solar diffuser observations
- Changes of radiometric response are similar both in spectral dependence and in magnitude:
  - o The “blue” band M2 is almost stable
  - o The “red” band M5 is moderately affected (~10% change over 3-4 months)
  - o The largest decline occurs for the NIR band M7 (~20%)
- Scaling of earlier measurements according to calibration coefficient lookup table (LUT) changes shows continuity of radiometric responses
- Weekly LUT updates have stabilized radiometric responses starting with LUT 4 (unfortunately the ending of austral summer increased uncertainty of recent Dome C measurements)

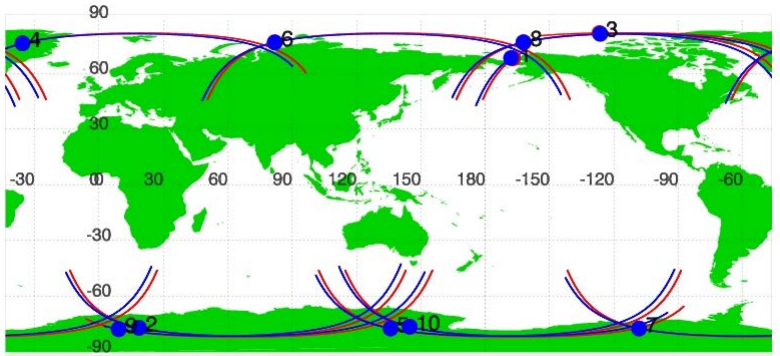


SNO Prediction and Analysis

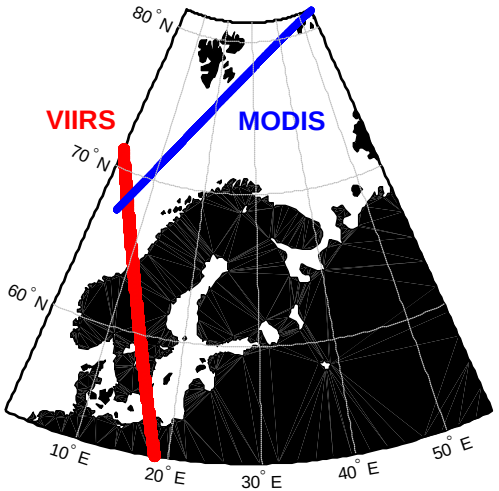
- Based on information from the NOAA/STAR/NCC SNO (simultaneous nadir overpass) prediction website, https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions, included all SNO datasets acquired by NPP VIIRS and by MODIS from both Aqua and Terra between February 14 and March 20, 2012
- For each SNO, averaged valid VIIRS and MODIS pixels from a 12-km by 12-km area selected at the intersection of the satellite ground tracks (16×16 750-m pixels for VIIRS and 12×12 1-km pixels for MODIS): typically provides closer spatial coincidence than temporal one (still within ~1-2 min.)
- The NPP – Aqua SNOs occurred over snow-covered Antarctica (some at the Dome C site), providing bright surfaces in the VisNIR bands, while the NPP – Terra SNOs occurred over northern Siberia, Scandinavia, and ocean (both dark and bright scenes)

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

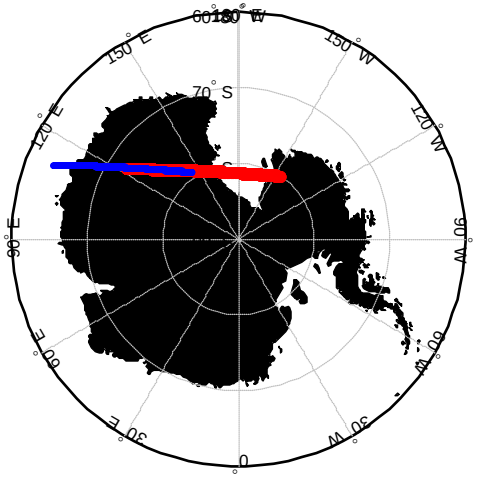
Index	Date (AQUA)	Time (AQUA)	AQUA Lat,Lon	Date (NPP)	Time (NPP)	NPP Lat,Lon	Distance(km)	Time Diff (sec)
1	02/12/2012	14:07:39	68.18,-167.05	02/12/2012	14:06:26	68.31,-168.01	42.15	73
2	02/12/2012	14:54:19	-76.97, 18.64	02/12/2012	14:54:19	-76.97, 18.68	1.08	0
3	02/12/2012	15:41:09	81.79,-126.79	02/12/2012	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



NPP and Terra SNO Example

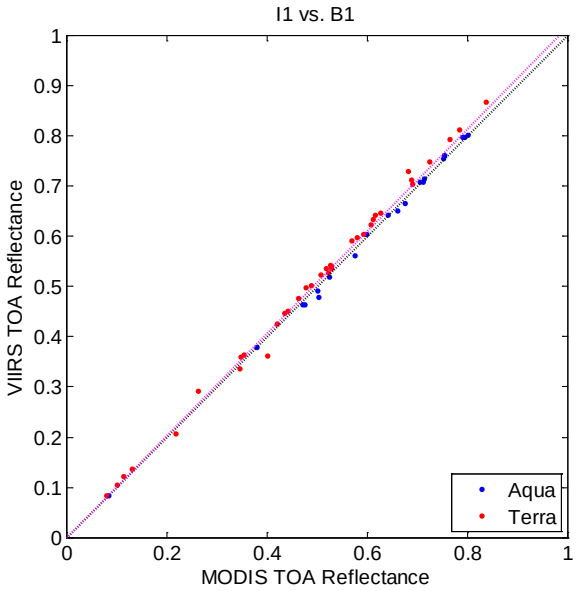


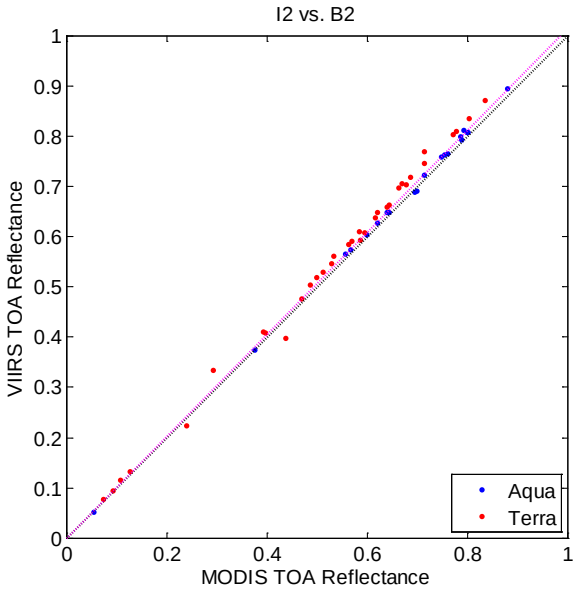
NPP and Aqua SNO Example



VIIRS vs. MODIS SNO Comparisons

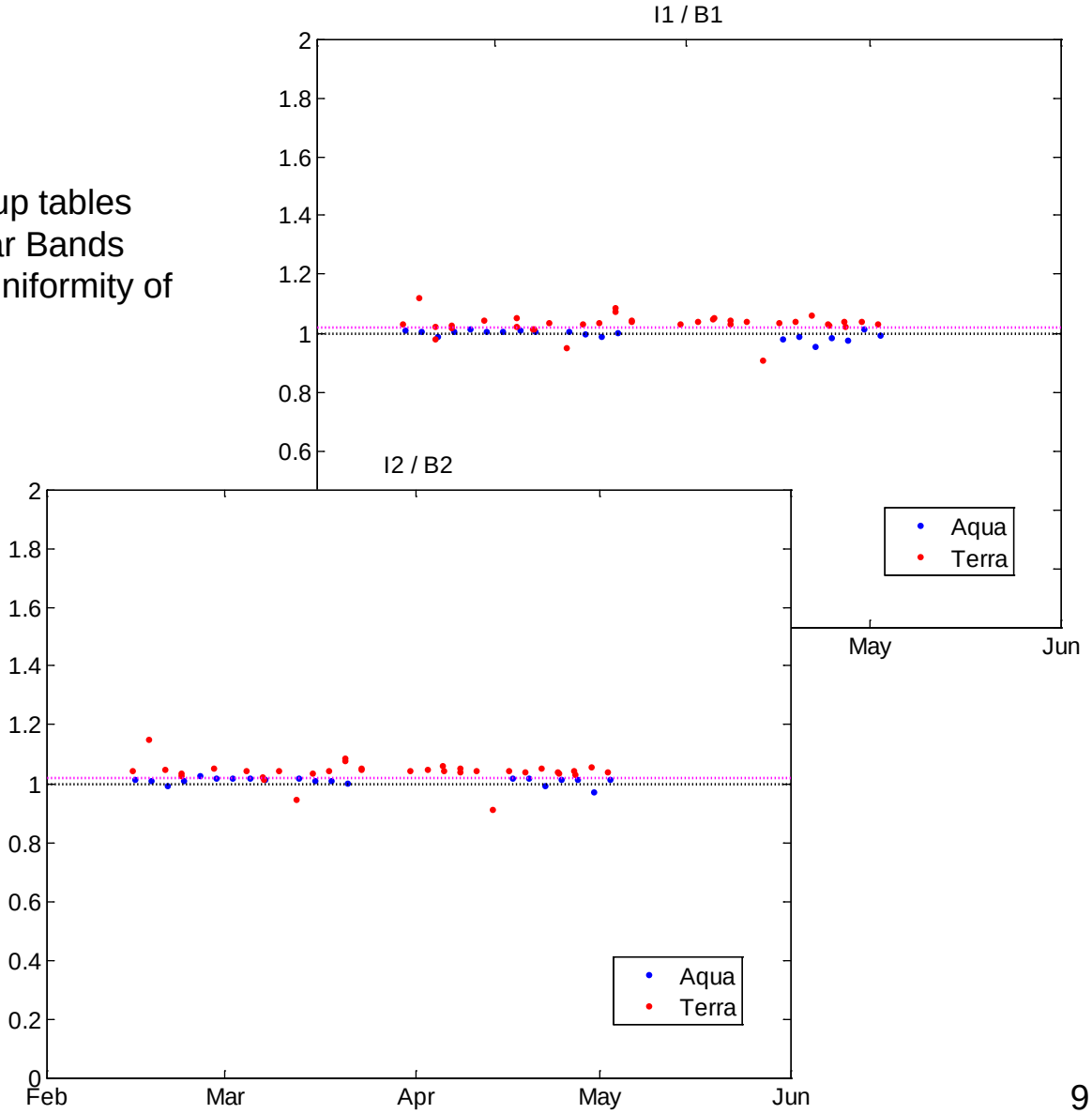
- Compared TOA (top-of-atmosphere) reflectance measured by VIIRS and MODIS at the SNO sites (accounts for solar zenith angle differences)
- Because of differences between spectral responses of VIIRS and MODIS bands, reflectance data do not match exactly
- The effect of the spectral response difference on the measured reflectance (spectral bias) was recently estimated using satellite hyperspectral data collected over the Antarctic Dome C site (Cao et al., submitted for publication)
- Ratios of the VIIRS band I2 and MODIS band 2 data (as well as I1 and band 1 data) agree very well with the prediction from that study
- This comparison confirms accuracy of the current radiometric calibration for VIIRS bands I2/M7, which are the bands the most affected by the mirror degradation anomaly
- Other VIIRS bands also display high correlation with MODIS counterparts: estimates of spectral biases for these bands are ongoing
- While Terra provides so far most of the low reflectance data, a small bias between Aqua and Terra data can be seen (will investigate)





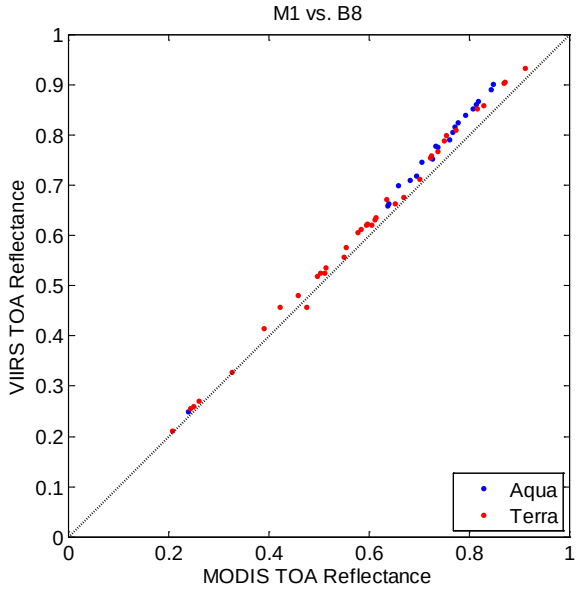
Monitoring Stability of Radiometric Calibration

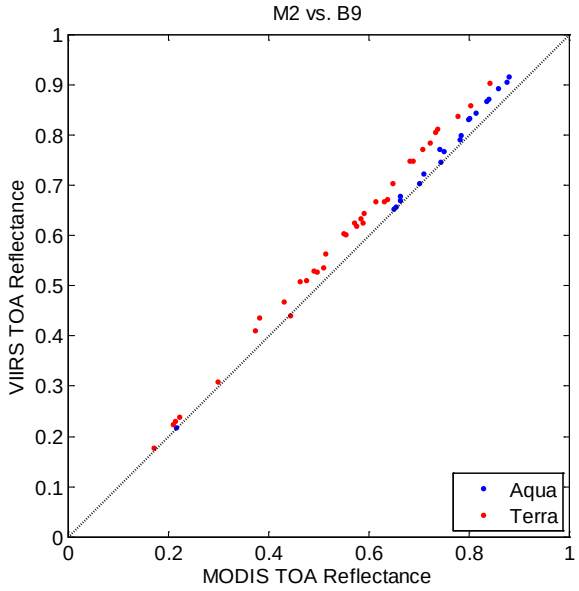
- Updates of the radiometric lookup tables (LUTs) for VIIRS Reflective Solar Bands have improved calibration and uniformity of radiometric response
- With the weekly LUT updates, radiometric calibration is stable and agrees well with MODIS measurements (barring small spectral biases)
- LUT updates should be applied more frequently than on the weekly basis: a scan-by-scan update is planned for July '12

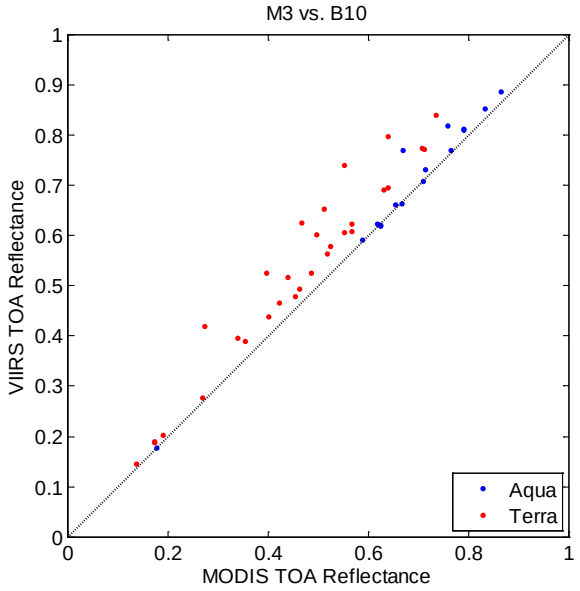


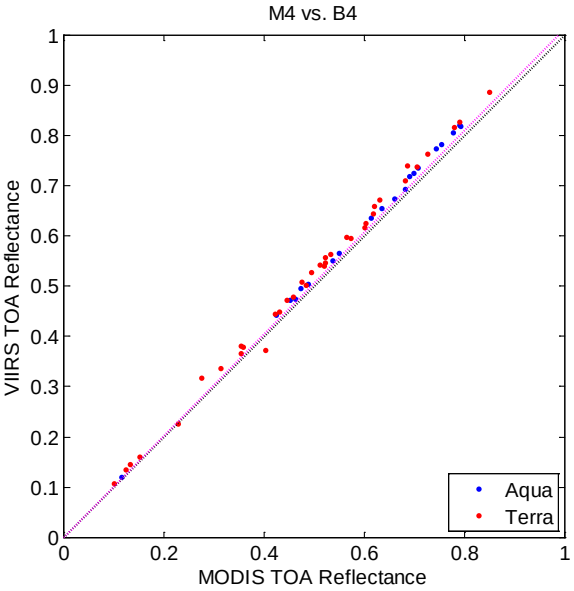
Backup Slides

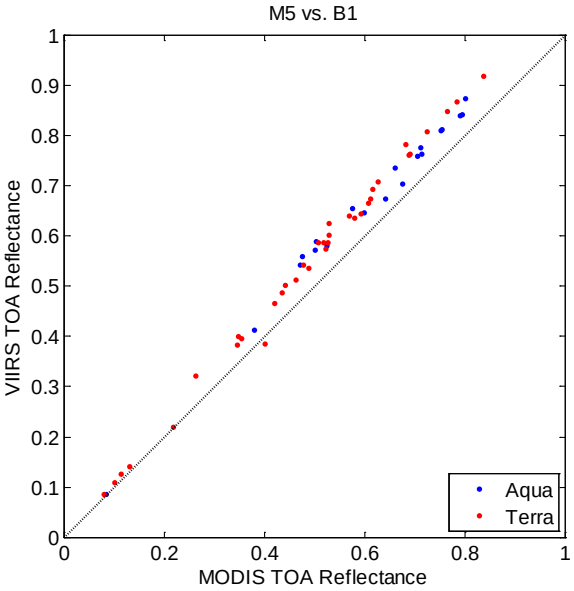
VIIRS vs. MODIS SNO Comparisons (cont.)

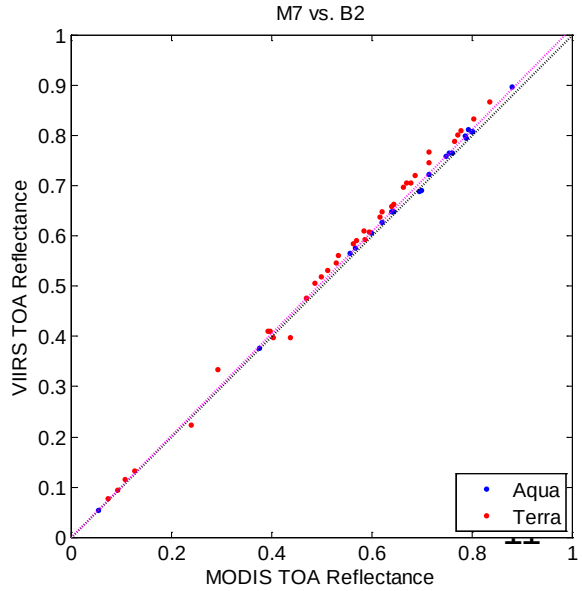




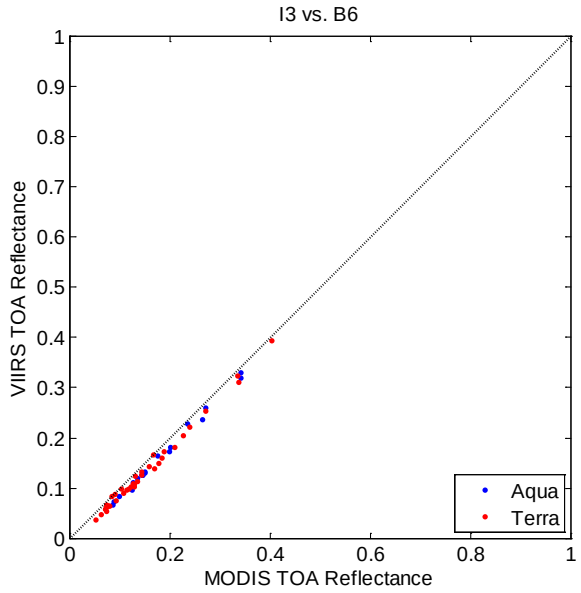


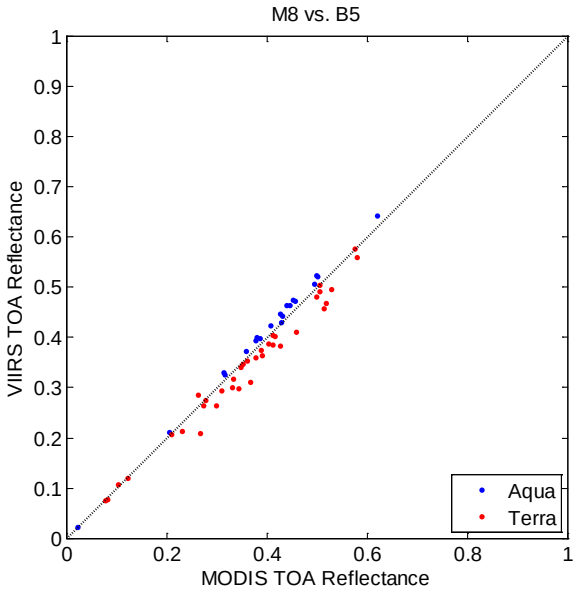


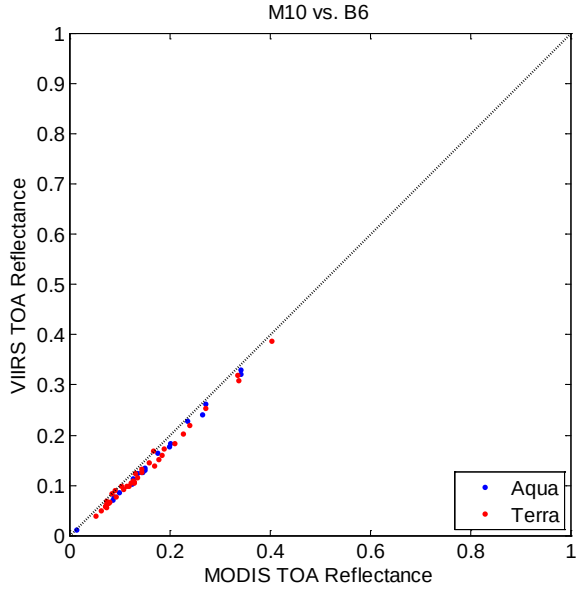


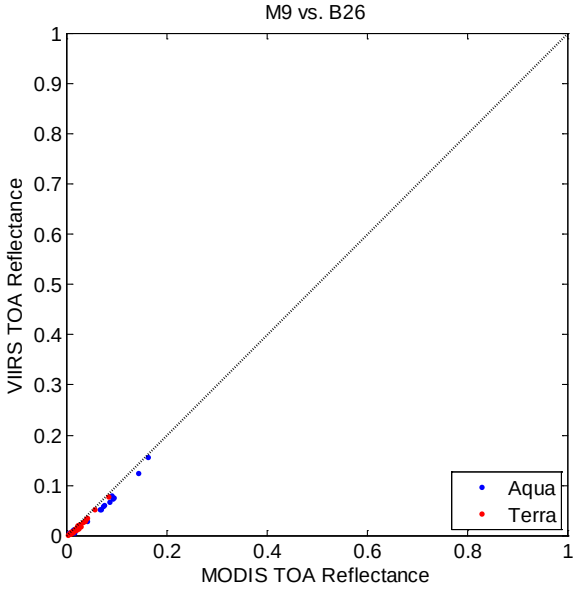


VIIRS vs. MODIS SNO Comparisons (cont.)









VIIRS-MODIS Spectral Response Comparison