Establishing Radiometric Consistency among VIIRS, MODIS and AVHRR Using SNO and SNOx methods

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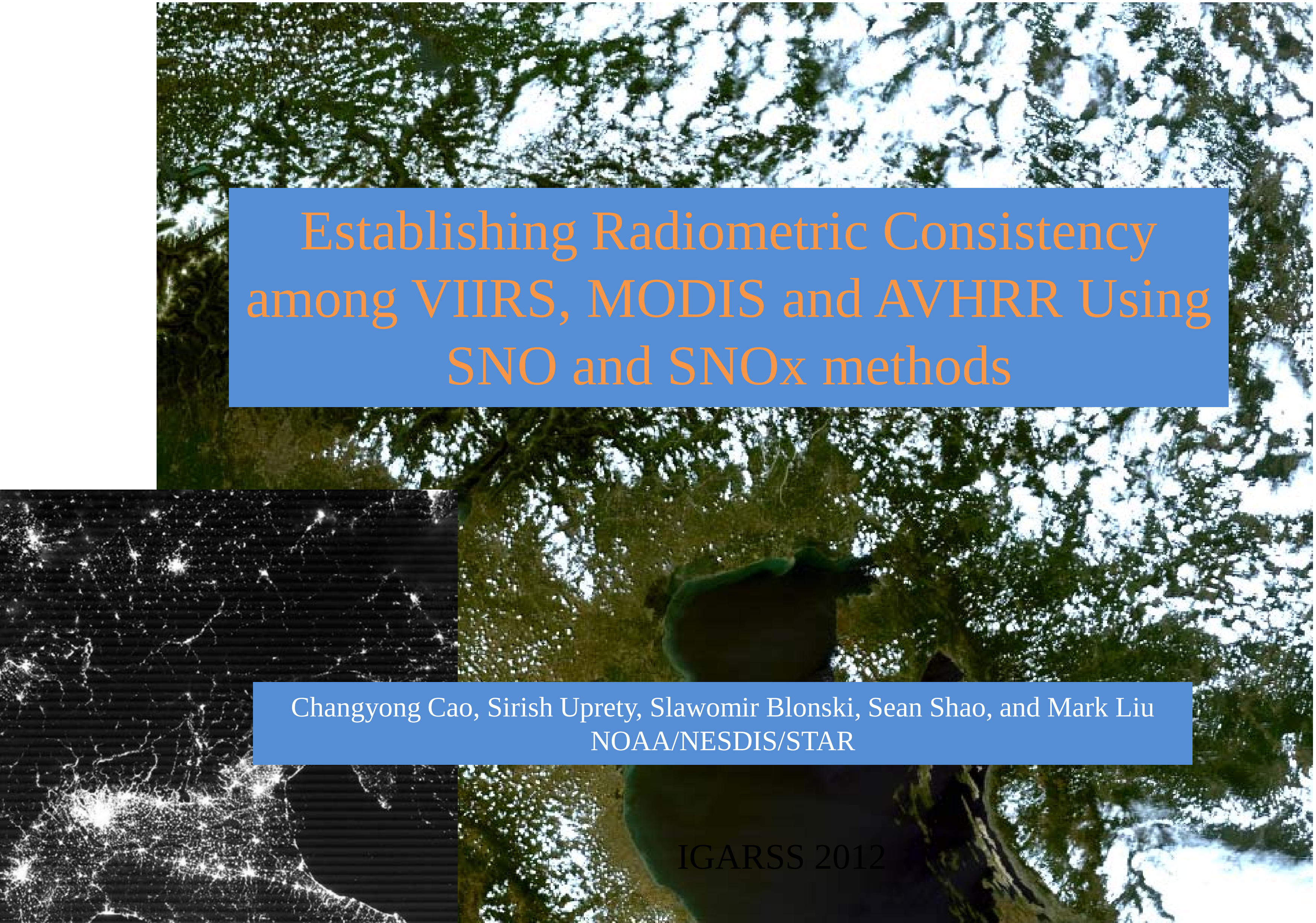
NOAA/NESDIS/STAR

IGARSS 2012



Background

•VIIRS Sensor Data Record (SDRs) have reached “Beta” maturity with relatively stable calibration. Data are now available to the public through http://www.class.noaa.gov

•VIIRS scan mirror degradation impact has been mitigated by more frequent (weekly, potentially daily) updates of calibration coefficients (AKA F-LUT).

•A decade of MODIS observations has been used as quasi-standard for calibration reference.

•AVHRR has accumulated more than 30 years of observations.

•Ensuring the radiometric consistency among VIIRS, MODIS, and AVHRR is important for all applications.

•This study examines the consistency using Simultaneous Nadir Observations (SNO) in both polar regions and low latitudes. All results are preliminary.

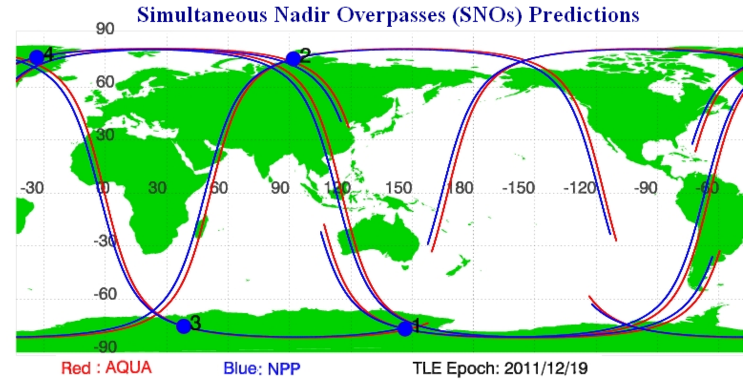
SNO and its extension to the Low Latitudes (SNOx)

•The Simultaneous Nadir Overpass (SNO) prediction software has been upgraded with the latest version of the orbital perturbation algorithm and a graphic interface

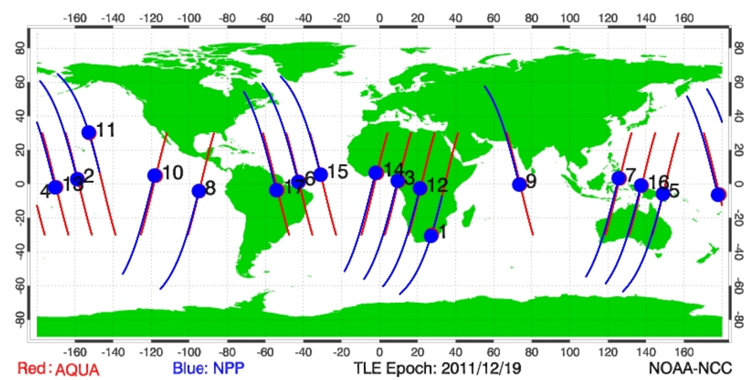
•New capabilities developed to predict both traditional SNOs and SNOx extended to the low latitudes

•The new system has been predicting routinely since NPP launch, and predicted SNOs with Aqua/MODIS are being used for VIIRS channel responsivity diagnosis

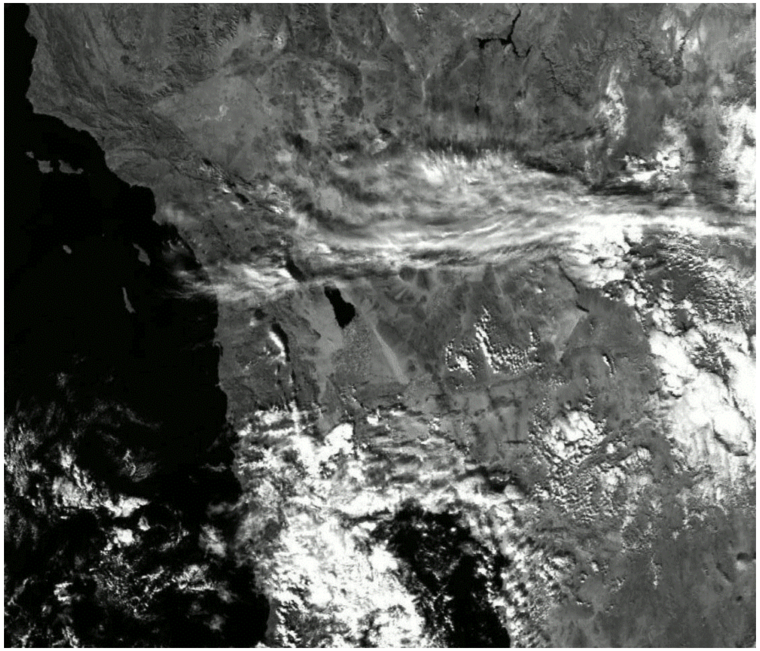
• The SNOs as well as daily NPP orbital predictions are readily available on the NCC website at: https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions



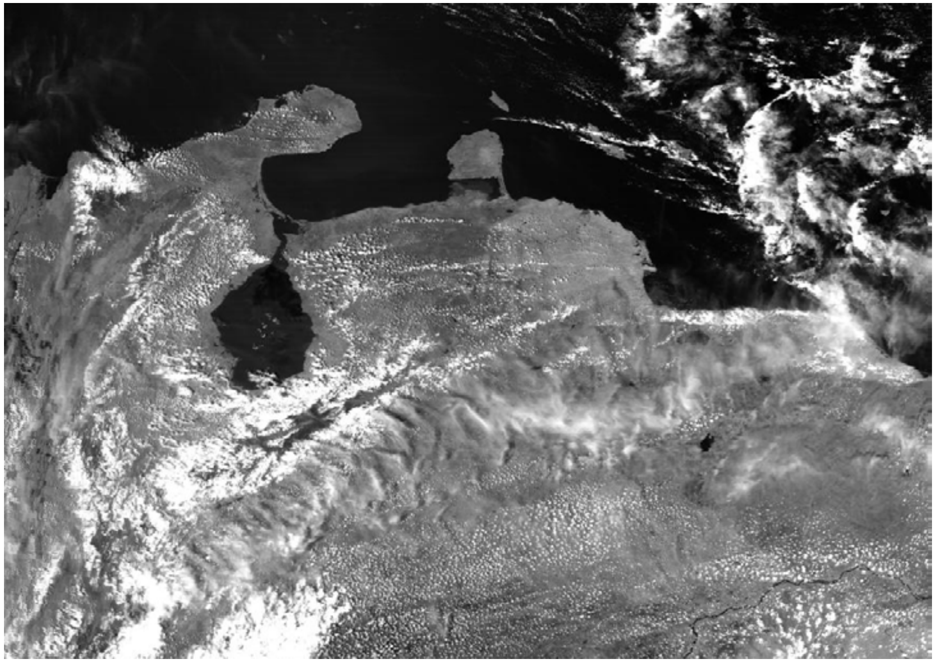
Index	Date	Time (AQUA)	AQUA Lat,Lon	NPP Lat,Lon	Distance(km)	Time Diff (sec)
1	12/21/2011	06:20:44	-76.77, 146.48	-76.77, 146.53	1.13	39
2	12/23/2011	21:47:58	75.93, 91.98	75.93, 91.93	1.46	11
3	12/26/2011	13:15:08	-75.29, 38.37	-75.29, 38.38	0.26	62
4	12/29/2011	06:20:26	76.76, -33.47	76.76, -33.49	0.67	43



Radiometric and Geospatial Differences between VIIRS and MODIS at SNOx



Before

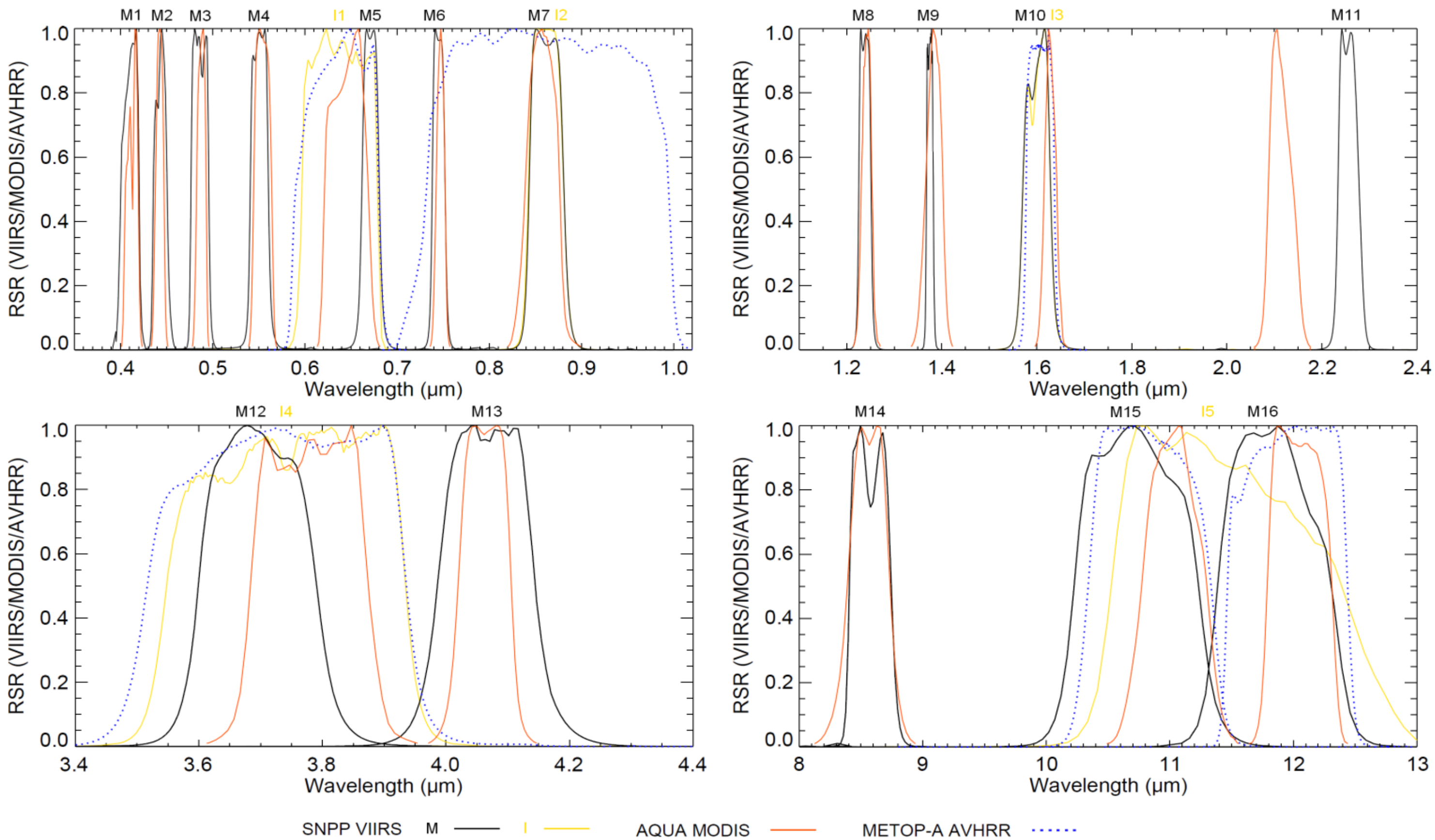


After

The difference image at the SNOx can be analyzed for both radiometric and geospatial differences between VIIRS and MODIS

Difference image not only shows cloud movement (within ~10 mins), but also geolocation displacements for land features before and after the Geo LUT update in Feb. 2012

VIIRS, AVHRR, and MODIS
Spectral Response Comparisons



Radiometric Biases between VIIRS and MODIS bands - synopsis

Comparisons between VIIRS and MODIS matching bands at the SNO/SNOx show that radiometrically:

-Bands match relatively well such as M3, M4, M7, M8?, M13-M16

-Blue bands M1-M2 (for ocean color) show biases up to 5% with MODIS C5, while bias much reduced with MODIS C6 (a known issue with MODIS C5 calibration, according to NASA report to GSICS EP in May 2012)

-Bands have large biases due to relative spectral response differences (RSR) such as M5, and M12

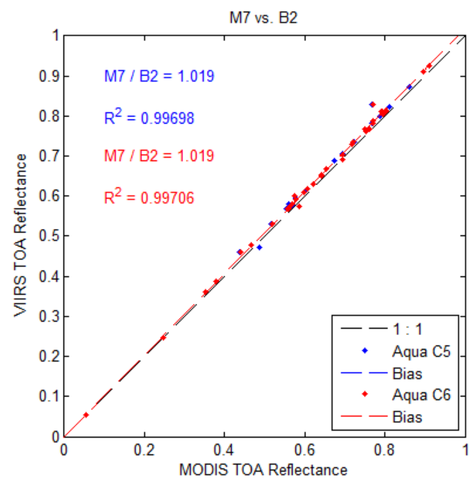
-Bands require further investigation: M4, M6, M9, M10

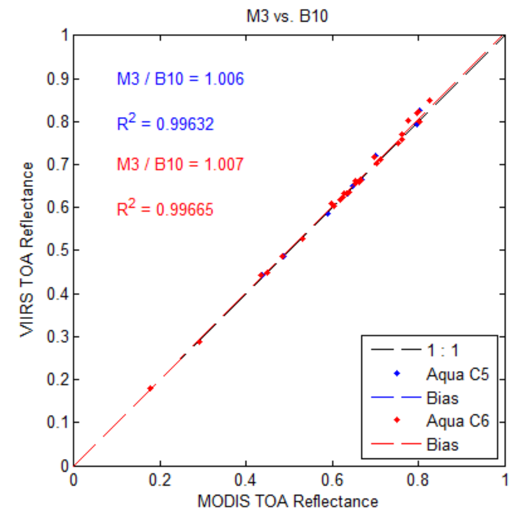
-Bands do not have matching spectral response: M11

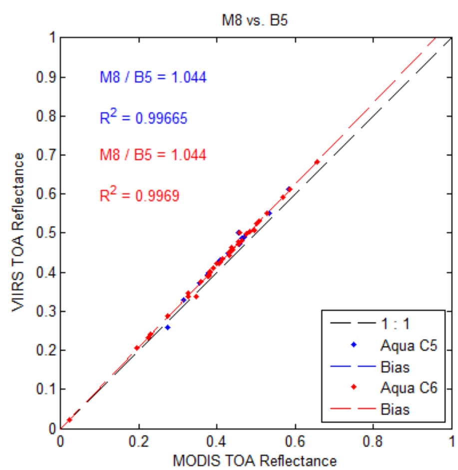
-This presentation focuses on the reflective solar bands (RSB)

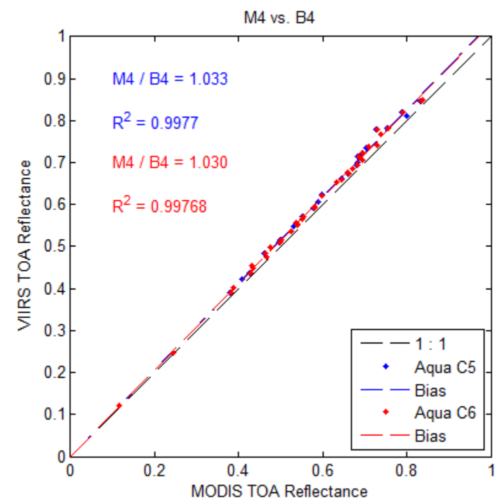
VIIRS and MODIS match relatively well for some bands- SNO

- VIIRS M3, M4, M7 and M8 bands match relatively well radiometrically with the equivalent bands of Aqua/MODIS

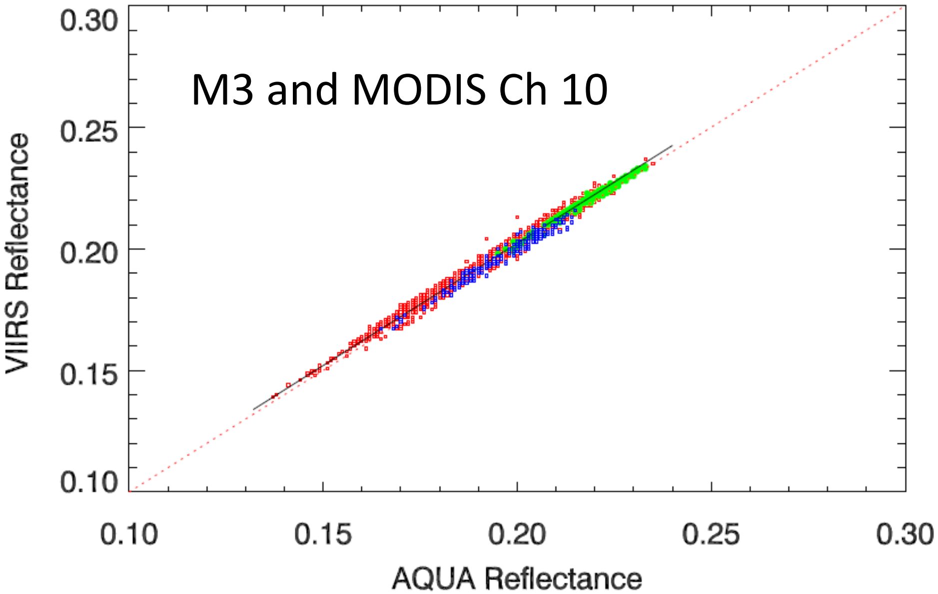


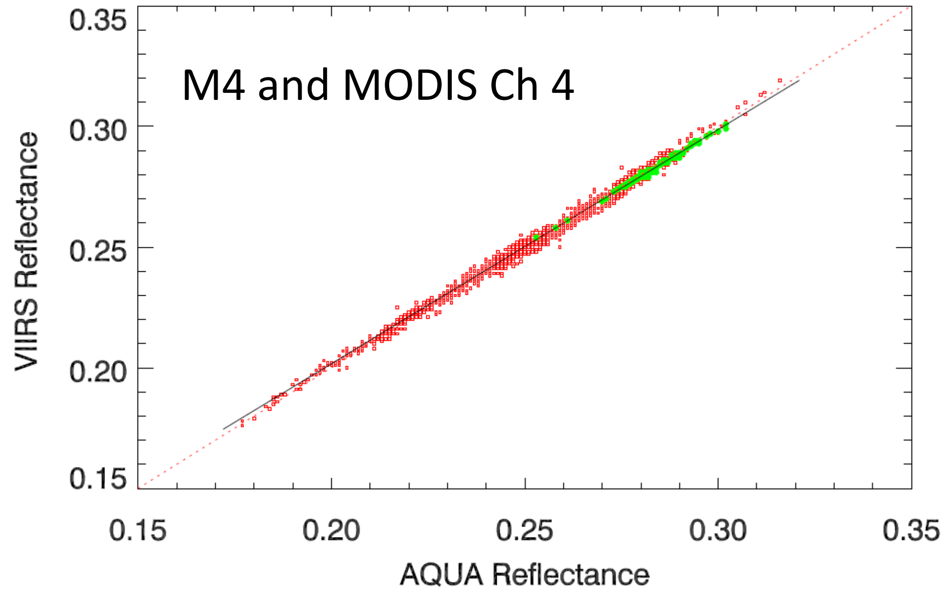


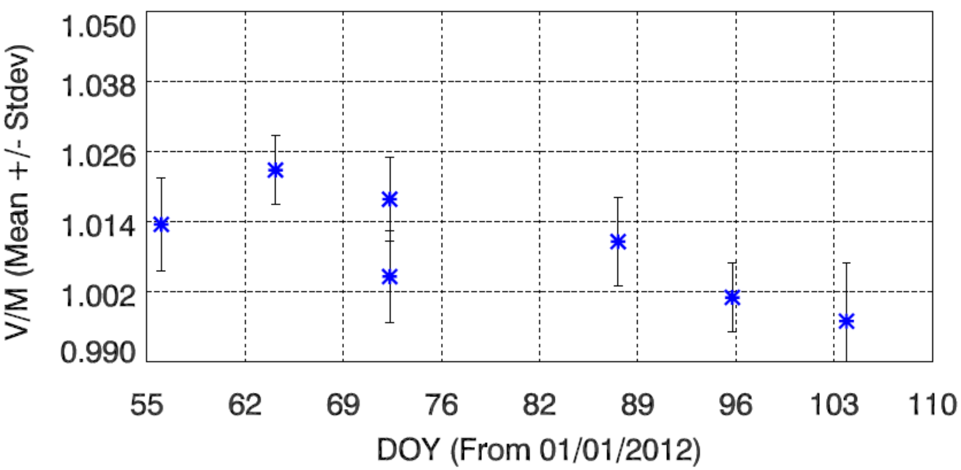


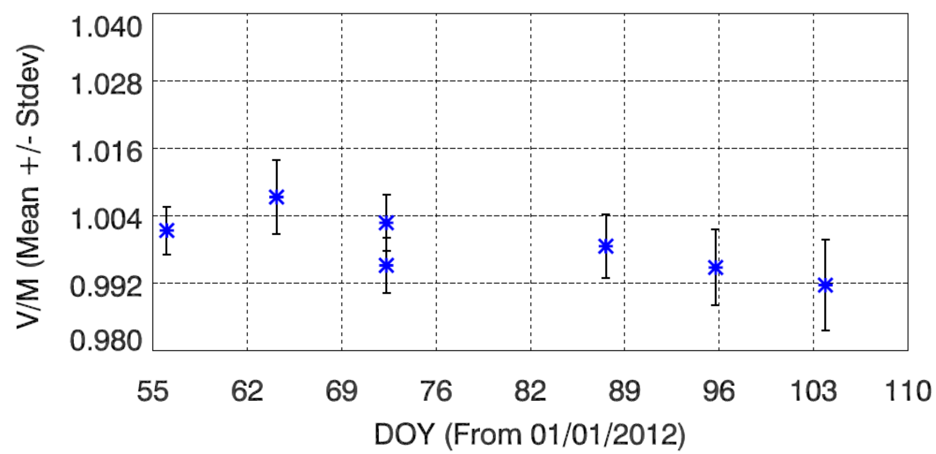


VIIRS M3 and M4 –SNOx over desert









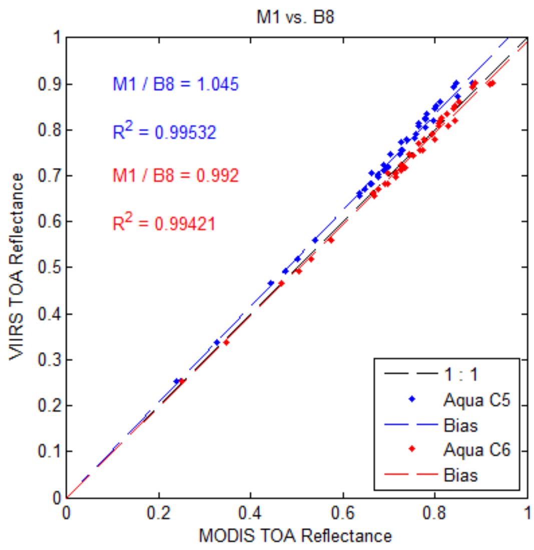
VIIRS SDR vs. MODIS C5/C6 biases -SNO

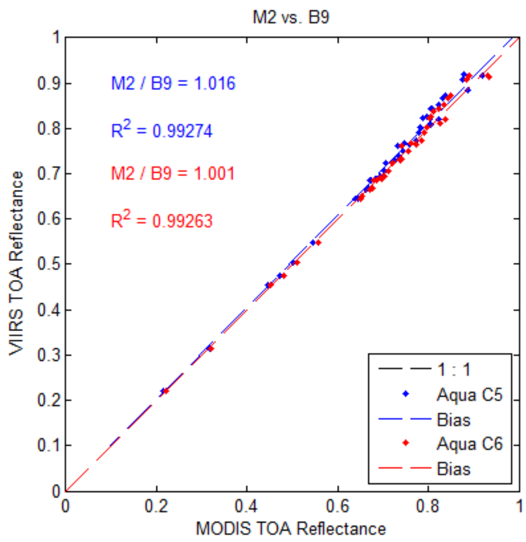
• A bias on the order of 5% was found between VIIRS M1 and MODIS B8 since VIIRS launch

•Biases are smaller for M2 and M3, although still noticeable

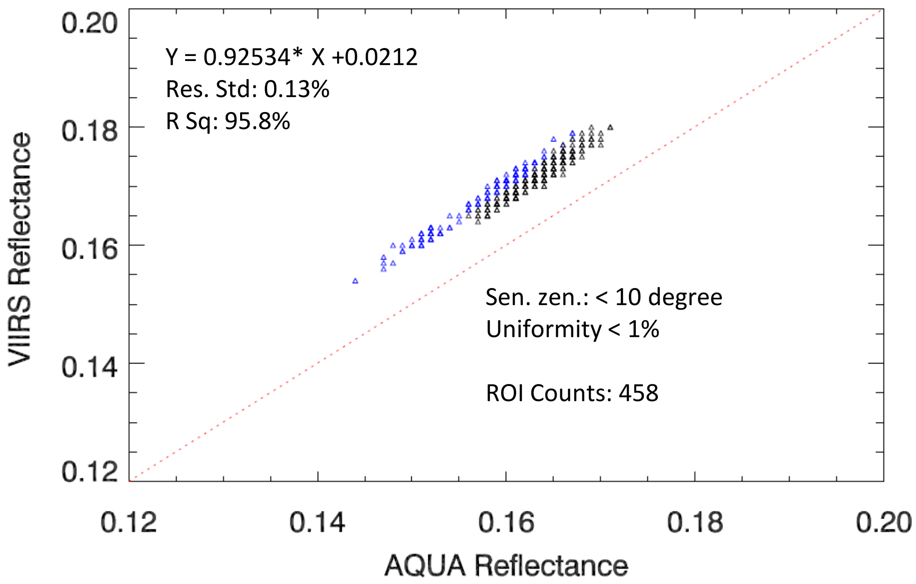
•Biases for these bands disappear when compared with MODIS C6 data, in which the calibration for the blue bands are corrected (according to NASA VCST)

•Data users should be aware that MODIS C5 data has a bias on the order of 5% for B8 (VIIRS M1)

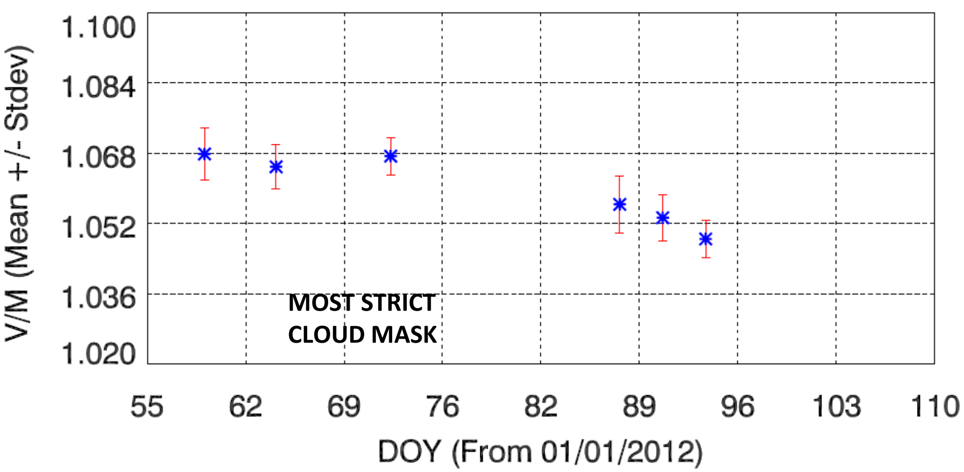


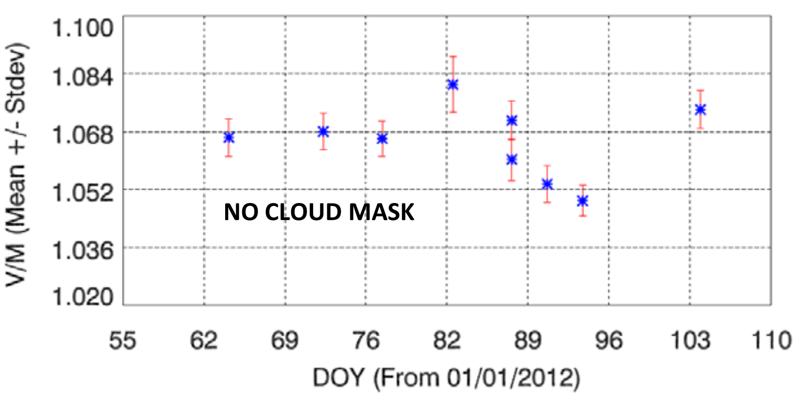


VIIRS M1 –Ocean Example (SNOx)



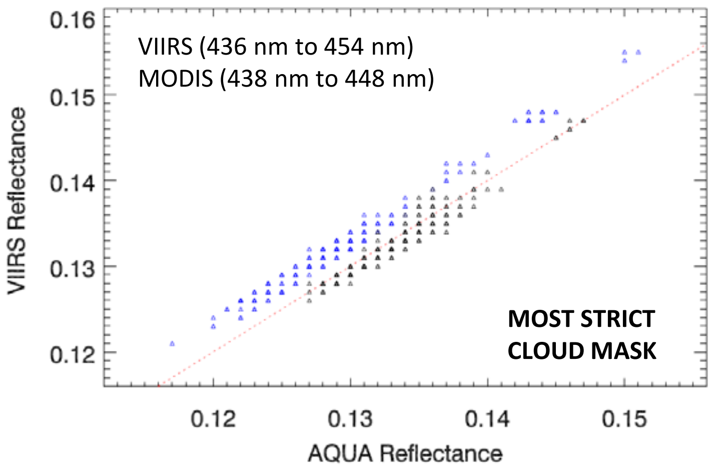
- Suggests slight degradation! Needs more SNOs to validate.
- Variability in the bias scatter plot increases with time.

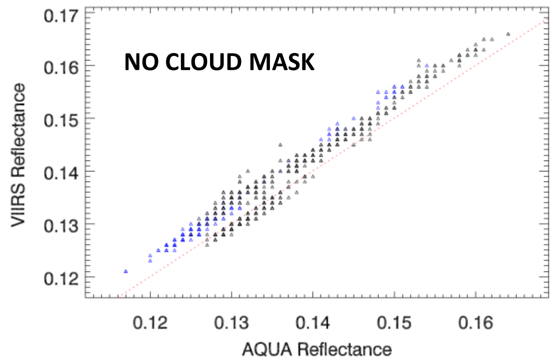


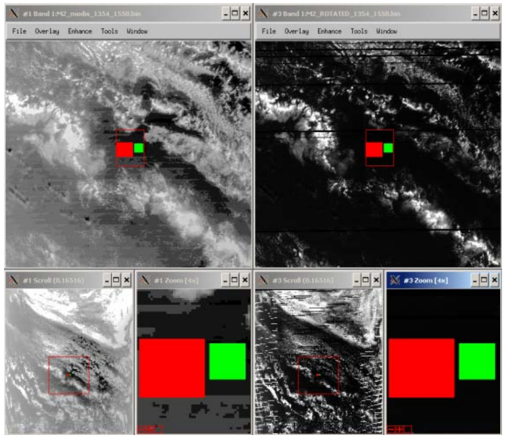


VIIRS M2 -Ocean

- 19 SNO events from Feb 28 to April 16.
- After applying filters, only 5 SNO events produce valid ROIs for comparison with MODIS.



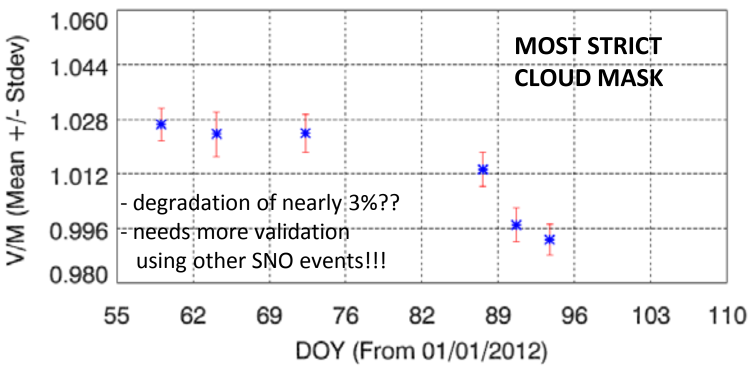


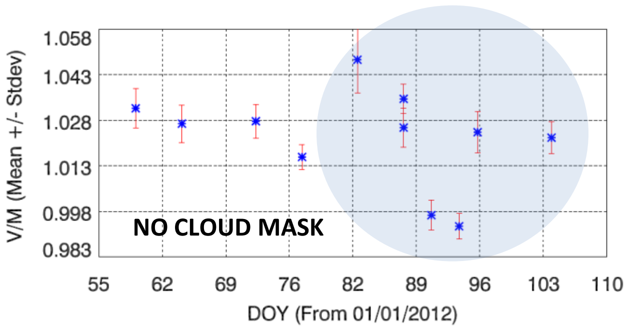


Note: sample case with manually verified result 2012_091

ROI 1, V/M=0.9959 ROI 2, V/M=0.9961

- Scatter plot in separate colors for each SNO event, otherwise, the variability seems to be large which is actually the contribution due to changing bias wrt time.

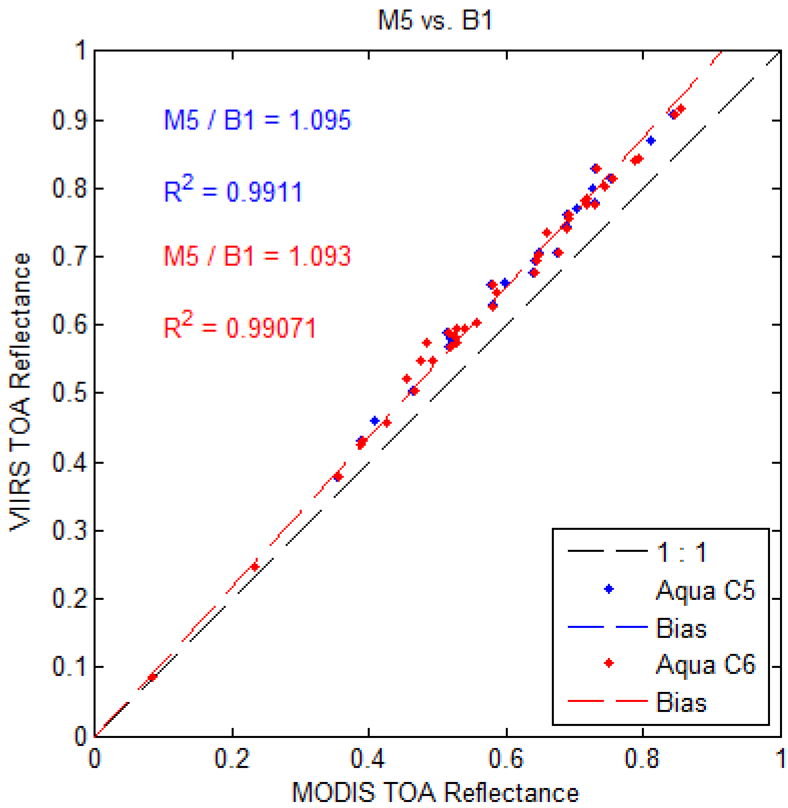




Spectral Response Difference Induced Biases (SNO)

The bias in M5 vs. MODIS B1 (on the order of 9%) is primarily due to spectral response differences, according to radiative transfer calculations

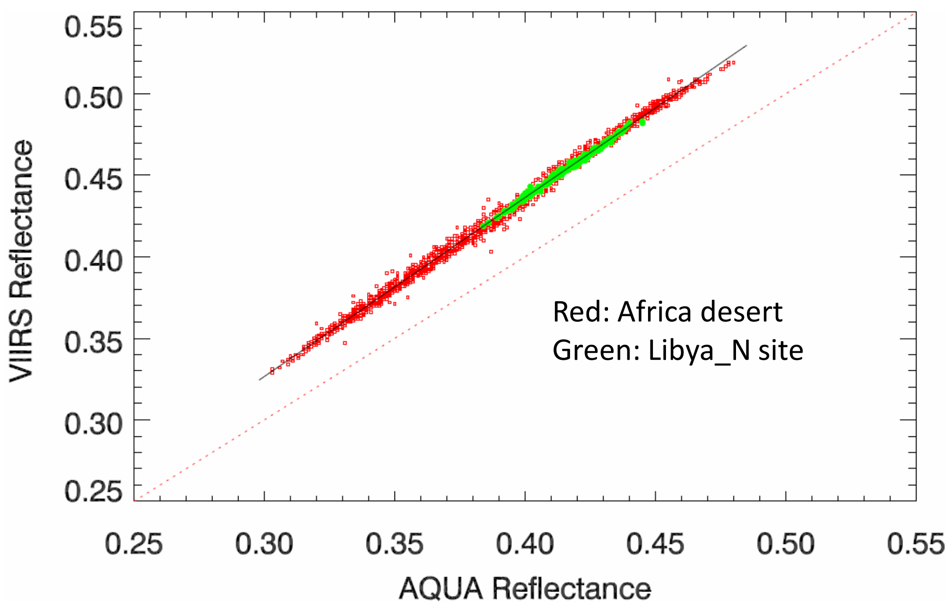
This bias amount remains the same between MODIS C5 and C6, as expected

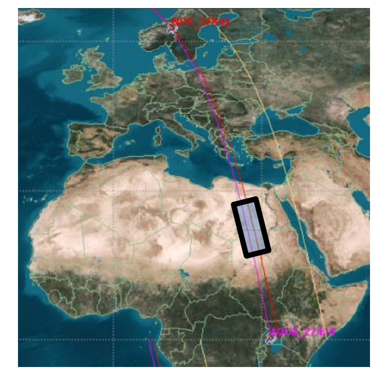


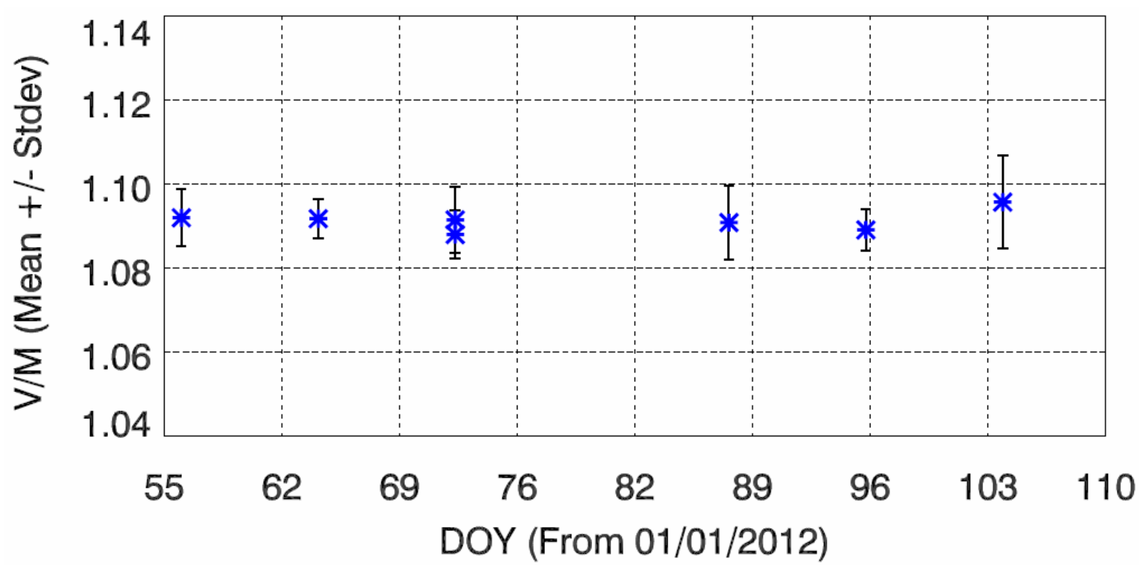
VIIRS M5 and MODIS Ch 1 (0.64 µm) (SNOx)

- Observed Bias (African Desert):
  V/M: **9.13% +/- 0.245%**
- **Spectral Bias:** **7.82% +/- 0.2**

Remaining Difference: 1.3%





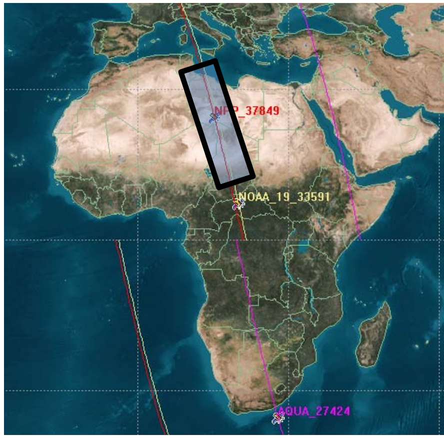


May 7, 2012

AVHRR vs. VIIRS (SNOx)

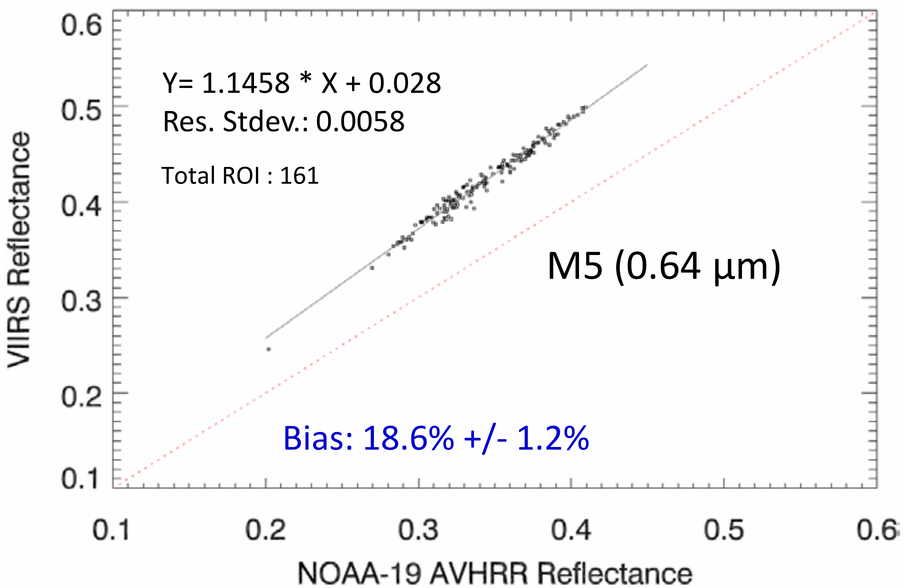
- VIIRS and NOAA-19 have SNOx events at low latitudes with time difference of about 6 minutes.
- The comparison between matching VIIRS and AVHRR channels are performed over Africa.
- VIIRS observation used in the study:
  - March 04, 2012, from 11:50 UTC to 12:10 UTC.
- ROI selection criteria:
  - size: 20km * 20km
  - spatial uniformity difference : < 1%
  - Sensor zenith: < 10^o
- Major sources of uncertainty:
  - Impact due to spectral differences of channels and different types of targets
  - Impact due to cloud movement (SNOx time difference is nearly 6 minutes)
  - effect due to differences in solar and sensor geometry (BRDF)
  - Collocation error and geolocation discrepancies
  - Solar models used to calculate the reflectance (applies to Solar Reflective Bands)

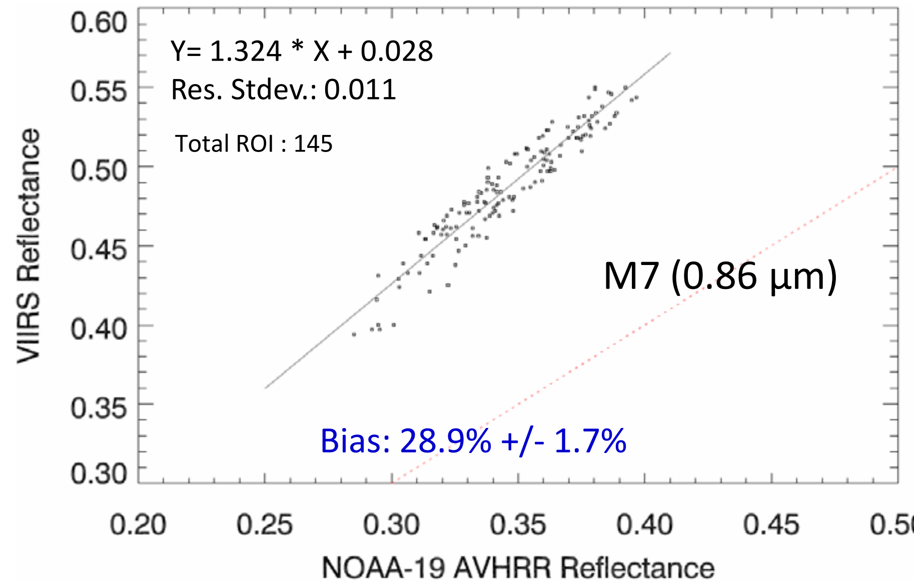
VIIRS	AVHRR
M5 (0.66 um - 0.68 um)	Ch 1 (0.58 - 0.68 um)
M7 (0.84 - 0.88 um)	Ch 2 (86 um)
M12 (3.61 um - 3.79 um)	Ch 3B (3.55 - 3.93 um)
M15 (10.8 um)	Ch 4 (10.8 um)
M16 (12 um)	Ch 5 (12 um)



	Expected biases between VIIRS , AVHRR, and MODIS					
	M2 (436-454)	M3 (478-498 nm)	M4 (545-565 nm)	M5 (662-682 nm)	M6 (739-754 nm)	M7 (846-885 nm)
	Libya NOAA cal site (%)					
MODIS	0.28 +/- 0.069	0.36 +/- 0.087	4.53 +/- 0.044	7.26 +/- 0.216	1.12 +/- 0.230	2.61 +/- 0.243
AVHRR				9.69 +/- 0.306		15.14 +/- 2.37

Visible/Near-Infrared Channel AVHRR Ch1 (0.64 um) and Ch2 (0.86 um)





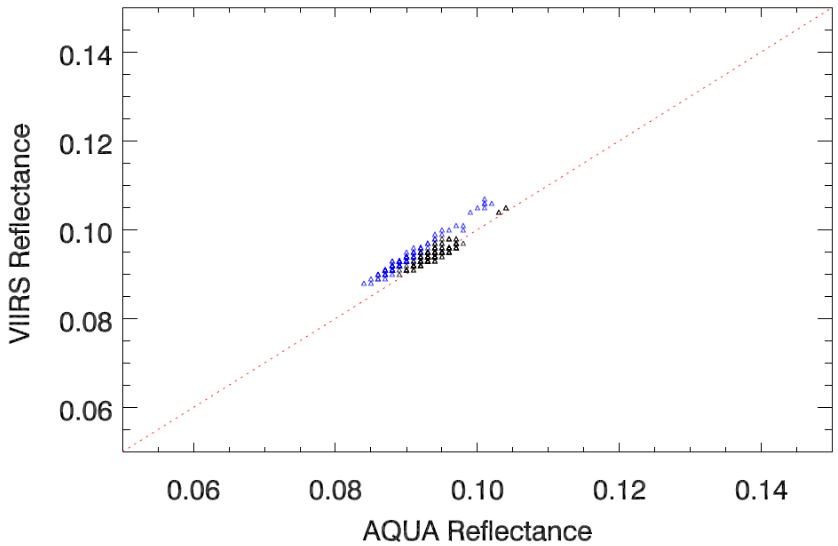
- Bias=(AVHRR-VIIRS)*100%/VIIRS
- **Expected Bias due to SRF differences at Libyan desert**
  - **Ch1: -9.69% +/- 0.306% Ch2: -15.14% +/- 2.37%**
- **The remaining actual bias for AVHRR Ch1 is -8.9% and for Ch2 is -13.7%.**
- Large bias for channel 1 is likely due to AVHRR calibration traceability while for channel 2, it could be due to water vapor absorption.

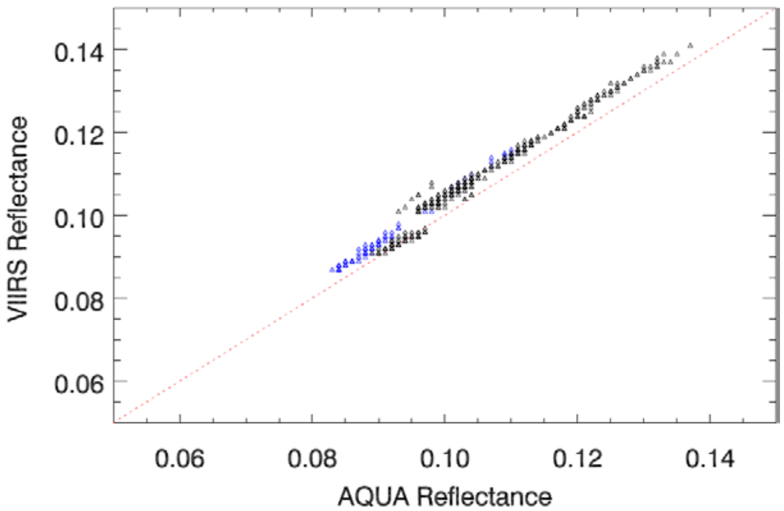
Summary

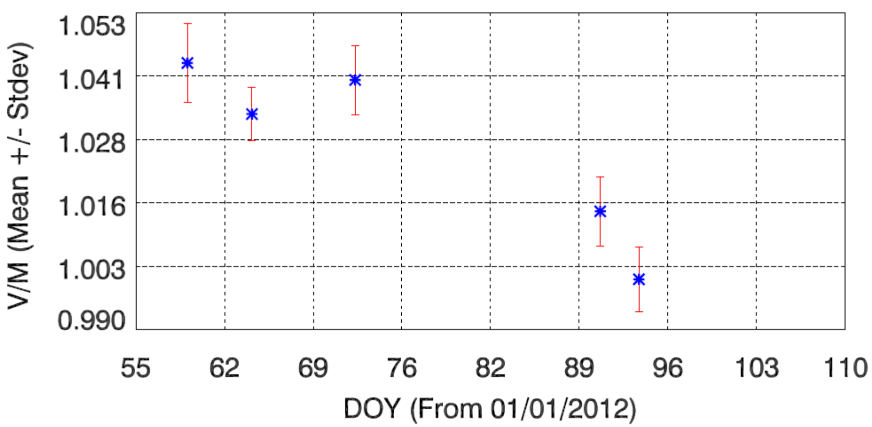
- It’s important to establish radiometric consistency among VIIRS, MODIS, and AVHRR
- Preliminary results show that for some bands, consistency is relatively good. However, for other bands, inconsistencies still exist
- Comparison with Aqua MODIS shows the 5% bias in MODIS C5 vs. C6 for M1, while the large bias in M5 is due to spectral differences
- Independent calibration/validation and cross comparison are essential to reduce the uncertainties in the calibration to ensure data quality

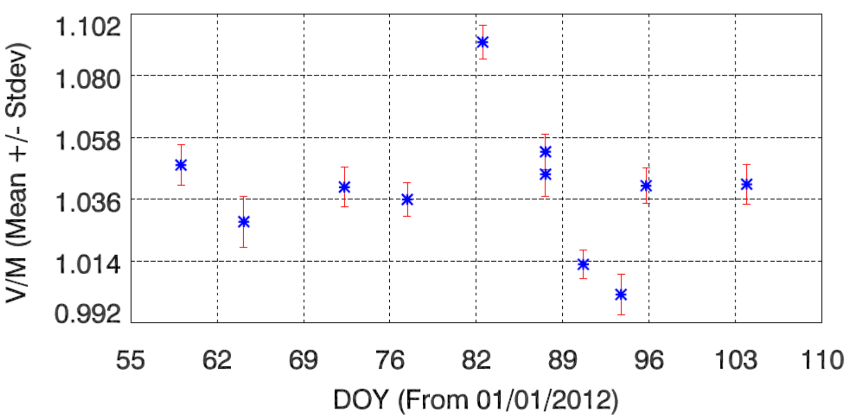
- Backup slides

M3 (478 nm to 498 nm) -Ocean

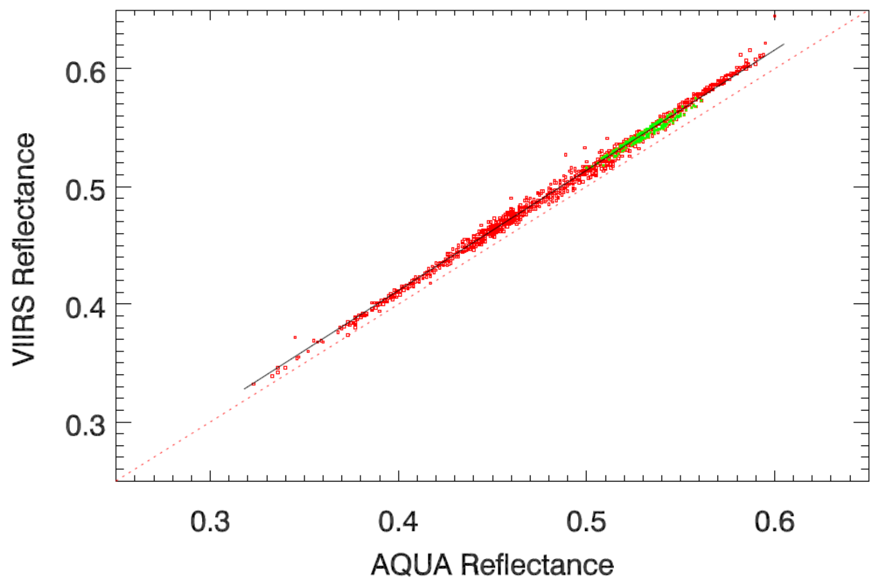






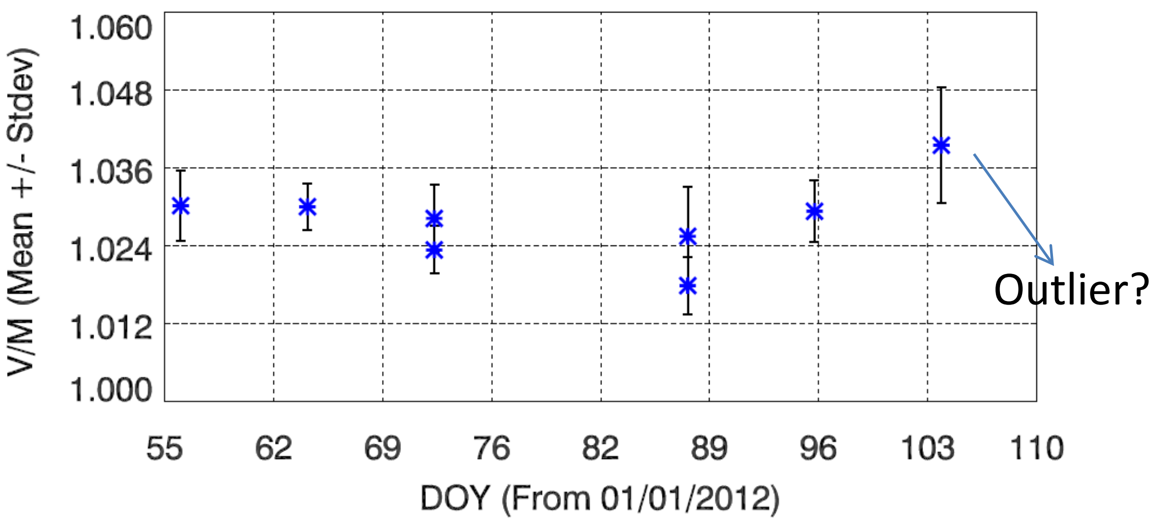


VIIRS M7 and MODIS Ch 2 (0.86 µm)

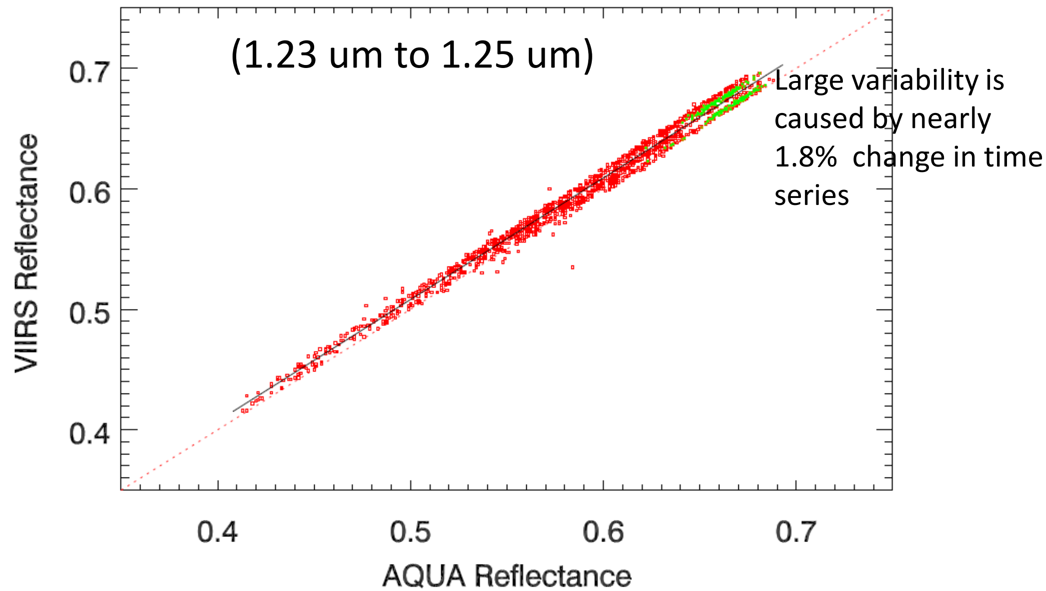


- Observed Bias (AFRICA Desert):
  V/M: 2.78% +/- 0.62%

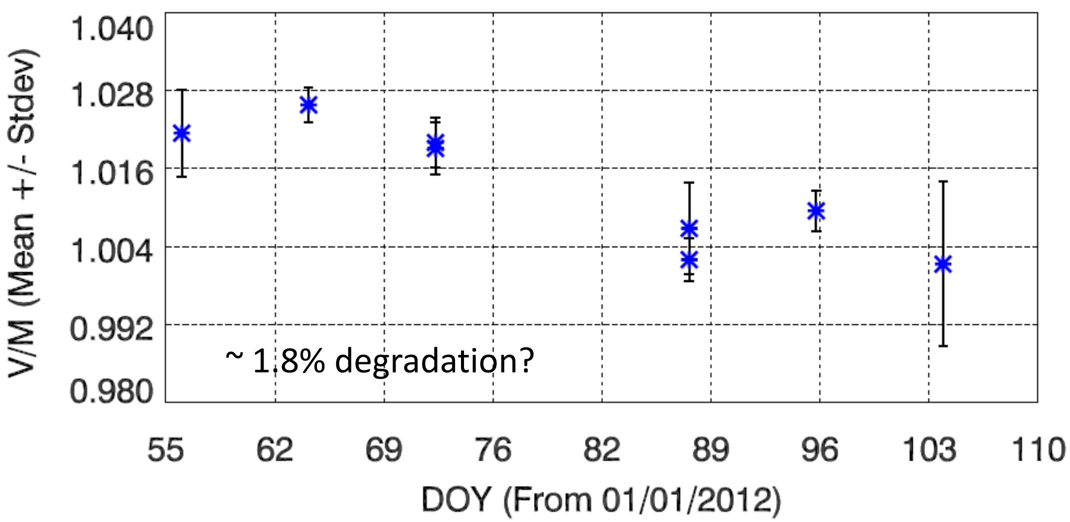
- **Spectral Bias: 2.67% +/- 0.3**



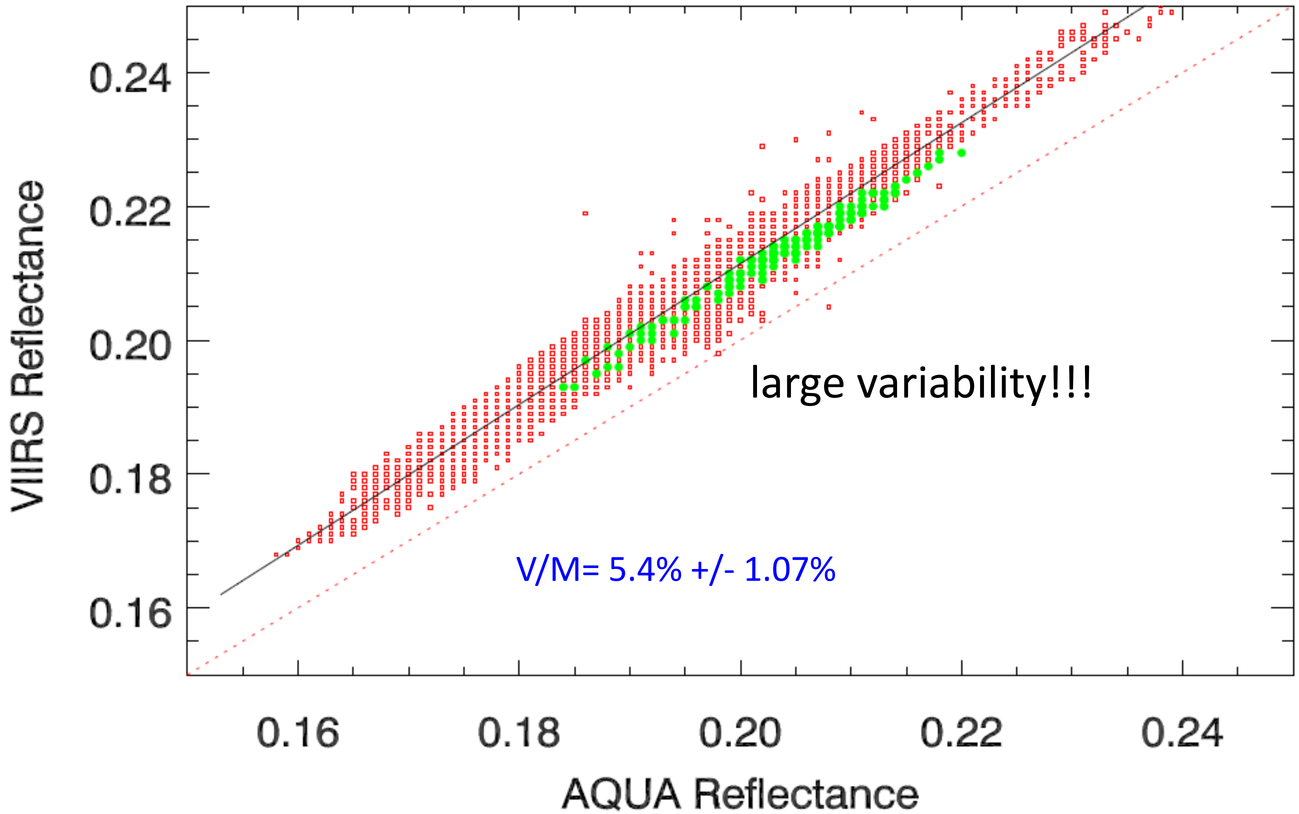
VIIRS M8 and MODIS Ch 5



- Indicates degradation of channel.
- needs more SNO analysis to confirm



M1 -desert

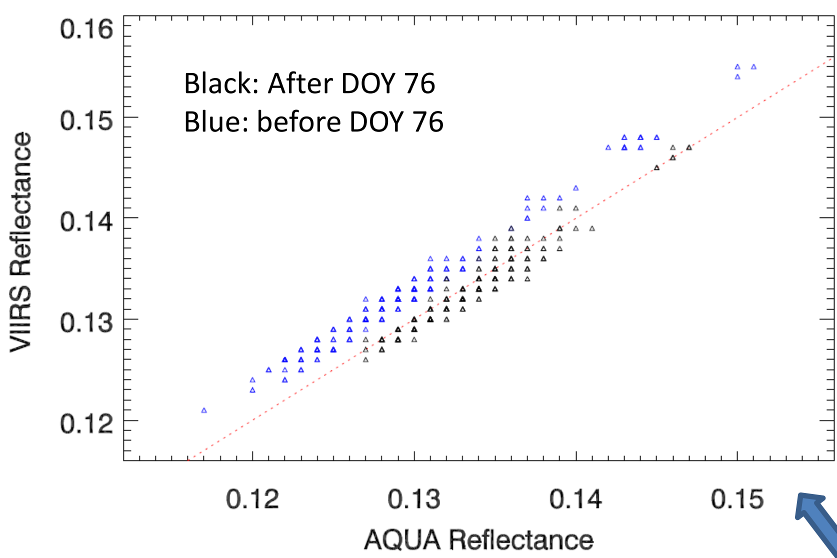


M1, M2 and M3:

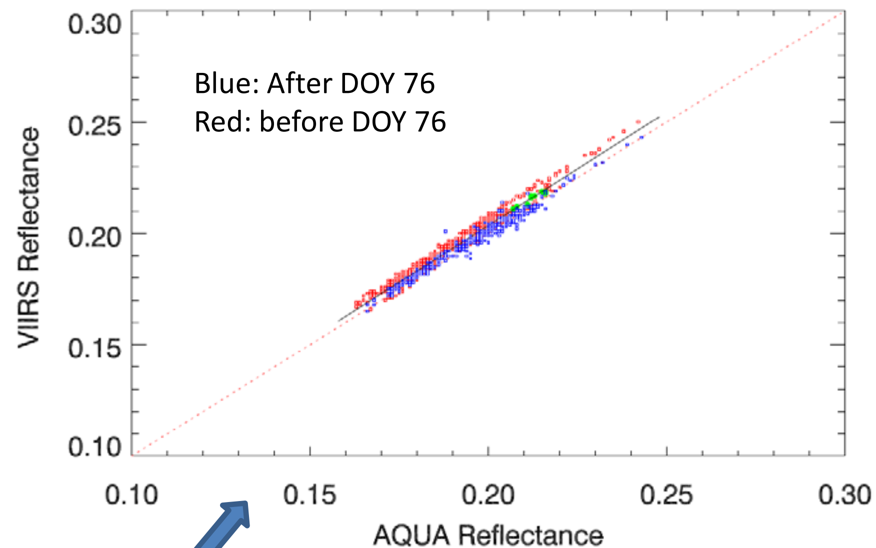
ROI size is 17km * 17km as compared to 9km * 9km of other channels

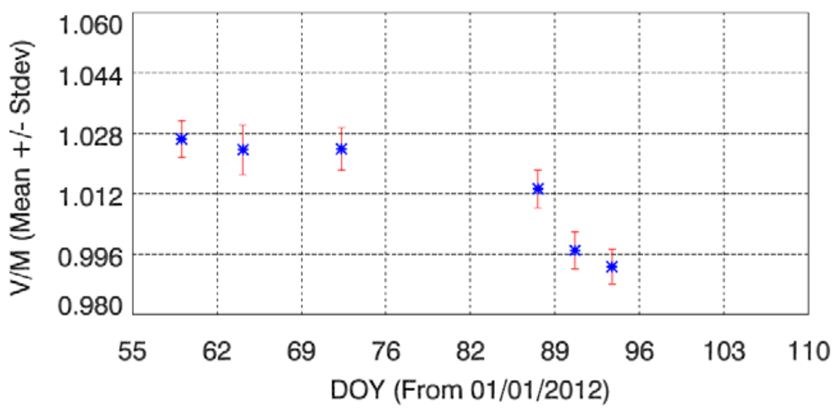
M2

SNOx on Ocean Surface



SNOx on African Desert



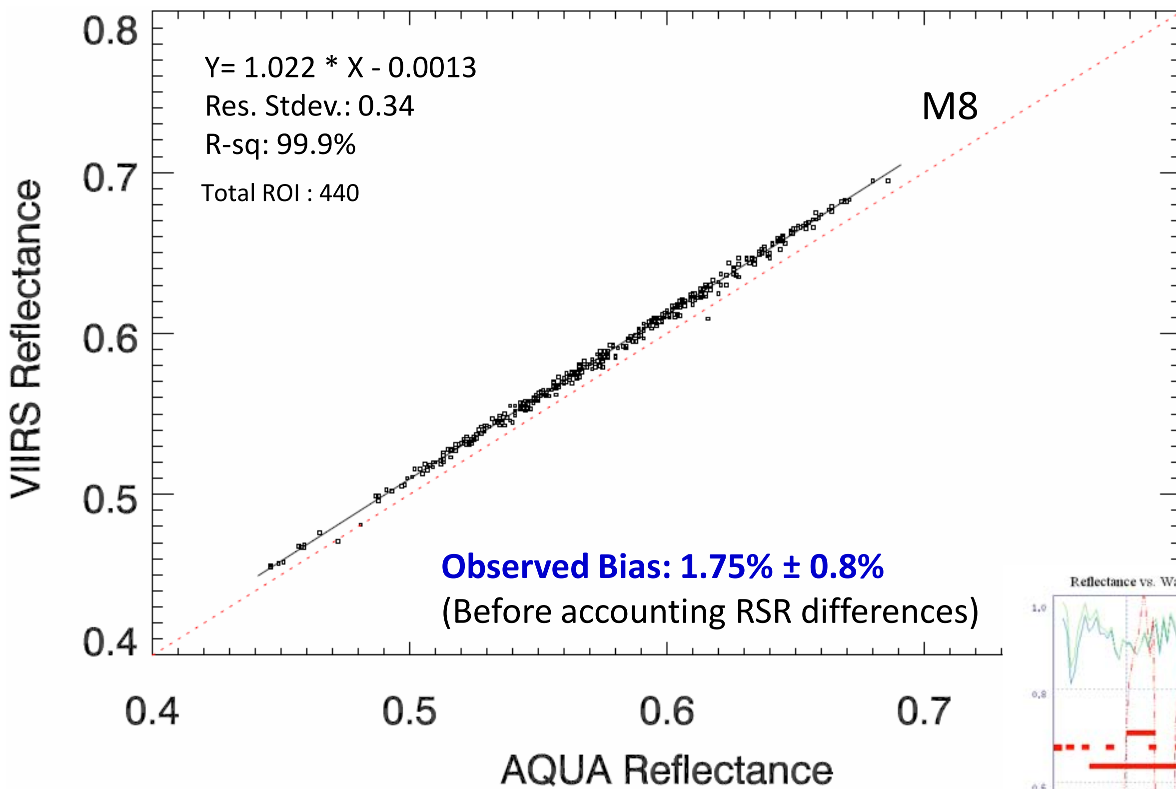


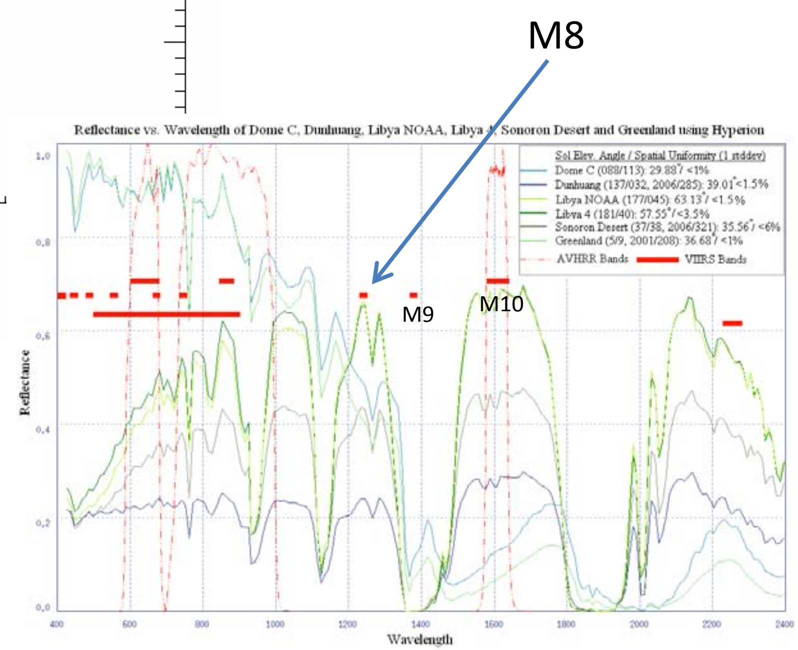
Similar change occurs before and after doy 76

This needs to be verified by analyzing SNOs after DOY 96!

Spectral bias: 0.3%

M8 (739nm to 754 nm) VIIRS vs. MODIS





NASA VCST findings

NASA GSFC Instrument Intercomparisons: MODIS Aqua and SNPP VIIRS

VIIRS/MODIS reflectance ratio differences (%)

	640 nm I1	865 nm I2	412 nm M1	445 nm M2	488 nm M3	555 nm M4	672nm M5	746 nm M6*	865 nm M7
MODIS C5	-0.3	1.3	5.0	2.2	1.5	2.5	6.7	2.1	1.4
MODIS C6	-1.1	2.6	0.5	-0.1	2.2	2.4	2.1	3.5	0.7

* Comparison for M6 is less reliable due to MODIS early saturation

?

VIIRS & Aqua MODIS brightness temperature (BT) differences (K)

BT (VIIRS) – BT (MODIS) (K)

BT (K)	3.70 µm M12	4.05 µm M13	8.55 µm M14	10.76 µm M15	12.01 µm M16	3.74 µm I4	11.45 µm I5
235	0.3	0.2	1.5	1.0	0.6	4.0	1.5
250	0.1	0.0	0.3	0.3	0.1	3.0	0.5
270	0.0	-0.2	0.1	0.1	0.0	1.5	0.4
285	-0.1	-0.4	0.0	0.0	0.1	0.3	0.4

May 2012

Source: GSICS EP Presentation by NASA: http://www.wmo.int/pages/prog/sat/meetings/documents/GSICS-EP-12_Doc_02-10_NASA.pdf

Spectrally induced radiometric biases expected at different sites