SNPP and N20 VIIRS reflective solar bands calibration difference assessment

December 18, 2020

VIIRS Characterization Support Team

Difference assessment methodology

- L1B EV Reflectance
  - **Desert Pseudo-Invariant Calibration Sites (PICS)**
  - **Simultaneous nadir overpasses (SNO)**
  - Results from Dome C also processed, but not presented here due to larger uncertainties (BRDF) and fewer overpasses (only from Nov-March)
  - Results from Deep Convective clouds processed with C1 (SNPP) and work is underway to convert the results to C2 (SNPP)
- Data Version and Scaling
- RSR mismatch correction
- Average the results of the two approaches

PICS approach

VIIRS RSB		
Band	CW (nm)	BW
M1	412	20
M2	445	18
M3	488	20
M4	555	20
M5	672	20
M6	746	15
M7	865	39
M8	1240	20
M9	1378	15
M10	1610	60
M11	2250	50
I1	640	80
I2	865	39
I3	1610	60

- Pseudo-Invariant Calibration Sites (PICS)
  - Widely used to assess the radiometric stability for RSB. Libya 4 site in the North African desert used for this assessment. Only near-nadir scenes (2 per month) used in this analysis—no known on-orbit RVS changes in VIIRS
  - Target area of 20 x 20 km to extract top-of-atmosphere (TOA) reflectance. Employ semi-empirical BRDF correction (using Roujean model). BRDF coefficients derived using 3-years of SNPP on-orbit measurements
  - Site dependent correction for the RSR mismatch between the two sensors accounted using SCIAMACHY hyperspectral profiles (acquired from SCIAMACHY's operational time)

M6 not included due to saturation issues, Assessment of M9 (cirrus channel) presents challenges using these methods and M11 has large uncertainty.

Xiong, X., A. Angal, T. Chang, K. Chiang, N. Lei, Y. Li, J. Sun, K. Twedt, and A. Wu, "MODIS and VIIRS Calibration and Characterization in Support of Producing Long-Term High-Quality Data Products", Remote Sensing, vol. 12, issue 19, pp. 3167, 2020.

SNO approach

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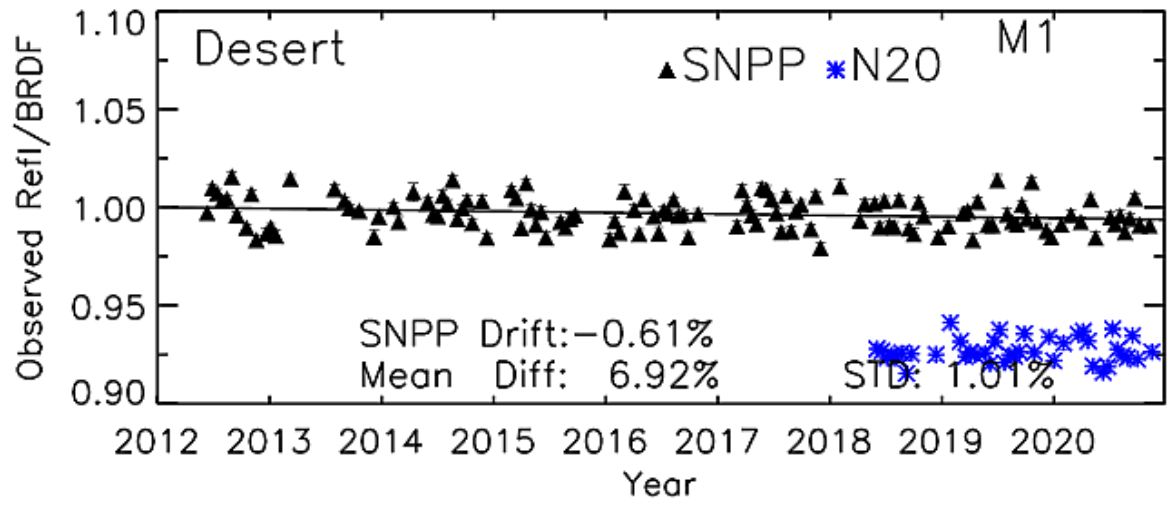
- Simultaneous Nadir Overpasses (SNO)
  - Aqua MODIS used as a transfer radiometer. Using high-latitude SNO (<30 seconds), TOA reflectance ratio between MODIS/VIIRS (SNPP and N20) is computed (2-3 days/month)
  - No BRDF correction applied.
  - Correction for RSR mismatch applied using a spectral signature of a typical high-latitude scene
  - Larger uncertainties in the SWIR bands (compared to the VIS/NIR bands) for both targets (desert and SNO) due to the noticeable RSR mismatch

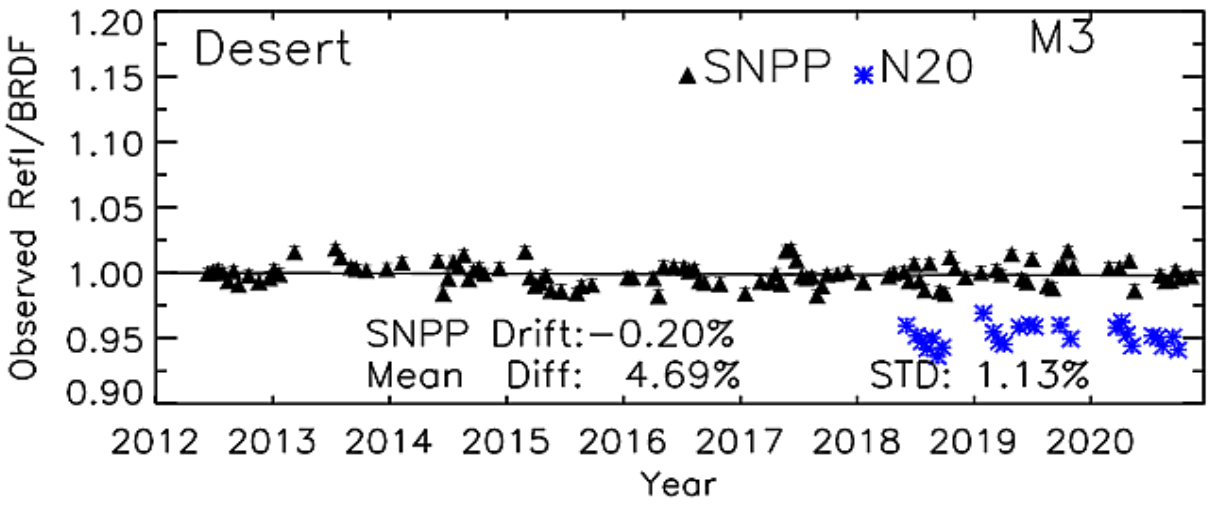
M6 not included due to saturation issues, Assessment of M9 (cirrus channel) presents challenges using these methods and M11 has large uncertainty.

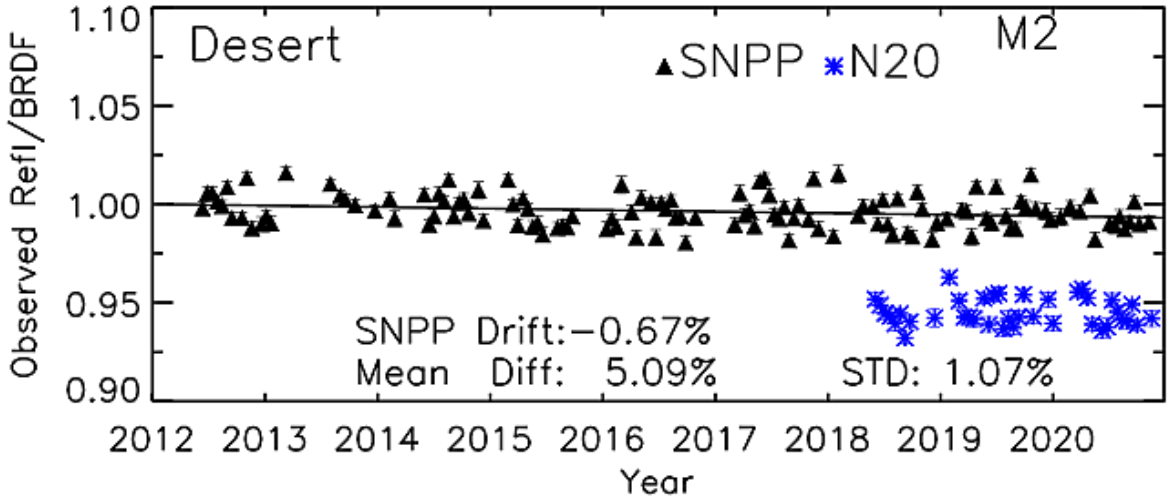
Data version conversion

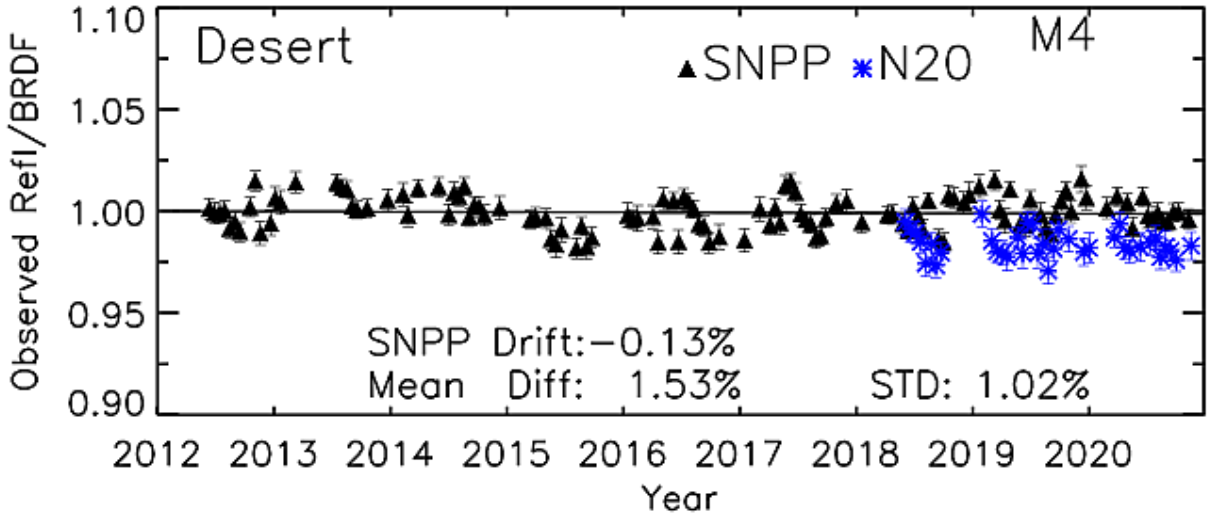
- Data Version and Scaling
  - SNPP Collection 1 L1B (AS 5000) used to retrieve the at-sensor TOA reflectance
    - Collection 2 improvements include correction for early mission SD gain on M1/M2 using re-fitted lunar calibration data. (L1B LSIPS for validation, not released official)
    - Notable differences observed in bands M1, M2 (0.5% and 0.2%) and temporal improvements in the reflectance trends for bands I1,I2.
    - A F-factor LUT (instrument gain) scaling ratio between Collection 2 (AS 5200) and Collection 1 is used to scale the time-series to provide the assessment using the most recent products
  - N20 Collection 2 L1B (AS 5200) used to retrieve the at-sensor TOA reflectance
    - No scaling applied as C2 is the most recent version
    - Minor differences (<0.1%) included in C2.1 due to the prelaunch RVS LUT changes

Reflectance trend over desert site



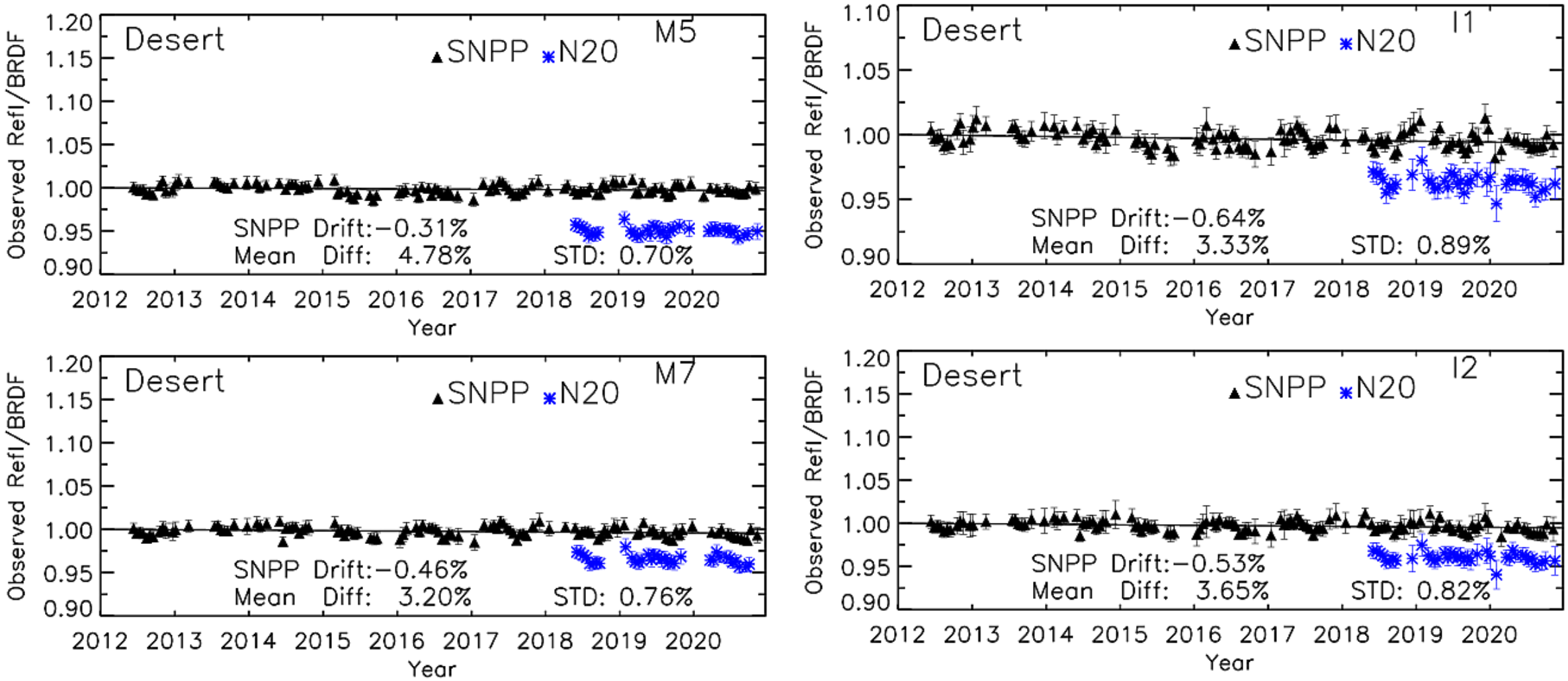






SNPP VIIRS (AS 5000) scaled using F-factor to AS 5200 Collection 2. N20 (AS 5200) Collection 2

Reflectance trend over desert site



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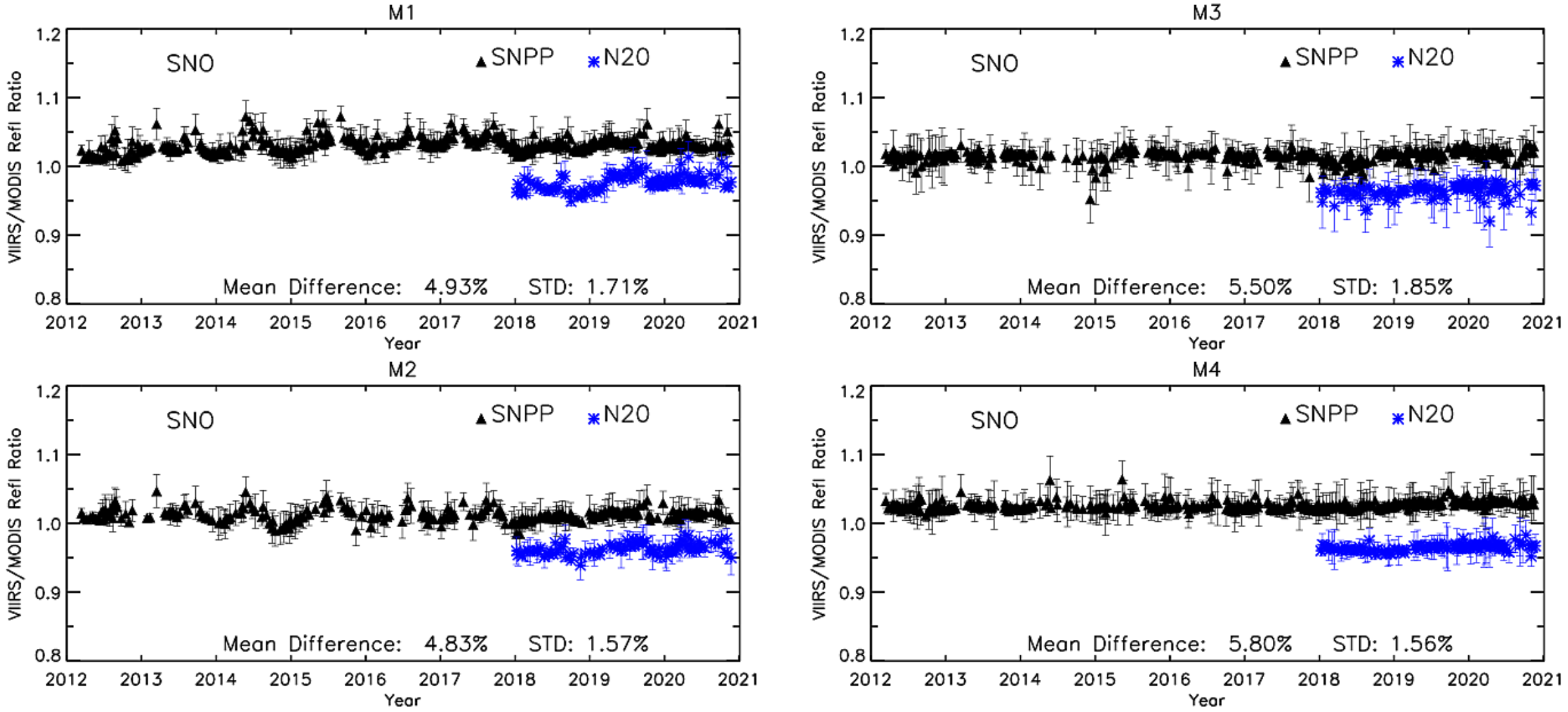
Reflectance ratio (VIIRS/Aqua MODIS)



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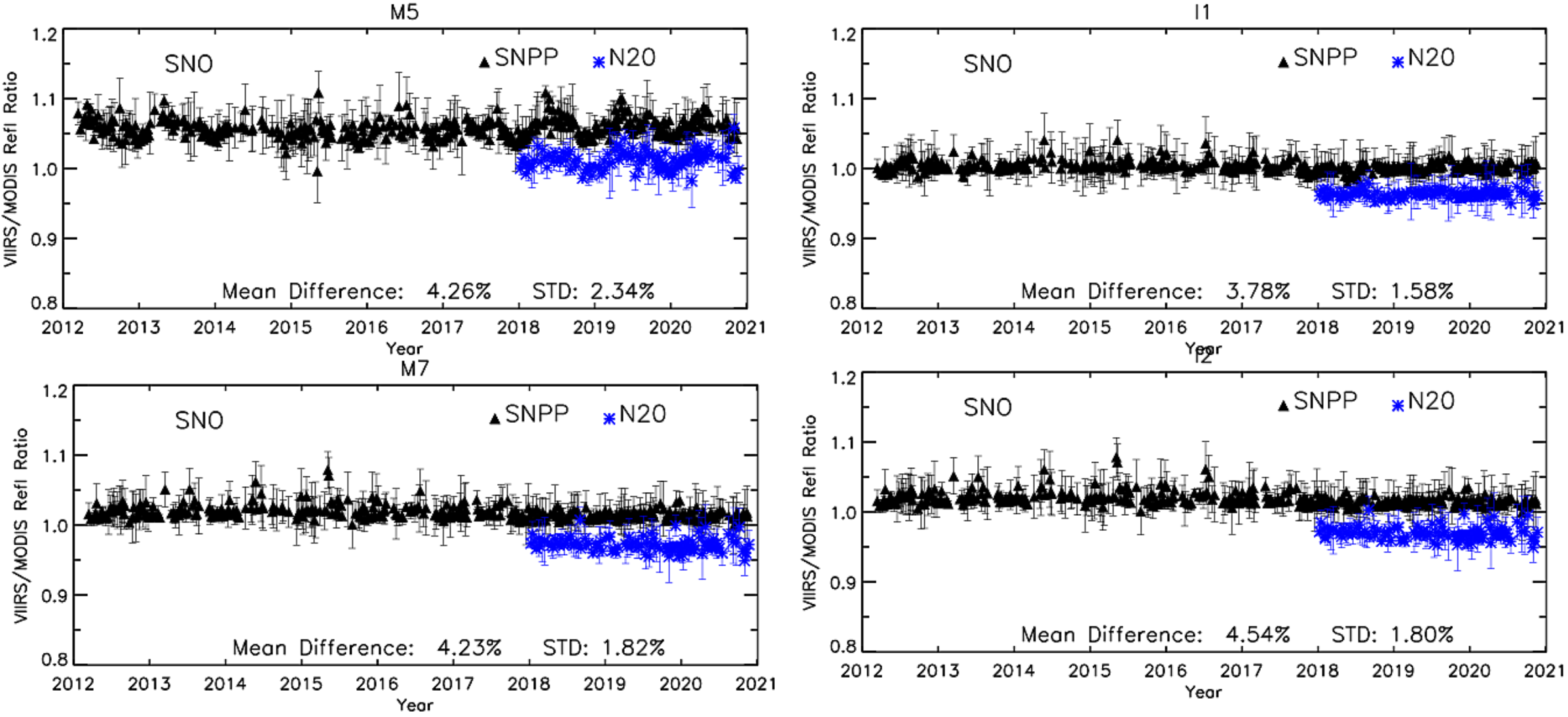


SNPP VIIRS (AS 5000) scaled using F-factor to AS 5200 Collection 2. N20 (AS 5200) Collection 2

SNPP and NOAA-20 VIIRS RSB Differences

(without RSR correction)

Band	Desert		SNO	
	N20/SNPP ratio	Std. error	N20/SNPP	Std. error
M1	0.930	0.010	0.951	0.017
M2	0.949	0.011	0.952	0.016
M3	0.953	0.011	0.945	0.019
M4	0.984	0.010	0.942	0.016
M5	0.952	0.007	0.957	0.023
M7	0.968	0.008	0.958	0.018
I1	0.966	0.009	0.962	0.016
I2	0.963	0.008	0.955	0.018
M8	0.978	0.012	0.972	0.014
M10	0.981	0.008	0.975	0.031
I3	0.966	0.008	0.963	0.032

Std. Error represents the fluctuation around the mean

SNPP and NOAA-20 VIIRS RSB Differences

(with RSR correction)

Band	Desert		SNO		
	N20/SNPP ratio (% Difference)	Std. error	N20/SNPP (% Difference)	Std. error	N20/SNPP ratio-avg (% diff)
M1	0.926 (7.369)	0.010	0.938 (6.194)	0.017	0.932 (6.8)
M2	0.937 (6.320)	0.011	0.941 (5.944)	0.016	0.939 (6.1)
M3	0.956 (4.391)	0.011	0.951 (4.868)	0.019	0.954 (4.6)
M4	0.966 (3.440)	0.010	0.952 (4.803)	0.016	0.959 (4.1)
M5	0.952 (4.786)	0.007	0.957 (4.333)	0.023	0.955 (4.5)
M7	0.973 (2.684)	0.008	0.968 (3.229)	0.018	0.971 (2.9)
I1	0.965 (3.539)	0.009	0.967 (3.303)	0.016	0.966 (3.4)
I2	0.971 (2.883)	0.008	0.968 (3.192)	0.018	0.970 (3.0)
M8	0.977 (2.314)	0.012	0.973 (2.720)	0.014	0.975 (2.5)
M10	0.981 (1.876)	0.008	0.974 (2.578)	0.031	0.978 (2.2)
I3	0.969 (3.100)	0.008	0.963 (3.673)	0.032	0.966 (3.4)

<4%
>4%

Std. Error represents the fluctuation around the mean

Summary and path forward

- Based on reflectance trending over desert site and intercomparison using SNO approach, the RSB differences are derived for the RSB of the two VIIRS instruments
- The table of the derived RSB differences can be applied to reduce the differences between the two instruments. We suggest to apply the correction beyond the L1B products
- We recommend to use NOA-20 as reference and scale the L1B products of the SNPP using the derived table since NOAA-20 is much stable than SNPP.
- Path forward
  - Consolidation of the results from other ground targets such as DCC, Dome C to assess consistency
  - Assess the impact of polarization sensitivity on the intercomparison, especially for N20 VIIRS that showed non-compliance with the spec (3% for M1 and M2, and 2.5% for M3,M4)

Backup Slides

Comparison with Aqua MODIS

Summary

- For the short wavelength VIS bands, N20 VIIRS is 4-6% lower than Aqua MODIS and SNPP VIIRS is 1-3% higher than Aqua MODIS
- For longer wavelength NIR and SWIR bands, N20 VIIRS is 1-3% lower than Aqua MODIS and SNPP VIIRS agrees to within 2% with Aqua MODIS
- In other words, Aqua MODIS reflectances fall in between N20 and SNPP VIIRS bands, closer to SNPP VIIRS

Assessment of Calibration Differences (with RSR correction)

Band	SNO			
	N20/MODIS ratio	Std. error	SNPP/MODIS ratio	Std. error
M1	0.979	0.015	1.044	0.007
M2	0.950	0.014	1.010	0.007
M4	0.968	0.015	1.018	0.005
M5	0.949	0.018	0.994	0.014
M7	0.972	0.017	1.000	0.005
I1	0.970	0.015	1.001	0.006
I2	0.973	0.017	1.001	0.005
M8	1.005	0.009	1.033	0.010
M10	0.988	0.020	1.014	0.024
I3	0.982	0.019	1.019	0.026

<4%
>4%

M3 overlaps partially with Aqua MODIS band 10, a high gain band that saturates for desert and SNO. Large spectral correction for band M5 (overlapped with MODIS band 1). Ideally M5 should be compared with Aqua MODIS band 13 (also experiences saturation)

SNPP VIIRS (AS 5000) scaled using F-factor to AS 5200 Collection 2. N20 (AS 5200) Collection 2, MODIS C6.1 L1B

Assessment of Calibration Differences (with RSR correction)

Band	Desert			
	N20/MODIS ratio	Std. error	SNPP/MODIS ratio	Std. error
M1	0.956	0.010	1.032	0.009
M2	0.945	0.008	1.008	0.008
M4	0.976	0.008	1.009	0.009
M5	0.957	0.006	1.004	0.007
M7	0.993	0.006	1.019	0.006
I1	0.964	0.007	0.999	0.007
I2	0.991	0.008	1.019	0.006
M8	0.971	0.009	0.995	0.009
M10	1.014	0.007	1.036	0.004
I3	1.000	0.007	1.035	0.005

<4%
>4%

SNPP VIIRS (AS 5000) scaled using F-factor to AS 5200 Collection 2. N20 (AS 5200) Collection 2, MODIS C6.1 L1B

VIIRS calibration differences from NOAA IDPS

Table 3. NOAA-20 VIIRS bias relative to S-NPP VIIRS.

Method	NOAA-20 Bias Relative to S-NPP (%)									
	M1	M2	M3	M4	M5	M7	M8	M10	I1	I2
SNO	-2.7%	-2.0%	-	-3.5%	-5.2%	-3.5%	-4.0%	-	-1.9%	-3.7%
SNOx	-2.5%	-2.5%	-2.5%	-2.0%	-5.0%	-4.0%	-3.0%	-2.0%	-	-

Uprety et.al, SPIE Proceeding 107810V

Summary

- For the short wavelength VIS bands, N20 VIIRS is 2-4% lower than SNPP VIIRS
- NOAA STAR has known large bias in M5 and M7 calibration based on their intercomparison result that further amplifies the disagreement (Uprety et.al, RSE 2015, "Suomi NPP VIIRS Reflective Solar Band On-Orbit Radiometric Stability and Accuracy Assessment Using Desert and Antarctica Dome C Sites")

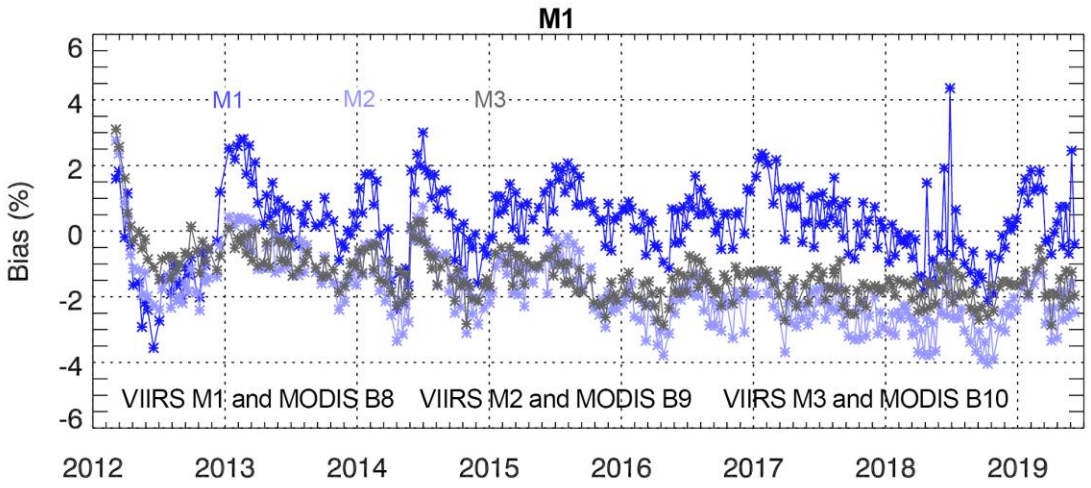
- Long-term drifts due to SD calibration in SNPP RSB not corrected, resulting ~2% lower for M1
- No correction for SD degradation calibration error for the time period from launch (10/28/2011 to April 2012), ~1.5%

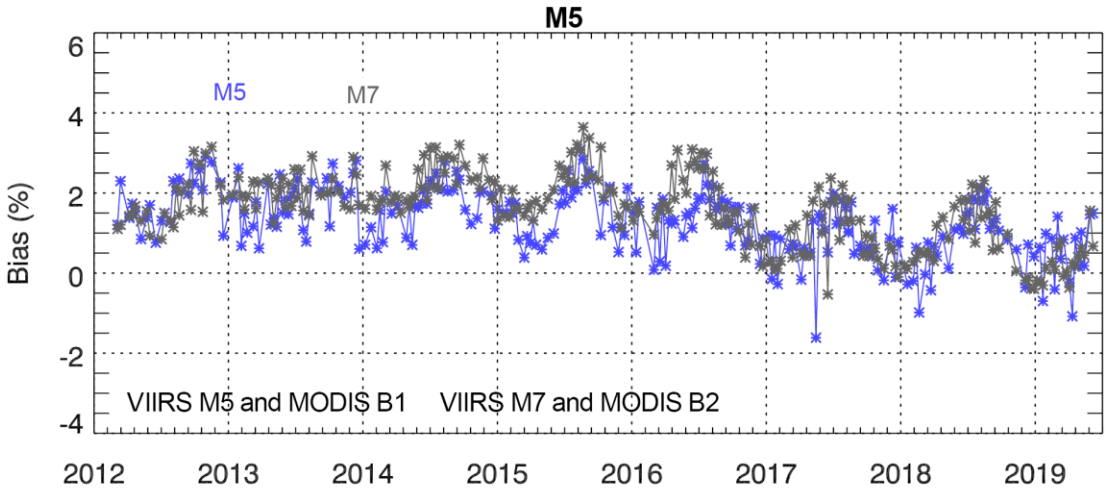
Table 4 NOAA-20 bias values relative to SNPP.

NOAA-20 VIIRS bias	M3 (0.48 μm)	M5 (0.67 μm)	M7 (0.86 μm)	M9 (1.38 μm)	M10 (1.61 μm)	M11 (2.25 μm)
Using double difference with ABI	−2% ± 1.2%	−3.5% ± 1.3%	−2.8% ± 1.1%	−5.2% ± 3.5%	−2.5% ± 2.1%	−2.9% ± 1.8%
Libya 4 site	−1.86 ± 0.69%	−3.48 ± 0.47%	−3.45% ± 0.58%		1.49% ± 0.54%	−0.8% ± 2.0%

Uprety et.al, JARS, 2020

VIIRS-MODIS calibration differences from NOAA STAR





Plots from the website:https://ncc.nesdis.noaa.gov/VIIRS/VIIRS_MODIS_Intercomparison.php

Summary

- SNPP and Aqua MODIS VIS/NIR bands show agreement to within 3%. Some temporal drifts seen in the bias-after 2017 (reason for the drift not specified on the website or documentation)
- Similar comparison for N20 with Aqua MODIS not published on the NOAA STAR website