Suomi NPP VIIRS Calibration Comparison between NOAA and NASA Versions and Impacts on L1b Products

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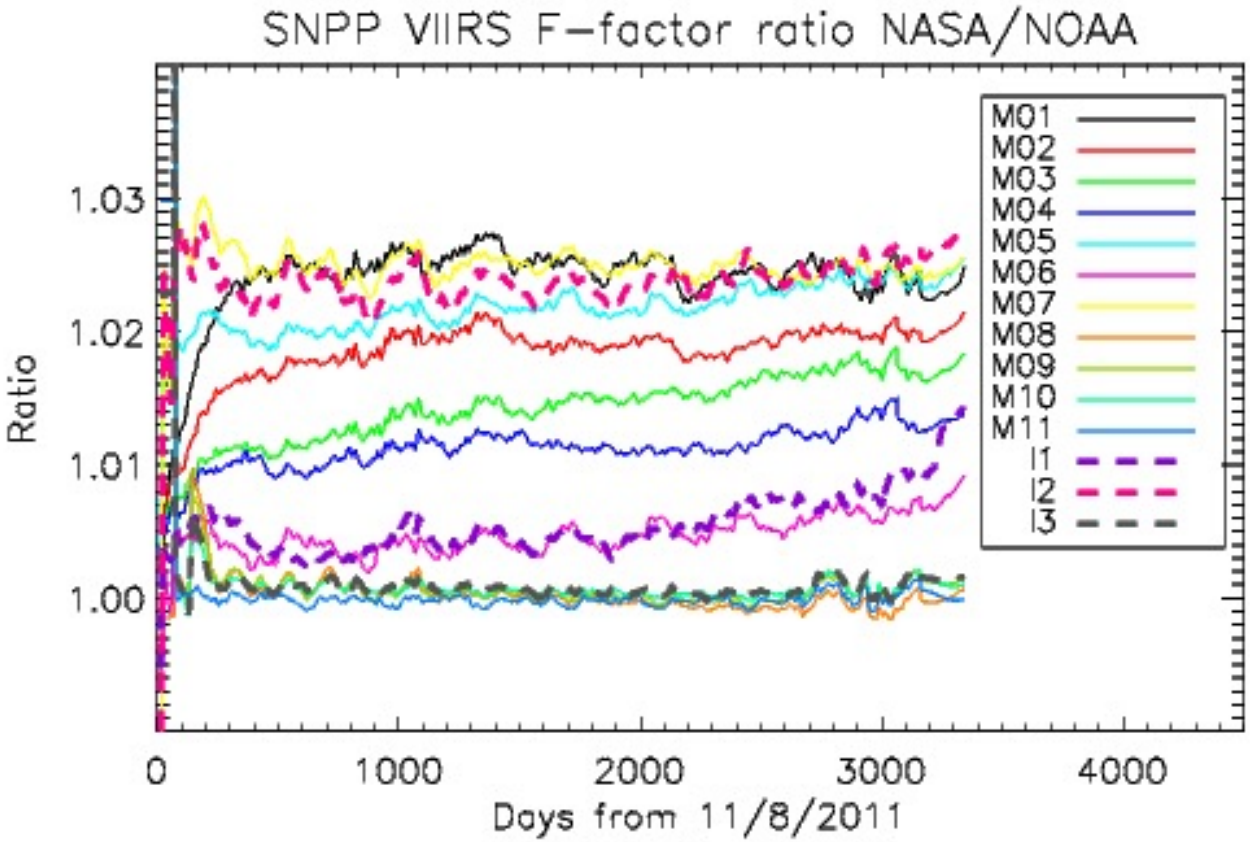
Background

- SNPP VIIRS has been performing well with excellent Earth observation data.
- Using decade long VIIRS data for long term climate records requires stringent calibration quality.
- Users' have option to choose reprocessed SNPP VIIRS SDRs based on NOAA STAR Version 2 reprocessing (Ref: Cao et al., 2021) and NASA C2 reprocessing
- This study focus on SNPP VIIRS calibration comparison between NOAA and NASA :
  - ❑ Comparing NOAA VIIRS V2 reprocessed F-factors with NASA C2 (5200) F-factors
  - ❑ Comparing NOAA VIIRS V2 reprocessed radiance product with NASA C2 (5200) radiance product
  - ❑ Comparing NOAA and NASA VIIRS calibration stability using DCC trends
- As the two major VIIRS data providers, the calibration difference between NOAA and NASA products needs to be quantified and monitored regularly to help users understand the impacts on higher level Environmental Data Records (EDRs).
- Solar irradiance models used
  - ❑ NASA's LUTs are based on Modtran4.3, 1999 (based on Kurucz). [Ref. Sun et al., 2021]
  - ❑ NOAA's LUT are based on Thuillier solar irradiance model (2002).
  - ❑ For this study, NOAA's LUT were converted to Modtran4.3 solar irradiance to match with NASA to quantify the calibration differences

Note: NOAA-20 VIIRS is a GSICS VISNIR calibration reference (Doelling et al., 2021)

NASA and NOAA F-factor Ratio

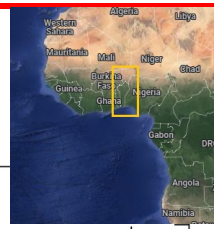


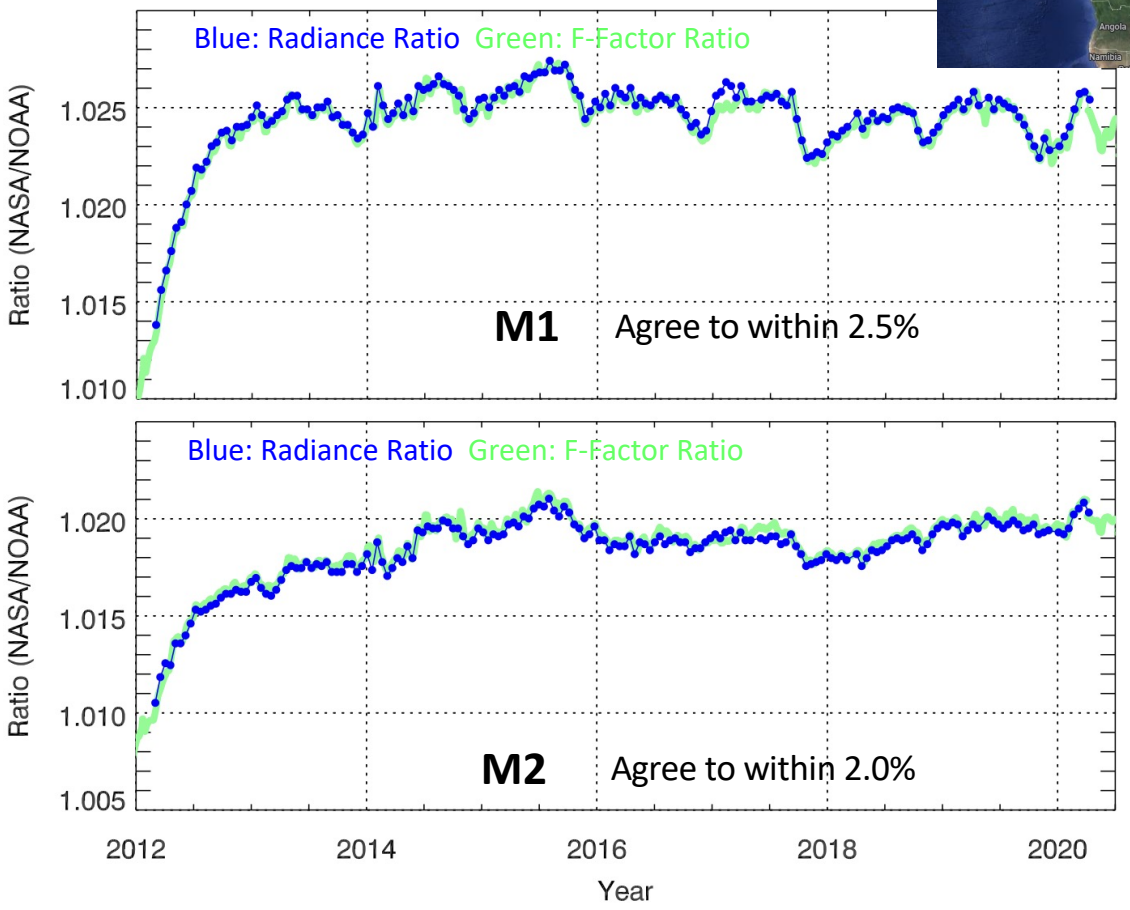
- NASA F-factors are higher than NOAA.
  - VISNIR bands agree within 2.5%; SWIR bands agree within 0.2% (up to 0.8% in early 2012)

- Ratios suggest stable responses except M3, M4, M5, M6, and I1
  - NASA's F-factors are gradually increasing compared to NOAA

Comparing NOAA and NASA VIIRS Radiance (M1 and M2)

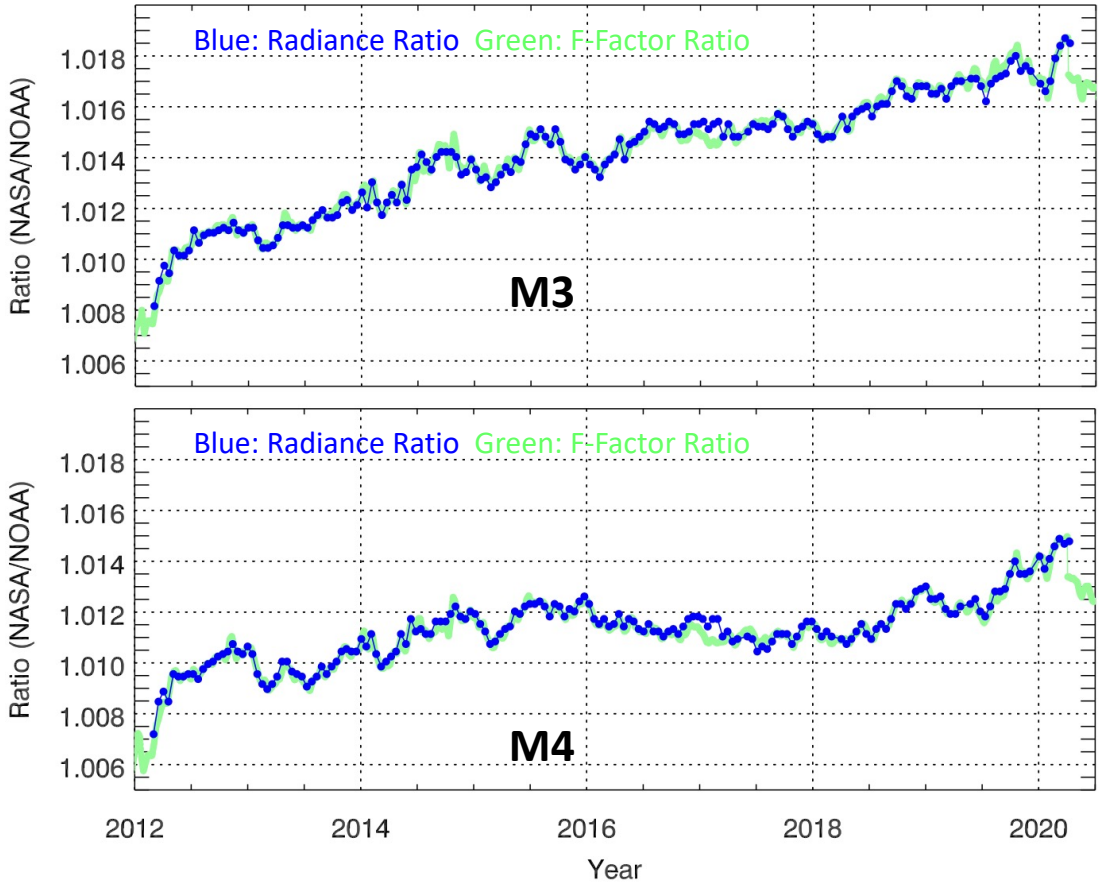
- Radiance ratio (HG and LG combined) time series derived for NASA and NOAA
  - For each VIIRS granule, non-bow-tie region used to compute radiance ratio (every 16 days)
- NOAA and NASA calibration agrees within 2.5%
- Radiance ratio (Blue) and F-factor ratio (Green) agree very well
- Increasing trend observed from 2012 to 2014, remains nearly stable afterwards
  - ~1% increase in 2012



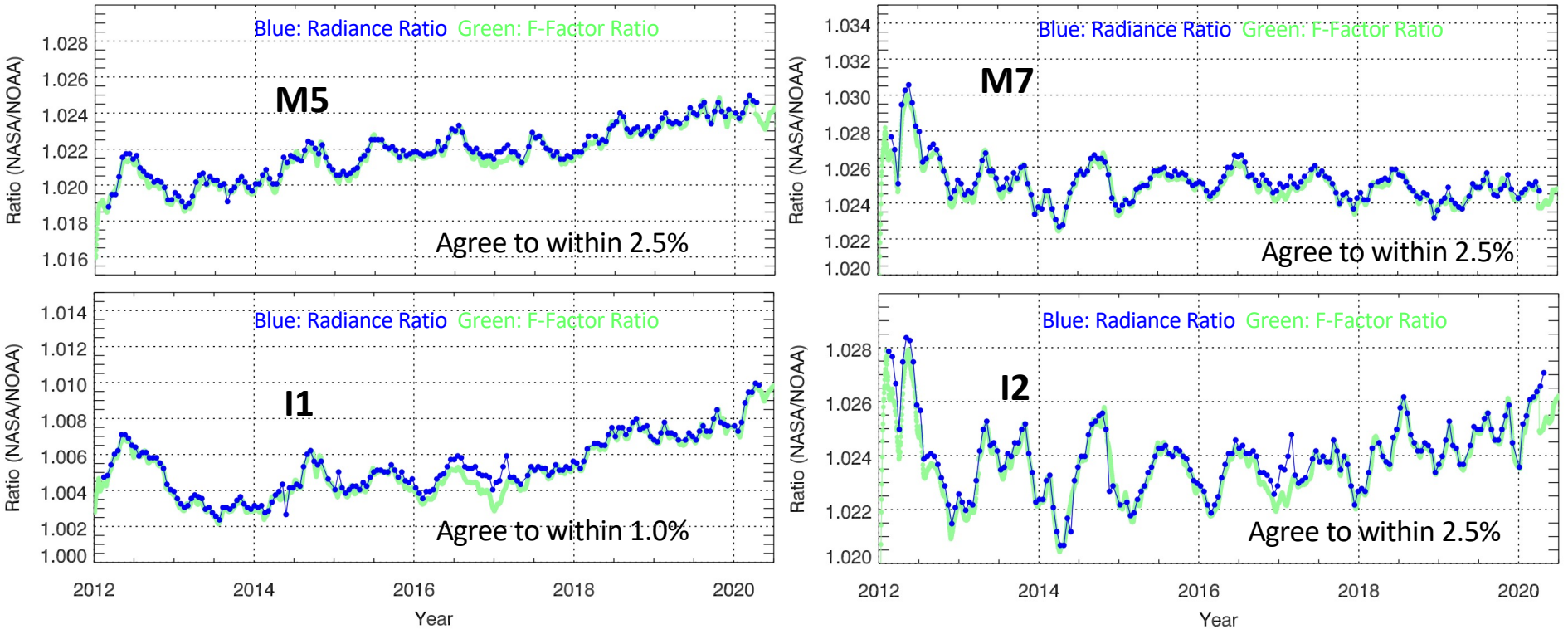


Comparing NOAA and NASA VIIRS Radiance (M3 and M4)

- NOAA and NASA calibration agree within 2.0%
- Increasing trend observed in both M3 and M4
  - Indicates larger residual degradation in NASA calibration

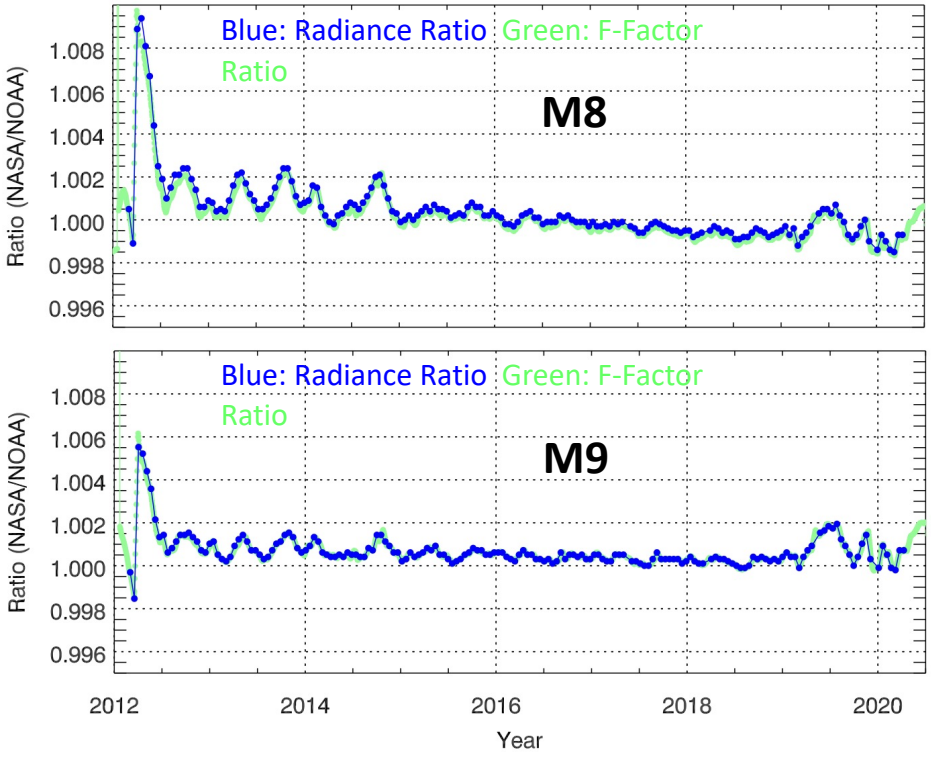


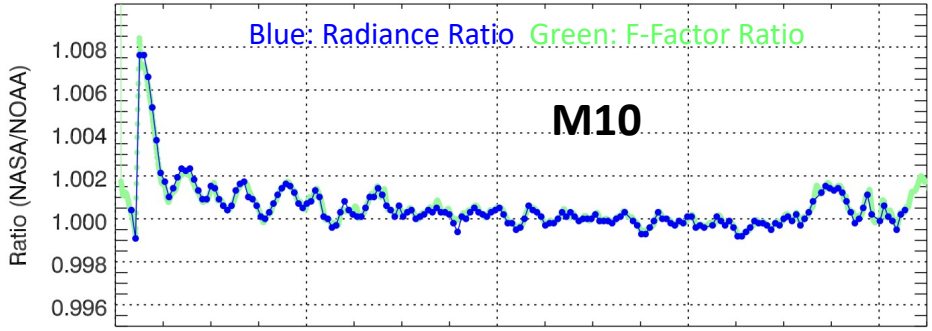
Comparing NOAA and NASA VIIRS Radiance (M5-7, I1-2)

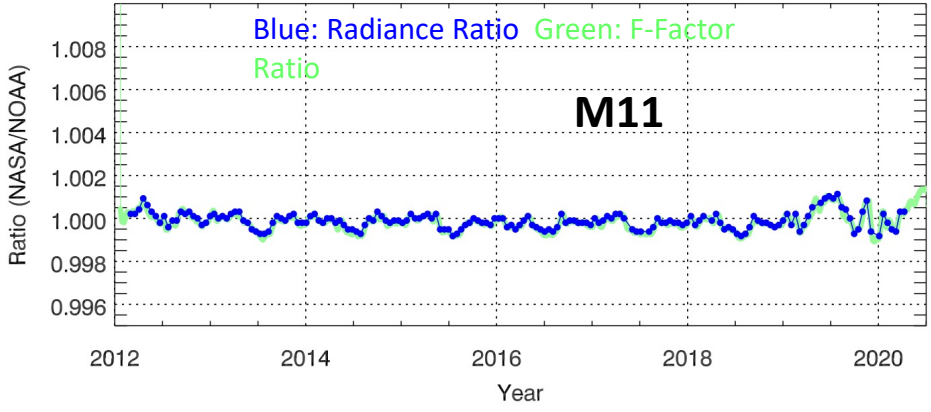


- M5, M7 and I2 differ by more than 2%
  - Bias correction (1.5% for M5 and 2% for M7, I2) applied in NOAA V2 reprocessing
- M5 and I1 indicate increasing trend by nearly 0.5%,
- M7 and I2 show nearly flat trend after 2013, although with annual oscillation

Comparing NOAA and NASA VIIRS SWIR Bands



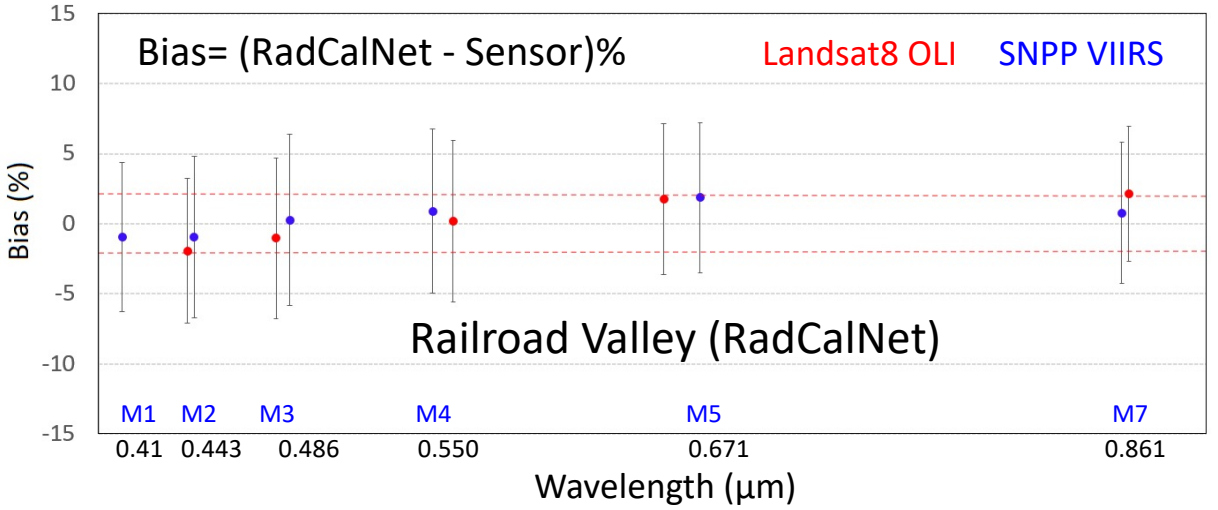


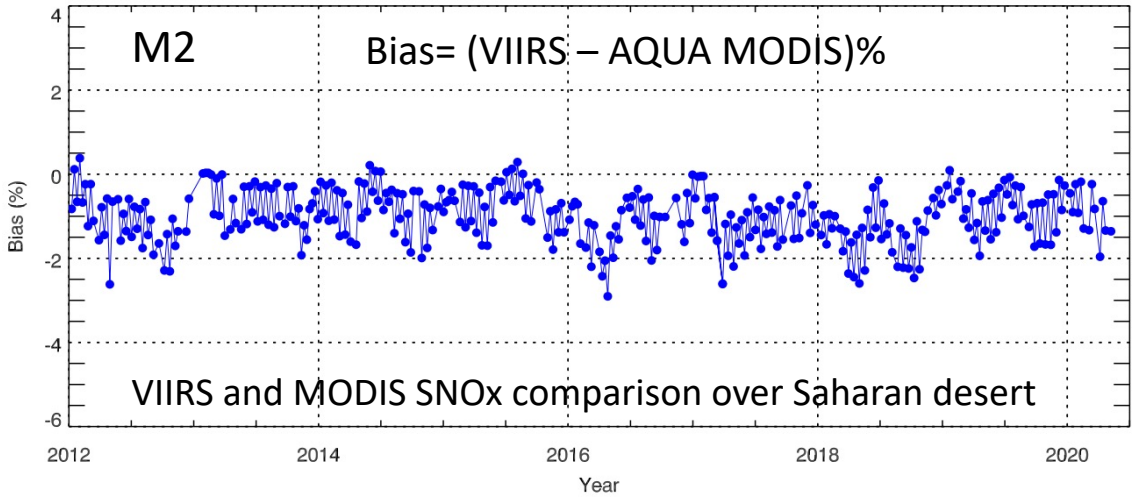


- Starting from mid 2012, SWIR bands agree to within 0.2%

V2 Reprocessed NOAA SNPP VIIRS Radiometric Accuracy

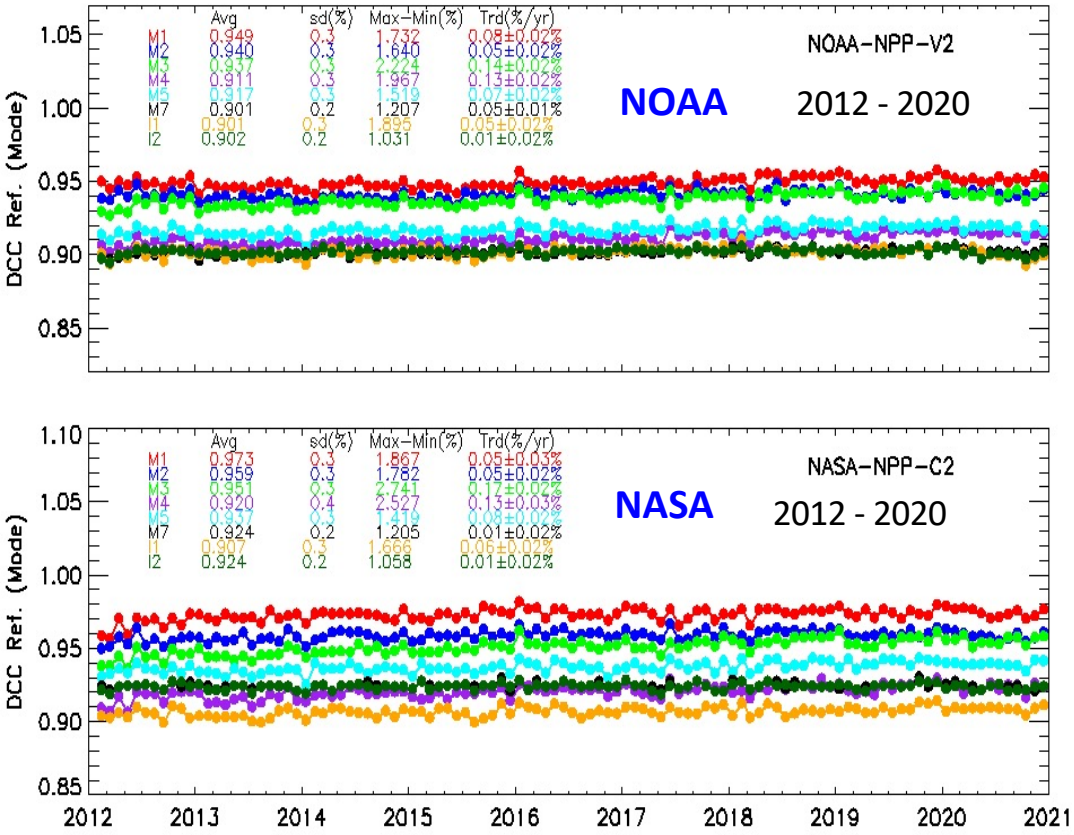
- Radiometric accuracy of V2 Reprocessed SNPP VIIRS is within 2% (Cao et al., 2021, Uprety et al., 2015)
- Evaluated using independent validation schemes
  - VIIRS agrees with RVUS RadCalNet to within 2%
  - VIIRS and Landsat 8 OLI (over RadCalNet and desert) agree well within 2%
  - VIIRS and AQUA MODIS (using SNOs) agree well within 2%





VIIRS Stability using Monthly DCC Time Series

- 2012-2020: the stability of NOAA-NPP-V2 VNIR bands is comparable with NASA-NPP-C2:
  - **M1-M2, M5, M7: trends < ±0.08%/year**
  - **M3-M4: trends ~0.13 – 0.17%/year**
- SWIR trends in the NOAA-NPP-V2 and NASA-NPP-C2 are generally comparable with each other **(<0.05%/year**).
- NOAA-NPP-V2 M10/I3 show slightly larger trends (-0.09%/year)



Summary of S-NPP VIIRS DCC Trends (2/2012 – 12/2020)

Trend ± 95%CI Unit: %/year		Center	NOAA	NASA
		Wavelength (μm)	(V2Reprocessed) %/year	Collection 2 %/year
VNIR	M1	0.411	0.08±0.02	0.05±0.03
	M2	0.444	0.05±0.02	0.05±0.02
	M3	***0.486***	***0.14±0.02***	***0.17±0.02***
	M4	***0.551***	***0.13±0.02***	***0.13±0.02***
	M5	0.672	0.07±0.01	0.08±0.02
	M7	0.862	0.05±0.01	0.01±0.02
	I1	0.639	0.05±0.02	0.06±0.02
	I2	0.862	0.01±0.02	0.01±0.02
SWIR	M8	1.238	-0.05±0.04	-0.05±0.04
	M9	1.375	-0.03±0.06	-0.02±0.07
	M10	1.602	-0.09±0.05	-0.06±0.06
	M11	2.256	-0.05±0.05	-0.04±0.05
	I3	1.602	-0.09±0.06	-0.05±0.06

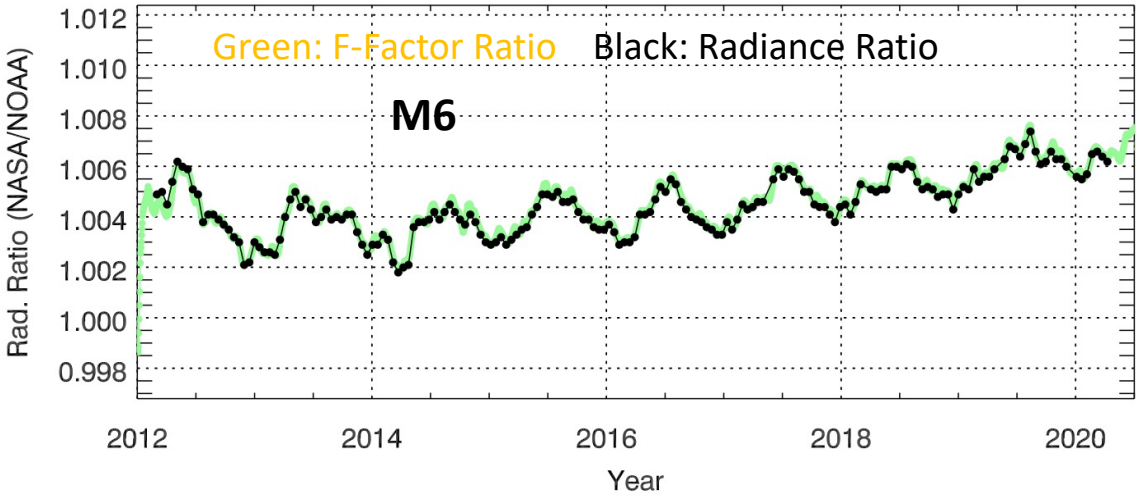
Summary

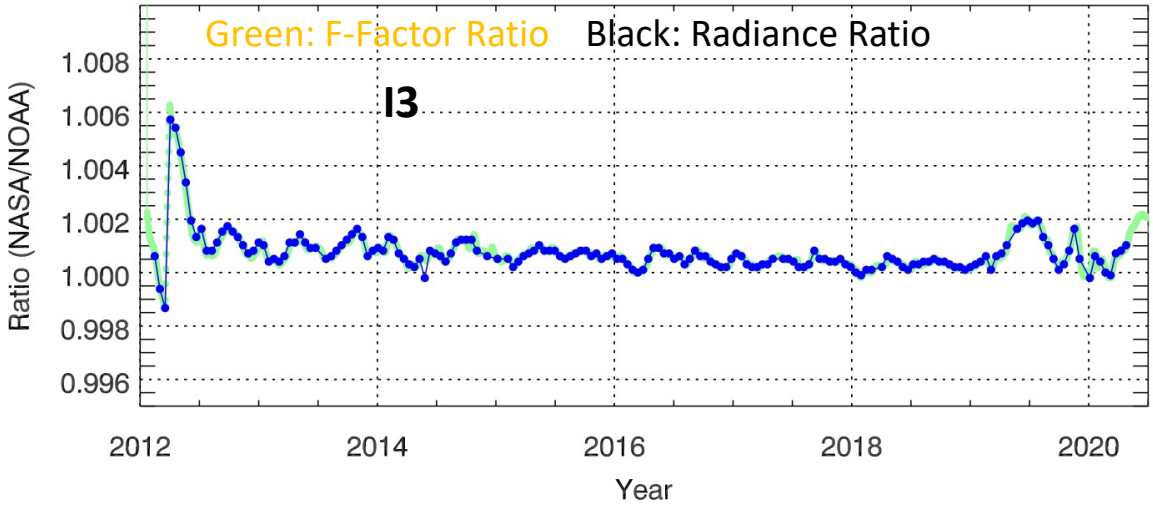
- NOAA and NASA calibration agree to within 2.5% for all the solar bands
  - The difference in M5, M7 and I2 by more than 2% is mainly due to the bias correction (1.5% for M5 and 2% for M7, I2) applied in NOAA V2 reprocessing (NASA didn't apply this correction)
  - Radiance ratio for M3, M4, M5, I1, and M6 suggest bias increasing trend including M1 to M2 during early 2012 (Possibly due to lunar calibration approach used for M1 to M4 bands)
  - Note: NOAA V2 reprocessed data uses Thuillier solar irradiance; NASA uses Modtran4.3 model
    - The difference has already been accounted in this study
- NOAA V2 calibration quality analyzed using independent validation techniques (intercomparison with RVUS Radcalnet, Landsat-8 OLI, and AQUA MODIS) indicate accuracy to within 2%
- NOAA and NASA calibration agree to within 0.2% for SWIR bands, although with larger difference (up to 0.8%) during early 2012
- The stability of both the VNIR and SWIR bands (derived using global DCC) are comparable between NASA and NOAA products (less than 1%)
  - M3 (NOAA: 1.3%, NASA: 1.7%) and M4 (1.4%) indicate larger degradation

Disclaimer

The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the author(s) and do not necessarily reflect those of NOAA or the Department of Commerce.

Backup

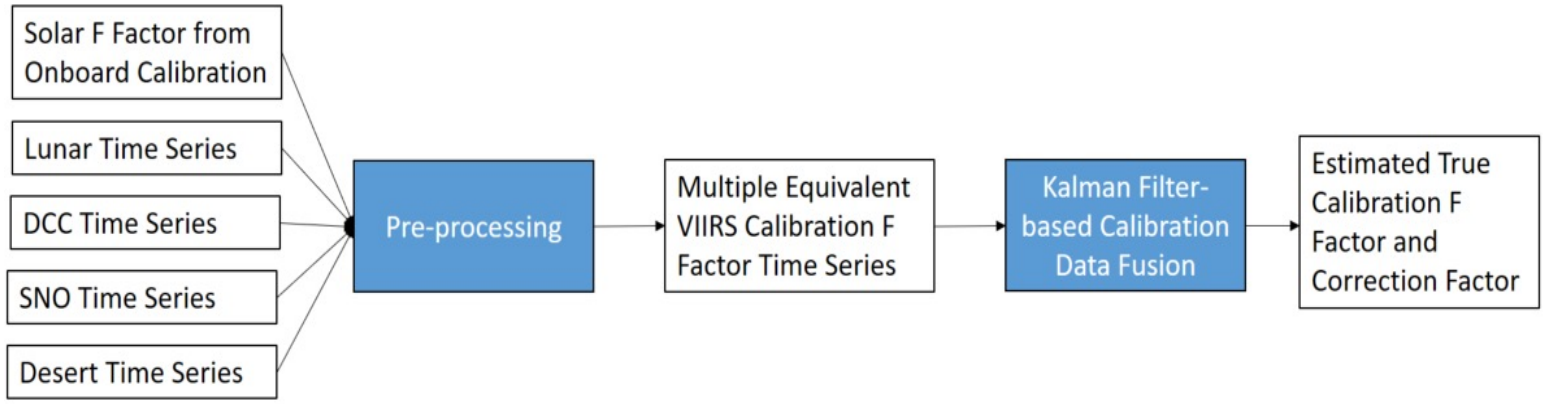

Green: F-Factor Ratio
Black: Radiance Ratio
M6
Rad. Ratio (NASA/NOAA)
1.012
1.010
1.008
1.006
1.004
1.002
1.000
0.998
2012
2014
2016
2018
2020
Year


Green: F-Factor Ratio
Black: Radiance Ratio
I3
Ratio (NASA/NOAA)
1.008
1.006
1.004
1.002
1.000
0.998
0.996
2012
2014
2016
2018
2020
Year

RSB Calibration Approach (Kalman and SRRS)

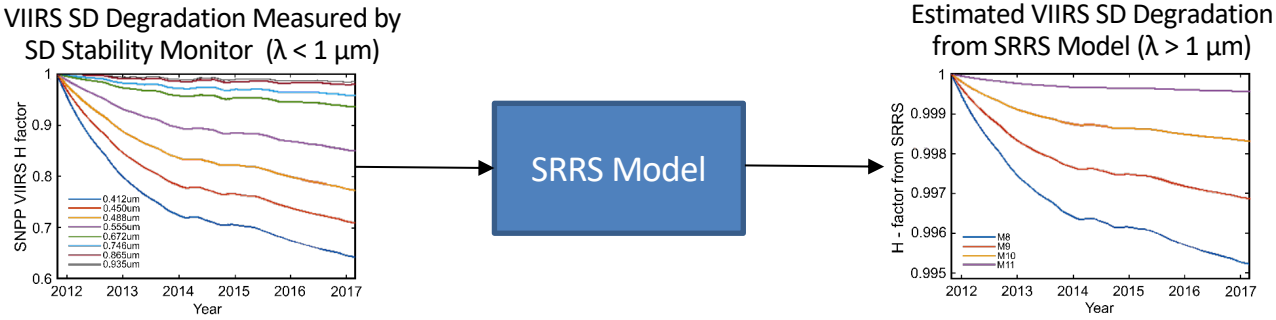
Framework of Kalman-Filter-based Calibration Data Fusion (KFCDF) system for VIIRS (Reflective Solar Bands (RSBs) with wavelength < 1 μm). The Kalman Filter is used to derive improved calibration gain.

VISNIR Bands



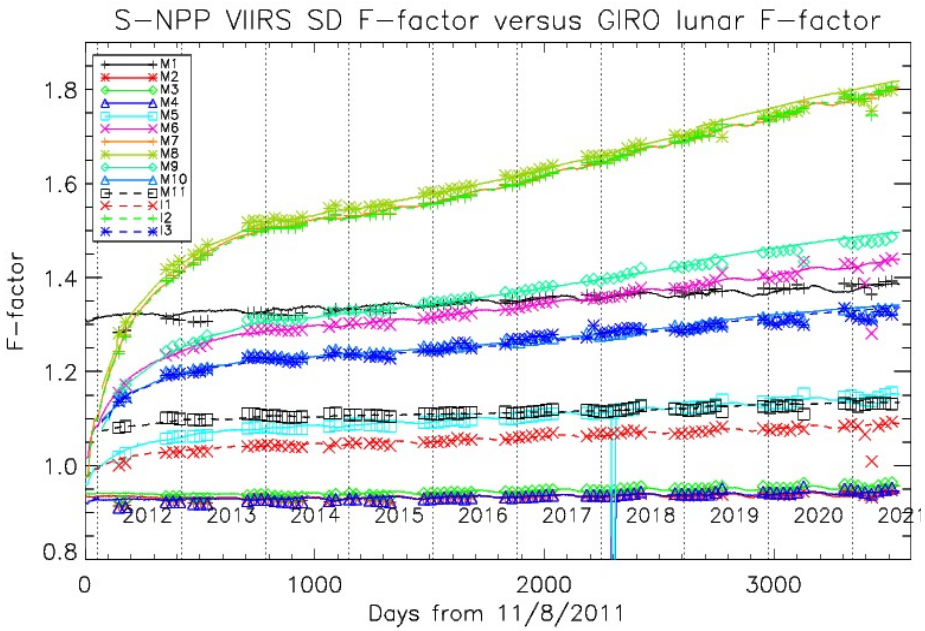
Framework of Surface Roughness Rayleigh Scattering (SRRS) model to correct solar diffuser (SD) degradation for VIIRS RSBs with wavelength > 1 μm.

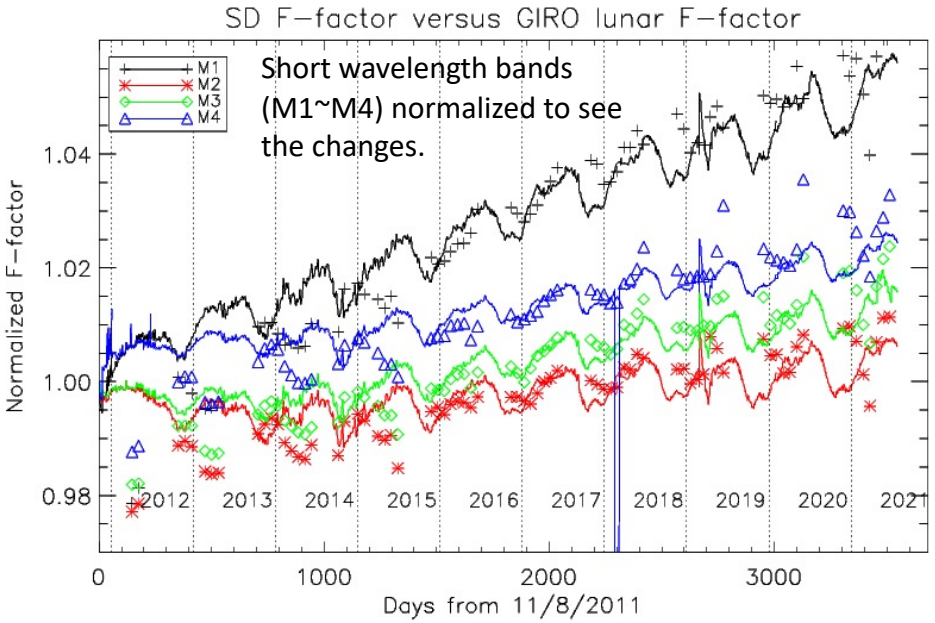
SWIR Bands



Ref: Cao, C.; Zhang, B.; Shao, X.; Wang, W.; Uprety, S.; Choi, T.; Blonski, S.; Gu, Y.; Bai, Y.; Lin, L.; Kalluri, S. Mission-Long Recalibrated Science Quality Suomi NPP VIIRS Radiometric Dataset Using Advanced Algorithms for Time Series Studies. Remote Sens. ***2021****, 13, 1075. https://doi.org/10.3390/rs13061075*

S-NPP VIIRS Lunar F-factors





- S-NPP VIIRS lunar F-factors (symbols) showed consistent results compared to the SD F-factors (lines).
- The two middle lunar F-factors with no-roll maneuver dropped from the trends because of the closer moon location to the Earth limb.
- The long-term trends between SD and lunar F-factors are mostly within ±1% level.