Assessing the Radiometric Consistency Between NOAA-20 and S-NPP VIIRS

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Abstract

The Visible Infrared Imaging Radiometer Suite (VIIRS) onboard S-NPP and NOAA-20 provides global coverage once per day for the reflective solar bands. To use VIIRS data for long term environmental related studies, it is critical to have radiometrically accurate and consistent data products from both instruments. Although the operational calibration of NOAA-20 VIIRS has been found to be very stable, past studies have shown that there exists a near consistent bias in RSBs between the two VIIRS instruments, with NOAA-20 VIIRS top-of-atmosphere (TOA) reflectance being lower by 2-3%. It is crucial to monitor the radiometric consistency between the two VIIRS instruments and help the user community understand the trending of the relative bias between two VIIRS and its impacts on the higher level EDR products. This study is focused on analyzing NOAA-20 VIIRS radiometric bias relative to S-NPP VIIRS operational SDR using different techniques such as the pseudo-invariant calibration sites (PICS) and inter-comparison with other satellite instruments using Simultaneous Nadir Overpasses (SNOs). In addition, S-NPP VIIRS data have been recalibrated and reprocessed at NOAA/STAR from Jan. 2012 to Mar. 2017. Novel approach used in the recalibration along with the resulting improvements in S-NPP VIIRS SDR data quality is also presented.

Background

- For long term environmental studies and to establish data continuity for broader scientific applications, radiometric consistency is a key requirement among satellite sensors.
- In order to evaluate the possible differences observed in higher level EDR products, it is very important for the user community to understand how well the two VIIRS SDR products compare with each other.
- With more than 8 years in space, S-NPP VIIRS has been rigorously calibrated and validated with a number of major look-up-table updates since launch.
- This study quantifies how well NOAA-20 VIIRS SDR agree with S-NPP VIIRS through intercomparison.
- To ensure that the intercomparison is free of any residual degradation in S-NPP VIIRS, it is more desirable to use recalibrated and reprocessed S-NPP VIIRS data.
- S-NPP VIIRS has been reprocessed with improved calibration stability and accuracy since early launch (Jan. 2012 to Mar. 2017).
- Reprocessed S-NPP VIIRS data are available to users https://ncc.nesdis.noaa.gov/VIIRS/index.php

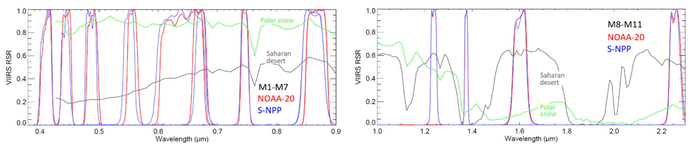


Figure 1. VIIRS RSRs and spectral features over polar snow and Saharan desert

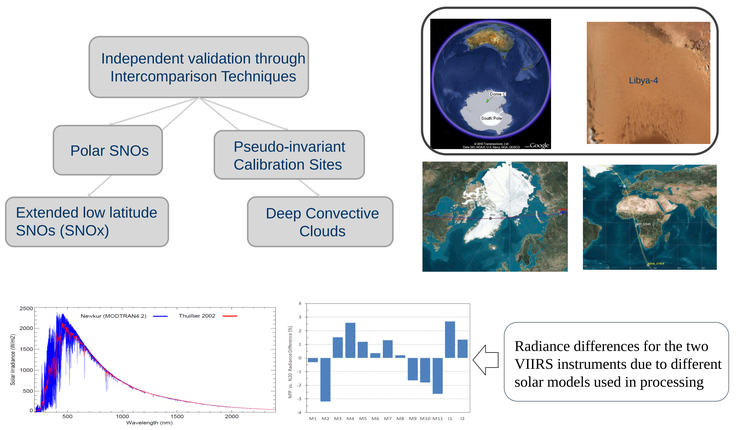


Figure 2. Intercomparison using multiple independent techniques and solar models

VIIRS Radiometric Consistency

Polar and Extended SNOs

- VIIRS bias trends are derived relative to AQUA MODIS, since no direct SNOs exists between VIIRS.
- Double differencing the two VIIRS bias trends indicates the VIIRS radiometric consistency

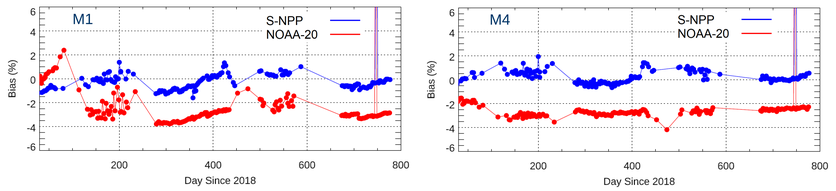


Figure 3. NOAA-20 VIIRS (M1 and M4) radiometric consistency with S-NPP VIIRS using polar SNOs. Although relative bias between the two VIIRS sensors looks nearly consistent, a small increase (<0.5%) in trend can be observed for blue and green bands in NOAA-20 VIIRS. Spikes near days 775 are due to recent VIIRS solar vector anomaly.

Extended SNOs Desert

Extended SNOs Ocean

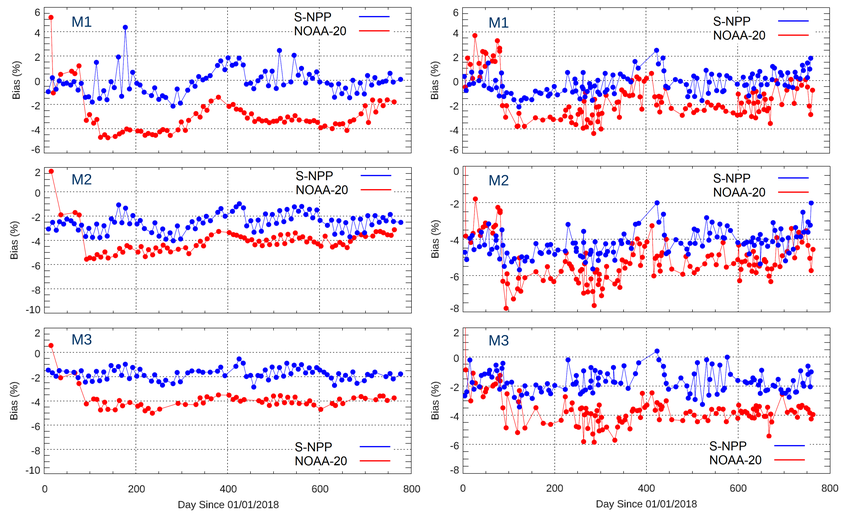


Figure 3. VIIRS bias time series relative to MODIS. The difference in two VIIRS bias time series (double difference) provides relative radiometric consistency between VIIRS onboard NOAA-20 and S-NPP.

- Near consistent bias for NOAA-20 VIIRS over both the desert and ocean (~-2%)
- VIIRS bias (relative to MODIS) indicate increasing trends for bands M1 and M2, M4.
- Rest of the VIIRS RSB suggest similar magnitude in bias (~2%) for NOAA-20 relative to S-NPP
- Bands M5 and M7 indicate large bias (~4%) mainly due to overestimation in S-NPP VIIRS absolute calibration by nearly 2%

PICS

- Comparing VIIRS reflectance trending over pseudo-invariant calibration sites (PICS) NOAA-20 VIIRS indicate bias relative to S-NPP, on the order of -2-4% (Libya 4, shown in Fig. 4).

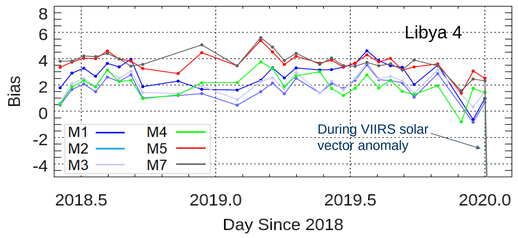
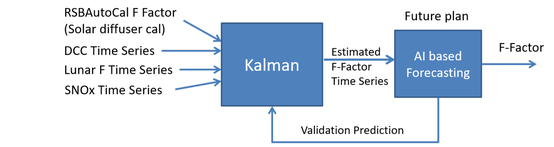


Figure 4. NOAA-20 and S-NPP VIIRS TOA reflectance trending based bias over Libya 4

S-NPP Recalibration and Reprocessing

- Improved radiometric consistency in the long-term data records
- STAR *Kalman Filter:* Bias correction factors based on LunarCal/DCC/SNO for VNIR bands
- STAR *Surface Roughness-induced Rayleigh Scattering (SRRS)* Model for SWIR bands
- Thuillier (2002) solar spectrum, consistent with NOAA-20
- Radiometric bias correction factors available to users for all bands



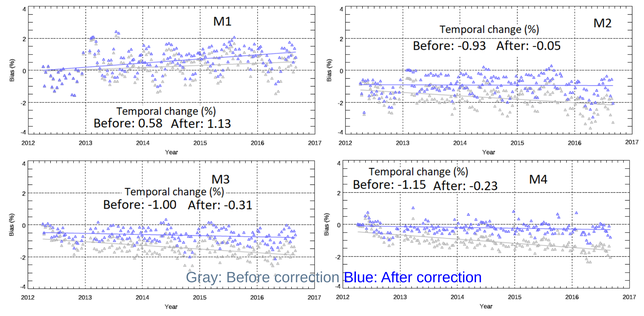
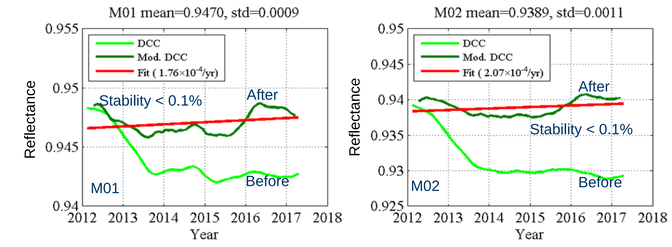


Figure 3. S-NPP VIIRS bias time series relative to MODIS using operational data (Before) and using reprocessed data (After).

- M1 shows dip in 2012, could be related to MODIS since this is not observed in DCC trend. Stable to 0.3% using data after 2013 only.
- Rest of the bands shows better than 0.3% stability with 1-sigma <0.5%.



Summary

- Radiometric consistency between NOAA-20 and S-NPP VIIRS reflective solar bands are independently validated
- All methods suggest that NOAA-20 VIIRS observed reflectance is consistently lower than that for S-NPP for all reflective solar bands under study by 2-3%.
- NOAA-20 VIIRS bias over desert (low gain) and ocean (high gain) agree well to within 1%.
- Radiometric intercomparison can be further improved in future by correcting residual degradation in S-NPP VIIRS which requires recalibration and reprocessing.
- S-NPP VIIRS has been recalibrated and reprocessed (from Jan 2012 to Mar. 2017) with accurate, consistent and temporally stable radiometric calibration, meeting all user needs
- Data servers established for distribution; web interface for user friendly data download

References:

[1] Uprety, S., Cao, C., Blonski, S., and Shao, X. (2018, October). Evaluating NOAA-20 and S-NPP VIIRS radiometric consistency. In Earth Observing Missions and Sensors: Development, Implementation, and Characterization V (Vol. 10781, p. 107810V). International Society for Optics and Photonics.

[2] Uprety, S., Cao, C., and Shao, X. (2019, September). Geo-Leo intercalibration to evaluate the radiometric performance of NOAA-20 VIIRS and GOES-16 ABI. In Earth Observing Systems XXIV (Vol. 11127, p. 111270S). International Society for Optics and Photonics.

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