



Radiometric Consistency Between S-NPP and NOAA-20 VIIRS Reflective Solar Bands

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- Background
- Sensor Intercomparison Techniques
 - SNO
 - SNOx
 - PICS
 - DCC
 - Ray matching based Geo-Leo
- Summary





- To ensure the calibration quality is well within specification, VIIRS radiometric performance needs to be continuously monitored and independently validated.
- The radiometric consistency of NOAA-20 and S-NPP VIIRS is evaluated using:
 - SNO over polar region
 - S-NPP bias relative to MODIS
 - NOAA-20 bias relative to MODIS
 - Bias between S-NPP and NOAA-20: Double differencing
 - Extended SNO (SNOx) over desert and ocean
 - SNOx extended over African desert and tropical ocean
 - Bias between S-NPP and NOAA-20: Double differencing (similar to SNO)
 - Pseudo-Invriant Calibration Sites (PICS)
 - VIIRS reflectance trending over Libya 4
 - NOAA-20 and S-NPP VIIRS are compared with Landsat OLI
 - Deep Convective Cloud (DCC)
 - Trending both the VIIRS instrument over DCC
 - Ray matching technique
 - Comparing each VIIRS sensor with GOES-16 ABI and double differencing





- S-NPP and NOAA-20 RSRs are not identical and can have minor differences.
 - Results in spectral bias
 - Spectral Band Adjustment factors (SBAF) used based on Sciamachy

Ref: NASA Langley tool (<u>https://www-</u> pm.larc.nasa.gov/cgi-<u>bin/site/showdoc?mnemonic=SBA</u> <u>F</u>)

 Spectral bias for all bands are on the order of 1% or less except M4 (desert: ~3.2%).



	Shc				A 20	5 MT /~100/0/5 MT				
Target	M1	M2	M3	M4	M5	M7	M8	M10	11	12
South Pole	0.3%	0.1%	0.1%	-0.8%	0.2%	-0.4%	0.0%	0.5%	0.3%	-0.4%
DCC	0.0%	0.7%	0.2%	-0.4%	0.0%	-0.4%	-0.1%	0.7%	0.2%	-0.4%
Libyan Desert	-1.1%	0.0%	0.1%	3.2%	0.3%	1.0%	0.1%	0.2%	1.5%	0.8%

Spectral Bias= (NOAA-20 - S-NPP)×100%/S-NPP





- Both NOAA-20 and S-NPP have SNOs with AQUA.
- Study uses SNOs from both SH and NH.
- SNO: Near identical solar and sensor geometry for both sensors.
- Use AQUA MODIS as a transfer radiometer.
- Double differencing indicates the radiometric consistency between S-NPP and NOAA-20 VIIRS.









- Bias trends are changing over time.
- After H-factor update (March 23, 2018), NOAA-20 is lower than S-NPP by ~-2.5-3%
- Further after F-factor update in end of April, NOAA-20 VIIRS drops by nearly 1%







• NOAA-20 reflectance lower than S-NPP by 3.6%





Large bias exists for M5 (~-5.5%) and M7 (~-3.5%) because S-NPP VIIRS M5 and M7 calibration are biased high by ~2%.

Evaluating NOAA-20 and S-NPP Consistency using Extended SNO (SNOx) over Saharan Desert

- SNOs extended to low latitude Saharan desert and tropical ocean.
- Allows instrument comparison within few minutes of time difference (usually <16 mins).
- Regularly used to monitor S-NPP Bias relative to MODIS since launch
 - <u>https://ncc.nesdis.noaa.gov/VIIRS/VIIRS_MO</u>
 <u>DIS_Intercomparison.php</u>
- Both NOAA-20and S-NPP VIIRS can be compared to and AQUA MODIS using SNO-x.
- Double differencing to evaluate the NOAA-20 and the S-NPP consistency.







M1-4 Bias Trends (Desert SNOx)





- ➤ M1-4 bias for NOAA-20 ranges from -3.5% to -2%.
- SNOx bias over Saharan desert consistent with SNO bias over polar region.





- Both M5 and M7 NOAA-20 VIIRS biases are lower than S-NPP.
- Bias agrees with polar SNO to within 0.5%
- M5 and M7 suggest large bias because S-NPP VIIRS M5 and M7 are biased high by about 2%.





M8 and M10 Bias Trends (Desert SNOx)

8

-10

0



NOAA-20 M8 (1.240 µm) S-NPP 6 4 Bias (%) NOAA-20 Bias: ~-3% 2 0 M8 -2 NOAA-20 VIIRS is lower than -4 S-NPP for both M8 (~-3%) 200 300 600 700 100 400 500 0 Day Since 01/01/2018 and M10 (~-2%). 4 NOAA-20 M10 (1.61 µm) S-NPP 2 0 Bias (%) -2 NOAA-20 Bias: ~-2% -4 -6 -8

100

200

300

400

Day Since 01/01/2018

500

600

700

Ocean SNOx (M1-3 Bias Trends)

State Mercenter

- Comparison performed over clear sky tropical ocean using SNOx.
- Uses VIIRS high gain only
- M1-3 suggest bias on the order of -2% more recently.
- HG (over ocean) and LG (Polar SNO and Desert SNOx) Bias are consistent.







Pseudo-invariant Calibration Site (Libya 4) to Validate VIIRS Radiometric Consistency





- ROI: 30 km at lat/lon: 28.55° /23.4°
- Clear sky nadir observations
- Spectral differences accounted
- NOAA-20 VIIRS reflectance is lower than S-NPP
- NOAA-20 VIIRS M1 indicates larger bias (-5%) whereas the bias for the rest of the bands agree well (mostly within 1%) with previous methods.







VIIRS Radiometric Consistency with landsat 8 OLI over Libya 4





Note: Both NOAA-20 and S-NPP VIIRS are scaled using SBAF to account spectral difference relative to OLI.



NOAA-20 and S-NPP DCC Ratio over VNIR and SWIR Bands





> All NOAA-20 bands are biased low, consistent to previous results.

Courtesy from Wenhui Wang, GST@ NOAA STAR17





- Intercomparison is performed near SNO using all sky tropical ocean observations
- Ray matching technique is used to match the sensor and solar geometry
- ROI size: :±20° lat/lon from sub-satellite location.
 - For each SNO, average all bias values computed over 0.5°*0.5° lat/lon bins.



ABI Band	Central Wavelength(µm)	Туре	Nickname	Best Spatial Resolution		
1	0.47	Visible	Blue	1		
2	0.64	Visible	Red	0.5		
3	0.86	Near-Infrared	Veggie	1		
4	1.37	Near-Infrared	Cirrus	2		
5	1.6	Near-Infrared	Snow/Ice	1		
6	2.2	Near-Infrared	Cloud particle size	2		

 Table Ref: <u>https://www.goes-r.gov/spacesegment/ABI-tech-summary.html</u>



Radiometric Consistency Between VIIRS





- Weekly averaged bias time series: more uniform sampling of dynamic range over bins
- NOAA-20 VIIRS TOA reflectance lower by ~2-3%, with noisier trends
- ABI band 2 has drop from April 2019:
 - operational calibration update lowering reflectance by nearly 6%
 - Improves the ABI agreement with VIIRS to ±2%





Summary

- Study suggests that NOAA-20 VIIRS observed TOA reflectance is consistently lower (2-3%) than S-NPP VIIRS for all RSB.
- Larger bias exists for M5 (-4.5%) and M7 (-4%) because S-NPP VIIRS M5 and M7 absolute calibration are biased high by ~2%.
- Results from five major independent validation methods agree to within 1% for most bands.
- VIIRS radiometric performance is regularly monitored using all the techniques presented.
- Bias for NOAA-20 VIIRS investigation will be continued for root cause.





Questions?