MONITORING OF THE CROSS-CALIBRATION BIASES BETWEEN THE S-NPP AND NOAA-20 VIIRS SENSOR DATA RECORDS USING GOES ADVANCED BASELINE IMAGER AS A TRANSFER

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ABSTRACT

To provide near-real time monitoring of SNPP and NOAA-20 data inter-sensor biases, this study extends the GEO-LEO intercalibration method established in [1] to the Visible Infrared Imaging Radiometer Suite (VIIRS) Sensor Data Record (SDR) data at six reflective solar bands (RSBs) and three thermal emissive bands (TEBs) bands via the STAR Integrated Calibration and Validation System (ICVS) framework. The GOES-16/17 Advanced Baseline Imager (ABI) is used respectively as a transfer to calculate double difference (DD) of VIIRS-ABI Simultaneous Nadir Overpass (SNO) pairs for the SNPP and NOAA-20 VIIRS SDR data biases cross-calibration. A series of sensitivity analyses on the dependence of the results to quality assurance, viewing geometries, spectral difference corrections, latitudinal variation, and cloud screening are conducted to produce more accurate inter-sensor biases. The findings are further verified by other independent approaches, namely the 32-day average difference method (32Day-AD) [2] and DD with radiative transfer model as a transfer (RTM-DD) method.

Index Terms *– S-NPP and NOAA-20 VIIRS Sensor Data Records, Near Real Time Cross-Calibration Bias Calculations, Integrated Calibration and Validation System, Double Difference via GOES-16/17 ABI*

1. INTRODUCTION

In celebrating its 10-year Anniversary in 2020, National Oceanic and Atmospheric Administration (NOAA) JPSS ICVS has served broad satellite science and operational communities with its vision of “Satellite observations are intercomparable and tied to international standards for weather, climate, ocean and other environmental applications”. With its uniqueness of monitoring multiple sensors across multiple platforms, ICVS’s long term monitoring of multiple sensors provides unprecedented opportunity to compare multi-sensor observations and to assess any persistent relative bias between instruments for cross-calibration. With the S-NPP launched in Oct 2011 and NOAA-20 launched in Nov 2017, it becomes imperative to better understand the consistency and discrepancy between the S-NPP and NOAA-20 SDRs that are crucially important for instrument stability, data quality assurance, and long term climate data record continuity.

Onboard of both S-NPP and NOAA-20, VIIRS features 13 reflective solar bands (RSBs), one day/night band (DNB) and 8 thermal emissive bands (TEBs) [3]. Cross-calibration of the VIIRS SDR from the two sensors has been conducted in the past studies with the implications that the radiometric accuracy and instrument stability of both sensors are well within the specification [1][3]-[8]. Considering the different orbital overpassing time of the two sensors, double difference calculated using the SNO from a 3rd sensor as transfer is frequently used for intersensor cross-calibration [1][4]. Latest research investigated the bias assessment uncertainty associated with quality assurance and use of methodologies, and highlighted the consistency and discrepancy in the findings from various cross-calibration approaches and a fused inter-sensor comparison methodology [9-11]. Based on these previous studies, this study further expands the GEO-LEO cross-calibration method in [1] to both RSB and TEB for both GOES-16 and GOES-17 for SNPP and NOAA-20 VIIRS cross-sensor bias assessment in near-real time (NRT) mode via the ICVS, and explores the result consistency to other independent assessment methods.

2. METHODOLOGY

To compare the S-NPP and NOAA-20 VIIRS SDR radiometric observations, the double difference using the ABI SNO as a transfer (ABI-DD) is calculated. As shown in the following schematic diagram, the ABI-DD method calculates the radiometric differences of the SNOs between VIIRS and ABI, for S-NPP and NOAA-20 respectively. A double difference is then calculated to gauge the radiometric differences between the two VIIRS instruments [1].

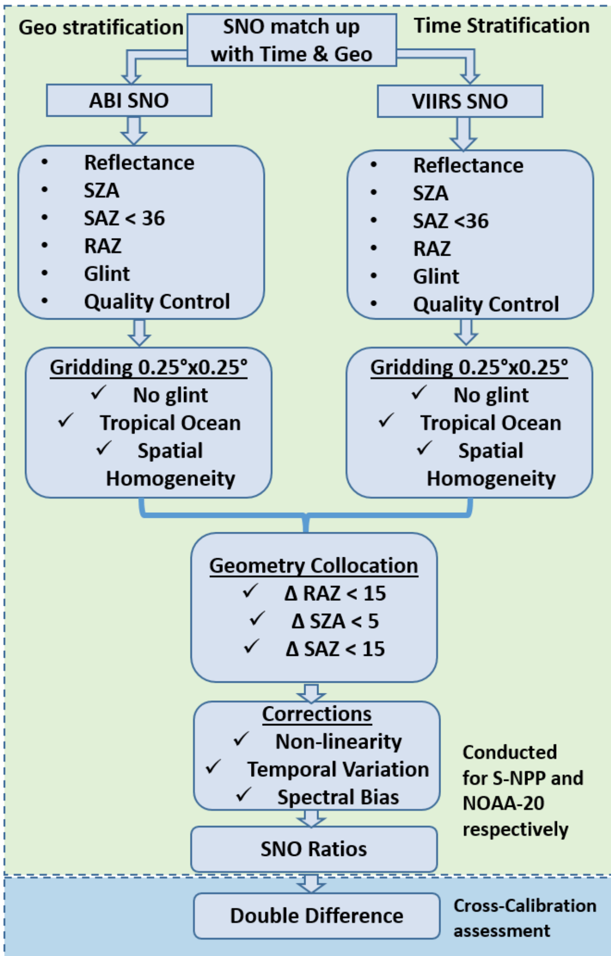

Fig. 1. Schematic diagram of the ABI-DD method with VIIRS-ABI SNO matchup and DD calculation

The spectral bands from S-NPP and NOAA-20 VIIRS and GOES-16/17 ABI that are assessed in this study are listed in Table 1.

Table 1. The spectral RSB and TEB bands from VIIRS and ABI assessed in the ABI-DD method

Spectral Region	Center Wavelength (µm)	VIIRS Bands	ABI Bands
RSB	0.488	M3	Ch 1
RSB	0.672	M5	Ch 2
RSB	0.865	M7	Ch 3
RSB	1.378	M9	Ch 4
RSB	1.61	M10	Ch 5
RSB	2.25	M11	Ch 6
TEB	3.7	M12	Ch 7
TEB	8.55	M14	Ch 11
TEB	10.763	M15	Ch 13

Fig. 2 illustrates how the VIIRS daytime observations (granules in red box and orbits in red dotted line) are matched up with ABI SNOs (nadir in the center of background ABI images). Regions of interest over tropical ocean areas are in black boxes.

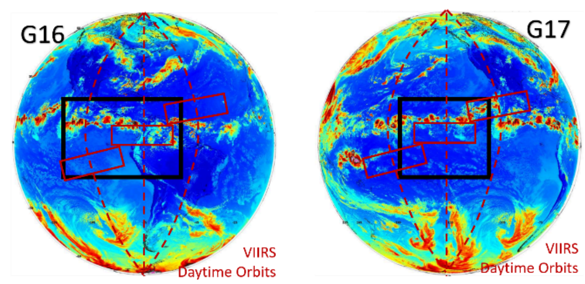

Fig.2. Illustration of the VIIRS vs. ABI inter-sensor SNO matchup (left: VIIRS vs. G16 ABI; right: VIIRS vs. G17 ABI).

Two other independent satellite instrument validation methods are discussed for result verification, including the 32-day averaged differences (32Day-AD) in [2] and the double difference using radiative transfer model simulations as a transfer (RTM-DD). The 32Day-AD method took into account that S-NPP and NOAA-20 observations are approximately 50 minutes apart and their direct comparison is only feasible over the features that have stable radiometric characterization over time and space. Thus the SDR means over 32 Day (two full global coverage cycles by VIIRS) of these features after quality assurance stratifications are calculated and compared for cross-calibration bias assessment. The detail of this method is referred to [2]. Taking the advantage of the RTM are simulating the same instrument and atmosphere as S-NPP and NOAA-20 VIIRS observations were taking place, the RTM-DD method uses RTM simulations as a transfer and compare VIIRS observations and RTM simulations for S-NPP and NOAA-20 VIIRS respectively, and then a double difference (DD) is calculated to assess the radiometric differences between the two VIIRS instruments.

3. RESULTS AND DISCUSSIONS

Assessed by both the ABI-DD and 32Day-AD methods, six VIIRS RSB bands are cross-calibrated between NOAA-20 and S-NPP. Double difference percentage (DDP, %) is calculated as the deviation of NOAA-20 VIIRS SDR in reference to S-NPP. As shown in Fig 3, both methods agree that NOAA-20 VIIRS RSB observations appear lower than the S-NPP counterparts, while the results from the 32Day-AD method tend to agree better with the results from previous independent studies [1][4]. The bias of NOAA-20 SDR deviated from S-NPP using ABI as a transfer are larger than that in the 32Day-AD method, attributable to spectral bias correction, collocation data stratification, and low reflectance nonlinearity correction in the method implementation [9]-[11].

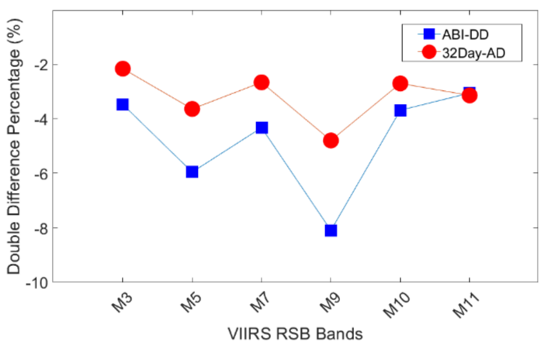

Fig 3. Reflectance double difference percentages between six RSB bands of NOAA-20 and S-NPP VIIRS as inferred from the 32Day-AD and 3rd Sensor-DD methods

Similarly, three VIIRS TEB bands are assessed for daytime and nighttime observations respectively by ABI-AD, 32Day-AD and RTM-DD methods. The findings from three methods showed that NOAA-20 VIIRS observations agree with S-NPP VIIRS very well, with very low absolute brightness temperature biases (<0.10 K) and a very small DDP (<0.03%). However, the results from the two methods are not always tracking each other very well for all bands, and more investigations on the uncertainty associated with quality assurance and data stratification procedures are warranted.

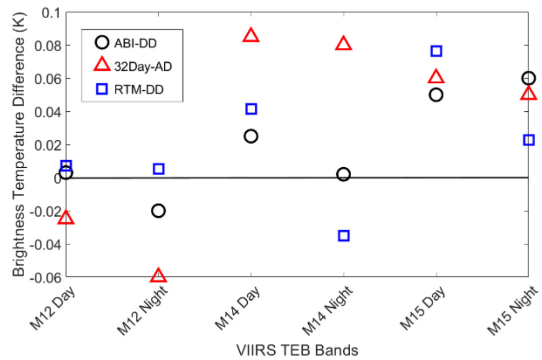

Fig 4. Absolute brightness temperature differences between three TEB bands of NOAA-20 and S-NPP VIIRS as inferred from the ABI-DD, 32Day-AD and RTM-DD methods, for daytime and nighttime respectively

4. CONCLUSIONS AND FUTURE WORK

Based on the methodology from previous study in [1] for the VIIRS RSB bands, more radiometric cross-calibration between the NOAA-20 and S-NPP VIIRS SDR observations, including 6 RSB bands and three TEB bands, were conducted using the ABI-DD method with GOES-16/17 ABI as a transfer radiometer. The results are also compared to two other independent methods, 32Day-AD and RTM-DD. The findings from difference methods are compared in terms of consistency and discrepancy, and result uncertainty associated with the methodologies are discussed. The methods agree that NOAA-20 VIIRS RSB bands tend to be only slightly lower than S-NPP, and NOAA-20 VIIRS TEB bands agree with S-NPP with very low absolute brightness temperature biases. However the result discrepancies remain non-negligible due to the uncertainty associated with quality assurance, data stratification, spectral bias correction, assessment criteria, SNO vs. non-SNO comparisons, and even the definition of double differences (DD) that should be corrected in future work. Further analysis is needed. Moreover, taking the advantage of the ICVS's near real time multisensor SDR performance monitoring capability, we are implementing this study to provide the near real time monitoring of the SNPP and NOAA-20 VIIRS data intersensor cross-calibration, which is crucial for instrument stability, sensor data quality assurance and long term climate data record continuity assessment.

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6. ACKNOWLEDGEMENT AND DISCLAIMER

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