

Advancements in DCC Calibration: VIS/NIR ATBD Update, Empirical BRDFs for SWIR wavelengths, and Future Directions

Raj Bhatt, Dave Doelling, Prathana Khakurel, Conor Haney, Arun Gopalan, Ben Scarino

CERES Imager and Geostationary Calibration Group NASA Langley Research Center

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Key assumptions of DCC-IT calibration method

- DCC-IT inter-calibration technique relies on a large ensemble of tropical DCC pixels identified using similar thresholds for reference LEO and target GEO sensors
- DCC-IT does not require simultaneous and ray-matched observations between GEO and LEO for inter-calibration
 - Agencies do not need to acquire real-time VIIRS data for calibrating GEOs
 - DCC response over a specific GEO domain is stable and characterized using the reference VIIRS instrument

Revised DCC-IT Calibration ATBD: key improvements

- Extends the methodology to all spectral channels between 0.4-1.0 μm
- Uses the most recent and well-calibrated NOAA-20 VIIRS sensor as a reference instrument for DCC characterization
- IR BT threshold normalization between GEO and VIIRS for consistent DCC sampling and response
- Seasonal corrections of GEO monthly DCC response
- Spectral corrections using NASA Langley's robust online SBAF computation tool
- *PDF bin optimization*

Link for preliminary draft of ATBD

<u>http://gsics.atmos.umd.edu/pub/Development/20210909/DCC_ATBD_2021a</u>
<u>.pdf</u>

VIS/NIR DCC Calibration ATBD Update

- DCC characterization updated with extended NOAA-20
 VIIRS C2.1 record (2018-2023)
- Reference DCC mode radiances are derived for the global tropical region along with nine geostationary satellite domains
- Associated 1-sigma uncertainties computed for each GEO domain based on temporal standard deviation

GEO Imagers DCC Identification Domains



±20° Lat/Lon from the GEO sub-satellite point



This study uses NOAA-20 VIIRS L1B Collection 2.1 products from NASA Land SIPS



- Regional variation of DCC mode is <1%
 - brightest over 0°E longitude

DCC reference mode radiances based on NOAA-20 VIIRS





Reference DCC Mode Radiances ($L_{VIIRS,Mode}$) and associated 1-sigma natural variability for GEO domains

NOAA-20 VIIRS based reference DCC radiance for GEO domains (based on 6 years of observation)										
Band	Global	GOES-W	GOES-E	0E	41E	57E	82E	100E	120E	140E
M3_0.48um	573.3351	574.9233	574.6403	576.2651	574.2777	572.2185	570.7969	570.3353	571.1668	571.4476
M4_0.55um	506.5673	508.0633	507.6811	509.2591	507.7496	505.5262	504.0547	503.5453	505.0821	505.5847
M5_0.67um	431.5638	432.725	432.5629	433.5989	432.4566	430.7561	429.6634	429.581	430.2929	430.5628
M7_0.86um	269.9388	270.1186	270.786	271.2761	271.0064	269.5704	268.6892	268.5538	269.0626	269.359
I1_0.65um	440.8696	442.01	442.1128	442.8726	442.1656	440.0756	438.8965	438.5818	439.7704	439.6406
		1-sign	na uncerta	ainty base	d on tem	poral stan	dard devi	iation		
Band	Global	<mark>1-sign</mark> GOES-W	na uncerta GOES-E	ainty base _{OE}	d on tem 41E	p <mark>oral stan</mark> 57E	dard dev 82E	iation 100E	120E	140E
Band M3_0.48um	Global 0.3637	1-sign GOES-W 0.7558	na uncerta GOES-E 0.5785	ointy base 0E 0.5831	d on tem 41E 0.5929	poral stan 57E 0.794	dard dev 82E 0.7836	iation 100E 0.6073	120E 0.6275	140E 0.5741
Band M3_0.48um M4_0.55um	Global 0.3637 0.4176	1-sign GOES-W 0.7558 0.8564	GOES-E 0.5785 0.5478	ointy base 0E 0.5831 0.58	d on tem 41E 0.5929 0.6677	poral stan 57E 0.794 0.9278	dard dev 82E 0.7836 0.8236	iation 100E 0.6073 0.8099	120E 0.6275 0.6038	140E 0.5741 0.6054
Band M3_0.48um M4_0.55um M5_0.67um	Global 0.3637 0.4176 0.3279	1-sign GOES-W 0.7558 0.8564 0.6629	GOES-E 0.5785 0.5478 0.4508	OE 0.5831 0.58 0.4931	d on tem 41E 0.5929 0.6677 0.5984	poral stan 57E 0.794 0.9278 0.7141	dard dev 82E 0.7836 0.8236 0.6869	iation 100E 0.6073 0.8099 0.652	120E 0.6275 0.6038 0.5897	140E 0.5741 0.6054 0.4961
Band M3_0.48um M4_0.55um M5_0.67um M7_0.86um	Global 0.3637 0.4176 0.3279 0.2249	1-sign GOES-W 0.7558 0.8564 0.6629 0.7181	GOES-E 0.5785 0.5478 0.4508 0.3585	OE 0.5831 0.58 0.4931 0.4066	d on tem 41E 0.5929 0.6677 0.5984 0.4163	poral stan 57E 0.794 0.9278 0.7141 0.5678	dard dev 82E 0.7836 0.8236 0.6869 0.5403	ation 100E 0.6073 0.8099 0.652 0.4653	120E 0.6275 0.6038 0.5897 0.4671	140E 0.5741 0.6054 0.4961 0.4566

• Units of these mode radiances are Wm⁻²µm⁻¹sr⁻¹

 $L_{GEO,Mode,reference} = SBAF \times L_{VIIRS,Mode} (Wm^{-2}\mu m^{-1} sr^{-1})$

Future work



DCC reference data in a netCDF file



DCC ATBD completion (Fall 2024)



DCC ATBD paper for reflective solar wavelengths

Part 1: Algorithm Formulation for VIS/NIR and Results with an example GEOPart 2: Validation of VIS/NIR algorithm (Agency wide implementation, results, and analysis)

Need for DCC BRDFs for SWIR bands



- VIS-NIR BRDFs are similar and covered by Hu-model
- At SWIR wavelengths,
 - DCC are more absorptive
 - SNR is low
 - Greater sensitivity with BT threshold
 - BRDF is seasonal and wavelength dependent
- Proper seasonal characterization of DCC allows the extension of DCC method to calibrate SWIR channels

Monthly DCC BRDFs are proposed for SWIR bands



DCC BRDF formulation

- BRDFs are constructed using the SNPP-VIIRS
 DCC samples from 2012-2023
- Pixel-level DCC reflectance values are partitioned into angular bins
 - Angular discretization:
 - VZA and SZA range from 0-60° with a 5° step size
 - RAA varies from 0-180° at 10° intervals
- For each SZA bin, mean TOA reflectance and standard deviation values are recorded
- SWIR band BRDFs are unique and wavelengthdependent

 $BRF = \frac{BRDF(22.5, 32.5, 145.0)}{BRDF(SZA, VZA, RAA, MONTH)}$ $\rho_{corrected} = \rho_{observed} * BRF$



Before and After BRDF Normalization

 After BRDF normalization, the monthly PDFs exhibit consistent shapes, signifying seasonal variance is mitigated in the SWIR bands DCC response



Effectiveness of DCC BRDFs

- Improved BRDF models reduce the SWIR band DCC temporal variability by up to 65%
- Monthly mean DCC response is more stable than mode for SWIR bands
- DCC method can detect a sensor trend of <1%/decade in all reflective solar bands of VIIRS instrument at a significance level of α=0.05





Effectiveness of improved DCC BRDFs (contd.)

- SNPP VIIRS-based BRDF models are applicable to Aqua-MODIS bands too
- MODIS band 7 (2.1 µm) is spectrally different than its counterpart band (M11) in VIIRS
 - MODIS band 7 DCC BRDF is derived using a similar method (described earlier) but utilizing MODIS data



DCC SWIR band BRDF data

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Panoply — Sources

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Datasets (Catalogs Bookmarks

			. /
Þ	CPF_CERES_N20_INTERCAL_L4.SIM_b	CLARREO-CERES Refl	Local File
Þ	DCC_TERRA_ADM_All_Months_TWP 1	DCC BRDF coefficients	Local File
Þ	DCC_TERRA_MODIS_ADM_All_Months	DCC BRDF coefficients	Local File
7	DCC_VIIRS_ADM_All_Months_all_regi	DCC BRDF coefficients	Local File
	🔻 🞑 channel_data	channel_data	-
	channel_brdf_coeff	channel brdf coeff	2D
	🥥 channel_id	channel id	-
	month_id	month id	-
	number_of_pixels	number of pixels	2D
	standard_deviation	standard deviation	2D
	🔻 🗳 geometry	geometry	-
	🤤 nbin_raa_bound	relative azimuth angle	1D
	nbin_sza_bound	solar zenith angle bin	1D
	nbin_vza_bound	view zenith angle bin	1D
	raa_bin_centers	relative azimuth angle	1D
	sza_bin_centers	solar zenith angle bin	1D
	vza_bin_centers	view zenith angle bin	1D

Long Name

Type

netcdf /Users/rbhatt1/Downloads/DCC_VIIRS_ADM_All_Months_all_regions.nc { dimensions: n channel = 10;n_sza = 18; n_month = 13; n raa = 18; n_vza = 18; group: geometry { variables: float nbin_sza_bound(n_sza=18); :long_name = "solar zenith angle bin boundaries"; :units = "degrees"; : lo_bound = 0.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0, 75.0, 80.0, 85.0; // double :high_bound = 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0, 75.0, 80.0, 85.0, 90.0; // double float nbin_raa_bound(n_raa=18); :long_name = "relative azimuth angle bin boundaries"; :units = "degrees"; : lo_bound = 0.0, 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0, 110.0, 120.0, 130.0, 140.0, 150.0, 160.0, 170.0; // double :high_bound = 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0, 110.0, 120.0, 130.0, 140.0, 150.0, 160.0, 170.0, 180.0; // double float nbin vza bound(n vza=18); :long_name = "view zenith angle bin boundaries"; :units = "dearees"; :lo_bound = 0.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0, 75.0, 80.0, 85.0; // double :high_bound = 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0, 75.0, 80.0, 85.0, 90.0; // double float raa bin centers(n raa=18); :centers = 5.0, 15.0, 25.0, 35.0, 45.0, 55.0, 65.0, 75.0, 85.0, 95.0, 105.0, 115.0, 125.0, 135.0, 145.0, 15.0, 165.0, 175.0; // double :long_name = "relative azimuth angle bin centers"; :units = "degrees"; :valid_range = 0.0f, 180.0f; // float :bounds = "raa bound"; float vza_bin_centers(n_vza=18); :centers = 2.5, 7.5, 12.5, 17.5, 22.5, 27.5, 32.5, 37.5, 42.5, 47.5, 52.5, 57.5, 62.5, 67.5, 72.5, 77.5, 82.5, 87.5; // double :long_name = "view zenith angle bin centers"; :units = "degrees"; :valid_range = 0.0f, 90.0f; // float :bounds = "vza_bound"; float sza_bin_centers(n_sza=18); :long_name = "solar zenith angle bin centers"; :units = "degrees"; :valid_range = 0.0f, 90.0f; // float :bounds = "sza bound"; :centers = 2.5, 7.5, 12.5, 17.5, 22.5, 27.5, 32.5, 37.5, 42.5, 47.5, 52.5, 57.5, 62.5, 67.5, 72.5, 77.5, 82.5, 87.5; // double

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Show: All variables

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Future Direction

- The CERES IGCG is presently focused on preparing a SWIR band BRDF netCDF file for MODIS and VIIRS. This file will be released to the GSICS community for evaluation.
- Publish SWIR band DCC intercalibration methodology and validation



Questions, comments, discussion?