Implementation of GOES-R ABI vs. VIIRS Ray-Matching Inter-Calibration Method

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05/12/2022

NOAA GOES-R CWG Ray-matching

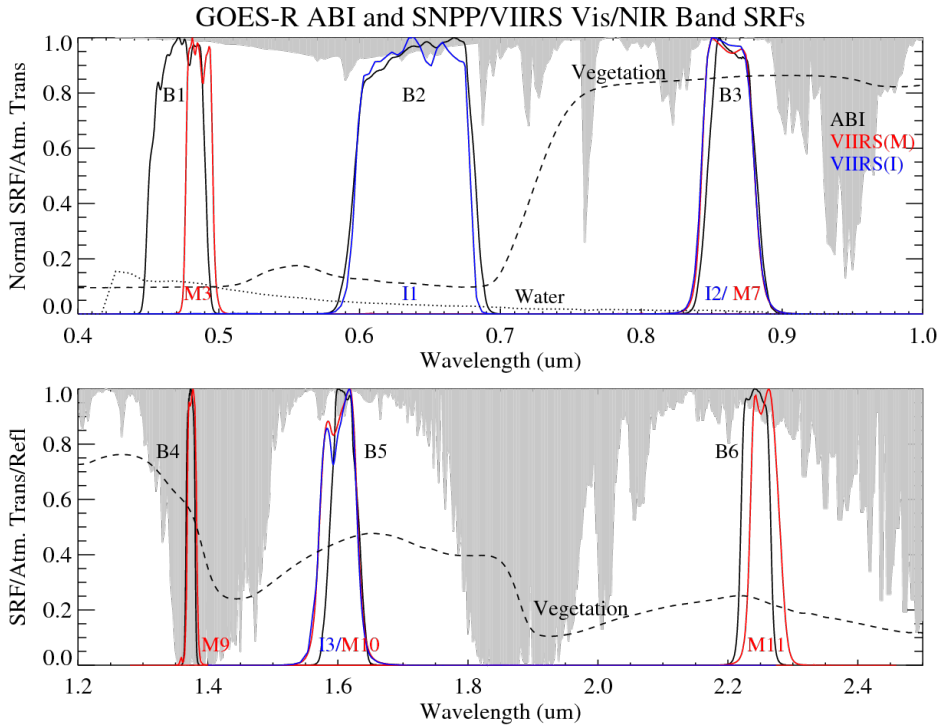
- Ray-matching is currently used to monitor the inter-calibration difference between GOES-R ABI and VIIRS onboard SNPP and NOAA-20
  - Operational ABI (L1b) and VIIRS (SDR) data are generated by NOAA

- Ray-matching algorithm and filtering criteria mainly follow the following two documents:
  - Doelling, D. 2011, ATBD
    http://gsics.atmos.umd.edu/pub/Development/AtbdCentral/GSICS_ATBD_RayMatch_NASA_2011_09.pdf
  - Yu, F. and X. Wu, 2016, Remote Sensing, 8(3), doi:10.3390/rs8030165

- NOAA is planning to implement the GSICS harmonization coefficients to the ABI L1B data
  - Linear correction
  - Wu, X., GSICS webmeeting in December 2021

Spectral Match: VIIRS VNIR Band Selection

GOES-R ABI VNIR SRF and the matched VIIRS SRF



GOES-R ABI	VIIRS (reference)
B1 (0.47µm)	M3 (0.49µm)
B2 (0.64µm)	I1 (0.64µm)
B3 (0.86µm)	M7 (0.87µm)
B4 (1.37µm)	M9 (1.38µm)
B5 (1.61µm)	M10 (1.61µm)
B6 (2.23µm)	M11 (2.25µm)

- VIIRS I1 band for ABI B2, M bands are preferred to I bands for the other ABI VNIR channels
  - M bands (dual gain) have lower noise than I bands, I1 has best spectral match with B2
- The operational VIIRS data processed by NOAA is used as the reference.

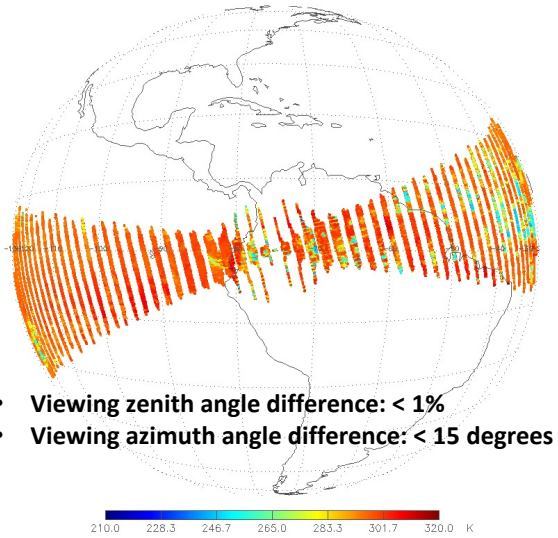
Ray-Matching Criteria Table for A

Ray-matching Criteria	Ray-matching threshold
Monitored sensor	GOES-R
Reference sensor and version	SNPP/NOAA-20 VIIRS, NOAA operational SDR data
Radiance or reflectance pair regression	Reflectance
SBAF	SCIAMACHY linear fitting
Latitude Domain	±1º latitude
Longitude Domain	~ +-1.5 hours, centered at the LEO Equatorial ascending time. (corresponding to ±25º longitude of GEO sub-satellite position)
Underlying surface	All-sky tropical land (GOES-East), All-sky tropical ocean (GOES-West)
Spatial resolution for matched scenes	2 km
GEO/LEO pixel resolution	0.5, 1.0, and 2.0 km / 0.375, and 0.75 km
GEO/LEO pixel subsampling	ABI B01-B03 and B05 are sub-sampled to 2 km from the native spatial resolutions
Spatial homogeneity	FOV and ENV CoV < 5% (FOV ~ ABI FOV; ENV size ~ 3 x FOV size, for all ABI VNIR bands)
Time matching difference	< half of ABI timeline interval (ABI current operational timeline interval is 10 minutes)
Solar zenith angle (SZA) difference	Not applied. Yet the difference should be less than ~2 degrees
View zenith angle (VZA) difference	| 1. – cos(VZA_GEO)/cos(VZA_LEO) | < 1%
Relative azimuth angle (RAA) difference	< 15 degrees
Scattering angle difference	?
Sun glint impact	Sun glint angle (> 40 degrees), TBD (need some analysis for GOES-West)
Linear regression, regression through space offset	linear regression (planning), y = ax + b

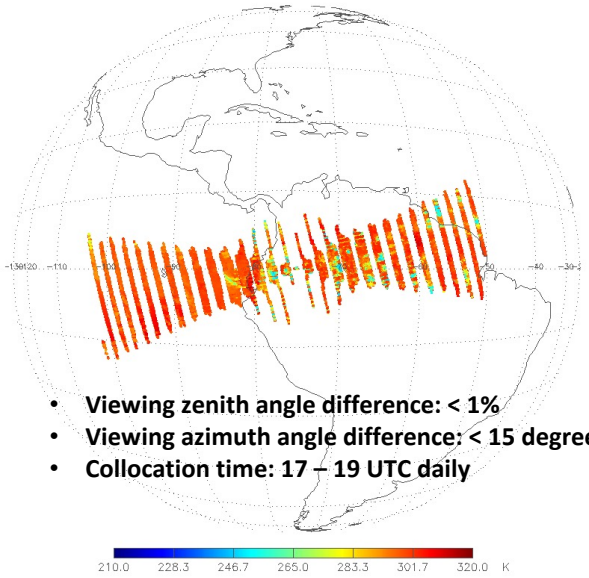
Timeline Criteria Table for B

Ray-matching ATBD	Ray-matching threshold
Timeline temporal resolution	TBD
Outlier Filter	Sunglint angle > 40 degrees
Other criteria	Uniform scenes (CoV of FOV and ENV < 5%) ~3 hours centered at the LEO equatorial ascending time
Temporal regression	-

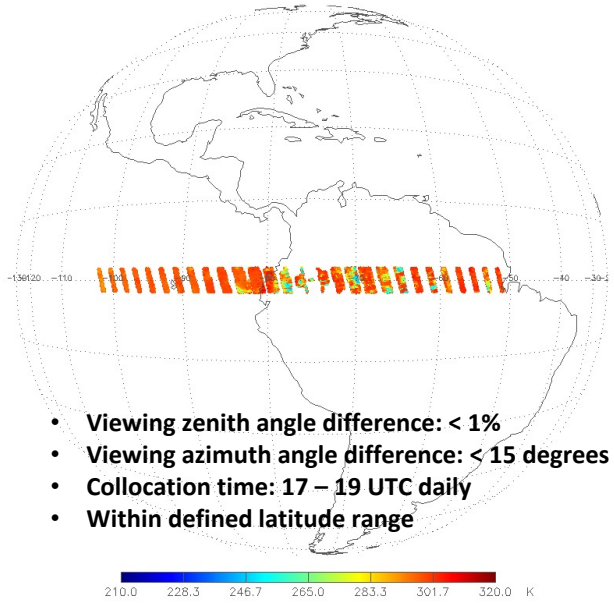
G16 Spatial Domain



- **Viewing zenith angle difference: < 1%**
- **Viewing azimuth angle difference: < 15 degrees**



- **Viewing zenith angle difference: < 1%**
- **Viewing azimuth angle difference: < 15 degrees**
- **Collocation time: 17 – 19 UTC daily**



- **Viewing zenith angle difference: < 1%**
- **Viewing azimuth angle difference: < 15 degrees**
- **Collocation time: 17 – 19 UTC daily**
- **Within defined latitude range**

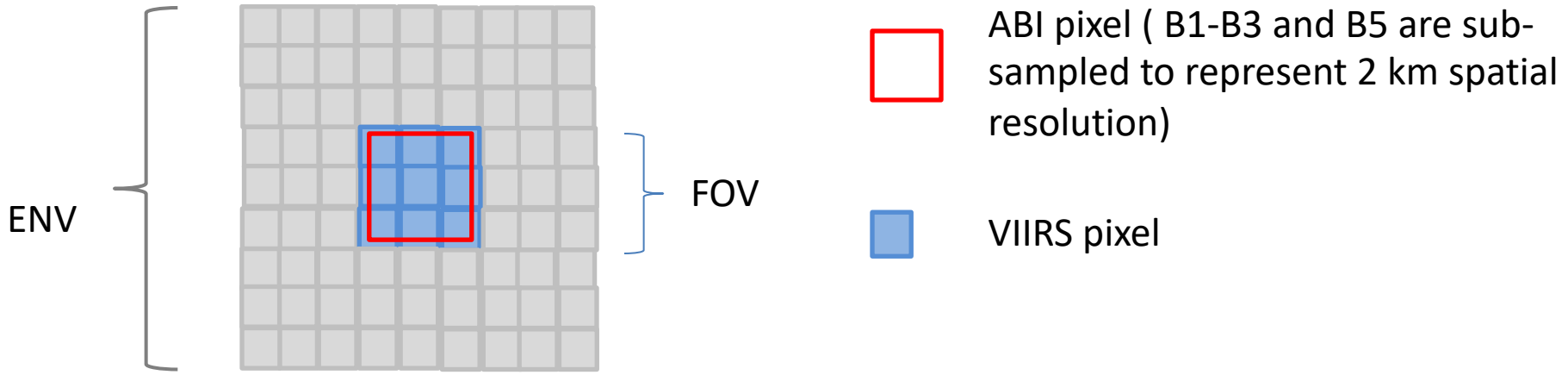
- Goal: reduce the data processing time by tailoring the input data
- ABI Input selection
  - Daytime
    - +-1.5 hours central at the LEO the ascending node crossing time (17 – 20 UTC for G16)
  - Spatial Domain:
    - Latitude range: [-1^{o}, +1^{o}]

Matching the FOV Sizes

GEO (ABI)	ABI Spatial Resolution at Nadir (m)	ABI Spatial Resolution used in Processing (m)	VIIRS Spatial Resolution at Nadir (m)	Geo/Leo Native FOV	Pseudo FOV: VIIRS Window Size (FOV Size)	ENV Size VIIRS Window Size (ENV Size)
B1 (0.47µm)	**1000**	**2000**	**750(M3, dual gain)**	1.33	**3 x 3 (2250m)**	9 x 9 (6750m)
B2 (0.64µm)	**500**	**2000**	**375(I1, dual gain)**	1.33	**7 x 7 (2625 m)**	17 x 17 (6375m)
B3 (0.87µm)	**1000**	**2000**	**750(M7, dual gain)**	1.33	**3 x 3 (2250m)**	9 x 9 (6750m)
B4 (1.38µm)	**2000**	**2000**	**750(M9, single gain)**	2.67	**3 x 3 (2250m)**	9 x 9 (6750m)
B5 (1.61µm)	**1000**	**2000**	**750(M10, single gain)**	1.33	**3 x 3 (2250m)**	9 x 9 (6750m)
B6 (2.25µm)	**2000**	**2000**	**750(M11, single gain)**	2.67	**3 x 3 (2250m)**	9 x 9 (6750m)

- Pseudo scenes are constructed with the higher spatial resolution instrument
  - In this case, it is VIIRS. Yet VIIRS reference data have a slight higher spatial resolution than ABI at B01, B02, B03 and B05, at the same magnitude
- To reduce the image processing time, ABI B01/02/03/05 images are sub-sampled to 2 KM spatial resolution.
  - B01/B03/B05: One from every two pixels
  - B02: One from every four pixels

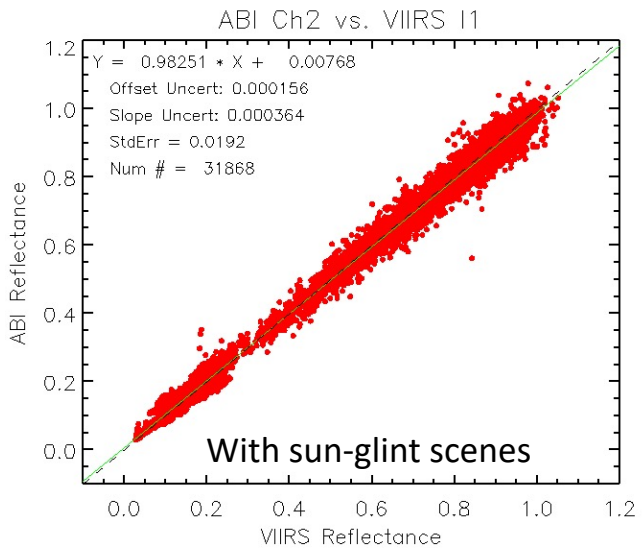
Uniform Scene Screening

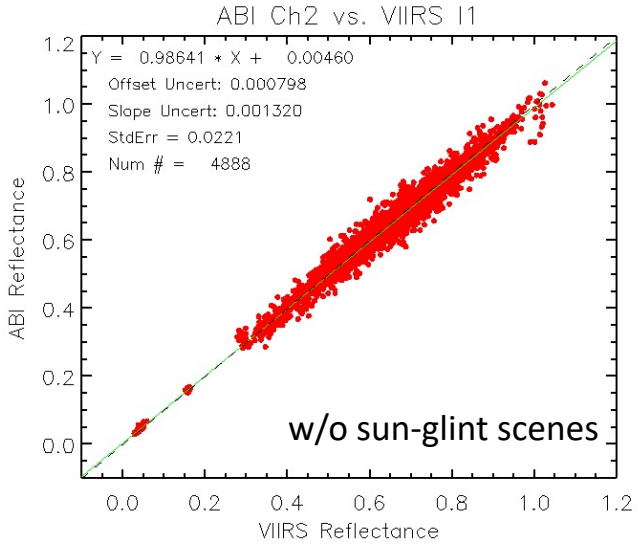


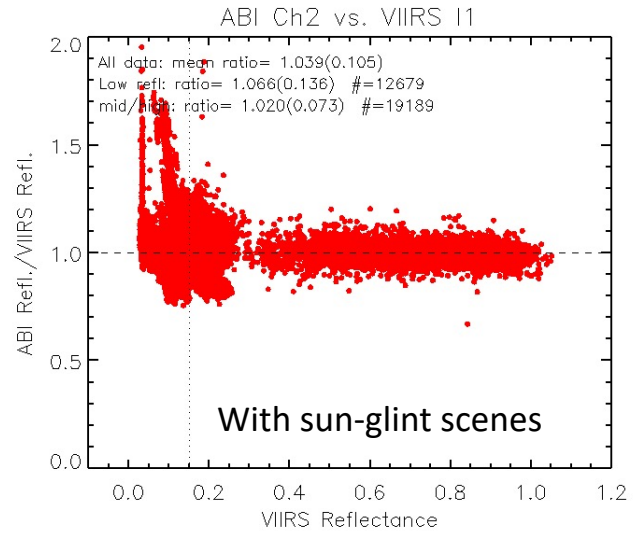
- Concepts of ENV(environ) and FOV scenes are from the GSICS GEO-LEO IR inter-calibration
- Uniform scenes should be applied to ensure the same targets observed by the two instruments
  - Possible difference of INR and MTF performance
  - Moving targets
  - Possible unexpected calibration issues or anomalies

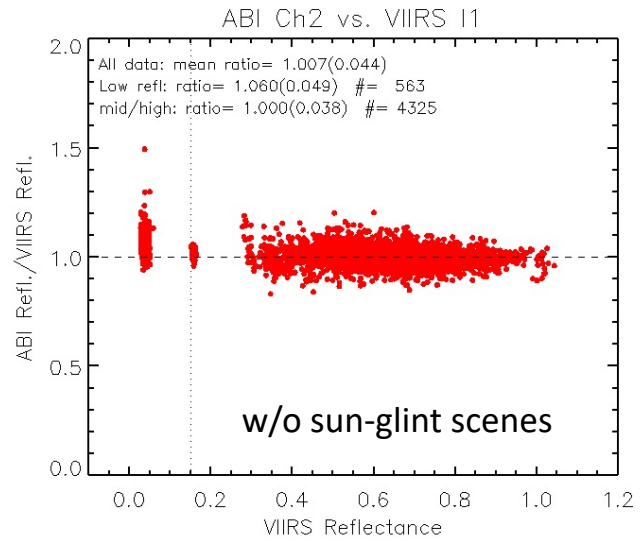
Impact of Sun-glint – Example 1

- Data: G16 vs. SNPP VIIRS from 2020/03/01 – 2020/03/31



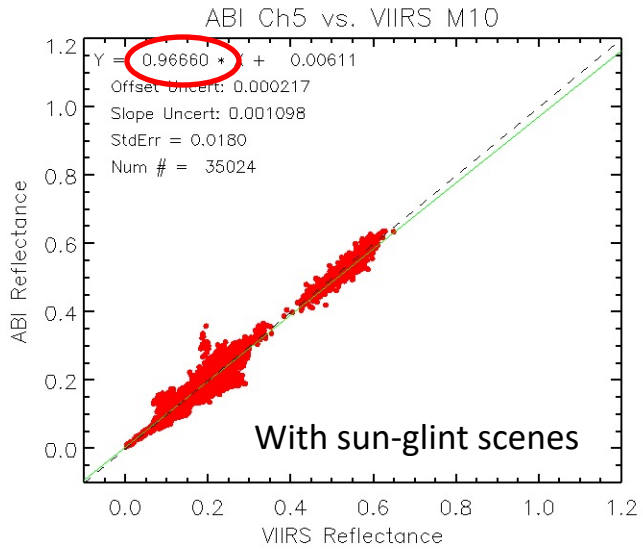


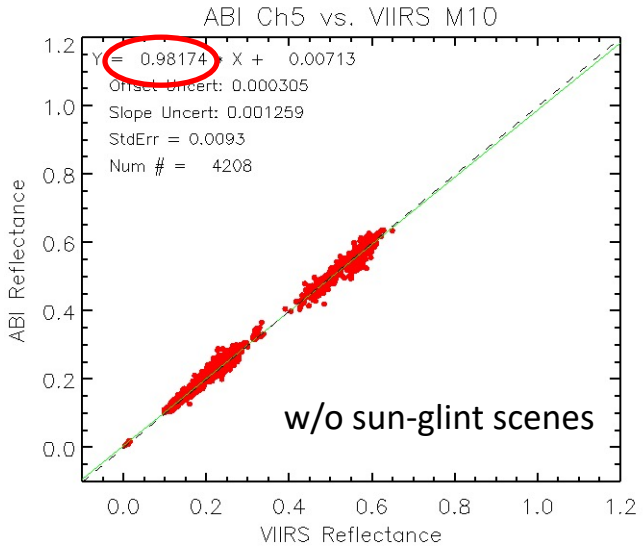


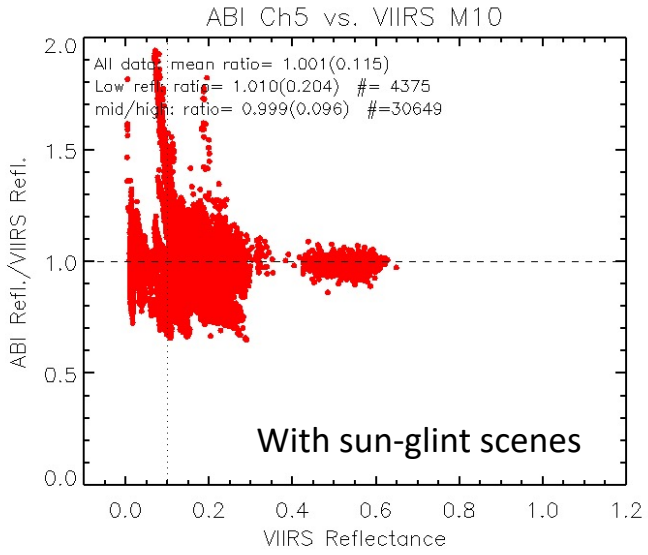


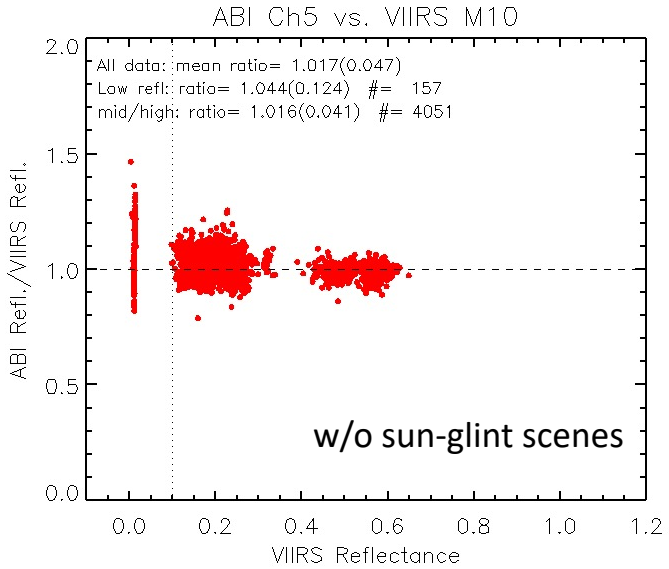
- Temporal, geolocation, spectral and uniform collocation criteria are applied to all the pixels in the figures
- Right two figures: sun-glint contaminated scenes were removed from the left two figures.
- Impact of sun-glint is most apparent at the low scene radiance

Impact of Sun-glint – Example 2









In this case, the residual of the sun-glint scenes can cause ~1.5% change of the fitting slope

Summary of Main Criteria

- Temporal match criteria
  - Less than half of operational timeline (e.g. <5 minutes for Mode6)
- Viewing geometry
  - zenith angle difference: 1% difference of the cosine viewing zenith angle
  - Viewing azimuth angle difference: 15 degrees
- Geolocation
  - Light of sight difference < VIIRS pixel scan angle
  - Spatial resolution for ABI: essentially, the native ABI pixel spatial resolutions are retained
- Same target criteria
  - Uniform scenes: FOV + ENV cov < 5%
  - Sun-glint removal
- Spectral match
  - SCIAMARCHY linear SBAF coefficients provided by NASA Langley
- Others
  - Spatial domain: ±1 degrees in latitude, ±25 degrees longitude of sub-satellite location
  - Time: 3 hours centered at the LEO equatorial ascending time