Validation results for AHI by ray-matching method with VIIRSs

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Validation methods for AHI VIS/NIR bands

- Ray-matching method

  https://www.data.jma.go.jp/mscweb/data/monitoring/gsics/vis/raymatch/monit_visraymatch.html

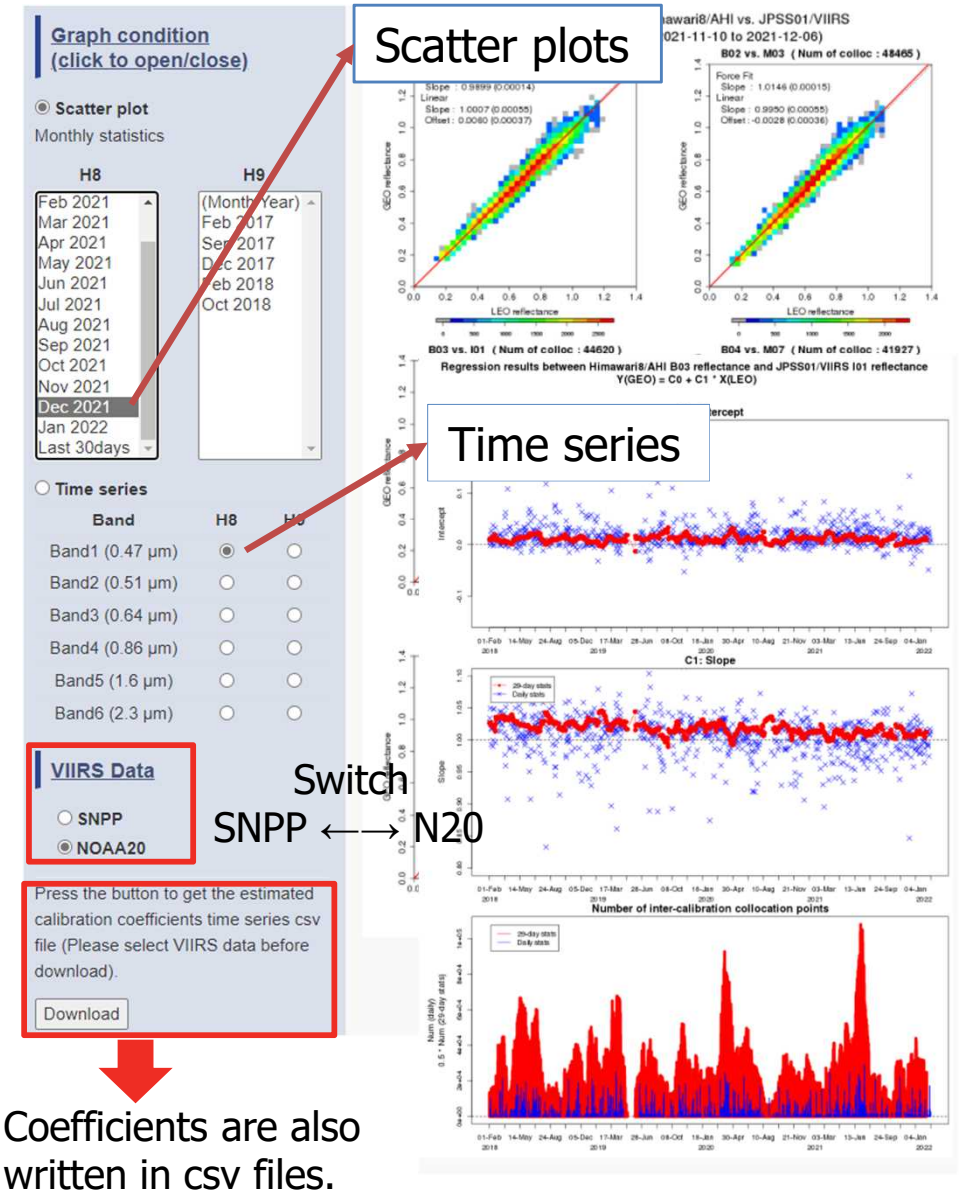
  – with SNPP/VIIRS
    - Monitoring page newly commenced last year
  – with N20/VIIRS
    - Monitoring page will be coming soon (in Q2 of 2022).
- Comparison with vicarious calibration approach using a RTM.

  https://www.data.jma.go.jp/mscweb/data/monitoring/gsics/vis/monit_visvical.html

  – with Terra and Aqua/MODIS
- DCC method
- Lunar Calibration

} Not available on our web page yet

Ray-matching method monitoring page



Coefficients are also written in csv files.
You can download them.

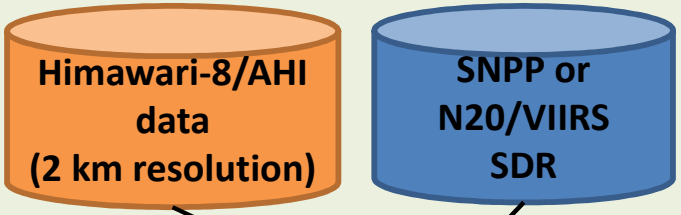
Outline

- Ray-matching method in JMA
- Updating the validation results: AHI vs. SNPP/VIIRS
- Comparison of ray-matching results against two VIIRSs.
  - Difference between N20 and SNPP from AHI8 ray-matching side
- AHI sensor sensitivity trend rate by GSICS validation methods
- Preparation of ray-matching for AHI9

Ray-matching method in JMA

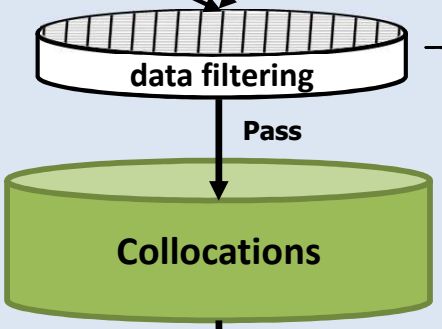
Input data

- Himawari-8 data is not corrected by solar diffuser on real-time basis
- VIIRS data is downloaded from NOAA CLASS server



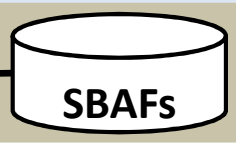
Himawari-8 /AHI	Band01 (0.47 µm)	Band02 (0.51 µm)	Band03 (0.64 µm)	Band04 (0.86 µm)	Band05 (1.6 µm)	Band06 (2.3 µm)
SNPP or N20 /VIIRS	M3 (0.49 µm)		I1 (0.64 µm)	M7 (0.87 µm)	M10 (1.6 µm)	M11 (2.3 µm)

Collocating



Observation time difference	< 5 min.
Satellite zenith angle difference	< 10 deg.
Satellite azimuth angle difference	< 10 deg.
Sun glint angle (AHI only)	> 25 deg.
Brightness temperature @ 10.4 µm (AHI only)	< 273.15 K
STDV of reflectance/Mean of reflectance	< 5%

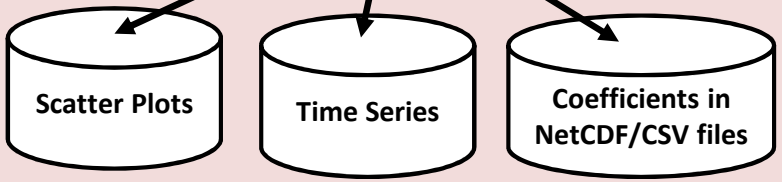
Apply SBAFs



Using NASA SBAF Tool (B01-05) and calculating radiative transfer model (B06)

Analysis

Outcomes



- based on Reflectance
- Regression type
  - Linear fit regression with/without offset

*** Coefficient in NetCDF files are Not online**

Updating the validation results AHI vs. SNPP/VIIRS

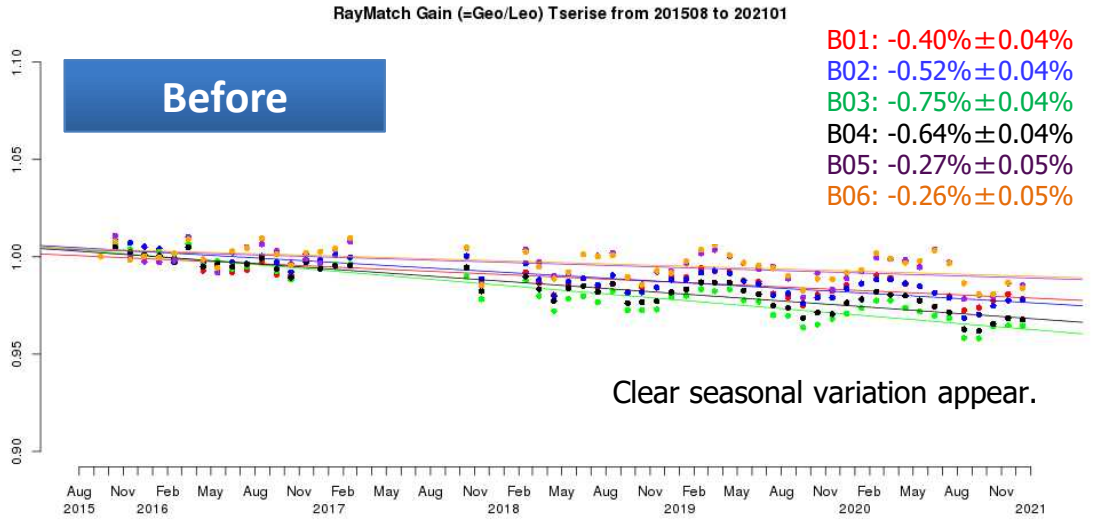
Our ray-matching results for AHI8 were presented in a monthly web meeting last year.

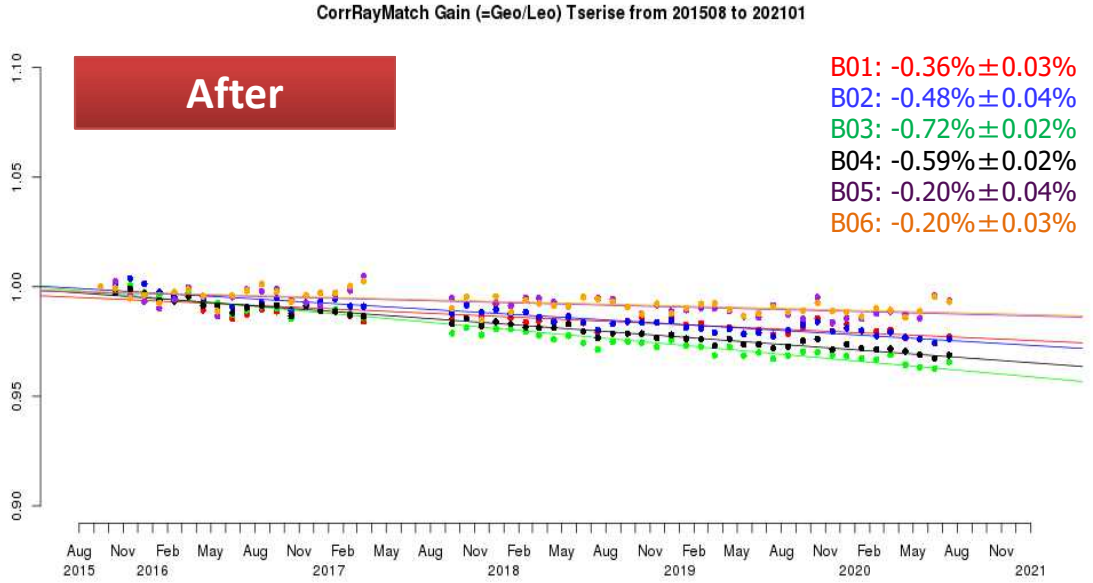
After that, a bug was found in our implementation

- Mishandling Sun-Earth distance in reflectance calculation.

By fixing this bug

Reducing the clear seasonal variation

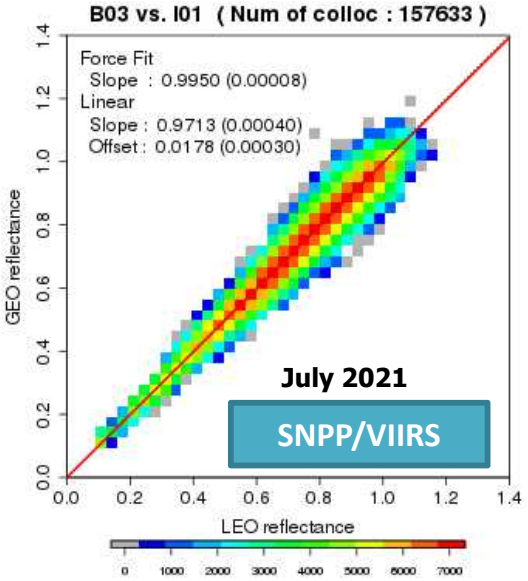


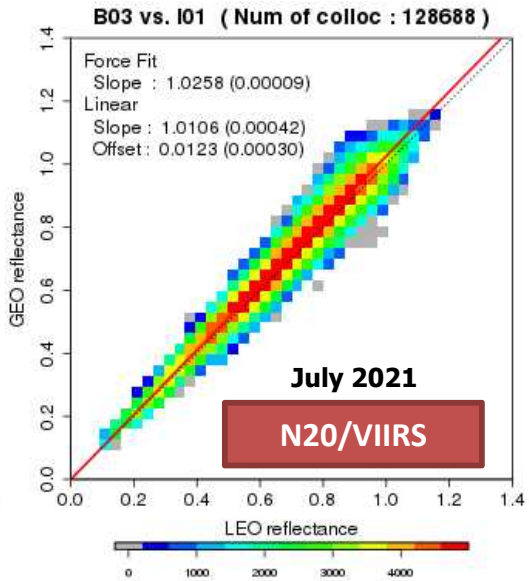


AHI8 ray-matching results with N20 and SNPP

- Mean biases by ray-matching results against N20 and SNPP in 2021

Mean biases	vs. SNPP/VIIRS	vs. N20/VIIRS
B01 (0.47 μm)	-3.33%	-0.86%
B02 (0.51 μm)	-0.42%	2.11%
B03 (0.64 μm)	-0.66%	2.40%
B04 (0.86 μm)	-1.66%	2.15%
B05 (1.6 μm)	5.41%	9.05%
B06 (2.3 μm)	-5.66%	-3.14%



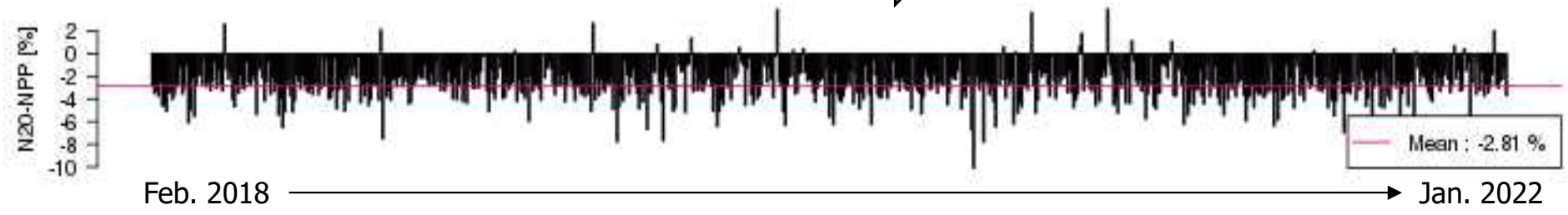


- Estimating N20 bias against SNPP from AHI8 ray-matching results;

$$\frac{\text{N20} - \text{SNPP}}{\text{SNPP}} \fallingdotseq \frac{\text{AHI}/Slope\_{vs.N20} - \text{AHI}/Slope\_{vs.SNPP}}{\text{AHI}/Slope\_{vs.SNPP}}$$

Daily difference between N20 and SNPP (Feb. 2018 to Jan.2022)

Mean diff. is -2.81% in 0.64um



Other validations for N20 and SNPP difference

Difference between N20 and SNPP	M3 0.488µm	M3 0.488µm	I1 0.640µm	M7 0.865µm	M10 1.61µm	M11 2.25µm
Mean diff. derived from AHI8 ray-matching results	B01(0.47µm)	B02(0.51µm)	B03(0.64µm)	B04(0.86µm)	B05(1.6µm)	B06(2.3µm)
	-2.29%	-2.27%	-2.81%	-3.71%	-2.99%	-2.27%
Doelling et al. (2021) *1	-1.66%		-	-3.80%	-2.27%	-

- Mean diff. based on AHI8 ray-matching are good agreement (<1%) with the N20 bias relative to SNPP reported on GSICS Quarterly Newsletter.
- Moyer *et al.* (2021) *2 points out that ~2% bias exists between SNPP and N20 in all reflective solar bands.

➢ The difference in our ray-matching results between N20 and SNPP can be explainable in terms of the biases between N20 and SNPP sensors.

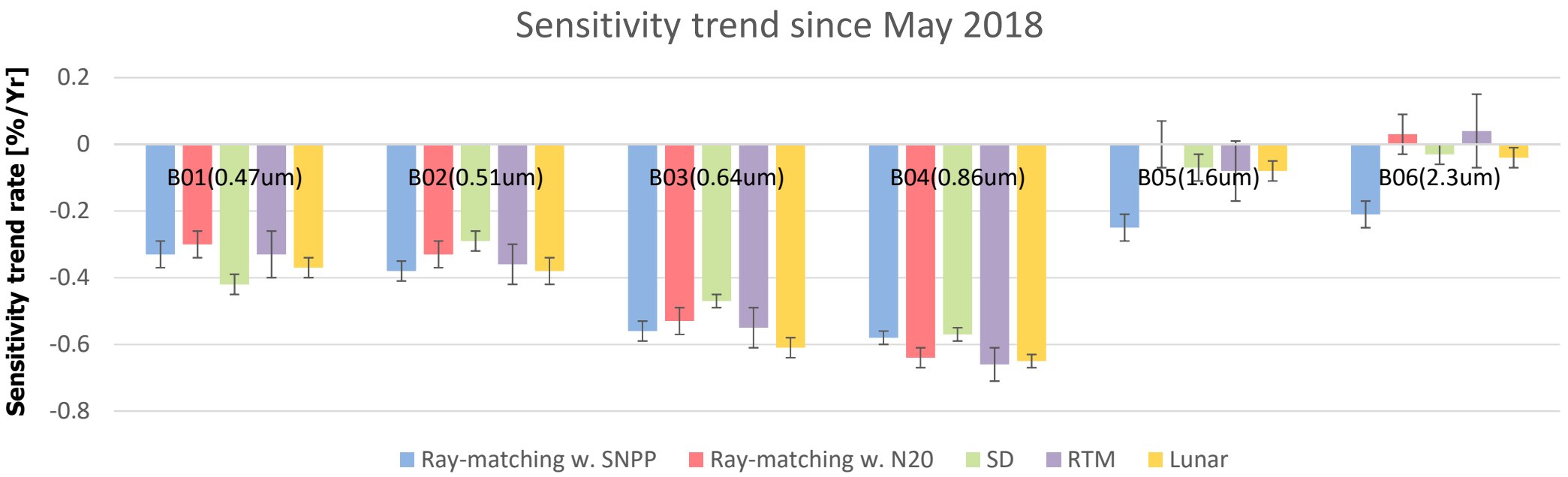
References

*1 :D. Doelling, C, Cao, and J. Xiong “GSICS recommends NOAA-20 VIIRS as reflective solar band (RSB) calibration reference” , GSICS quarterly Winter Issue 2021,Vo.14 No4,2021; https://repository.library.noaa.gov/view/noaa/29005

*2: D. Moyer, S. Uprety, W. Wang, C. Cao, and I. Guch "S-NPP/NOAA-20 VIIRS reflective solar bands on-orbit calibration bias investigation", Proc. SPIE 11829, Earth Observing Systems XXVI, 1182912 (3 August 2021); https://doi.org/10.1117/12.2595175

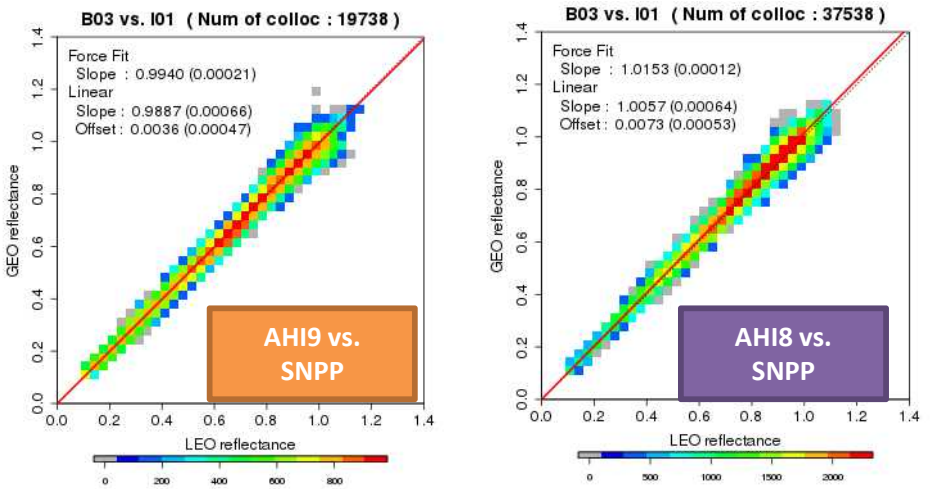
AHI8's sensitivity trend by GSICS methods

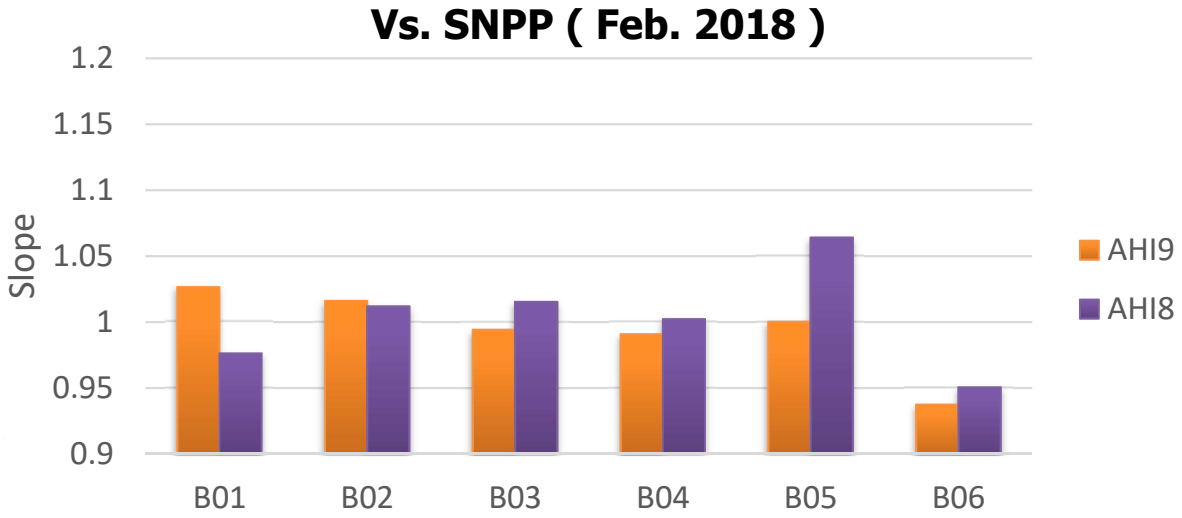
- In VNIR bands of AHI, correction coefficients derived from Solar Diffuser observation are stored in dataset. These coefficients are updated every year.
- AHI VNIR bands are calibrated by applying these coefficients to dataset.
  - ➢ We validate AHI sensitivity trends based on SD observation by comparing with the trend based on GSICS method.



- Ray-matching with N20 is in better agreement with SD results than that with SNPP except B01 and B04

Preparation of ray-matching for AHI9





- Comparison AHI9 health check data with SNPP
  - ➢ The differences between AHI8 and AHI9 are < ~5%. (B05 is a bit larger)
- Comparison with N20 also indicate there are similar differences.

- We have been working on some preparations for AHI9 calibration toward operational start.
  - ➢ So, it is possibility that final AHI9 data quality slightly change.

Summary and Future work

Summary

- The validation results for AHI by ray-matching with N20 will be available in Q2 of 2022.
- The difference of AHI ray-matching results with SNPP and N20 are good agreement with the bias between SNPP and N20 reported by other researches.
- On the validation of sensor sensitivity trends, the results of ray-matching with N20 are in better agreement with SD results than that with SNPP. (Except B01 and B04)
- The differences between AHI8 and AHI9 on VNIR bands are < ~ 5% by ray-matching methods.

Future work

- Investigation collocation conditions for AHI and N20.
- Implementation of ray-matching with other sensors.
- Further investigations and validations for AHI9 calibration toward operation start of AHI9 around Dec. 2022.

- Backup

JMA Ray-matching criteria Table

Table A

Ray-Matching criteria	Ray-Matching threshold
Monitored sensor	Himawari8 and Himawari9 / AHI
Reference sensor and version	SNPP and NOAA20 / VIIRS NOAA
Radiance or reflectance pair regression	Reflectance
SBAF	SCIAMACHY 1st order fit (for AHI B01~B05) Radiative transfer model (for AHI B06) *Under condition of “All sky tropical ocean”
Latitude Domain	± 20° latitude of sub-satellite location
Longitude Domain	± 20° longitude of sub-satellite location
Underlying surface	Targets meeting TB < 273.15K
Spatial grid resolution	AHI 1 pixel vs. average of VIIRS 3x3 pixels (for M band) AHI 1 pixel vs. average of VIIRS 5x5 pixels (for I band) * See the backup slide of “Our implementation details –resolution difference-”
AHI/VIIRS pixel resolution	2km / 0.75km(M) or 0.375km(I) * We use AHI data resampled to 2km resolution for All VNIR bands.
AHI/VIIRS sub-sampling	2km / 0.75km(M) or 0.375km(I)
Spatial homogeneity (STDV of reflectance/Mean of reflectance)	< 5% * See the backup slide of “Our implementation details –spatial homogeneity-” slide.

JMA Ray-matching criteria Table

Table A

Ray-Matching criteria	Ray-Matching threshold
Time matching difference	< 5 minutes
Solar zenith angle (SZA) difference	<10°
View zenith angle (VZA) difference	<10°
Relative azimuthal angle (RAA) difference	<10°
Scattering angle difference	-
Sun glint angle (Scattering angle)	>25° for AHI only
Linear regression, regression through space offset	Linear regression with offset and linear regression via the origin (force-fit regression)

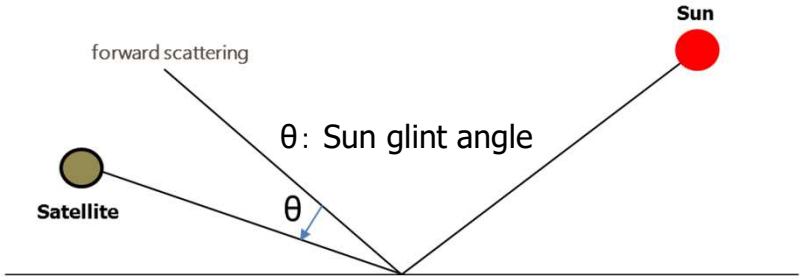
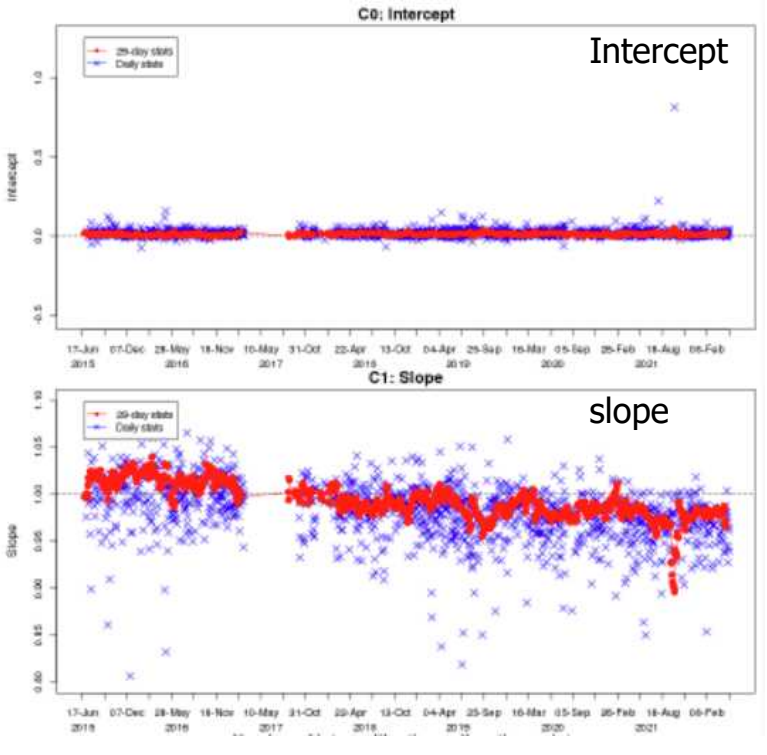


Table B

Ray-Matching ATBD 2011 (NASA)	Ray-Matching threshold
Timeline temporal resolution	Monthly and daily
Outlier Filter	-
Other criteria	-
Temporal regression	-



Our implementation details – resolution difference -

To considering resolution difference of Input data, our implementation is following way.

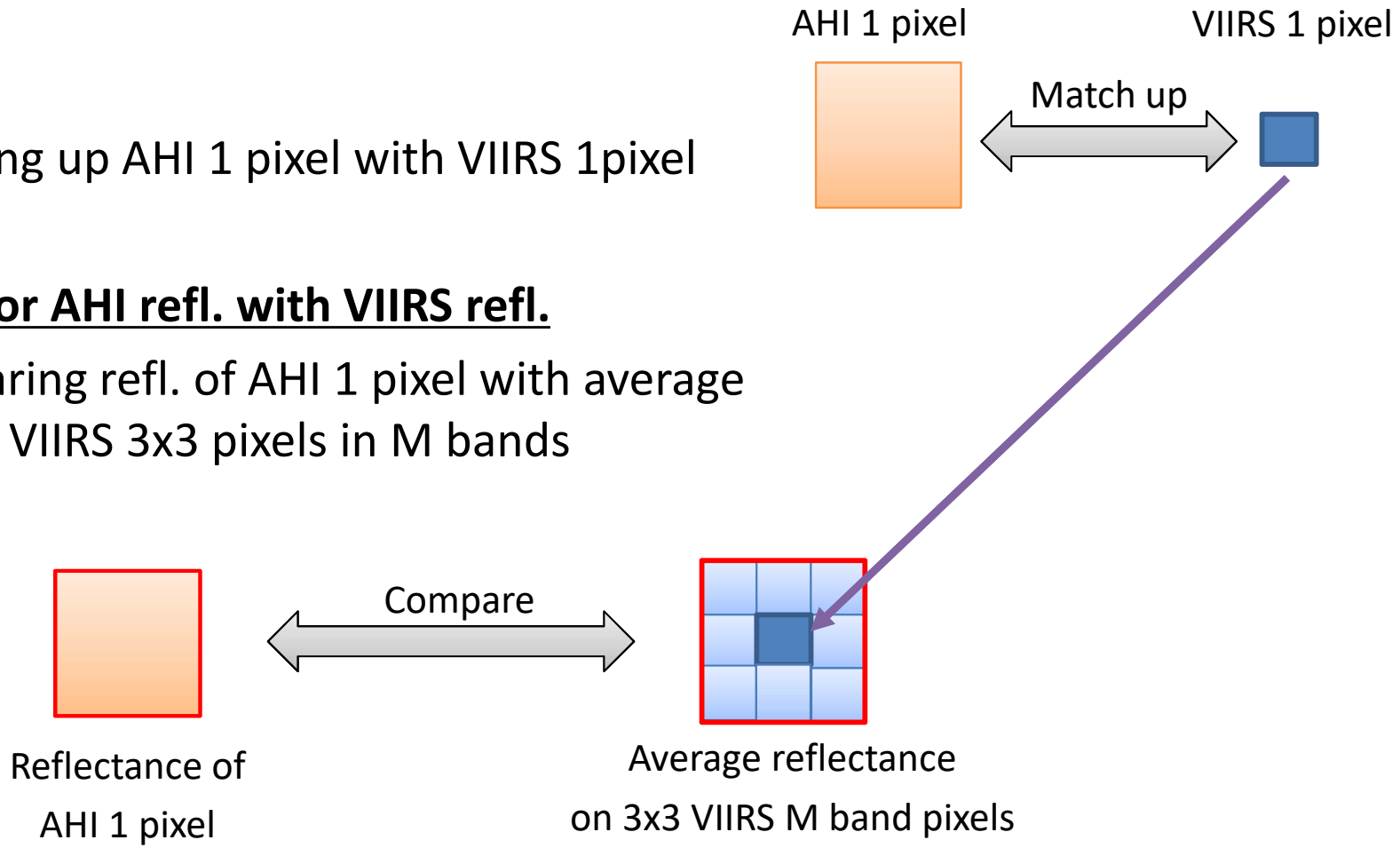
Input Data we use in ray-matching
AHI : 2km resolution
VIIRS : 0.75km(M) 0.375km(I)

Collocating

- Matching up AHI 1 pixel with VIIRS 1pixel

Comparison for AHI refl. with VIIRS refl.

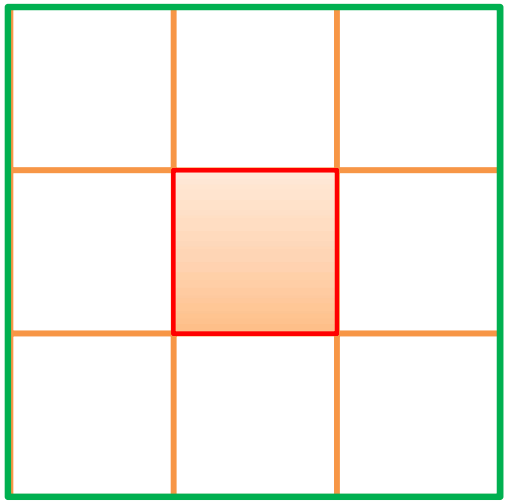
- Comparing refl. of AHI 1 pixel with average refl. of VIIRS 3x3 pixels in M bands



Our implementation details – spatial homogeneity -

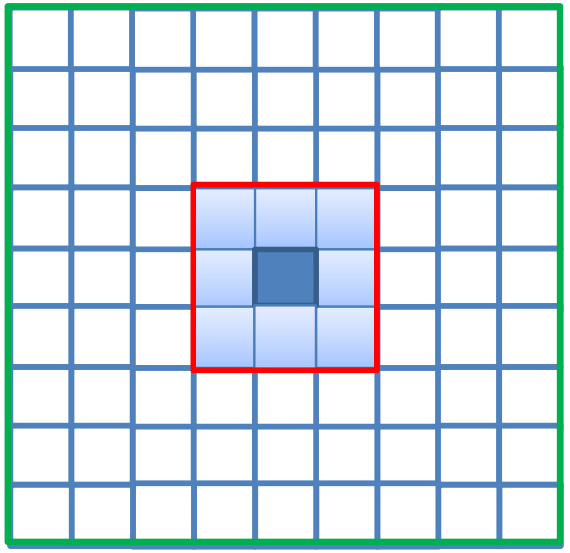
- Pixels in green area are used for checking spatial homogeneity.
- The condition of spatial homogeneity check is

$$\frac{\textbf{STDV of reflectance}}{\textbf{Mean of reflectance}} < 5\%$$



AHI data

2km / 1pixel



VIIRS data M bands

0.75km / 1pixel

Spatial homogeneity area