Summary of the SGLI products Validation results (Ver. 3.00)

Earth Observation Research Center
Japan Aerospace Exploration Agency
25 Nov. 2021

History

23 Dec. 2017	GCOM-C (SHIKISAI) launched from Tanegashima Space Center
01 Jan. 2018	Release of the SGLI First-light images
28 Mar. 2018	Initial function verification completed
20 Dec. 2018	Public release of first version Level- 1 and Level- 2 SGLI products
Aug. 2019	GCOM-C Science team decided version-up products
Jun. 2020	Public release of second version Level- 1 and Level- 2 SGLI products
30 Aug. 2021	Online mini-workshop
07 Sep. 2021	SGLI user committee meeting
29 Nov. 2021	Public release of third version Level- 2 SGLI products
Late 2022	Final review for the full/extra success of GCOM-C mission

Validation summary of the SGLI L1/L2 products

GCOM-C Success criteria (*data production aspect only*)

Success Level	Minimum Success [L + 1 yr]	Full Success [L + 5 yr]	Extra Success [L + 5 yr]
Standard Products	Complete the Cal. & Val. phase and start data distribution of more than 20 products achieving the release accuracy thresholds	Achieve standard accuracy thresholds of all standard products	Achieve target accuracy thresholds of one or more standard products

Results of the version-upgrade validation

Level/Area [The number of products]	L1 [1]	Land [9]	Atmosphere [8]	Ocean [7]	Cryosphere [4]	Total [29]
Release accuracy	1	9	8	7	4	29
Standard accuracy	1	9 (+5)	8 (+3)	7 (+2)	4 (+2)	29 (+12)
Target accuracy*	0	0	2	1 (±0)	0	3 (±0)

*the number of products achieved standard and target accuracy threshold
The numbers in parentheses are the differences of achieved product number from Ver.1.
Confirmation of achievement of standards and target accuracy will take place five years after launch.

Twelve products achieved newly standard accuracy through version-upgrade validation.

Standard products version up summary

-	Product	Algorithm	Validation	Ver.3 Major changes
L1	Level-1	JAXA		Correction for sensor sensitivity aging Reduction of linear noise (VNR) and horizontal stripes (TIR)

-	Product	Algorithm	Validation	Ver.3 Major changes
Land	Precise geometric correction	JAXA		NA
	Atmospheric corrected reflectance (incl. cloud detection)	JAXA	Land PIs	Revise of BRDF estimation and update QA
	Vegetation Index			NA
	Shadow Index	Land PI		Brush up the estimation coefficient and validation method and added solar altitude data
	Above-ground biomass	Land PIs	Land PIs	Update LUTs based on GEDI's observed data
	Vegetation roughness index	Land PI		NA
	fAPAR	JAXA, Land PI	Land PIs	Update of forest structure map using SGLI
	Leaf area Index			
	Land surface temperature	Land PI		Revise of cloud screening using *CLFG*

-	Product	Algorithm	Validation	Ver.3 Major changes
Atmosphere	Cloud flag/Classification	Atmosphere PIs	JAXA, Atmosphere PIs	Add the cloud and heavy aerosol screening using machine learning method focused on the snow region and night-time
	Classified cloud fraction	Atmosphere PIs	Atmosphere PIs	
	Cloud top temp/height			NA
	Water cloud optical thickness/effective radius			
	Ice cloud optical thickness			
	Aerosol over the ocean	JAXA, Atmosphere PIs	Atmosphere PIs	Integrated of aerosol retrieval algorithms using polarization channels and non-polarization channels
	Land aerosol by near ultra-violet			
	Aerosol by polarization			

Standard products version up summary

-	Product	Algorithm	Validation	Ver.3 Major changes
Ocean	Normalized water leaving radiance (incl. cloud detection)	Ocean PIs, JAXA	Ocean Pis	Algorithm and QA improvements, including modification of aerosol model and addition of underwater model.
	Atmospheric correction parameters			
	Photosynthetically available radiation	JAXA, Ocean PI		NA
	Chlorophyll-a concentration	JAXA		
	Suspended solid concentration	Ocean PI		NA
	Colored dissolved organic matter	Ocean PI		NA
	Sea surface temperature (incl. cloud detection)	JAXA		Revised cloud detection

-	Product	Algorithm	Validation	Ver.3 Major changes
Cryosphere	Snow and ice covered area (incl. cloud detection)	Cryosphere PI	Cryosphere PI	Revised training data set
	Okhotsk sea-ice distribution			
	Snow and ice surface temperature			Updated emissivity table Revised training data set Add the Snow Albedo as a research product
	Snow grain size of shallow layer			

Evaluation Status(1/2)

Ver.1/Ver.2 already achieved

	Products	Ver.3 Accuracy	Release Accuracy	Standard Accuracy	Target Accuracy
Land	Precise geometric correction	VNR:0.15-0.21,IRS:0.15-0.29	<1pixel	<0.5pixel	<0.25pixel
	Atmospheric corrected reflectance (incl. cloud detection)	**0.022 (<=443nm) 0.035 (>443nm)**	0.3 (<=443nm), 0.2 (>443nm)	**0.1 (<=443nm), 0.05 (>443nm)**	0.05 (<=443nm), 0.025 (>443nm)
	Vegetation Index* NDVI EVI	Grass:8.4%, Forest:11.8% Grass:16.0%, Forest:14.7%	Grass: 25%, Forest: 20%	Grass: 20%, Forest: 15%	Grass: 10%, Forest: 10%
	Shadow Index	**14.0%**	30%	20%	10%
	Above-ground biomass	**Grass:18.2%, Forest:31.9%**	Grass : 50%, Forest : 100%	Grass : 30%, Forest : 50%	Grass : 10%, Forest : 20%
	Vegetation roughness index	**18.5%**	40%	20%	10%
	fAPAR	**Grass:26.1%, Forest:8.5%**	Grass: 50%, Forest: 50%	**Grass: 30%, Forest: 20%**	Grass: 20%, Forest: 10%
	Leaf area Index	**Grass:28.5%, Forest:28.8%**	Grass: 50%, Forest: 50%	Grass: 30%, Forest: 30%	Grass: 20%, Forest: 20%
	Land surface temperature	**1.996 K**	3.0 K	**2.5 K**	1.5 K
Atmosphere	**Cloud flag/Classification**	10.2%	10% (with whole-sky camera)	Incl. below cloud amount	Incl. below cloud amount
	Classified cloud fraction	10.2%	20% (on solar irradiance)	15% (on solar irradiance)	10% (on solar irradiance)
	Cloud top temp/height	-	1K	3K/2km	1.5K/1km
	Water cloud optical thickness/effective radius	**82%**	10%/30% (CloutOT/raduis)	100% (as cloud liquid water)	50%/20%
	Ice cloud optical thickness	**56%**	30%	70%	20%
	Aerosol over the ocean	**670nm:0.072 865nm:0.051**	0.1 (monthly ta_670,865)	0.1 (Scene ta_670,865)	0.05 (Scene ta_670,865)
	Land aerosol by near UV	**0.137**	0.15 (monthly ta_380)	**0.15 (scene ta_380)**	0.1 (scene ta_380)
	Aerosol by polarization	**0.137**	0.15 (monthly ta_670,865)	0.15 (scene ta_670,865)	0.1 (scene ta_670,865)

V3 updated algorithms

Ver.3 newly achieved

In principle, the numerical values of accuracy targets are defined in terms of root mean square error (RMSE), which has the same units as physical quantities. Note that the accuracy value described in the unit of ratio (%) is evaluated by the ratio between RMSE and the average value of field data. For the flag type product (cloud flag / type), the error rate (%) of the flag is statistically evaluated using the in-situ.

Evaluation Status(1/2)

Ver.1/Ver.2 already achieved

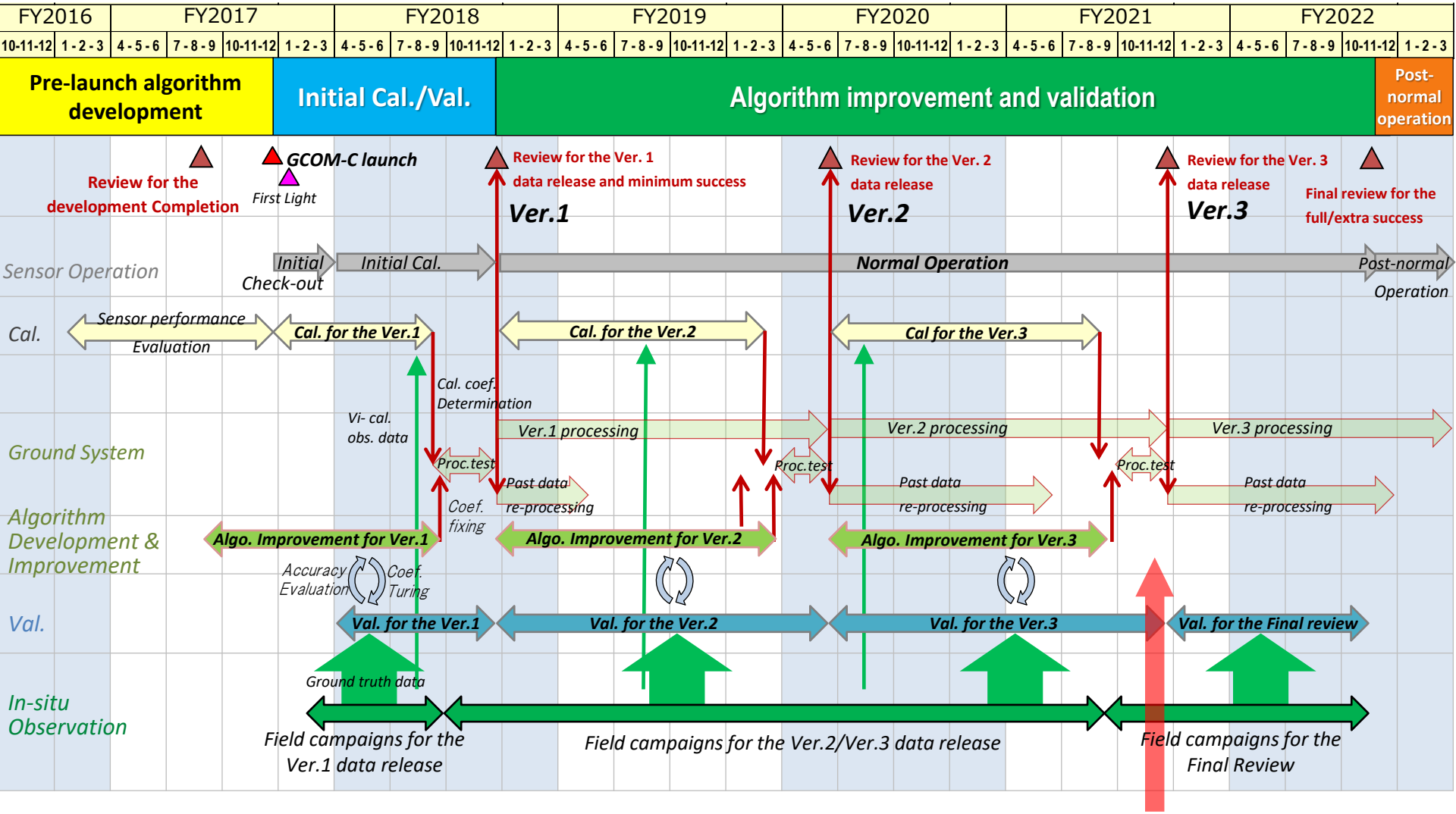
	Products	Ver.3 Accuracy	Release Accuracy	Standard Accuracy	Target Accuracy
Ocean	**Normalized water leaving radiance (incl. cloud detection)**	**23~45% (<600nm) 0.50W/m²/sr/um(>600nm)**	60% (443~565nm)	50% (<600nm)	30% (<600nm)
				0.5W/m²/str/um (>600nm)	0.25W/m²/str/um (>600nm)
	Atmospheric correction parameters	**46%**	80% (ta_865nm)	50% (ta_865nm)	30% (ta_865nm)
	Photosynthetically available radiation	**8.9%**	20% (10km/month)	15% (10km/month)	**10% (10km/month)**
	Chlorophyll-a concentration	**-55~+121%**	-60~+150% (offshore)	**-60~+150%**	-35~+50% (offshore) -50~+100% (coast)
	Suspended solid concentration	**-59-+141%**	-60~+150% (offshore)	**-60~+150%**	-50~+100%
	Colored dissolved organic matter	**-54~+119%**	60% (443~565nm)	**-60~+150%**	-50~+100%
	Sea surface temperature (incl. cloud detection)	**Day:0.4 K,Night:0.4 K**	0.8K (daytime)	0.8K (day/night)	0.6K (day/night)
Cryosphere	**Snow and Ice covered area (incl. cloud detection)**	**6.5%**	10% (vicarious val. with other sat. data)	7%	5%
	Okhotsk sea-ice distribution	**5.0%**	10% (vicarious val. with other sat. data)	5%	3%
	Snow and ice surface Temperature	**1.6 K**	5K (vicarious val. with other sat. data and climatology data)	2K	1K
	Snow grain size of shallow layer	**50%**	100% (vicarious val. with climatology between temp-size)	**50%**	30%

V3 updated algorithms

Ver.3 newly achieved

In principle, the numerical values of accuracy targets are defined in terms of root mean square error (RMSE), which has the same units as physical quantities. Note that the accuracy value described in the unit of ratio (%) is evaluated by the ratio between RMSE and the average value of field data. For the flag type product (cloud flag / type), the error rate (%) of the flag is statistically evaluated using the in-situ.

Schedule for the GCOM-C mission



Ver.3 Release - 2021.11.29

Ver.3 Land Products

Evaluation Summary

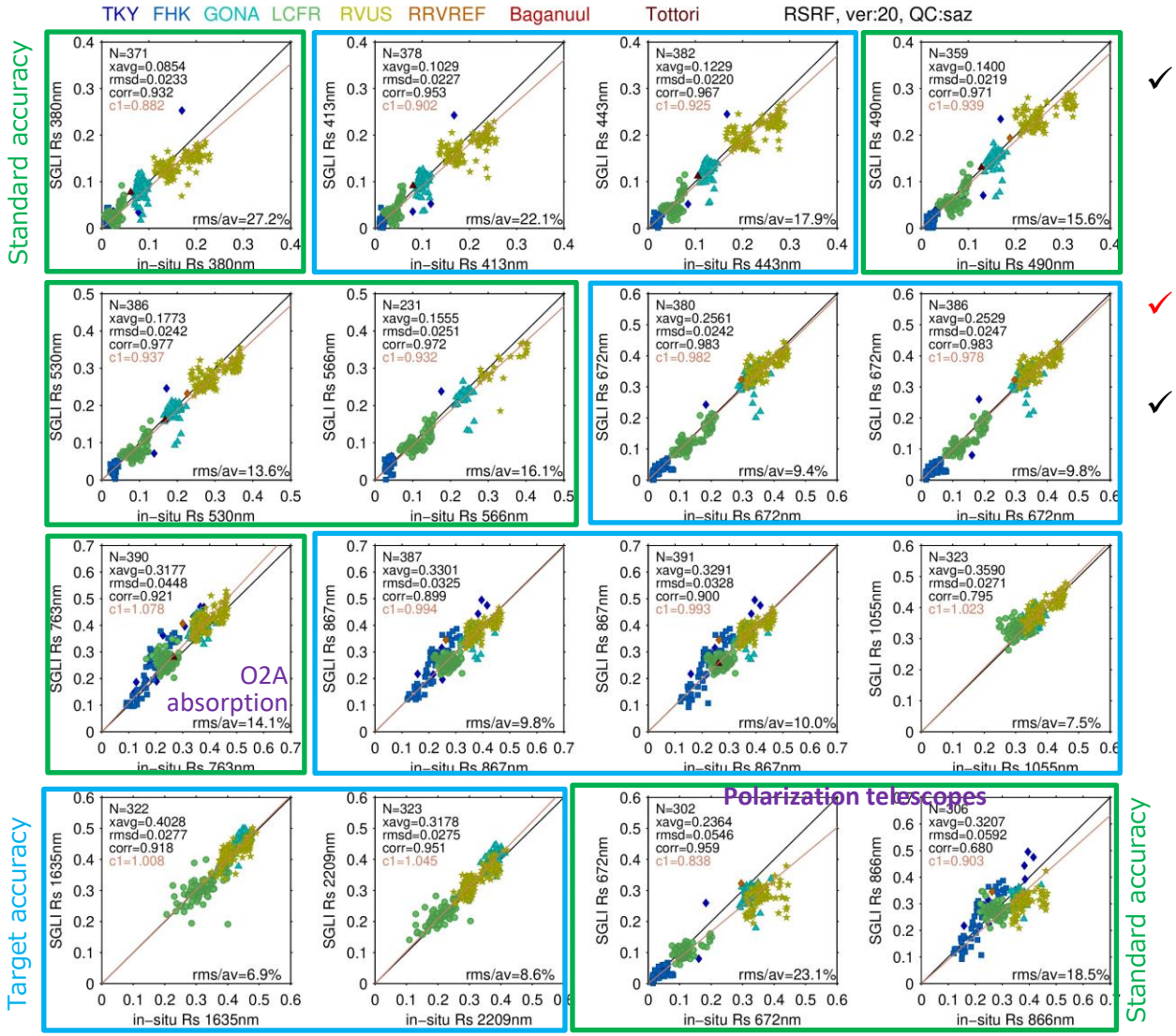
Product	Release threshold	Standard accuracy	Target accuracy	Status*1	Evaluation Methods
Precise geometric correction	<1 pixel	<0.5 pixel	<0.25 pixel	◎	Evaluation of geolocation accuracies with GCPs prepared using AVNIR-2 data.
Atmospheric corrected reflectance (incl. cloud detection)	0.3 (<=443nm) 0.2 (>443nm) (scene)	0.1 (<=443nm) 0.05 (>443nm) (scene)	0.05 (<=443nm), 0.025 (>443nm) (scene)	◎	Comparison with in-situ observed reflectance.
Vegetation index	Grass:25% (scene), forest:20% (scene)	Grass:20% (scene), forest:15% (scene)	Grass:10% (scene), forest:10% (scene)	○ ⇒ ◎	Comparison with in-situ observation and other satellite data.
Above-ground biomass	Grass:50%, forest: 100%	Grass:30%, forest:50%	Grass:10%, forest:20%	○ ⇒ ◎	Comparison with in-situ observation (incl. the data from the literatures).
Vegetation roughness index	Grass & forest: 40% (scene)	Grass & forest:20% (scene)	Grass & forest:10% (scene)	○ ⇒ ◎	Comparison with in-situ observations.
Shadow index	Grass & forest: 30% (scene)	Grass & forest:20% (scene)	Grass & forest:10% (scene)	○ ⇒ ◎	Comparison with in-situ observations.
fAPAR	Grass:50%, forest: 50%	Grass:30%, forest:20%	Grass:20%, forest:10%	◎	Comparison with in-situ observation and other satellite data.
Leaf area index	Grass:50%, forest: 50%	Grass:30%, forest:30%	Grass:20%, forest:20%	○ ⇒ ◎	Comparison with in-situ observation.
Surface temperature	<3.0 K (scene)	<2.5 K (scene)	<1.5 K (scene)	◎	Comparison with in-situ observation and other satellite data.

*1 Symbols denote as follows; ○: the release threshold achieved, ◎: the standard accuracy achieved, ☆: the target accuracy achieved.

Atmospheric corrected surface reflectance (RSRF)

- ✓ **Key revisions for Ver.3**
  - (1) Improvement of cloud and shadow screening
  - (2) Add polarization reflectance of PL1 and PL2
  - (3) Ocean surface aerosol LUT over the ocean area
  - (4) Add correction of radiometric offset calibration
  - (5) Reduce processing time
  - (6) Bug fix (sample number count of POL, uninitialized value..)
  - ✓ The first guess and vicarious calibration gains are not changed for the consistency to the Ver.2 data
  - ✓ More improvement will be needed for BRDF especially in NUV-blue bands, and remaining contamination of the cloud shadow
- ✓ All CH achieve the standard accuracy (10CHs achieved the target accuracy for the nadir observations, and 12CHs achieve with BRDF correction in the total 16CHs)

Validation results of Ver. 2 (RSRF)



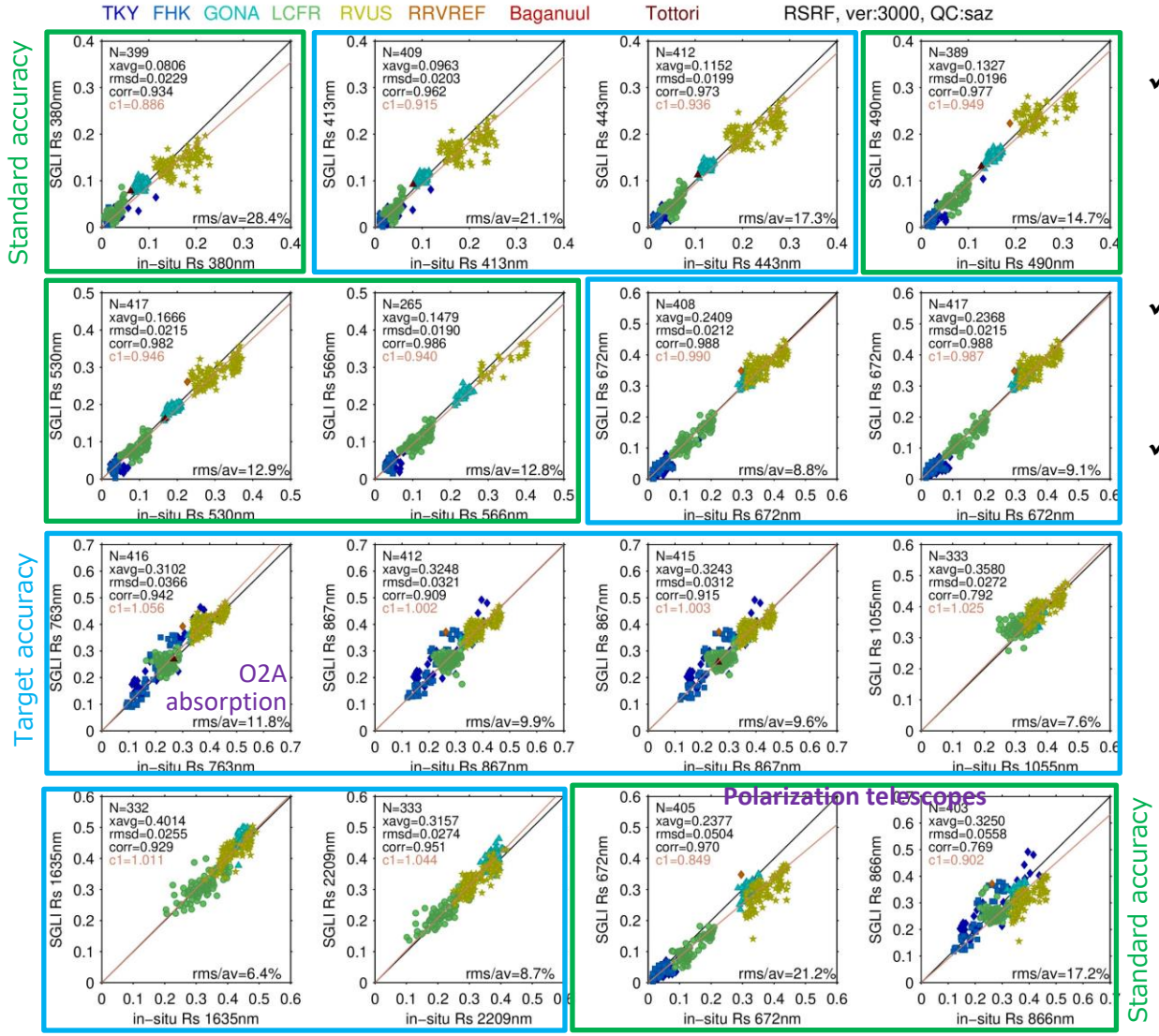
- ✓ Takayama (PEN), Fuji-hokuroku (PEN), RadCalNet (Namibia, France, US), RRV (PI Moriyama), Mongolia (PI Nasahara), tottori (PI Susaki)
- ✓ Saz is limited (saz<20deg except for POL
- ✓ smooth surface: Std of 3x3 RSRF is less than 0.01

The accuracy targets are defined as error ratios of "solar zenith angle<30 deg, smooth surface of reflectance ~0.2" Convert to error% by RMS/0.2

Validation results	Release accuracy (L+1yr)	Standard accuracy (L+5yr)	Target accuracy (L+5yr)
0.023, 27% (<=443nm) 0.059, 23% (>443nm)	0.3 (<=443nm) →150% 0.2 (>443nm) →100%	0.1 (<=443nm) →50% 0.05 (>443nm) →25%	0.05 (<=443nm) →25% 0.025 (>443nm) →12.5%

Worst value (VN01, PI02, PI01)

Validation results of Ver. 3 (RSRF)



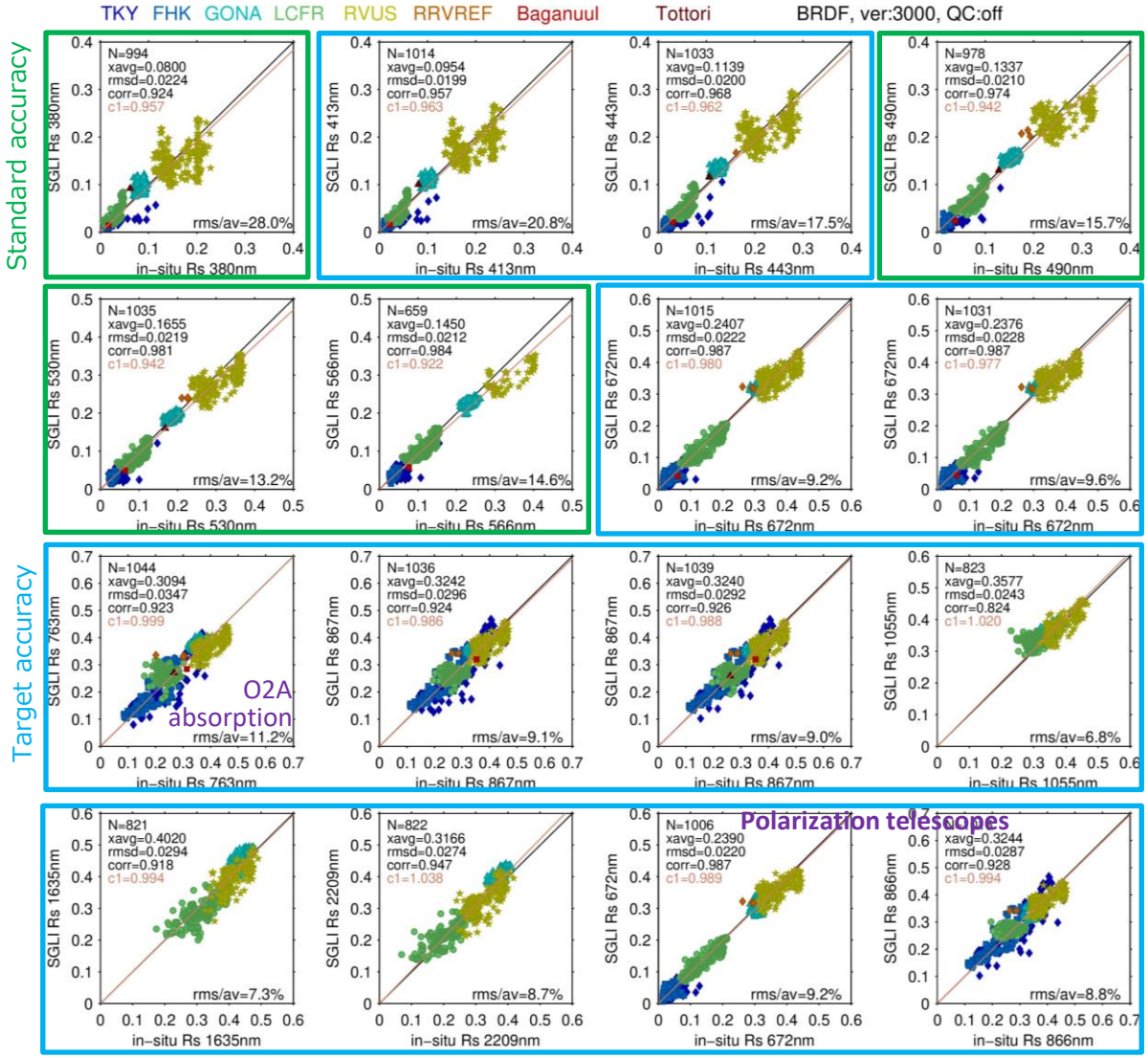
- ✓ Takayama (PEN), Fuji-hokuroku (PEN), RadCalNet (Namibia, France, US), RRV (PI Moriyama), Mongolia (PI Nasahara), tottori (PI Susaki)
- ✓ In-situ is nadir observation: Saz is limited (saz<20deg except for POL)
- ✓ smooth surface: Std of 3x3 RSRF is less than 0.01

The accuracy targets are defined as error ratios of "solar zenith angle<30 deg, smooth surface of reflectance ~0.2" Convert to error% by RMS/0.2

Validation results	Release accuracy (L+1yr)	Standard accuracy (L+5yr)	Target accuracy (L+5yr)
0.023, 28% (<=443nm) 0.056, 21% (>443nm)	0.3 (<=443nm) →150% 0.2 (>443nm) →100%	0.1 (<=443nm) →50% 0.05 (>443nm) →25%	0.05 (<=443nm) →25% 0.025 (>443nm) →12.5%

Worst value (VN01, PI02, PI01)

Validation results of Ver. 3 (corr by BRDF)



- ✓ Takayama (PEN), Fuji-hokuroku (PEN), RadCalNet (Namibia, France, US), RRV (PI Moriyama), Mongolia (PI Nasahara), tottori (PI Susaki)
- ✓ In-situ is nadir observation: Saz (0-51 or 53-63deg) is corrected to the nadir by BRDF
- ✓ smooth surface: Std of 3x3 RSRF is less than 0.01

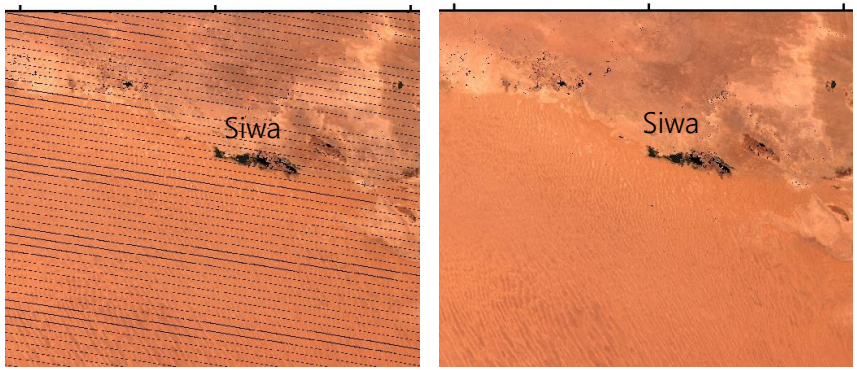
The accuracy targets are defined as error ratios of "solar zenith angle<30 deg, smooth surface of reflectance ~0.2" Convert to error% by RMS/0.2

Validation results	Release accuracy (L+1yr)	Standard accuracy (L+5yr)	Target accuracy (L+5yr)
0.022, 28% (<=443nm) 0.035, 16% (>443nm)	0.3 (<=443nm) →150% 0.2 (>443nm) →100%	0.1 (<=443nm) →50% 0.05 (>443nm) →25%	0.05 (<=443nm) →25% 0.025 (>443nm) →12.5%

Worst value (VN01, VN09, VN04)

(Appendix) RSRF: examples of the V2-V3 difference

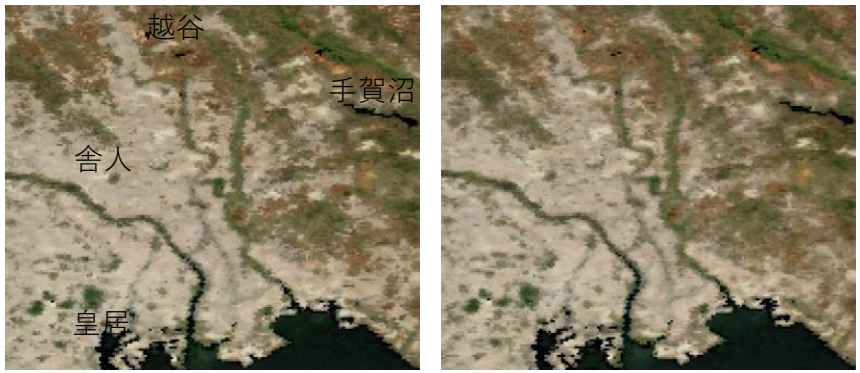
2021/06/19 T0620 Northeast of Saharan Des.



Ver. 2 Ver. 3

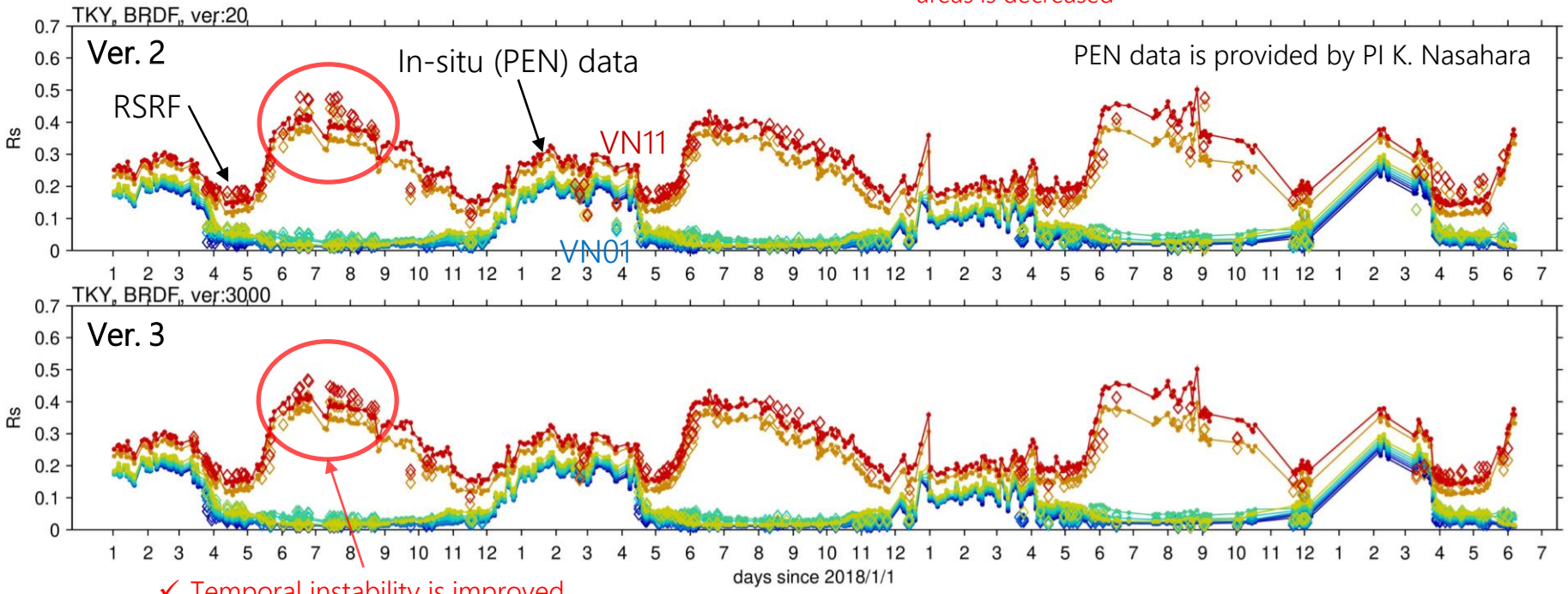
✓ Error of cloud mask due to the short term TIR gain anomaly is recovered

2021/04/22 T0529 Tokyo



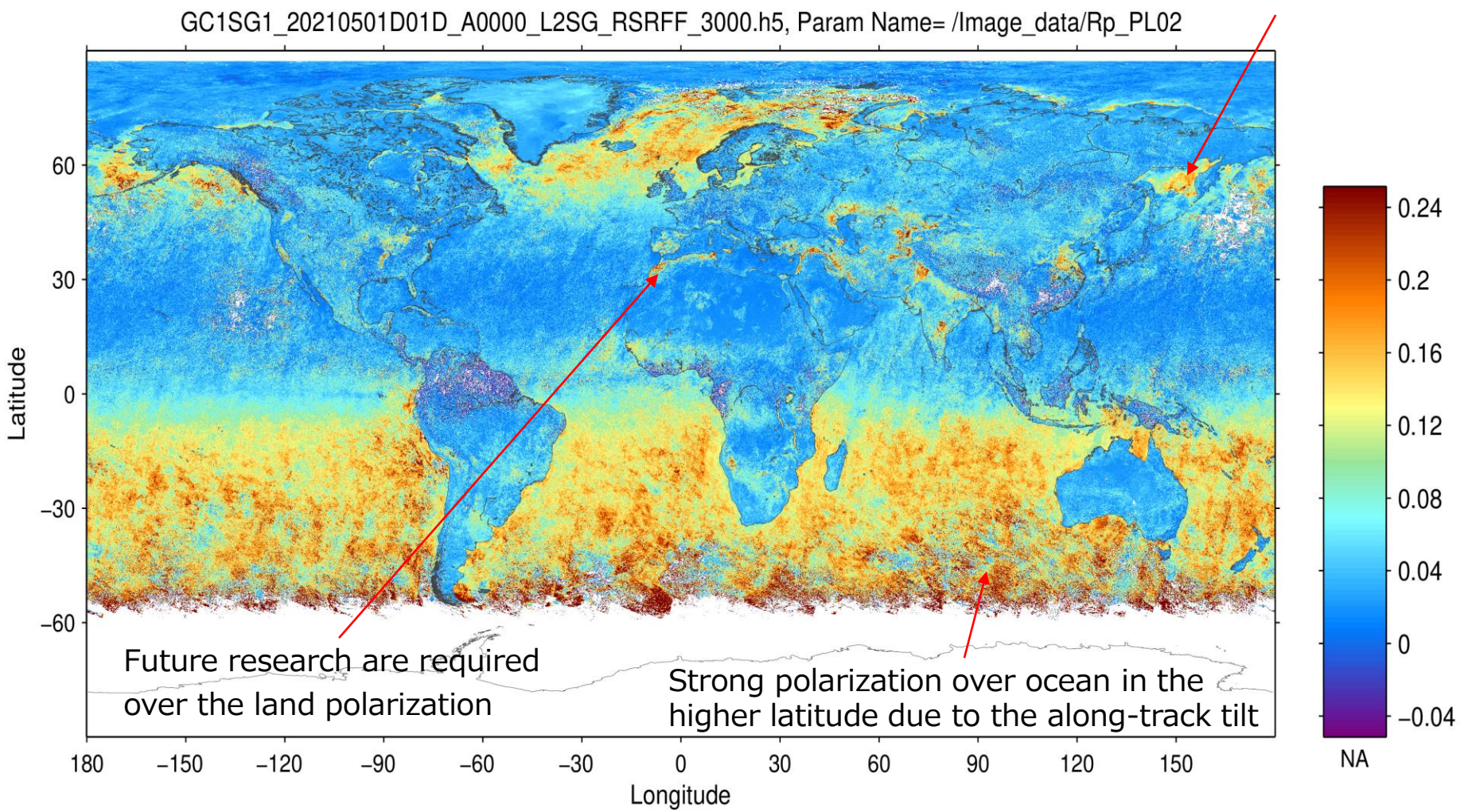
Ver. 2 Ver. 3

✓ Unrealistic reflectance gap between urban and vegetation areas is decreased

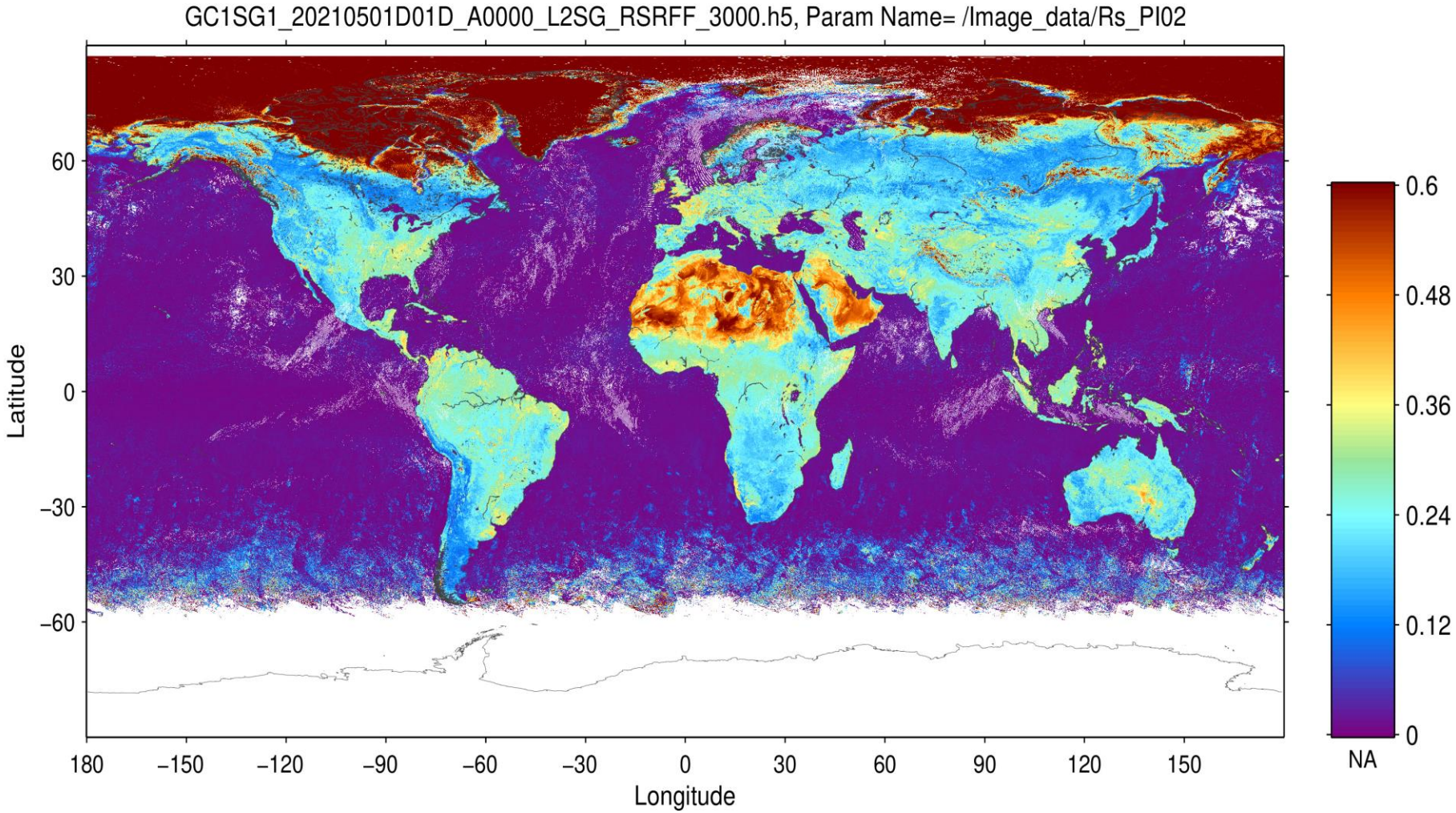


✓ Temporal instability is improved

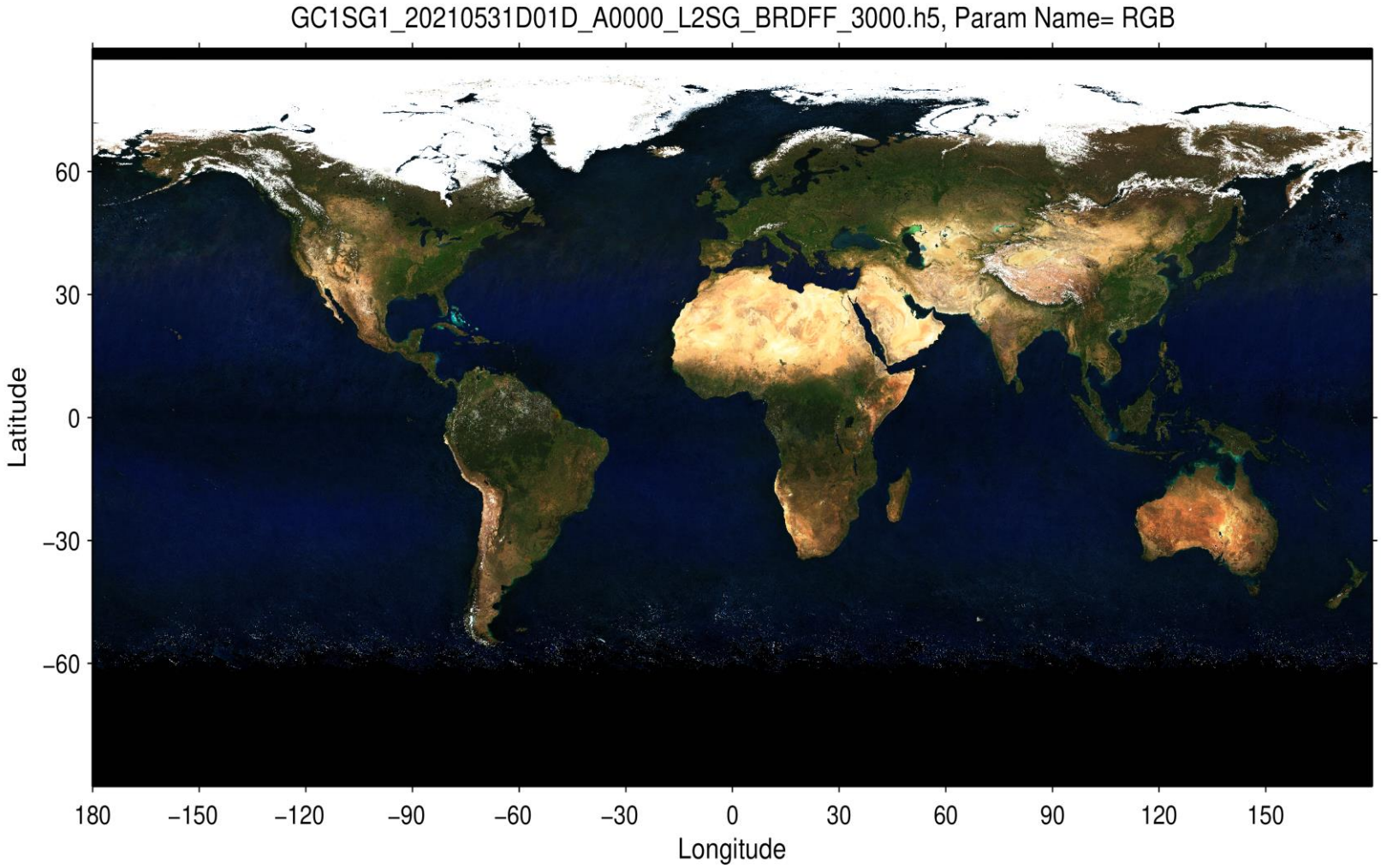
(Appendix) Add polarization reflectance of PL1 and PL2 polarization reflectance of PL2 (865nm)



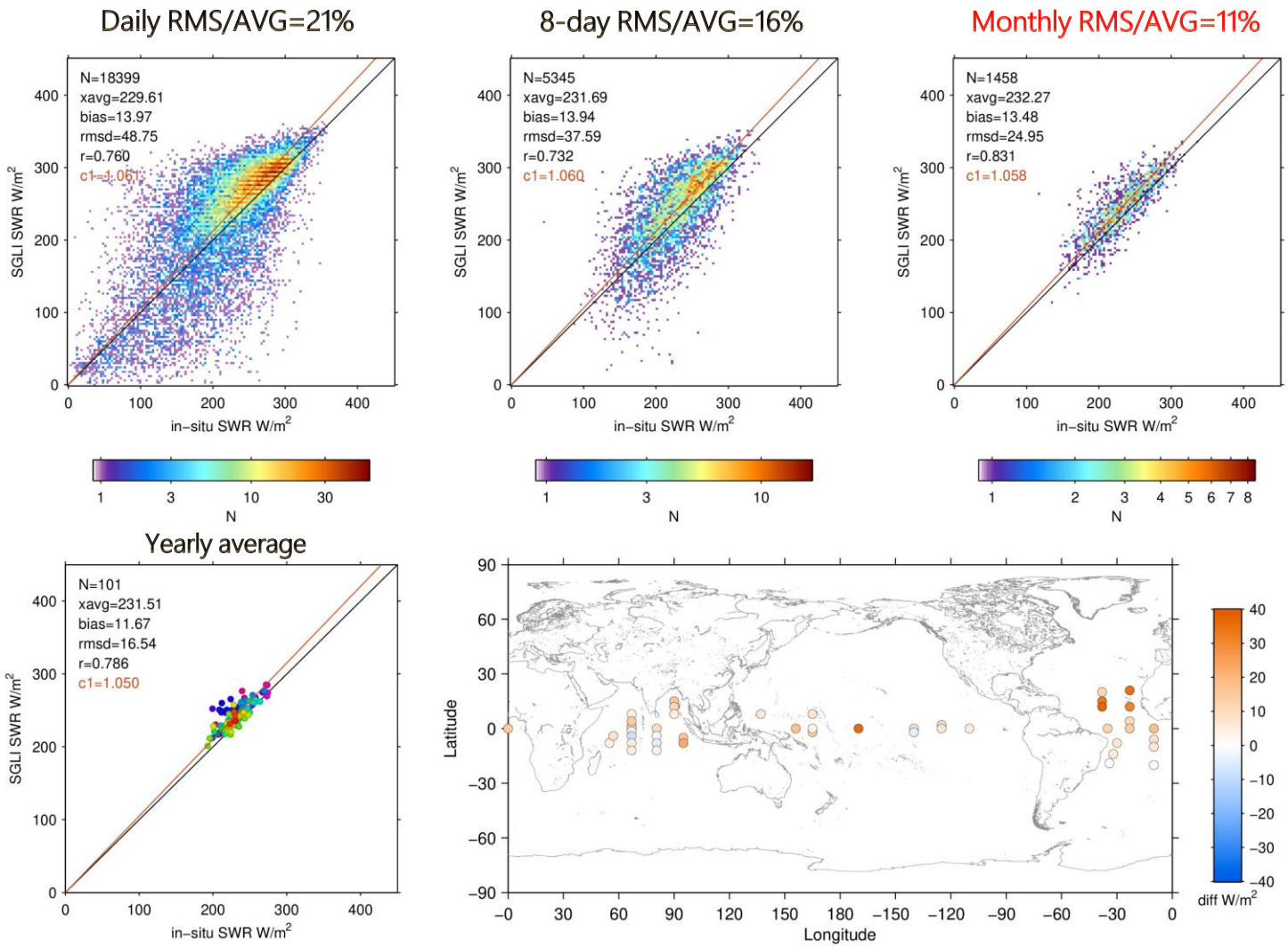
(Appendix) Reference: Intensity of PL02



(Appendix) Reference: RGB image (for reference)

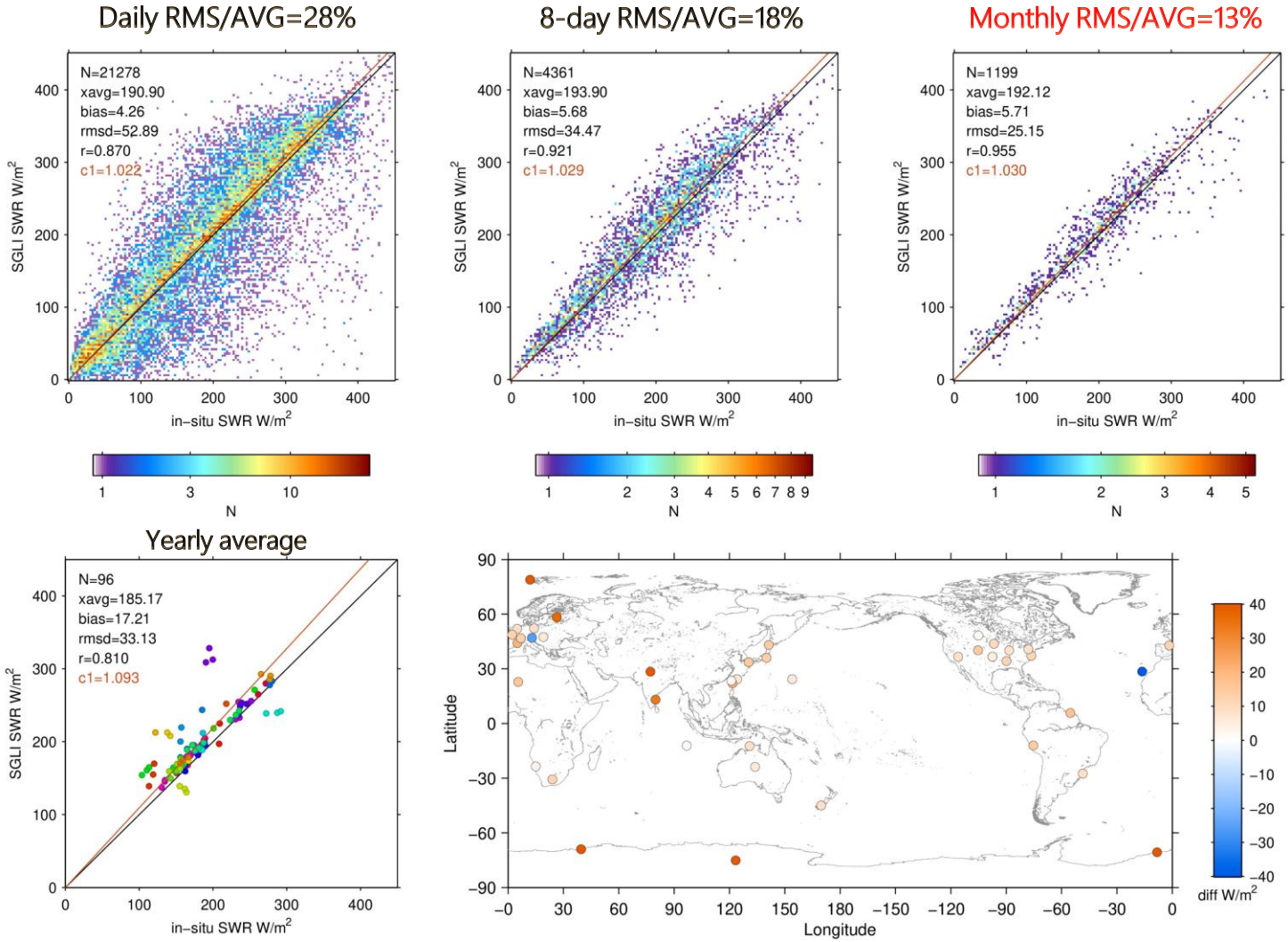


(Appendix) (Research product) Shortwave radiation (by TAO/PIRATA/RAMA SWR)



- ✓ Comparison with in-situ Daily SWR is provided by NOAA PMEL Global Tropical Moored Buoy Array, TAO/PIRATA/RAMA (https://www.pmel.noaa.gov/gtmba/)
- ✓ 11% does not achieve the SWR target accuracy (monthly 10W/m^2); the daily change should be considered in the future version
- ✓ Anomaly is useful for applications such as agriculture and long-term weather monitoring

(Appendix) (Research product) Shortwave radiation (by BSRN SWR)



- ✓ Daily SWR is estimated by instantaneous transmittance of visible channels and stored by 8 bit (/Image_data/SWR)
- ✓ Comparison with in-situ measurements by BSRN
- ✓ 13% does not achieve the SWR target accuracy (monthly 10W/m^2); the daily change should be considered in the future version
- ✓ Anomaly is useful for applications such as agriculture and long-term weather monitoring

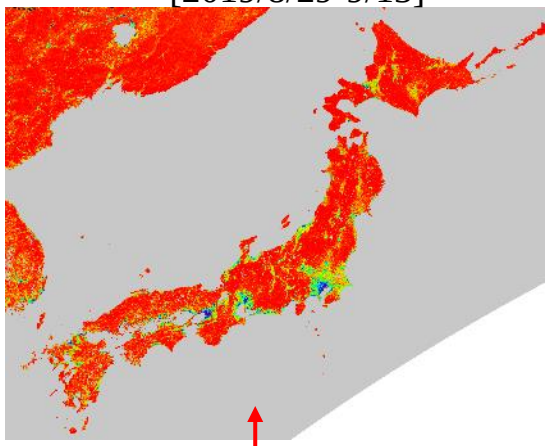
T2A/VeGetation Index (VGI): NDVI

Key updates

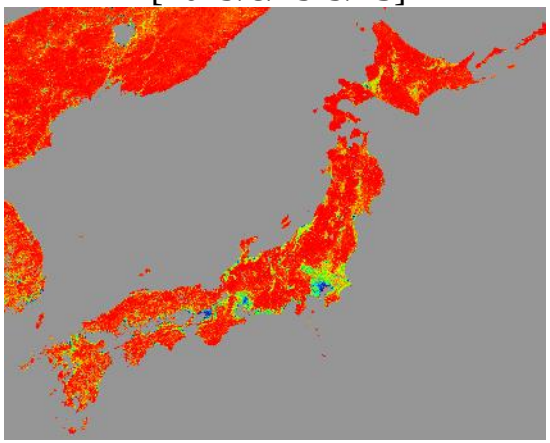
- ✓ No modification for the algorithm.
- ✓ Input data [RSRFQ] was changed.
- ✓ Validation data was increased.

NDVI 0 1 others

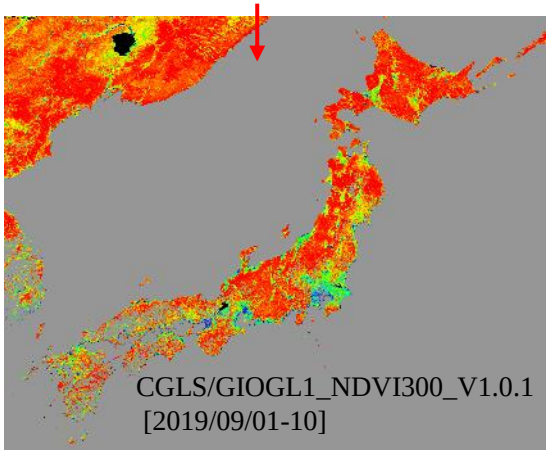
Ver.3 NDVI (MVC, input: Ver.2) [2019/8/29-9/13]

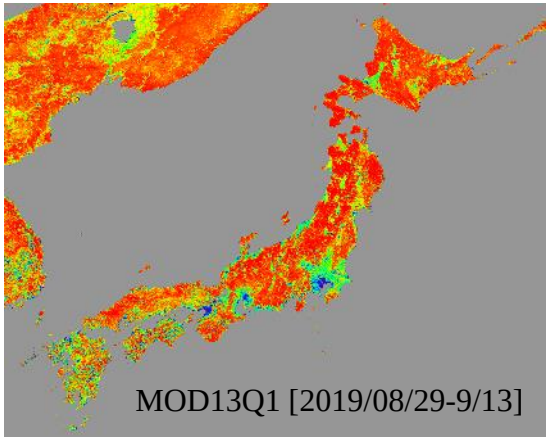


Ver.2 NDVI (MVC) [2019/8/29-9/13]



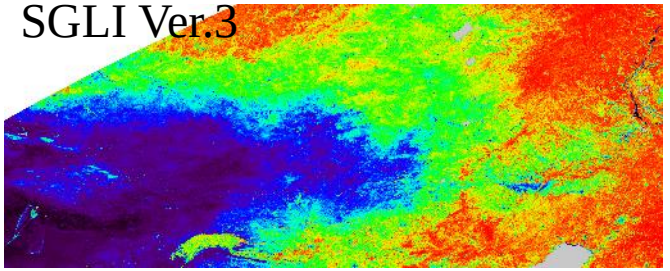
Similar distribution



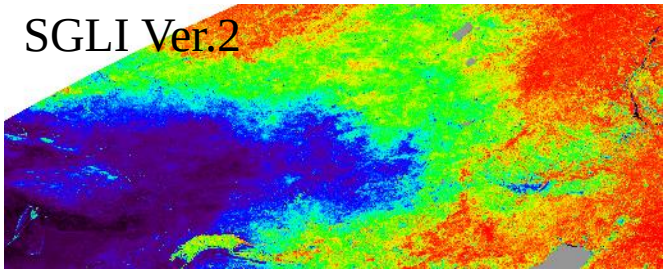


Around Japan

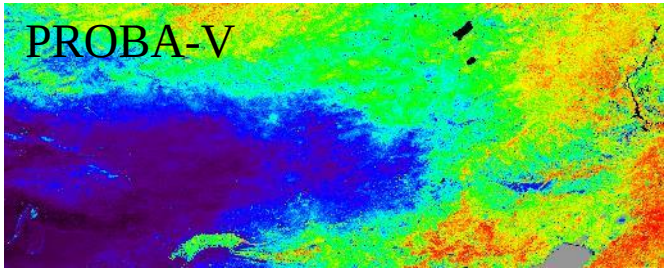
SGLI Ver.3



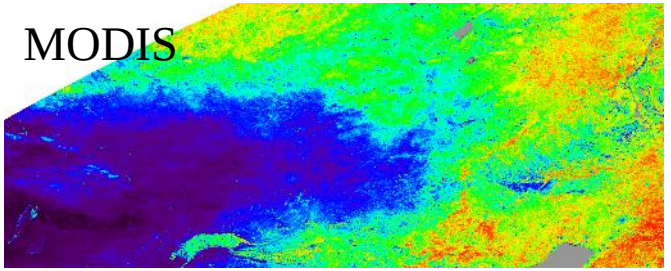
SGLI Ver.2



PROBA-V



MODIS



Around the eastern part of Mongolia

T2A/ VGI：NDVI

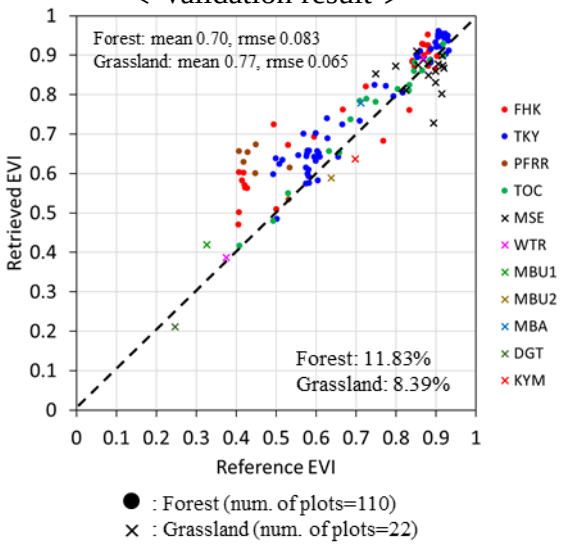
Validation method

- The accuracy of SGLI/NDVI was evaluated using the reference NDVI for forests and grasslands. The reference NDVI was derived from the spectral reflectance measurements at the field observation sites.
- The effects of observation tower were corrected by shielding devices at TKY, FHK and PFRR sites.
- The data was not used for the evaluation when the "prob. cloud" or "shadow" bits are set or when cloud pixels are adjacent.
- The validation pixel was moved for MSE site because the nearest neighbor pixel includes the river.

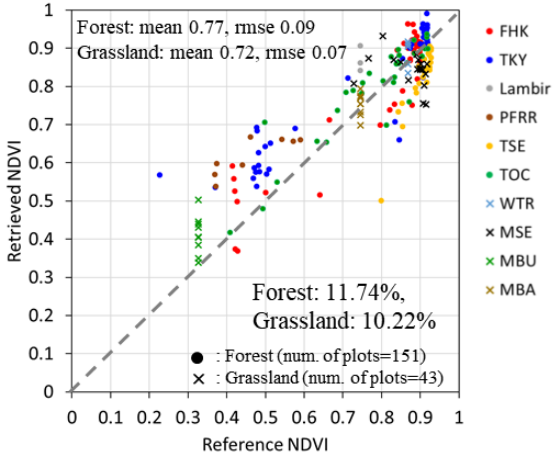
Validation data and period

- The data obtained at clear weather condition were used for validation, referring to solar radiation and sky cameras synchronized with the ground observation. However, the data of the day with the maximum NDVI in 20 days were used for WTR, MBU, MBN, DGT or KYM sites because there is no information of weather condition. The data during snow season were excluded from the evaluation.
- The in-situ spectral reflectance data were upscaled to the SGLI scale using the Sentinel-2A/B Multispectral Imager(MSI) Level 1C/2A data (Band4 and 8b) for TKY, FHK, PFRR, and MSE sites.
- Validation period: TKY [2018/4/1-2021/7/31], FHK [2018/4/1-2019/12/31], TOC [2018/4/26-10/31], PFRR [2018/9/1-9/30], MSE [7/1-8/31 for 2018, 2019, 2020 and 2021], MBN/MBU/DGT/KYM/WTR [the day with the smallest cloud effect within ± 10 days of field observation]

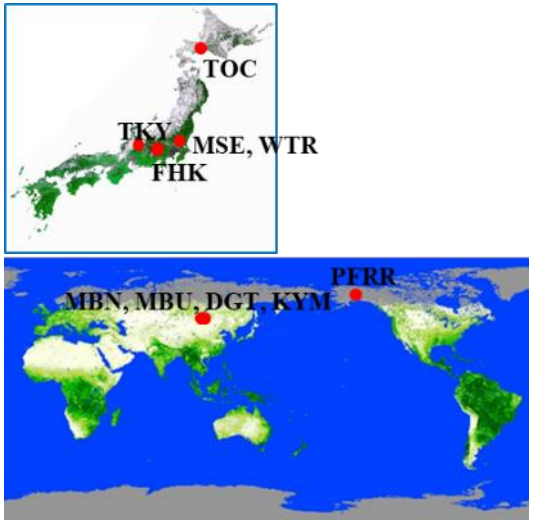
＜ Validation result ＞



＜ Validation result for ver.2 ＞



＜ validation sites ＞



Estimated accuracy	Release threshold	Standard accuracy	Target accuracy
11.7 → 11.8 % 10.2 → 8.4 %	20% (Forest) Scene, 25% (Grassland) Scene	15% (Forest) Scene, 20% (Grassland) Scene	10% (Forest) Scene, 10% (Grassland) Scene

The standard accuracy is expected to be achieved.

T2A/VeGetation Index (VGI): EVI

Key updates

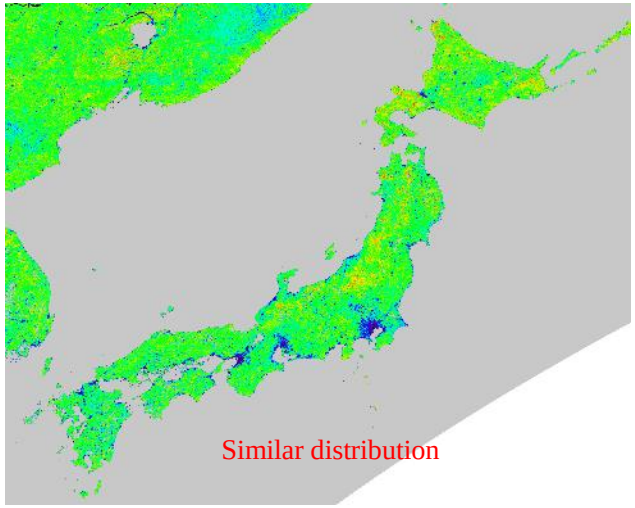
- ✓ No modification for the algorithm.
- ✓ Input data [RSRFQ] was changed.
- ✓ Validation data was increased.

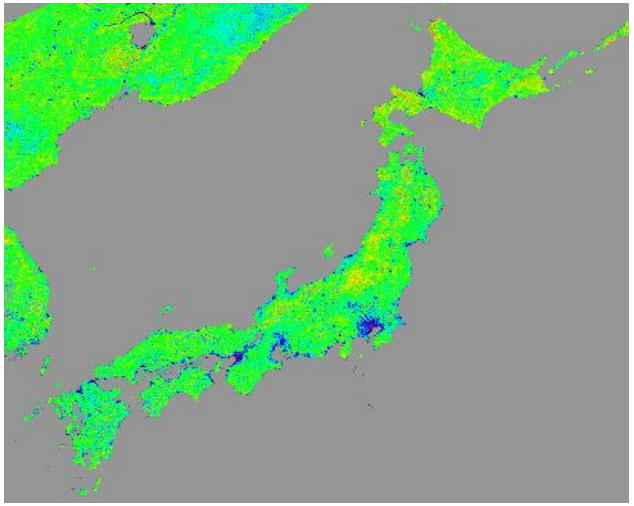
EVI 0 1 others

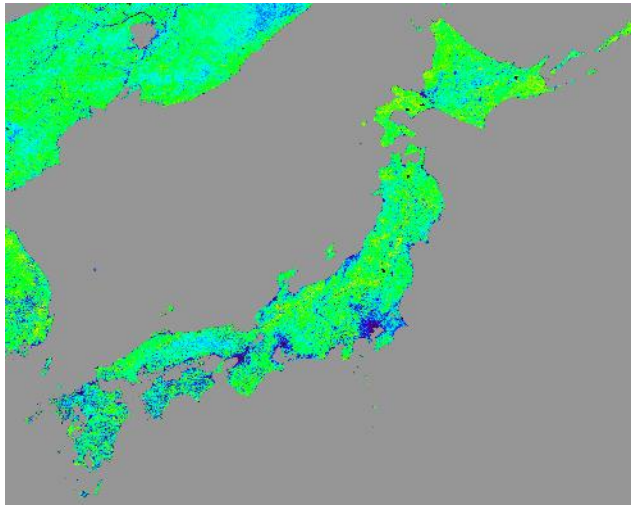
Ver.3 EVI (ndvi_MVC, input: Ver.2) [2019/8/29-9/13]

Ver.2 EVI (ndvi_MVC) [2019/8/29-9/13]

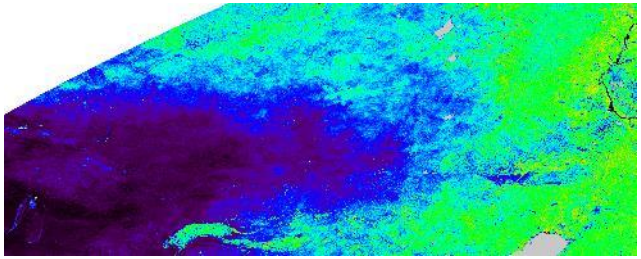
MOD13Q1 [2019/08/29-9/13]

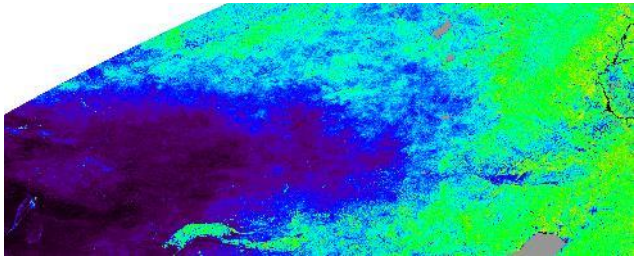


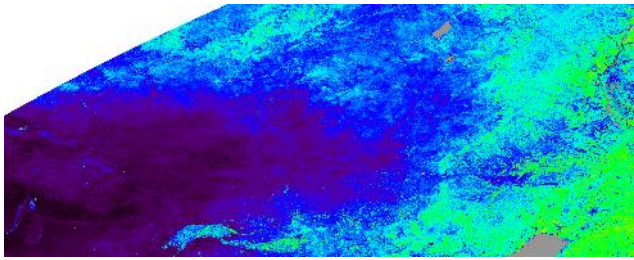




Around Japan







Around the eastern part of Mongolia

➢ Distribution is similar to MODIS products.

T2A/ VGI：EVI

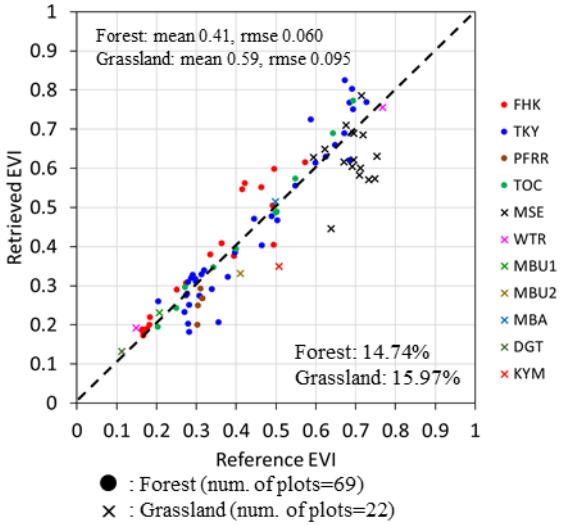
Validation method

- The accuracy of SGLI/EVI was evaluated using the reference EVI for forests and grasslands. The reference EVI was derived from the spectral reflectance measurements at the field observation sites.
- The effects of observation tower were corrected by shielding devices at TKY, FHK and PFRR sites.
- The data was not used for the evaluation when the "prob. cloud" or "shadow" bits are set or when cloud pixels are adjacent. The data was not used for forest sites when the satellite zenith angle is larger than 30 degrees.
- The validation pixel was moved for MSE site because the nearest neighbor pixel includes the river.

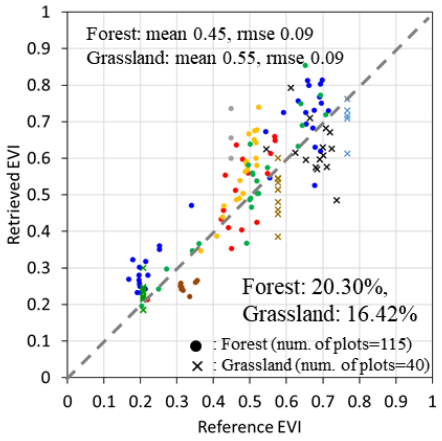
Validation data and period

- The data obtained at clear weather condition were used for validation, referring to solar radiation and sky cameras synchronized with the ground observation. However, the data of the day with the maximum NDVI in 20 days were used for WTR, MBU, MBN, DGT or KYM sites because there is no information of weather condition. The data during snow season were excluded from the evaluation.
- The in-situ spectral reflectance data were upscaled to the SGLI scale using the Sentinel-2A/B Multispectral Imager(MSI) Level 1C/2A data (Band4 and 8b) for TKY, FHK, PFRR, and MSE sites.
- Validation period: TKY [2018/4/1-2021/7/31], FHK [2018/4/1-2019/12/31], TOC [2018/4/26-10/31], PFRR [2018/9/1-9/30], MSE [7/1-8/31 for 2018, 2019, 2020 and 2021], MBN/MBU/DGT/KYM/WTR [the day with the smallest cloud effect within ± 10 days of field observation]

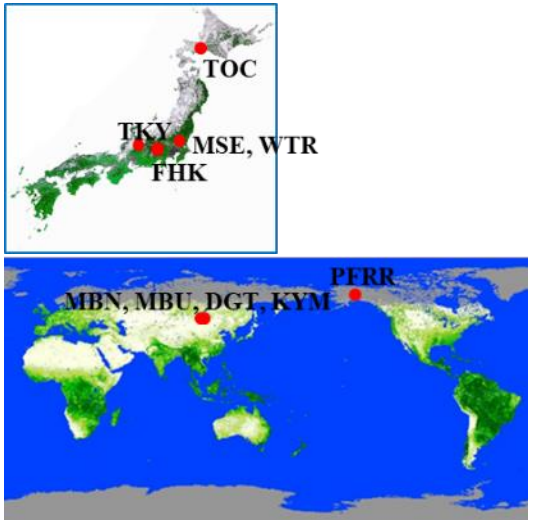
＜ Validation result ＞



＜ Validation result for ver.2 ＞



＜ Validation sites ＞



Estimated accuracy	Release threshold	Standard accuracy	Target accuracy
20.3 → 14.7 % 16.4 → 16.0 %	20% (Forest) Scene, 25% (Grassland) Scene	15% (Forest) Scene, 20% (Grassland) Scene	10% (Forest) Scene, 10% (Grassland) Scene

The standard accuracy is expected to be achieved.

The list of validation sites

Forests

- FHK: Fuji Hokuroku Flux Observation site, Japan
- Lambir: Lambir Hills site, Malaysia
- PFRR: Poker Flat Research Range site, USA
- TKY: Takayama Deciduous Broadleaf Forest site, Japan
- TOC: Tomakomai Crane Site, Japan
- TSE: Teshio CC-LaG Experiment site, Japan

Grasslands and paddy fields

- DGT: Delgertsogt JAXA Super Site 500, Mongolia
- KYM: Khar Yamaat JAXA Super Site 500, Mongolia
- MBN: Baganuul JAXA Super Site 500, Mongolia
- MBU: Bayan-Unjuul JAXA Super Site 500, Mongolia
- MSE: Mase Paddy Flux site, japan
- WTR: Watarase JAXA Super Site 500, Japan

Acknowledgements

- ✓ The field data were mainly collected by GCOM-C PIs, AKITSU Tomoko, HONDA Yoshiaki, KAJIWARA Koji, KOBAYASHI Hideki, MORIYAMA Masao, NAGAI Shin, NASAHARA Kenlo Nishida, and SUSAKI Junichi.
- ✓ The CGLS/GIOGL1_LAI300, FAPAR300 and NDVI300 products were used for the comparison with SGLI products in this article. They were generated by the global component of the Land Service of Copernicus, the Earth Observation program of the European Commission. The research leading to the current version of the product has received funding from various European Commission Research and Technical Development programs. The products are based on PROBA-V 333m data ((c) Belgian Science Policy and distributed by VITO NV).
- ✓ Sentinel-2A/B Multispectral Imager(MSI) Level-1C/2A data were produced by European Space Agency (ESA). They were acquired from the Copernicus Open Access Hub of the ESA.
- ✓ MOD13Q1 MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006 were acquired from NASA EOSDIS Land Processes DAAC from https://lpdaac.usgs.gov, maintained by the NASA EOSDIS Land Processes Distributed Active Archive Center (LP DAAC) at the USGS Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota.

References

- ➢ Akitsu, T. K., Nakaji, T., Yoshida, T., Sakai, R., Mamiya, W., Terigele, Takagi, K., Honda, Y., Kajiwara K., Nasahara, K. N., 2020. Field data for satellite validation and forest structure modeling in a pure and sparse forest of Picea glehnii in northern Hokkaido. *Ecological Research*, **2020**, pp.1-15. doi:10.1111/1440-1703.12114.
- ➢ Akitsu, T. K., Nakaji, T., Kobayashi, H., Okano, T., Honda, Y., Bayarsaikhan, U., Terigele, Hayashi, M., Hiura, T., Ide, R., Igarashi, S., Kajiwara, K., Kumikawa, S., Matsuoka, Y., Nakano, Ta., Nakano, To., Okuda, A., Sato, T., Tachiiri, K., Takahashi, Y., Uchida, J., Nasahara, K. N., 2020. Large-scale ecological field data for satellite validation in deciduous forests and grasslands. *Ecological Research*, **2020**, ERDP-2020-16.1.1(http://db.cger.nies.go.jp/JaLTER/metacat/metacat/ERDP-2020-16.1.1/jalter-en)
- ➢ Kobayashi, H., Nagai, S., Kim, Y., Yang, W., Ikeda, K., Ikawa, H., Nagano, H. and Suzuki, R., 2018. In situ observations reveal how spectral reflectance responds to growing season phenology of an open evergreen forest in Alaska. *Remote Sensing*, **10**(7), p.1071. (Data are available from Arctic Data archive System (ADS), Japan, https://ads.nipr.ac.jp/dataset/A20181212-002)

T2A/ ShaDow Index（SDI）

Key updates

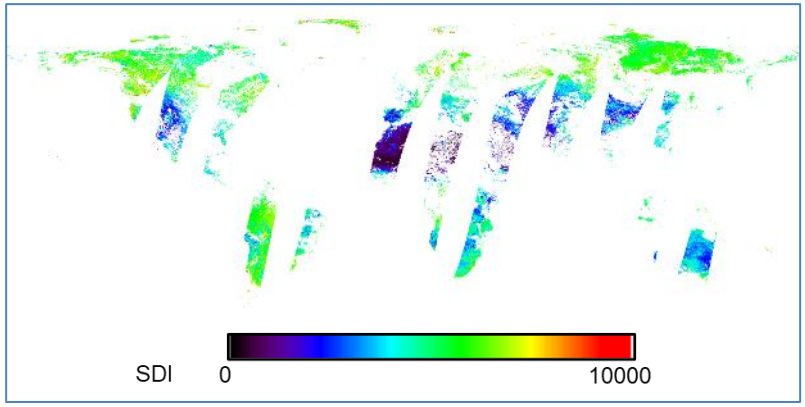
- ✓ Revision of coefficients for estimating SDI.
- ✓ Addition of “Cosine_of_solor_incidence” calculated from DEM and solar geometry in Geometry data.
- ✓ Modification of QA flag.

Validation method

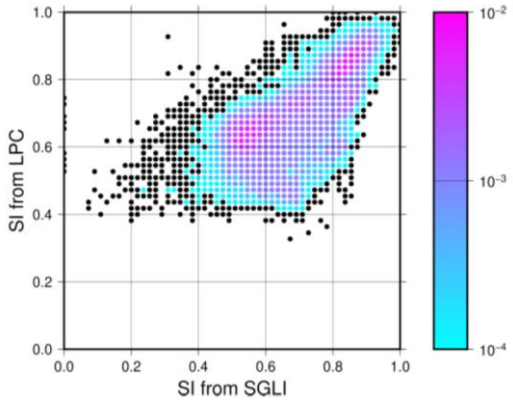
- SGLI/SDI is evaluated by the shadow-areas truth data calculated using the in-situ observation data.
- The shadow-areas truth data are generated based on the DSM data from USGS 3 Dimensional Elevation Programme (3DEP) and Solar Zenith Angle (SZA). SGLI/SDI is compared with the shadow-areas truth data correspond to each SGLI pixel (250[m]).
- The land pixels (Landwater=100) with NDVI > 0.75 are validated. The pixels adjacent to cloud or probably cloud are excluded from validation.

＜ Estimated SDI ＞

SDI by Ver.3 algorithm [2020/08/01]



＜ Validation ＞



Validation sites

Sitename	Patches	Tile
WA_Western_South	20	V04H09
WI_Statewide	16	V04H11
MA_ME	7	V04H12
CA_FEMA	20	V05H08
UT_WashingtonCo	7	V05H09
FL_Panhandle_B3	14	V05H10
FL_SRWMD	6	V05H10

(Elevation range in a patch is less than 100[m])

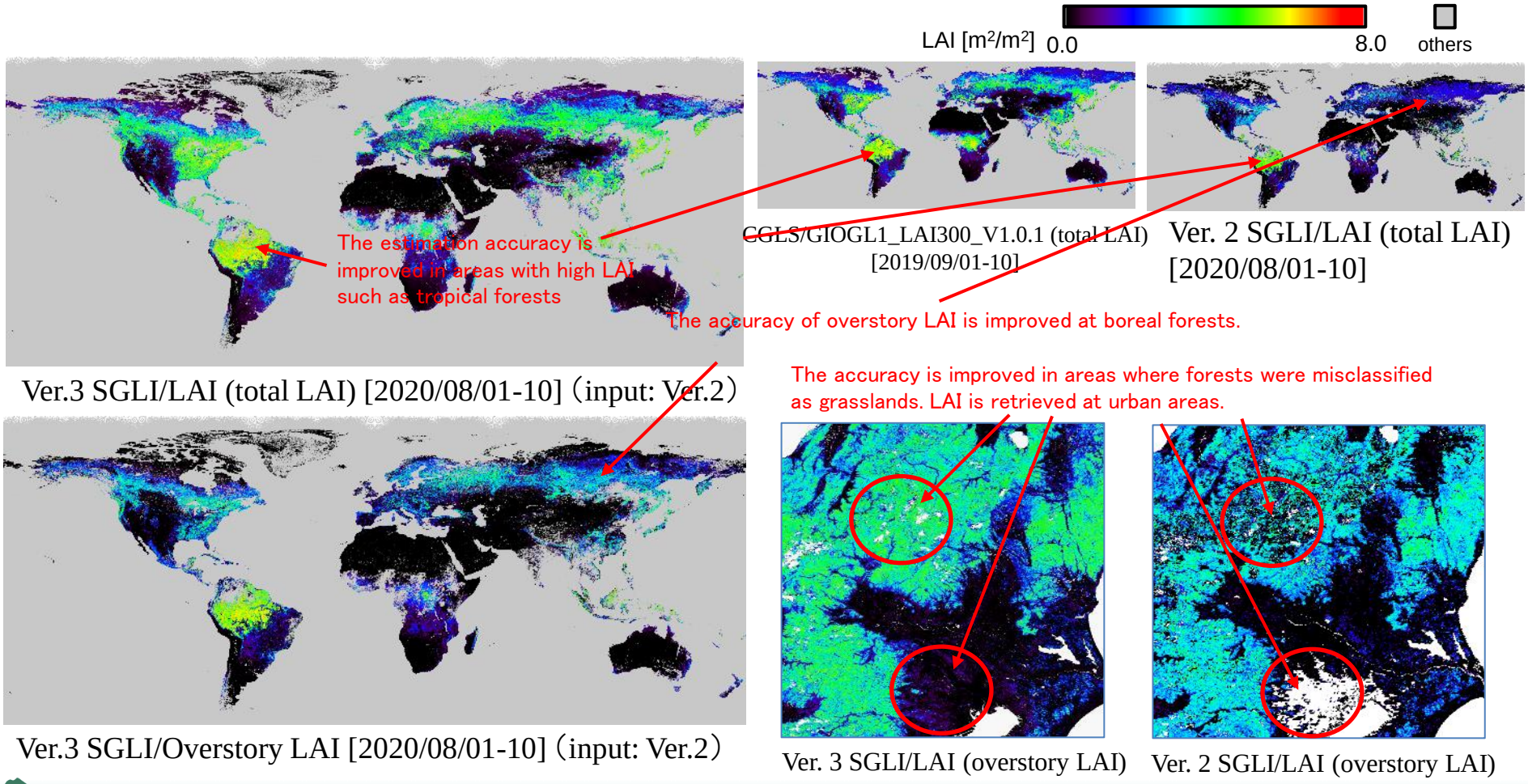
Estimated accuracy	Release threshold	Standard accuracy	Target accuracy
26.3 → 14.0%	30% (Forest･Grassland) Scene	20% (Forest･Grassland) Scene	10% (Forest･Grassland) Scene

The standard accuracy is expected to be achieved.

T2B/ Leaf Area Index (LAI)

Key updates

- ✓ Creation of base map using SGLI data and increase of forest cover type from 7 to 17 types → The estimation accuracy is improved.
- ✓ Modification of LUTs and reduction of LAI-intervals at low LAI → The estimation accuracy is improved.
- ✓ Increase of the site for validation: Yona-site (Evergreen broadleaf forest)



T2B/ Leaf Area Index (LAI)

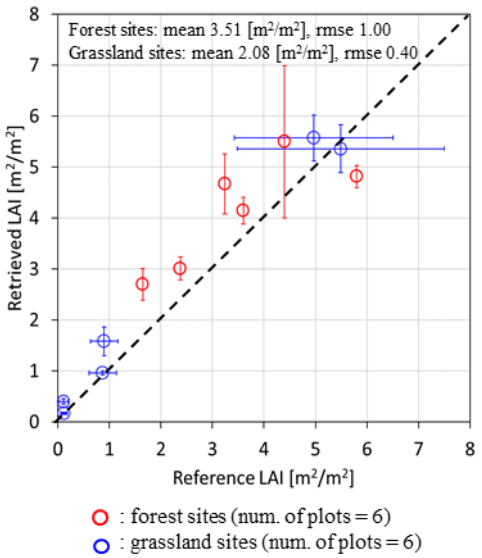
Validation method

- The accuracy of SGLI/LAI was evaluated using the reference LAI data at validation sites for forests and grasslands. The reference LAI was derived from in-situ observation data.

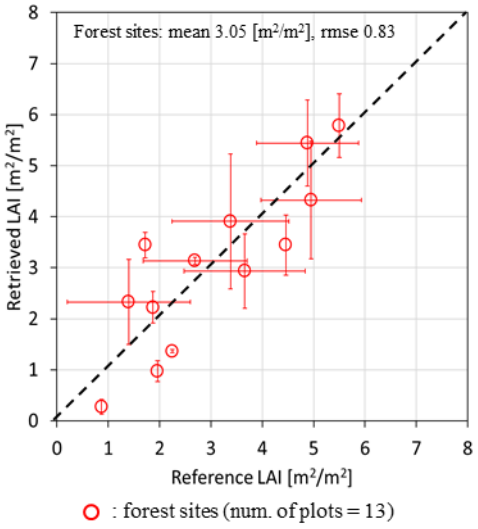
SGLI data used for validation

- The daily SGLI/LAI was averaged for 11 days and compared with reference LAI [PFRR/Lambir/TMM/Yamashiro: date of field data acquisition ±5 days in 2020, other sites: date and year of field data acquisition ±5 days.]. The period was extended for another 11 days if there was only one day or less of valid data within the 11 days.
- RSRFQ ver.2 was used as input data for LAI retrieval.
- The data was not used for the evaluation when the "cloud shadow", "bad air condition", "backup algorithm" or "poor quality" bits were set, though the data with "poor quality" bit were used when all the data were set as "poor quality" for one month.

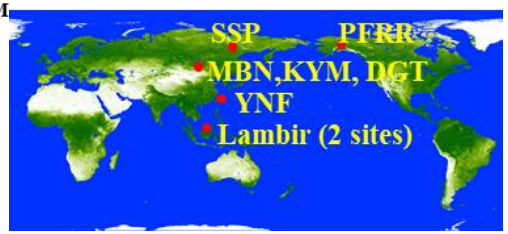
Total LAI < Forest and grassland >



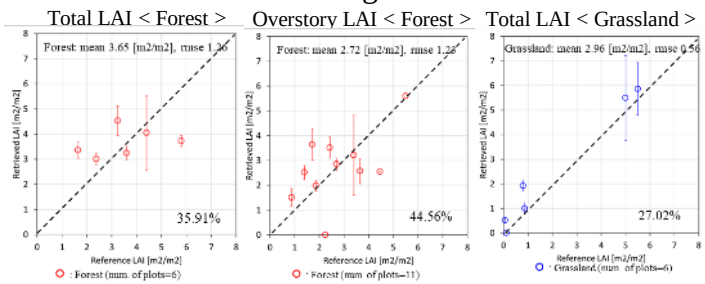
Overstory LAI < Forest >



< Validation sites >



Validation results for ver.2 algorithm in 2019



Estimated accuracy	Release threshold	Standard accuracy	Target accuracy
Forest (total LAI): 35.9% → 28.5%、 Forest (overstory LAI): 44.6% → 27.2% Grassland: 27.0% → 19.1%	50% (Forest), 50% (Grassland)	30% (Forest), 30% (Grassland)	20% (Forest), 20% (Grassland)

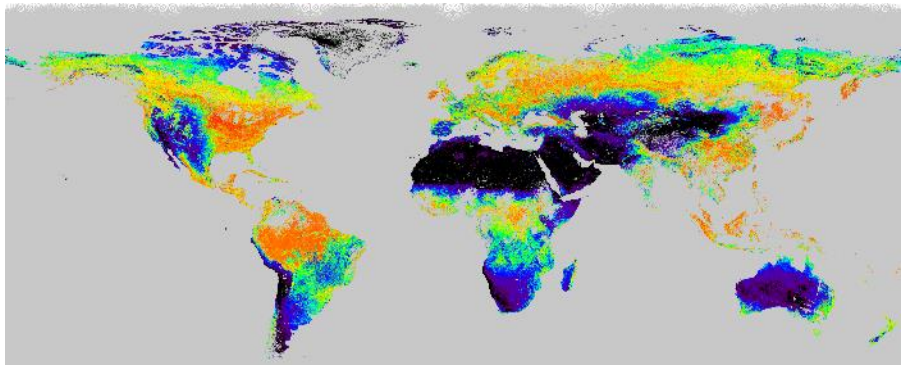
The standard accuracy is expected to be achieved.

T2B/ Fraction of Absorbed Photosynthetically Active Radiation（FAPAR）

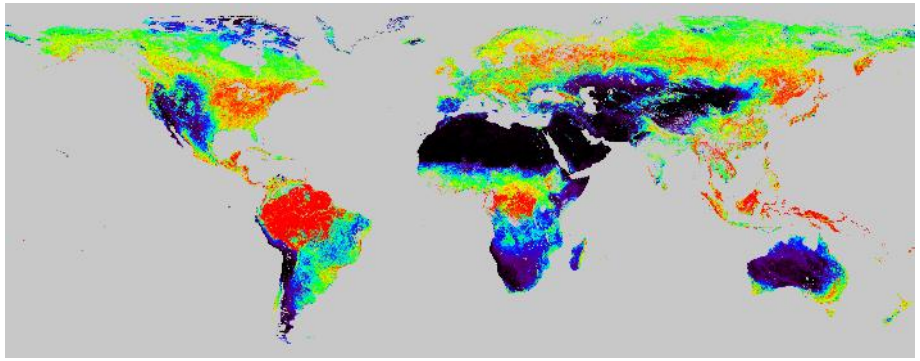
Key updates

- ✓ Creation of base map using SGLI data and increase of forest cover type from 7 to 17 types → The estimation accuracy is improved.
- ✓ Modification of LUTs → The estimation accuracy is improved.

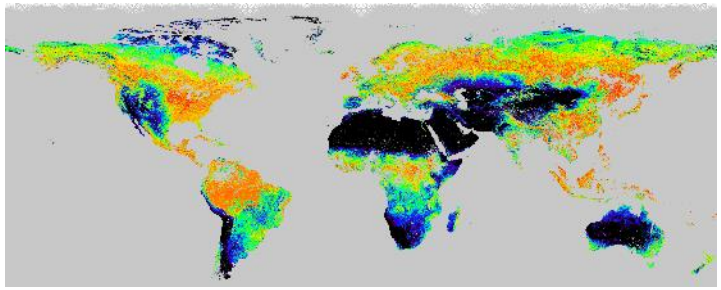
FAPAR 0 1 others



Ver.3 T2B/FAPAR [2020/08/01-10]（input: Ver.2）

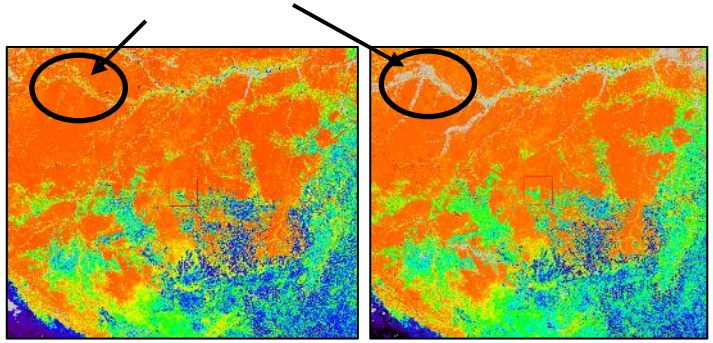


CGLS/GIOGL1_FAPAR300_V1.1.1 [2020/08/01-10]



Ver. 2 T2B/FAPAR [2020/08/01-10]

The estimation accuracy was improved.



Around Amazon

Ver.3 T2B/FAPAR Ver.2 T2B/FAPAR

T2B/ FAPAR

Validation method

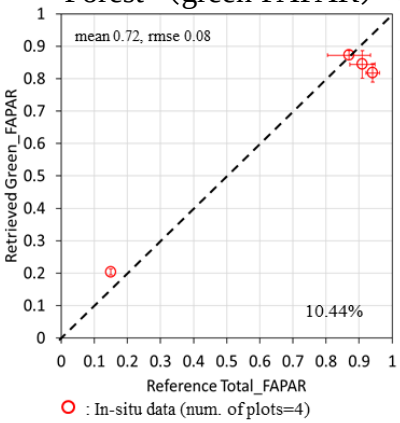
- The accuracy of SGLI/FAPAR was evaluated using the reference FAPAR (total FAPAR) data at validation sites for forests and grasslands. The reference total FAPAR was derived from in-situ observation data.
- In addition to SGLI/green FAPAR (T2B output value), SGLI/total FAPAR was evaluated to assess with the same FAPAR definition as the validation data in forests. SGLI/total FAPAR was re-estimated from SGLI data using the same algorithm with T2B,.

SGLI data used for validation

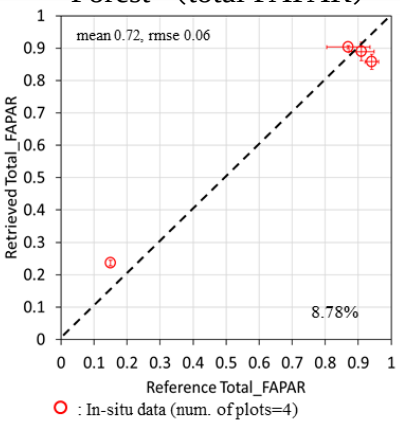
- The daily SGLI/FAPAR was averaged for 11 days and compared with reference FAPAR [PFRR: date of field data acquisition ±5 days in 2020, other sites: date and year of field data acquisition ±5 days.]. The period was extended for another 11 days if there was only one day or less of valid data within the 11 days.
- RSRFQ ver.2 was used as input data for FAPAR retrieval.
- The data was not used for the evaluation when the “cloud shadow”, “bad air condition”, “backup algorithm” or “poor quality” bits were set.

< Validation sites >

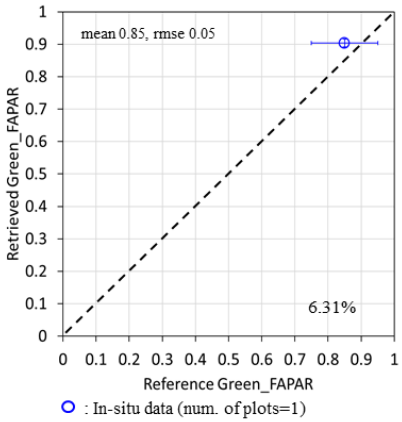
Forest*1（green FAPAR）



Forest*2（total FAPAR）

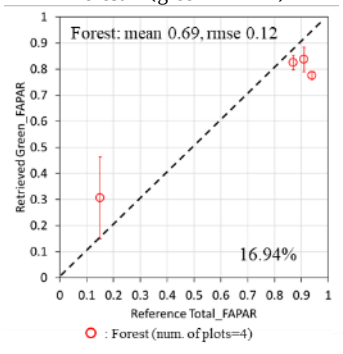


Grassland

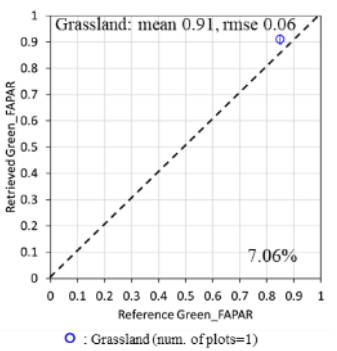


Validation results for ver.2 algorithm in 2019

Forest*1（green FAPAR）



Grassland



※FAPAR by canopy was used as the definition at PFRR site.

Estimated accuracy	Release threshold	Standard accuracy	Target accuracy
Forest: 16.9% → 10.4%*1 Grassland: 7.1% → 6.3%	50% (Forest), 50% (Grassland)	20% (Forest), 30% (Grassland)	10% (Forest), 20% (Grassland)

*1 Validation for green FAPAR, though the total FAPAR was used as in-situ data

*2 Validation for total FAPAR.

The standard accuracy is expected to be achieved.

The list of validation sites

Forests

- AK06: AK06 Alaska Forest site, USA
- FHK: Fuji Hokuroku Flux Observation site, Japan
- Lambir: Lambir Hills site, Malaysia
- Lambir Oil Palm: Lambir Oil Palm Plantation site, Malaysia
- PFRR: Poker Flat Research Range site, USA
- SSP: Spasskaya Pad site, Russia
- TKY: Takayama Deciduous Broadleaf Forest site, Japan
- TMM: Tokachi Mitsumata JAXA Super Site 500, Japan
- TOC: Tomakomai Crane Site, Japan
- TOS: Hokkaido University Tomakomai Experimental Forest site, Japan
- TSE: Teshio CC-LaG Experiment site, Japan
- URY: Hokkaido University Uryu Experimental Forest site, Japan
- YNF: Yona Field, Japan
- Yamashiro: Yamashiro site, Japan

Grasslands and paddy fields

- DGT: Delgertsogt JAXA Super Site 500, Mongolia
- KYM: Khar Yamaat JAXA Super Site 500, Mongolia
- MBN: Baganuul JAXA Super Site 500, Mongolia
- MBU: Bayan-Unjuul JAXA Super Site 500, Mongolia
- MSE: Mase Paddy Flux site, japan
- WTR: Watarase JAXA Super Site 500, Japan

Acknowledgements

- ✓ The field data were mainly collected by GCOM-C PIs, AKITSU Tomoko, HONDA Yoshiaki, KAJIWARA Koji, KOBAYASHI Hideki, MORIYAMA Masao, NAGAI Shin, NASAHARA Kenlo Nishida, and SUSAKI Junichi.
- ✓ The CGLS/GIOGL1_LAI300, FAPAR300 and NDVI300 products were used for the comparison with SGLI products in this article. They were generated by the global component of the Land Service of Copernicus, the Earth Observation program of the European Commission. The research leading to the current version of the product has received funding from various European Commission Research and Technical Development programs. The products are based on PROBA-V 333m data ((c) Belgian Science Policy and distributed by VITO NV).
- ✓ Sentinel-3A daily FAPAR (OLCI Global Vegetal Index (faPAR)) were used for the comparison with SGLI/FAPAR. They were produced by European Space Agency (ESA) and acquired from the Copernicus Open Access Hub of the ESA.

References

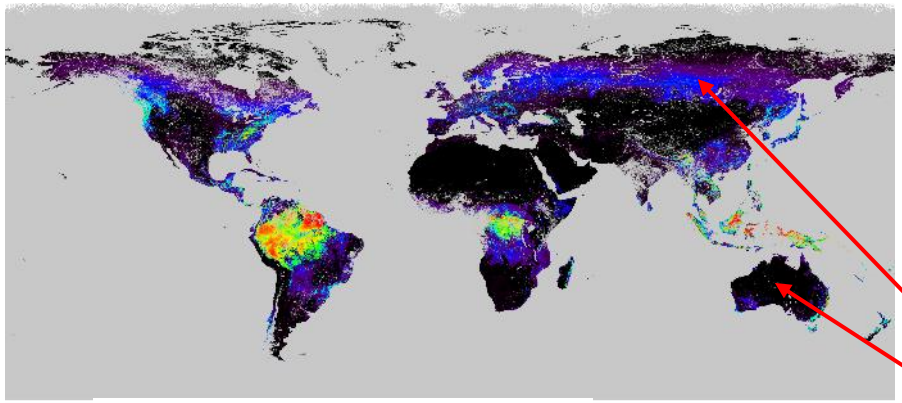
- ➢ Akitsu, T. K., Nakaji, T., Yoshida, T., Sakai, R., Mamiya, W., Terigele, Takagi, K., Honda, Y., Kajiwara K., Nasahara, K. N., 2020. Field data for satellite validation and forest structure modeling in a pure and sparse forest of Picea glehnii in northern Hokkaido. *Ecological Research*, **2020**, pp.1-15. doi:10.1111/1440-1703.12114.
- ➢ Akitsu, T. K., Nakaji, T., Kobayashi, H., Okano, T., Honda, Y., Bayarsaikhan, U., Terigele, Hayashi, M., Hiura, T., Ide, R., Igarashi, S., Kajiwara, K., Kumikawa, S., Matsuoka, Y., Nakano, Ta., Nakano, To., Okuda, A., Sato, T., Tachiiri, K., Takahashi, Y., Uchida, J., Nasahara, K. N., 2020. Large-scale ecological field data for satellite validation in deciduous forests and grasslands. *Ecological Research*, **2020**, ERDP-2020-16.1.1(http://db.cger.nies.go.jp/JaLTER/metacat/metacat/ERDP-2020-16.1.1/jalter-en)
- ➢ Kobayashi, H., Nagai, S., Kim, Y., Yang, W., Ikeda, K., Ikawa, H., Nagano, H. and Suzuki, R., 2018. In situ observations reveal how spectral reflectance responds to growing season phenology of an open evergreen forest in Alaska. *Remote Sensing*, **10**(7), p.1071. (Data are available from Arctic Data archive System (ADS), Japan, https://ads.nipr.ac.jp/dataset/A20181212-002)
- ➢ Nagai, S., Kotani, A., Sato, T., Sugimoto, A., Maximov, T. C., Nogovitcyn, A., Miyamoto, Y., Kobayashi, H., and Tei, S. (in press). Direct measurement of leaf area index in a deciduous needle-leaf forest, eastern Siberia, *Polar Science*, (in press).

T3A/ Above Ground Biomass（AGB）

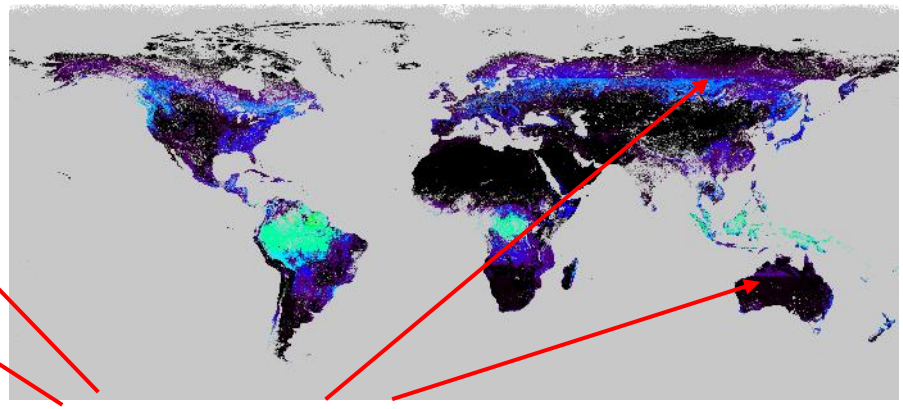
Key updates

- ✓ AGB values estimated from GEDI data were used for the determination of the coefficients of LUT in evergreen broadleaved forests and mixed forest. The GEDI spot values were spatially extended for this purpose. → The AGB underestimation has been improved mainly in tropical forests.
- ✓ The coefficients of LUT was assigned differently for each latitude, mainly north of 40° N. → AGB gaps were resolved.
- ✓ All validation data were reviewed, and the data inappropriate for validation were excluded.

ver.3 AGB (input: RSRFQ ver.2) [2020/08/01-31]



ver.2 AGB (input: RSRFQ ver.2) [2020/08/01-31]

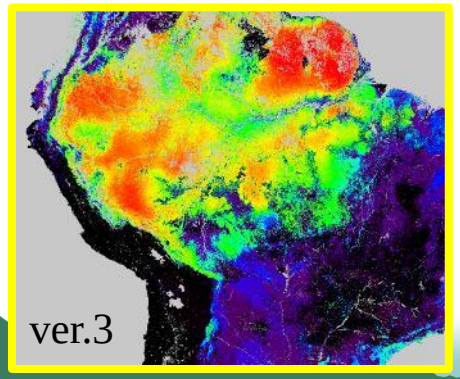


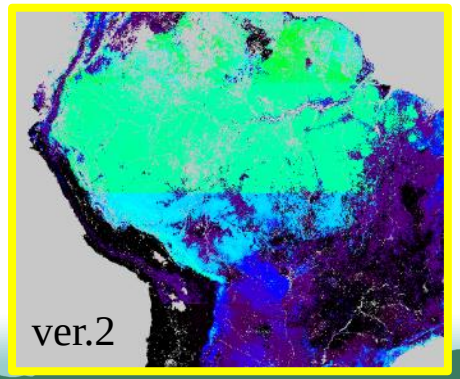
AGB [t/ha] 0 500 others

Large AGB gaps at specific latitudes have been improved.

※ The data with the QA information of low quality, probably cloud or bad geometry was not used in these maps.

< Detailed ma for South America>





The AGB underestimation of ver. 2 algorithm in tropical forests has been improved.

T3A/ AGB

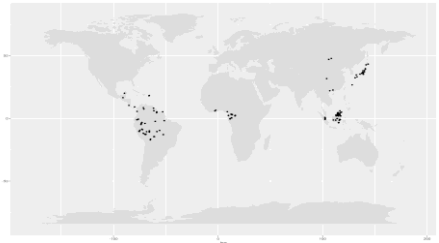
Validation method

- The accuracy of SGLI/AGB was evaluated using the reference AGB data at validation sites for forests and grasslands. The reference AGB was derived from in-situ observation data.
- The validation data was selected by considering spatial uniformity, vegetation type, and topography, etc.

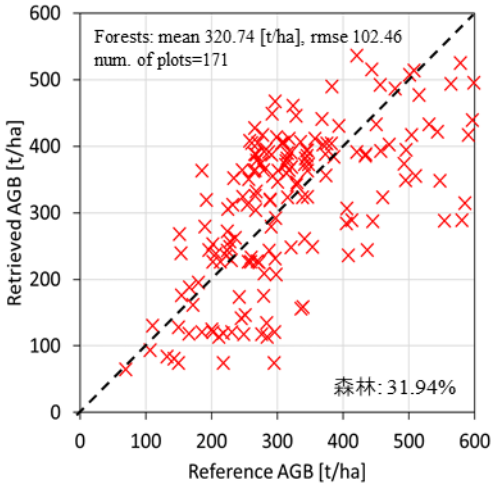
SGLI data used for validation

- Forests: The daily SGLI/AGB from August 1, 2020 to August 31, 2020 were averaged and compared with the reference AGB regarding the forest biomass as that stay consistent for one month.
- Grasslands: The daily SGLI/AGB was averaged for 21 days [date and year of field data acquisition ±10 days] and compared with the reference AGB.
- RSRFQ ver.2 was used as input data.
- The data was not used for the evaluation when the "low quality", "probably cloud" or "bad geometry" bits were set.

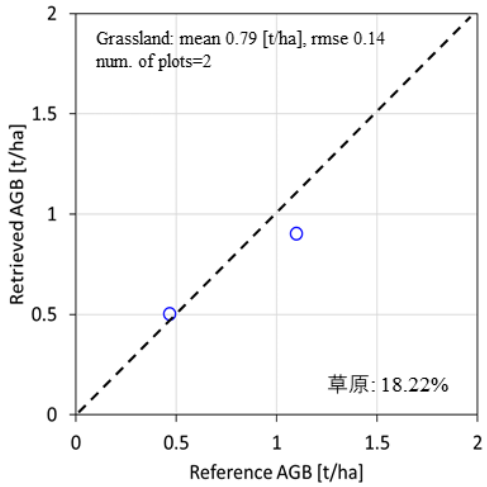
< Validation sites >



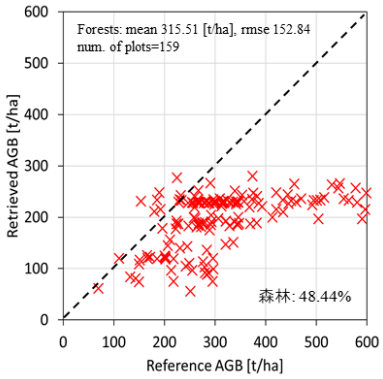
Validation result < Forest >

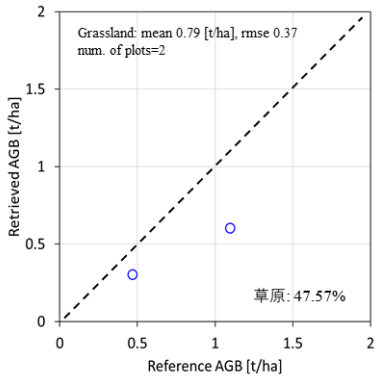


Validation result < Grassland >



Validation results for ver.2





The estimation accuracy was improved in tropical forest.

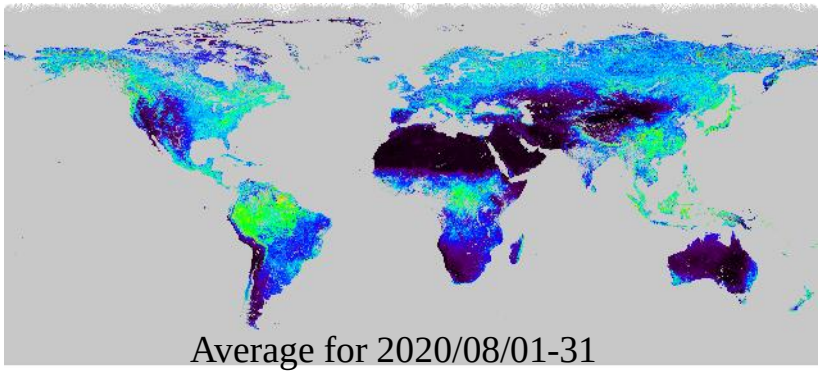
Estimated accuracy	Release threshold	Standard accuracy	Target accuracy
Forest: 48.4% → 31.9% Grassland: 47.6% → 18.2%	100% (Forest), 50% (Grassland)	50% (Forest), 30% (Grassland)	20% (Forest), 10% (Grassland)

The standard accuracy is expected to be achieved.

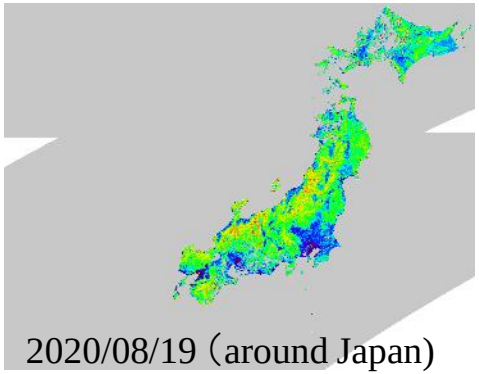
T3A/ Vegetation Roughness Index（VRI）

No updates

Ver.3 VRI [input: ver.2]



Average for 2020/08/01-31



2020/08/19（around Japan）

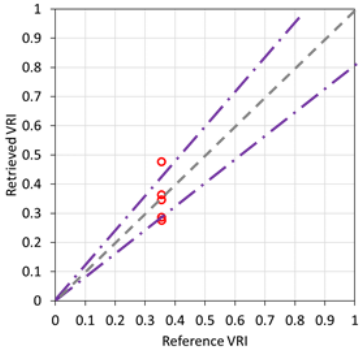
VRI 0 1

Validation method

- SGLI/ VRI was evaluated using reference VRI. Reference VRI was calculated from the same equation with T3A using in-situ observed directional surface reflectance factor data which was collected for the same sun-target-satellite geometry with SGLI data. .
- The SGLI data is not used when the quality flag indicates cloud, probably cloud or pol. cloud.

Validation period

- SGLI/VRI: May 1, 2018 to June 10, 2018 (daily data). Only the data with ±10° of the view zenith angle for the in-situ data is used.
- Reference VRI: May 21, 2018 at WTR site



-·- : standard accuracy

The standard accuracy is expected to be achieved.

Estimated accuracy	Release threshold	Standard accuracy	Target accuracy
18.5%	40% (Forest, Grassland) scene	20% (Forest, Grassland) scene	10% (Forest, Grassland) scene

Acknowledgements

✓ The validation data were mainly collected from literature survey by NAGAI Shin, GCOM-C PI. The field data were collected by GCOM-C PI and AKITSU Tomoko.

References

- Akitsu, T. K., Nakaji, T., Yoshida, T., Sakai, R., Mamiya, W., Terigele, Takagi, K., Honda, Y., Kajiwara K., Nasahara, K. N., 2020. Field data for satellite validation and forest structure modeling in a pure and sparse forest of Picea glehnii in northern Hokkaido. *Ecological Research*, **2020**, pp.1–15. doi:10.1111/1440-1703.12114.
- Akitsu, T. K., Nakaji, T., Kobayashi, H., Okano, T., Honda, Y., Bayarsaikhan, U., Terigele, Hayashi, M., Hiura, T., Ide, R., Igarashi, S., Kajiwara, K., Kumikawa, S., Matsuoka, Y., Nakano, Ta., Nakano, To., Okuda, A., Sato, T., Tachiiri, K., Takahashi, Y., Uchida, J., Nasahara, K. N., 2020. Large-scale ecological field data for satellite validation in deciduous forests and grasslands. *Ecological Research*, **2020**, ERDP-2020-16.1.1(http://db.cger.nies.go.jp/JaLTER/metacat/metacat/ERDP-2020-16.1.1/jalter-en)
- Motohka Takeshi, 2012. Measurement of biomass to verify forest carbon stocks in Riau province, Sumatora, Indonesia. Phase 2.
- Baker, T. R., et al., 2004. Increasing biomass in Amazonian forest plots. *Phil. Trans. R. Soc. Lond. B*, 359, pp.353–365. 10.1098/rstb.2003.1422. Dataset is in ForC-db, https://github.com/forc-db/ForC
- Lewis, S. L., et al., 2009. Increasing carbon storage in intact African tropical forests. *Nature*, 457, pp.1003–1006. 10.1038/nature07771. Dataset is in ForC-db, https://github.com/forc-db/ForC
- Chave, J., et al., 2003. Spatial and temporal variation of biomass in a tropical forest: results from a large census plot in Panama. *The Journal of ecology*, 91(2), pp.240–252. 10.1046/j.1365-2745.2003.00757.x
- Liu, L. B., et al., 2016. Forest biomass and net primary productivity in southwestern China: A meta-analysis focusing on environmental driving factors. *forests*, 7(8), 173. DOI: 10.3390/f7080173
- Slik, J. W. F., et al., 2009. Environmental correlates of tree biomass, basal area, wood specific gravity and stem density gradients in Borneo's tropical forests. *Global Ecology and Biogeography*, 19, pp.50–60. DOI: 10.1111/j.1466-8238.2009.00489.x
- Lourens, P., et al., 2016. Biomass resilience of Neotropical secondary forests. *Nature*, 530, pp211–214. doi:10.1038/nature16512
- Akiyama, T. 2006. Analysing water shed vegetation changes along space and time by remote sensing.

Ver.3 Atmosphere Products

Evaluation Summary

Product	Release threshold	Standard accuracy	Target accuracy	Status*1	Evaluation Methods
Cloud flag/Classification	10% (with whole-sky camera)	Incl. below cloud amount	Incl. below cloud amount	☆	Comparison with in-situ observation (sky-camera images) for release threshold. Evaluations for standard and target accuracies were performed as the Classified cloud fraction products.
Classified cloud fraction	20% (on solar irradiance)	15% (on solar irradiance)	10% (on solar irradiance)	☆	Comparison of SGLI-derived solar irradiance using cloud products including cloud flag, cloud fraction etc. with ground-measured solar irradiance.
Cloud top temp/height	1 K	3 K/2 km (top temp/height)	1.5 K/1 km (temp/height)	◎	Evaluation was made as vi-cal. of SGLI TIR bands for the release threshold. In addition, comparison with other satellite data for evaluating the achievement of the standard accuracy.
Water cloud OT/effective radius	10%/30% (CloudOT/radius)	100% (as cloud liquid water)	50% / 20%	○ → ◎	Comparison with in-situ observation.
Ice cloud optical thickness	30%	70%	20%	○ → ◎	Comparison with in-situ observation.
Aerosol over the ocean	0.1 (Monthly τa_670,865)	0.1 (scene τa_670,865)	0.05 (scene τa_670,865)	○ → ◎	Comparison with in-situ observation.
Land aerosol by near ultra violet →Aerosol over the land	0.15 (Monthly τa_380)	0.15 (scene τa_380)	0.1 (scene τa_380)	◎	Comparison with in-situ observation.
Aerosol by Polarization →Merged to ARNP	0.15 (Monthlyτa_670, 865)	0.15 (scene τa_670,865)	0.1 (scene τa_670,865)	◎	Comparison with in-situ observation and other satellite (MODIS) data.

*1 Symbols denote as follows; ○: the release threshold achieved, ◎: the standard accuracy achieved, ☆: the target accuracy achieved.

CLFG (CLoud FlaG)

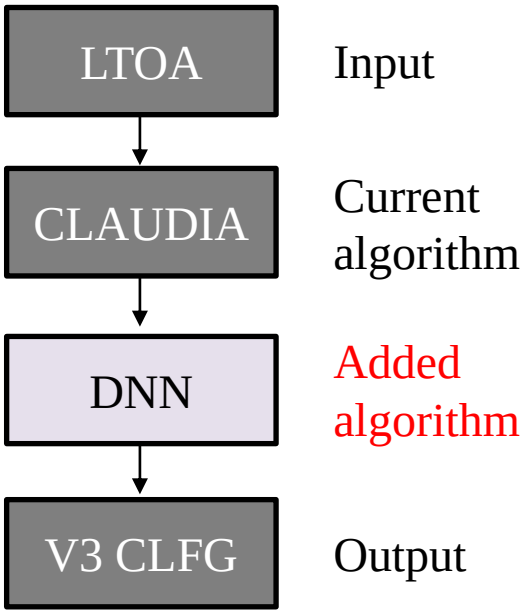
■Algorithm PI : Takashi Nakajima
■Implement + V3 update : Kazuhisa Tanada

■Problems of V2 CLFG

Misclassification	Impact
①day：snow（○）→land clear（×）	Overestimation in ARNP/AOT
②day：heavy aerosol（○）→cloud（×）	Decreasing effective pixels in ARNP
③night：snow、clear（○）→cloud（×）	Decreasing effective pixels in LST

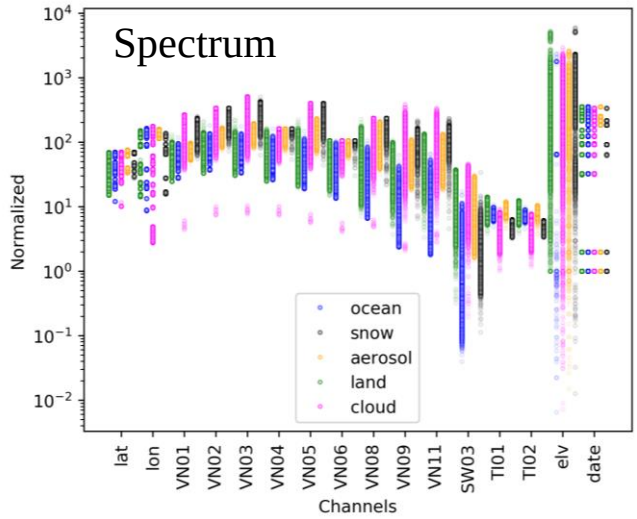
■Method of V3 CLFG

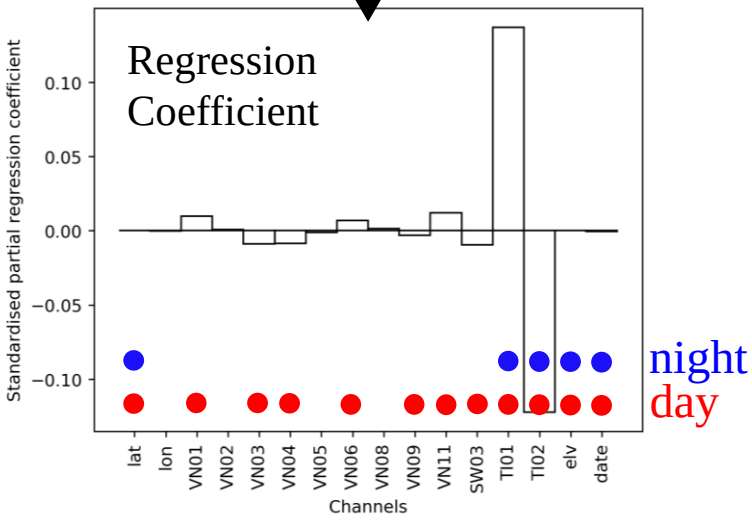
Method：DNN（Deep Neural Network）
Ground truth：made by checking the RGB & SIPR images
Input data：
day…lat,VN01,03,04,06,09,11,
SW03,TI01,02,elavation,date (12 data)
night…lat,TI01,02,elavation,date (5 data)
Output labels：
day…land, ocean, cloud, aerosol, snow (5 labels)
night…land&ocean, cloud, aerosol, snow (4 labels)



CLFG (CLoud FlaG)

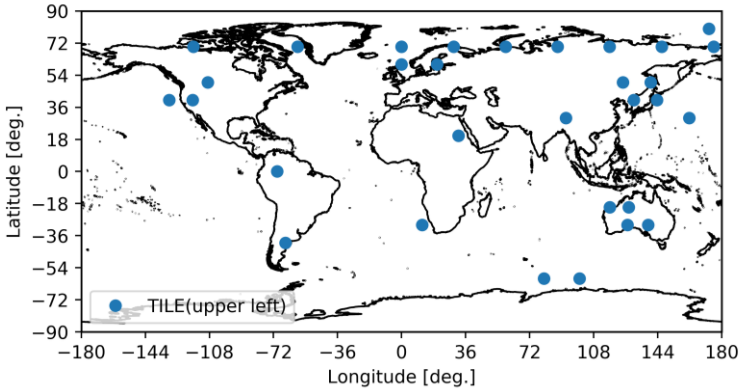
■Input parameter selection





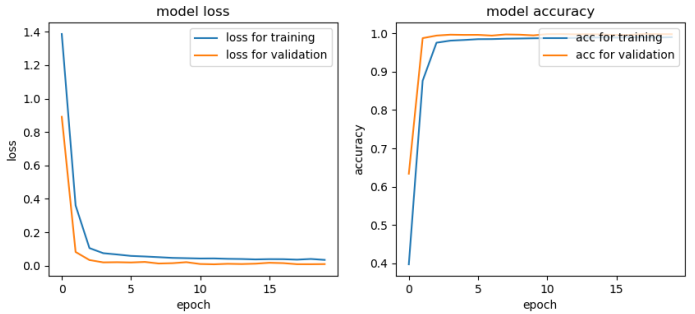
We chose the SGLI channel which has large coefficient.

■Training dataset



We used 500,000 pixels, various locations and periods.

■Training results



Accuracy **Corrected pixels / Total pixels**

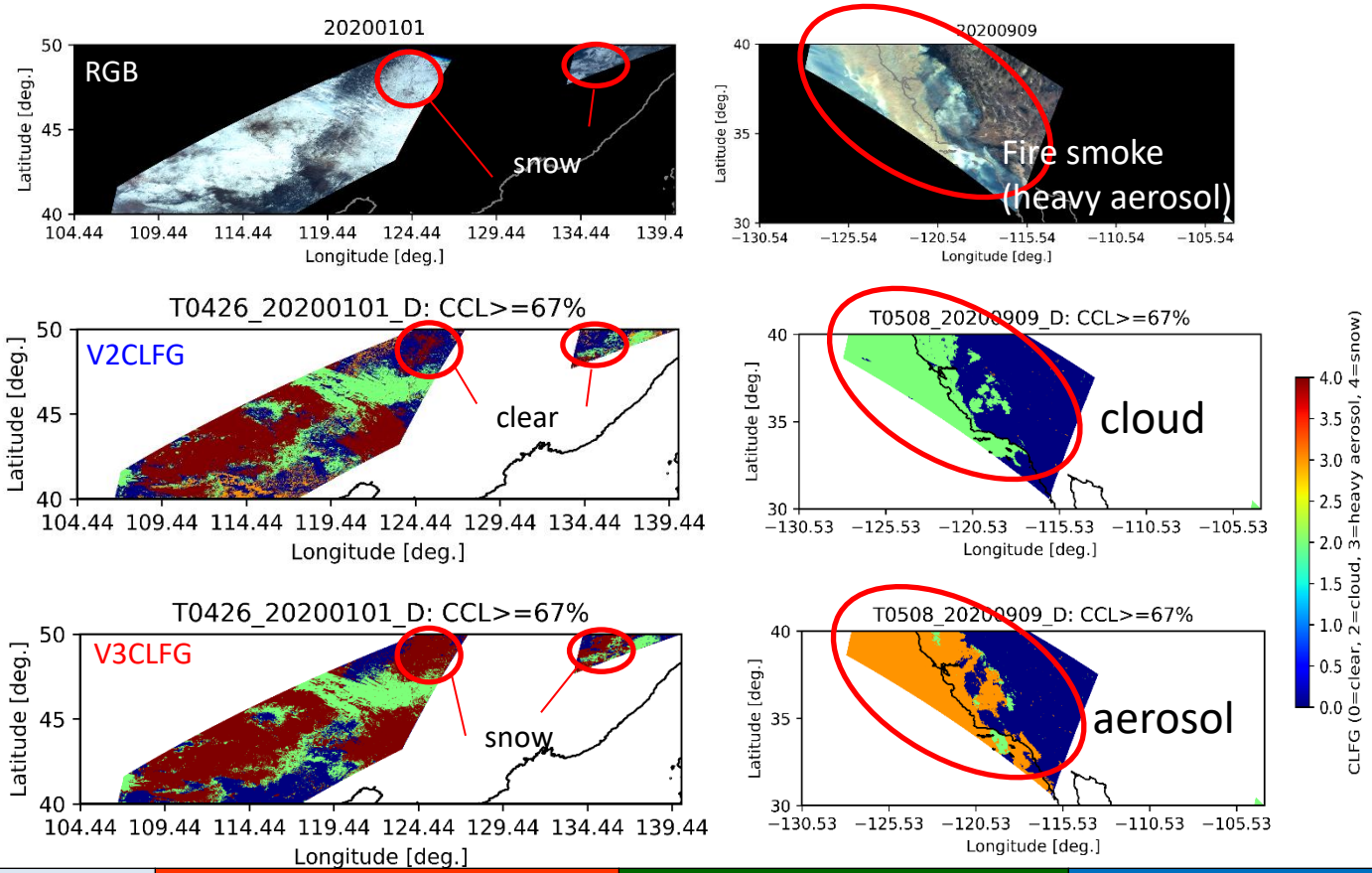
Total Acc = 99.78% 5226469/5238201
land Acc = 99.67% 1230057/1234083
ocean Acc = 99.93% 811784/812343
cloud Acc = 99.84% 1362311/1364443
aerosol Acc = 99.70% 958309/961198
snow Acc = 99.75% 864008/866134

CLFG (CLoud FlaG)

■Results

We partially **solved these issues of V2 CLFG and improved it**.

The CLFG product is expected to remain on the target accuracy, because V2 CLAUDIA algorithm is continuously used for the area where there are no misclassifications.

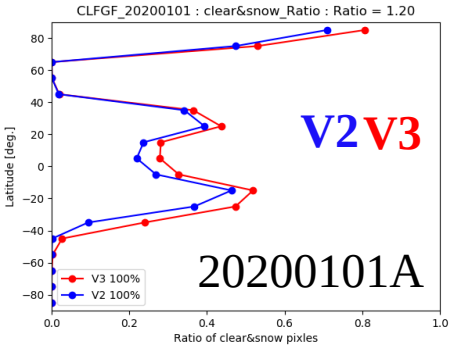


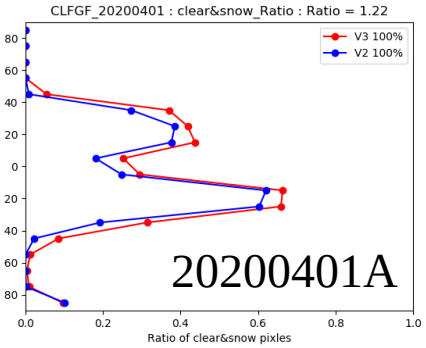
Validation result	Release accuracy	Standard accuracy	Target accuracy
[Ver.1/Ver.2] 10.2 %	10% (with whole-sky camera)	15% (Evaluate with cloud fraction on solar irradiance)	10% (Evaluate with cloud fraction on solar irradiance)

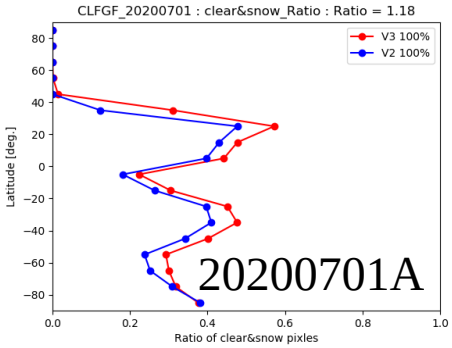
The standard accuracy is expected to be achieved.

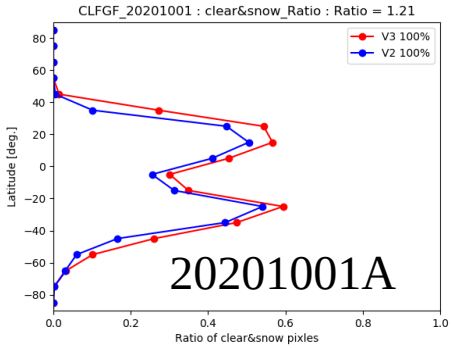
(Appendix) CLFG at night

Clear pixels **increase** by ~ 20% **at night** (however, still few at high latitudes)

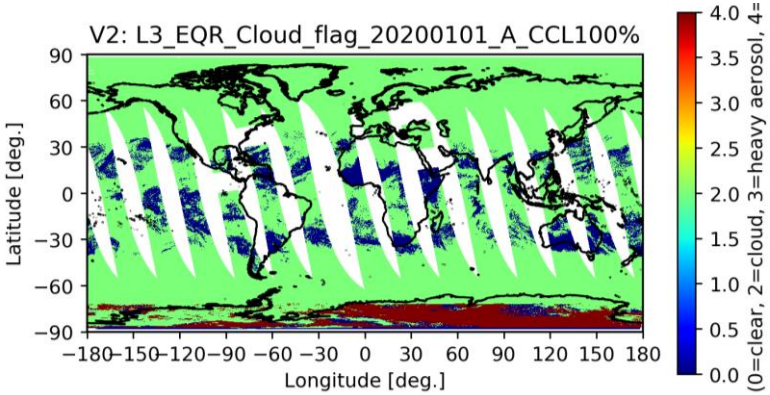


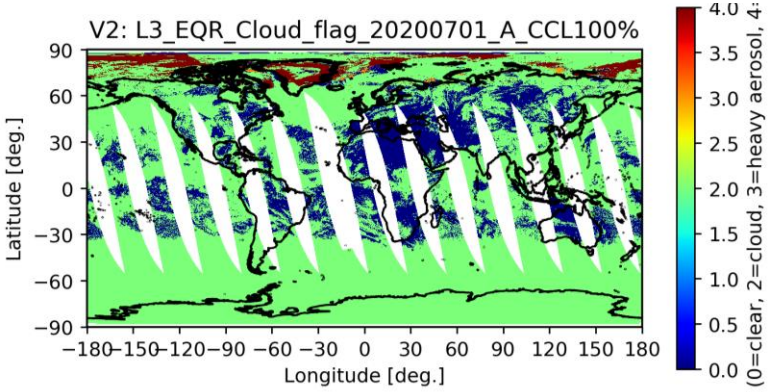




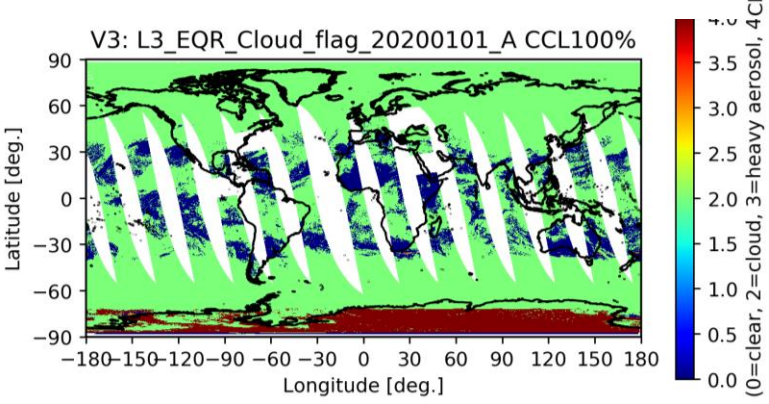


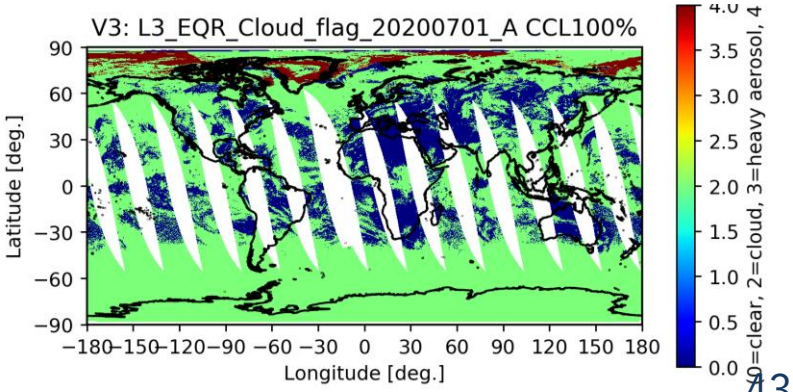
V2





V3

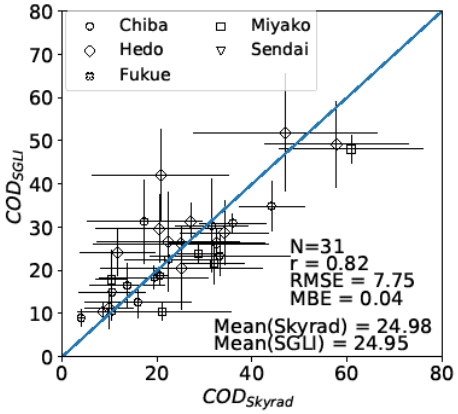


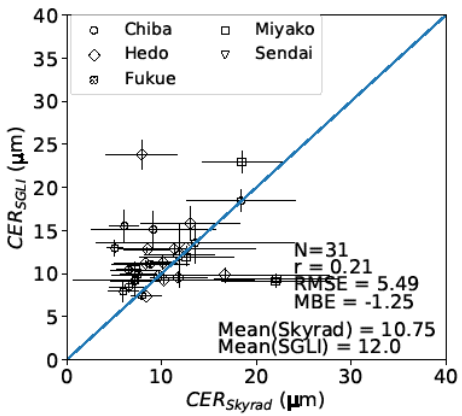


CLPR (CLoud PRopertis)

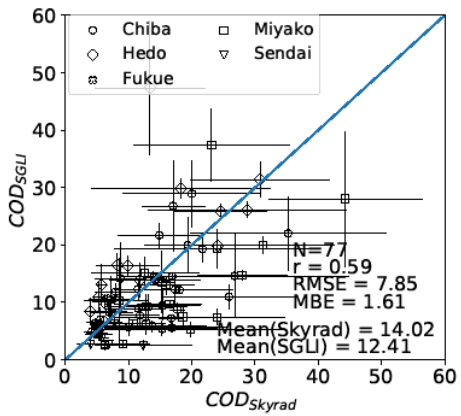
- Major changes
  - Algorithm has not been changed
  - Screening the validation data with strictly quality check
- Validation method
  - Comparing with the in-situ observation of sky radiometers
  - Using the average values of SGLI's 5x5 pixels around the in-situ site
  - Only using the in-situ data observed within +/-30 minutes of SGLI observation time.
  - Data period is July 2019 – December 2020

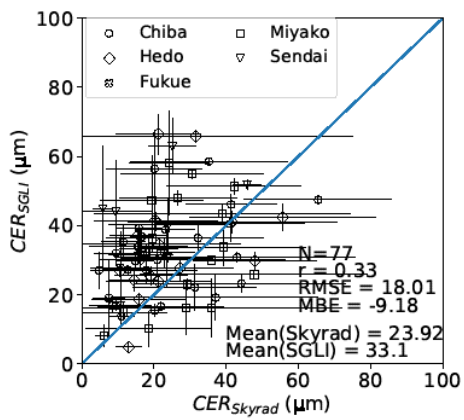
Water Clouds





Ice Clouds





Validation result	Release accuracy	Standard accuracy	Target accuracy
<u>Water cloud</u> Optical thickness: 8-9%(vs. MODIS) Effective radius: 2-5%(vs. MODIS) Cloud liquid water: **82.07%(in-situ)**	(with other satellite) 10% 30% -	(with in-situ) - - 100%	(with in-situ) 20% - 50%
<u>Ice cloud</u> Optical thickness: **55.99%(in-situ)**	(with other satellite) 30%	(with in-situ) 70%	(with in-situ) 20%

The standard accuracy is expected to be achieved.

ARNP
(AeRosol properties using Numerical Prediction)
Atmosphere Product
-Aerosol over Land and Ocean

- Algorithm (RESTEC Yoshida)
  - Use the forecast from aerosol assimilation system of Himawari-8/AHI as a priori estimate of retrieval.

- Major improvement from Ver.2
  - Utilize both polarization and non-polarization observation
  - Consider the error covariance of surface reflectance
  - Apply V3 cloud flag (retrieval of heavy aerosol)
  - Add the estimated uncertainties of aerosol optical thickness, angstrom exponent, and single scattering albedo
  - Integrate output over ocean and land

- Channels used
  - Land：VN01, VN02, VN03, VN05, VN08, P02
  - Ocean：VN10, SW01, SW03, SW04, P02

ARNP: Validation methods

- Method:
  - Standard accuracy: RMS errors are evaluated comparing SGLI derived AOT with those from In-situ data (scene by scene)
- In-situ data
  （1）Land：Sky-radiometer
    - Source: Irie PI@Chiba univ. (SKYNET), Aoki PI@Toyama univ., JMA, AERONET*1
    - Period：March 27, 2018 ～ November 30, 2020
      (V2: March 2018, June 2018, Feb. 2018, Jan. 2020, Feb. 2020)
  （2）Ocean: Microtops on ships
    - Source：AERONET - Maritime Aerosol Network*1
    - Period： March 27, 2018 ～ July 1, 2020
      (V2: March 2018, June 2018, Feb. 2019)

  *1 Aerosol Robotic Network
  (Giles et al., 2019; O'Neill et al., 2003),
  https://aeronet.gsfc.nasa.gov/
- Matchup conditions
  - Observed within 30 minutes
  - SGI AOT is averaged within 10km from in-situ site, where the valid pixel is larger than 50%, and the standard deviation is less than 0.1
  - QA_flag is considered for bit 0,2,3,5,9,10,12,13,15

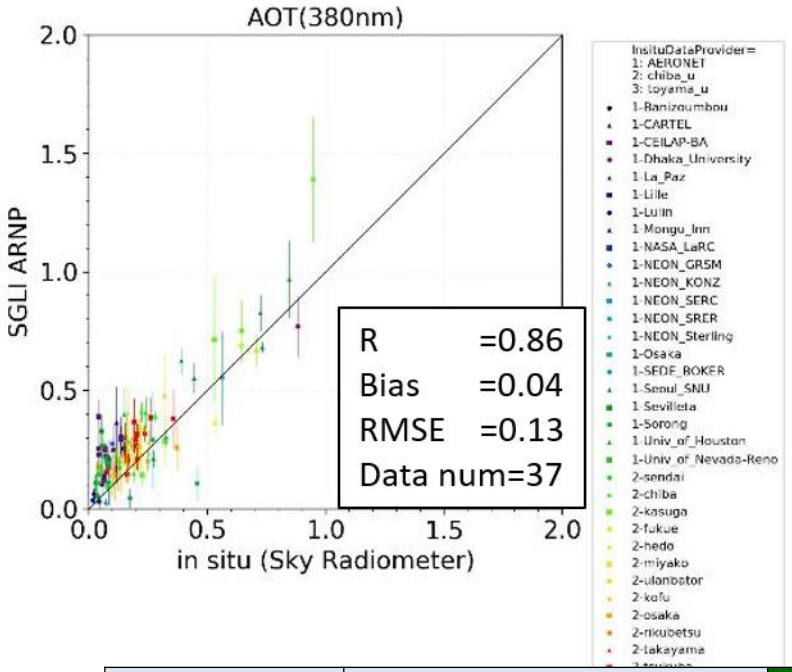
QA flags in V3

Bit	ver.3	Description
0	Data Availability	0=Available, 1=Not Available
1	Land / Water Flag	0=Water, 1=Land
2	Coastal Flag	0=No, 1=Yes
3	Cloud Flag	0=Clear, 1=Cloudy
4	Aerosol Optical Thickness Confidence Flag	00=Very Good; 01=Good, 10=Marginal,
5	Aerosol Optical Thickness Confidence Flag	11=No Confidence or Fill
6	Angstrom Exponent Confidence Flag	00=Very Good; 01=Good, 10=Marginal,
7	Angstrom Exponent Confidence Flag	11=No Confidence or Fill
8	Aerosol Single Scattering Albedo Confidence Flag	0=Very Good or Good, 1=Marginal or No Confidence or Fill
9	Heavy aerosol	0=No, 1=Yes
10	Sunglint Flag	0=No, 1=Yes
11	Stray-Light Flag	0=No, 1=Yes
12	Cloud Shadow Possibility Flag	0=No, 1=Yes
13	Uncertain Surface Reflectance Flag (Turbid Water, Snow/Ice Covered Surface or Rtoa_obs < Rtoa_Rayleigh)	0=No, 1=Yes
14	Use Polarization	0=No, 1=Yes
15	A prior of retrieval	0=MODEL, 1=CONSTANT

ARNP: Validation results over land

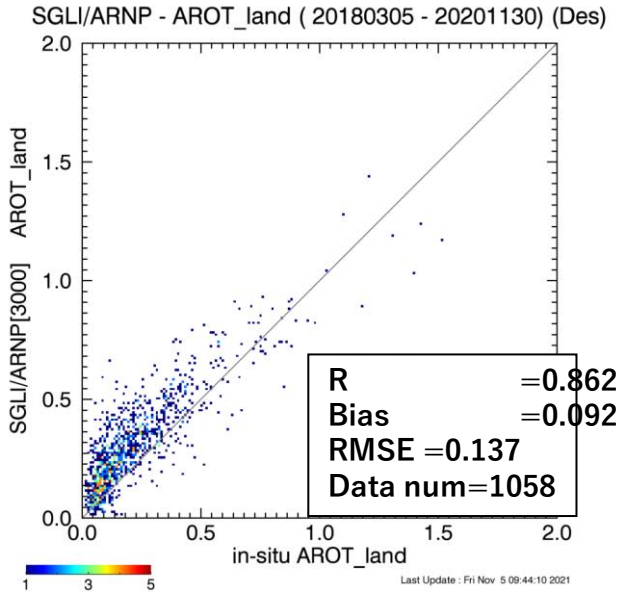
AOT over land@380nm (Ver. 2)

Averaged SGLI within 10km vs. Sky radiometer at the same time



AOT over land@380nm (Ver. 3)

Averaged SGLI within 10km vs. Sky radiometer at the same time

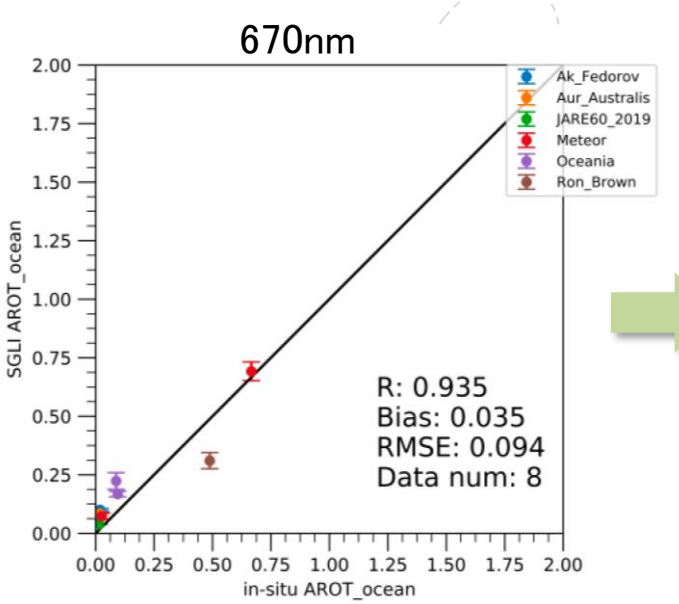


Product	Estimated RMSE	Standard accuracy (L+5)	Target accuracy (L+5)
AOT over land	**0.137**（Scene）	0.15（Scene）	0.10（Scene）

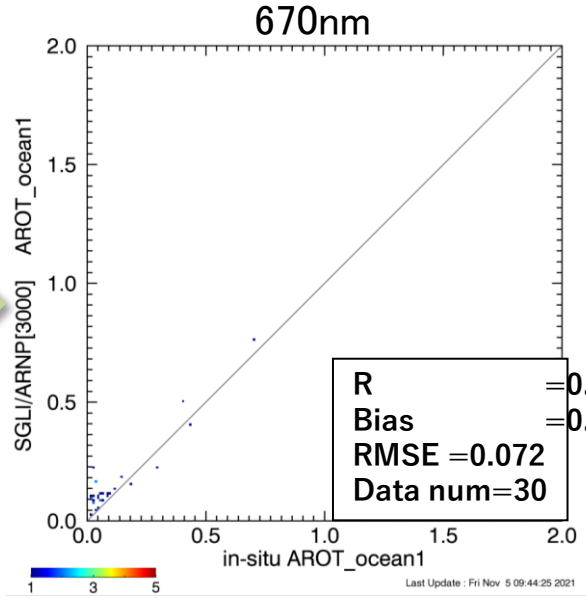
- More validation sample number than V2
- Standard accuracy will be archived

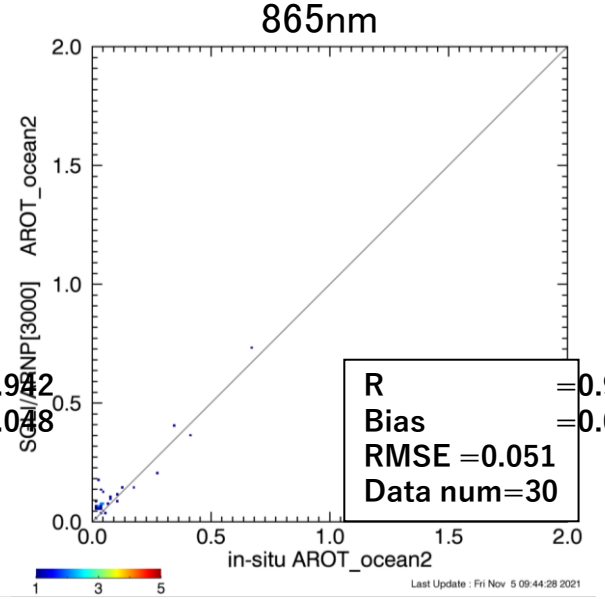
ARNP: Validation results over ocean

AOT over ocean@670nm (Ver. 2)
Averaged SGLI within 10km vs. shipborne microtops at the same time



AOT over ocean@670nm and 865nm (Ver. 3)
Averaged SGLI within 10km vs. shipborne microtops at the same time





Product	Estimated RMSE	Standard accuracy (L+5)	Target accuracy (L+5)
AOT over ocean	**0.072@670nm** **0.051@865nm** (Scene)	0.1 (Scene)	0.05 (Scene)

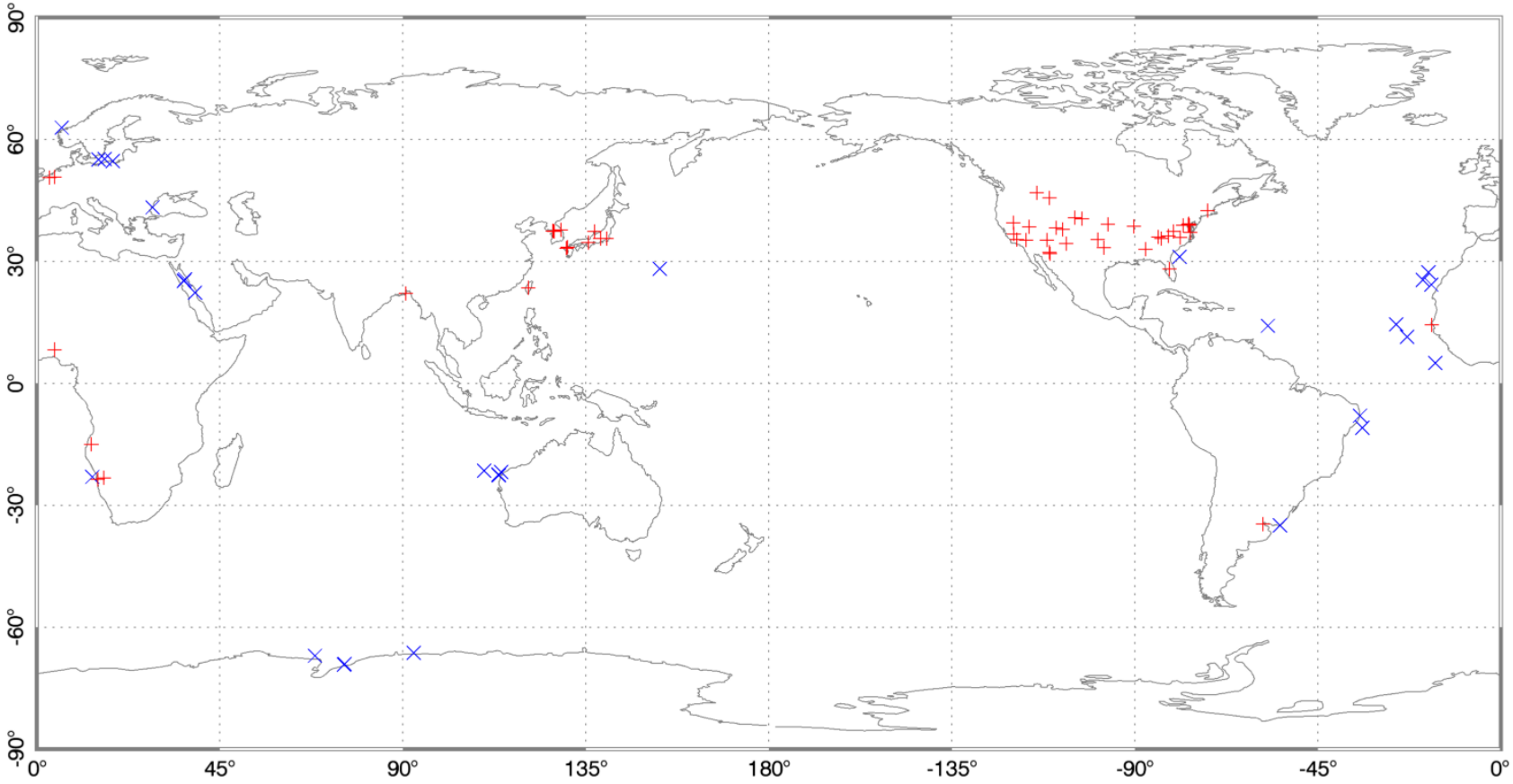
- More validation sample number than V2
- Standard accuracy will be archived

ARNP: Summary

Product	Period	Evaluation Method	Estimated RMSE	Release	Standard	Target
AOT_ocean @670,865	2018/3/27 ～ 2020/11/30	In-situ (Scene)	**0.072@670nm** **0.051@865nm** (Scene)	0.1 (Month)	0.1 (Scene)	0.05 (Scene)
AOT_land @380	2018/3/27 ～ 2020/11/30	In-situ (Scene)	**0.137** (Scene)	0.15 (Month)	0.15 (Scene)	0.10 (Scene)

The standard accuracy is expected to be achieved.

(Appendix) Site maps of ARNP validation data



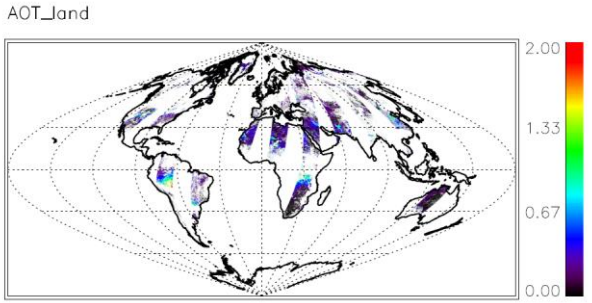
Blue: Ocean
Red: Land

(Appendix) ARNP Image (global)

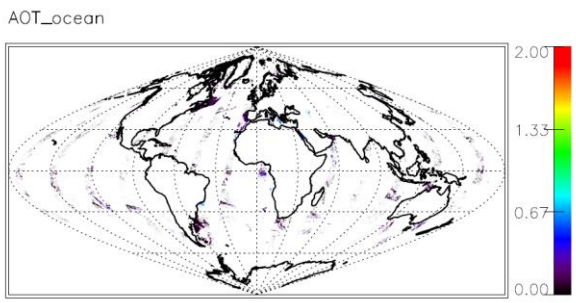
Sep. 7 2020 (California Forest fire)

V2(ARNPF)

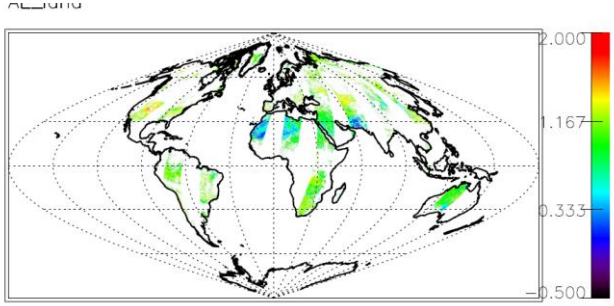
AOT land

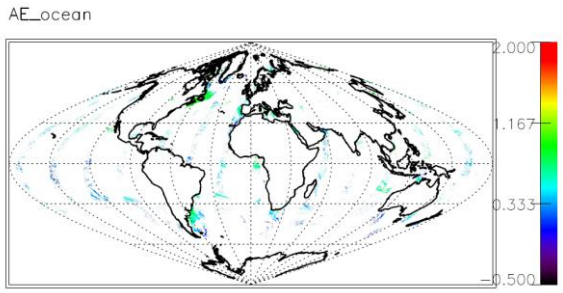


ocean

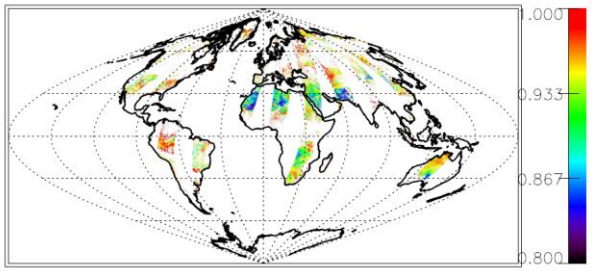


AE

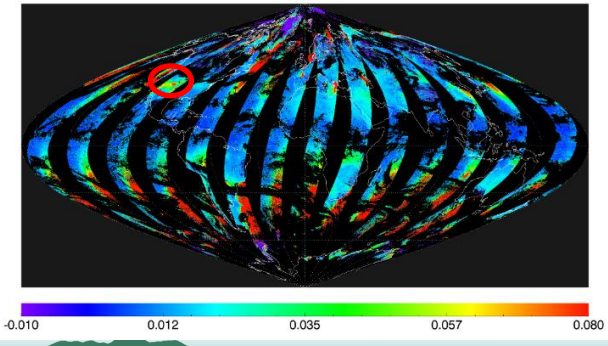




SSA

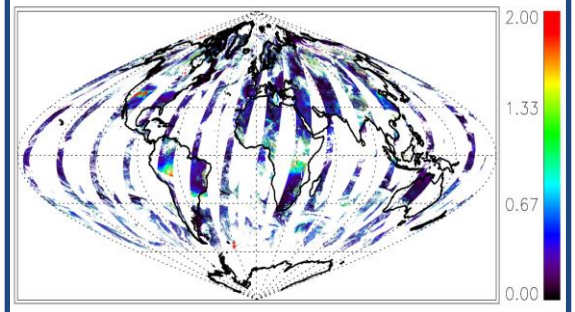


P2 polarization reflectance

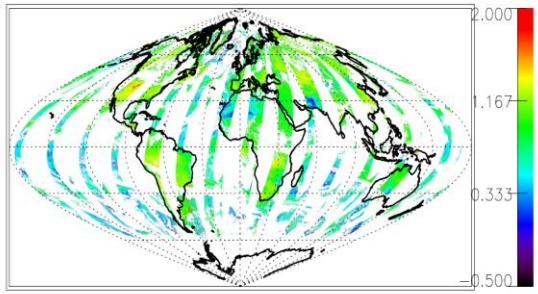


V3(ARNPF)

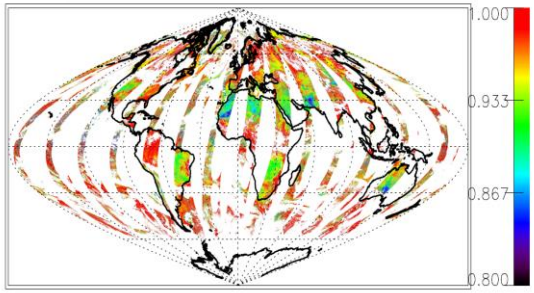
AOT



AE



SSA

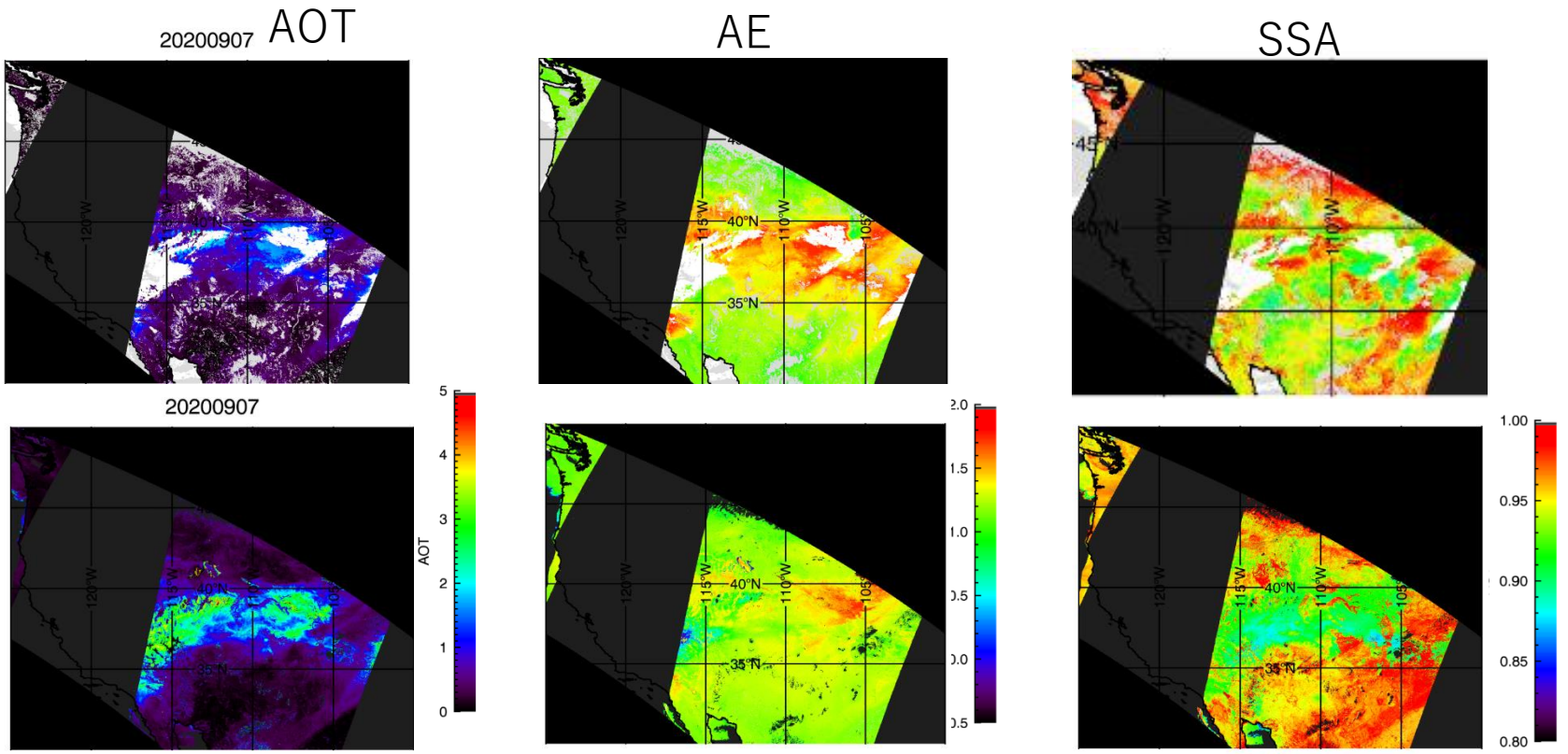


(Appendix)　ARNP Image (Tile)

Sep. 7 2020 (California Forest fire)

V2
(Land)

V3
(ARNPK)



Ver.3 Ocean Products

Evaluation Summary

Product	Release threshold	Standard accuracy	Target accuracy	Status*1	Evaluation Methods
Normalized water leaving radiance (incl. cloud detection)	60% (443~565nm)	50% (<600nm) 0.5W/m²/str/um (>600nm)	30% (<600nm) 0.25W/m²/str/um (>600nm)	◎	Comparison with in-situ observation data.
Atmospheric correction parameters	80% (AOT@865nm)	50% (AOT@865nm)	30% (AOT@865nm)	○ ⇒ ◎	Comparison with in-situ observation data.
Photosynthetically available radiation	20% (10km/month)	15% (10km/month)	10% (10km/month)	☆	Comparison with in-situ observation data.
Chlorophyll-a concentration	–60~+150% (offshore)	–60~+150%	–35~+50% (offshore), –50~+100% (coast)	◎	Comparison with in-situ observation data.
Total suspended matter concentration	–60~+150% (offshore)	–60~+150%	–50~+100%	◎	Comparison with other satellite data (GOCI).
Colored dissolved organic matter	–60~+150% (offshore)	–60~+150%	–50~+100%	◎	Comparison with in-situ observation and other satellite data (MODIS).
Sea surface temperature	0.8 K (daytime)	0.8 K (day & night time)	0.6 K (day & night time)	☆	Comparison with in-situ observation data.

*1 Symbols denote as follows; ○: the release threshold achieved, ◎: the standard accuracy achieved, ☆: the target accuracy achieved.

Validation Results of Ocean NWLR Products: Normalized Water-Leaving Radiance - NWLR

Major Updates of Algorithm:

- Added water leaving reflectance estimation model in the red(VN07) and near-infrared(VN10) bands using Linear combination index (LCI)
- Applied the vicarious calibration
- Improved sunglint correction method
- Added negative NWLR correction
- Revision of QA flags and Mask for statistics

Validation Method:

Validated the accuracies of predicted NWLR data from the SGLI algorithm comparing with in-situ data: ship observation, buoy(MOBY and BOUSSOLE) and AERONET-OC

Quality Control:

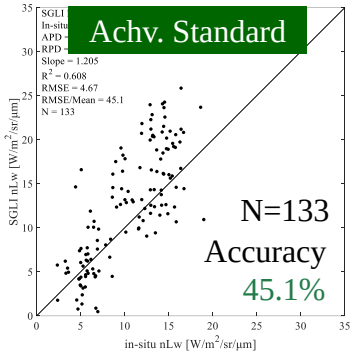
- *In-situ* data: time difference in ±3 hours to SGLI observation
- SGLI data: average of the data passed the following conditions within a 5 by 5 pixel centered the in-situ point (for details refer to Bailey *et al*, 2006)
    1. 13 or more pixels which satisfies the following conditions: aerosol optical thickness < 0.5, solar zenith angle < 70 degrees, NWLR of all channels > 0, CLDAFFCTD flag isn't set.
    2. Median CV (coefficient of variation) computed from NWLR_380-565nm and Taua_865nm less than 0.15

Period of Validation:

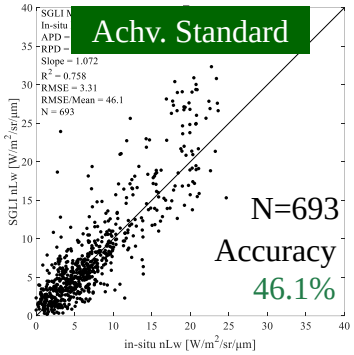
- January 1, 2018 - July 31, 2021

Validation Results of Ocean NWLR Products: Normalized Water-Leaving Radiance - NWLR

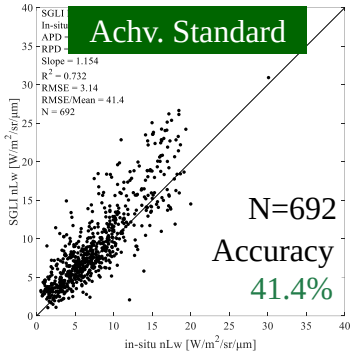
380nm



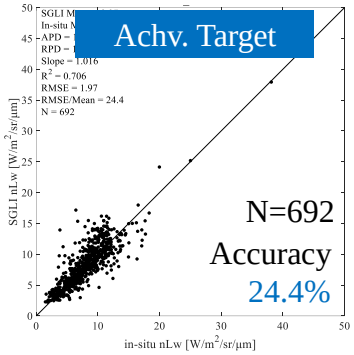
412nm



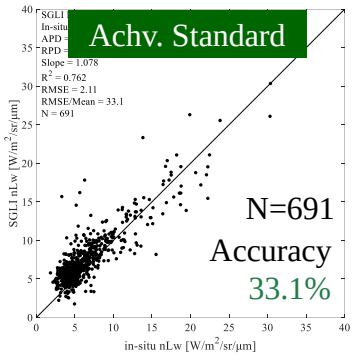
443nm



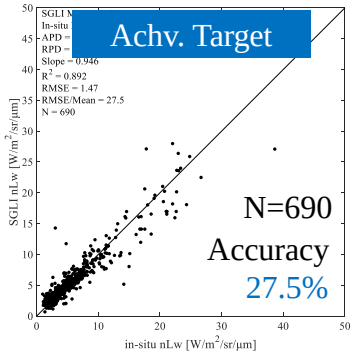
490nm



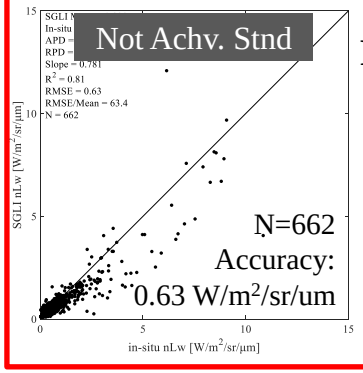
530nm



565nm

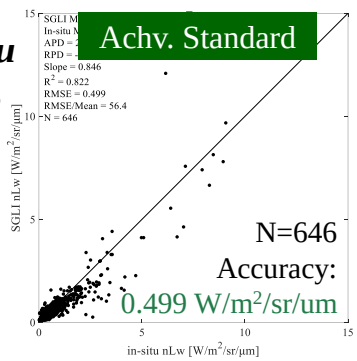


673.5nm



Remove *in-situ* data on lakes

673.5nm



- NWLR(673.5nm) didn't achieved the standard accuracy on coastal regions.
  → Standard accuracy is achieved when in-situ data on lakes, which are not originally subject to validation, are excluded.

- NWLR(490nm, 565nm) achieved the target accuracies, NWLR(380-443nm, 530nm, 673.5nm) achieved the standard accuracies.
- Increased number of valid pixels [Version 2]: 117-616 points → [Version3]: 133-693 points

Validation Result	Release Accuracy	Standard Accuracy	Target Accuracy
[Ver. 2] 21-42%→[Ver. 3] 23-46%	60%(443-565 nm)	50% (≦600 nm)	30% (≦600 nm)
[Ver. 2]0.61 →[Ver. 3] 0.499W/m²/sr/um	N/A	0.5W/m2/sr/um (>600 nm)	0.25W/m2/sr/um (>600 nm)

Validation Results of Ocean NWLR Products: Normalized Water-Leaving Radiance - ACP

Major Updates of Algorithm:

- Added water leaving reflectance estimation model in the red(VN07) and near-infrared(VN10) bands using Linear combination index (LCI)
- Applied the vicarious calibration
- Improved sunglint correction method
- Added negative NWLR correction
- **Described correction formula for TAUA_670 and TAUA_865 in HDF attributes**

Validation Method:

Validated the accuracies of predicted aerosol optical thickness at 865nm(Taua_865) from the SGLI algorithm comparing with *in-situ* data of AERONET-OC and AERONET Maritime Aerosol Network (MAN)

Quality Control:

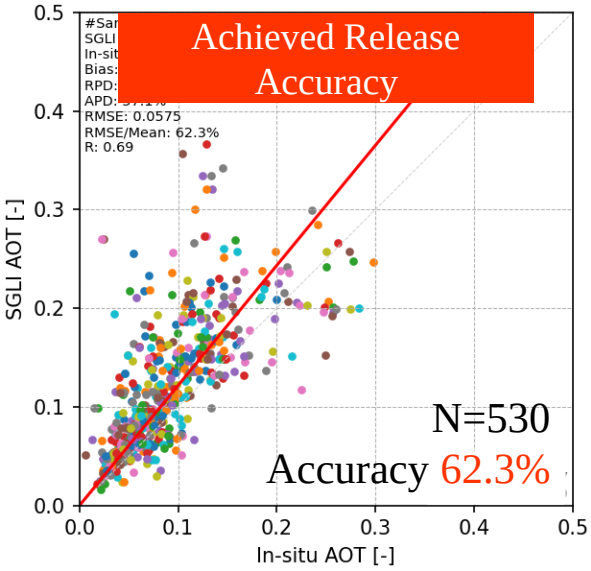
- *In-situ* data: time difference in ±3 hours to SGLI observation
- SGLI data: average of the data passed the following conditions within a 5 by 5 pixel centered the in-situ point (for details refer to Bailey *et al*, 2006)
  1. 13 or more pixels which satisfies the following conditions: aerosol optical thickness < 0.5, solar zenith angle < 70 degrees, NWLR of all channels > 0, CLDAFFCTD, GAMMMA-OUT and OVERITER flags aren't set.
  2. Coefficient of variation for TAUA_865 less than 0.05

Period of Validation:

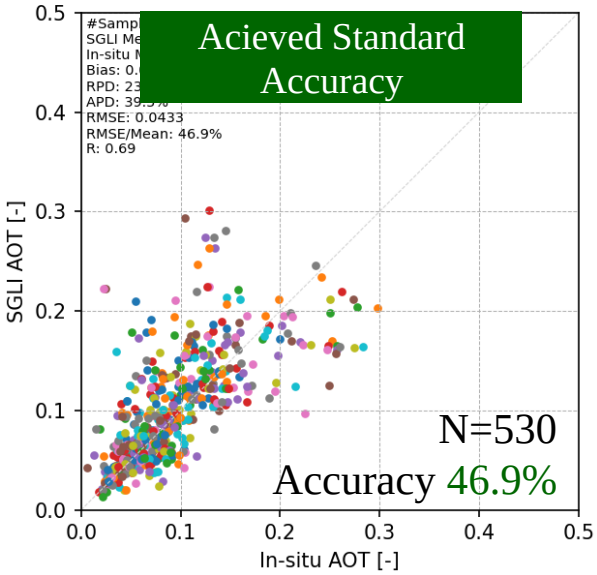
- January 1, 2018 - March 31, 2021

Validation Results of Ocean NWLR Products: Normalized Water-Leaving Radiance - ACP

TAUA_865



TAUA_865_corrected



There is a positive bias because the aerosol model used in the atmospheric correction is optimized for NWLR not AOT estimation.

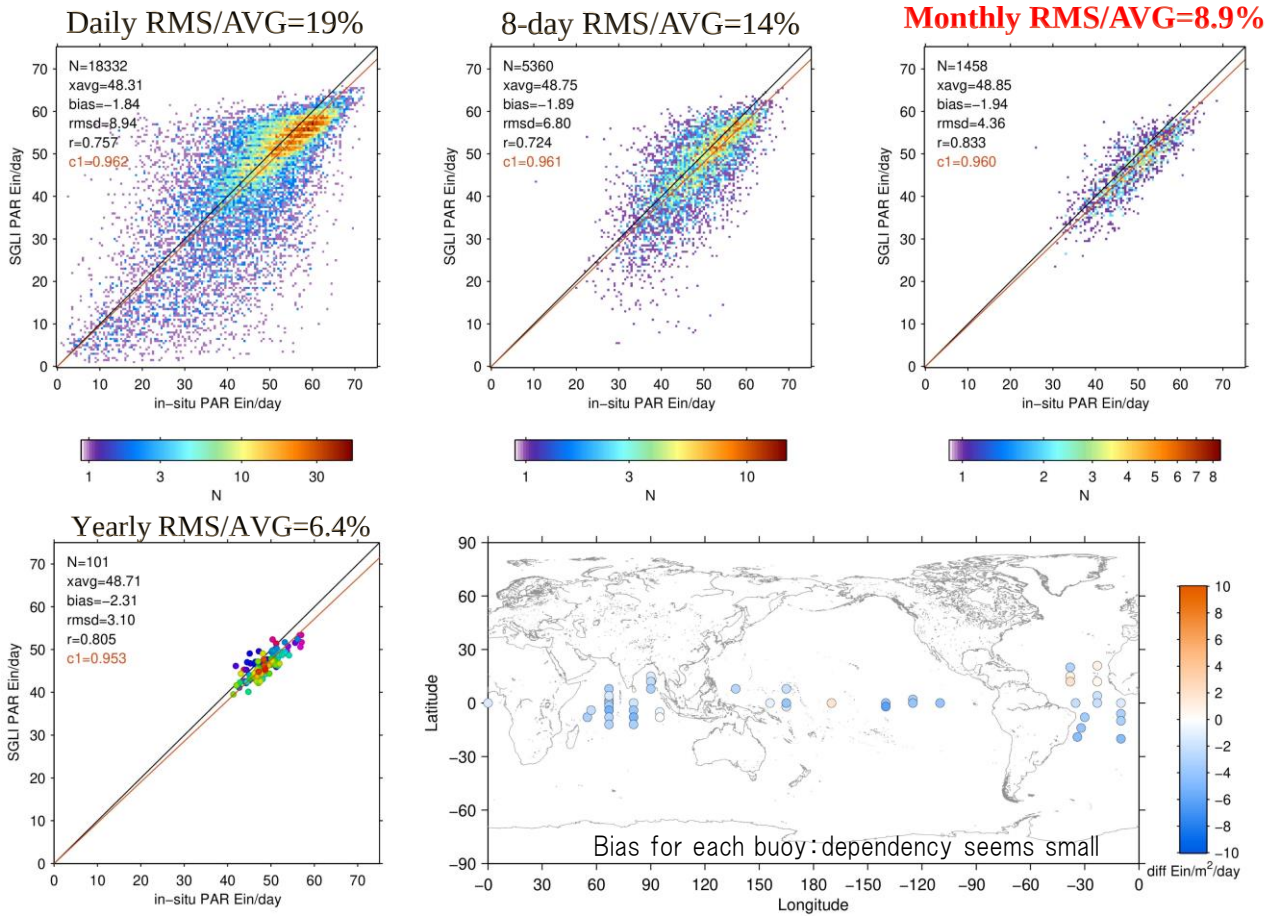
→ It is possible to obtain values closer to reality and achieve standard accuracy by applying the correction formula.

Correction formula：TAUA_865_corrected = 0.822 * TAUA_865 + 0.0

Validation Result	Release Accuracy	Standard Accuracy	Target Accuracy
[Ver. 2] 65%(not corrected) [Ver. 3] 46%(corrected)	80% (AOT@865)	50% (AOT@865)	30% (AOT@865)

Achieved Standard Accuracy

Photosynthetically available radiation



- Daily PAR is estimated by instantaneous transmittance from visible channels.
- Reference PAR is made from daily SWR observed by buoy, PAR/SWR ration estimated by Pstar-4 calculation and objective analysis water vapor data
- Achieved the target accuracy(No change from ver.2)

Validation result	Release accuracy	Standard accuracy	Target accuracy
[Ver.2] 9.5%→**[Ver.3] 8.9%**	20% (10km/month)	15% (10km/month)	10% (10km/month)

Validation Results of Ocean IWPR Products: Chlorophyll-a Concentration - CHLA

Major Updates of Algorithm:

- None of major updates

Validation Method:

Validated the accuracies of predicted CHLA data from the SGLI algorithm comparing with *in-situ* data(High Performance Liquid Chromatography: HPLC or fluorescence method) of ship observation.

Quality Control:

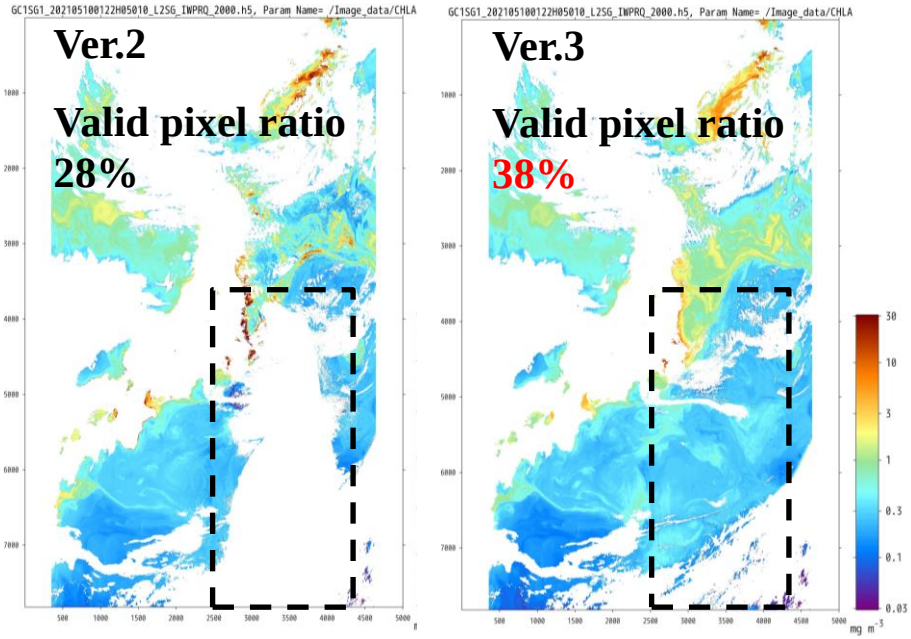
- *In-situ* data: time difference in ±3 hours to SGLI observation
- SGLI data: average of the data passed the following conditions within a 5 by 5 pixel centered the in-situ point
    1. 13 or more pixels which satisfies the following conditions: aerosol optical thickness < 0.5, solar zenith angle < 70 degrees, NWLR of all channels > 0, CLDAFFCTD flag isn't set.
    2. Median CV (coefficient of variation) computed from NWLR_380-565nm and Taua_865nm less than 0.15

Period of Validation:

- January 1, 2018 - December 31, 2020

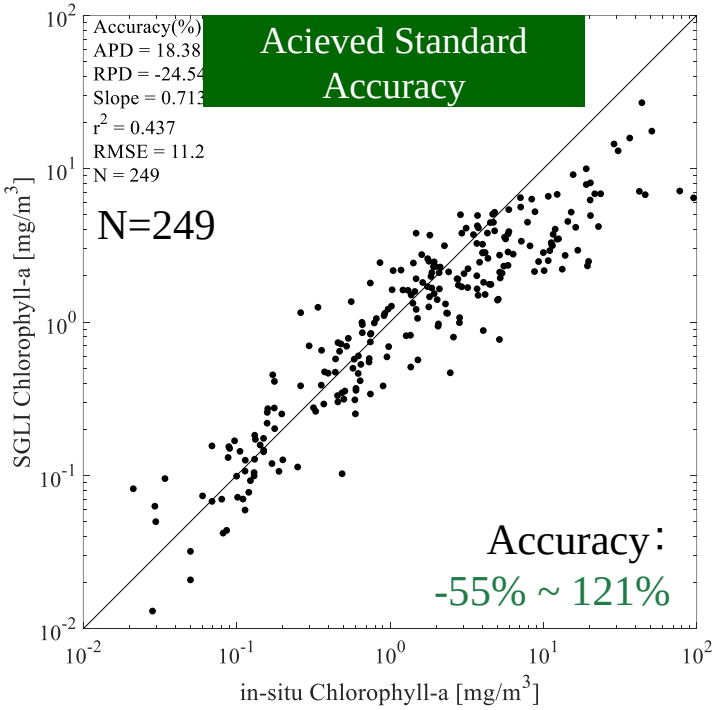
Validation Results of Ocean IWPR Products: Chlorophyll-a Concentration - CHLA

The coast of Japan (2021/05/10)



Valid pixel ratio= number of valid pixels/ number of total pixels

CHLA



- Achieved Standard Accuracy
- Increased the number of validation points on coastal and sunglint areas because of the improvement of NWLR estimation.

Validation Result	Release Accuracy	Standard Accuracy	Target Accuracy
[Ver. 2] -55~121% →[Ver. 2] -58~137%	-60%~+150%(offshore)	-60%~+150%	-35%~+50%(offshore) -50%~+100%(coastal)

Validation Results of Ocean IWPR Products: Colored Dissolved Organic Matter - CDOM

Major Updates of Algorithm:

- None of major updates

Validation Method:

Validated the accuracies of predicted CDOM data from the SGLI algorithm comparing with *in-situ* data of ship observation.

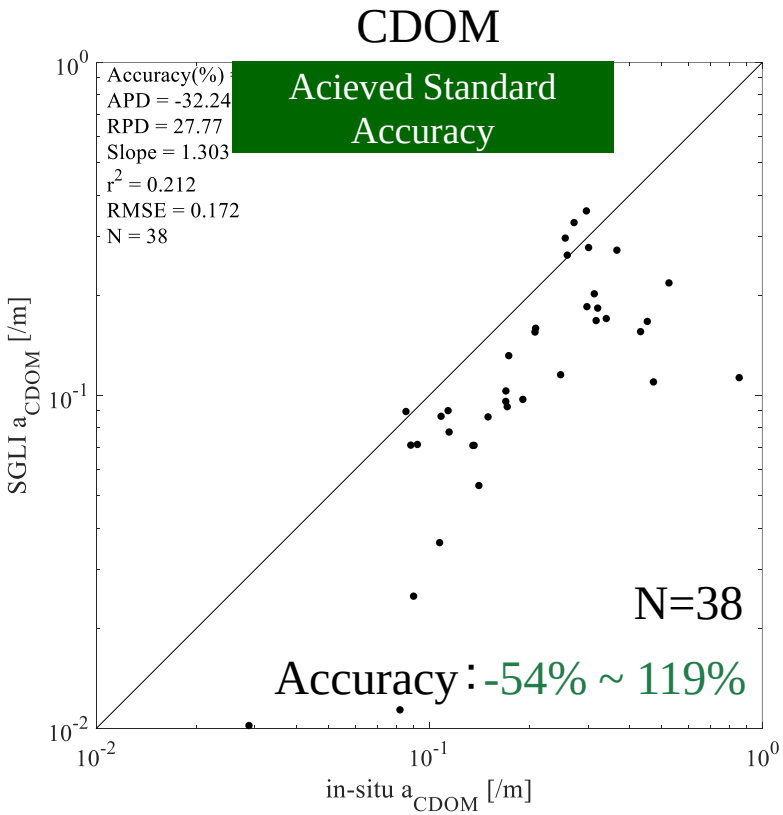
Quality Control:

- *In-situ* data: time difference in ±3 hours to SGLI observation
- SGLI data: average of the data passed the following conditions within a 5 by 5 pixel centered the in-situ point
  1. 13 or more pixels which satisfies the following conditions: aerosol optical thickness < 0.5, solar zenith angle < 70 degrees, NWLR of all channels > 0, CLDAFFCTD flag isn't set.
  2. Median CV (coefficient of variation) computed from NWLR_380-565nm and Taua_865nm less than 0.05

Period of Validation:

- January 1, 2018 - December 31, 2020

Validation Results of Ocean IWPR Products: Colored Dissolved Organic Matter - CDOM



- Achieved Standard Accuracy
- Increased the number of validation points on coastal and sunglint areas because of the improvement of NWLR estimation.

Validation Result	Release Accuracy	Standard Accuracy	Target Accuracy
[Ver. 1] -52~107% →[Ver. 2] -55~121%	-60%~+150%(offshore)	-60%~+150%	-50%~+100%

Validation Results of Ocean IWPR Products: Total Suspended Matter - TSM

Major Updates of Algorithm:

- None of major updates

Validation Method:

Validated the accuracies of predicted TSM data from the SGLI algorithm comparing with *in-situ* data of ship observation.

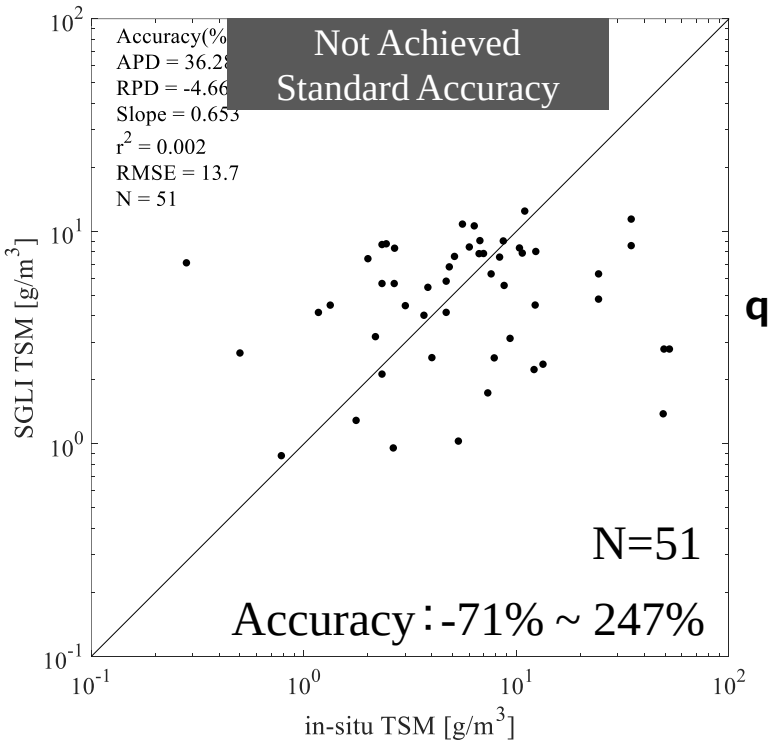
Quality Control:

- *In-situ* data: time difference in ±3 hours to SGLI observation
- SGLI data: average of the data passed the following conditions within a 5 by 5 pixel centered the in-situ point
  1. 13 or more pixels which satisfies the following conditions: aerosol optical thickness < 0.5, solar zenith angle < 70 degrees, NWLR of all channels > 0, CLDAFFCTD flag isn't set.
  2. Median CV (coefficient of variation) computed from NWLR_380-565nm and Taua_865nm less than 0.15

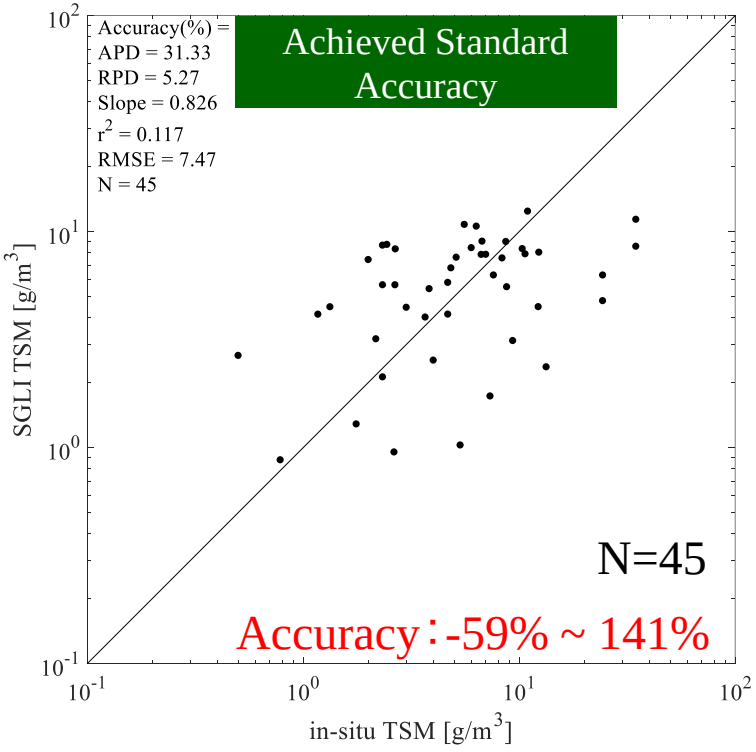
Period of Validation:

- January 1, 2018 - December 31, 2020

Validation Results of Ocean IWPR Products: Total Suspended Matter - TSM



***in-situ* data quality control**



Standard accuracy is achieved except when there are errors in in-situ data or when the TSM concentration is particularly high, as on the English Channel.
(See appendix for details on quality control.)

Validation Result	Release Accuracy	Standard Accuracy	Target Accuracy
[Ver. 2] -70~232% →[Ver. 3] -63~171%	-60%~+150%(offshore)	-60%~+150%	-50%~+100%

Validation Results of Ocean SST Products: Sea Surface Temperature - SST

Major Updates of Algorithm:

- Introduction of atmospheric optical thickness climatology to improve atmospheric correction.
- Cloud mask method:
  1. Improvements by introduction of 1.6 micron data and so on (Daytime) and
  2. Readjustment of thresholds for each quality level (Nighttime).
- Introduction of a preprocessing to reduce stripes and random noise in L1B data.

Validation Method:

SGLI SST Version 3 was validated by comparing SGLI SSTs with in-situ SSTs.

Quality Control:

- *In-situ* data: Moored and drifting buoys data provided by NOAA/iQuam (version 2.1). The data were screened based on the QC result of the iQuam. High qualified data (iquam flag = 0 and quality level = 5) were used for the validation.

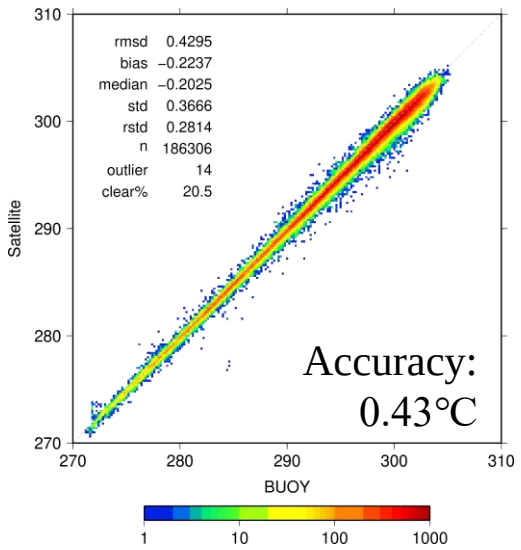
- SGLI data: SGLI SST V3 of the 1-km spatial resolution with the quality assured as good or acceptable: which are used to calculate L3 statistics. An SGLI SST nearest to the center was chosen for each 1hr x 3km collocation window centered on each buoy data and compared with the centered buoy data.

Period of Validation:

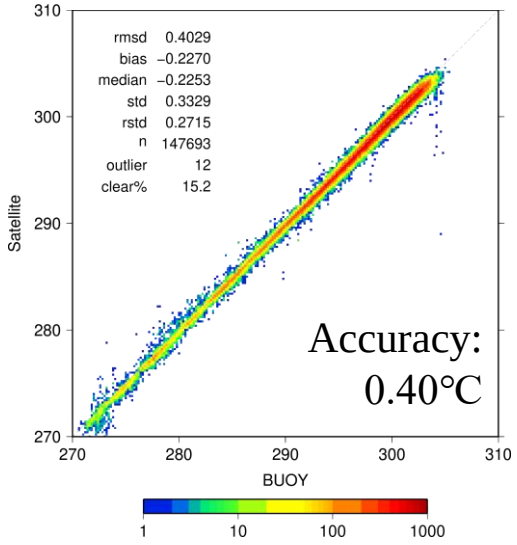
- January 1, 2018 - December 31, 2019

Validation Results of Ocean SST Products: Sea Surface Temperature - SST

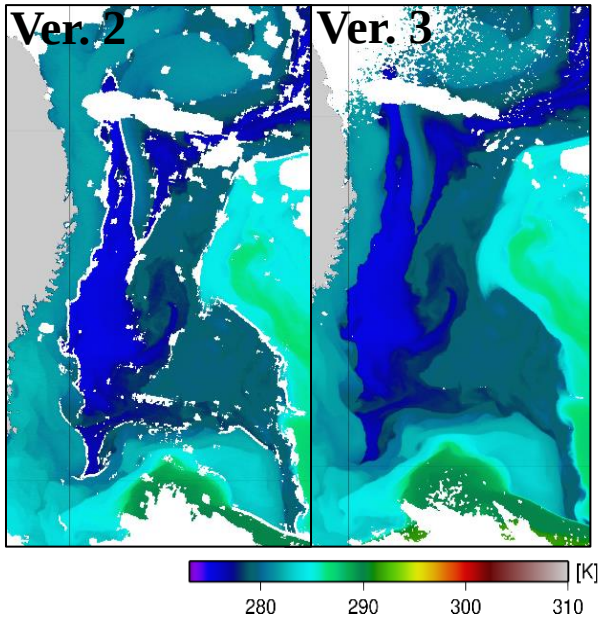
SST (Daytime)



SST (Nighttime)



Improved cloud mask



- The increased total number of valid pixels is due to the improved cloud masking.
- Cloud contaminations have been improved at night due to adjusted thresholds.

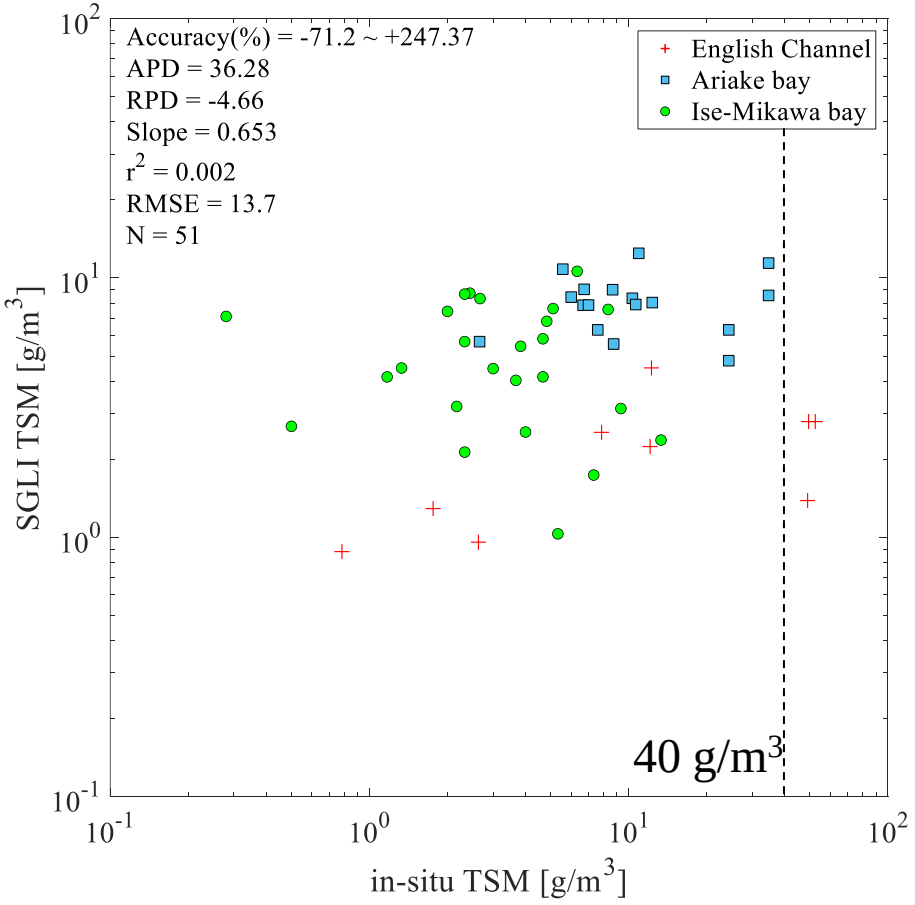
Modified cloud masking has also improved cloud masks at and around SST fronts during the daytime.

Validation Result	Release Accuracy	Standard Accuracy	Target Accuracy
0.4(V2) → 0.4℃ (daytime) 0.7(V2) → 0.4℃ (nighttime)	0.8℃ (日中)	0.8℃	0.6℃

Achieved Target Accuracy

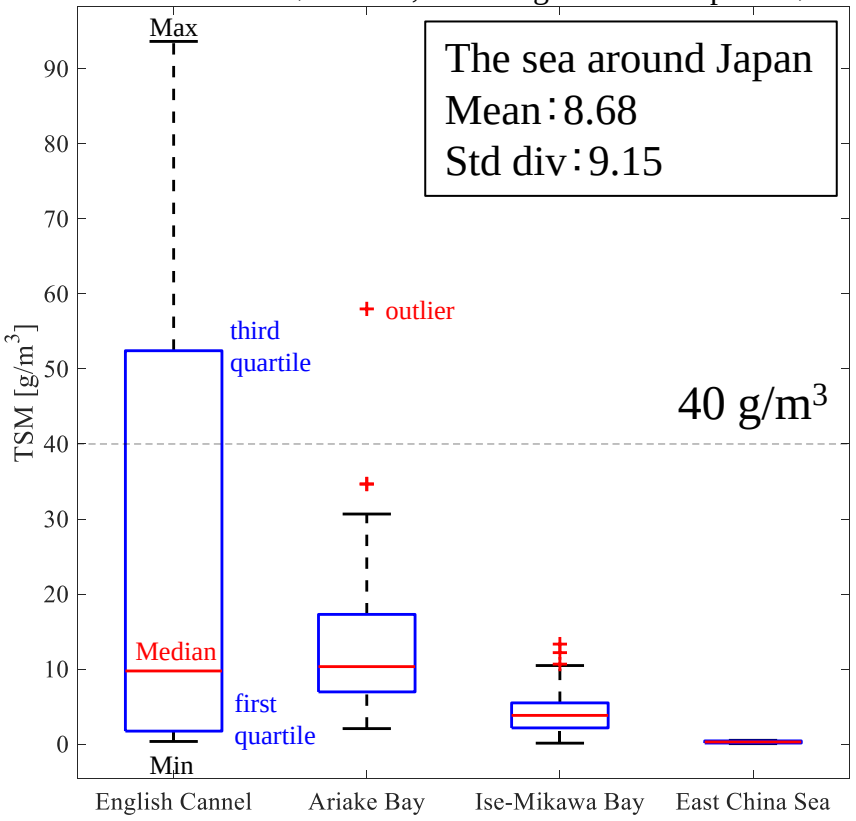
(Appendix) Validation Results of Ocean IWPR Products: Total Suspended Matter - TSM

TSM validation results color-coded by sea area.



Distribution of in-situ TSM by sea area

（All data, including non-matchup data）

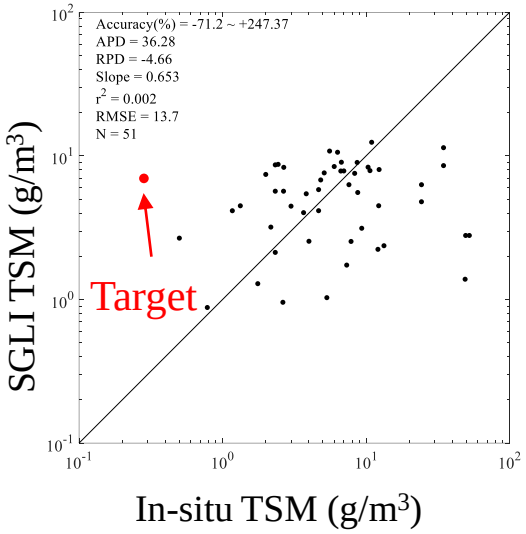


※The outlier is the value that is more than 1.5 times the quartile range away from the first and third quartiles.

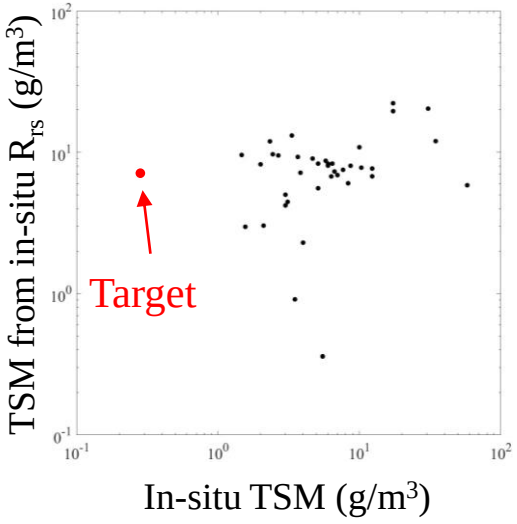
- TSM on the English Channel in spring are extremely high and rarely exceed 40 g/m3 on the sea around Japan.
- In this validation, *in-situ* data of TSM > 40g/m^3 is removed.

(Appendix) Validation Results of Ocean IWPR Products: Total Suspended Matter - TSM

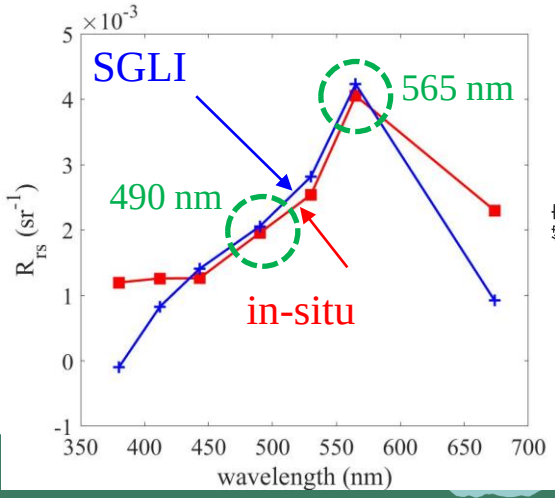
(A) *in-situ* TSM vs. SGLI TSM



(B) *in-situ* TSM vs. TSM estimated from *in-situ* R_{rs}



(C) Rrs comparison of the target point



(D) Water sampling points on the same day

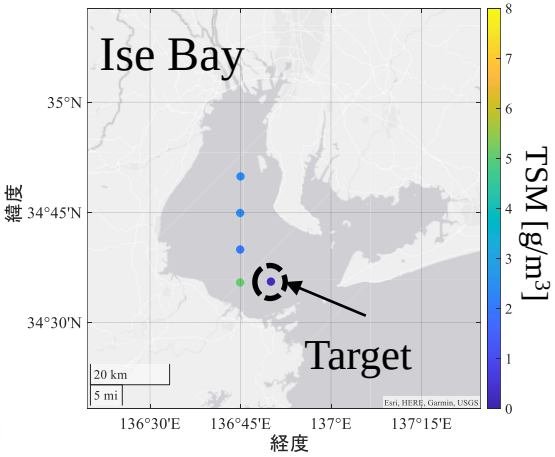


Table 1: Comparison of estimated and in-situ values for TSM and Chl-a

	TSM (g/m^3)	Chl-*a* (mg/m^3)
in-situ	0.28	36.55
SGLI	7.11	15.85

- Estimation error of R_{rs} (NWLR) is unlikely to be the cause of outlier of TSM estimate at the target point :
  - TSM estimation from in-situ Rrs at the TSM sampling point is far off (Figure B).
  - R_{rs} at 490 nm and 565 nm, which are necessary for TSM estimation, are close to in-situ R_{rs} (Figure C).
- High possibility of measurement error in in-situ TSM :
  - TSM at the near stations on the same day (Figure D) varied from 2 to 5 g/m3 , but Chl-a was similar at 21 to 44 mg/m3.
  - TSM value is too small for Chl-a (Table 1)

Removed as an outlier in this validation

Ver.3 Cryosphere Products

Evaluation Summary

Product	Release threshold	Standard accuracy	Target accuracy	Status*1	Evaluation Methods
Snow and Ice covered area (incl. cloud detection)	10%	7%	5%	○ ⇒ ◎	Comparison with other satellites data (e.g. MODIS, VIIRS, Sentinel-3…).
Okhotsk sea-ice distribution	10%	5%	3%	○ ⇒ ◎	Comparison with other satellites data (e.g. MODIS, VIIRS, Sensinel-3…).
Snow and ice surface Temperature	5K	2K	1K	◎	Comparison with in-situ observation (Automatic weather station thermal radiometer data) and other satellites data (e.g. MODIS, VIIRS Sentinel-3…).
Snow grain sizeof shallow layer	100%	50%	30%	◎	Comparison with in-situ data for the standard and target accuracy thresholds.

*1 Symbols denote as follows; ○: the release threshold achieved, ◎: the standard accuracy achieved, ☆: the target accuracy achieved.

Validation results of Cryosphere products – SICE/OKID

- Version 3 Major changes and validation details

C1AB/SICE - Snow and Ice cover area algorithm

- Revised cloud detection/surface classification training data set using Neural network machine learning method
- All training data were simulated by DISORT radiative transfer model

C1C/OKID - Okhotsk sea-ice distribution algorithm

- Revised cloud detection/surface classification training data set using Neural network machine learning method – communalize with C1AB
- All training data were simulated by DISORT radiative transfer model

Validation data for the C1AB/ SICE

- Snow area: MOD10C2 Snow Cover Extent Product
- Sea ice area*: MOD29E1D Sea Ice Product

Validation data for the C1C/OKID

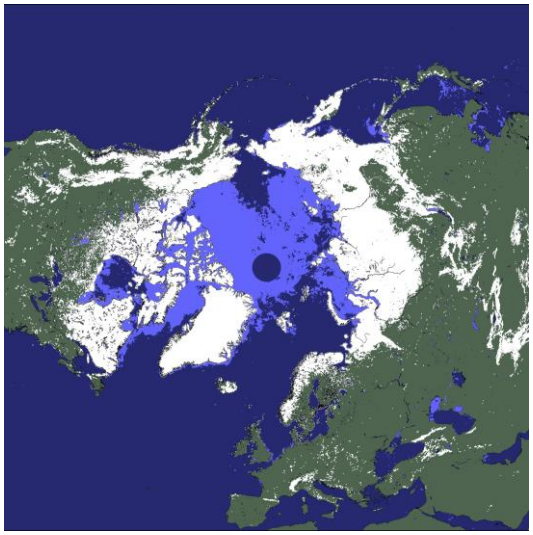
- Sea ice area* : MOD29E1D Sea Ice Product

*NSIDC defines sea ice exists in case of the ice fraction/ice concentration more than 15%.

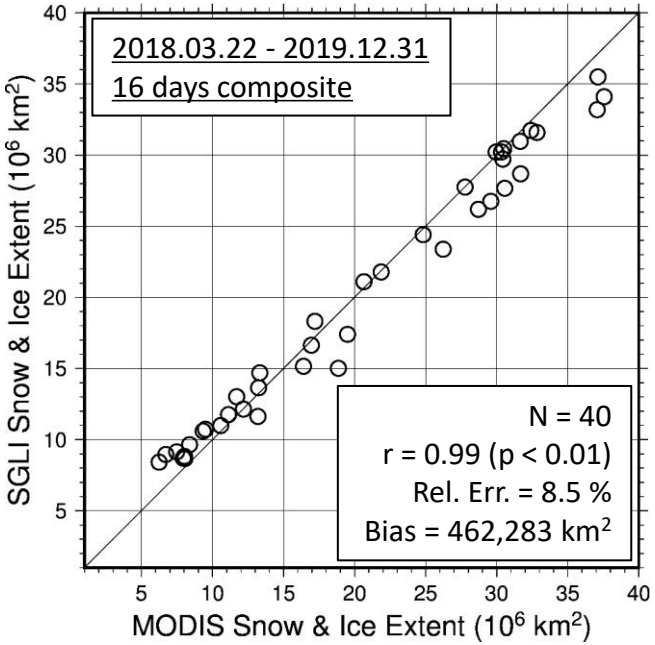
Validation results of Cryosphere products - SICE

- Snow and Ice cover extent product validation results using other satellite products

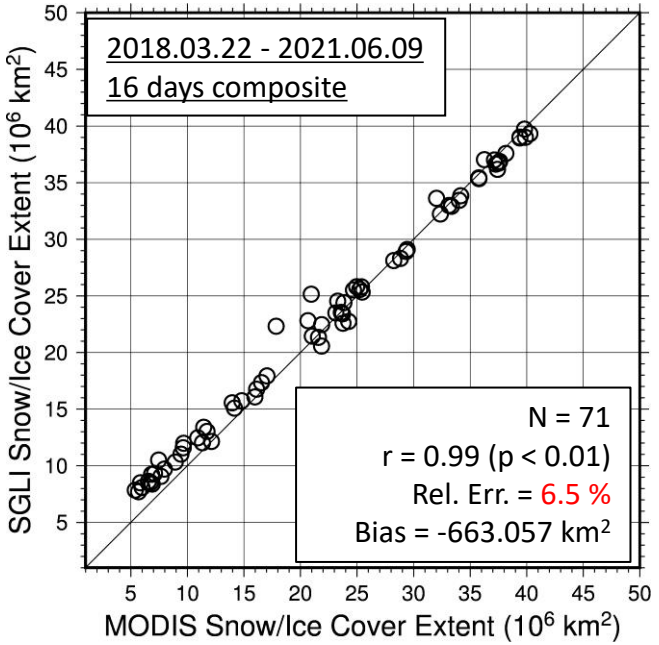
Ver.3 sample image
2019.05.09 – 2019.05.24



Validation result of Ver. 2



Validation result of Ver. 3



Validation period was expanded: 1.5 year to 3 year.

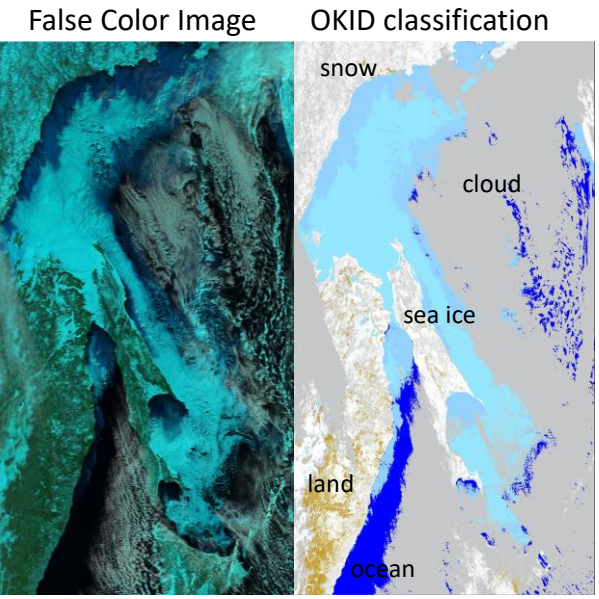
Validation result	Release accuracy	Standard accuracy	Target accuracy
Ver.2: 8.5 % (Mar. 2018 - Dec. 2019) Ver.3: **6.5 %** (Mar. 2018 - Jun. 2021)	10 %	7 %	5 %

Accuracy improved and SICE product is achieved the standard accuracy

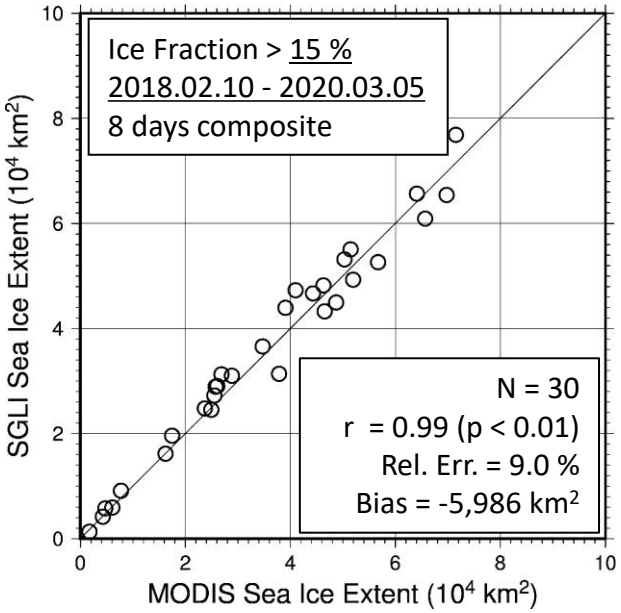
Validation results of Cryosphere products - OKID

- Okhotsk sea-ice distribution product validation results using other satellite products

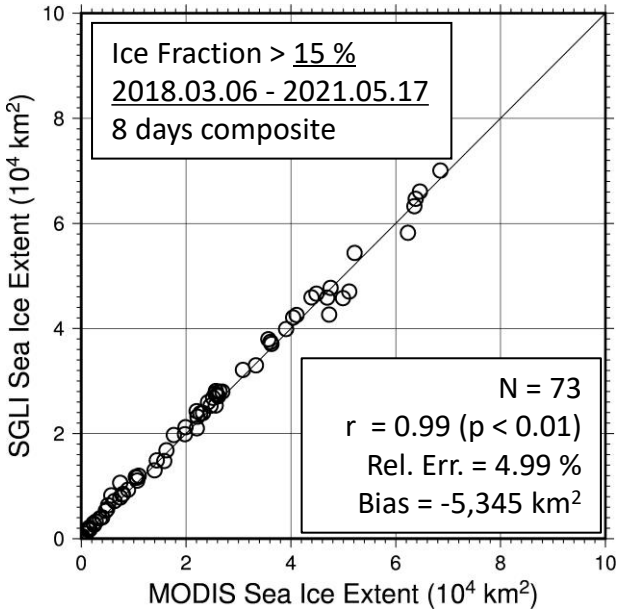
Ver.3 sample image
2021.02.27



Validation result of Ver. 2



Validation result of Ver. 3



1. Validation period was expanded: 2 season to 4 season.
2. Surface classification was improved from visual evaluation compared with False color image.

Validation result	Release accuracy	Standard accuracy	Target accuracy
Ver.2: 9.0 % (Feb. 2018 - Mar. 2018) Ver.3: **5.0 %** (Feb. 2018 - May. 2021)	10 %	5 %	3 %

Accuracy improved and OKID product is achieved the standard accuracy

Validation results of Cryosphere products - SIPR

- Version 3 Major changes and validation details

SGSL - Snow grain size of shallow layer

- Revised snow grain size estimation algorithm using Neural network machine learning method
  - Revised the training data set (BRDF data set) using Neural-net: improved inversion accuracy

SIST - Snow and Ice surface temperature

- Revised the emissivity table

SALB - Broadband blue sky Snow ALBedo

- **Add the direct retrieval of broadband blue sky snow albedo product as a research product**
- **Snow albedo estimation using Neural network machine learning algorithm same as snow grain size**

Validation data for the SGSL

- Field campaign carried out on the Greenland Ice Sheet East-GRIP site (Jul. 2018), Japan/Hokkaido Nakasatsunai site (Feb. 2020), and JARE observation data (2019) on the Antarctic Ice Sheet Dome Fuji Site
- Surface Specific Area (SSA) measured by IceCube and HISSGraS and converted to optical equivalent snow grain size
- All data match-up conditions are in 10 minutes and 250 meters from nearest point of satellites

Validation data for the SIST

- Ground surface temperature was converted from Longwave radiation Flux observation by Automatic weather station (PROMICE)
- All data match-up conditions are in 10 minutes and 250 meters from nearest point of satellites

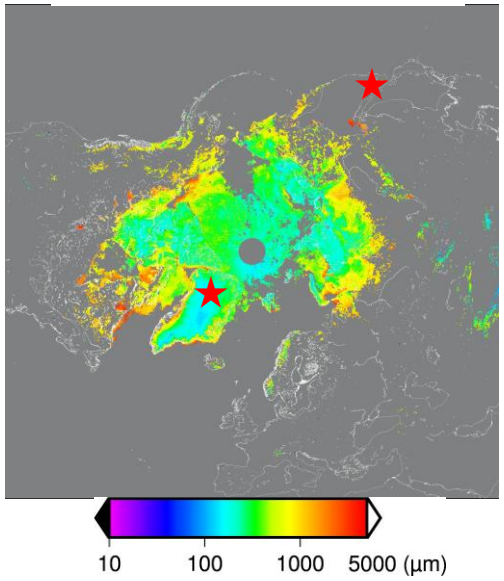
Validation data for the SALB

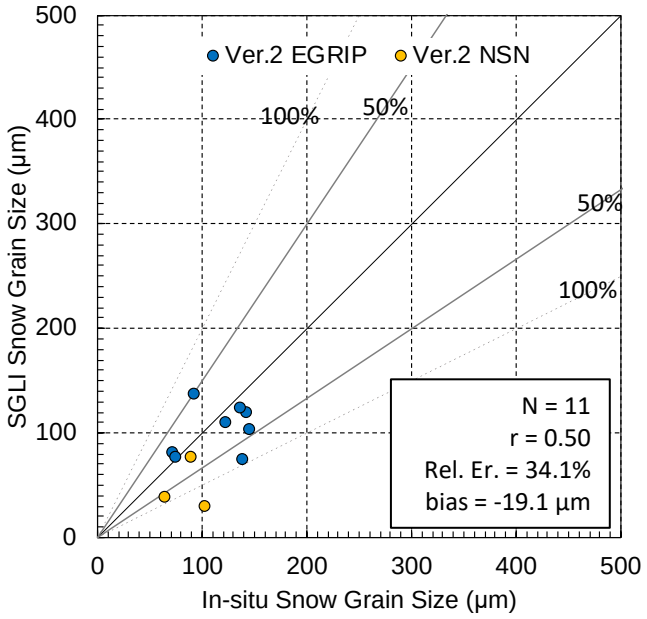
- Surface albedo was calculated from Downward and Upward shortwave radiation flux observation by Automatic weather station (PROMICE)
- All data match-up conditions are in 10 minutes and 250 meters from nearest point of satellites

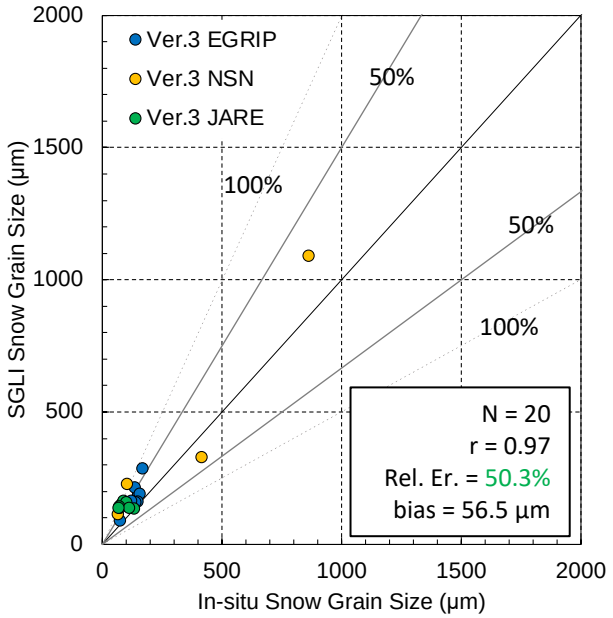
Validation results of Cryosphere products - SIPR

- Snow grain size of shallow layer product validation results using in-situ observation data

Ver.3 sample image
2019.05.09 - 2019.05.24







Validation sites were added: around Dome Fuji site by JARE.

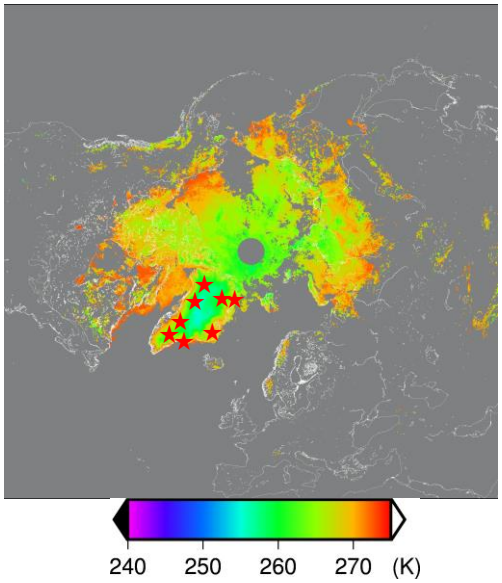
Validation result	Release accuracy	Standard accuracy	Target accuracy
Ver.2: 34 % (Greenland and Japan) Ver.3: **50 %** (Added the Antarctica)	100 %	50 %	30 %

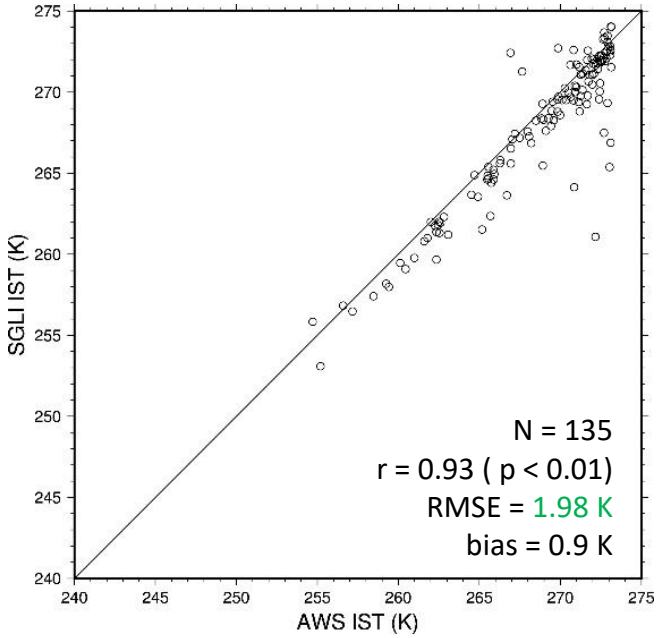
Retrieval became stable on wide region and SGSL product achieved the standard accuracy

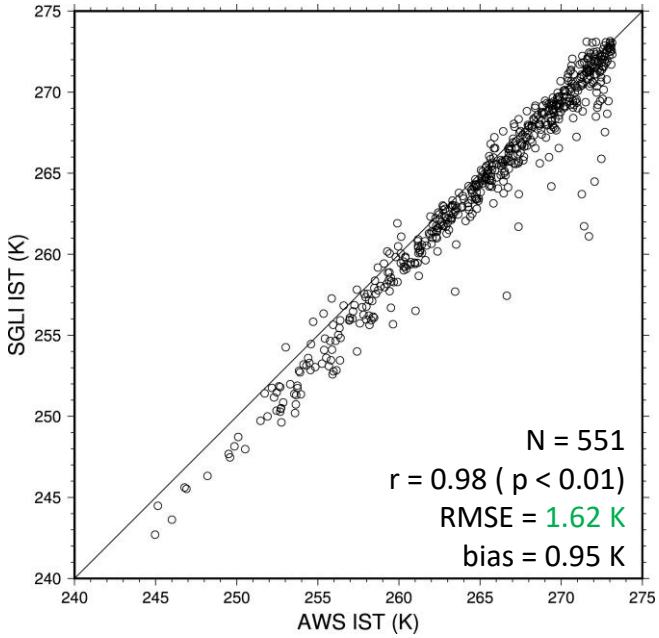
Validation results of Cryosphere products - SIPR

- Snow and Ice surface temperature product validation results using AWS observation data

Ver.3 sample image
2019.05.09 - 2019.05.24







Validation period was expanded: 2 years to 3 years.

Validation result	Release accuracy	Standard accuracy	Target accuracy
Ver.2: 2 K (GrIS: 2018 - 2019) Ver.3: **1.6 K** (GrIS: 2018 - 2020)	5 K	2 K	1 K

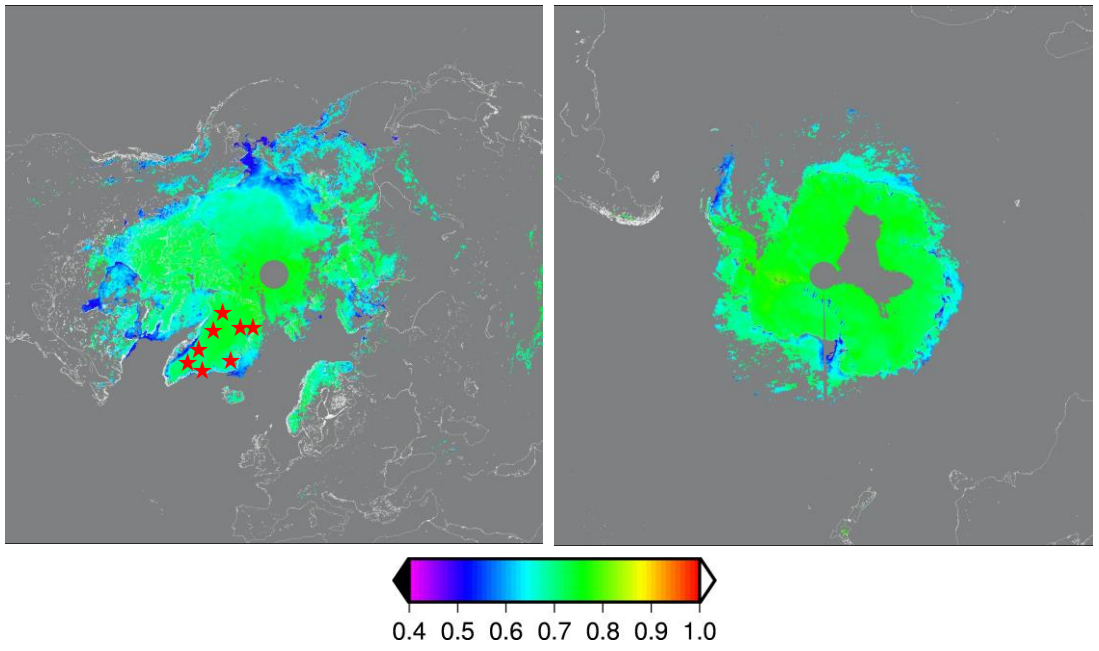
Accuracy improved and SIST product achieved the standard accuracy

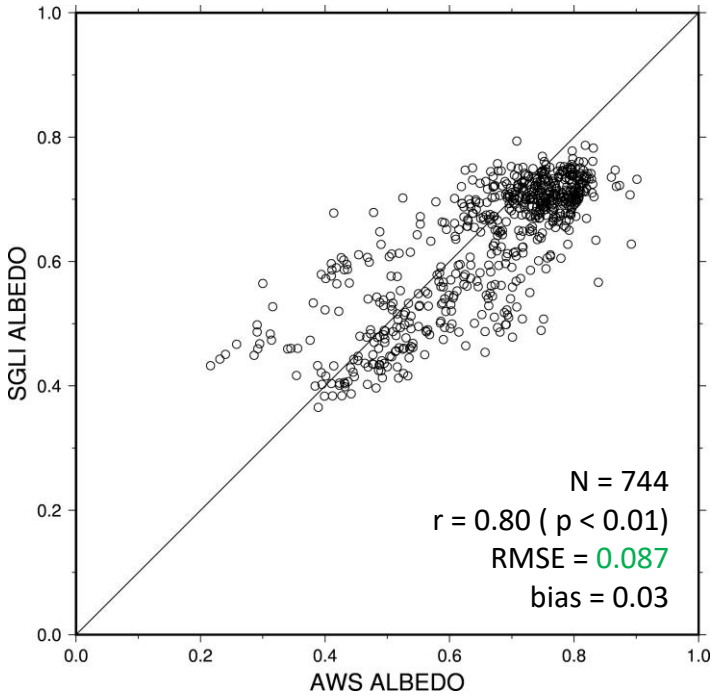
Validation results of Cryosphere products - SIPR

- Snow and Ice surface albedo product validation results using AWS observation data

Sample image
2020.05.09 - 2020.05.24

Sample image
2020.11.17 - 2020.12.02





Validation result	Release accuracy	Standard accuracy	Target accuracy
0.087 (13 %)	-	-	7 %

SALB product needs more in-situ data & quality control