# Detailed Reports on the Validation of the SGLI Products

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2. Land Products
3. Atmosphere Products
4. Ocean Products
5. Cryosphere Products

# 1. Summary of the Validation of SGLI L2 Products

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

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

**Results of the Post-Launch Validation**

| Level/Area[The number of products] | Land [9] | Atmosphere [8] | Ocean [7] | Cryosphere [4] | Total [28] |
|---|---|---|---|---|---|
| Release threshold achieved | 9 | 8 | 7 | 4 | 28 |
| Standard accuracy threshold achieved | 1 | 4 | 3 | 1 | 9 |
| Target accuracy achieved | 0 | 2 | 1 | 0 | 3 |

✓ The release thresholds (the first accuracy target) of all L2 standard products have been achieved. In addition, the evaluation results indicate that nine (and three) L2 products have already reached the levels of the standard accuracy for the full success (and the target accuracy for the extra success) at this stage.

# 1. Summary of the Validation of SGLI L2 Products

## Accuracy Requirements of SGLI L2 products and Current Evaluation Status (1/2)

| Area | Group | Product | Status*1 | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|---|---|---|
| Land | Surface reflectance | Precise geometric correction | ◎ | <1 pixel | <0.5 pixel | <0.25 pixel |
| | | 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) |
| | Vegetation and carbon cycle | Vegetation index | ○ | Grass:25% (scene), forest:20% (scene) | Grass:20% (scene), forest:15% (scene) | Grass:10% (scene), forest:10% (scene) |
| | | Above-ground biomass | ○ | Grass:50%, forest: 100% | Grass:30%, forest:50% | Grass:10%, forest:20% |
| | | Vegetation roughness index | ○ | Grass & forest: 40% (scene) | Grass & forest:20% (scene) | Grass & forest:10% (scene) |
| | | Shadow index | ○ | Grass & forest: 30% (scene) | Grass & forest:20% (scene) | Grass & forest:10% (scene) |
| | | fAPAR | ○ | Grass:50%, forest: 50% | Grass:30%, forest:20% | Grass:20%, forest:10% |
| | | Leaf area index | ○ | Grass:50%, forest: 50% | Grass:30%, forest:30% | Grass:20%, forest:20% |
| | tempera ture | Surface temperature | ○ | <3.0 K (scene) | <2.5 K (scene) | <1.5 K (scene) |
| Atmosphere | Cloud | Cloud flag/Classification | ☆ | 10% (with whole-sky camera) | Incl. below cloud amount | Incl. below cloud amount |
| | | Classified cloud fraction | ☆ | 20% (on solar irradiance) | 15% (on solar irradiance) | 10% (on solar irradiance) |
| | | Cloud top temp/height | ◎ | 1 K | 3 K/2 km (top temp/height) | 1.5 K/1 km (temp/height) |
| | | Water cloud OT/effective radius | ○ | 10%/30% (CloudOT/radius) | 100% (as cloud liquid water) | 50% / 20% |
| | | Ice cloud optical thickness | ○ | 30% | 70% | 20% |
| | aerosol | Aerosol over the ocean | ○ | 0.1 (Monthly τa_670,865) | 0.1 (scene τa_670,865) | 0.05 (scene τa_670,865) |
| | | Land aerosol by near ultra violet | ○ | 0.15 (Monthly τa_380) | 0.15 (scene τa_380) | 0.1 (scene τa_380 ) |
| | | Aerosol by Polarization | ◎ | 0.15 (Monthlyτa_670,865) | 0.15 (scene τa_670,865) | 0.1 (scene τa_670,865) |

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

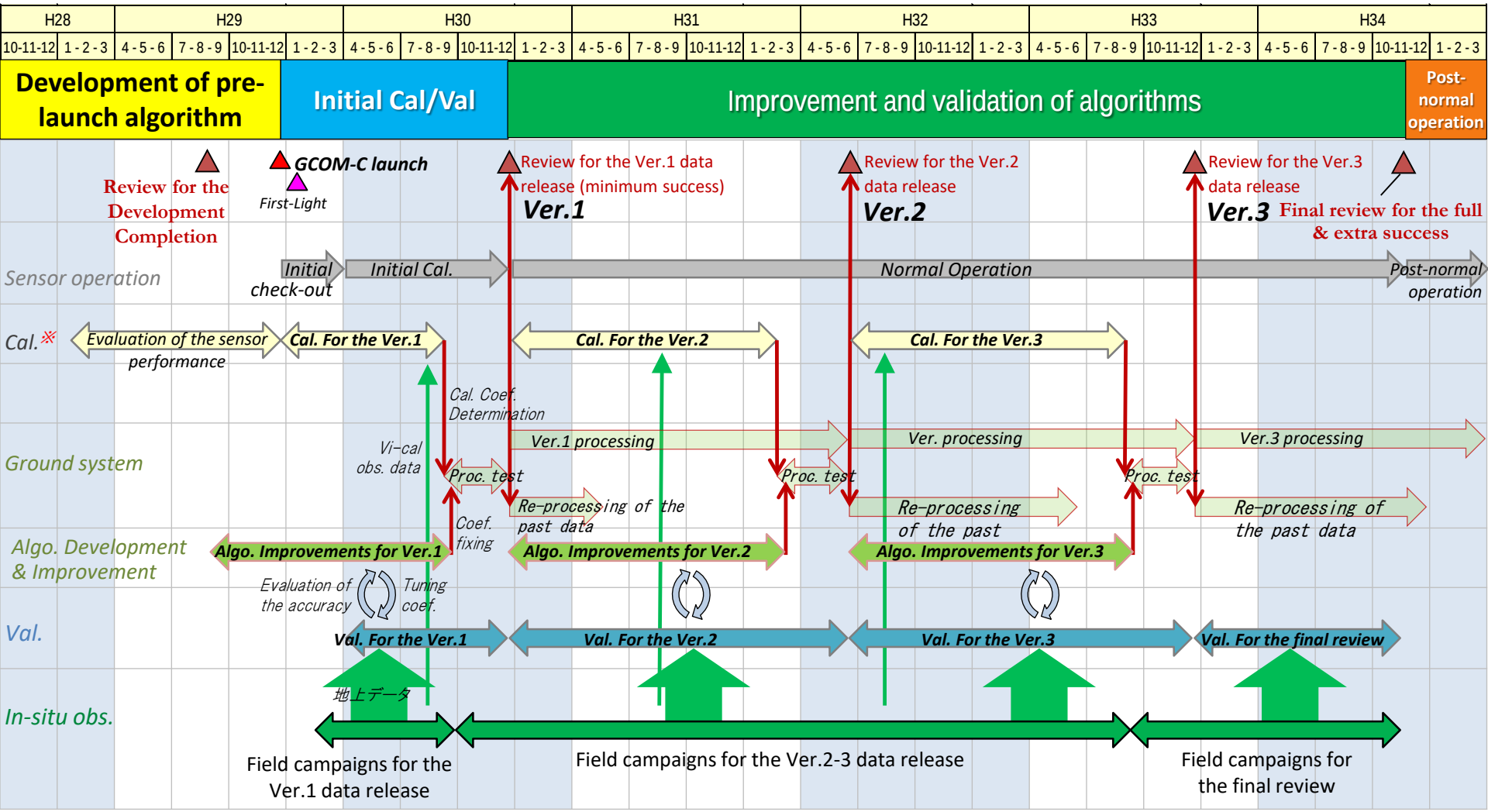
# 1. Summary of the Validation of SGLI L2 Products

## Accuracy Requirements of SGLI L2 products and Current Evaluation Status (2/2)

| Area | Group | Product | Status*1 | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|---|---|---|
| Ocean | Ocean color | **Normalized water leaving radiance (incl. cloud detection)** | ◎ | 60% (443~565nm) | 50% (<600nm)<br>0.5W/m$^2$/str/um (>600nm) | 30% (<600nm)<br>0.25W/m$^2$/str/um (>600nm) |
| | | **Atmospheric correction parameters** | ○ | 80% (AOT@865nm) | 50% (AOT@865nm) | 30% (AOT@865nm) |
| | | **Photosynthetically available radiation** | ◎ | 20% (10km/month) | 15% (10km/month) | 10% (10km/month) |
| | In-water | **Chlorophyll-a concentration** | ○ | –60~+150% (offshore) | –60~+150% | –35~+50% (offshore),<br>–50~+100% (coast) |
| | | **Suspended solid concentration** | ○ | –60~+150% (offshore) | –60~+150% | –50~+100% |
| | | **Colored dissolved organic matter** | ○ | –60~+150% (offshore) | –60~+150% | –50~+100% |
| | temperature | **Sea surface temperature** | ☆ | 0.8 K (daytime) | 0.8 K (day & night time) | 0.6 K (day & night time) |
| Cryosphere | Area/ distribution | **Snow and Ice covered area (incl. cloud detection)** | ○ | 10% (vicarious val with other sat. data) | 7% | 5% |
| | | **Okhotsk sea-ice distribution** | ○ | 10% | 5% | 3% |
| | Surface properties | **Snow and ice surface Temperature** | ◎ | 5 K (vicarious val with other sat. data and climatology) | 2 K | 1 K |
| | | **Snow grain size of shallow layer** | ○ | 100% (vicarious val with climatology between temp-size) | 50% | 30% |

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

# Schedule for the version-up of SGLI products



# 2. Validation Results of Land Products
## 2.1 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 other satellite data. |
| **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 and other satellite data. |
| **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.

# 2. Validation Results of Land Products

## 2.2 (a) Precise geometrically corrected Top-of-Atmosphere (TOA) radiance（LTOA）

Validation Method:

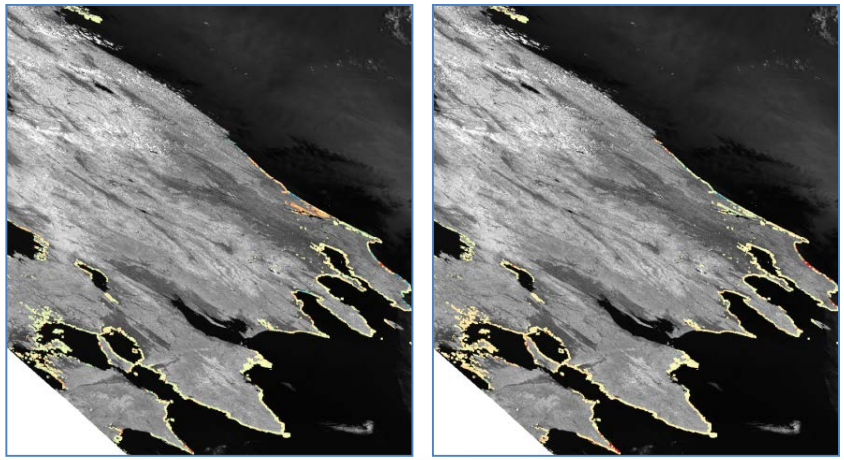
- The geometric accuracies were evaluated by automatic matching of SGLI VN11 for VNR and SW3 for IRS at 250 m resolution with AVNIR-2 ortho-corrected mosaic data around Japan islands.
- The accuracies of POL bands were evaluated as registration errors relative to the VNR band that were resampled to 1 km resolution by averaging.
- Evaluation method is quadratic curve fitting of cross-correlation coefficients (considering pixel locking correction)

Validation data and condition, period etc.

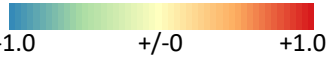
- Reference data: ortho-corrected mosaic of AVNIR-2 with less cloud covers as shown below*1
  GC1SG1_20180625D01D_T0529_L2SG_LTOAQ_0006.h5
- Dependence of geometric errors on altitude was evaluated for confirming the accuracies of the ortho-corrected images

*1) Overall geometric accuracies of LTOA depend also on those of L1B. Regarding the geometric accuracies of L1B, please refer to the “geometric correction” on the SGLI calibration pages.

Target Image example: GC1SG1_20180625D01D_T0529_L2SG_LTOAQ_0104.h5



Horizontal (X)　　Vertical (Y)

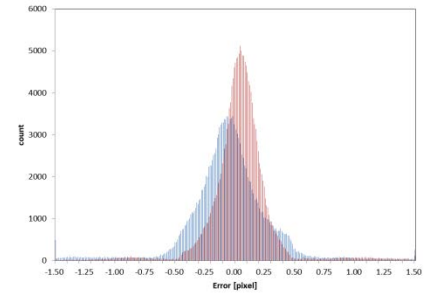


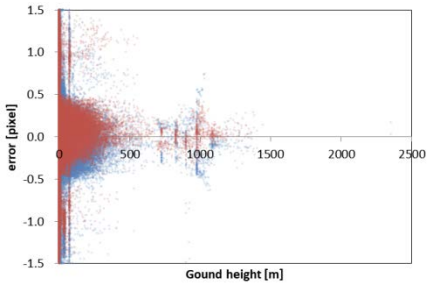

Distribution of geolocation error between SGLI/Lt_VN11 and AVNIR-2/Band4

# 2. Validation Results of Land Products

## 2.2 (a) Precise geometrically corrected Top-of-Atmosphere (TOA) radiance（LTOA）

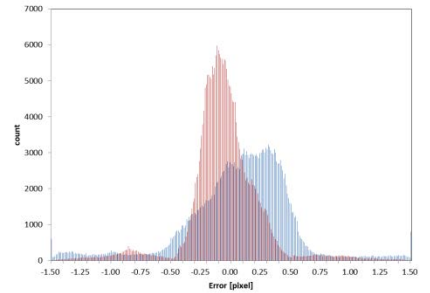
Validation Results: Histograms (upper), altitude dependences (middle), statistics (lower) of estimated geometric errors

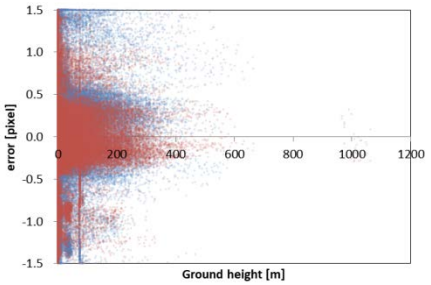



| | ave | std | rms |
|---|---|---|---|
| x | -0.05 | 0.36 | 0.36 |
| y | 0.04 | 0.28 | 0.28 |

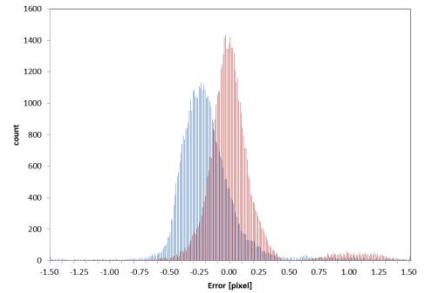
VNR 183844 samples

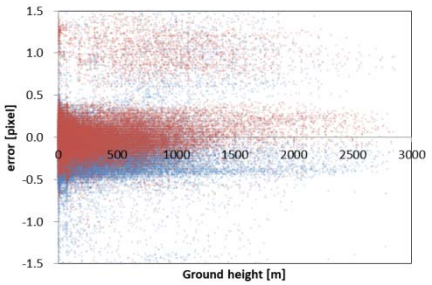



| | ave | std | rms |
|---|---|---|---|
| x | 0.07 | 0.46 | 0.46 |
| y | -0.06 | 0.32 | 0.32 |

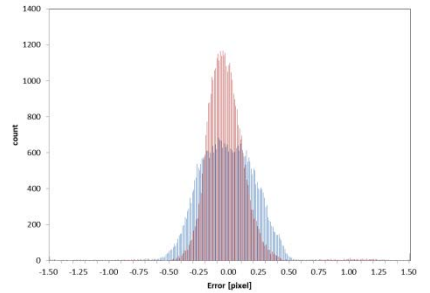
IRS 263228 samples

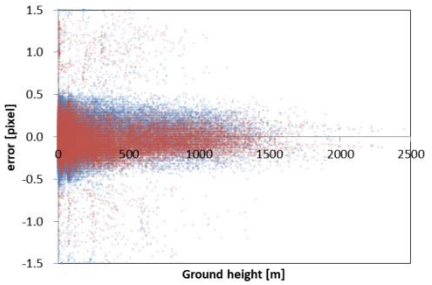



| | ave | std | rms |
|---|---|---|---|
| x | -0.19 | 0.29 | 0.34 |
| y | 0.03 | 0.28 | 0.28 |

POL (P1) 48525 samples




| | ave | std | rms |
|---|---|---|---|
| x | -0.02 | 0.26 | 0.26 |
| y | -0.04 | 0.19 | 0.20 |

POL (P2) 41421 samples

Note: There is no systematic error depending on altitude, indicating that the ortho-correction works well.

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| < 0.36 (VNR)<br>< 0.46 (IRS)<br>< 0.34 (POL) | < 1.0 pixel | < 0.5 pixel | <0.25pixel |

**Release threshold & Standard accuracy are achieved**

# 2. Validation Results of Land Products

## 2.2 (b) Atmospherically corrected reflectance (RSRF)


GCOM-C Global Change Observation Mission-Climate

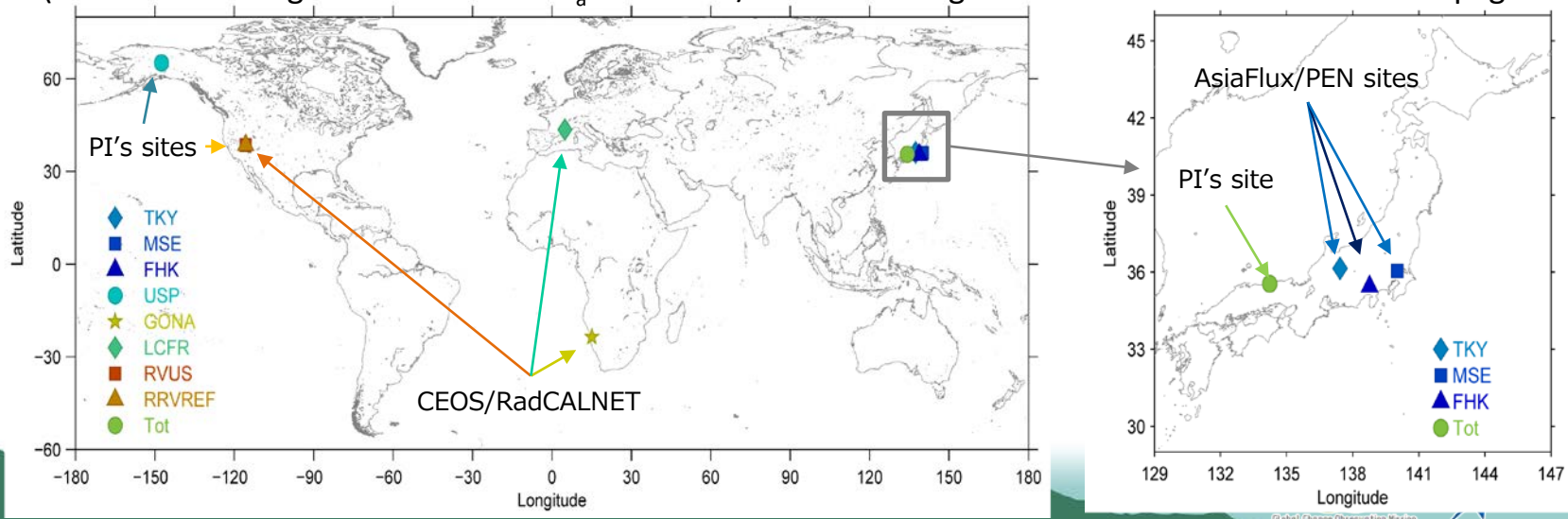
### Validation Method:

- Accuracy targets were defined as RMSE of the reflectances acquired at the ground surface with moderate reflectance of around 0.2 at solar zenith angles SZA less than 30 degrees. In addition, the release threshold is defined as the value acquired at the condition of aerosol optical depth AOT (at the wavelength of 500 nm) less than 0.25.
- In-situ measured reflectances simultaneously acquired with the SGLI observations were used for evaluating RMSE. (Relative errors for the reflectance of 0.2 were also evaluated for comparison).

### Validation data and condition etc.:

- In-situ data measured within the time window of 1-1.5 hours at the sites shown in the figure below (for the period during Jan. 24 to Sep. 28, 2018)
- All the SGLI channels except for VN07 and VN10 (saturated at land areas) and SW02 (water vapor absorption channel) were evaluated.
- The data of pixels at AOT>0.8 and/or with cloudy or cloud shadow flags were eliminated.

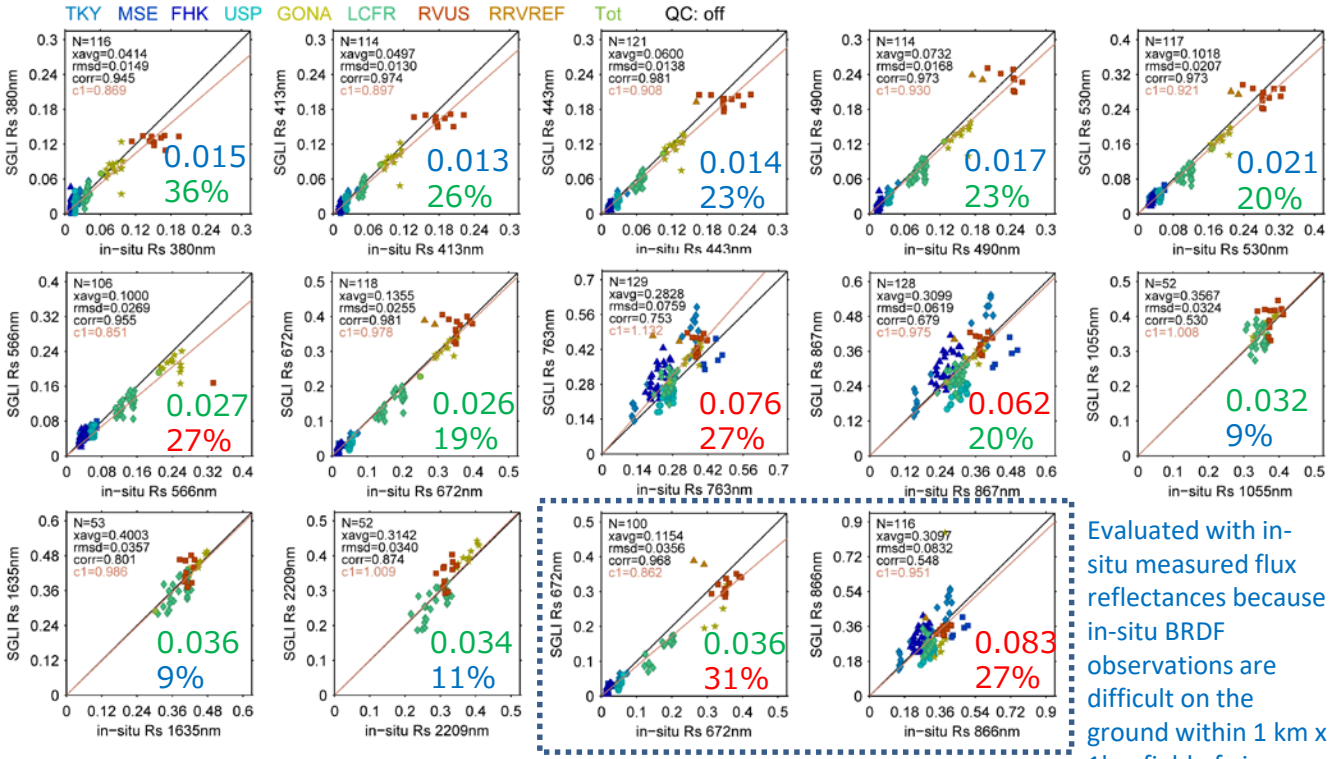
(There is no change at conditions of $\tau_a \leq 0.25$ and/or SZA $\leq$ 30deg. See the table shown on the next page)



# 2. Validation Results of Land Products

## 2.2 (b) Atmospherically corrected reflectance (RSRF)

Validation Results:




Evaluated with in-situ measured flux reflectances because in-situ BRDF observations are difficult on the ground within 1 km x 1km field of view.

RMS differences due to QC types

| band | left fig. | sza<30 | aot<0.25 | Both |
|---|---|---|---|---|
| N= | 52-116 | 21-65 | 44-92 | 16-43 |
| VN01 | 0.015 | 0.016 | 0.014 | 0.014 |
| VN02 | 0.013 | 0.013 | 0.013 | 0.011 |
| VN03 | 0.014 | 0.014 | 0.014 | 0.012 |
| VN04 | 0.017 | 0.014 | 0.018 | 0.013 |
| VN05 | 0.021 | 0.019 | 0.021 | 0.018 |
| VN06 | 0.027 | 0.031 | 0.029 | 0.034 |
| VN08 | 0.026 | 0.019 | 0.027 | 0.017 |
| VN09 | 0.076 | 0.085 | 0.078 | 0.086 |
| VN11 | 0.062 | 0.065 | 0.056 | 0.060 |
| SW01 | 0.032 | 0.031 | 0.030 | 0.029 |
| SW03 | 0.036 | 0.040 | 0.033 | 0.036 |
| SW04 | 0.034 | 0.038 | 0.032 | 0.034 |
| PI01 | 0.036 | 0.026 | 0.040 | 0.026 |
| PI02 | 0.083 | 0.068 | 0.087 | 0.067 |

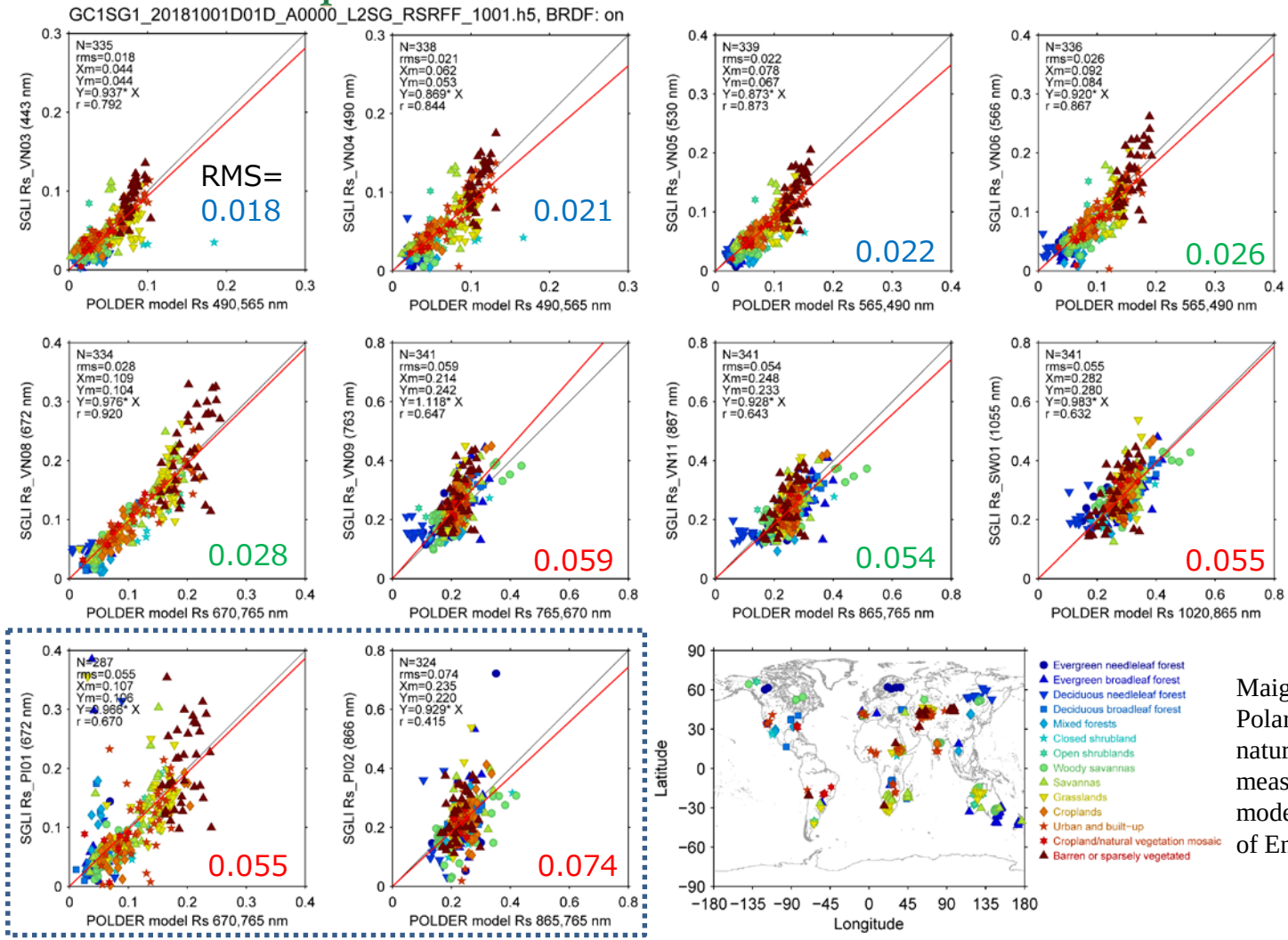
| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 0.019(<=443nm)<br>0.084 (>443nm) | 0.3 (<=443nm) →150%<br>0.2 (>443nm) →100% | 0.1 (<=443nm) →50%<br>0.05 (>443nm) →25% | 0.05 (<=443nm) →25%<br>0.025 (>443nm) →13% |

Relative errors estimated for the reflectance of 0.2

**Release threshold is achieved**

# 2.2 (b) Atmospherically corrected reflectance (RSRF)

## Comparison with BRDF models of POLDER



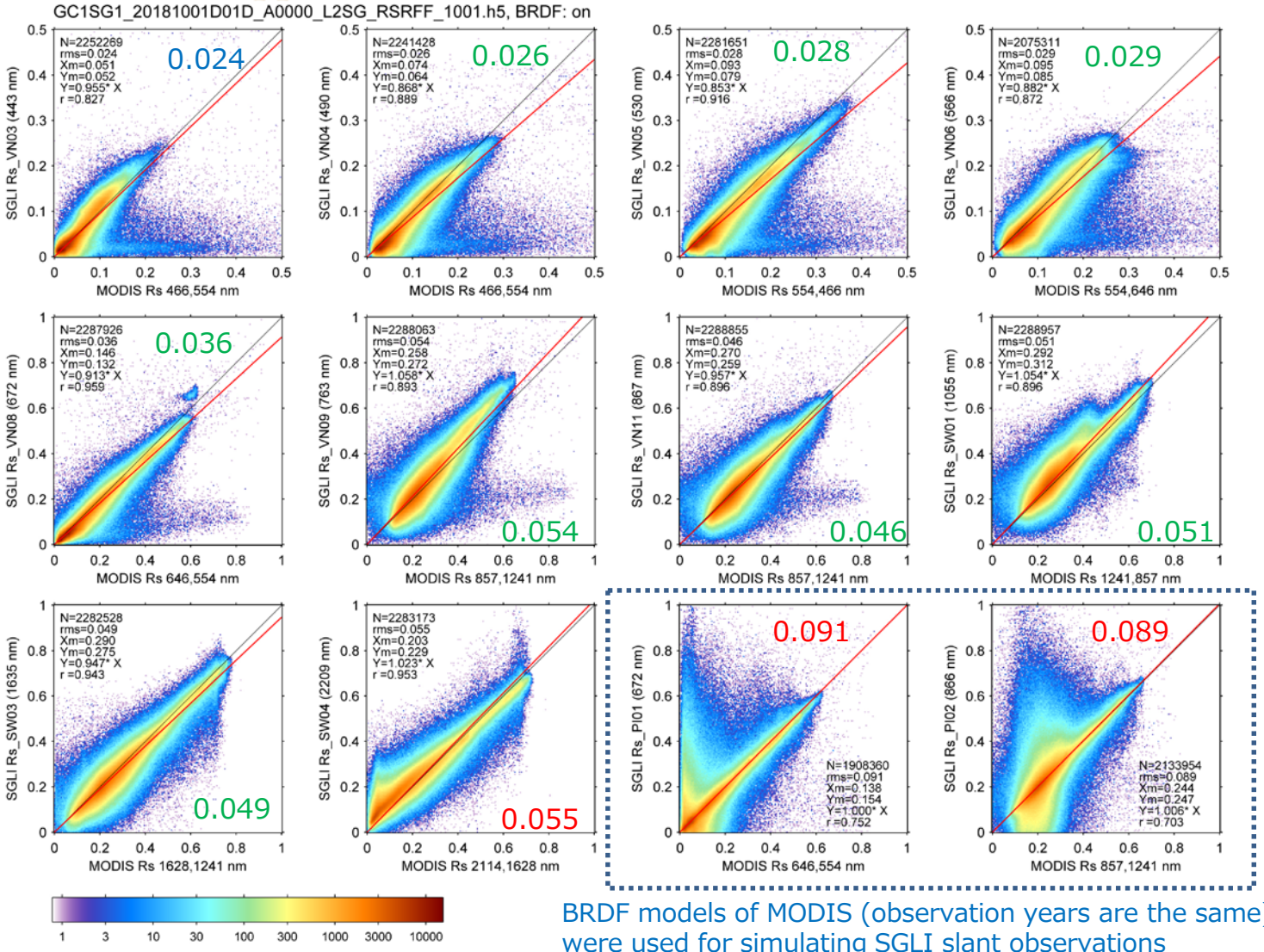

Maignan, F., et al., Polarized reflectances of natural surfaces: Spaceborne measurements and analytical modeling, Remote Sensing of Environment (2009)

BRDF models of POLDER (observation years are different) were used for simulating SGLI slant observations

- ✓ BRDF models of POLDER are derived for land cover classes with relatively homogeneous surface.
- ✓ The differences in center wavelengths of SGLI and POLDER were corrected by interpolation.
- ✓ SGLI-derived reflectances are consistent well with those of POLDER except at bare land.

# 2.2 (b) Atmospherically corrected reflectance (RSRF)

## Supplemental evaluations for slant observations




BRDF models of MODIS (observation years are the same) were used for simulating SGLI slant observations

- ✓ Comparison with MODIS-derived global BRDF products.
- ✓ The differences in center wavelengths of SGLI and MODIS were corrected by interpolation.
- ✓ **SGLI-derived reflectances are consistent well with that of MODIS within the same orders of RMS for in-situ observation.**
- ✓ **Peak and frequency were consistent well with those of MODIS with relatively large variances of slant observation bands** (*possibly due to the difference in the direction of slant observation path. That is, the line of sight of SGLI is along track whereas that of MODIS is cross-track.)

# 2. Validation Results of Land Products

## 2.2 (c) Vegetation indices (VGI: NDVI, EVI)

### Validation Method:

- Comparisons of SGLI-derived VGIs with those derived from in-situ observed spectral reflectances[*1] were made for forest and grass areas.

  *1: Comparisons were made only for the sites with a homogeneous land cover class (LCC) within one pixel (250mx250m) of SGLI after checking the homogeneity of LCC with high resolution satellite imagery

- As a supplemental evaluation, comparison with other satellite products (MODIS Terra 16-days composites [MOD13Q1]) was also made.

### Validation data and condition etc.:

- Sky-camera data were used to eliminate cloud contaminated SGLI data.
- For the in-situ sites with less observation data within the validation periods (Baganuul, BayanUnjuul, Watarase, Teshio, Lambir) 10-day composite of SGLI data was compared with in-situ data assuming that there is no change in VGIs during the composite period.
- Because there are few in-situ data for grass land, the data at Mase (LCC: Paddy) acquired during July 1st to August 30th were used for the ground truth of grass land.
- Comparisons with other satellite products were made for a date within the composite period of each products.

### Validation period:

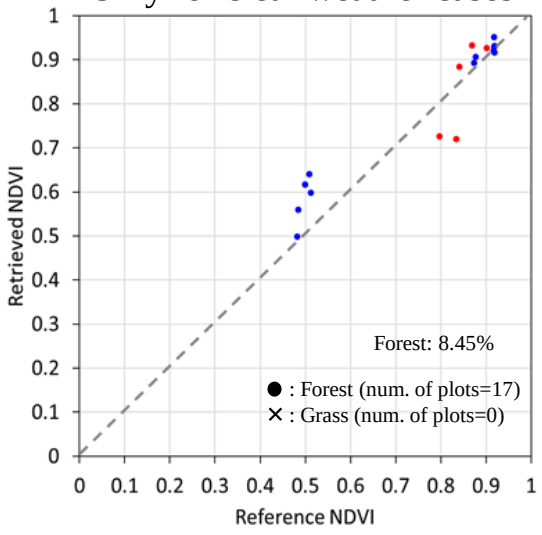
- August 22nd to October 30th 2018 for all the sites.
- April 21st to July 31st 2018 for Takayama (TKY), Fuhihokuroku (FHK) Watarase (WTR), Mase (MSE).
- The in-situ data during the period with solar zenith angle larger than 70 degree for Poker Flat Research Range (PFRR) were eliminated.
- The data on August 29, 30, and 31 were used for the comparison with MODIS products.

# 2. Validation Results of Land Products

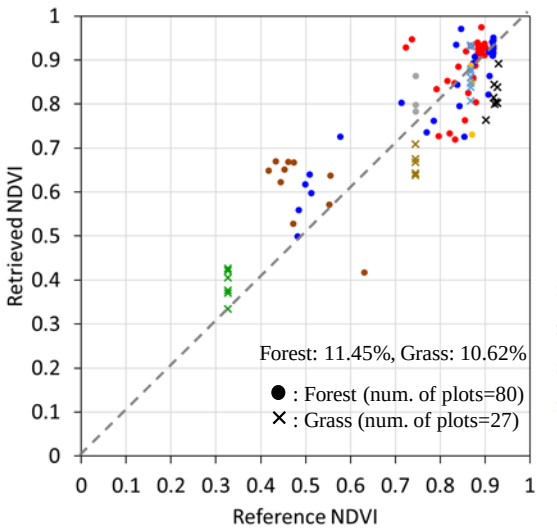
## 2.2 (c) Vegetation indices (VGI: NDVI)

Validation Results (vs. in-situ observation):

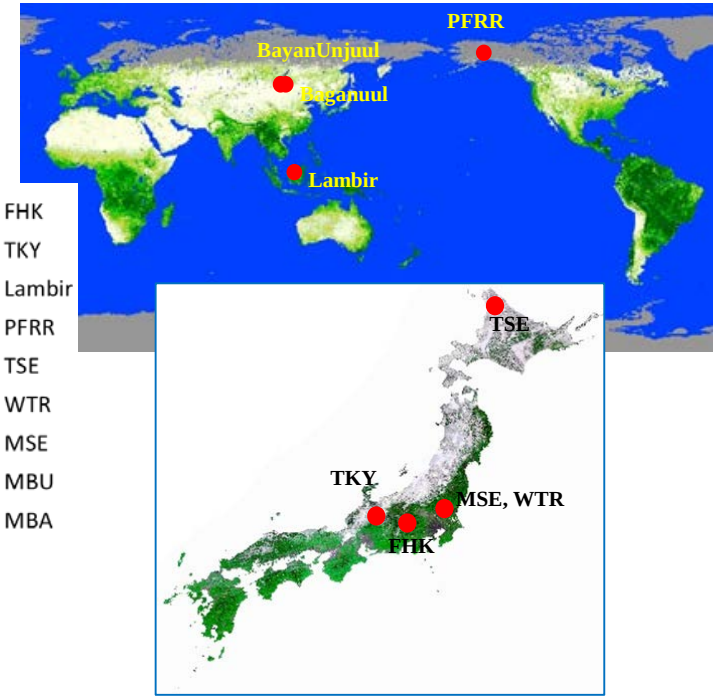
Only for clear weather cases




All cases




Location of in-situ sites




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 8 (11*1) %<br>11*1 % | 20% (Forest) scene,<br>25% (Grass) scene | 15% (Forest) scene,<br>20% (Grass) scene | 10% (Forest) scene,<br>10% (Grass) scene |

*1 Evaluated errors using all the data including potentially cloud contaminated ones

**Release threshold & Standard accuracy are achieved**

**(Remarks: The standard accuracy are achieved even using possibly cloud contaminated data. Currently there are few in-situ data for grass land. )**

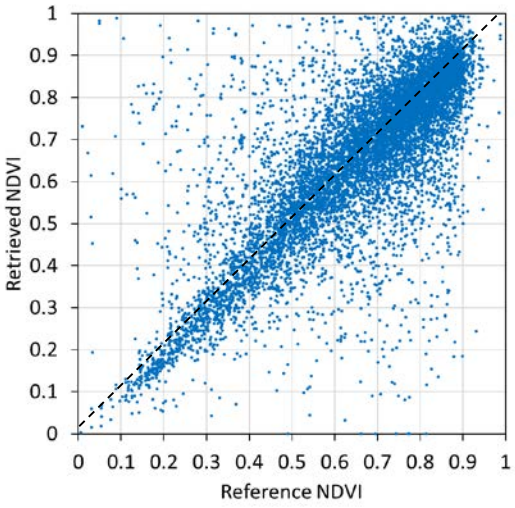
# 2. Validation Results of Land Products

## 2.2 (c) Vegetation indices (VGI: NDVI)

Validation Results (vs. other satellite product of NDVI):

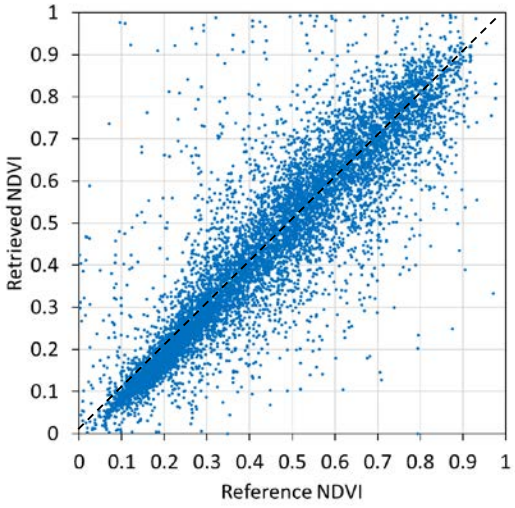
MOD13Q1

Forest




- num. of plots=9997

Grass

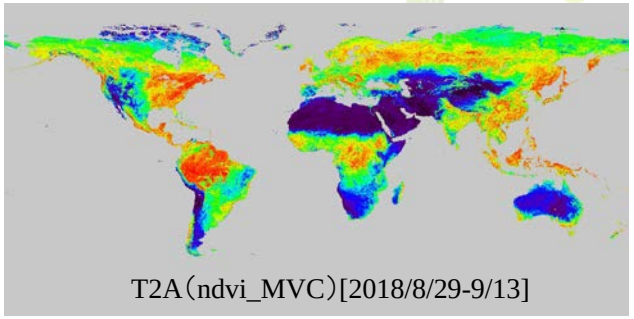



- num. of plots=10225

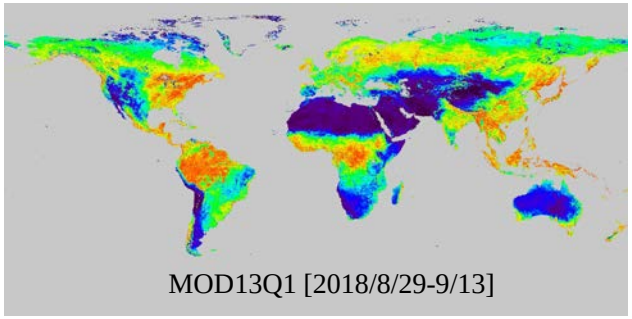
MOD13Q1: Aug.29-Sep.12 [16-day composites] vs. SGLI: Aug. 29, 30,31

Forest: GlobCover's forest class

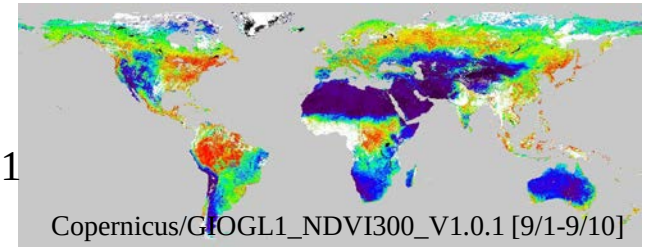
Grass: GlobCover's grass, sparse vegetation, farm classes



T2A（ndvi_MVC）[2018/8/29-9/13]



MOD13Q1 [2018/8/29-9/13]



Copernicus/GIOGL1_NDVI300_V1.0.1 [9/1-9/10]


| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 19 %<br>24 % | 20% (Forest) scene,<br>25% (Grass) scene | 15% (Forest) scene,<br>20% (Grass) scene | 10% (Forest) scene,<br>10% (Grass) scene |

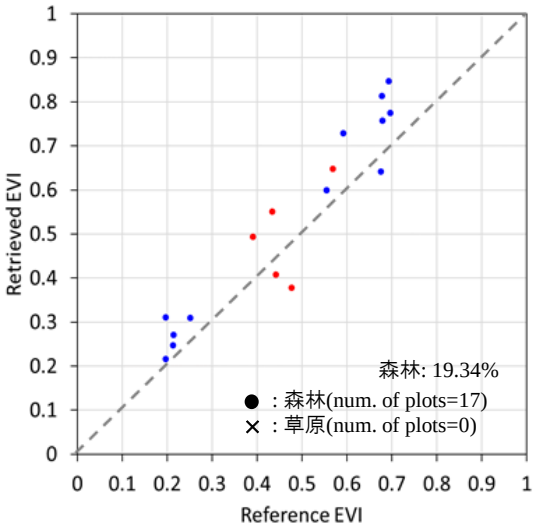
**Release threshold is achieved (vs. other satellite products)**

# 2. Validation Results of Land Products

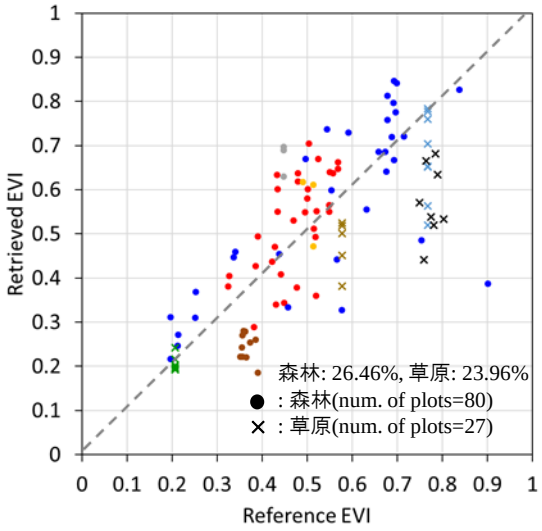
## 2.2 (c) Vegetation indices (VGI: EVI)

Validation Results (vs. in-situ observation):

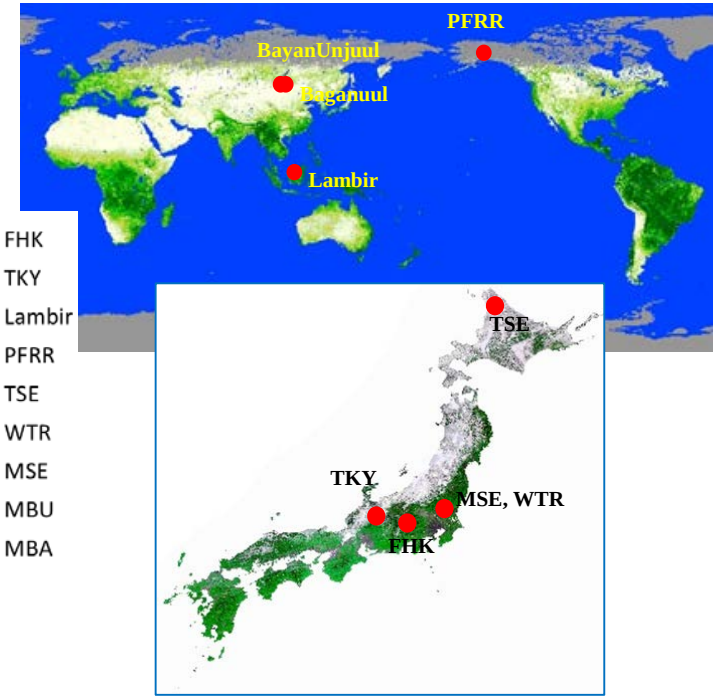
Only for clear weather cases




All cases




Location of in-situ sites




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 19(26*1) %<br>24*1 % | 20% (Forest) scene,<br>25% (Grass) scene | 15% (Forest) scene,<br>20% (Grass) scene | 10% (Forest) scene,<br>10% (Grass) scene |

*1 Evaluated errors using all the data including potentially cloud contaminated ones

**Release threshold & Standard accuracy are achieved**

**(Remarks: The standard accuracy are achieved even using possibly cloud contaminated data. Currently there are few in-situ data for grass land. )**

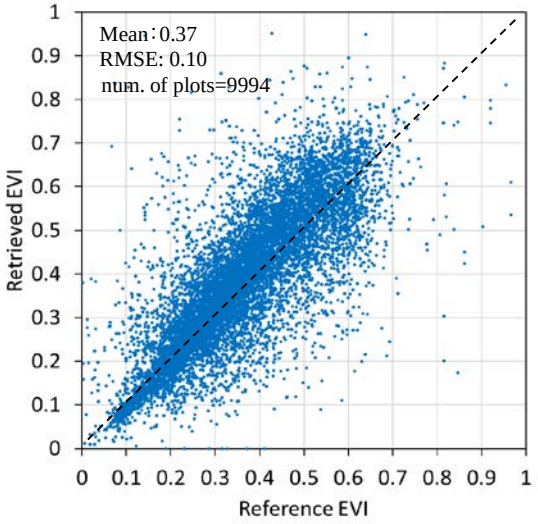
# 2. Validation Results of Land Products

## 2.2 (c) Vegetation indices (VGI: EVI)

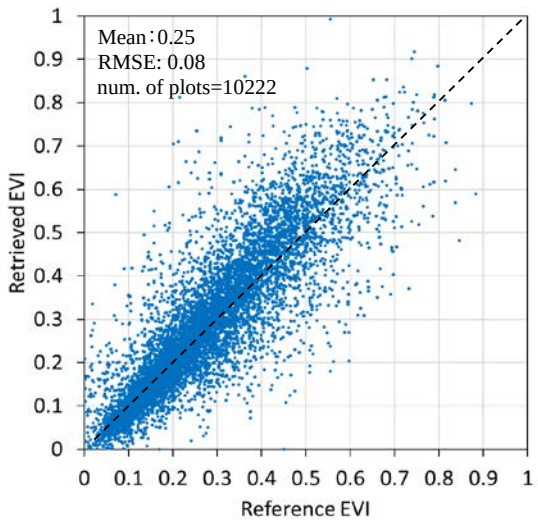
Validation Results*1 (vs. other satellite product of EVI):

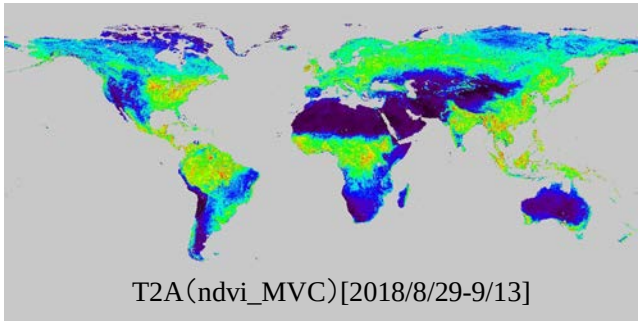
MOD13Q1

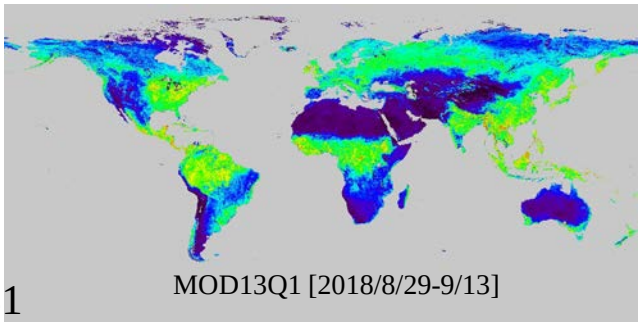
Forest




Grass




MOD13Q1: Aug.29-Sep.12 [16-day composites] vs. SGLI: Aug. 29, 30,31

Forest: GlobCover's forest class

Grass: GlobCover's grass, sparse vegetation, farm classes


*1 These are supplemental results because EVI depends on satellite zenith angle and weather condition etc.

# 2. Validation Results of Land Products

## 2.2 (d) Above-ground biomass (AGB)

Validation Method:

- Comparisons of SGLI-derived AGBs with those derived from in-situ observations were made for forest and grass areas.
- As supplemental data for the in-situ reference, AGB obtained from FOS data (http://forest-observation-system.net/) were used.
- As a supplemental evaluation, comparison with other satellite products (Global Forest Biomass Map by WUR, GlobalBiomassCarbon2000, GlobBiomass) was also made.

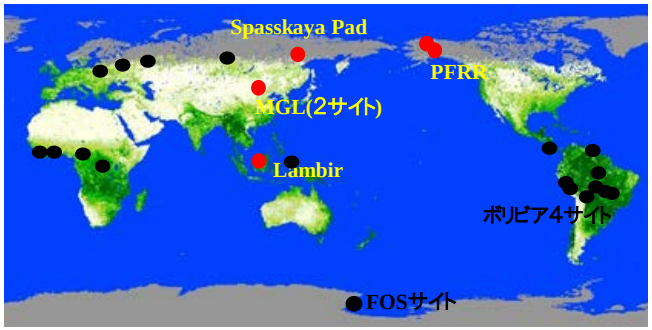
Validation data and condition etc.:

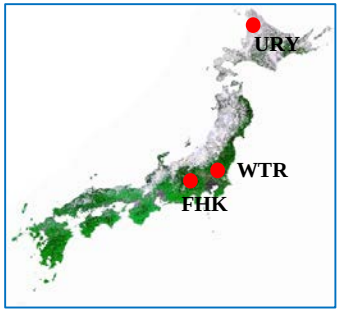
- One-month averages of SGLI AGB data were compared with in-situ data assuming that there is no change in AGBs during one-month.
- The pixels with bit-flags of low quality and probably cloudy were eliminated.
- Before the comparison with SGLI-derived AGBs, the quality of AGB data from FOS were checked and filtered in order to ensure that the value of AGB does not change even in the SGLI's spatial resolution.
- Comparison with other satellite products was made based on image appearance.

Validation period:

- August 23nd to September 25th 2018.

Location of in-situ sites

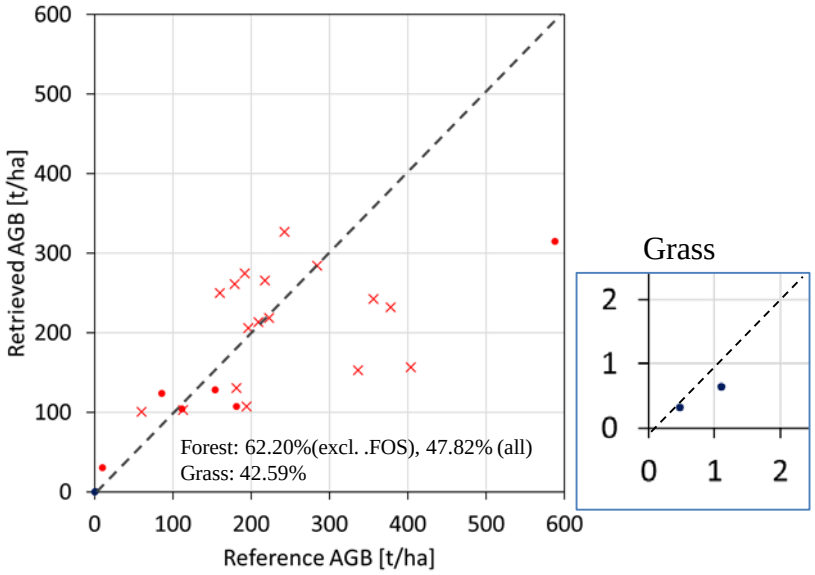


# 2. Validation Results of Land Products

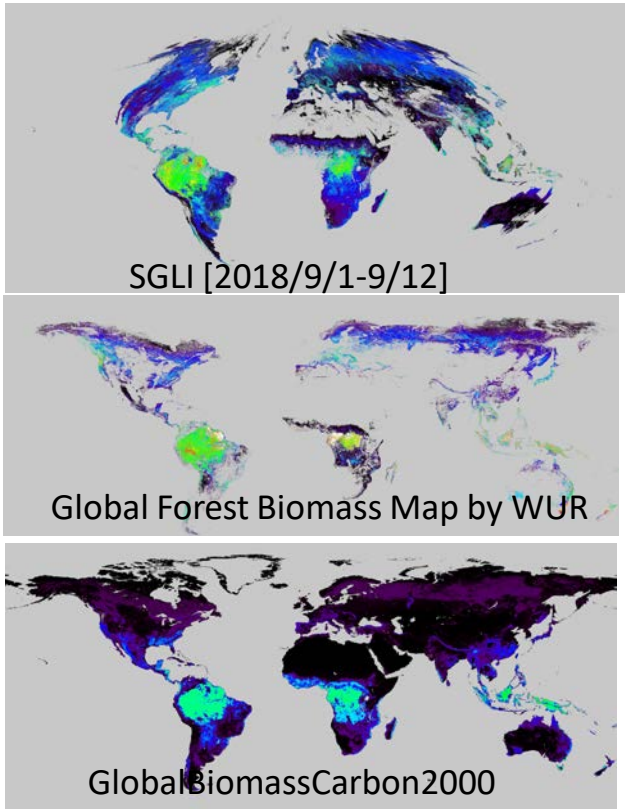
## 2.2 (d) Above-ground biomass (AGB)

### Validation Results:




● : In-situ data
× : FOS data
Forest (num. of plots=23)
Grass (num. of plots=2)

### Comparison with other satellite products




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 48 (62*1)%<br>43 % | 100% (Forest),<br>50% (Grass) | 50% (Forest),<br>30% (Grass) | 20% (Forest),<br>10% (Grass) |

*1 Results excluding FOS data

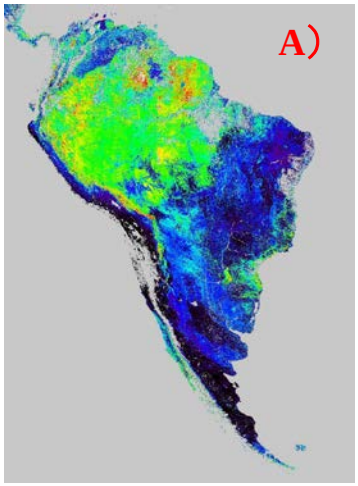
**Release threshold is achieved**

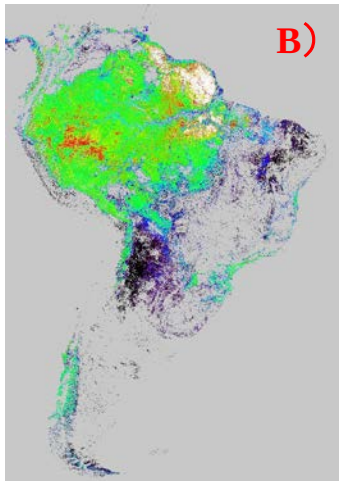
# 2. Validation Results of Land Products

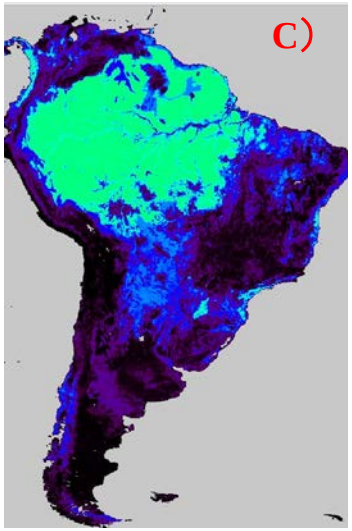
## 2.2 (d) Above-ground biomass (AGB)

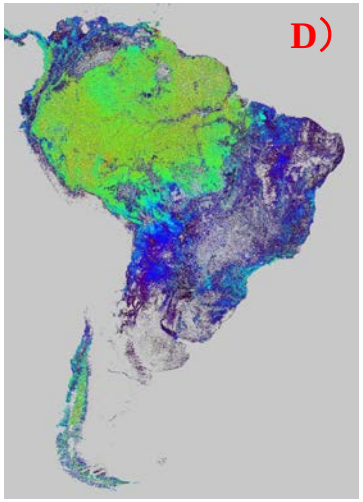
Validation Results (cont.):

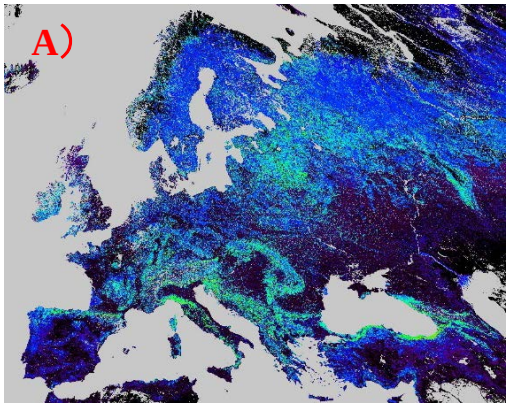
Comparison with other satellite-derived AGB products

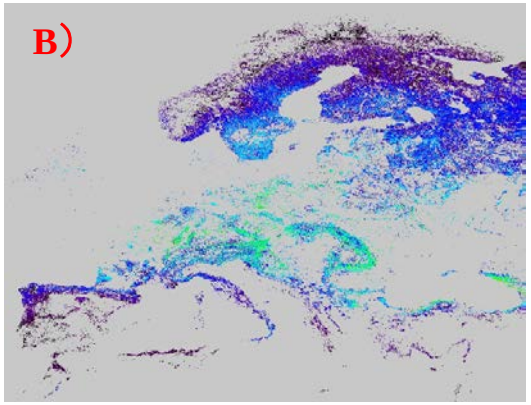


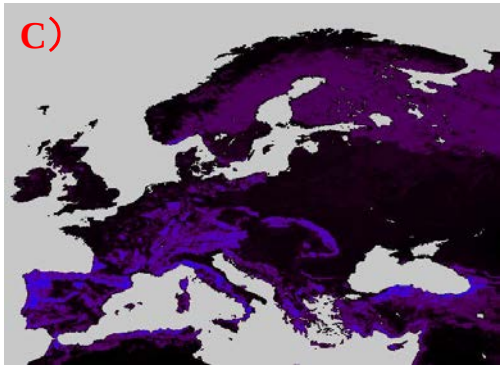



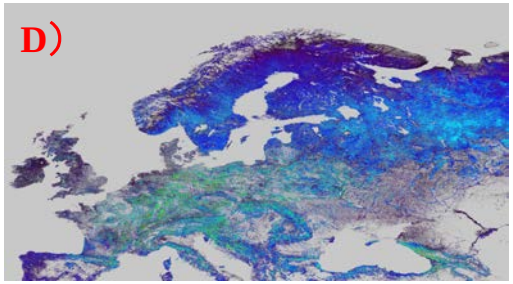





A): SGLI（averaging [9/1-12]）

B): GlobalForestBiomassMap by WUR [GEOCARBON] (forest area only)

C): New IPCC Tier1 Global Biomass Carbon Map For the Year 2000

D): DUE GlobBiomass by ESA (forest area only)

# 2. Validation Results of Land Products

## 2.2 (e) Vegetation roughness index (VRI)

Validation Method:

- Comparisons of SGLI-derived VRIs with those derived from in-situ observed directional reflectances were made for forest and grass areas.
- Due to the bad weather in 2018, there are no in-situ data obtained under clear sky conditions. That is why the comparisons were made with in-situ data obtained under cloudy conditions and other satellite products.

Validation data and condition etc.:

- In-situ VRIs were first derived from reflecnances observed at the same geometric conditions as SGLI observations using the same equation defined in the SGLI algorithm, and then compared with SGLI-derived VRIs.
- The pixels with bit-flags of low quality were eliminated.
- Due to the bad weather in 2018, evaluations were made using only the data shown below;
  - Simulated VRIs derived from MODIS/BRDF product (MCD43A1) acquired on October 28, 2018 using only the reflectances at the same geometric conditions as those of SGLI.
  - In-situ derived VRIs calculated from BRDF data acquired at Watarase on May 21, 2018 under cloudy conditions (Only the SGLI and in-situ data with the same sensor zenith angle of within ±5 degree were used for comparison).

Validation period:

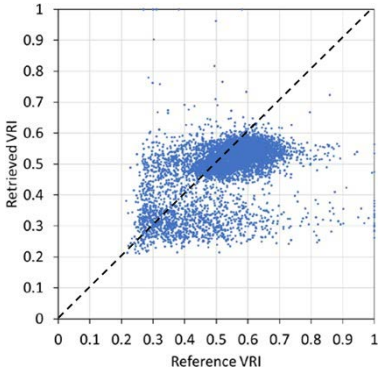
- October 28$^{th}$, November 3$^{rd}$ 2018 (vs. MCD43A).
- May 1$^{st}$ to June 10$^{th}$ 2018 (vs. Watarase).

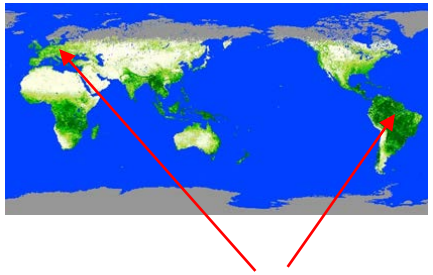
# 2. Validation Results of Land Products

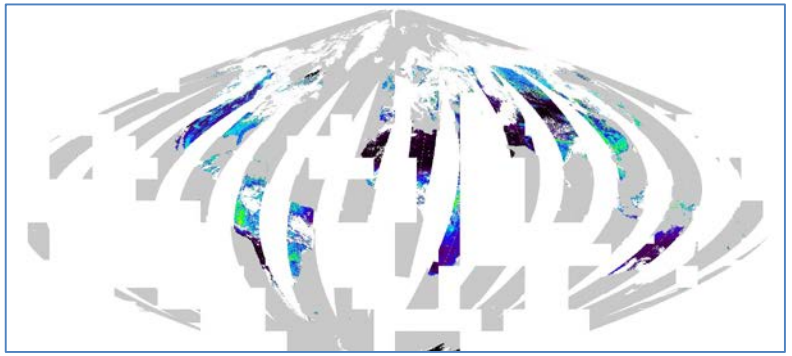
## 2.2 (e) Vegetation roughness index (VRI)

### Validation Results:

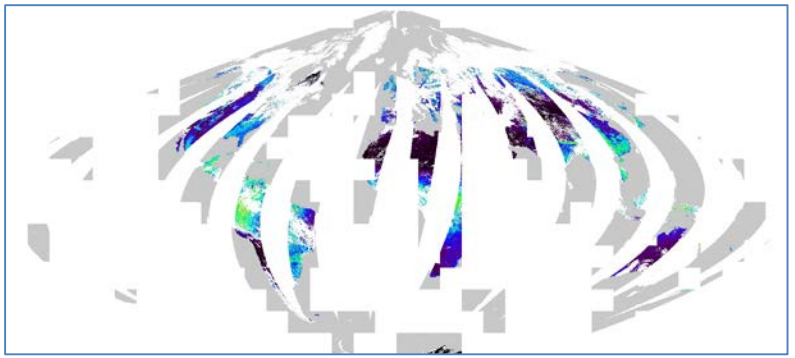
Comparison with VRIs derived from MCD43A1



SGLI/VRI [2018/10/28]

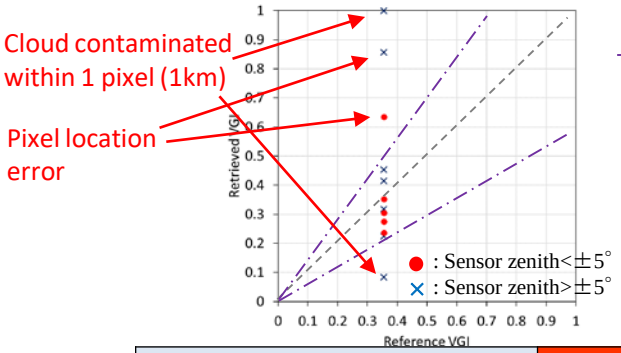


MCD43A1/VRI

*The error pixels of SGLI data were eliminated in the comparison.

VRI 0 — 1

Comparison with in-situ derived VRIs at Watarase under cloudy condition




*By eliminating the pixels with cloud contamination and/or pixel location errors, the estimated errors become 23.26% (below the release threshold) .

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 21*1, 23*2% | 40% (Forest, Grass) Scene | 20% (Forest, Grass) Scene | 10% (Forest, Grass) Scene |

*1 Results compared with MCD43A1 data, *2 Result compared with in-situ data at Watarase under cloudy condition.

**Release threshold is achieved**

# 2. Validation Results of Land Products

## 2.2 (f) Shadow index (SDI)

Validation Method:

- Comparisons of SGLI-derived SDIs with those derived from in-situ observation data were made for forest and grass areas.

Validation data and condition etc.:

- First, direct solar radiation for each SGLI scene was simulated using the Numerical digital surface model (DSM)*1 (spatial resolution of approx. 50 cm) provided from USGS 3 Dimensional Elevation Programme (3DEP). Second, the areas with zero solar radiation were identified as shadow and integrated to calculate the areal fraction of shadow within one pixel of SGLI. Then, the areal fraction was used as ground truth.
  *1: The DSM was derived from lidar observation data obtained from 2015 to 2018.
- Only the pixels meeting the following conditions were used for validation;
  - NDVI > 0.65
  - The pixel is not adjacent to cloudy pixels
  - Satellite zenith angle < 8 deg.

Validation period:

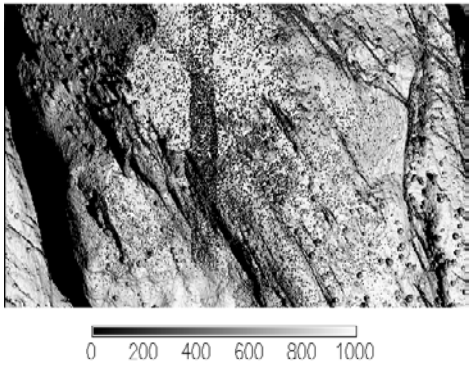
- June to October 2018

Data for validation

| Name | SGLI TILE | Rows x cols | Date of SGLI obs. (# of scenes) |
|---|---|---|---|
| WalnutGulch, AZ | V05H08 | 27 x 76 | 2018/08/25 – 09/24 (2) |
| Mesa, CO | V05H09 | 12 x 10 | 2018/06/18 – 09/24 (10) |
| Olgalake, MI | V04H11 | 18 x 32 | 2018/06/02 – 10/16 (18) |
| Glacier NP., MT | V04H10 | 35 x 60 | 2018/06/05 – 09/20 (17) |
| Zion NP., UT | V05H09 | 17 x 14 | 2018/06/02 – 09/27 (6) |
| Zion NP. 2, UT | V05H09 | 26 x 35 | 2018/06/02 – 09/27 (6) |

# 2. Validation Results of Land Products

## 2.2 (f) Shadow index (SDI)



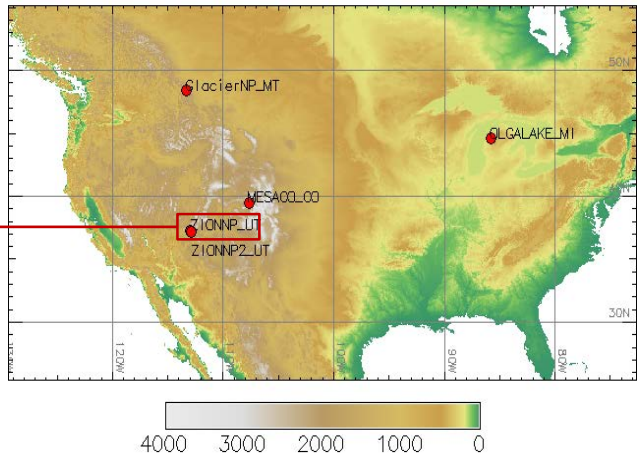

Simulated direct solar radiation (W/m$^2$)

Direct solar radiation simulated from DSM around Zion NP. site

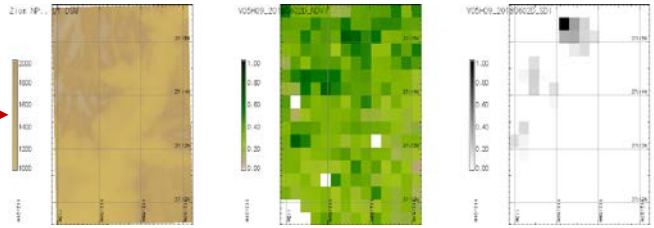
↓

The area with 0 W/m$^2$ is identified as shadow.

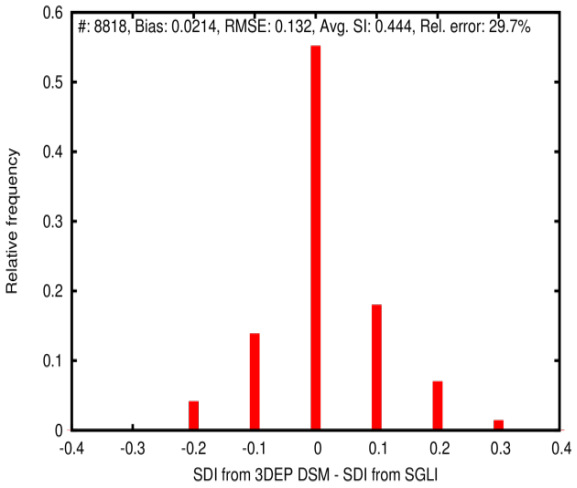
## Validation Results:



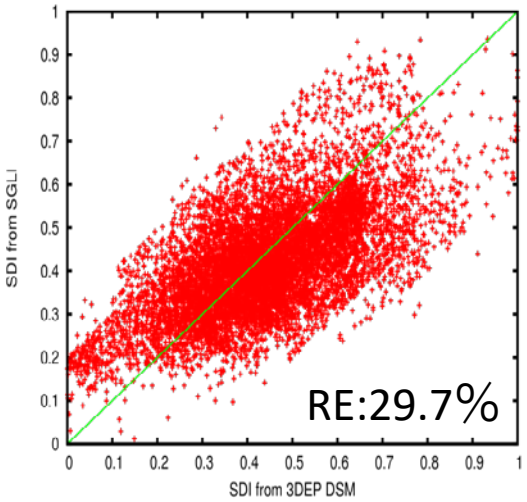

Location of validation sites



DSM (left), NDVI (mid), and SDI (right) at Zion NP. site




Frequency distribution of the differences between in-situ and SGLI data




Comparison results

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 30% | Grass, Forest: 30% | Grass, Forest: 20% | Grass, Forest: 10% |

**Release threshold is achieved**

# 2. Validation Results of Land Products

## 2.2 (g) Fraction of absorbed PAR (FAPAR)

Validation Method:

- Comparisons of SGLI-derived FAPARs with those derived from in-situ observation data (PAR meter and spectroradiometer) were made for forest and grass areas.
- As supplemental data for the in-situ reference, FAPARs obtained from other satellite products (Copernicus/GIOGL1_FAPAR) and those obtained from the literatures published in the past were used.

Validation data and condition etc.:

- Ten-day averages of SGLI FAPAR data were compared with in-situ data assuming that there is no change in FAPARs during ten days.
- Comparisons of SGLI-FAPARs with other satellite products were made for same composite periods and with the same definition of FAPAR that is the sum of the green FAPARs derived for the upper and lower layers.
- Discrimination of forest and grass was done using an existed land cover map (GlobCover).
- When comparing SGLI-FAPARS with in-situ derived ones which include the effects of stems and branches, SGLI-FAPARs were converted to the ones with the same definition as the in-situ data and then compared.
- When the temporal period of data acquisition were different between SGLI-FAPARs and in-situ derived ones including those from the past literatures, the temporal consistency of FAPAR was confirmed using SGLI-NDVI and other satellite products.

Validation period:

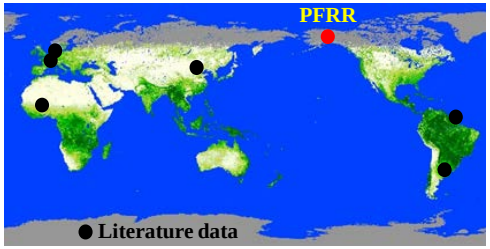
- Sep. 1st to 12th 2018 (vs. GIOGL1_FAPAR).
- Sep. 1st to 10th*1 2018 (vs. in-situ data and literatures).
- Apr. 21st to Jul. 31st 2018 (vs. in-situ data obtained at Fujihokuroku (FHK), Watarase (WTR), Takayama (TKY), Fujiyoshida (FJY)).

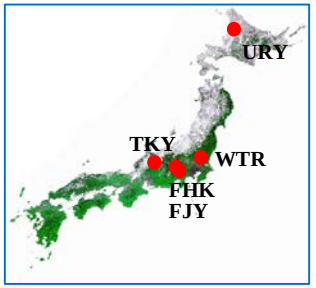
*1 When there is no SGLI-derived FAPARs during the period, SGLI data of 10-day before and after the period were used for comparison. Temporal consistency of FAPAR during the comparison period was confirmed using NDVI and other satellite-derived LAIs.

# 2. Validation Results of Land Products

## 2.2 (g) Fraction of absorbed PAR (FAPAR)

Location of in-situ sites and literatures' sites

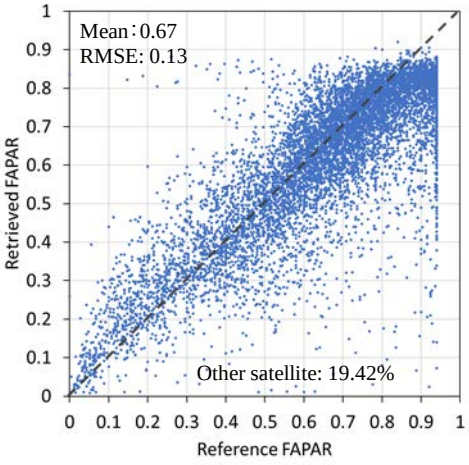



## Validation Results:

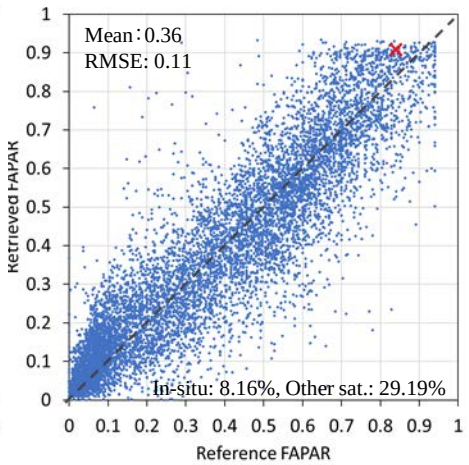
Comparison results for green FAPAR of Upper + Lower layer

Forest



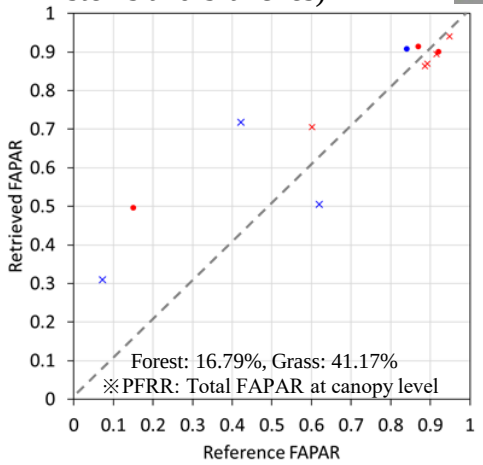

● :GEOV (num. of plots=9196)

Grass




● :GEOV (num. of plots=8883)
× :In-situ (num. of plots=1)

Comparison results for total FAPAR (incl. the effects of stems and branches)




● : In-situ data
× : Literatures
Forest (num. of plots=8)
Grass (num. of plots=4)

Forest: GlobCover's forest class
Grass: GlobCover's grass, sparse vegetation, crop land classes

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 19 (17[*1])%<br>41% [in-situ + literature], 29%[other satellite] | 50% (Forest),<br>50% (Grass) | 20% (Forest),<br>30% (Grass) | 10% (Forest),<br>20% (Grass) |

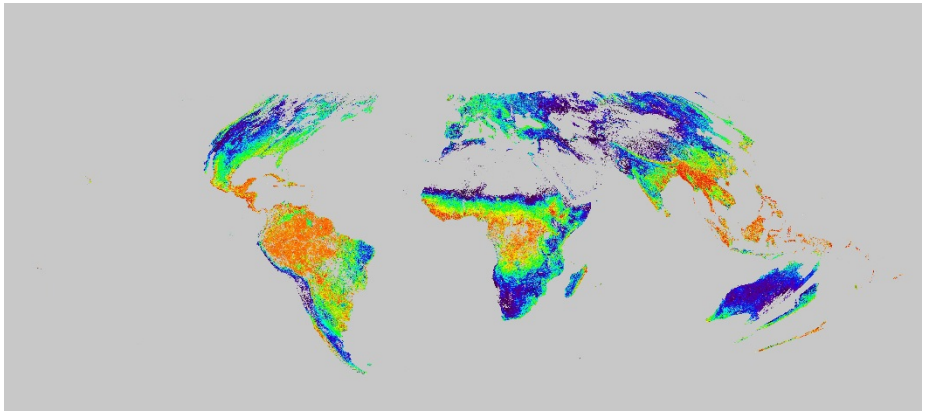
[*1] As total FAPAR

**Release threshold is achieved**

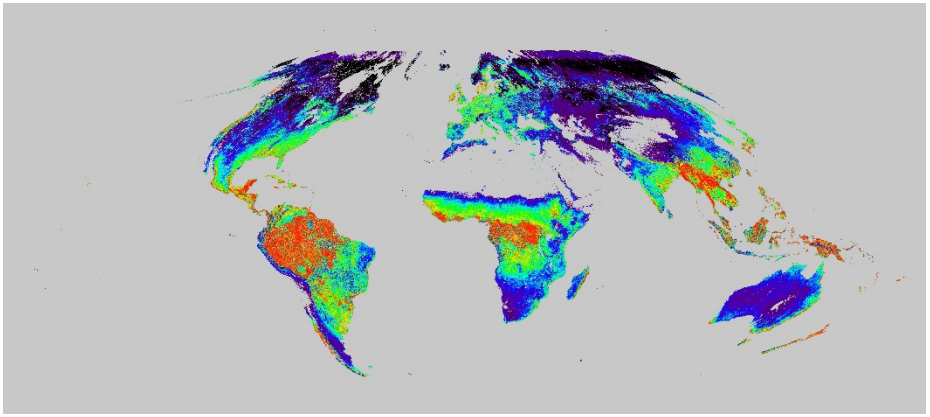
# 2. Validation Results of Land Products

## 2.2 (g) Fraction of absorbed PAR (FAPAR)

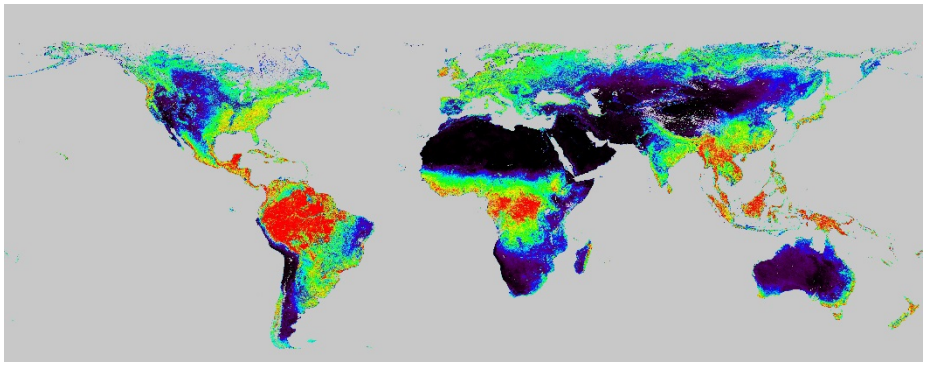
FAPAR retrieved results (Comparison with other satellite products




T2A（fapar_MVC）[2018/11/1-11/8]



MCD15A2H [2018/11/1-11/8]



Copernicus/GIOGL1_LAI300_V1.0.1 [10/20]

- ✓ MCD15A2H: Nov. 1st-8th [8-days composite with maximum FAPAR, 500m]
- ✓ GIOGL1: Oct. 11th-20th 2018 [10-day composite with MV (vza/sza), 300m]

- ➢ Spatial distribution of SGLI (T2A) is consistent with other satellite products.

# 2. Validation Results of Land Products

## 2.2 (h) Leaf area index (LAI)

### Validation Method:

- Comparisons of SGLI-derived LAIs with those derived from in-situ observation data (LAI-2000 and spectroradiometer) were made for forest and grass areas.
- As supplemental data for the in-situ reference, LAIs obtained from other satellite products (Copernicus/GIOGL1_LAI) and those obtained from the literatures published in the past were used.

### Validation data and condition etc.:

- Ten-day averages of SGLI LAI data were compared with in-situ data assuming that there is no change in LAIs during ten days.
- Comparisons of SGLI-LAIs with in-situ data and other satellite products for the confirmation of the release threshold achievement were made for the total LAI (the sum of LAIs of upper layer and that of lower layers), and also for the upper layer LAI as a supplemental data at the present. In future, the achievement of the accuracies for the upper layer LAI is a goal of the SGLI LAI products.
- Discrimination of forest and grass was done using an existed land cover map (GlobCover).
- When comparing SGLI-FAPARS with in-situ derived ones which include the effects of stems and branches, SGLI-FAPARs were converted to the ones with the same definition as the in-situ data and then compared.
- When the temporal period of data acquisition were different between SGLI-FAPARs and in-situ derived ones including those from the past literatures, the temporal consistency of FAPAR was confirmed using SGLI-NDVI and other satellite products.
- In-situ data and other satellite products were used for the total LAI evaluation, and in-situ data and literature data were used for that of upper layer LAI.
- The comparisons with other satellite products were done for the same composition period. When the temporal period of data acquisition were different between SGLI-LAIs and in-situ derived ones including those from the past literatures, the temporal consistency of LAI was confirmed using SGLI-NDVI and other satellite products.

### Validation period:

- Sep. 1st to 12th 2018 (vs. GIOGL1_LAI).
- Sep. 1st to 10th*1 2018 (vs. in-situ data and literatures).
- Apr. 21st to Jul. 31st 2018 (vs. in-situ data obtained at Fujihokuroku (FHK), Watarase (WTR).

*1 When there is no SGLI-derived FAPARs during the period, SGLI data of 10-day before and after the period were used for comparison. Temporal consistency of FAPAR during the comparison period was confirmed using NDVI and other satellite-derived LAIs.

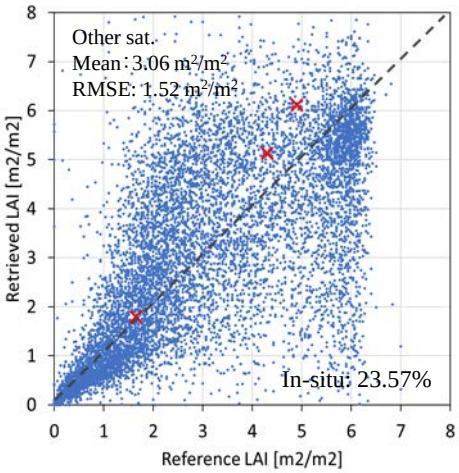
# 2. Validation Results of Land Products

## 2.2 (h) Leaf area index (LAI)

## Validation Results:

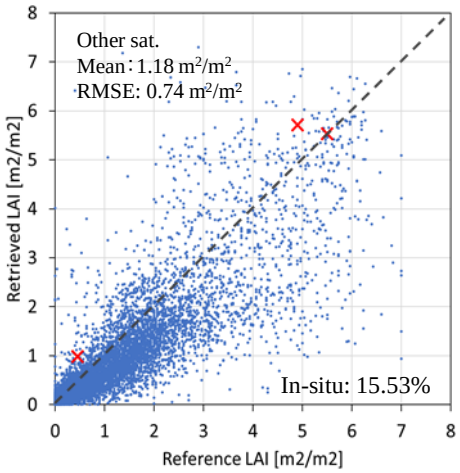
Comparison results for LAI of upper and lower layers

Forest



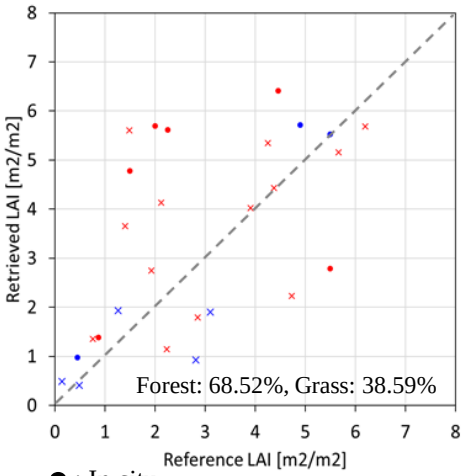

● :GEOV (num. of plots=9199)
× :In-situ (num. of plots=3)

Grass




● :GEOV (num. of plots=8889)
× : In-situ (num. of plots=3)

Comparison results for LAI f upper layer

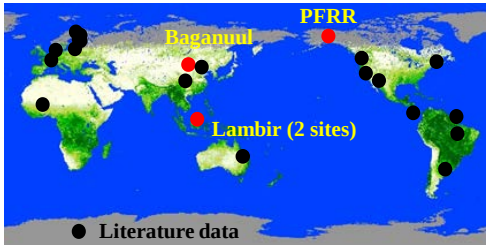


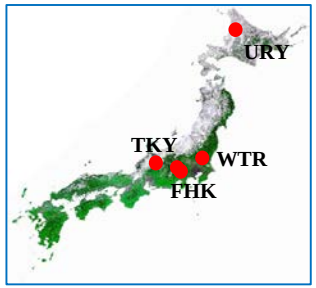

● : In-situ
× : Literature

Forest (num. of plots=19)
Grass (num. of plots=8)

Forest: GlobCover's forest class
Grass: GlobCover's grass, sparse vegetation, crop land classes

Location of in-situ sites and literatures' sites




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 24%(69%*1) [in-situ]<br>39%[in-situ + literature] | 50% (Forest),<br>50% (Grass) | 30% (Forest),<br>30% (Grass) | 20% (Forest),<br>20% (Grass) |

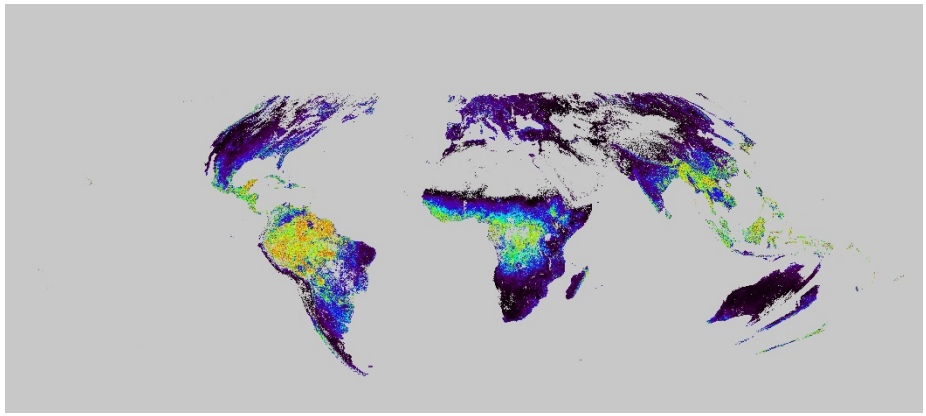
*1As LAI of upper layer (canopy_LAI)

**Release threshold is achieved**

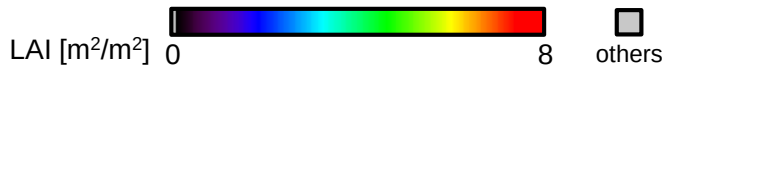
# 2. Validation Results of Land Products

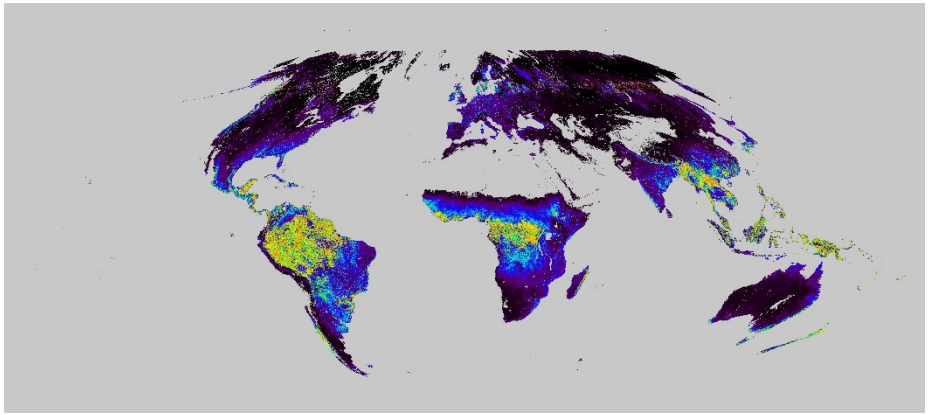
## 2.2 (h) Leaf area index (LAI)

LAI retrieved results (Comparison with other satellite products

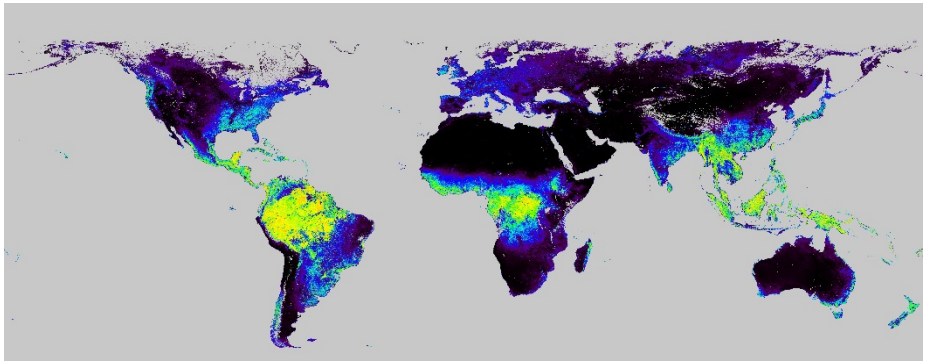


T2A（fapar_MVC）[2018/11/1-11/8]



MCD15A2H [2018/11/1-11/8]



Copernicus/GIOGL1_LAI300_V1.0.1 [10/20]

- ✓ MCD15A2H: Nov. 1st-8th [8-days composite with maximum FAPAR, 500m]
- ✓ GIOGL1: Oct. 11th-20th 2018 [10-day composite with MV (vza/sza), 300m]

- ➢ Spatial distribution of SGLI (T2A) is consistent with other satellite products.

# 2. Validation Results of Land Products

## 2.2 (i) Land surface temperature (LST)

### Validation Method:

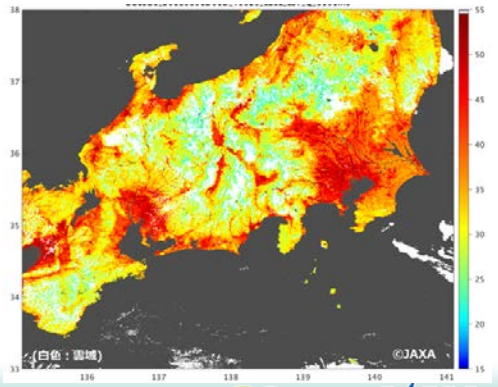
- Comparisons of SGLI-derived LSTs with other satellite products (MOD11C1: Daily global product of MODIS) were made using the equation (1) shown below.
- Comparisons of SGLI-derived LSTs with those derived from in-situ observation data (brigntness temperature estimated from the data of thermal radiometer at ground sites taking into account the emissivity of the surface) were made using the equation (1).

Evaluation variable: $$RMSE[K] = \sqrt{\frac{\sum(S(i)-T(i))^2}{N}} \quad (1)$$

N: the number of observation data
$S(i)$: SGLI-derived LST
$T(i)$: LST derived from in-situ data

### Validation data and condition etc.:

- When comparing with MOD11C1 (pixel size is approx. 5 km), SGLI LST data of 250 m resolution were averaged to have the same pixel size. Other conditions for the comparison are the following;
  - Observation time difference between SGLI and MODIS is less than 10 min.
  - Valid MODIS LST data: the lowest two bits of the MODIS QC flag are '00'.
  - Valid SGLI LST data (see QA flag and Mask_for_statistics of SGLI products)
- In addition, SGLI-derived LST data were compared with in-situ data at Mase and Fujihokuroku (emissivity is assumed to be 0.98 for both sites) which were acquired within the time difference of 15 minitues from the SGLI observations. Other QC conditions for in-situ data are the following;
  - Conversion residuals of SGLI are less than 1 Kelvin.
  - In-situ data are also qualified with the difference of upper and lower radiation fluxes and the variations of the low fluxes within 15 min.




### Validation period:

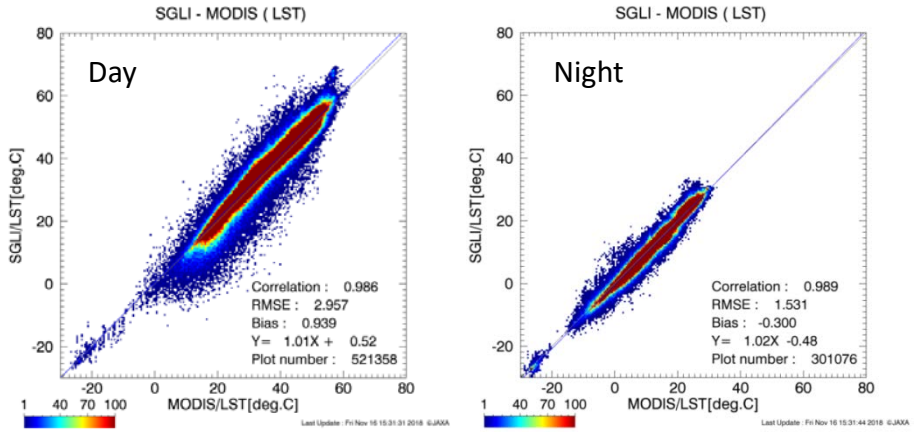
- Aug. 22nd to Sep. 17th 2018 (vs. MOD11C1).
- Mar. 14th to Sep. 28th 208 (vs. in-situ data).

# 2. Validation Results of Land Products

## 2.2 (i) Land surface temperature (LST)

### Validation Results:

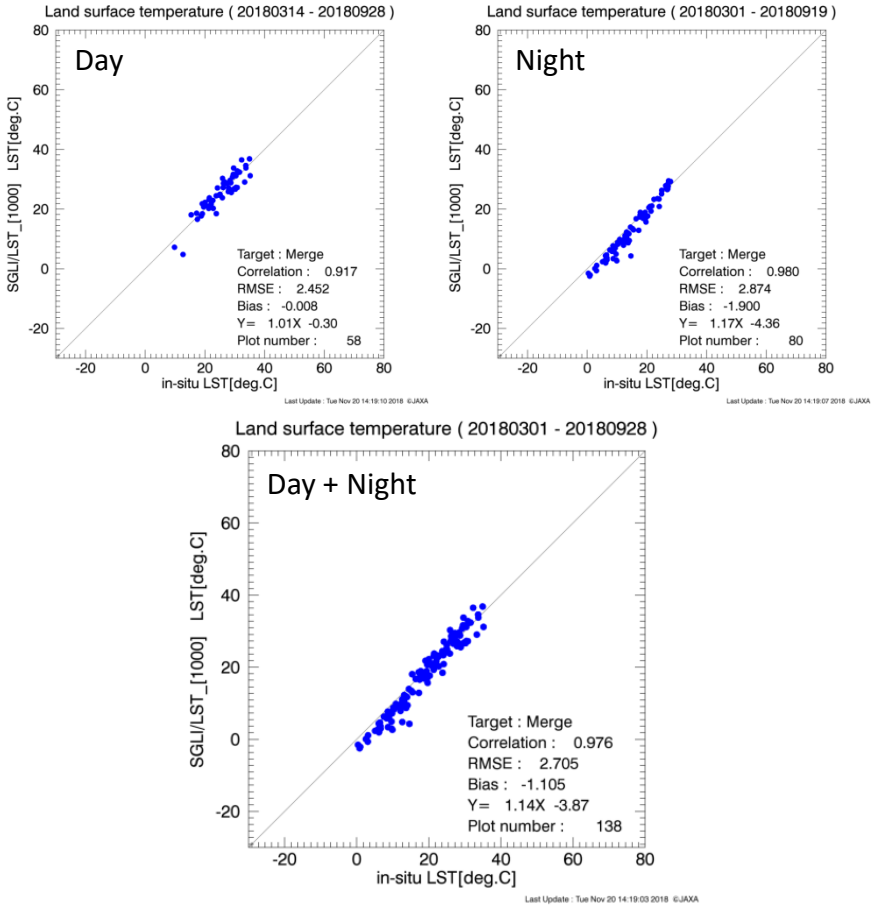
Comparison results with MODIS products (Aug. 27, 2018)




Summary (Aug.22 to Sep.17 2018)

| | RMSE Ave. [K] |
|---|---|
| Day | 2.95 |
| Night | 2.09 |
| Day + Night | 2.52 |

Comparison results with in-situ data




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 2.5 [K]@MODIS<br>2.7 [K]@in-situ | < 3.0K | < 2.5K | < 1.5K |

**Release threshold is achieved**

# 3. Validation Results of Atmosphere Products

## 3.1 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 other satellite (MODIS) data. |
| **Ice cloud optical thickness** | 30% | 70% | 20% | ○ | Comparison with other satellite (MODIS) data. |
| **Aerosol over the ocean** | 0.1 (Monthly τa_670,865) | 0.1 (scene τa_670,865) | 0.05 (scene τa_670,865) | ○ | Comparison with other satellite (MODIS) data. |
| **Land aerosol by near ultra violet** | 0.15 (Monthly τa_380) | 0.15 (scene τa_380) | 0.1 (scene τa_380 ) | ○ | Comparison with in-situ observation and other satellite (MODIS) data. |
| **Aerosol by Polarization** | 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.

# 3. Validation Results of Atmosphere Products

## 3.2 (a) Cloud flag/Classification (CLFG)

Validation Method:

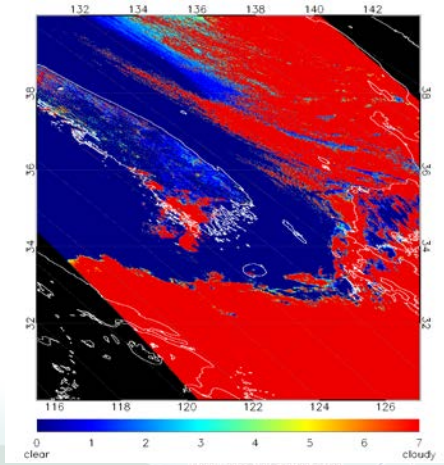
- Release Threshold: Overall classification errors are evaluated comparing SGLI derived CLFG with those derived from sky-camera images (by matching the field of view of SGLI and sky-camera).
- Standard and target accuracies: Evaluated as the classified cloud fraction product.

Validation data and condition etc.:

- In-situ data: Binary classification of clear/cloudy was applied to sky-camera images using red, green, and blue band digital data of the images. Sky-area within the field of view of 120 degree circle was used for the analysis of cloud fraction.
- SGLI data: SGLI-derived cloud flag was binary classified into clear and cloudy pixels using the data of clear probability. The areas within the circle of 6 km from the in-situ camera sites are extracted from SGLI CLFG images and analyzed to derive cloud fraction to be compared with in-situ data.

Validation period:

- Daytime: Apr. 1st to Jul. 7th 2018 for seven sites (Ny-Alesund, Sapporo, Tsukuba (JAXA), Tsukuba (Meteorological Research Institute), Kumamoto, Miyako-jima, Syowa Station at Antarctica).
- Nighttime: Apr. 1st to Sep. 1st 2018 for three sites (Sapporo, Tsukuba (JAXA), and Kitami)

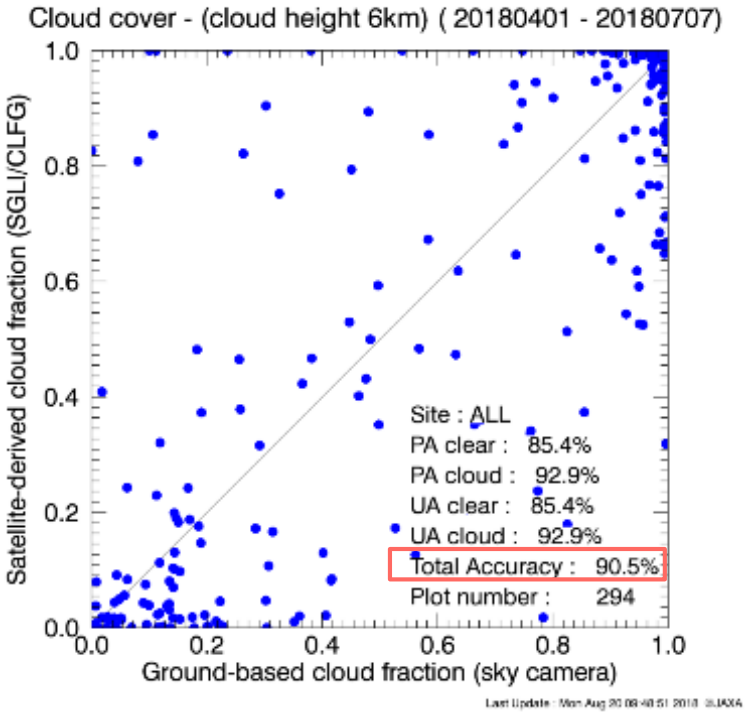


# 3. Validation Results of Atmosphere Products

## 3.2 (a) Cloud flag/Classification (CLFG)

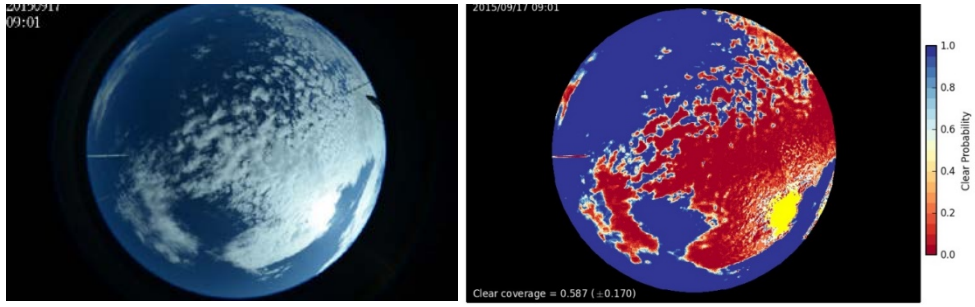
Validation Results:

Daytime

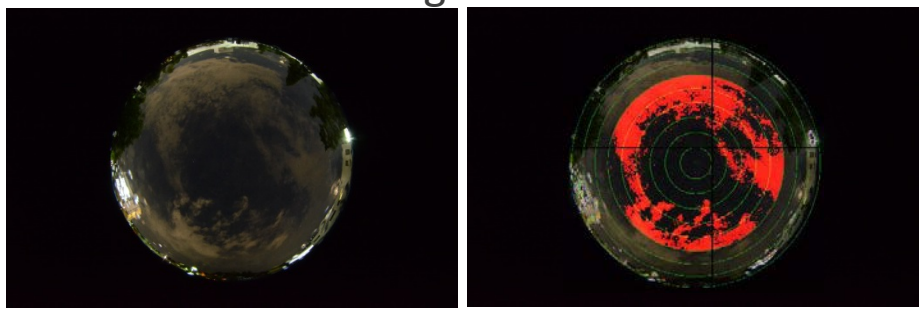



Binary classification of sky-camera images

Daytime




Nighttime



| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 9.5 % (Day)<br>8.6 % (Night) | 10 % | Evaluated as the classified cloud fraction product. | |

**Release threshold is achieved***

(*Standard and Target accuracies are also achieved evaluated as the cloud fraction product)

# 3. Validation Results of Atmosphere Products

## 3.2 (a) Cloud flag/Classification (CLFG)

Validation Results:

Supplemental slides

Results of individual sites

| 精度 Accuracies*1 | Ny-Alesund | 札幌 (Sapporo) | つくば TKSC | つくば Tsukuba | 熊本 Kumamoto | 宮古島 Miyako-jima | 昭和基地 Syowa St. | 全体 All |
|---|---|---|---|---|---|---|---|---|
| **N** | 53 | 25 | 58 | 25 | 53 | 47 | 33 | 294 |
| **$UA_{cloud}$** | 100.0 | 95.0 | 91.7 | 100.0 | 100.0 | 82.9 | 86.7 | **92.9** |
| **$PA_{cloud}$** | 92.1 | 90.5 | 100.0 | 100.0 | 82.9 | 93.5 | 96.3 | **92.2** |
| **OA** | 94.3 | 88.0 | 94.8 | 100.0 | 88.7 | 83.0 | 84.8 | **90.5** |

***1 In the case of cloud height at 6 km**

UA: User's Accuracy

PA: Producer's Accuracy

# 3. Validation Results of Atmosphere Products

## 3.2 (a) Cloud flag/Classification (CLFG)

**Supplemental slides**

### Evaluation method: BI-SI method for cloud classification

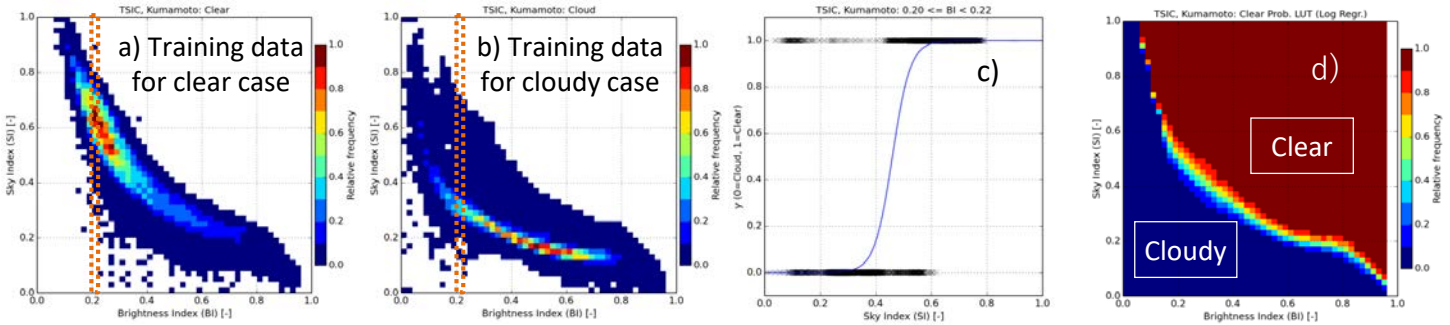



Fig X1 Example of analysis method of the Logistic regression approach. a) 2D-histogram for clear training data, b) 2D-histogram for cloudy training data, c) example of the Logistic regression curve, and d) calculated clear probability on the BI-

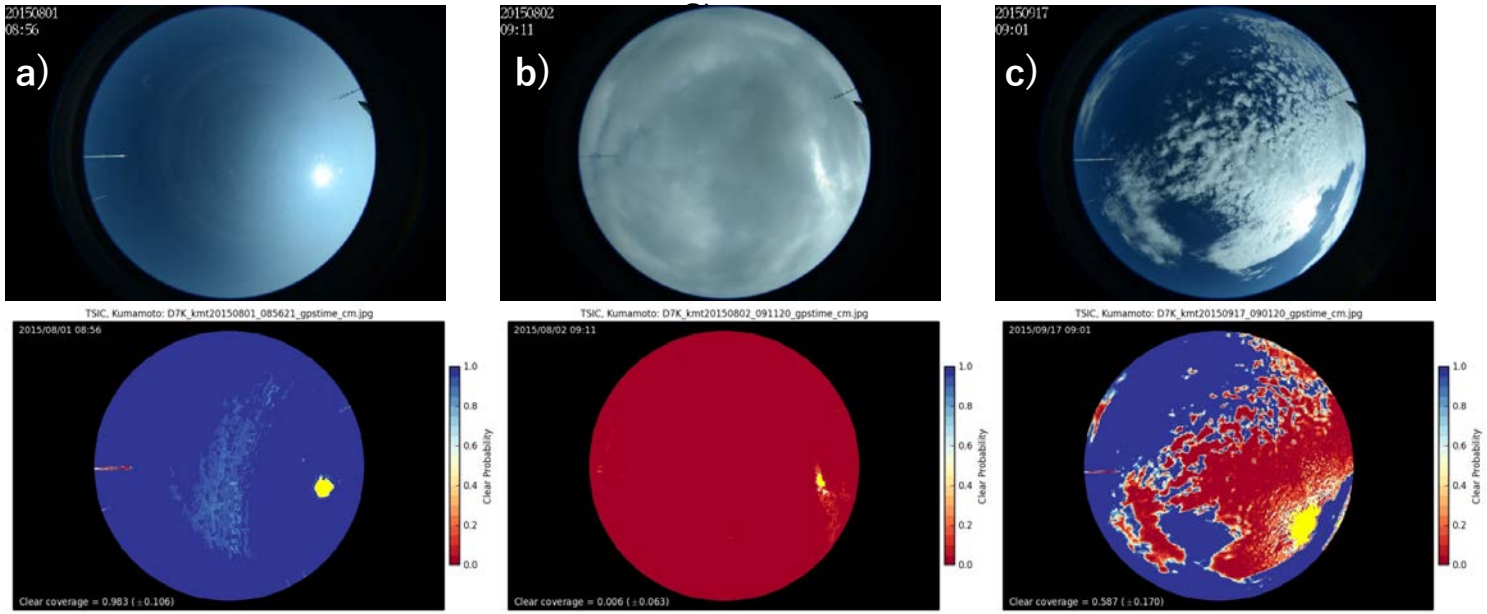



Fig X2 Examples of raw sky-camera images (upper images) and analyzed sky-camera images (lower images) for a) completely clear sky, b) completely cloudy, c) mixture of clear and cloudy.

# 3. Validation Results of Atmosphere Products

## 3.2 (b) Classified cloud fraction (CLFR)

Validation Method:

- Overall classification errors are evaluated by comparing SGLI-derived solar radiation, which is monthly average for every 0.1 degree global grids, with in-situ measured solar radiation (monthly average).

Validation data and condition etc.:

- Solar radiation was derived using SGLI cloud related products, i.e., cloud flag (CLFG), cloud properties (CLPR), atmospherically corrected land surface reflectance (RSRF) , and ancillary data (meteorological data, elevation etc.).
- When comparing with in-situ data, only the in-situ data meeting the following conditions were used in order to eliminate variable in-situ data due to the horizontal heterogeneity of clouds;
  - The time difference between SGLI and in-situ observation was less than 5 minutes.
  - Standard deviation of the in-situ data was less than 10 % of the in-situ data average.

Validation period:

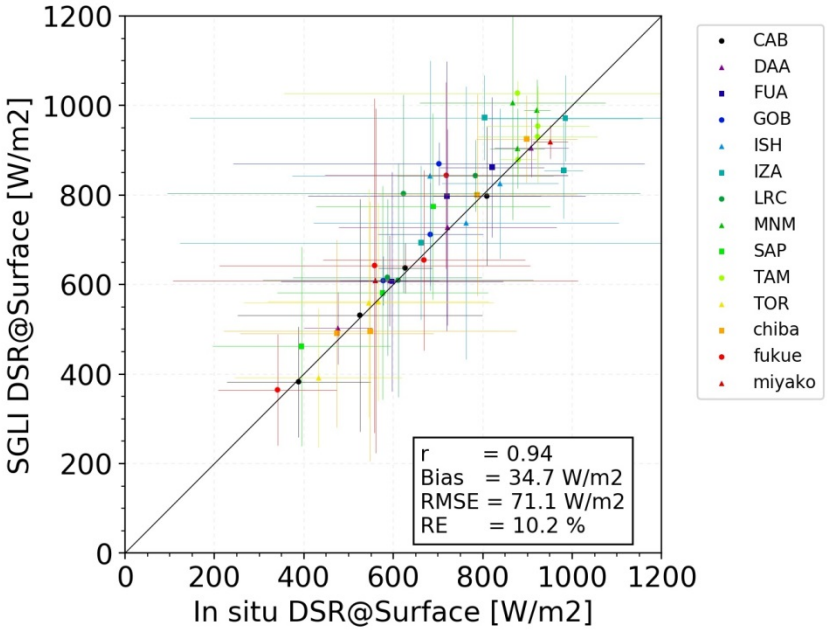
- BSRN : Jul. 1st to Oct. 31st 2018 for 22 sites
- SKYNET : Jul. 1st to Oct. 31st 2018 for 3 domestic sites

# 3. Validation Results of Atmosphere Products

## 3.2 (b) Classified cloud fraction (CLFR)

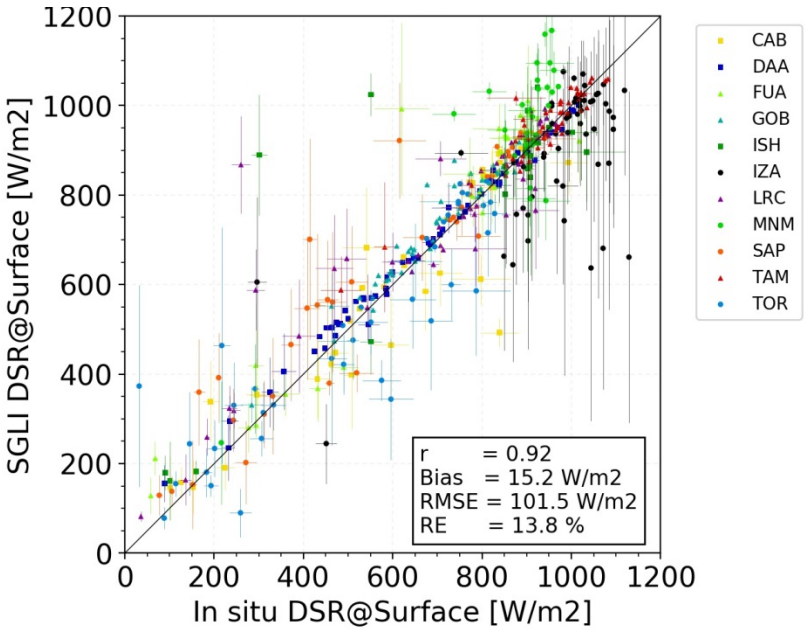
### Validation Results:

Monthly average




Supplemental: Non-monthly average

SGLI: 0.1 deg. Grid average vs. In-situ instantaneous values




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 10 % (as solar radiation) | 20% (as solar radiation) | 15% (as solar radiation) | 10%（as solar radiation) |

**Release threshold, Standard and Target accuracies are achieved***

(*Standard and Target accuracies of cloud flag/classification product are also achieved)

# 3. Validation Results of Atmosphere Products

## 3.2 (c) Cloud top temperature/Cloud top height (CLTT/CLTH)

Validation Method:

- Release threshold: Evaluated as vicarious calibration of SGLI TIR bands.
- Standard and target accuracies: Relative errors are evaluated comparing SGLI-derived cloud top temperature and height with those derived from in-situ (ground and airborne) and/or other satellite products (Terra/MODIS: MOD06 C6) for uniform liquid clouds with moderate optical thickness.

Validation data and condition etc.:

- Only the data of water clouds with MOD06 cloud optical depth larger than 5 and cloud top temperature higher than 270 K were used for comparison.

Validation period:

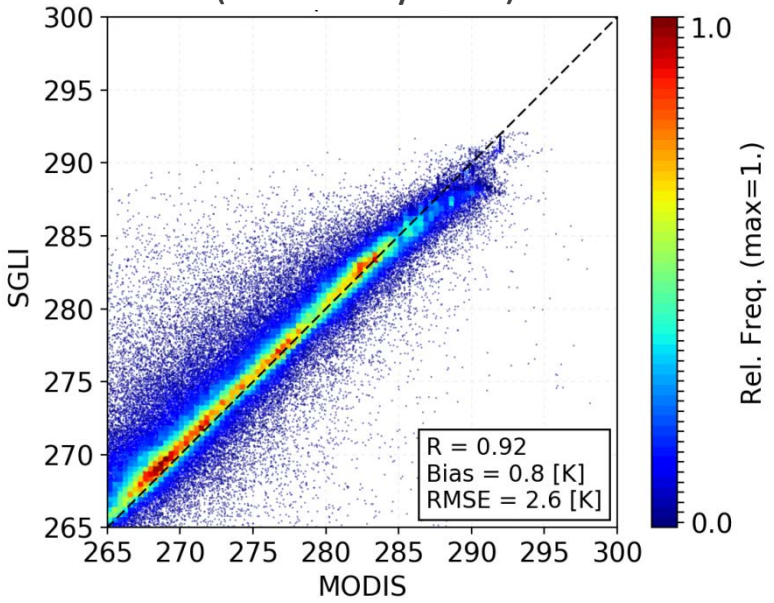
- MOD06 : Aug. 22nd to Sep. 14th 2018

# 3. Validation Results of Atmosphere Products

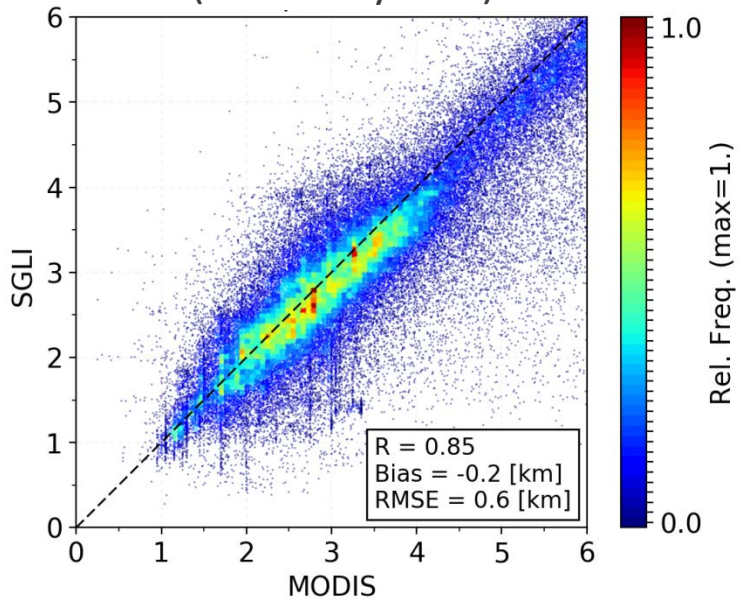
## 3.2 (c) Cloud top temperature /Cloud top height (CLTT/CLTH)

Validation Results:

Cloud top temperature
(Land: daytime)




Cloud top height
(Land: daytime)




| Estimated errors (Ocean, Land) | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| TIR band Vi. Cal.： 0.55 K | 1 K | - | - |
| Cloud top temp.: 2.1 K, 2.6 K | - | 3 K | 3 K |
| Cloud top height: 1.2 km, 0.6 km | - | 2 km | 2 km |

**Release threshold and Standard accuracy are achieved**

# 3. Validation Results of Atmosphere Products

## 3.2 (d) Water cloud optical thickness/Water cloud effective radius (CLOT_W/CLER_W)

Validation Method:

- Release threshold: Relative errors are evaluated comparing SGLI derived cloud optical thickness and effective radius with those from other satellite products (MODIS: MOD06, C6) for clouds of mid- to low latitude regions (monthly average).
- Standard accuracy: Relative errors are evaluated comparing cloud liquid water converted from SGLI derived cloud optical thickness and effective radius products with those measured with microwave radiometer on the ground.

Validation data and condition etc.:

- Only the data of MOD06 data acquired within 30 minutes from SGLI observations were used for comparison.

Validation period:

- MOD06 : Aug. 22nd to Sep. 14th 2018

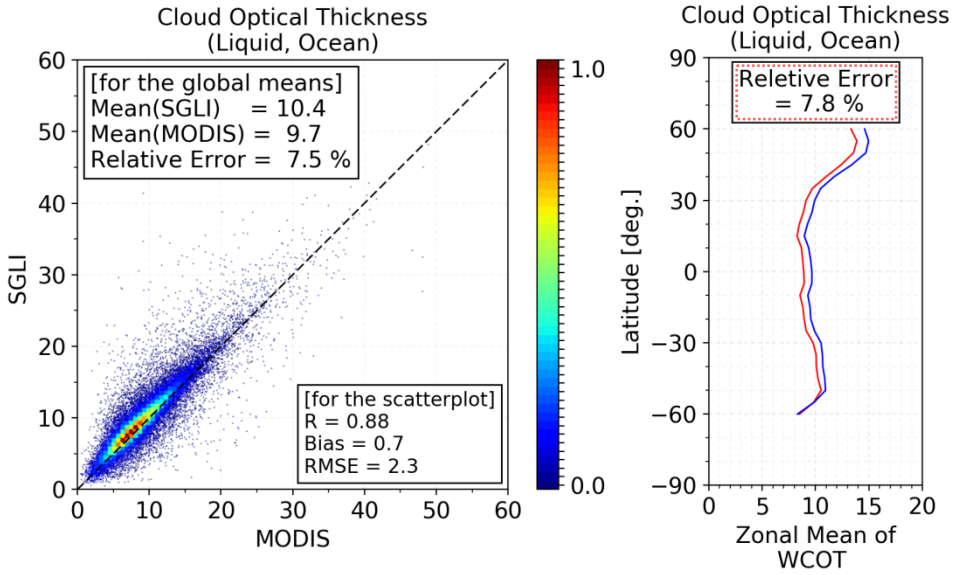
# 3. Validation Results of Atmosphere Products

## 3.2 (d) Water cloud optical thickness/Water cloud effective radius (CLOT_W/CLER_W)

### Validation Results:

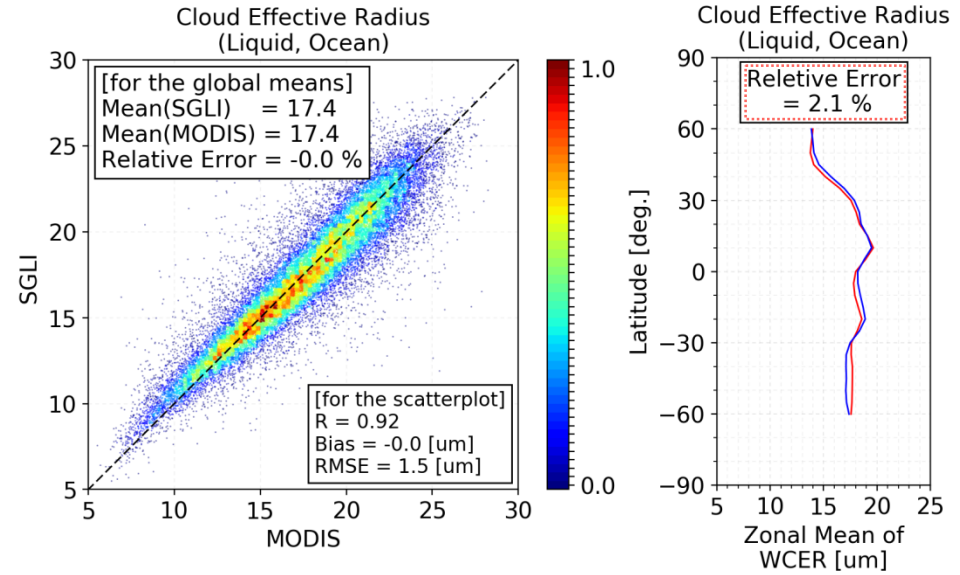
Water cloud optical thickness

(Left: One-deg. grid average over ocean, Right: zonal average)




Water cloud effective radius

(Left: One-deg. grid average over ocean, Right: zonal average)




| Estimated errors (Ocean, Land) | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| Optical thickness: 8, 9 % | 10 %* (vs. MODIS) | - | 20% (vs. in-situ obs.) |
| Effective radius: 2, 5 % | 30 %* (vs. MODIS) | - | - |
| Cloud liquid water: -, - | - | 100 % (vs. in-situ obs.) | 50% (vs. in-situ obs.) |

*As monthly average of mid- to low latitude regions

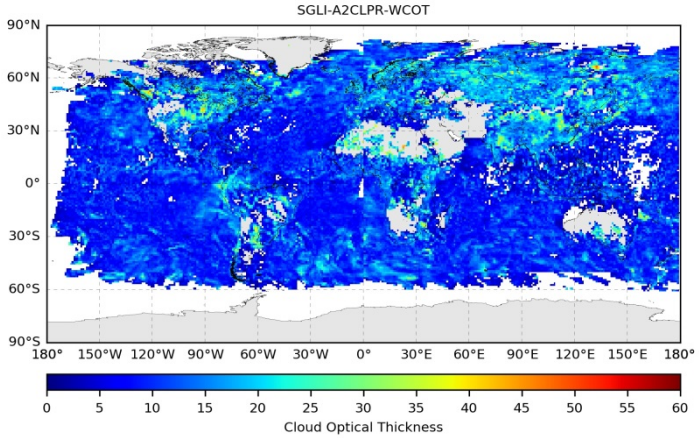
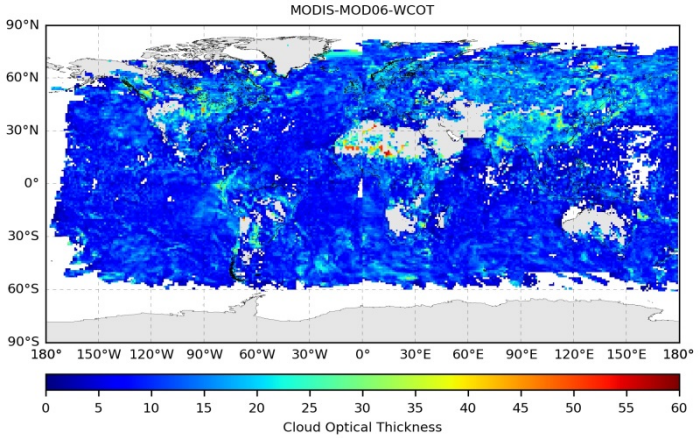
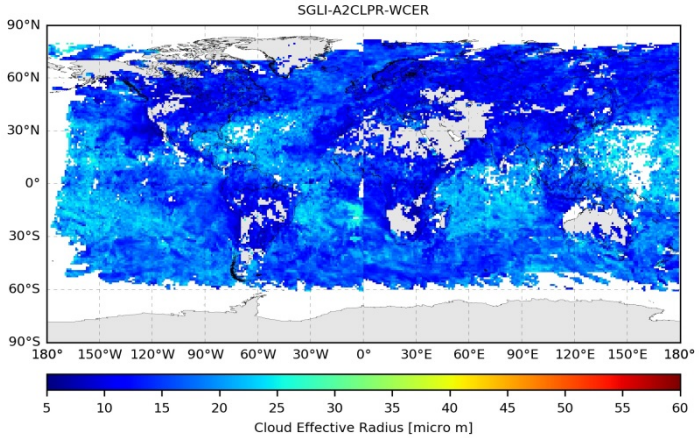
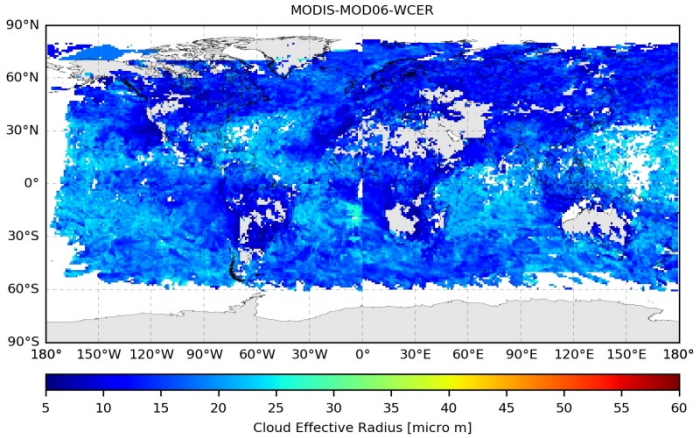
**Release threshold is achieved**

# 3. Validation Results of Atmosphere Products

## 3.2 (d) Water cloud optical thickness/Water cloud effective radius (CLOT_W/CLER_W)

Supplemental slides

Validation Results: Global distribution (Monthly average)

| | SGLI-CLPR | MOD06 |
|---|---|---|
| Water cloud optical thickness |  |  |
| Water cloud effective radius |  |  |

# 3. Validation Results of Atmosphere Products

## 3.2 (e) Ice cloud optical thickness (CLOT_I)

Validation Method:

- Release threshold: Relative errors are evaluated comparing SGLI derived ice cloud optical thickness with those from other satellite products (MODIS: MOD06, C6) for clouds of mid- to low latitude regions (monthly average).
- Standard accuracy: Relative errors are evaluated comparing SGLI derived ice cloud optical thickness with those measured with sky-radiometers on the ground.

Validation data and condition etc.:

- Only the data of MOD06 data acquired within 30 minutes from SGLI observations were used for comparison.

Validation period:

- MOD06 : Aug. 22nd to Sep. 14th 2018

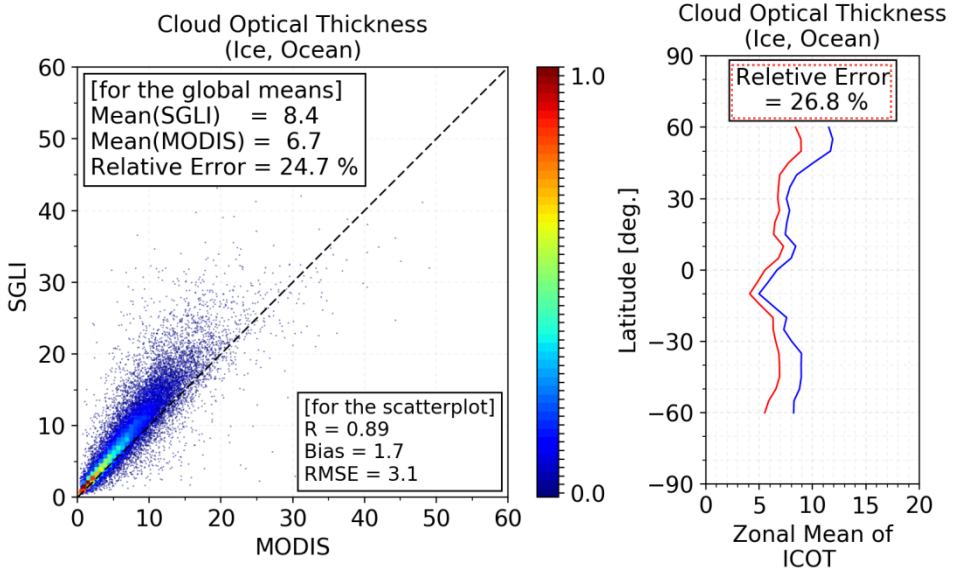
# 3. Validation Results of Atmosphere Products

## 3.2 (e) Ice cloud optical thickness (CLOT_I)

Validation Results:

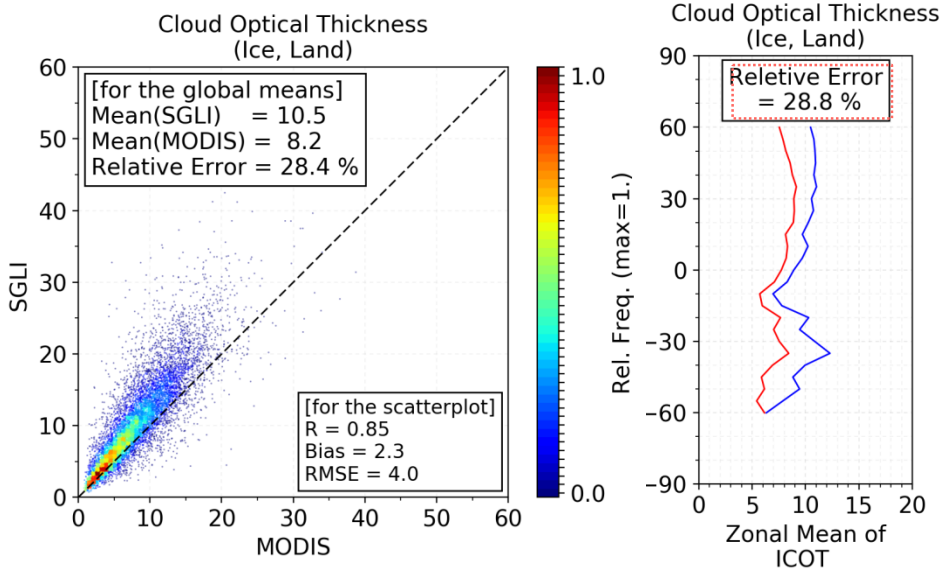
Over Ocean

(Left: One-deg. grid average over ocean, Right: zonal average)




Over Land

(Left: One-deg. grid average over ocean, Right: zonal average)




| Estimated errors (Ocean, Land) | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 27, 29 % (vs. Other satellite) | 30 % (vs. Other satellite) | 70 % (Sky-radiometer) | 20 % (Sky-radiometer) |

**Release threshold is achieved**

# 3. Validation Results of Atmosphere Products

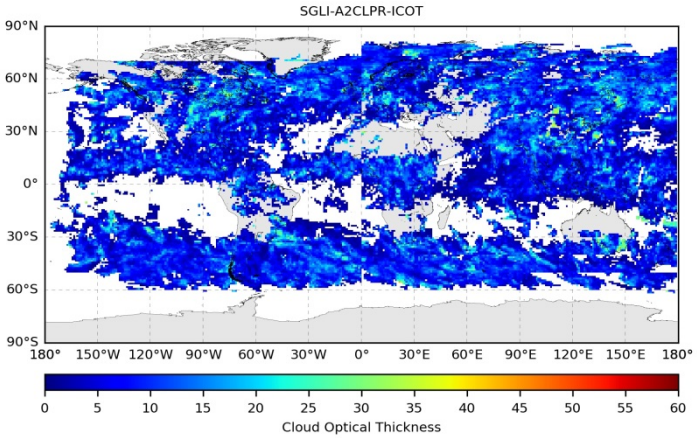
## 3.2 (e) Ice cloud optical thickness (CLOT_I)

Supplemental slides

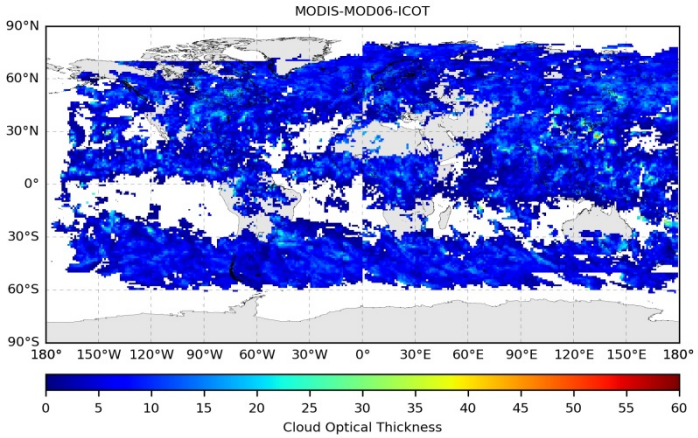
Validation Results: Global distribution (Monthly average)

Ice cloud optical thickness

SGLI-CLPR




MOD06



# 3. Validation Results of Atmosphere Products

## 3.2 (f) Aerosol over ocean and land (Non-polarization/Polarization) (ARNP-O, ARNP-L, ANPL)

### Validation Method:

Aerosol over ocean:

- Release threshold: Overall RMS errors are evaluated comparing SGLI derived aerosol optical thickness (AOT) with those from other satellite sensors (monthly average).
- Standard accuracy: RMS errors are evaluated comparing SGLI derived AOT with those from other satellite sensors and shipborne in-situ observations (AERONET/Maritime Aerosol Network) (scene by scene).

Aerosol over land:

- Release threshold: RMS errors are evaluated comparing SGLI derived AOT with those from sky-radiometers at ground observation network (Skynet and AERONET) and other satellite sensors. (monthly average).
- Standard accuracy: RMS errors are evaluated comparing SGLI derived AOT with those from other satellite sensors and sky-radiometer at ground observation network (Skynet and AERONET) (scene by scene).

### Validation data and condition etc.:

- vs. Sky-radiometer: the SGLI data within 10 km from the sky-radiometer sites were used and averaged for comparison with the data of sky-radiometers.

### Validation period:

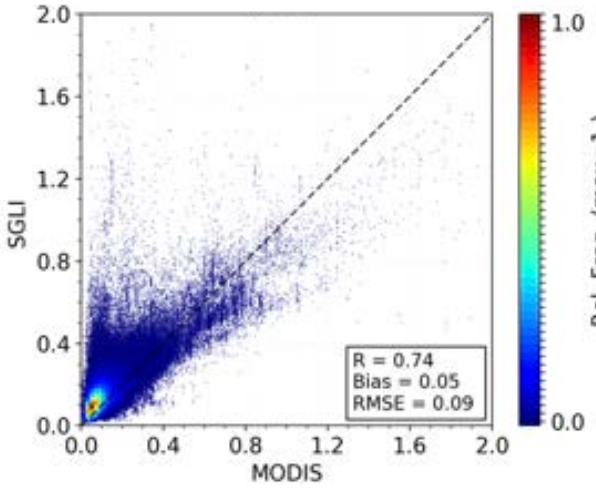
- MODIS: Sep. 1st to 30th 2018
- In-situ (sky-radiometer) data for land products:
  - Data sources: SKYNET (Chiba Univ., Toyama Univ.), Japan Meteorological Agency, AERONET
  - Period: Aug. 1st to Oct. 22nd 2018 (for non-polarization AOT products); Aug. 5th to Sep. 30th 208 (for Polarization AOT product).

# 3. Validation Results of Atmosphere Products

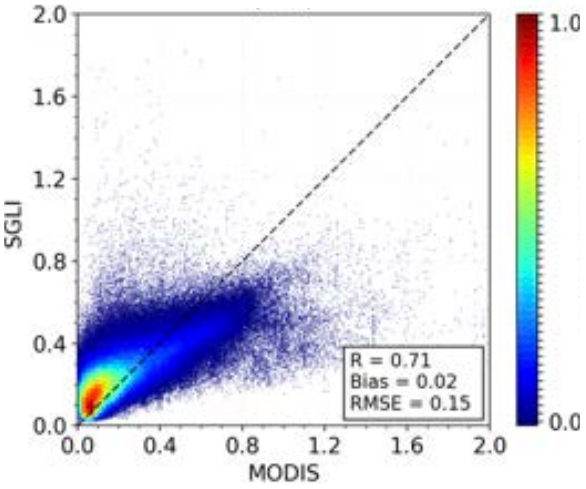
## 3.2 (f) Aerosol over ocean and land (Non-polarization) (ARNP-O, ARNP-L)

Validation Results: Non-polarization AOTs over ocean and land

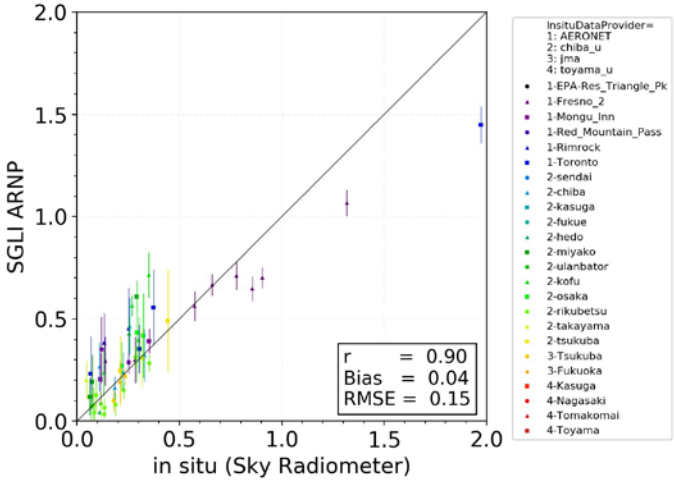
AOT over Ocean
(Monthly average)
vs. MODIS (DT method)




AOT over Land
(Monthly average)
vs. MODIS (DT method)




AOT over Land
SGLI 0.1 deg. Grid average
vs. In-situ instantaneous values




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 0.09（ocean-other sat., monthly ave.） | 0.10（monthly ave.） | 0.10（scene） | 0.05（scene） |
| 0.15（land-other sat., monthly ave.）<br>0.15（land-in-situ, scene） | 0.15（monthly ave.） | 0.15（scene） | 0.10（scene） |

**Release threshold is achieved**

# 3. Validation Results of Atmosphere Products

## 3.2 (f) Aerosol over ocean and land (Non-polarization) (ARNP-O, ARNP-L)

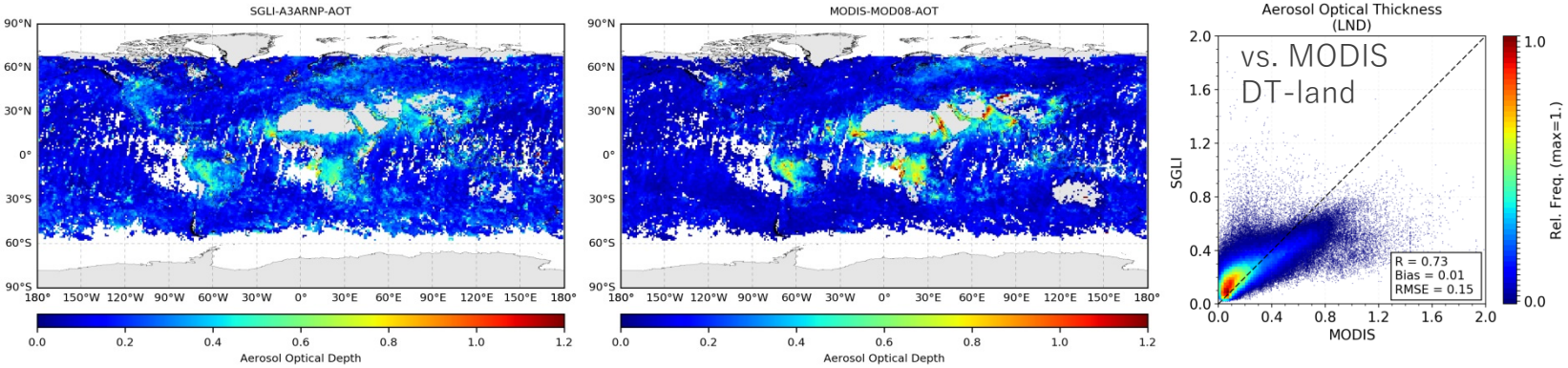
Validation Results: Global distribution (Monthly average)

＊Upper and lower images indicate different results of MODIS land algorithms

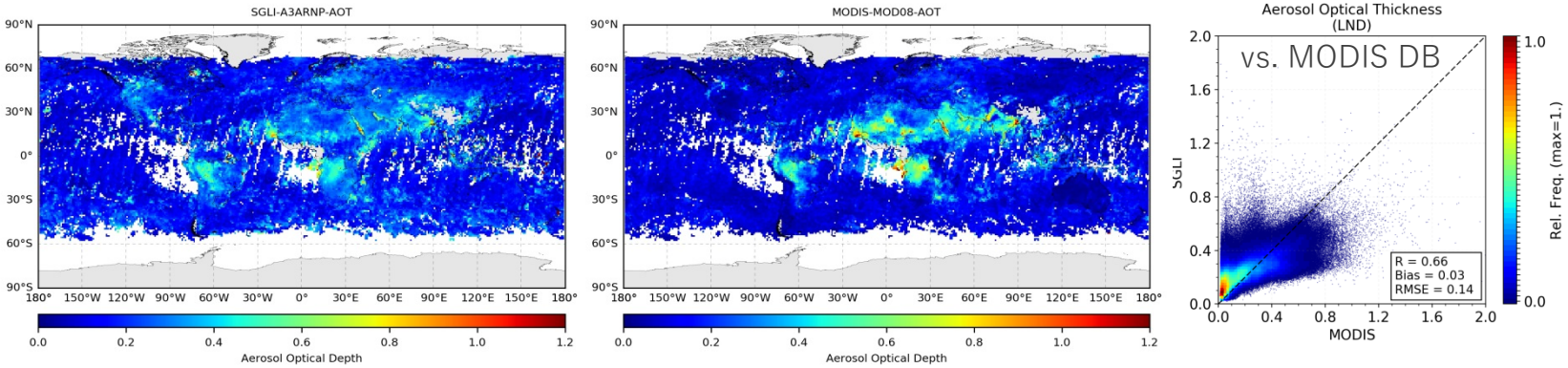
SGLI-ARNP

MODIS

SGLI-ARNP vs. MODIS Ocean: DT Land: DT




SGLI-ARNP vs. MODIS Ocean: DT Land: DB




Note:

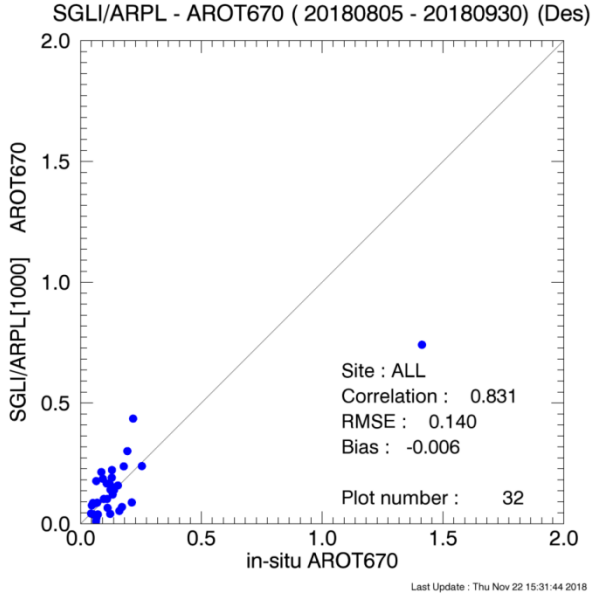
- DT：Dark Target algorithm
- DB：Deep Blue algorithm

# 3. Validation Results of Atmosphere Products

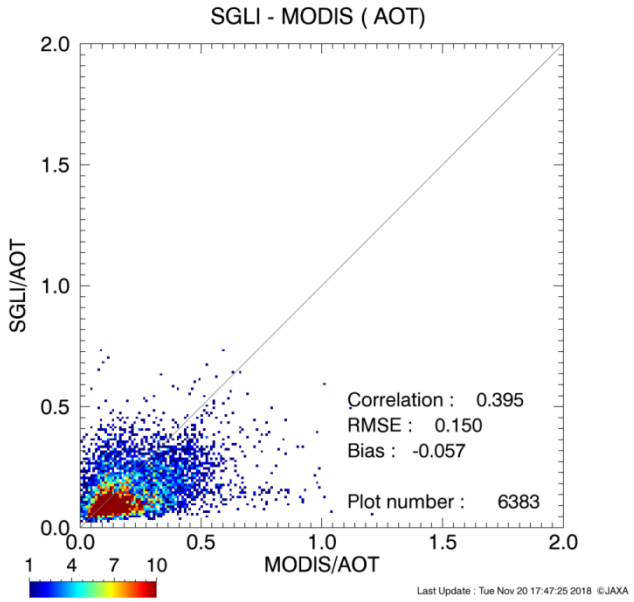
## 3.2 (f) Aerosol over land (Polarization) (ANPL)

Validation Results: Polarization AOTs over land

Vs. in-situ data (sky-radiometer)（Scene）




Vs. MODIS (monthly ave.)




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 0.14 (in-situ, scene)<br>0.15 (other sat., monthly ave.) | 0.15（monthly ave.） | 0.15（scene） | 0.10（scene） |

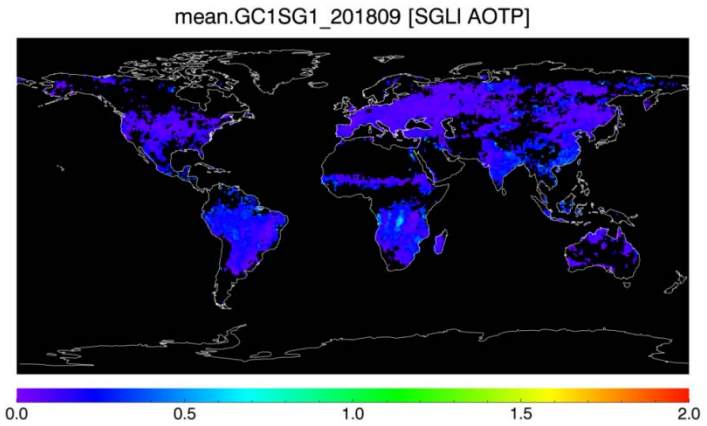
**Release threshold and Standard accuracy are achieved**

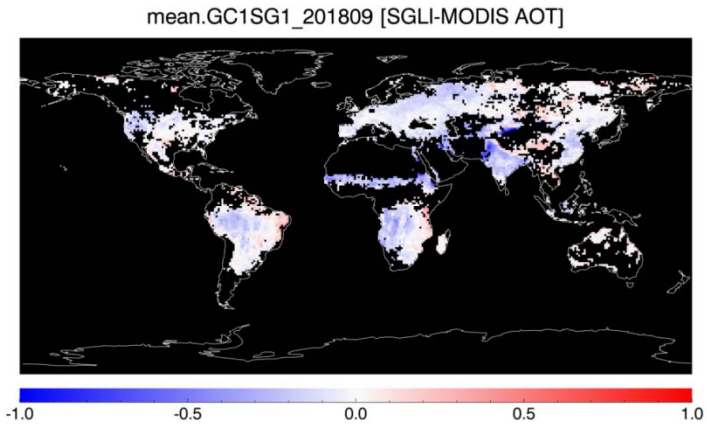
# 3. Validation Results of Atmosphere Products

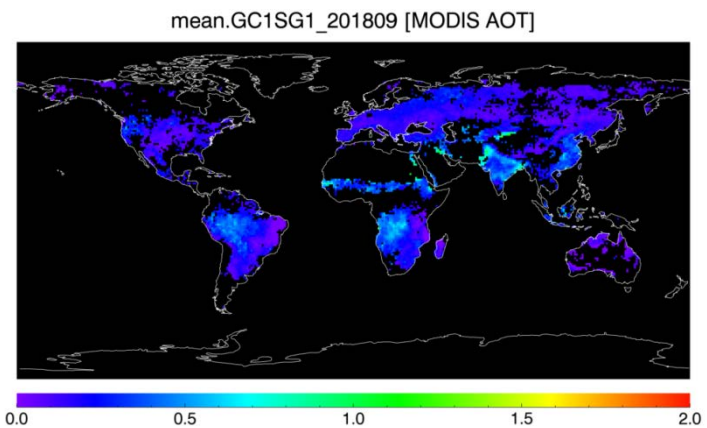
## 3.2 (f) Aerosol over land (Polarization) (ANPL)

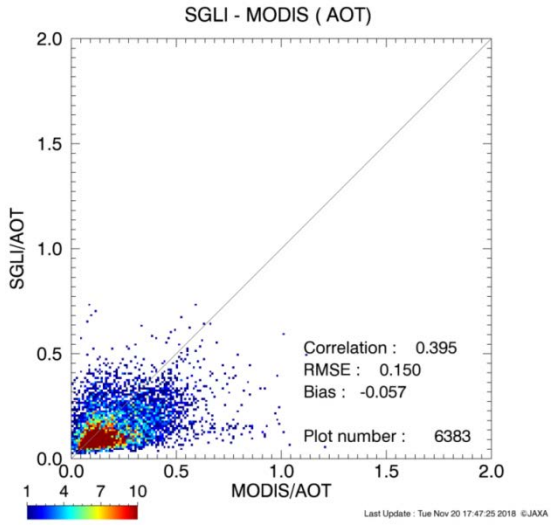
Validation Results: Global distribution (Monthly average)

SGLI vs. MODIS：AOT September 2018 (Descending)



# 4. Validation Results of Ocean Products

## 4.1 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/m$^2$/str/um (>600nm) | 30% (<600nm) 0.25W/m$^2$/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.

# 4. Validation Results of Ocean Products

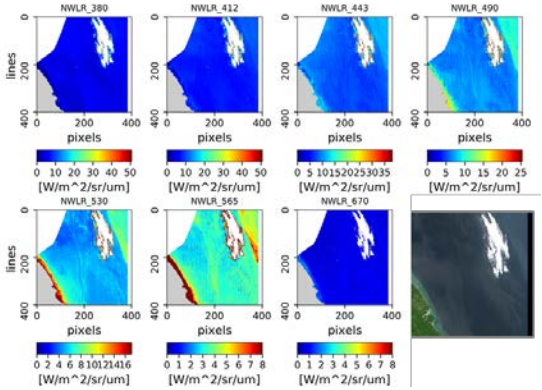
## 4.2 (a) Normalized water leaving radiance (NWLR)

### Validation Method:

- RMS errors are evaluated comparing SGLI-derived NWLR with in-situ optical measurements conducted during simultaneous buoy (MOBY*1), tower (AERONET-OC: sky- and ocean-radiometer installed on oceanic towers) and the campaigns of ship observations and also comparing with other satellite products.

### Validation data and condition etc.:

- In-situ data acquired within 3 hours from SGLI observations were used for comparison.
- SGLI data were extracted from 5 by 5 pixels near the in-situ observation sites to have one averaged value and then the data were selected by the following criteria (Bailey, 2006);
  1. Aerosol optical thickness (AOT) ≤ 0.3, solar zenith angle ≤ 70 deg., the atmospheric correction scheme passed successfully, the target pixel is neither near the cloudy pixel nor within the region of the sun-glint correction, and the number of valid pixels ≥ 13.
  2. A coefficient of variation (CV) is computed for pixels which passed the 1st test (1.) for bands between 412 and 565 nm and for the AOT 865 nm using the arithmetic mean and standard deviation of the 5x5 pixels, and the median CV is less than 0.15.




### Validation period:

- Yoko-Maru: Feb. 2nd to Oct. 16th 2018
- Shinsei-Maru: May 21st to 28th 2018
- Nagasaki-Maru: Jul. 19th to 27th 2018
- MOBY*: Jan. 1st to Jul. 9th 2018
- AERONET-OC: Jan. 1st to Oct. 26th 2018

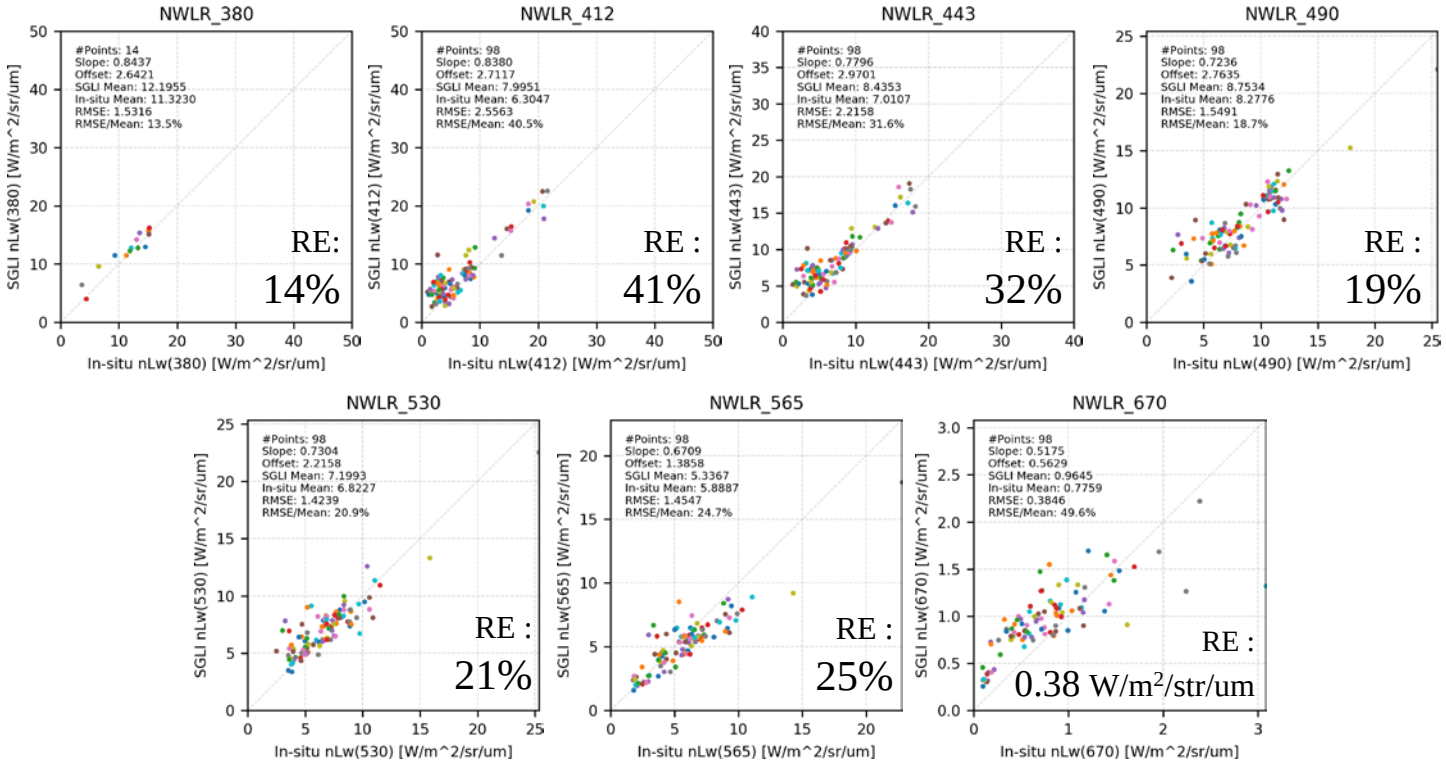
*1: MOBY data are provided from NOAA through the agreement (a memorandum of understanding (MoU)) between JAXA and NOAA.

Reference: Bailey, S.W., and Werdell, P.J. (2006). A multi-sensor approach for the on-orbit validation of ocean color satellite data products. Rem. Sens. Environ. 102, 12-23.

# 4. Validation Results of Ocean Products

## 4.2 (a) Normalized water leaving radiance (NWLR)

### Validation Results:




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 14 ~ 41% (<=600nm)<br>0.38W/m$^2$/str/um (>600nm) | 60% (443 ~ 565 nm) | 50% (<600 nm),<br>0.5W/m$^2$/str/um (>600nm) | 30% (<600 nm),<br>0.25W/m$^2$/str/um (>600nm) |

**Release threshold and Standard accuracy are achieved**

# 4. Validation Results of Ocean Products

## 4.2 (b) Atmospheric correction parameters (ACP)

### Validation Method:

- RMS errors are evaluated comparing SGLI-derived aerosol optical thickness (AOT) with in-situ measurements of AOT at the wavelength of 865 nm conducted during simultaneous tower (AERONET-OC: sky- and ocean-radiometer installed on oceanic towers).

### Validation data and condition etc.:

- In-situ data acquired within 3 hours from SGLI observations were used for comparison.
- SGLI data were extracted from 5 by 5 pixels near the in-situ observation sites to have one averaged value and then the data were selected by the following criteria (Bailey, 2006);
  1. Aerosol optical thickness (AOT) ≤ 0.4, solar zenith angle ≤ 70 deg., the atmospheric correction scheme passed successfully, the target pixel is neither near the cloudy pixel nor within the region of the sun-glint correction, and the number of valid pixels ≥ 13.
  2. A coefficient of variation (CV) is computed for pixels which passed the 1st test (1.) for bands between 412 and 565 nm and for the AOT 865 nm using the arithmetic mean and standard deviation of the 5x5 pixels, and the median CV is less than 0.15.

### Validation period:

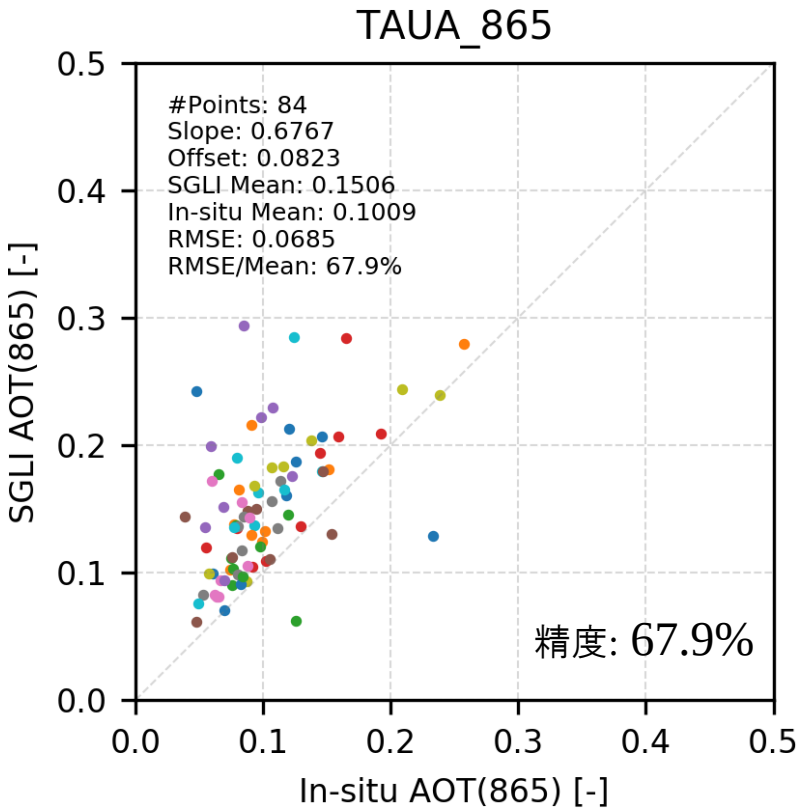
- AERONET-OC: Jan. 1st to Oct. 26th 2018

Reference: Bailey, S.W., and Werdell, P.J. (2006). A multi-sensor approach for the on-orbit validation of ocean color satellite data products. Rem. Sens. Environ. 102, 12-23.

# 4. Validation Results of Ocean Products

## 4.2 (b) Atmospheric correction parameters (ACP)

Validation Results:




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 68% (AOT@865nm) | 80% (AOT@865nm) | 50% (AOT@865nm) | 30% (AOT@865nm) |

**Release threshold is achieved**

# 4. Validation Results of Ocean Products

## 4.2 (c) Photosynthetically available radiation (PAR)

### Validation Method:

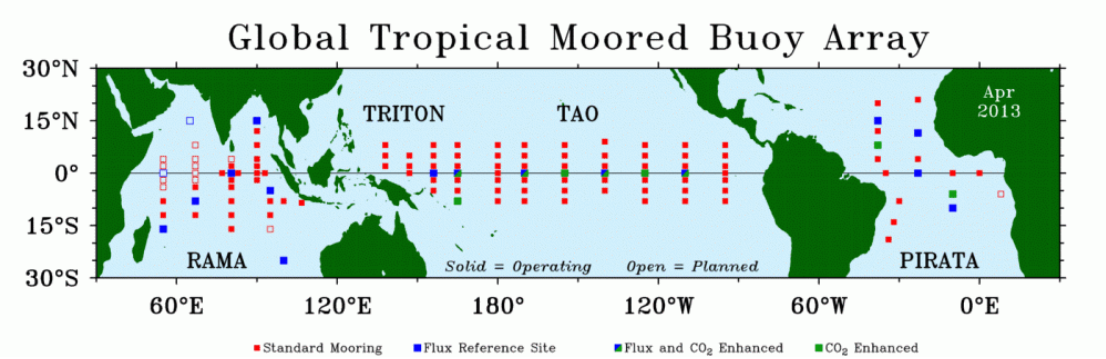
- RMS errors are evaluated comparing SGLI-derived monthly averaged PAR with those derived from mooring buoys such as TAO/TRITON, PIRATA, RAMA.

### Validation data and condition etc.:

- In-situ data acquired within 3 hours from SGLI observations were converted to daily PARs and then averaged to monthly PARs for comparison with SGLI- PARs.
- Daily SGLI-PARs within 10 km box at the center of in-situ observation sites were extracted and then averaged to monthly PARs.

### Validation period:

- TAO/TRITON、PIRATA、RAMA : Jan. 1st to Oct. 31th 2018

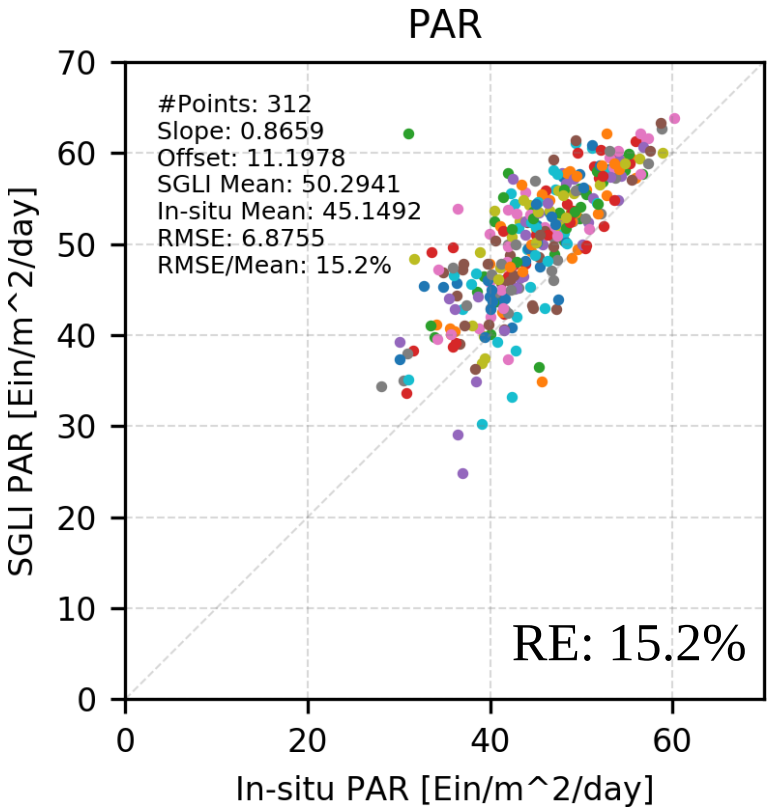



Reference: National Center for Atmospheric Research Staff (Eds). Last modified 01 Nov 2013. "The Climate Data Guide: Tropical Moored Buoy System: TAO, TRITON, PIRATA, RAMA (TOGA)." Retrieved from https://climatedataguide.ucar.edu/climate-data/tropical-moored-buoy-system-tao-triton-pirata-rama-toga.

# 4. Validation Results of Ocean Products

## 4.2 (c) Photosynthetically available radiation (PAR)

Validation Results:




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 15% (10km/monthly ave.) | 20% (10km/monthly ave.) | 15% (10km/monthly ave.) | 10% (10km/monthly ave.) |

**Release threshold and Standard accuracy are achieved**

# 4. Validation Results of Ocean Products

## 4.2 (d) Chlorophyll-a concentration (CHLA)

### Validation Method:

- RMS errors are evaluated comparing SGLI derived CHLA with those derived from in-situ sampled sea water by fluorescence method or HPLC analysis and also with other satellite products.

### Validation data and condition etc.:

- In-situ data acquired within 3 hours from SGLI observations were used for comparison.
- SGLI data were extracted from 5 by 5 pixels near the in-situ observation sites to have one averaged value and then the SGLI data were selected by the following criteria (Bailey, 2006);
  1. Aerosol optical thickness (AOT) ≤ 0.3, solar zenith angle ≤ 70 deg., the atmospheric correction scheme passed successfully, the target pixel is neither near the cloudy pixel nor within the region of the sun-glint correction, and the number of valid pixels ≥ 13.
  2. A coefficient of variation (CV) is computed for pixels which passed the 1st test (1.) for bands between 412 and 565 nm and for the AOT 865 nm using the arithmetic mean and standard deviation of the 5x5 pixels, and the median CV is less than 0.15.
- Comparisons between SGLI and other satellite CHLA products were conducted for monthly averaged global data projected on grids with 1/24 deg. Interval.

### Validation period:

- Yoko-Maru: Feb. 2nd to Oct. 16th 2018
- Shinsei-Maru: May 21st to 28th 2018
- Nagasaki-Maru: Jul. 19th to 27th 2018
- Hokko-Maru: Jun. 1st to 8th 2018
- Aqua/MODIS: Oct. 1st to 31st 2018

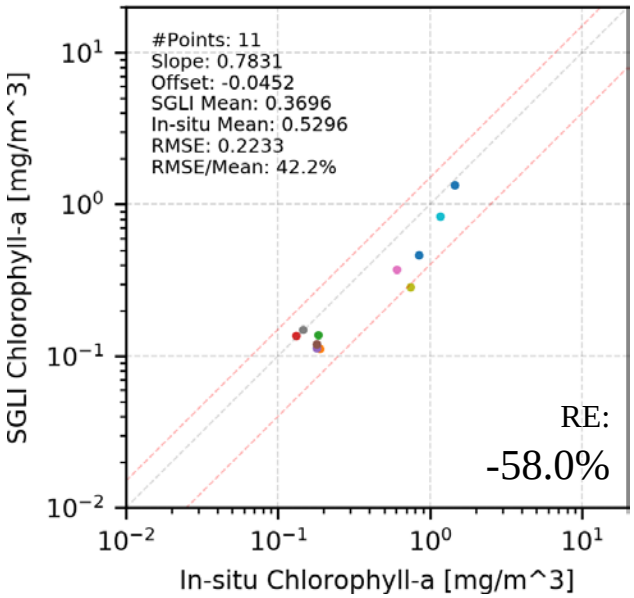
Reference: Bailey, S.W., and Werdell, P.J. (2006). A multi-sensor approach for the on-orbit validation of ocean color satellite data products. Rem. Sens. Environ. 102, 12-23.

# 4. Validation Results of Ocean Products

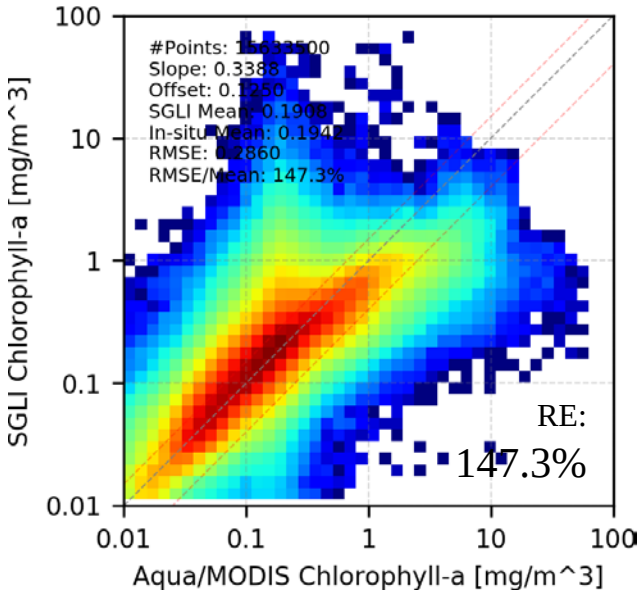
## 4.2 (d) Chlorophyll-a concentration (CHLA)

### Validation Results:

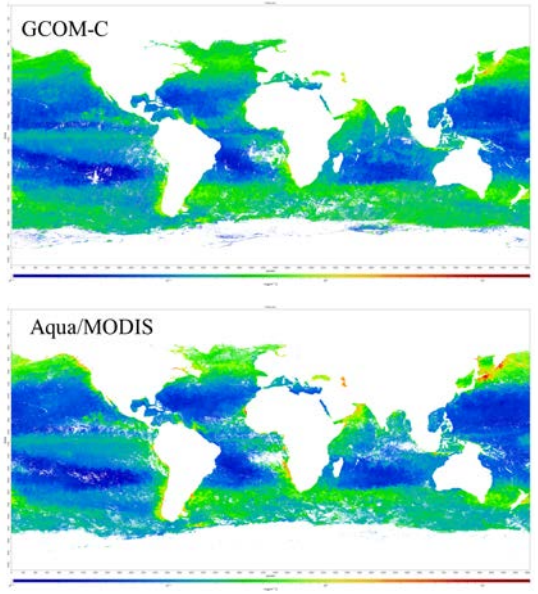
VS. In-situ data (open sea)




VS. Aqua/MODIS (open sea)




Monthly (Oct.) ave. Chl-*a*




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| -58% (in-situ, open sea)<br>147% (Aqua/MODIS, open sea) | –60~+150% (open sea) | –60~+150% | –35~+50% (open sea),<br>–50~+100% (coastal) |

**Release threshold is achieved**

# 4. Validation Results of Ocean Products

## 4.2 (e) Total suspended matter concentration (TSM)

### Validation Method:

- RMS errors are evaluated comparing SGLI derived TSM with those derived from in-situ sampled sea water by filtration method (weighting the dried filters before and after the filtration to estimate the mass of suspended matter) and also with other satellite products.

### Validation data and condition etc.:

- Comparisons only with other satellite products were conducted because there are no in-situ data available at the moment of evaluation 1-year after the GCOM-C launch.
- Korean's geostationary satellite "GOCI"-derived TSM was used for the comparison with SGLI for the TSM range of 0.1 to 65 $g/m^3$ (*1). The comparison was made on the spatial grids of 1 km.

### Validation period:

- GOCI: Oct. 31, 2018.

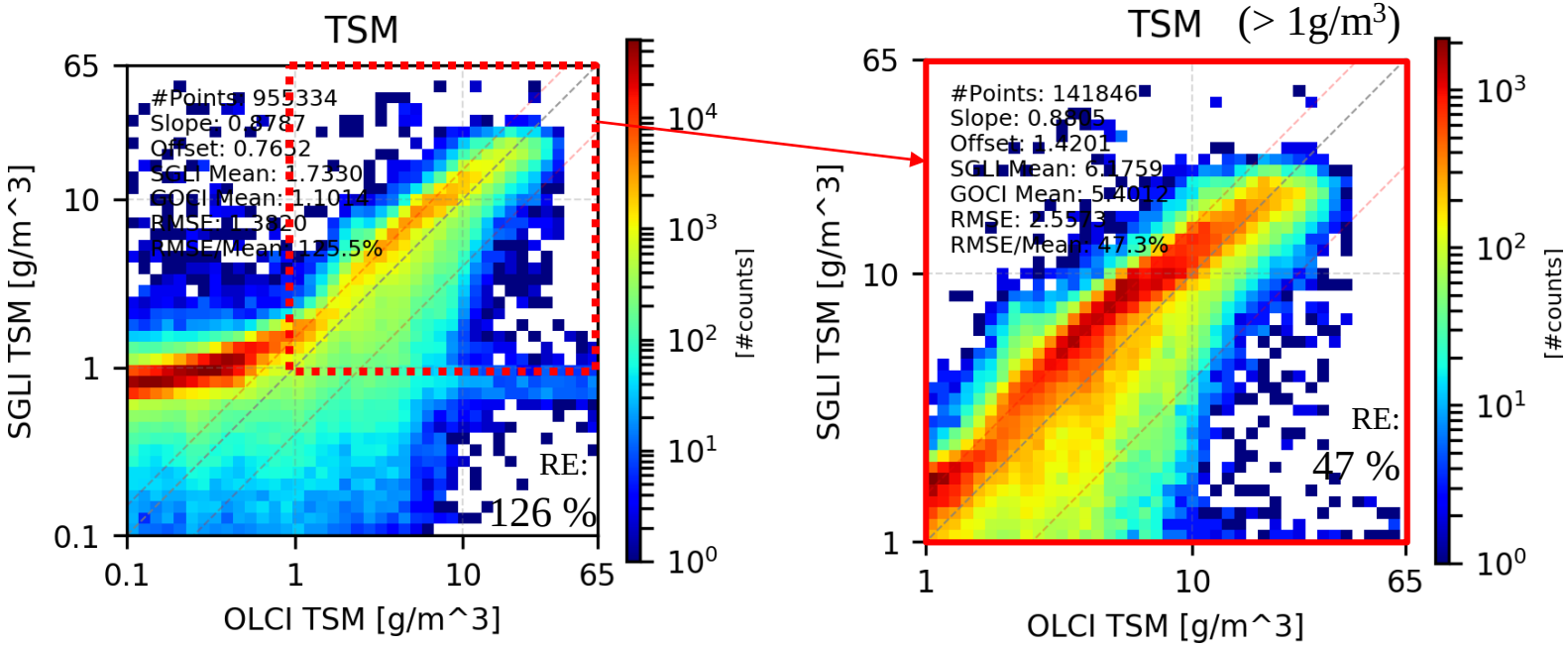
*1: The definition of GOCI's TSM is different from that of SGLI. That is, GOCI's TSM is the amount of floating inorganic matte in seawater, whereas SGLI's TSM is the sum of floating inorganic and organic matter in seawater. Thus, SGLI's TSM is considered to be larger than that of GOCI.

# 4. Validation Results of Ocean Products

## 4.2 (e) Total suspended matter concentration (TSM)

Validation Results:

Comparison with GOCI




※The definition of GOCI's TSM: "The amount of floating inorganic matte in seawater"*1)

*1) http://kosc.kiost.ac.kr/eng/p30/kosc_p33.html

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 126% (*vs.* GOCI)<br>-53% (*vs.* GOCI, > 1g/m$^3$) | −60~+150% (open sea) | −60~+150% | −50~+100% |

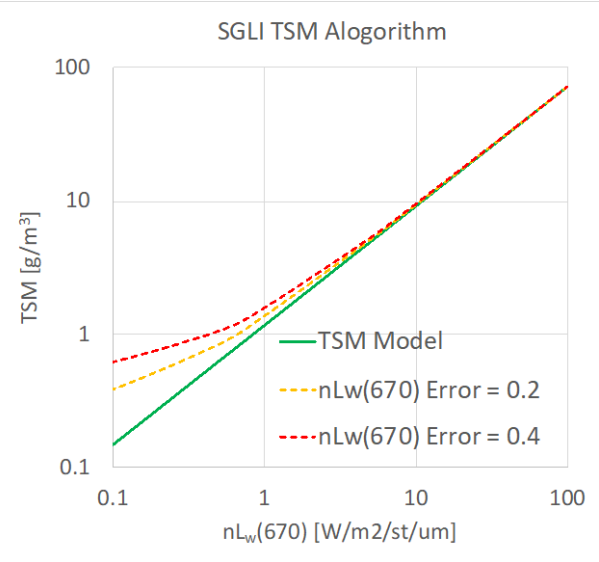
**Release threshold is achieved**

# 4. Validation Results of Ocean Products

## 4.2 (e) Total suspended matter concentration (TSM)

### Validation Results (Cont.):

- SGLI-derived TSMs tend to be higher than those of GOCI for the TSM range higher than 1 g/m$^3$ which is considered due to the difference of the TSM definition between SGLI and GOCI as described before.
- In addition, SGLI-derived TSMs become significantly higher than those of GOCI at the lower TSM range less than 1 g/m$^3$ which can be considered due to an overestimation of NWLR at 670 nm as shown in the figure below. The overestimation of TSM could be reduced after the improvement of the SGLI NWLR product by next update.




The effects of NWLR (670) errors on TSM

- NWLR(670) error of 0.4 W/m$^2$/sr/µm is the estimated accuracy in this evaluation (within the standard accuracy).
- nLw(670) error of 0.2 W/m$^2$/sr/µm is the estimate using in-situ data from MOBY*1 (within the target accuracy).

*1: MOBY data are provided from NOAA through the agreement (a memorandum of understanding (MoU)) between JAXA and NOAA.

# 4. Validation Results of Ocean Products

## 4.2 (f) Colored dissolved organic matter (CDOM)

### Validation Method:

- RMS error is evaluated comparing SGLI derived CDOM with those derived from in-situ sampled sea water by optical measurements and also with other satellite products.

### Validation data and condition etc.:

- In-situ data acquired within 3 hours from SGLI observations were used for comparison.
- SGLI data were extracted from 5 by 5 pixels near the in-situ observation sites to have one averaged value and then the SGLI data were selected by the following criteria (Bailey, 2006);
  1. Aerosol optical thickness (AOT) ≤ 0.3, solar zenith angle ≤ 70 deg., the atmospheric correction scheme passed successfully, the target pixel is neither near the cloudy pixel nor within the region of the sun-glint correction, and the number of valid pixels ≥ 13.
  2. A coefficient of variation (CV) is computed for pixels which passed the 1st test (1.) for bands between 412 and 565 nm and for the AOT 865 nm using the arithmetic mean and standard deviation of the 5x5 pixels, and the median CV is less than 0.15.
- Comparisons between SGLI and other satellite CDOM products were conducted for monthly averaged global data projected on grids with 1/24 deg. Interval.

### Validation period:

- Yoko-Maru: Feb. 2nd to Oct. 16th 2018
- Shinsei-Maru: May 21st to 28th 2018
- Nagasaki-Maru: Jul. 19th to 27th 2018
- Hokko-Maru: Jun. 1st to 8th 2018
- Aqua/MODIS: Oct. 1st to 31st 2018

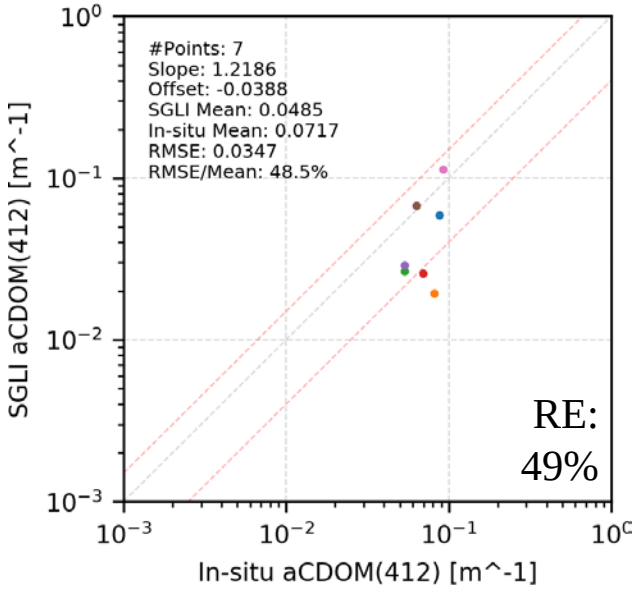
Reference: Bailey, S.W., and Werdell, P.J. (2006). A multi-sensor approach for the on-orbit validation of ocean color satellite data products. Rem. Sens. Environ. 102, 12-23.

# 4. Validation Results of Ocean Products

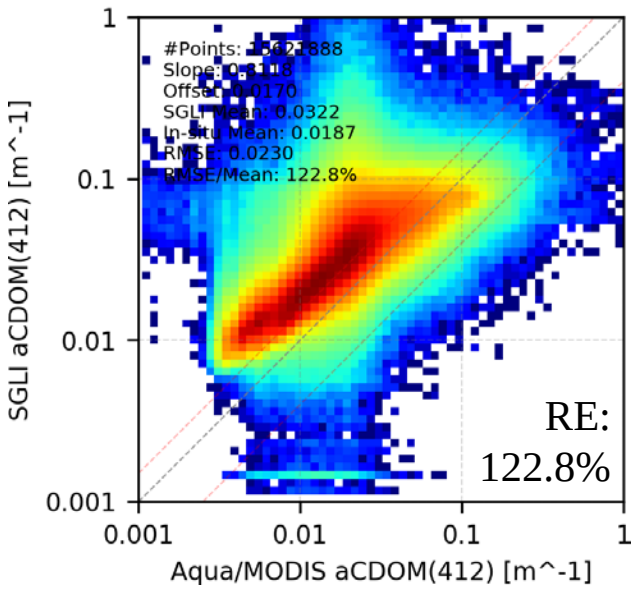
## 4.2 (f) Colored dissolved organic matter (CDOM)

### Validation Results:

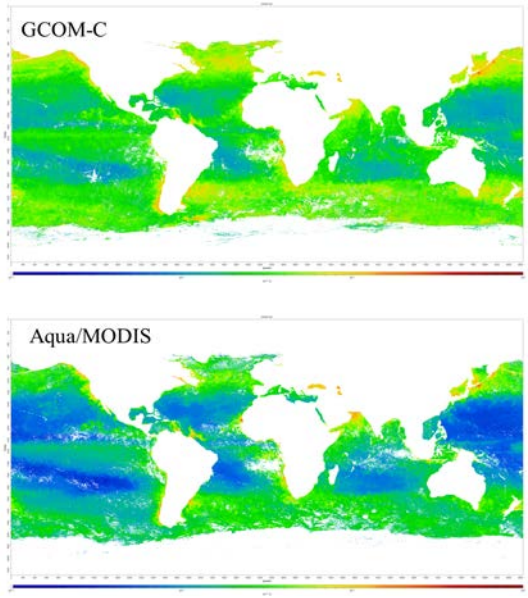
VS. In-situ data (open sea)




VS. Aqua/MODIS (open sea)




Monthly (Oct.) ave. CDOM




| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| -51% (in-situ, open sea)<br>123% (Aqua/MODIS, open sea) | –60~+150% (open sea) | –60~+150% | –50~+100% |

**Release threshold is achieved**

# 4. Validation Results of Ocean Products

## 4.2 (g) Sea surface temperature (SST)

### Validation Method:

- Overall RMS errors are evaluated comparing SGLI derived SST with those derived from buoy measurements obtained from iQuam.

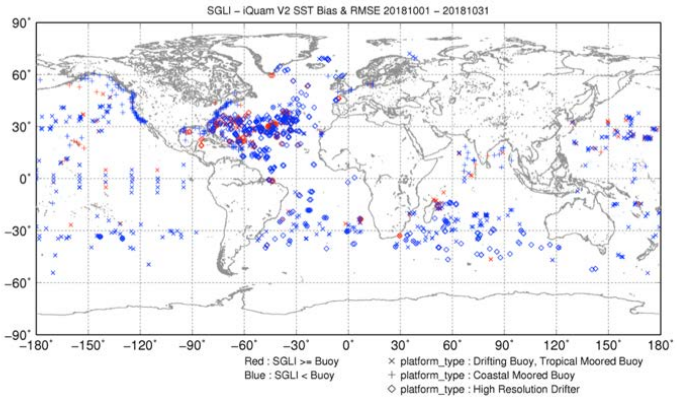
### Validation data and condition etc.:

- In-situ buoy data acquired within the spatial difference of 10 km and time difference of 2 hours from SGLI observations were used for comparison. In addition, before the comparison, the SGLI SSTs that meet the following conditions were selected;
  1. Standard deviation of SGLI SST within 5 x 5 pixels around the buoy location is less than 1.0 ℃.
  2. The difference between maximum and minimum of SGLI SSTs within the 5x5 pixel box is less than 3.0 ℃.
  3. The difference between SGLI SST and iQuam SST is less than 5 ℃.
- SGLI SSTs at the spatial resolution of 1 km with the quality flag of “good” or “acceptable” were used for comparison (same as the input for Level-3 processing).
- The buoy data with the quality assurance flag of iquam_flag=0 and quality_level=5 were obtained from NOAA iQuam site and used for the comparison.

### Validation period:

- Oct. 1st to 31st 2018.

Location of buoy data

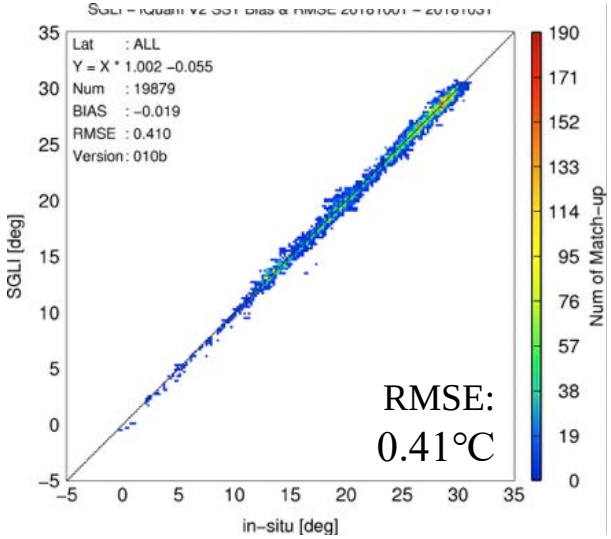


# 4. Validation Results of Ocean Products

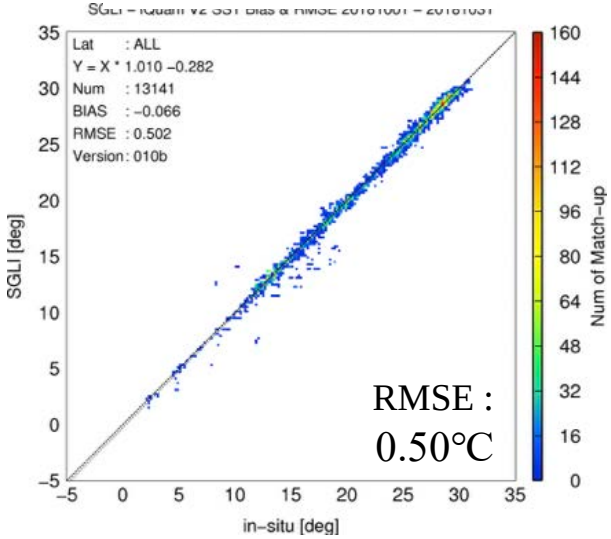
## 4.2 (g) Sea surface temperature (SST)

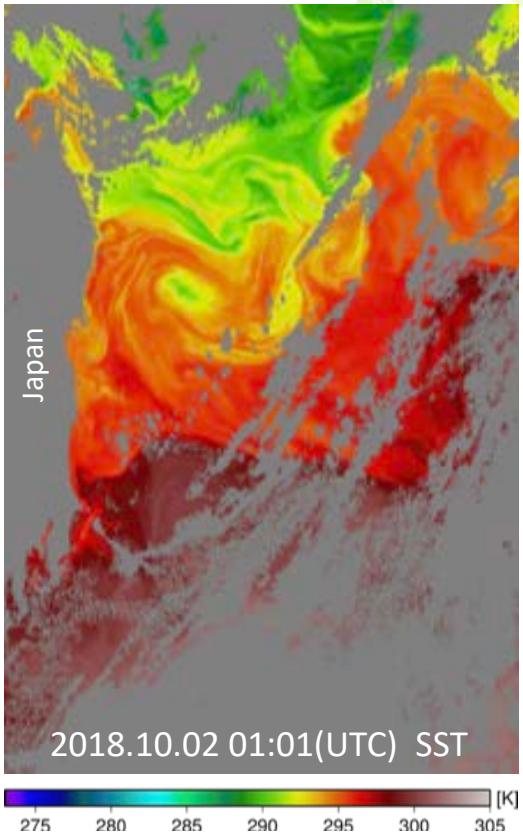
### Validation Results:

Daytime




Nighttime




Spatial distribution of SGLI SST (the western North Pacific Ocean off Japan)

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 0.4℃ (day)<br>0.5℃ (night) | 0.8℃ (day) | 0.8℃ | 0.6℃ |

**Release threshold, Standard and Target accuracies are achieved**

# 5. Validation Results of Cryosphere Products

## 5.1 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 satellite (MODIS) data. |
| **Okhotsk sea-ice distribution** | 10% | 5% | 3% | ○ | Comparison with other satellite (MODIS) data. |
| **Snow and ice surface Temperature** | 5K | 2K | 1K | ◎ | Comparison with in-situ observation (AWS thermal radiometer data) other satellite (MODIS) data. |
| **Snow grain size of shallow layer** | 100% | 50% | 30% | ○* | Comparison with climatology (relation between snow surface temperature and snow grain size) for the release threshold. In addition, comparison with in-situ observation data at Greenland for the standard accuracy. *After the quality control of SGLI data, the snow grain size product has a potential to achieve the standard accuracy. |

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

# 5. Validation Results of Cryosphere Products

## 5.2 (a) Snow and Ice covered area (SICE)

### Validation Method:

- Overall classification errors are evaluated comparing SGLI derived SICE with other satellite products. Relative errors are calculated by using the following equation.

$$Relative\ Error\ (\%) = \frac{\sqrt{\frac{1}{N}\sum\left(S(i) - T(i)\right)^2}}{\frac{1}{N}\sum T(i)} * 100$$

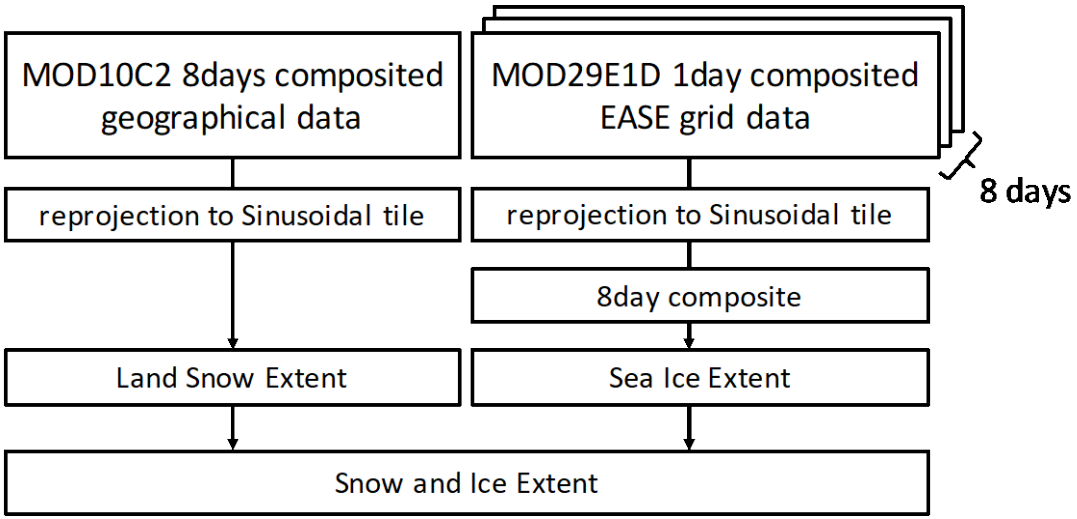
(N: the number of data, S: SGLI obs., T: other satellite data.)

### Validation data and condition etc.:

- Snow covered area: MOD10C2 Snow Cover Extent Product
- Sea-ice covered area: MOD29E1D Sea Ice Product
- Sun-lit regions in the Northern Hemisphere are the target area for the evaluation of SICE accuracy. Eight-day composite data of SICE were generated for SGLI and MODIS and then used for the comparison.

### Validation period:

- Mar. 14th to Aug. 20th 2018

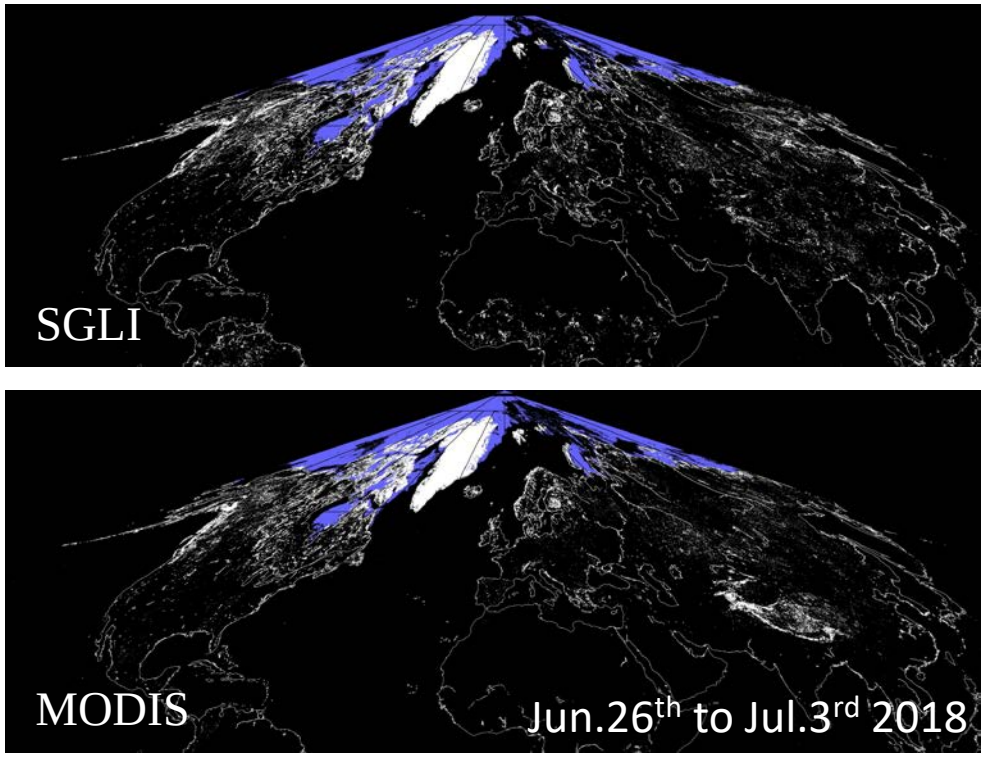


# 5. Validation Results of Cryosphere Products

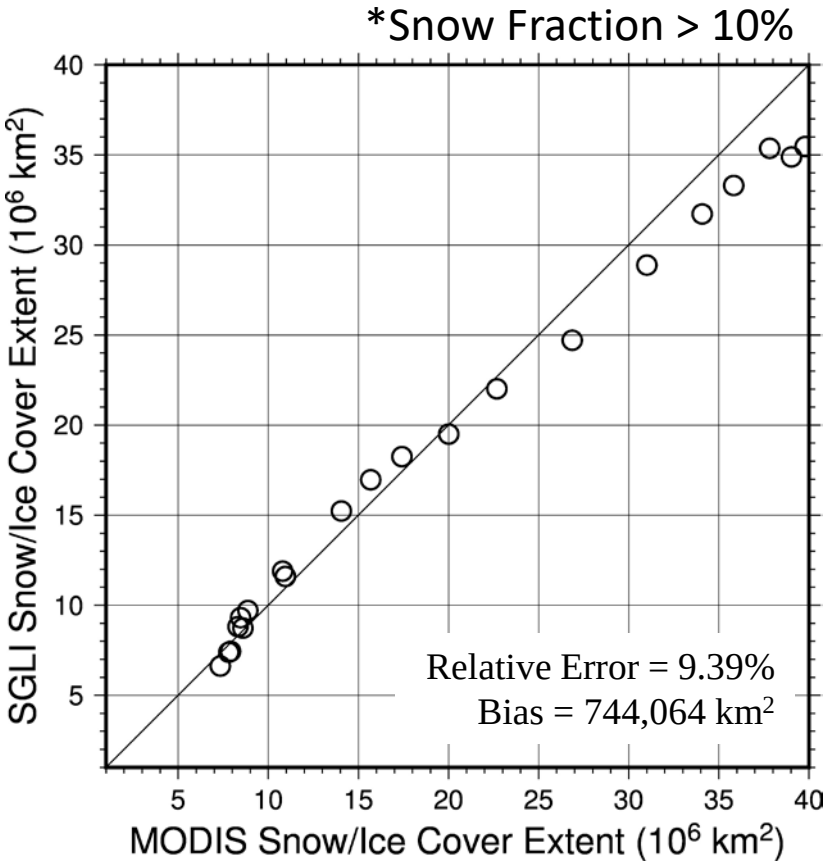
## 5.2 (a) Snow and Ice covered area (SICE)

Validation Results:

White: snow cover, Blue: sea-ice cover




Snow and sea-ice cover derived from SGLI and MODIS data




Scatter plot between MODIS and SGLI SICE

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 9.4% | 10% | 7% | 5% |

**Release threshold is achieved**

# 5. Validation Results of Cryosphere Products

## 5.2 (b) Okhotsk sea-ice distribution (OKID)

### Validation Method:

- Overall classification errors are evaluated comparing SGLI derived sea-ice distribution with other satellite products. Relative errors are calculated by using the following equation.

$$Relative\ Error\ (\%) = \frac{\sqrt{\frac{1}{N}\sum(S(i) - T(i))^2}}{\frac{1}{N}\sum T(i)} * 100$$

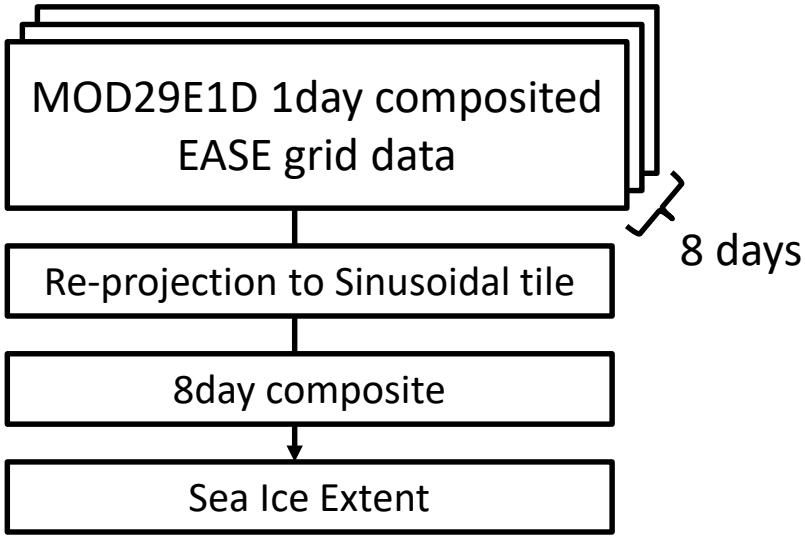
(N: the number of data, S: SGLI obs., T: other satellite data.)

### Validation data and condition etc.:

- Sea-ice covered area: MOD29E1D Sea Ice Product
- Sun-lit regions within the Okhotsk sea (43-63 deg.N, 135-163 deg.E) are the target area for the evaluation of OKID accuracy. Eight-day composite data of OKID were generated for SGLI and MODIS and then used for the comparison.

### Validation period:

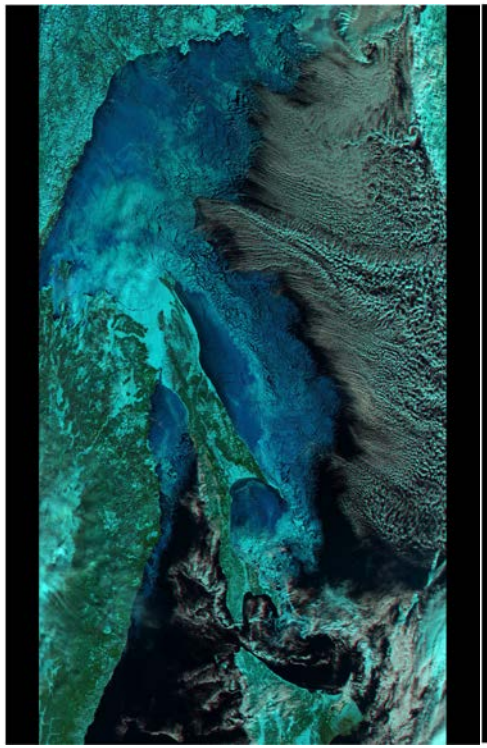
- Mar. 14th to Aug. 20th 2018



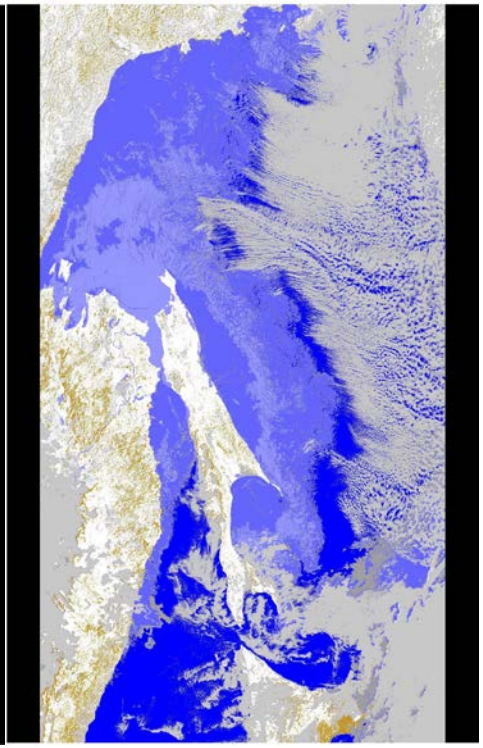
# 5. Validation Results of Cryosphere Products

## 5.2 (b) Okhotsk sea-ice distribution (OKID)

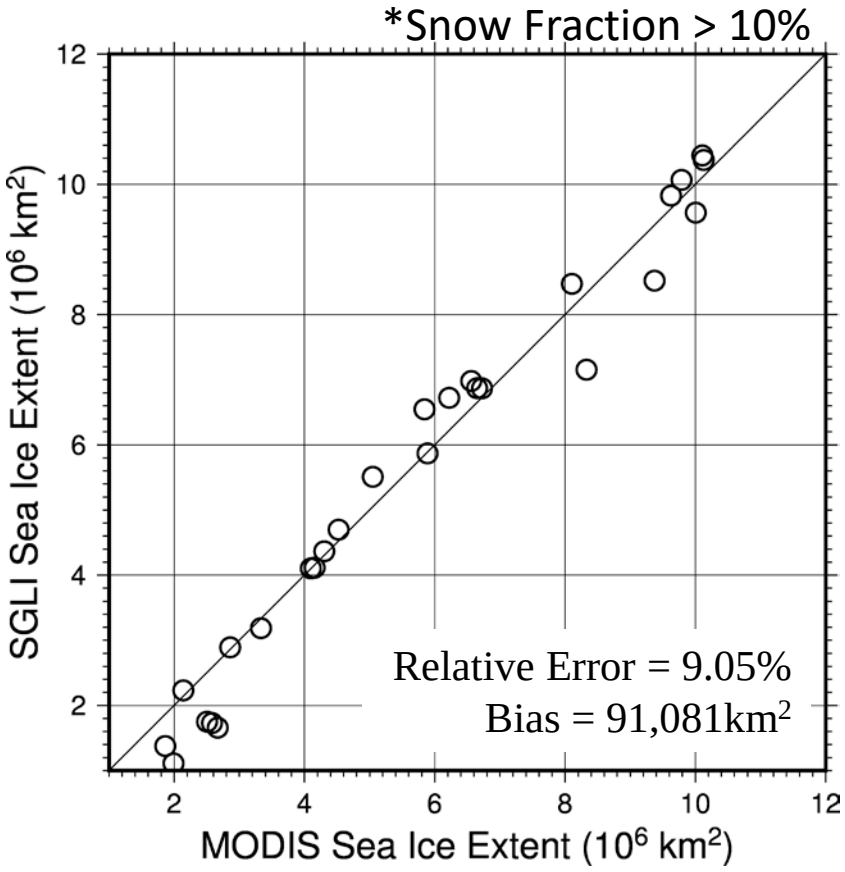
Validation Results:



SGLI Reflectance



SGLI sea-ice (OKID)




Scatter plot between MODIS and SGLI SICE

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 9.1% | 10% | 5% | 3% |

**Release threshold is achieved**

# 5. Validation Results of Cryosphere Products

## 5.2 (c) Snow and ice surface Temperature (SIST)

### Validation Method:

- Release threshold: Overall RMS errors are evaluated comparing SGLI derived SIST with those from other satellite products.
- Standard accuracy: RMS errors are evaluated comparing SGLI SIST with those from in-situ thermal radiometer measurements on the ground.

### Validation data and condition etc.:

- Snow and ice surface temperature: MOD11A1 Land Surface Temperature Product (1 km tile)
- Other satellite: Sun-lit regions in the Northern Hemisphere are the target area for the evaluation of SIST accuracy. Daily tile data of SGLI SIST were compared with that of MOD11A1 product.
- In-situ data: In-situ measured SISTs calculated from thermal radiometer data installed at the PROMICE Automatic Weather Stations (AWS) were used for the comparison with SGLI SIST. The in-situ data acquired at within the time difference of 30 minutes from SGLI observations are used and compared with SGLI SISTs at the nearest neighbor of in-situ sites.

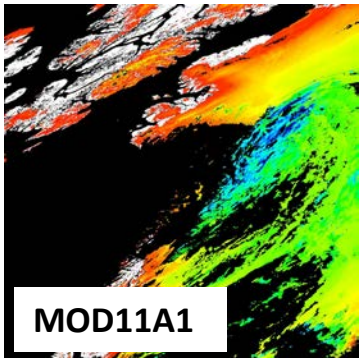
### Validation period:

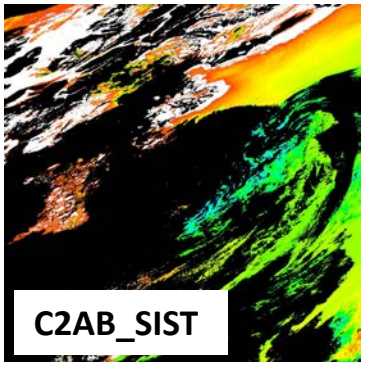
- Jul. 1$^{st}$ to Sep. 30$^{th}$ 2018

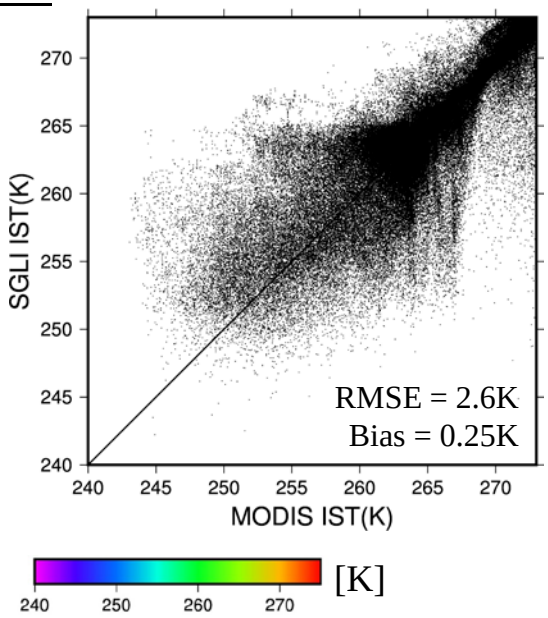
# 5. Validation Results of Cryosphere Products

## 5.2 (c) Snow and ice surface Temperature (SIST)

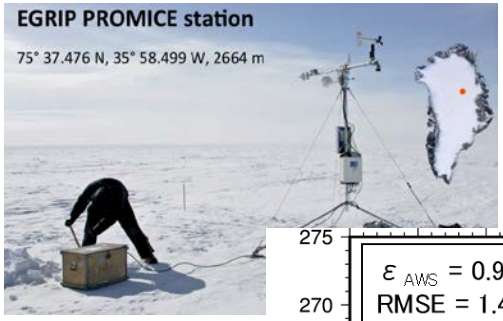
### Validation Results:

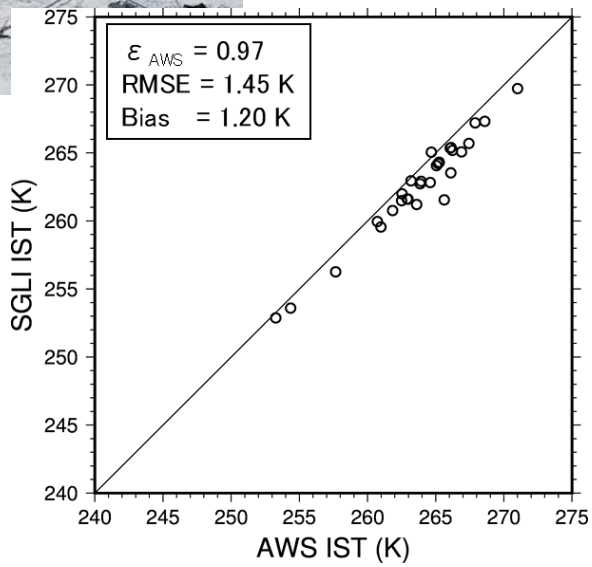



**For the release threshold evaluation (vs. MODIS product)**




**For the standard accuracy evaluation (vs. AWS measurements)**

| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| Other sat.: 2.6K<br>In-situ: 1.5K | 5K（vs. other sat.） | 2K（vs. in-situ） | 1K（vs. in-situ） |

**Release threshold and Standard accuracy are achieved**

# 5. Validation Results of Cryosphere Products

## 5.2 (d) Snow grain size of shallow layer (SGSL)

### Validation Method:

- Release threshold: Overall errors are evaluated comparing SGLI derived SGSL with climatological relationship between snow grain size and snow surface temperature derived from the past observations.
- Standard accuracy: RMS errors are evaluated comparing SGLI SGSL with those from in-situ data obtained by snow pit works on the ground. Relative errors are calculated by using the following equation.

$$Relative\ Error\ (\%) = \frac{\sqrt{\frac{1}{N}\sum(S(i) - T(i))^2}}{\frac{1}{N}\sum T(i)} * 100$$

(N: the number of data, S: SGLI obs., T: other satellite data.)

### Validation data and condition etc.:

- Climatology: Surface temperature dependence of snow grain size observed in the past study using GLI (Hori et al., 2006) was confirmed. For example, steep increase of snow grain size at the melting point of ice, and gradual increase of snow grain size with surface temperature at the lower temperature range below 0 ℃.
- In-situ data: A sun-lit snow field (E-GRIP site) over the Greenland ice sheet is the target area for the evaluation of SGSL accuracy. In-situ data were obtained with instruments (IceCube/ HISSGraS) that measures specific surface area (SSA) of snow particles. The in-situ derived SSAs acquired within the time difference of 10 minutes from SGLI observations were converted to optically equivalent sphere grain sizes and then compared with SGLI SGSL (250 m resolution) at the nearest neighbor of the in-situ site.

### Validation period:

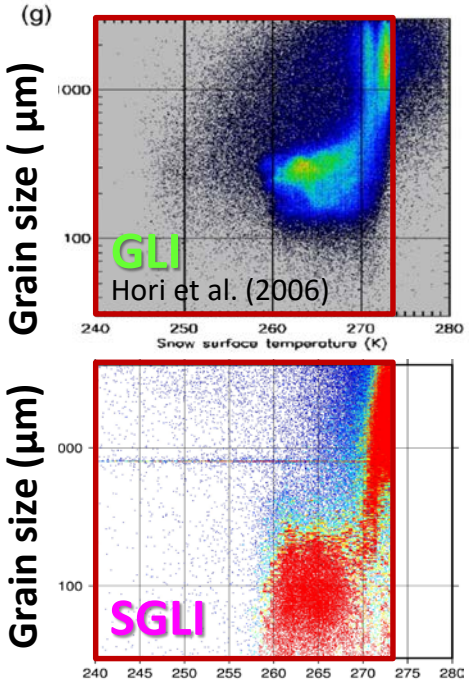
- Jul. 2nd to 16th 2018

Reference: Hori, M., Aoki, Te., Stamnes, K., Li, W. (2007). ADEOS-II/GLI snow/ice products - Part III: Retrieved results, Remote Sensing of Environment, 111, 291-336.

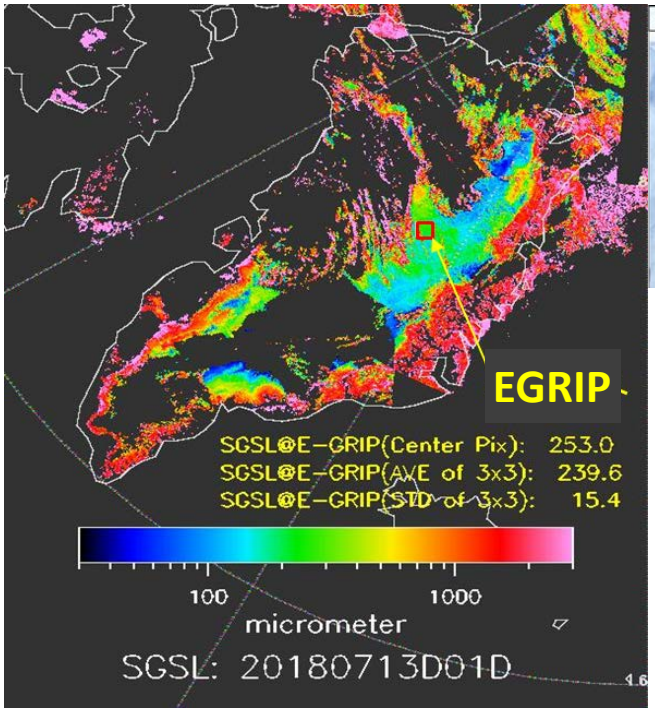
# 5. Validation Results of Cryosphere Products

## 5.2 (d) Snow grain size of shallow layer (SGSL)

### Validation Results:



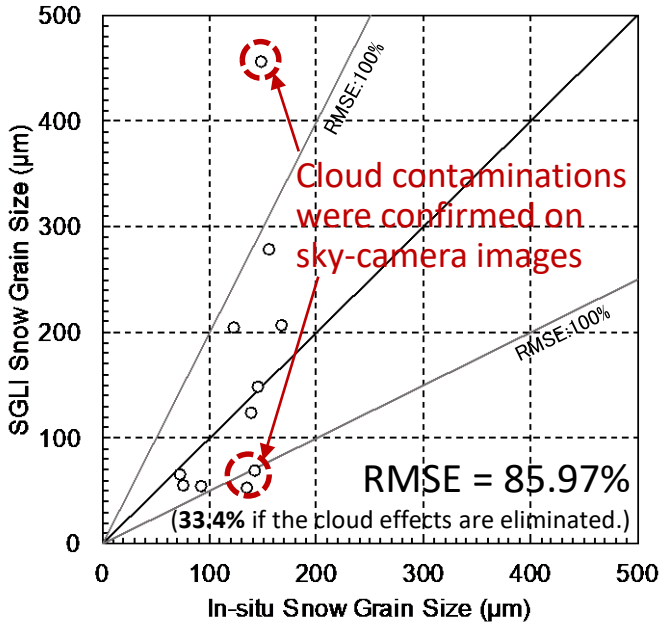

Climatological relationship between snow surface temperature and snow grain size




SGLI-derived snow grain size on Jul. 13th 2018

SGLI-derived SGSLs are consistent with those obtained at the Greenland ice sheet (EGRIP) in July 2018.

Field experiments at EGRIP, Greenland in 2018


| Estimated errors | Release threshold | Standard accuracy | Target accuracy |
|---|---|---|---|
| 86% (33%*) | 100% | 50% | 30% |

**Release threshold is achieved**

(*if the cloud effects are eliminated by quality assurance process in next updates, the standard accuracy can be achieved.)