Detailed Reports on the Validation of the SGLI Products

5. Cryosphere Products

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.

5.2 (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.

$$Relative\ Error\ (\%) = \frac{\sqrt{\frac{1}{N}\sum(S(i)-T(i))^2}}{\frac{1}{N}\sum T(i)} * 100 \quad \text{(N: the number of data, S: SGLI obs., T: other satellite data.)}$$

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.

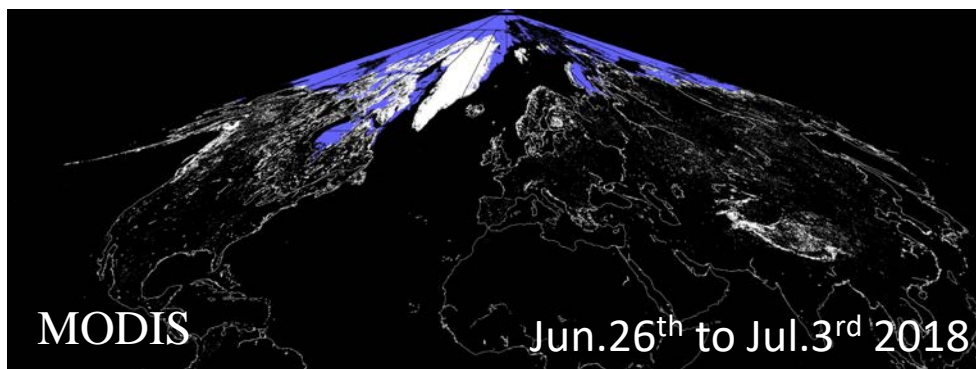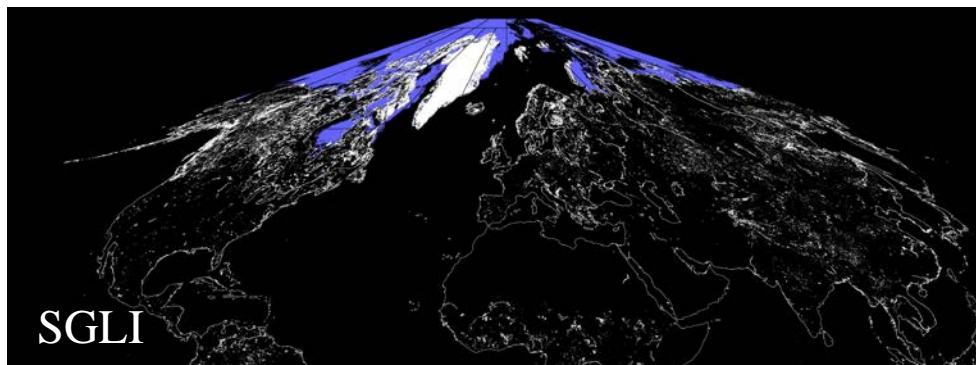## Validation period:

- Mar. 14th to Aug. 20th 2018
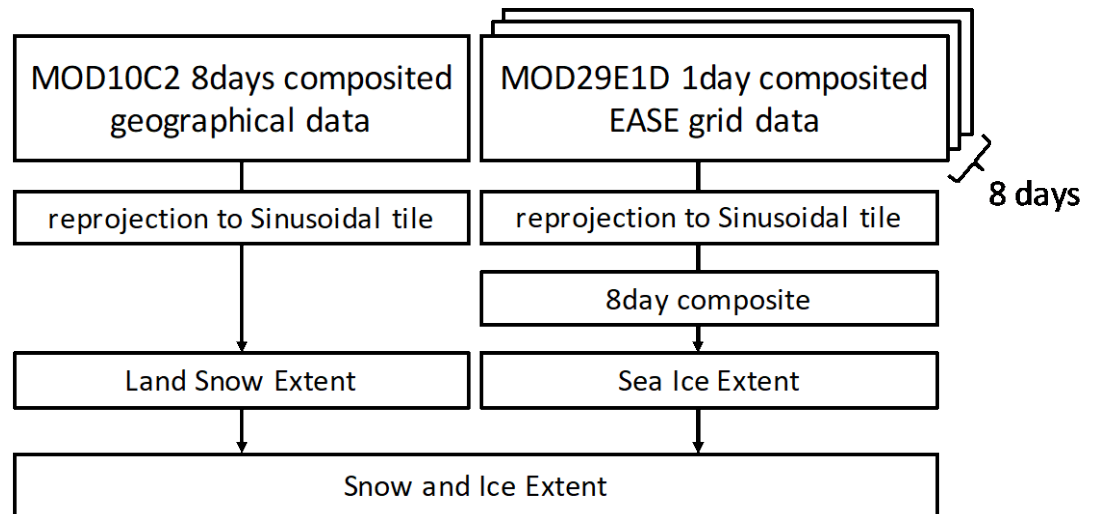
5.2 (a) Snow and Ice covered area (SICE)

Validation Results:

White: snow cover, Blue: sea-ice cover

SGLI

MODIS

Jun.26th to Jul.3rd 2018

Snow and sea-ice cover derived from SGLI and MODIS data
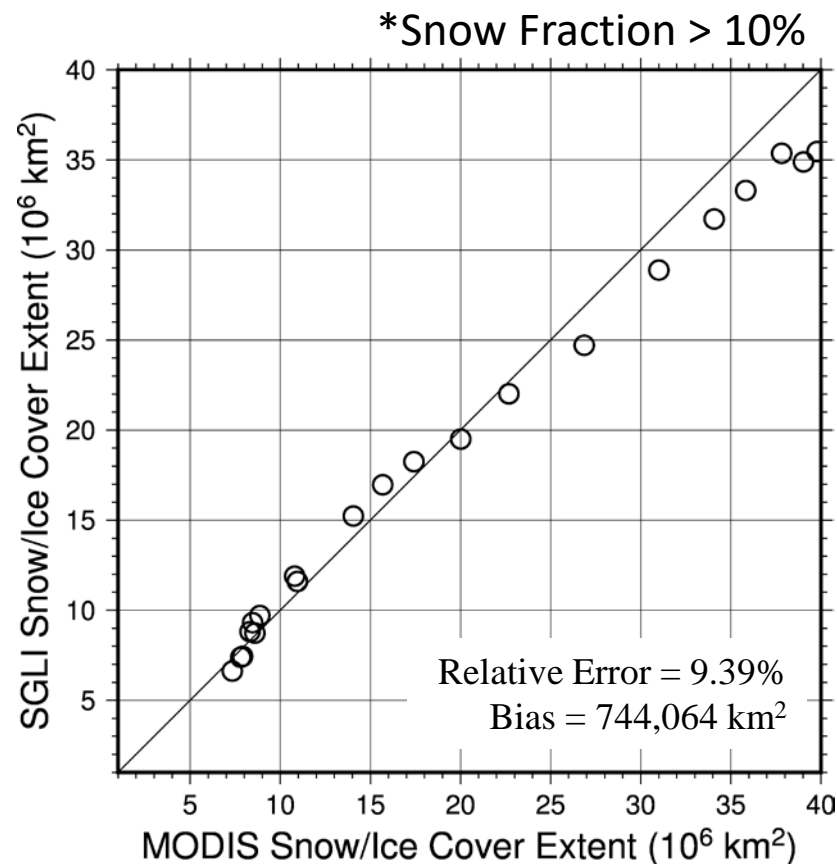
*Snow Fraction > 10%

Relative Error = 9.39%
Bias = 744,064 km^2

Scatter plot between MODIS and SGLI SICE

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

Release threshold is achieved

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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.
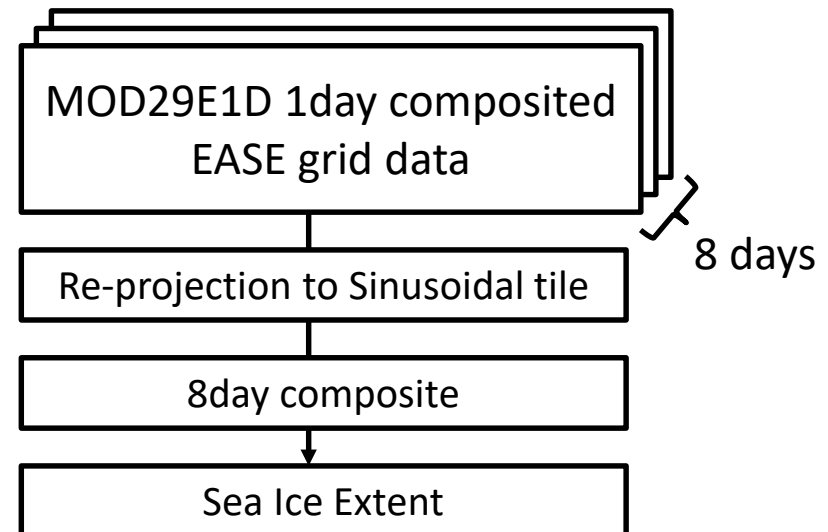
$$Relative\ Error\ (\%) = \frac{\sqrt{\frac{1}{N}\sum(S(i) - T(i))^2}}{\frac{1}{N}\sum T(i)} * 100$$ (N: the number of data, S: SGLI obs., T: other satellite data.)

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.
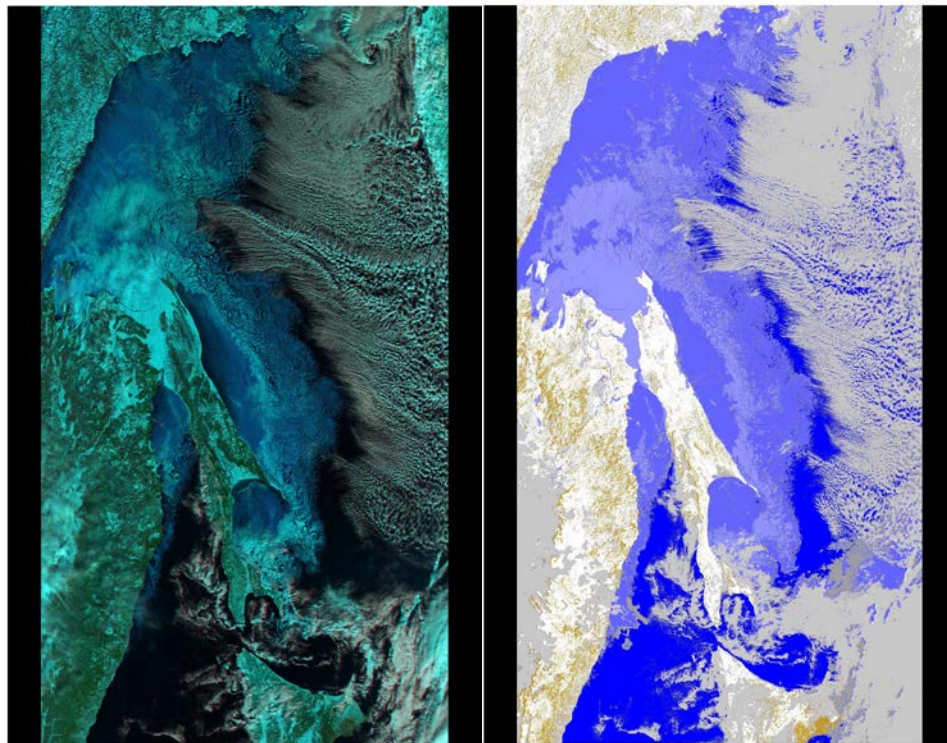
Validation period:

- Mar. 14th to Aug. 20th 2018

MOD29E1D 1day composited
EASE grid data

8 days

Re-projection to Sinusoidal tile

8day composite

Sea Ice Extent

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

<u>Validation Results:</u>

SGLI Reflectance

SGLI sea-ice (OKID)
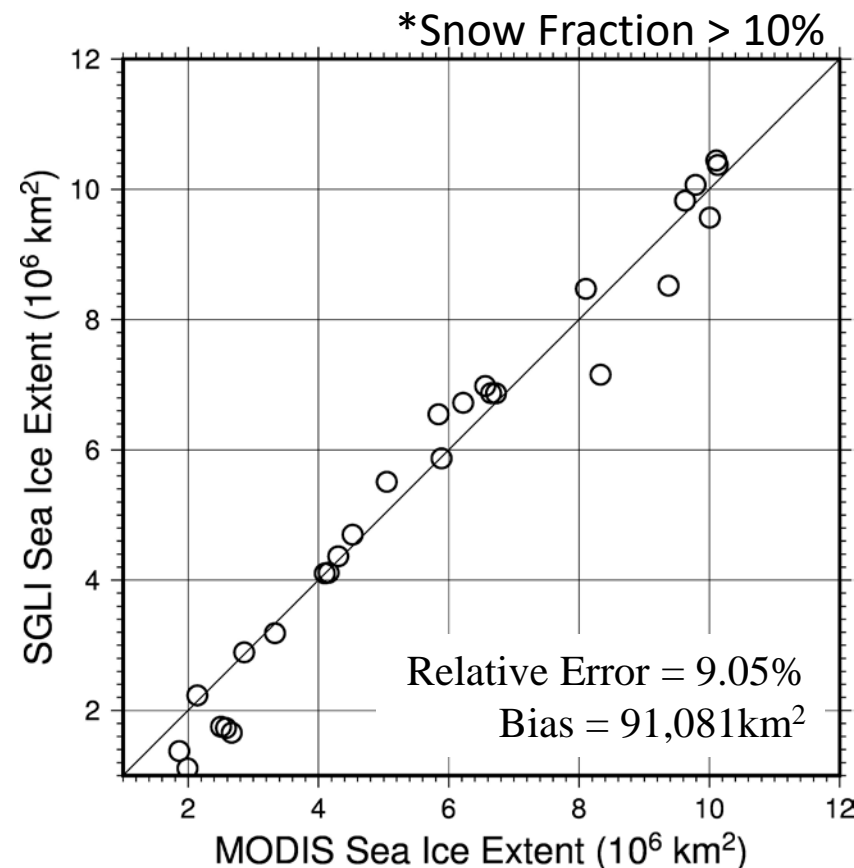
*Snow Fraction > 10%

Relative Error = 9.05%

Bias = 91,081km^2

Scatter plot between MODIS and SGLI SICE

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

Release threshold is achieved

5.2 (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.
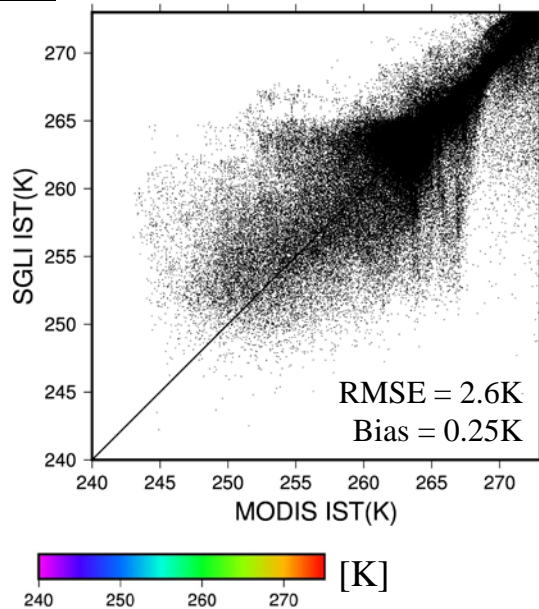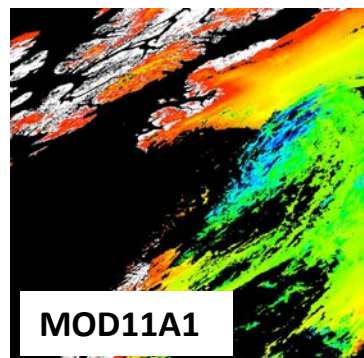
Validation period:
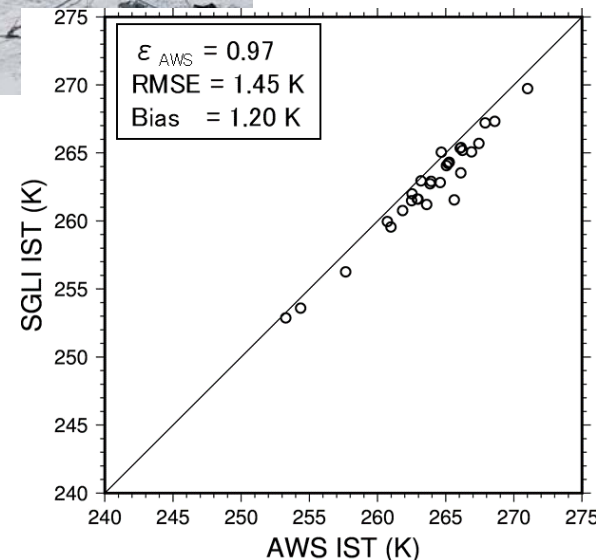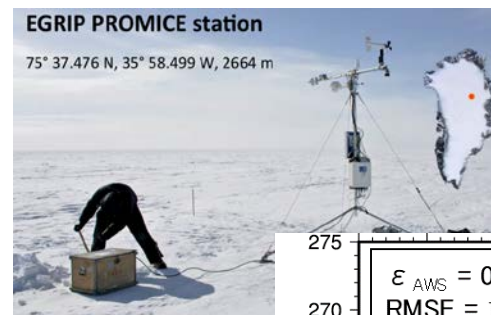
- Jul. 1st to Sep. 30th 2018

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

Validation Results:

MOD11A1

C2AB_SIST

EGRIP PROMICE station
75° 37.476 N, 35° 58.499 W, 2664 m

RMSE = 2.6K
Bias = 0.25K

ε_{AWS} = 0.97
RMSE = 1.45 K
Bias   = 1.20 K

[K]

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 In-situ: 1.5K	5K（vs. other sat.）	2K（vs. in-situ）	1K（vs. in-situ）

Release threshold and Standard accuracy are achieved

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.

$$Relative\ Error\ (\%) = \frac{\sqrt{\frac{1}{N}\sum(S(i) - T(i))^2}}{\frac{1}{N}\sum T(i)} * 100 \quad \text{(N: the number of data, S: SGLI obs., T: other satellite data.)}$$

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.
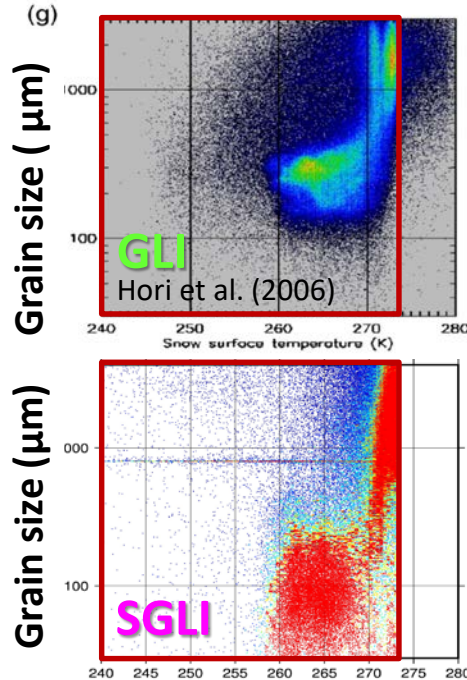
Validation period:

- 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.
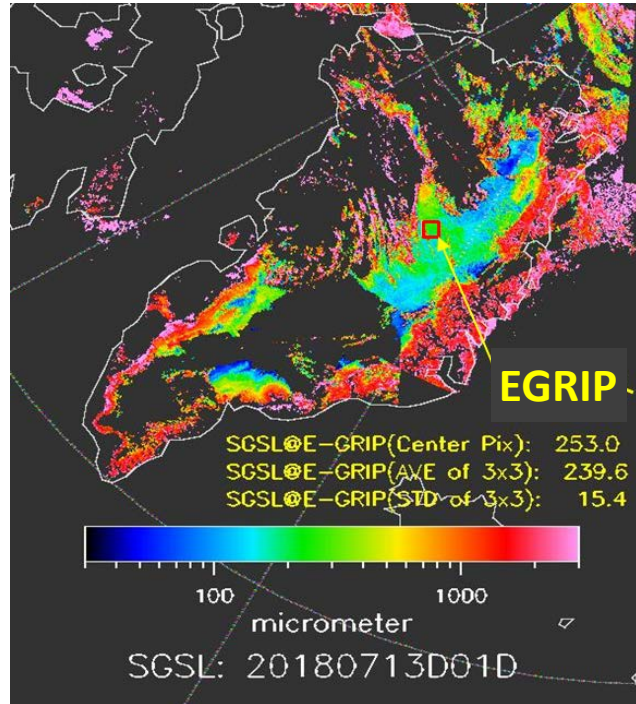
5. Validation Results of Cryosphere Products

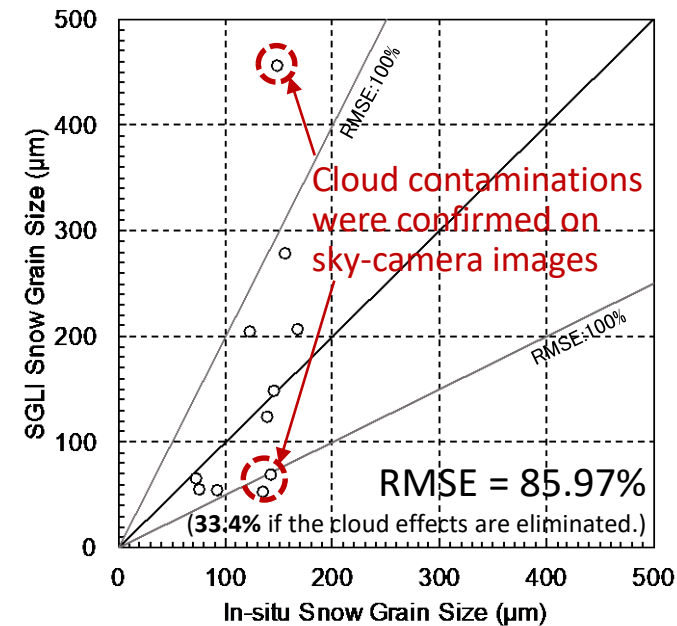## 5.2 (d) Snow grain size of shallow layer (SGSL)

Field experiments at EGRIP, Greenland in 2018

Validation Results:

GLI
Hori et al. (2006)

SGLI

Surface temp.(K)

Climatological relationship between snow surface temperature and snow grain size

SGSL@E-GRIP(Center Pix):   253.0
SGSL@E-GRIP(AVE of 3x3):   239.6
SGSL@E-GRIP(STD of 3x3):   15.4

SGSL: 20180713D01D

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.

Cloud contaminations were confirmed on sky-camera images

RMSE = 85.97%
(**33.4%** if the cloud effects are eliminated.)

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.)