Lessons learned from the GCOM-C (Shikisai)/SGLI cloud observations

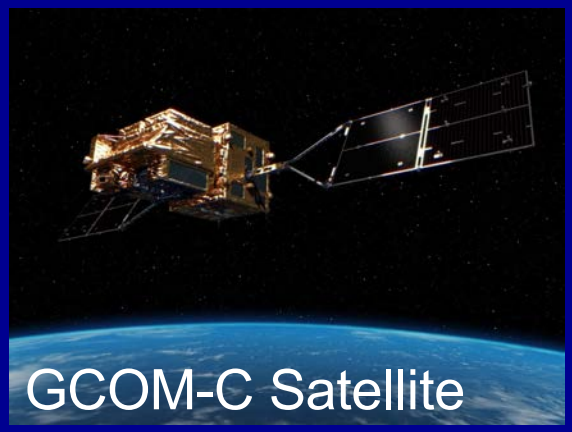
Takashi Y. Nakajima,
Takashi M. Nagao, Masahiro Hori
Riko Higuchi, Haruma Ishida
Husi Letu, Nagai Shin
Kanta Shimizu

Tokai University

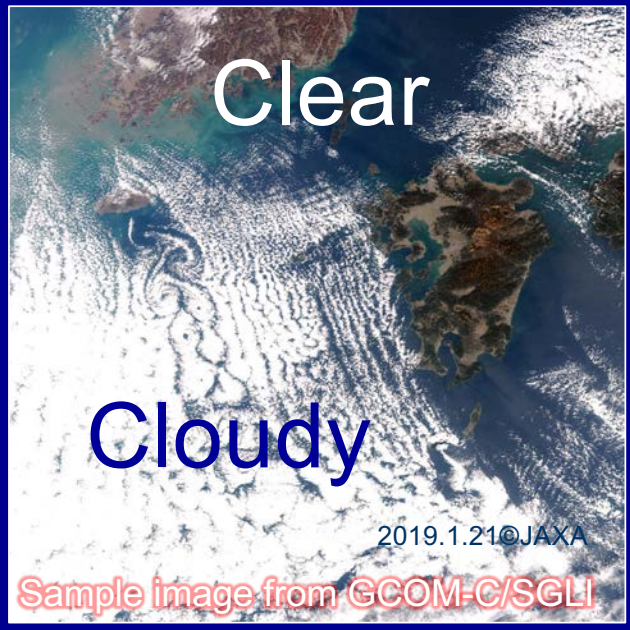
EarthCARE Workshop in 2023

GCOM-C/SGLI

GCOM-C/SGLI
- was launched in December 2017.
- has 19 channels from the ultraviolet to thermal infrared wavelength regions.
- is a follow-on sensor for the GLI aboard the ADEOS-II (Midori-II).


GCOM-C Satellite


GCOM-C



Band specification of the GCOM-C/SGLI

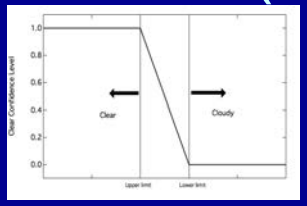
Table 2. SGLI Band Specifications[a]

Band No.	Wavelength (μm)	IFOV (km)
VN1	0.380	0.25
VN2	0.412	0.25
VN3	0.443	0.25
VN4	0.490	0.25
VN5	0.530	0.25
VN6	0.565	0.25
VN7	0.670	0.25
VN8	0.670	0.25
VN9	0.763	1.0
VN10	0.865	0.25
VN11	0.865	0.25
P1	0.670	1.0
P2	0.865	1.0
SW1	1.05	1.0
SW2	1.38	1.0
SW3	1.63	0.25
SW4	2.21	1.0
T1	10.8	0.5
T2	12.0	0.5

[a]VN, unpolarized visible and near-infrared band; P, polarized band; SW, short-wave infrared; T, thermal–infrared.

Swath = 1400km

CLAUDIA algorithm (for cloud flags)



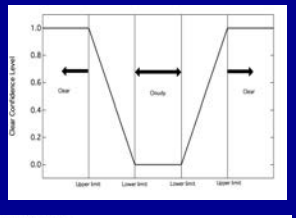
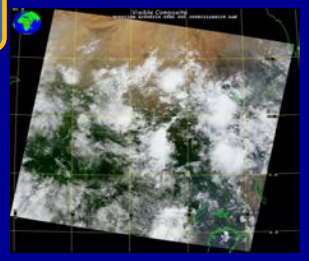
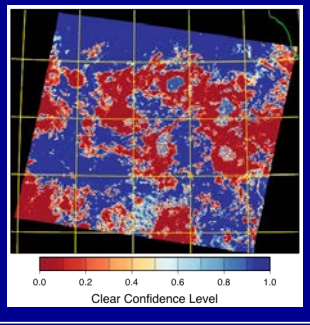


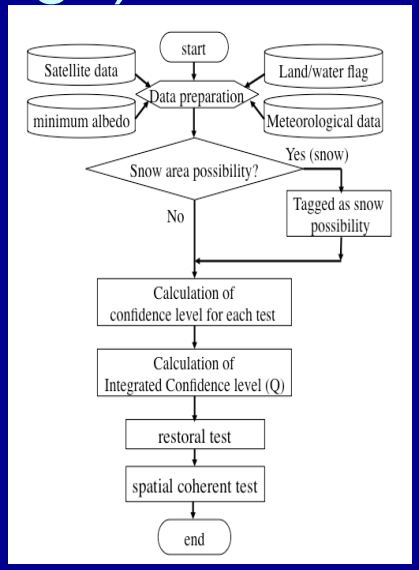
Table 6. Individual Tests and Thresholds

Tests	Ocean		Land		Polar	
	Group	Threshold	Group	Threshold	Group	Threshold
R0.67 (land or polar) or R0.87 ocean)	1	R min +0.12∓0.075	1	R min +0.18∓0.075	1	R min +0.16∓0.04
R0.87/R0.67	1	0.78 ± 0.12 1.25∓0.1	1	0.78 ± 0.12 1.4∓0.3	—	—
NDVI = (R0.87 − R0.67)/(R0.87 + R0.67)	1	−0.16 ± 0.06 0.34∓0.12	1	−0.16 ± 0.06 0.34∓0.12	1	−0.2 ± 0.02 0.4∓0.05
R0.87/R1.64	—	—	1	0.96 ± 0.1	—	—
R1.24/R0.55	—	—	1	1.86∓0.12	—	—
SW BT3.9-BT3.7				>− 11[K]		
SW BT11-BT3.7				>− 15[K]		
R0.905/R0.935	1	2.9∓0.1	—	—	—	—
SW BT11-BT3.7		>− 15[K]				
SW R0.905		<0.08				
BT11	2	267[K]∓6[K]	R	297.5[K]∓5[K]	—	—
R1.38	2	0.04∓0.01	—	—	—	—
BT6.7	2	220[K]∓10[K]	2	220[K]∓10[K]	—	—
BT11-BT3.9	2	−8[K]∓4[K]	2	−20[K]∓4[K]	1	−7[K]∓3[K]-
BT13.9	2	226[K]∓4[K]	2	224[K]∓4[K]	—	—

*x∓y denotes that the lower and upper limit are x − y and x + y, respectively. R in a group name denotes a restoral test, SW denotes "switch."

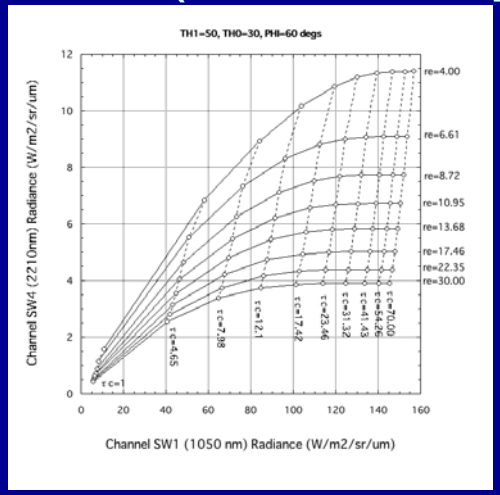


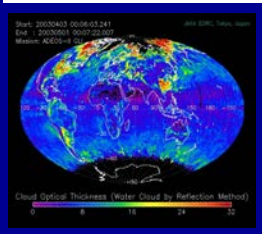


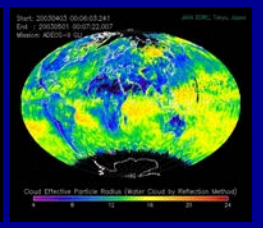


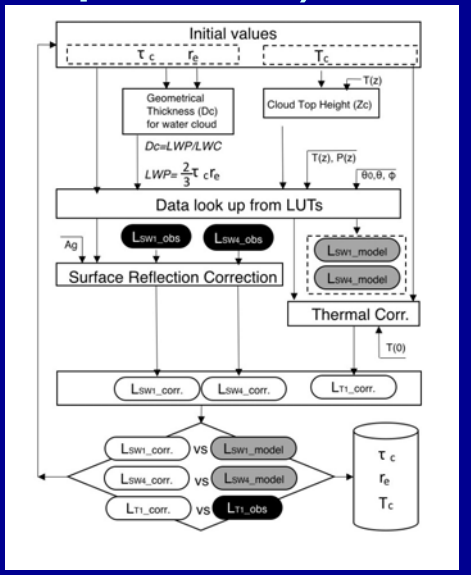
Ishida, H., and T. Y. Nakajima, 2009: Development of an unbiased cloud detection algorithm for a spaceborne multispectral imager. Journal of Geophysical Research-Atmospheres, 114, doi:10.1029/2008JD010710.
Nakajima, T. Y., T. Tsuchiya, H. Ishida, and H. Shimoda, 2011: Cloud detection performance of spaceborne visible-to-infrared multispectral imagers. Applied Optics, 50, 2601-2616

CAPCOM algorithm (for cloud properties)





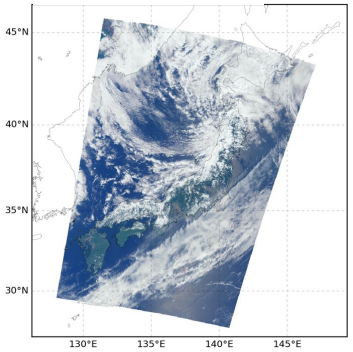




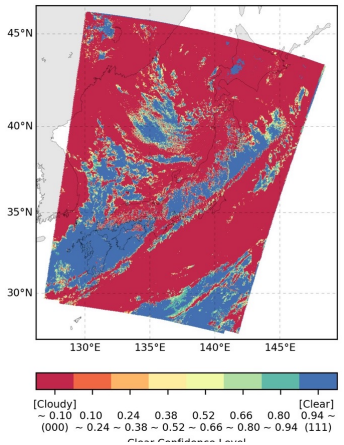
Nakajima, T. Y., and T. Nakajima, 1995: Wide-area determination of cloud microphysical properties from NOAA AVHRR measurements for FIRE and ASTEX regions. Journal of the Atmospheric Sciences, 52, 4043-4059.
Kawamoto, K., T. Nakajima, and T. Y. Nakajima, 2001: A global determination of cloud microphysics with AVHRR remote sensing. Journal of Climate, 14, 2054-2068.

SGLI vs MODIS (Cloud Flag)

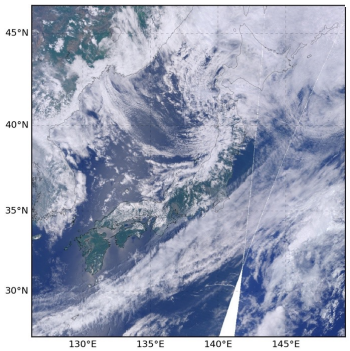
a) SGLI RGB



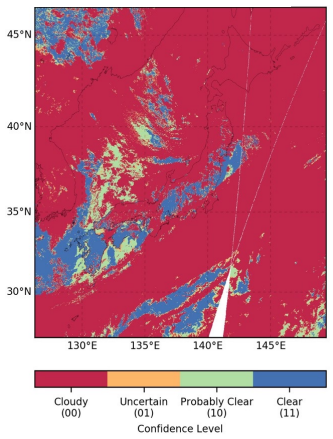
SGLI Cloud Flag



c) MODIS RGB

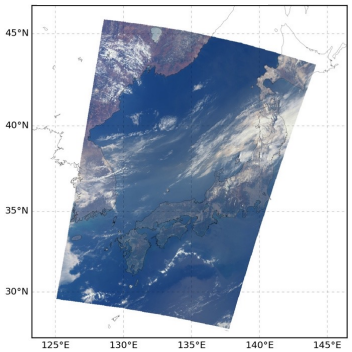


MODIS Cloud Flag

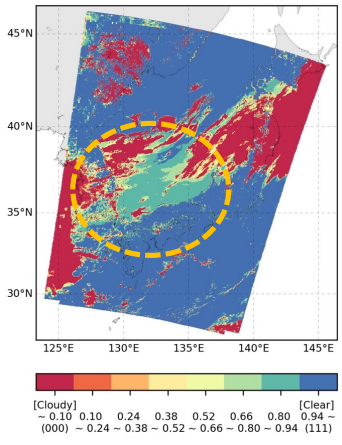


MODIS cloud flag is “clear conservative”

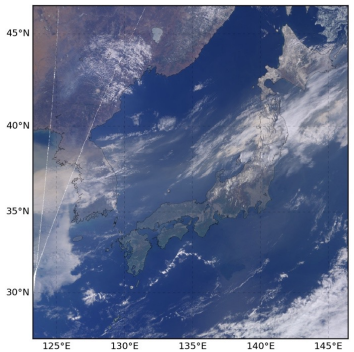
a) SGLI RGB



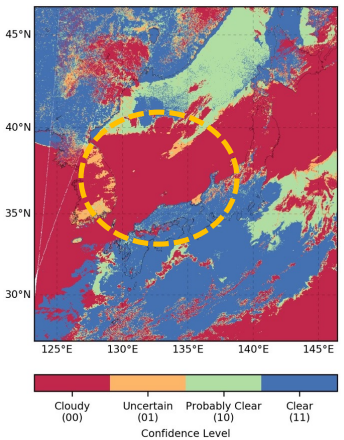
SGLI Cloud Flag



c) MODIS RGB

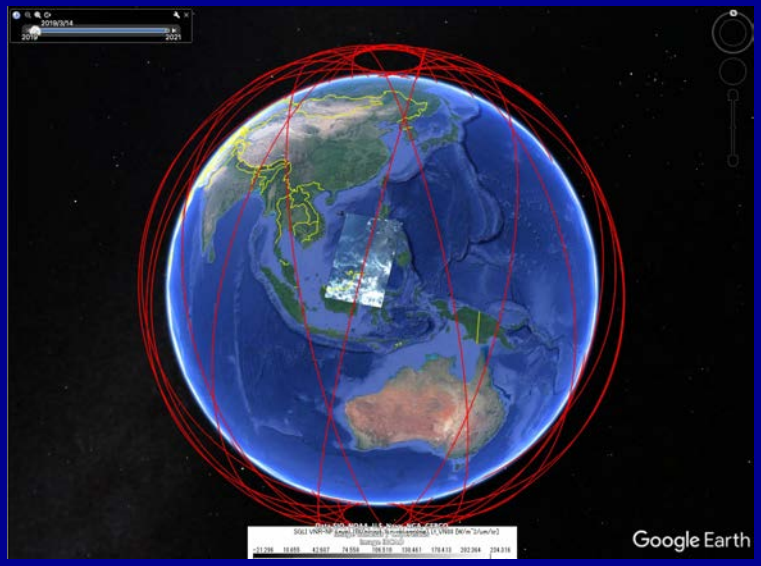


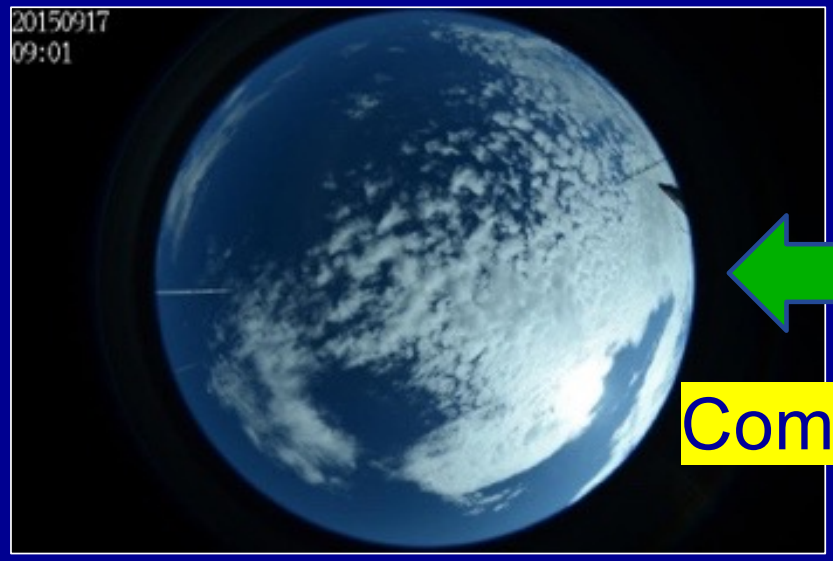
MODIS Cloud Flag



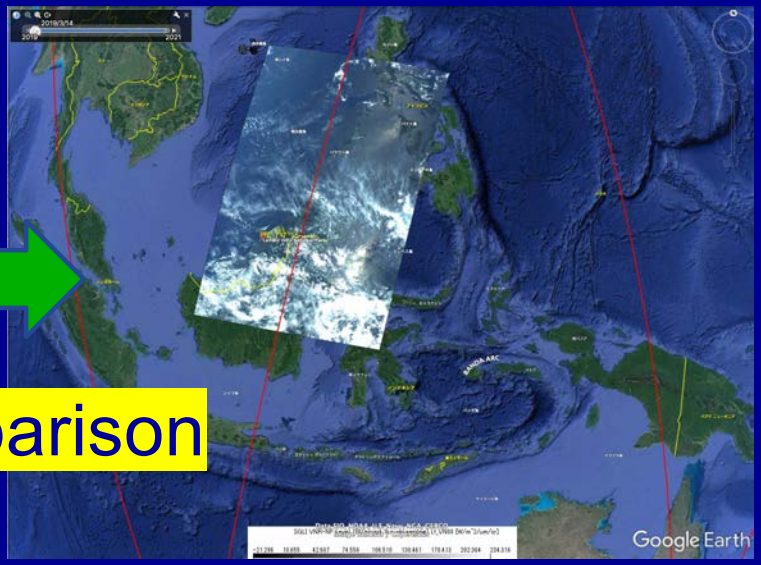
MODIS cloud flag discriminated yellow sands as clouds

Validation of the satellite-derived cloud flag, using ground-based sky camera images

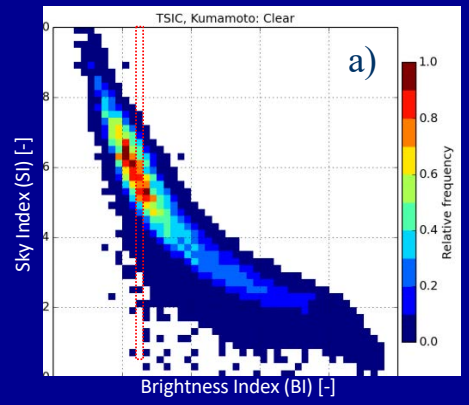


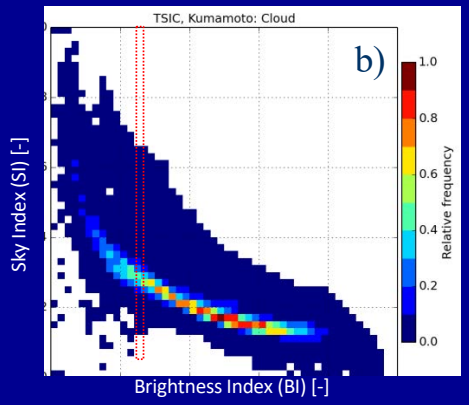


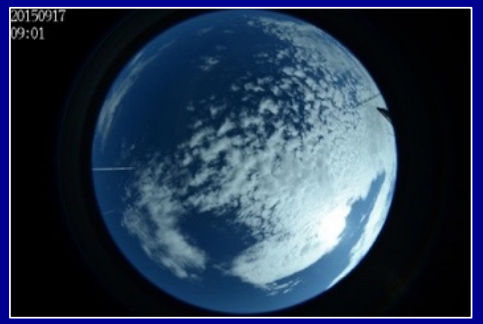
Comparison

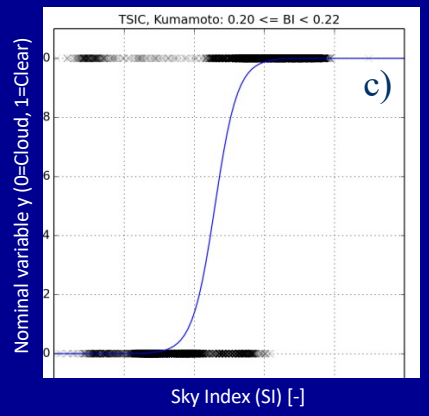


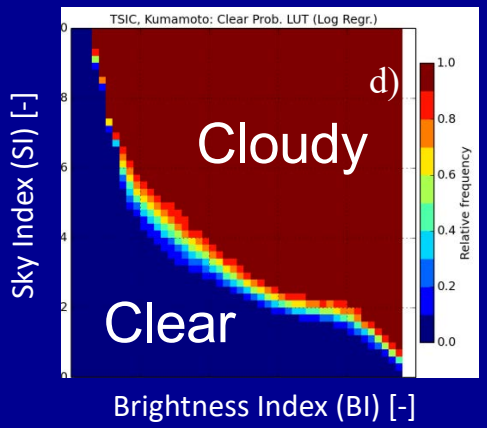
Validation: Whole Sky Camera Analysis

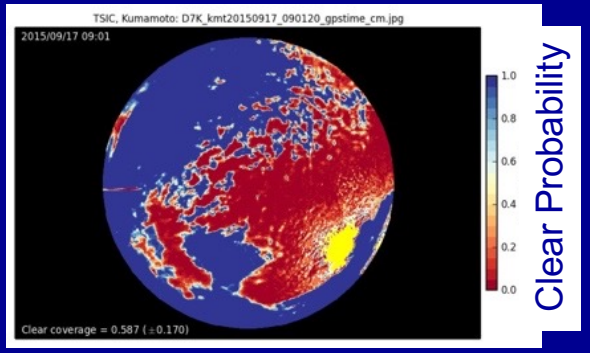






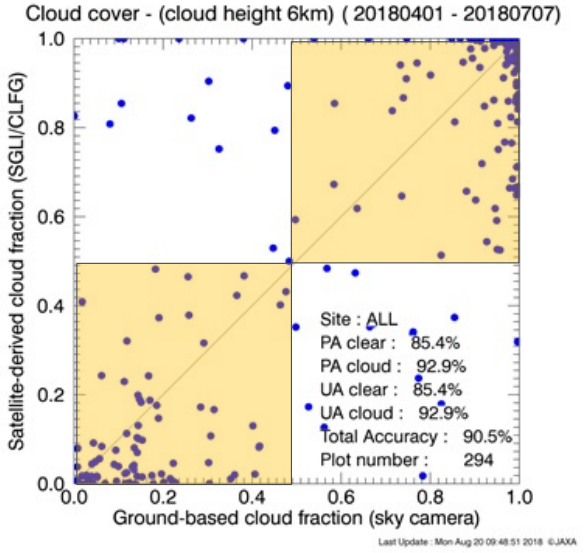






- SI=(Blue-Red)/(Blue+Red)
- BI=(Red+Green+Blue)/(255*3)

Validation of cloud flag by using Sky camera systems



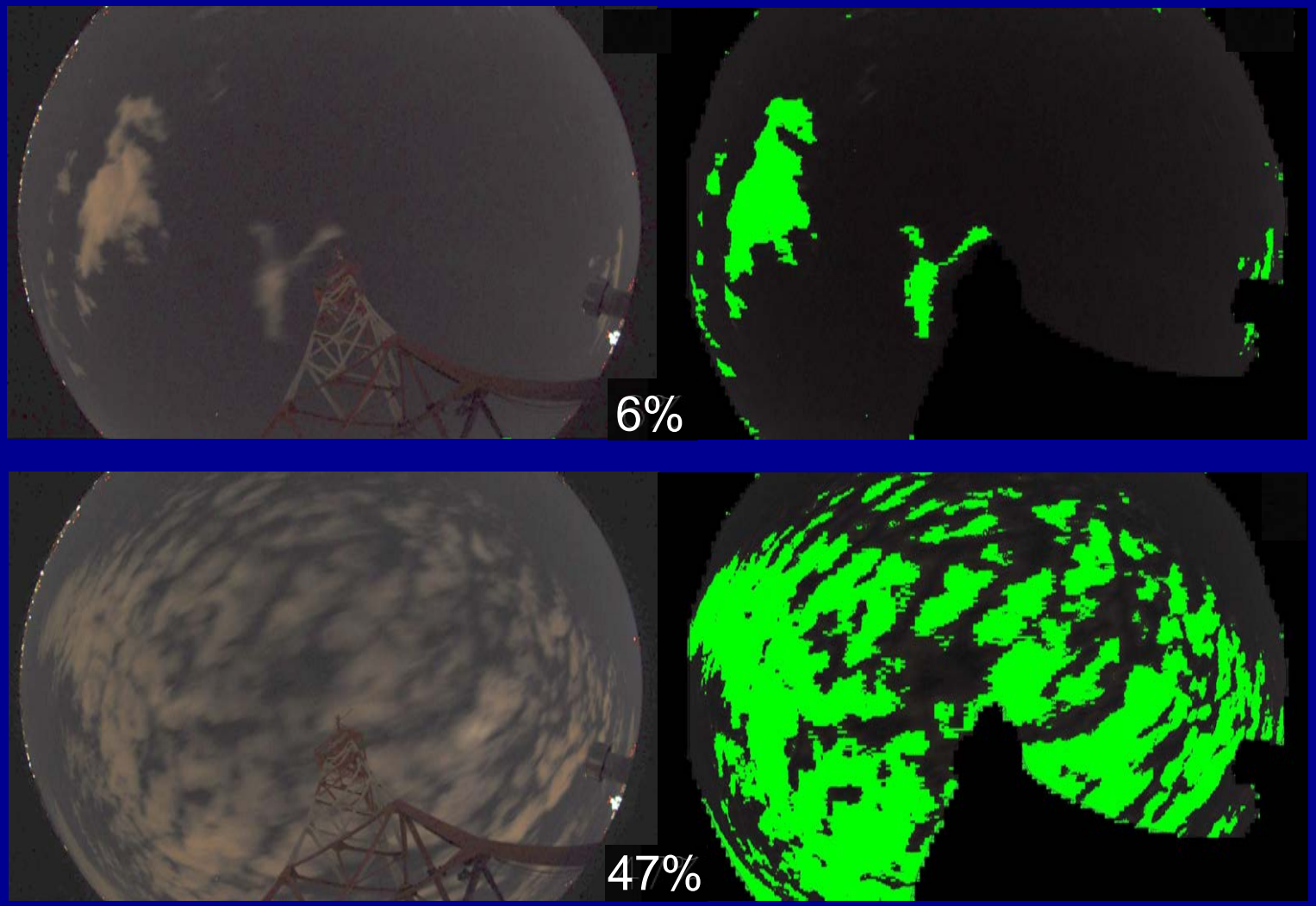
Accuracies *1	Ny-Alesund	Sapporo	Tsukuba TKSC	Tsukuba MRI	Kumamoto	Miyako-jima	Syowa Station	All
N	53	25	58	25	53	47	33	294
Accuracy (%)	94.3	88.0	94.8	100.0	88.7	83.0	84.8	**90.5**

*1 In the case of cloud height at 6 km

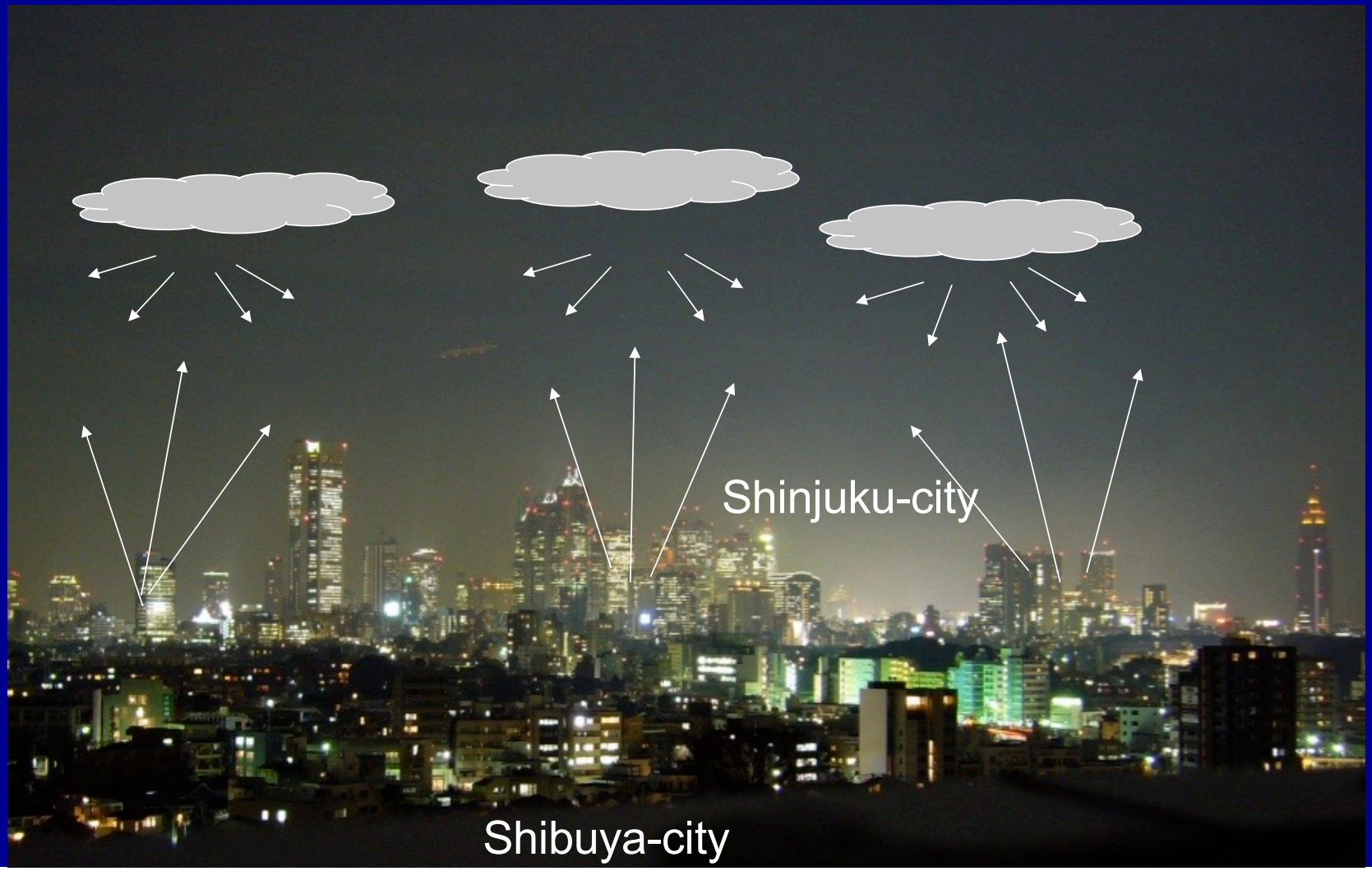
=> Meet the release criterion

Nakajima, T. Y., and Coauthors, 2019: Theoretical basis of the algorithms and early phase results of the GCOM-C (Shikisai) SGLI cloud products. Prog Earth Planet Sci 6:52.

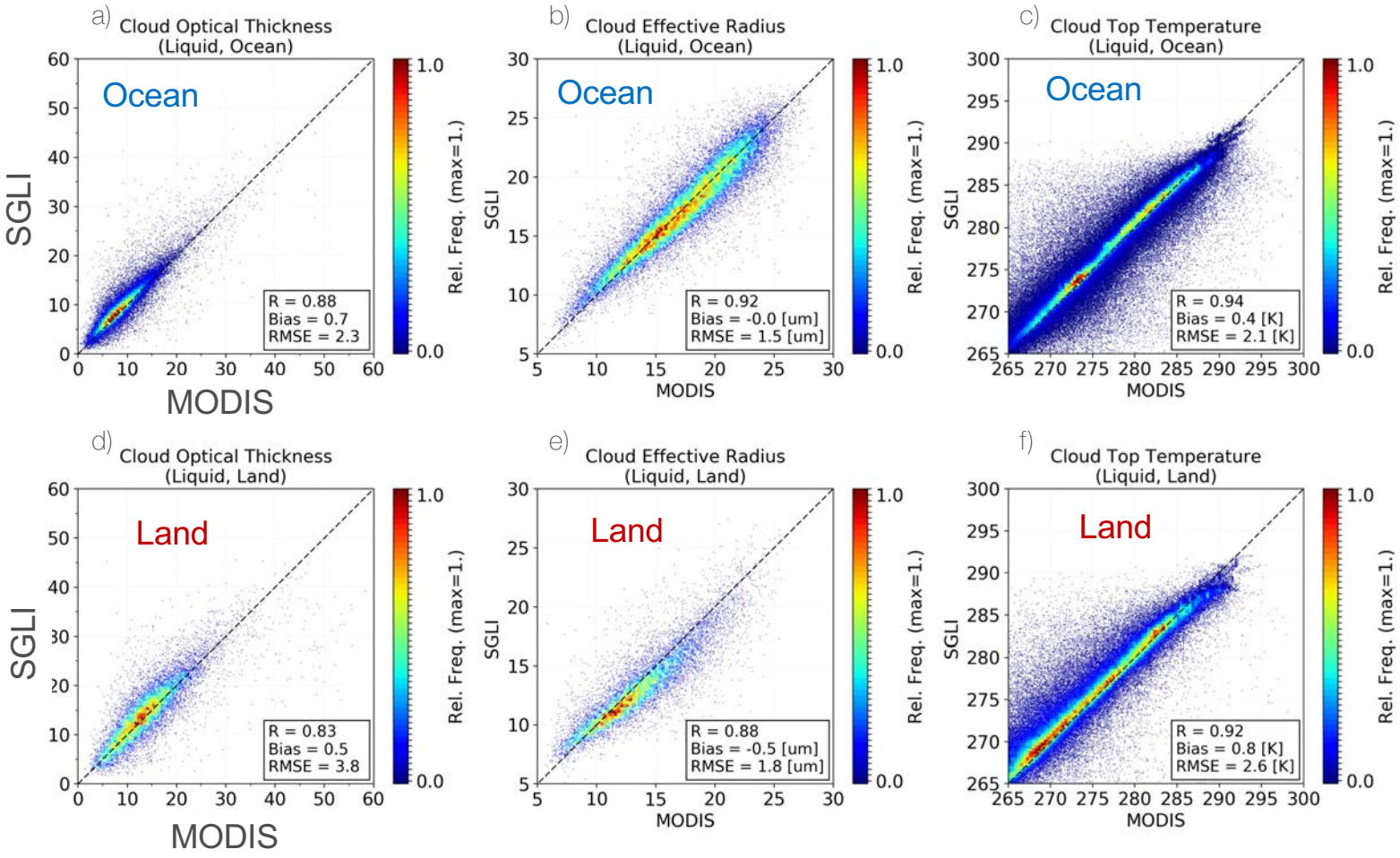
The lights of the city of Shinjuku capture clouds even at night.



Night Time (***Shibuya, Tokyo*** Japan)

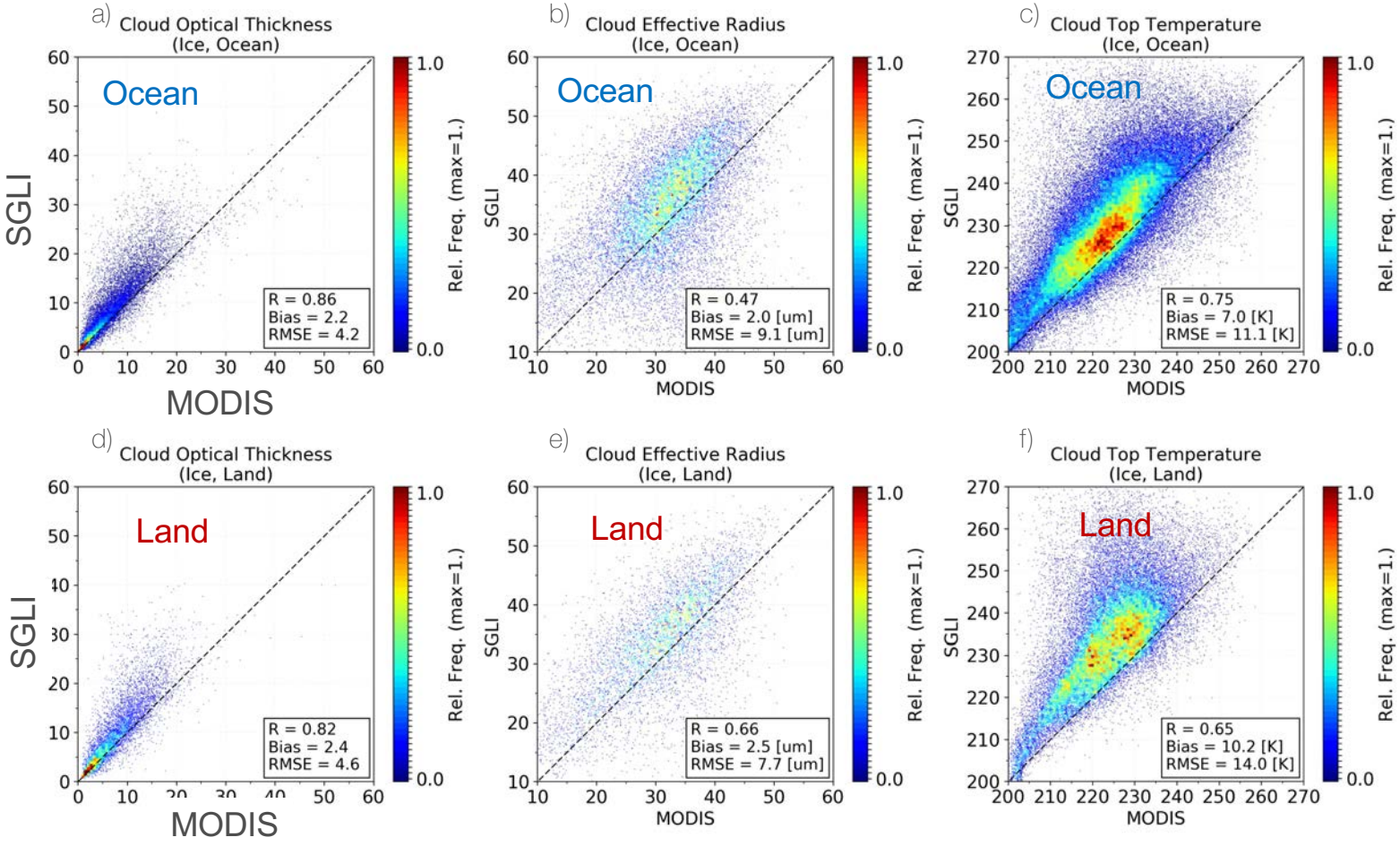

Shinjuku-city
Shibuya-city

Comparison between SGLI and MODIS (**Water Cloud** Properties)



Nakajima et al. 2019

Comparison between SGLI and MODIS (**Ice Cloud** Properties)



Nakajima et al. 2019

Various size and habit of **Voronoi** models for ice cloud

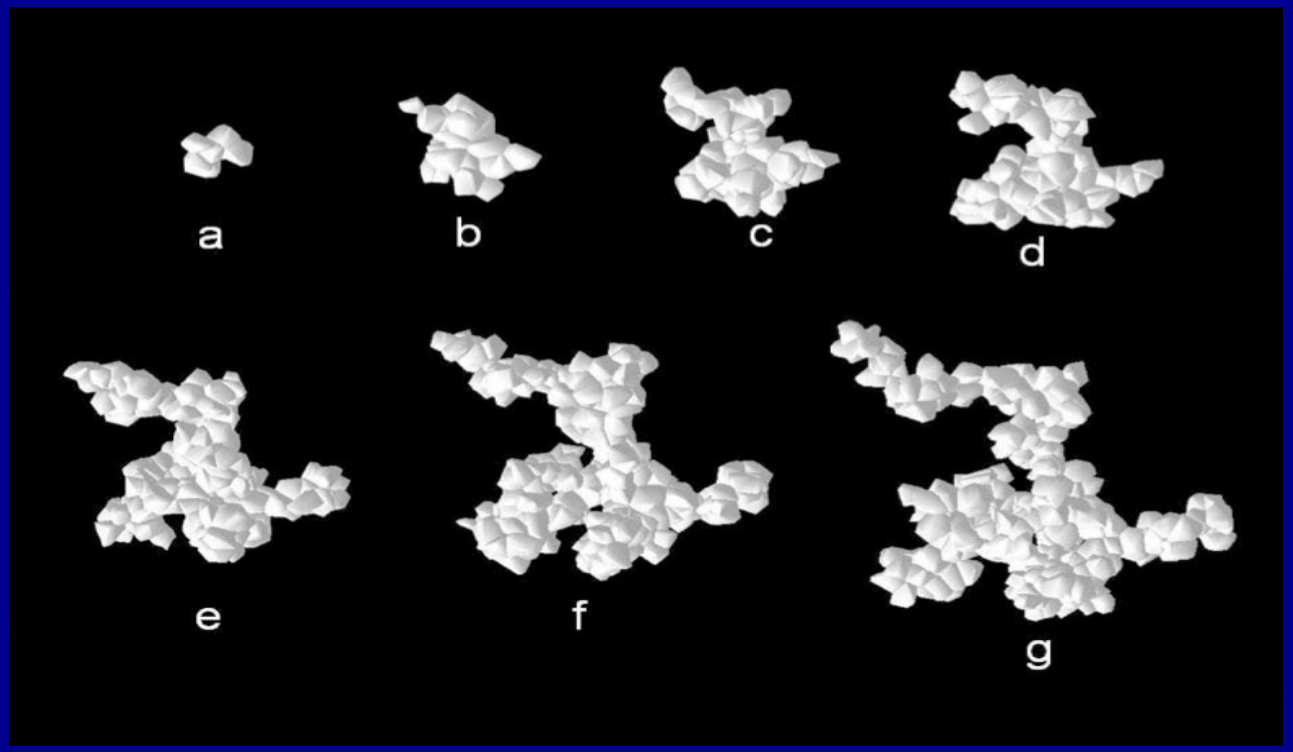


Figure : Various size and habit of Voronoi models (Ishimoto et al., 2012)
(shape (a): size parameter (SZP) < 660; shape (b) – (g): 660 < SZP < 2250)

Summary

- The GCOM-C PI team sets seven sky-camera systems located on Ny-Alesund, Sapporo, Tsukuba (TKSC), Tsukuba (MRI), Kumamoto, Miyakojima, and Showa station (Antarctic) , for validating cloud flags.
- The results shows that total accuracy of cloud flag up to 90.5%.
- SGLI-derived cloud properties are consistent with past studies by TRMM, ADEOS2, and Terra Aqua/MODIS.
- Narrower swath of the MSI comparing with the SGLI

  ➔ more ground validation stations are needed.
- Validate cloud top heights using the ATLID.