Comparisons of Sea Surface Temperature Algorithms for GEO-KOMPSAT-2A Geostationary Satellite Data

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Abstract : To develop sea surface temperature (SST) retrieval algorithms for GEO-KOMPSAT-2A (*Geostationary* - Korea Multi-Purpose Satellite-2A), we compare previously known algorithms such as MCSST and NLSST methods, as well as a recently developed hybrid algorithm and a 4-band algorithm that uses 4-channel brightness temperatures. The traditional empirical algorithms (MCSST and NLSST methods) have been widely used in spite of their local bias according to various and time-varying atmospheric conditions. SST coefficients retrieved by these algorithms are fundamentally based on a regression method between satellite-observed brightness temperatures and in-situ SST measurements from drifters or moored buoys. The hybrid algorithm, based on a regression method between the incremental values and a scaling method, is applied to estimate the coefficients of Himawari-8 data as a proxy for GK-2A data. In addition, the performance of the 4-band algorithm, as another regression method, is tested for SST estimation using Himawari-8 data. Root-mean-square (RMS) and bias errors are presented for each algorithm in comparison to drifter temperatures. The comparison with in-situ SST measurements shows that hybrid SSTs have accuracies similar to the 4-band SSTs, with RMS errors are 0.55°C and 0.48°C, respectively. However, the errors of the estimated SSTs reveal, in some cases, a significant difference between hybrid SSTs and 4-band SSTs in terms of atmospheric variables such as moisture, wind speed, and distance from the cloud edge.

SST Retrieval Algorithm

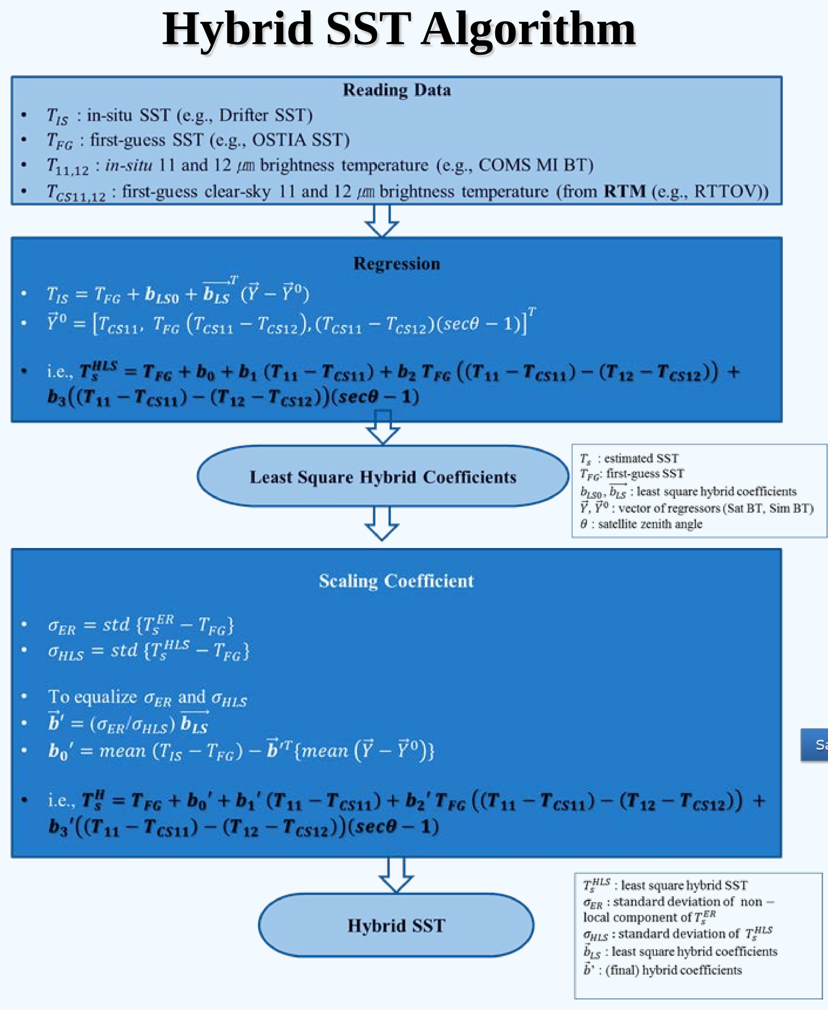
Linear (MCSST) Algorithm

$$MCSST = a_0 T_i + a_1 (T_i - T_j) + a_2 (T_i - T_j)(\sec\theta - 1) + a_3(sec\ \theta - 1) + a_4$$

Nonlinear (NLSST) Algorithm

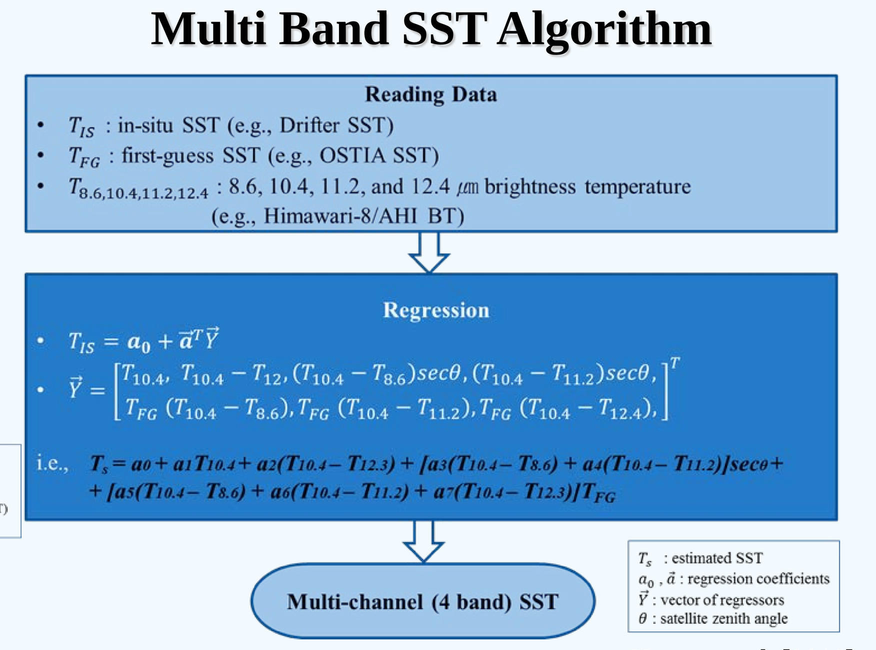
$$NLSST = a_0 T_i + a_1 T_{sfc} (T_i - T_j) + a_2 (T_i - T_j)(\sec\theta - 1) + a_3(sec\ \theta - 1) + a_4$$

Hybrid SST Algorithm



Ignatov et al. [2010]

Multi Band SST Algorithm

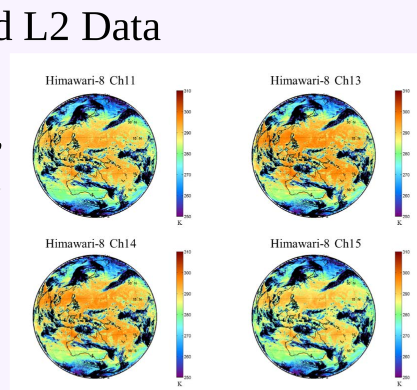


Kramar et al. [2016]

Data

Satellite (Proxy) Data

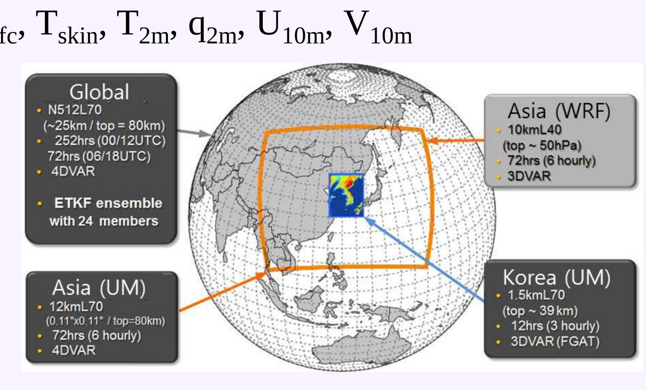
- Himawari-8/AHI L1B and L2 Data
  - Channels : Ch11(8.6 μm), Ch13(10.4 μm), Ch14(11.2 μm), Ch15(12.3 μm)
  - Resolution Temporal : 10 min, Spatial : 2 km
  - Period : April 2016



Data		Spatial Resolution	Temporal Resolution
Himawari-8/AHI L1B and L2 Data	Ch11 (8.6 ㎛) Brightness Temperature	2 km	10 min (1 hour)
	Ch13 (10.4 ㎛) Brightness Temperature		
	Ch14 (11.2 ㎛) Brightness Temperature		
	Ch15 (12.3 ㎛) Brightness Temperature		
	Cloud Mask (NOAA)		
	Land/Sea Mask	2 km	-

NWP Data

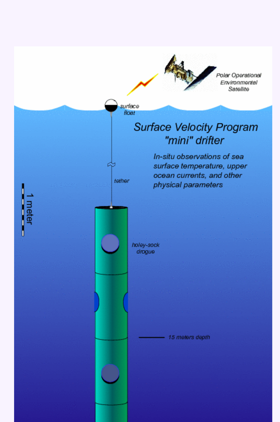
- UM Data
  - T, p, q vertical profiles
  - p_{sfc}, T_{skin}, T_{2m}, q_{2m}, U_{10m}, V_{10m}

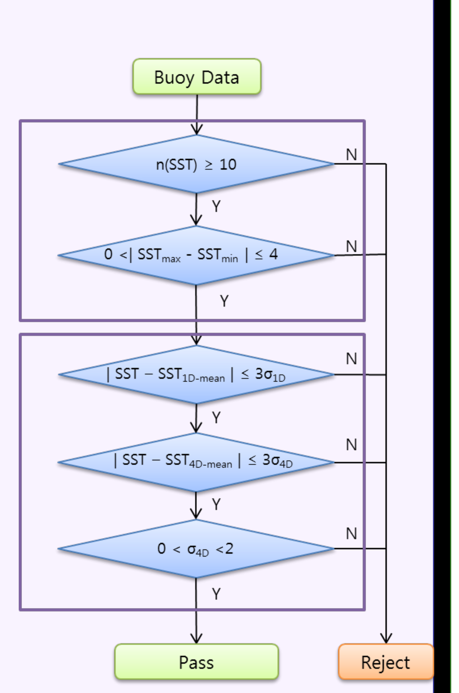


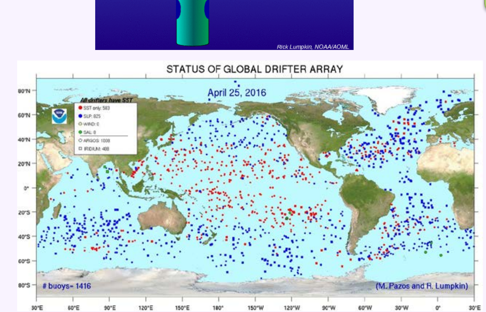
Spatial Resolution	N512 (25 km)
Vertical Level	L70 (Top 80 km)
Number of Grid	1024(east-west) x 769(south-north)
Prediction Interval	1 hour

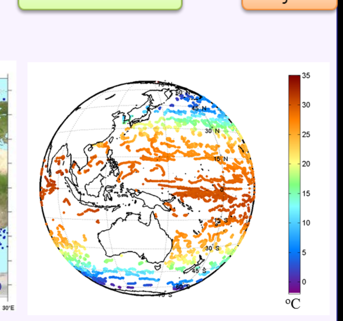
In-situ Data

- Drifter Data
  - GTS Data
  - 20,000-30,000 each day, real-time

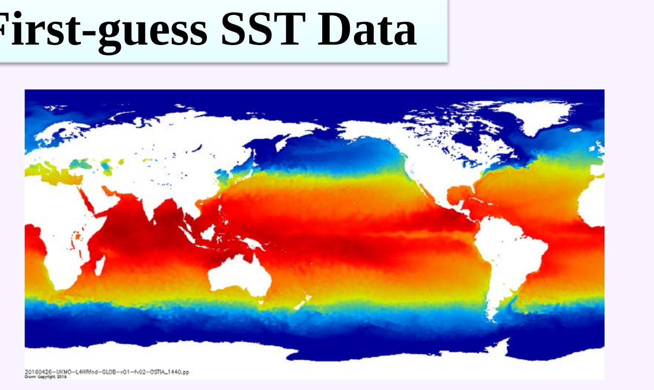








First-guess SST Data

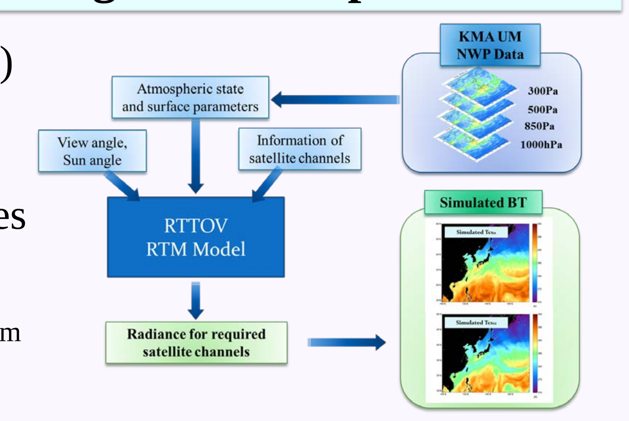


- OSTIA Data
  - Daily composite SST
  - Spatial resolution : 0.05°

Clear-sky Brightness Temperature

- RTM (RTTOV)

Input : UM Data
T, p, q vertical profiles
p_{sfc}, T_{skin}, T_{2m}, q_{2m}, U_{10m}, V_{10m}



- Simulated Clear-sky Brightness Temperature

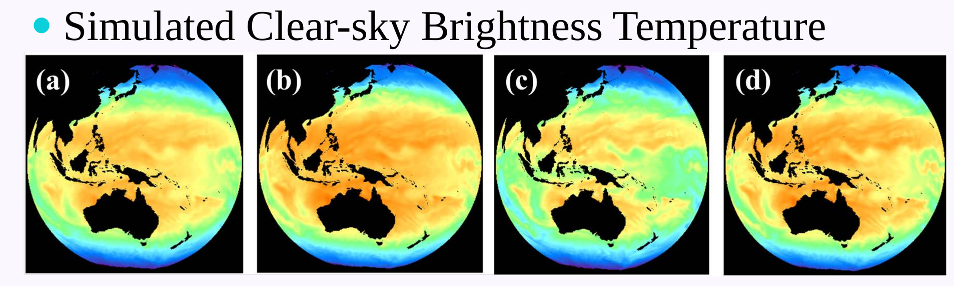


Fig. Example of RTM-simulated (a) 8.6-㎛ (Ch11), (b) 10.4-㎛ (Ch13), (c) 11.2-㎛ (Ch14), and (d) 12.3-㎛ (Ch15) clear-sky brightness temperatures.

Matchup Procedure

- Temporal interval : < 30 minutes
- Spatial criteria : < 2 km (pixel size of Himawari-8/AHI image)

Matchup Database	Area	Period	#
Himawari8 – GTS Drifter – Simulated BT – OSTIA SST	90°S~90°N, 60°E~220°E	2016.4.1 ~ 2016.4.30	66,965

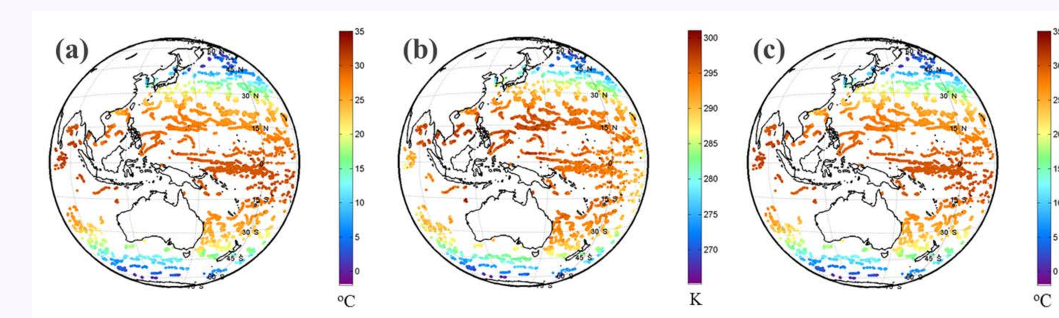


Fig. (a) in-situ SST, (b) satellite-observed 10.4-㎛ BT, and (c) first-guess SST (OSTIA SST) on the collocation points.

SST Coefficient

Hybrid SST

$$T_s = T_{FG} + a_0 + a_1(T_{11} - T_{CS11}) + a_2[(T_{11} - T_{CS11}) - (T_{12} - T_{CS12})]T_{FG} + a_3[(T_{11} - T_{CS11}) - (T_{12} - T_{CS12})](sec\theta - 1)$$

a_0	a_1	a_2	a_3
-0.4381	0.9475	0.0566	-0.4655

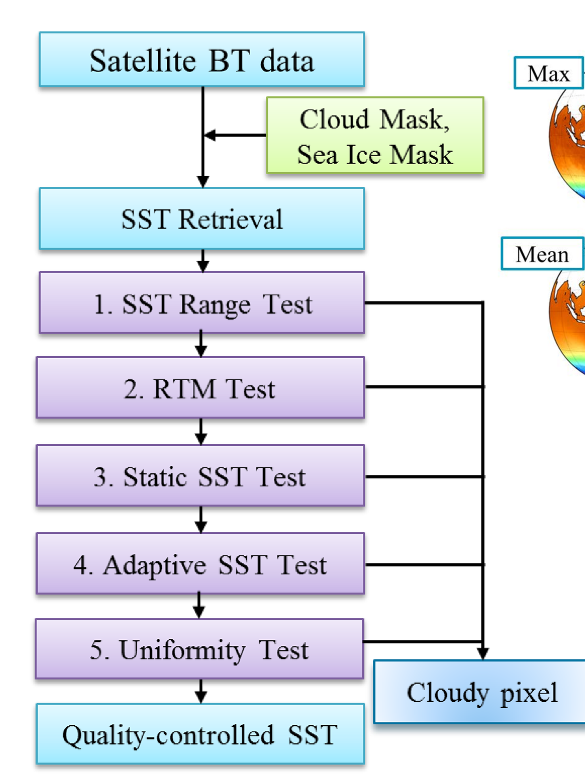
4-Band SST

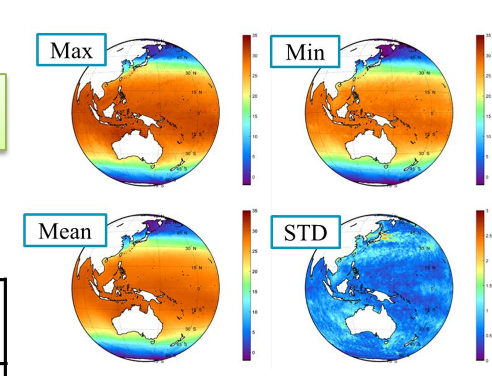
$$T_s = a_0 + a_1 T_{10.4} + a_2(T_{10.4} - T_{12.4}) + [a_3(T_{10.4} - T_{8.6}) + a_4(T_{10.4} - T_{11.2})]sec\theta + [a_5(T_{10.4} - T_{8.6}) + a_6(T_{10.4} - T_{11.2}) + a_7(T_{10.4} - T_{12.4})]T_{FG}$$

a_0	a_1	a_2	a_3
24.0775	0.9243	-1.2284	0.5087

a_4	a_5	a_6	a_7
0.7260	-0.0259	-0.0062	0.0724

SST Quality Control





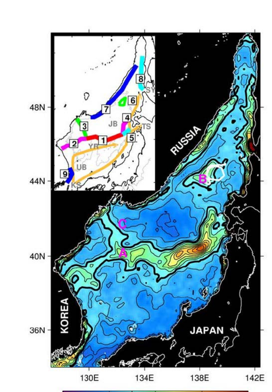


Fig. Flowchart of SST quality control

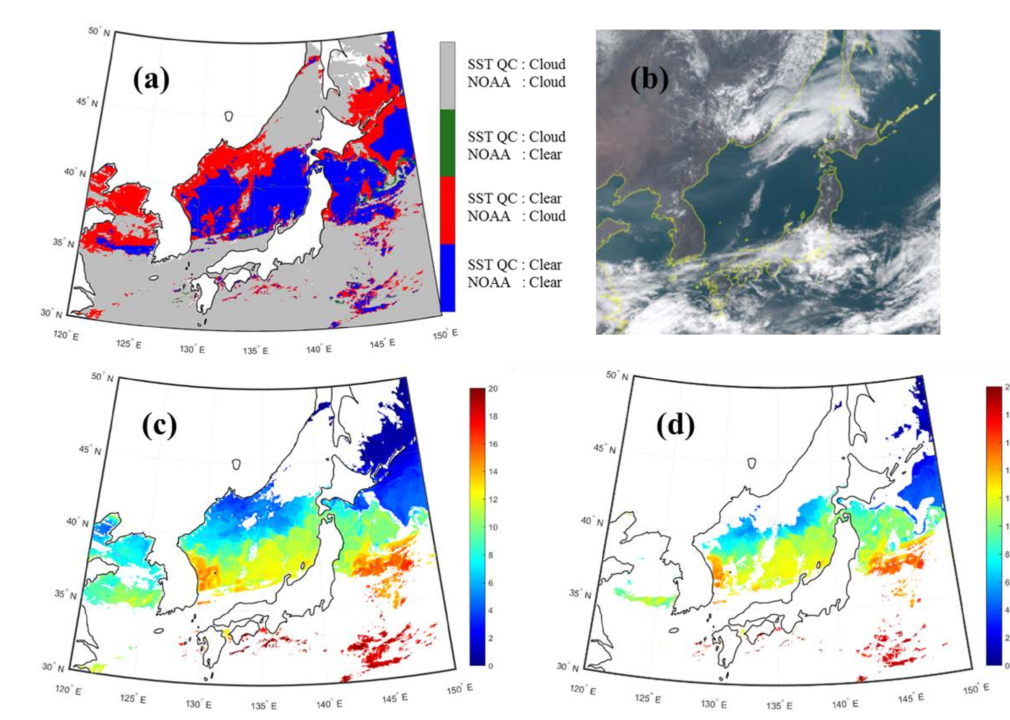


Fig. (a) comparison of quality flag between NOAA and this study, (b) RGB image, and SST images quality controlled from (c) this study and (d) NOAA at 03:00 UTC on 5 April 2016.

Factors causing the difference of quality f

- Kind of RTM, input data of RTM, first-guess SST, window size of adaptive SST test, and thresholds of each test

Validation

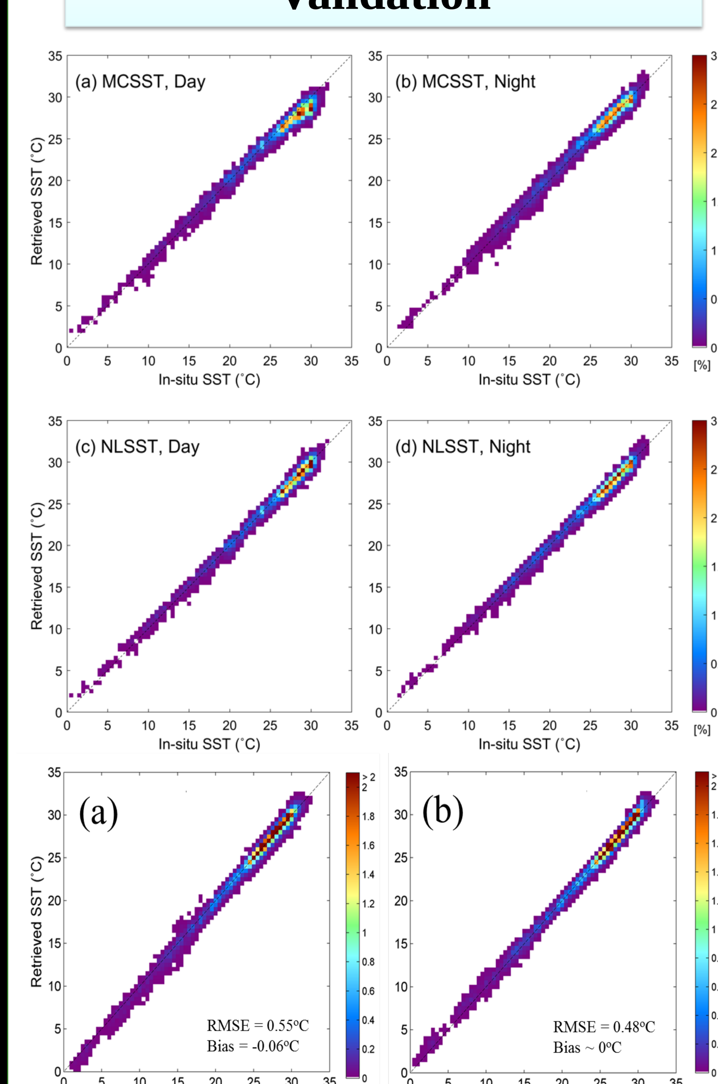


Fig. Comparison between MCSST and in-situ SST (a) daytime and (b) nighttime. (c) and (d) as (a) and (b) but for NLSST. The color scale represent the percentage of the data in each 0.5°C × 0.5°C bin..

Fig. Comparison between (a) hybrid SST and *in-situ* SST and (b) multi band SST and *in-situ* SST. The color scale represent the percentage of the data in each 0.5°C × 0.5°C bin..

Table The RMSE and bias values for each of the SST retrieval algorithms

	RMSE		Bias	
	Day	Night	Day	Night
4-band SST	0.4734		0.0071	
Hybrid SST	0.5513		-0.0126	
MCSST	0.8828	0.6670	-0.4675	0.0778
NLSST	0.5417	0.5353	-0.1113	-0.1025

Error Dependency

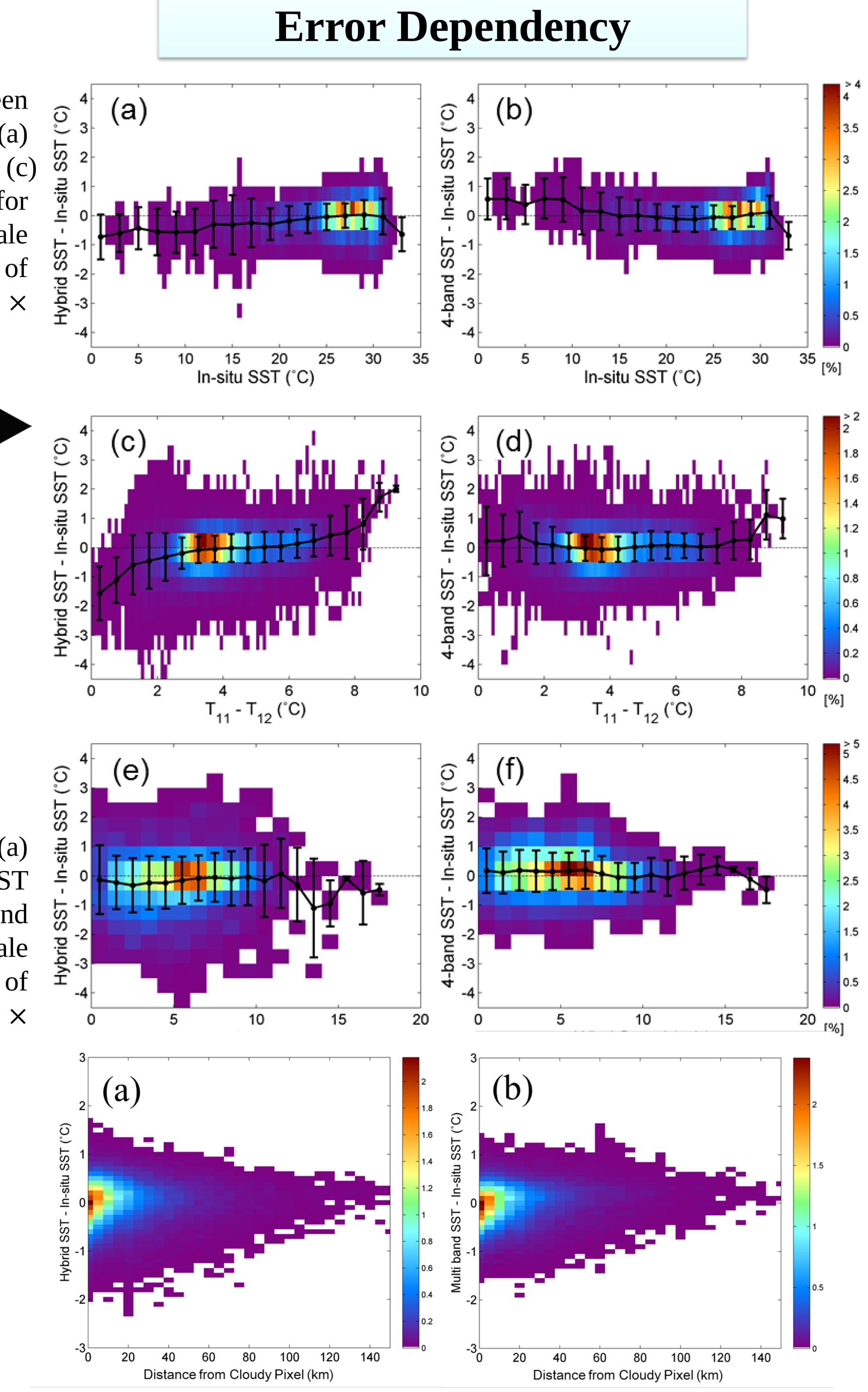


Fig. Error dependency of (a) hybrid SST minus *in-situ* SST and (b) multi band SST minus *in-situ* SST on *in-situ* SST. Error dependency of (c) hybrid SST minus *in-situ* SST and (d) multi band SST minus *in-situ* SST on atmospheric moisture. (e) and (f) as (c) and (d) but for wind speed. The color scale represents the frequency.

Fig. Differences (°C) of (a) hybrid SSTs and (b) multi band SSTs from drifter temperatures as a function of a distance from a nearest cloudy pixel.

Summary and Conclusion

- The four SST retrieval algorithms were applied to geostationary satellite observed data and accuracy of these algorithms was examined.
- Comparison with in-situ SST measurements showed that the hybrid SSTs had similar accuracy with the multi band SSTs, whose root-mean-square errors (RMSEs) were 0.55°C and 0.47°C.
- It is important to remove the cloud pixel exactly for retrieving accurate SST data from GK2A/AMI.

Acknowledgement

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