SEA SURFACE TEMPERATURE ALGORITHM OF GEO-KOMPSAT-2A / ADVANCED METEOROLOGICAL IMAGER

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Abstract : As the second geostationary satellite of Korea, following on the Communication, Ocean and Meteorological Satellite (COMS), GEO-KOMPSAT-2A (Geostationary Korea Multi-Purpose Satellite-2A, GK-2A) is launched to be positioned at 128.2°E over the earth equator in October 2018. Advanced Meteorological Imager (AMI) on the GK-2A will have sixteen channels similar to ABI of GOES-16 and AHI of Himawari-8/9. The spatial resolution of infrared channel observation for the estimation of sea surface temperature (SST) is about 2 km and temporal interval is about 10 minute in the full-disk region for real-time operational purposes. In this study, we introduce current status of operational GK-2A/AMI SST algorithm development performed by SNU team and Korea Meteorological Administration (KMA) during the past few years. Both hybrid algorithm using RTM results and multi-band algorithm have been applied for SST retrieval using 8.6, 10.4, 11.2, and 12.3 μm channel data of Himawari-8/AHI as proxy data. In order to reduce SST errors, related to failure in the removal procedure of cloud or cloud-contaminated pixels, a series of quality control processes are developed using real-time RTM data and SST climatology data. Quality-controlled SST data are incorporated to produce a daily SST, 5-day and 10-day SST composites. In addition, daily blended SST composite image is produced using all available SST data from multi satellites such as Himawari-8, NOAA-18/19, and AMSR2 as well as all in-situ measurements from surface drifters and moored buoys around Korean peninsula.

SST Retrieval Procedure

Pre-processing

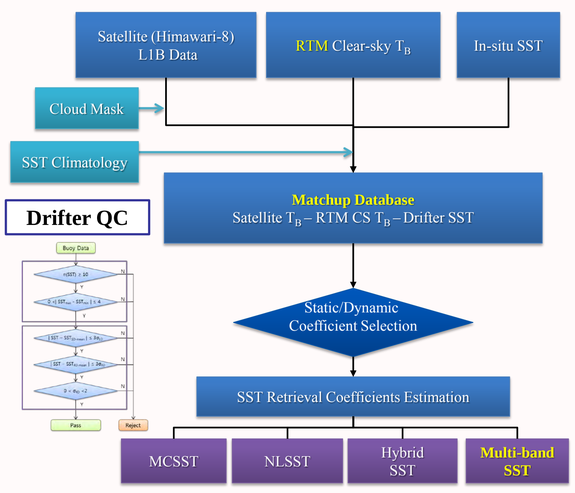


Fig. Flowchart of pre-processing for sea surface temperature retrieval.

Main Processing

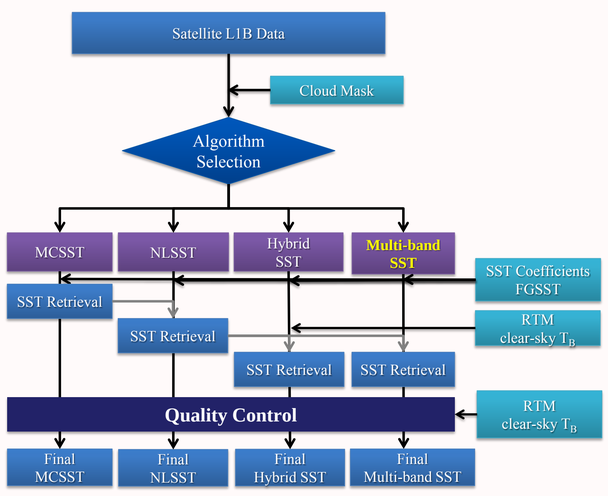
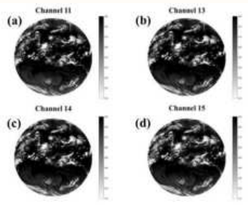


Fig. Flowchart of main processing for sea surface temperature retrieval.

Data

Satellite (Proxy) Data

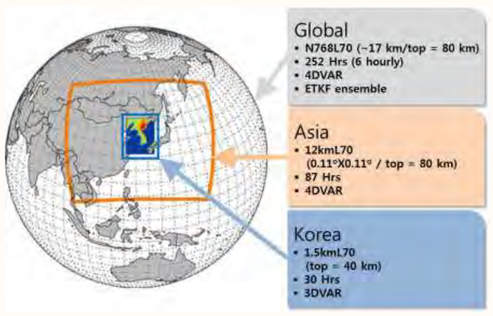
- **Himawari-8/AHI L1B and L2 Data**
  - Channels : Ch11(8.6 μm), Ch13(10.4 μm), Ch14(11.2 μm), Ch15(12.3 μm)
  - Resolution Temporal: 10 min, Spatial: 2 km
  - Period : July 2016-August 2017



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

NWP Data

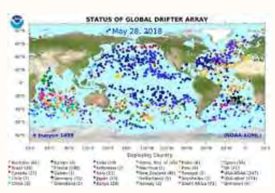
- **UM Data**



Data	T, p, q vertical profiles p_{sfc}, T_{skin}, T_{2m}, q_{2m}, U_{10m}, V_{10m}
Spatial Resolution	N768 (17 km)
Vertical Level	L70 (Top 80 km)
Number of Grid	1,536(east-west) x 1,152(south-north)
Prediction Interval	1 hour

In-situ Data

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



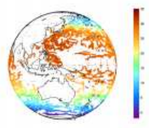


Fig. Spatial distribution of drifter water temperature in July and August, 2017.

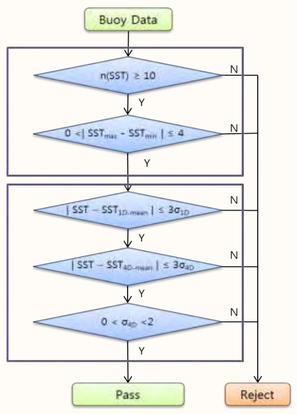


Fig. Flowchart of quality control procedure of buoy water temperature measurements.

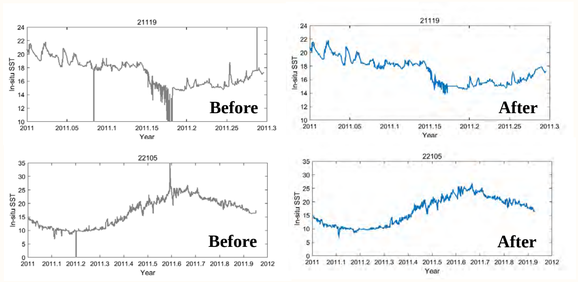


Fig. Examples of quality control of in-situ measurements.

SST Climatology

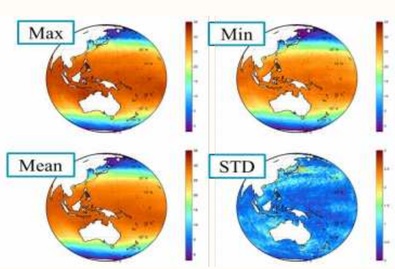
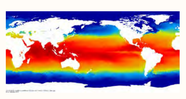


Fig. Examples of SST climatology data used for SST quality control procedure.

FGSST Data

- OSTIA Data



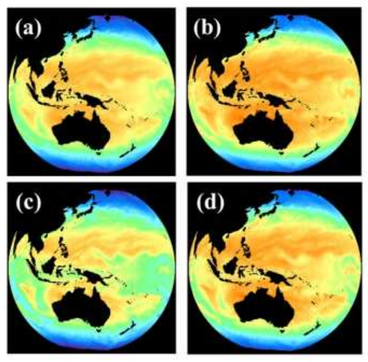
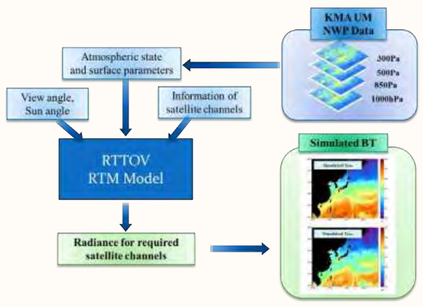


Fig. Examples of RTM-simulated (a) 8.6-μm (Ch11), (b) 10.4-μm (Ch13), (c) 11.2-μm (Ch14), and (d) 12.3-μm (Ch15) clear-sky brightness temperatures.

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}



Pre-processing for SST Retrieval

Matchup Procedure

- Data
  - Himawari-8/AHI Channel data (Ch. 11,13,14,15)
  - Buoy measurements (water temperature, wind speed, wind direction, air temperature, etc.)
  - Clear-sky BT (Ch. 11,13,14,15)
  - SST climatology, First-guess SST, and Cloud Mask
- Area: 70°S~70°N, 60°E ~ 130°E
- Period: 2016.8.1~2017.7.31
- Temporal interval : < 10 minutes
- Spatial criteria : < 2 km (pixel size of satellite)

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

SST Retrieval Coefficients

- Static/Dynamic Coefficients

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================================ Static Coefficients ============================
I. Multi-band SST ------------------------------------------------------------
   MSST = C1*T13 + C2*(T13-T15) + C3*(T13-T11)*(SECSZA-1) + C4*(T13-T14)*(SECSZA-1)
        + C5*FGSST*(T13-T11) + C6*FGSST*(T13-T14) + C7*FGSST*(T13-T15) + C8
II. Multi-channel SST (Split)------------------------------------------------
   MCSST = C1*T13 + C2*(T13-T15) + C3*(T13-T15)*(SECSZA-1) + C4
III. Non-linear SST (Split) --------------------------------------------------
   NLSST = C1*T13 + C2*FGSST*(T13-T15) + C3*(T13-T15)*(SECSZA-1) + C4
IV. Hybrid SST ---------------------------------------------------------------
   HSST  = FGSST + C1*(T13-TCS13) + C2*FGSST*((T13-TCS13)-(T15-TCS15))
         + C3*((T13-TCS13)-(T15-TCS15))*(SECSZA-1) + C4
------------------------------------------------------------------------------
Algorithm :  C1        C2        C3        C4        C5        C6        C7        C8
MSST      :  0.965554  -1.030181  0.803268  1.775060  -0.056463 -0.004013 0.078980  4.672542
MCSST(D):  1.010963  1.320451  0.396917  -0.825112
MCSST(N):  0.989462  1.357500  0.384146  -0.394404
MCSST     :  0.998357  1.340641  0.386814  -0.569528
NLSST(D):  0.887705  0.041174  0.383038  2.630488
NLSST(N):  0.868111  0.042398  0.372000  2.99433
NLSST     :  0.876111  0.041873  0.374585  2.846422
HSST      :  0.754061  0.063054  -0.260546 0.025403
==============================================================================
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SST Quality Control

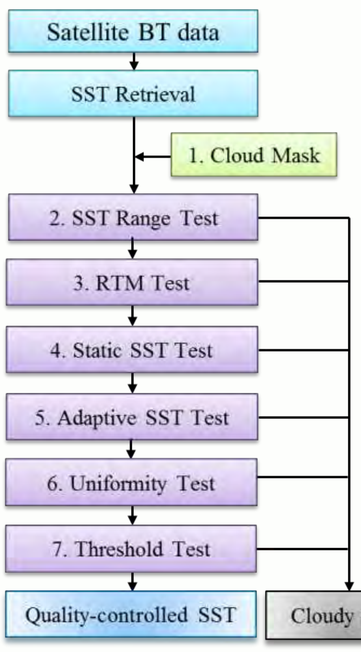

Fig. Flowchart of quality control procedure for sea surface temperature retrieval.

1. **CLD Mask**
   - Apply the CLD Mask (Level 2)
2. **Extremely abnormal SST Range Test**:
   $SST < SST_{min}$ or $SST_{max} < SST$
3. **RTM Test** (Petrenko, 2011)
   - Verify accuracy of fitting the vector of observed BTs with the clear-sky vector of simulated BTs
   $[\Delta T_B - B_{BT}]^T \Delta^{-1} [\Delta T_B - B_{BT}]/N > D_{SST_{RTM}}$
4. **Static SST Test** (Petrenko, 2011)
   - Detect obviously unrealistic SST values
   $\Delta T_S - B_{SST} > D_{SST_{static}}$
5. **Adaptive SST Test** (Petrenko, 2011)
   - Detect ambient cloudiness at the boundaries of cloud
   $|\Delta T_S - \Delta T_{CLD}|/\sigma_{CLD} < |\Delta T_S|/(\sigma_{CLR})$
6. **Uniformity Test** (Petrenko, 2011)
   - Detect residual subpixel clouds using median filter (3 x 3 pixels)
7. **Threshold Test**
   - Band difference test
   - 3×3 STD, Min-Max test
   - Thin Cirrus test

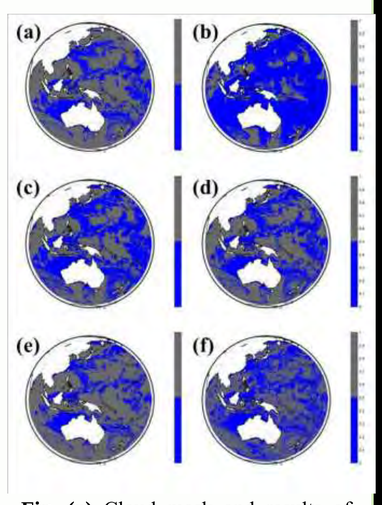

Fig. (a) Cloud mask and results of quality control procedure ((b) range test, (c) RTM test, (d) static SST test, (e) adaptive SST test, and (f) uniformity test). Blue and gray indicate clear and cloudy sky, respectively.

Retrieved SST

Level 2

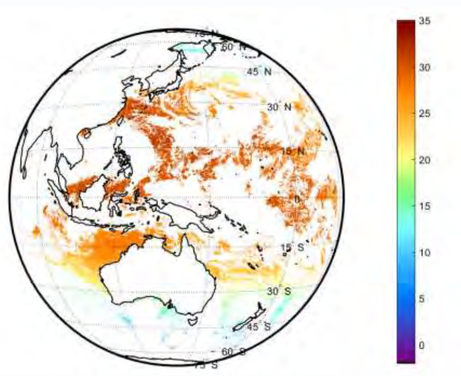

Fig. An example of spatial distribution of retrieved SST from Himawari-8/AHI data at 15 UTC on July 27, 2017.

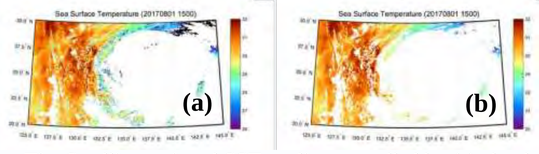

Fig. Satellite retrieved SST quality controlled by (a) cloud mask and (b) SST quality flag as well as cloud mask.

Level 3

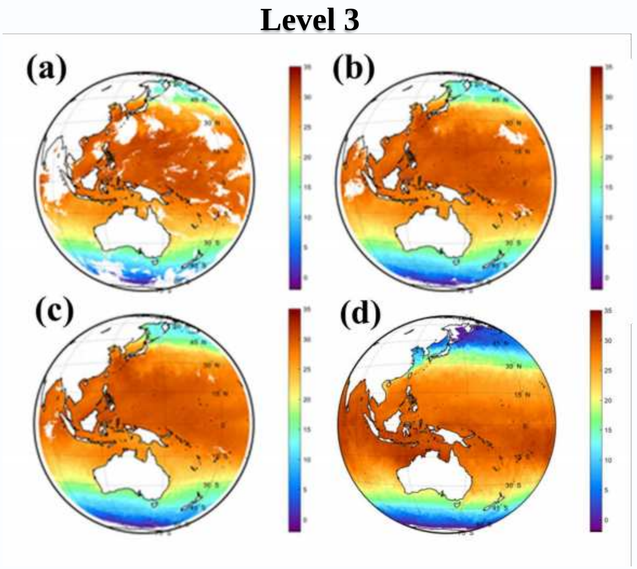

Fig. Spatial distribution of (a) daily, (b) 5-day, and (c) 10-day sea surface temperature composites using simple mean method on 5 August 2017 and (d) multi-satellite (Himawari-8/AHI, NOAA/AVHRR, GCOM-W/AMSR2, and drifter measurement) daily sea surface temperature composites on 24 July 2017.

Validation

Accuracy Assessment

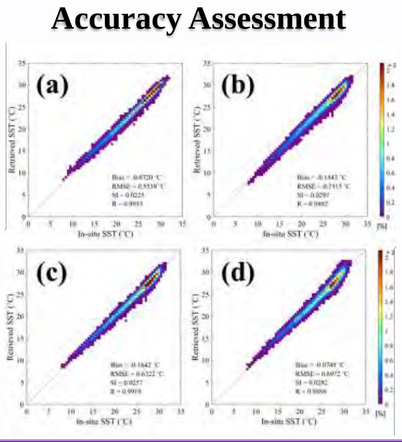

Fig. Comparison between (a) Multi-band SST, (b) MCSST, (c) NLSST, and (d) Hybrid SST and *in-situ* measurements from 1 August 2016 to 31 July 2017. The color scale represent the percentage of the data in each 0.5°C × 0.5°C bin.

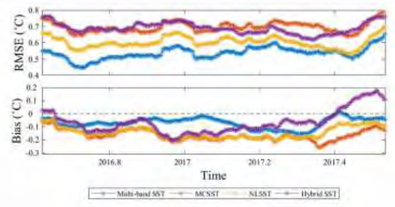

Fig. Time series of RMSE and bias of retrieved SSTs using static SST coefficients from 1 August 2016 to 31 July 2017.

Spatial Distribution of Errors

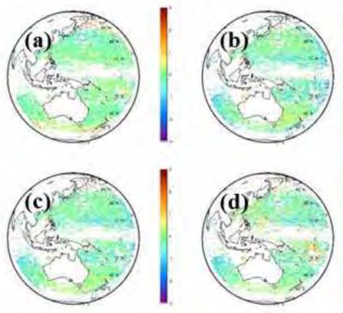

Fig. Spatial distribution of errors of (a) Multi-band SST, (b) MCSST, (c) NLSST, and (d) Hybrid SST from 1 August 2016 to 31 July 2017.

Summary and Conclusion

- GEO-KOMPSAT-2A will be launched on the back of COMS in October 2018.
- SST retrieval algorithm for GEO-KOMPSAT-2A/AMI was developed to provide the customized information over the Now-casting, NWP, Typhoon/ocean, climate changes and environmental weather monitoring, and converging technology area using Hiamwari-8/AHI data as a proxy.
- The RMS error and bias of the retrieved SST are about 0.55°C and -0.07°C, respectively..

Acknowledgement

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