

PREPARATION FOR SST RETRIEVAL USING GK-2A AT KMA

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Abstract

National Meteorological Satellite Center (NMSC) of Korea Meteorological Administration (KMA) has been operating the Communication, Ocean, and Meteorological Satellite (COMS) which is the first Korean geostationary meteorological satellite since 2011, and then now NMSC is preparing for the operation of GeoKOMPSAT-2A (GK-2A) launched in Dec. 2018, from July this year. Sea Surface Temperature (SST) is one of the sixteen baseline meteorological products of the COMS and is based on Multi-Channel SST (MCSST) with split window channels. Validation result shows that COMS SST has around 1 degree bias compared with drift buoy data. Meanwhile, GK-2A SST algorithm is under developing and is 4-band algorithm using 4 infrared channels. Preliminary validation using Himawari-8 data shows a lot promising with the bias less than 0.2 degree and RMSE less than 0.7 degree. NMSC is planning to update regression coefficients through a matchup with in-situ data to be applied to the SST formula in a long-term way of using cumulative data. This preparation is to provide official service of GK-2A SST data in March 2020. In this presentation, we will introduce the algorithms of GK-2A SST and the preparation process for operation, and will present the preliminary results of GK-2A SST.

I. GK-2A vs. COMS

The **COMS** is the **first geostationary multi-purpose satellite for Korea** in the application of meteorology, ocean, and communication. MI is imager on board COMS.

COMS: Communication, Ocean, and Meteorological Satellite

- Launch date/Operation: June 27th, 2010 (KST) / **April 2011**
- Operation Orbit: 128.2E / 35,800 km above the Equator
- Multiple Payloads: MI, GOCI, Ka-band Transponders

MI: Meteorological Imager

- Multispectral imaging radiometer
- 1 visible (1 km) and 4 infrared (4 km) channels
- Observation mode:
 - Full Disk (FD, every 3 hour),
 - Extended Northern Hemisphere (ENH, 4 times a hour),
 - Local Area (LA, 4 times a hour)

COMS Meteorological Data (L2+)

- 16 baseline products from the COMS MI observation



Figure 3. 16 baseline products of the COMS MI

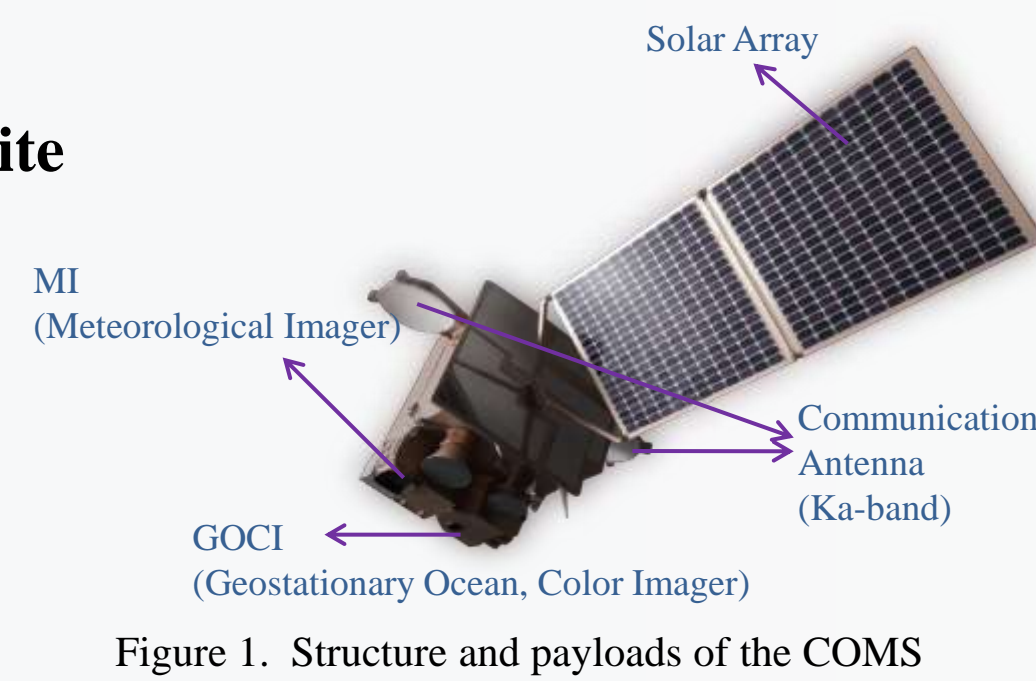


Figure 1. Structure and payloads of the COMS

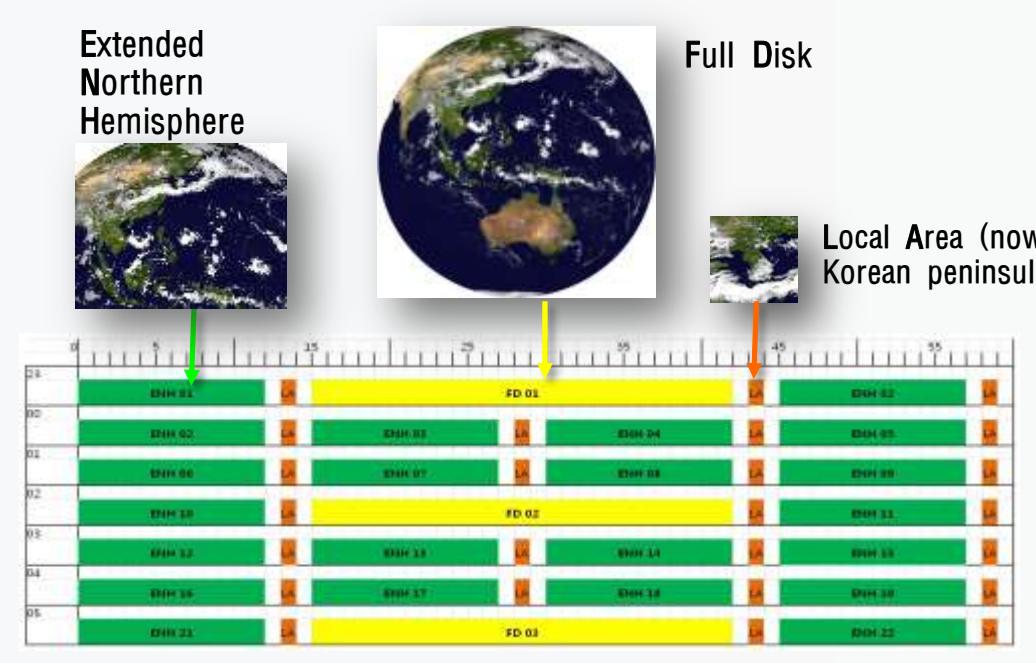


Figure 2. Observation mode of the COMS MI

Table 1. COMS MI channel information

| Channel Number | Channel Full Width at Half Maximum (μm) | | Spatial Resolution Half-Amplitude (IFOV in μrad) (km) |
|----------------|---|-------|---|
| | Lower | Upper | |
| VIS | 0.55 | 0.80 | 28 (1km) |
| SWIR | 3.5 | 4.0 | 112 (4km) |
| WV | 6.5 | 7.0 | 112 (4km) |
| IR1 | 10.3 | 11.3 | 112 (4km) |
| IR2 | 11.5 | 12.5 | 112 (4km) |

The **GK-2A** is the **2nd geostationary meteorological satellite of Korea**. AMI is imager on board GK-2A.

GK-2A: GEO-KOMPSAT-2A/ Geostationary Earth Orbit - Korea Multi-Purpose Satellite - 2A

- Launch date/Operation: December 5th, 2018 (KST) / **July 2019**
- Operation Orbit: 128.2E / 35,800 km above the Equator
- Multiple Payloads: AMI, KSEM

AMI: Advanced Meteorological Imager

- Observation mode:

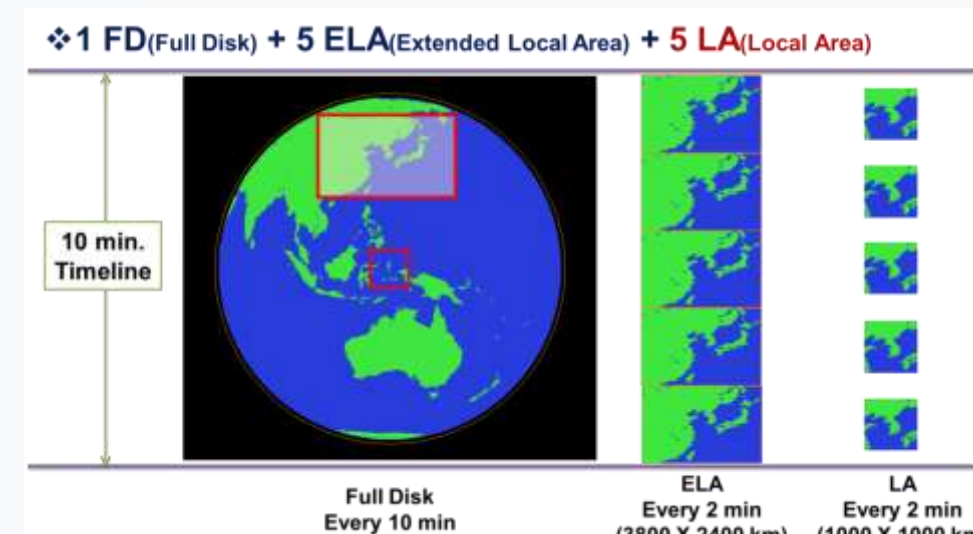


Figure 8. Observation mode of the GK-2A AMI

- 16 Channels:

Table 2. GK-2A AMI channel information comparison with GOES-16/ABI and with Himawari-8/AHI

| Channel Number | Center wavelength (μm) | | Spatial Resolution Half-Amplitude (IFOV in μrad) (km) |
|----------------|------------------------|------------------|---|
| | AMI (Resolution) | ABI (Resolution) | |
| 1 (blue) | 0.47 (1km) | 0.47 | 0.46 |
| 2 (green) | 0.51 (1km) | 0.51 | 0.51 |
| 3 (red) | 0.64 (0.5km) | 0.64 | 0.64 |
| 4 | 0.85 (1km) | 0.85 | 0.85 |
| 5 | 1.38 (2km) | 1.378 | 1.51 |
| 6 | 1.61 (2km) | 1.61 | 1.6 |
| 7 | 3.830 (2km) | 2.25 | 2.3 |
| 8 | 6.241 (2km) | 3.90 | 3.9 |
| 9 | 6.382 (2km) | 6.185 | 6.2 |
| 10 | 7.344 (2km) | 6.35 | 7.0 |
| 11 | 8.592 (2km) | 7.34 | 7.3 |
| 12 | 9.626 (2km) | 8.50 | 8.6 |
| 13 | 10.403 (2km) | 10.35 | 10.4 |
| 14 | 11.212 (2km) | 11.2 | 11.2 |
| 15 | 12.368 (2km) | 12.3 | 12.3 |
| 16 | 13.31 (2km) | 13.3 | 13.3 |

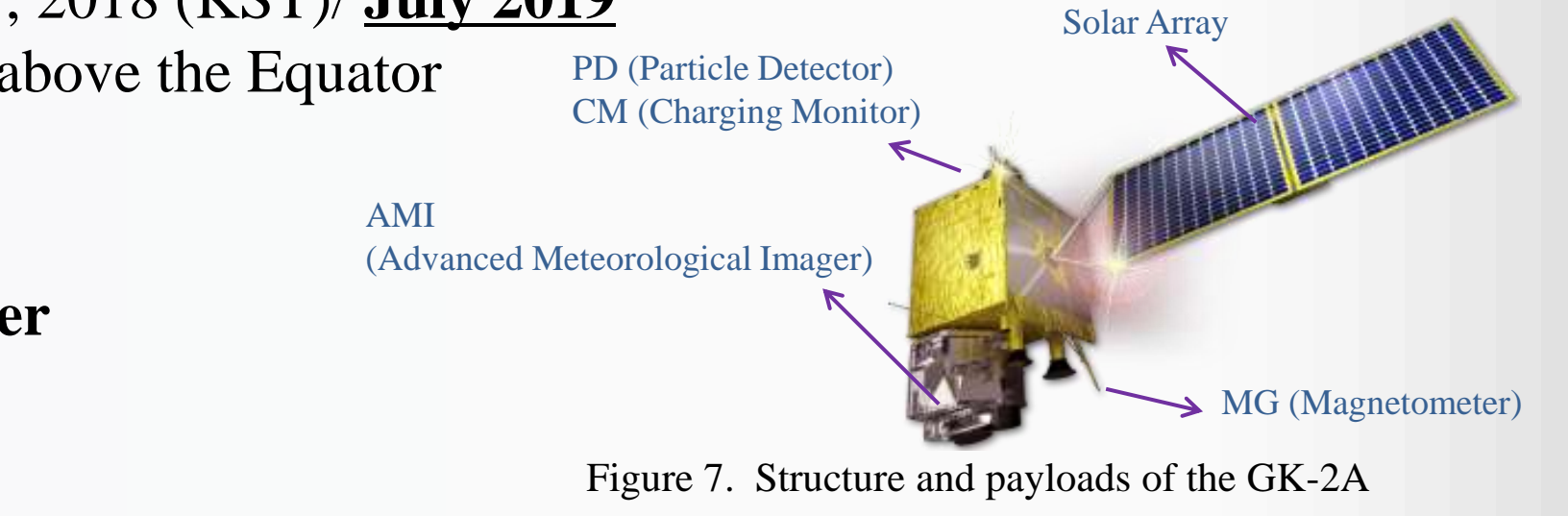


Figure 7. Structure and payloads of the GK-2A

KSEM: Korea Space Weather Monitor

- Sensors: Particle Detector, Charging Monitor, Magnetometer

GK-2A Meteorological Data (L2+)

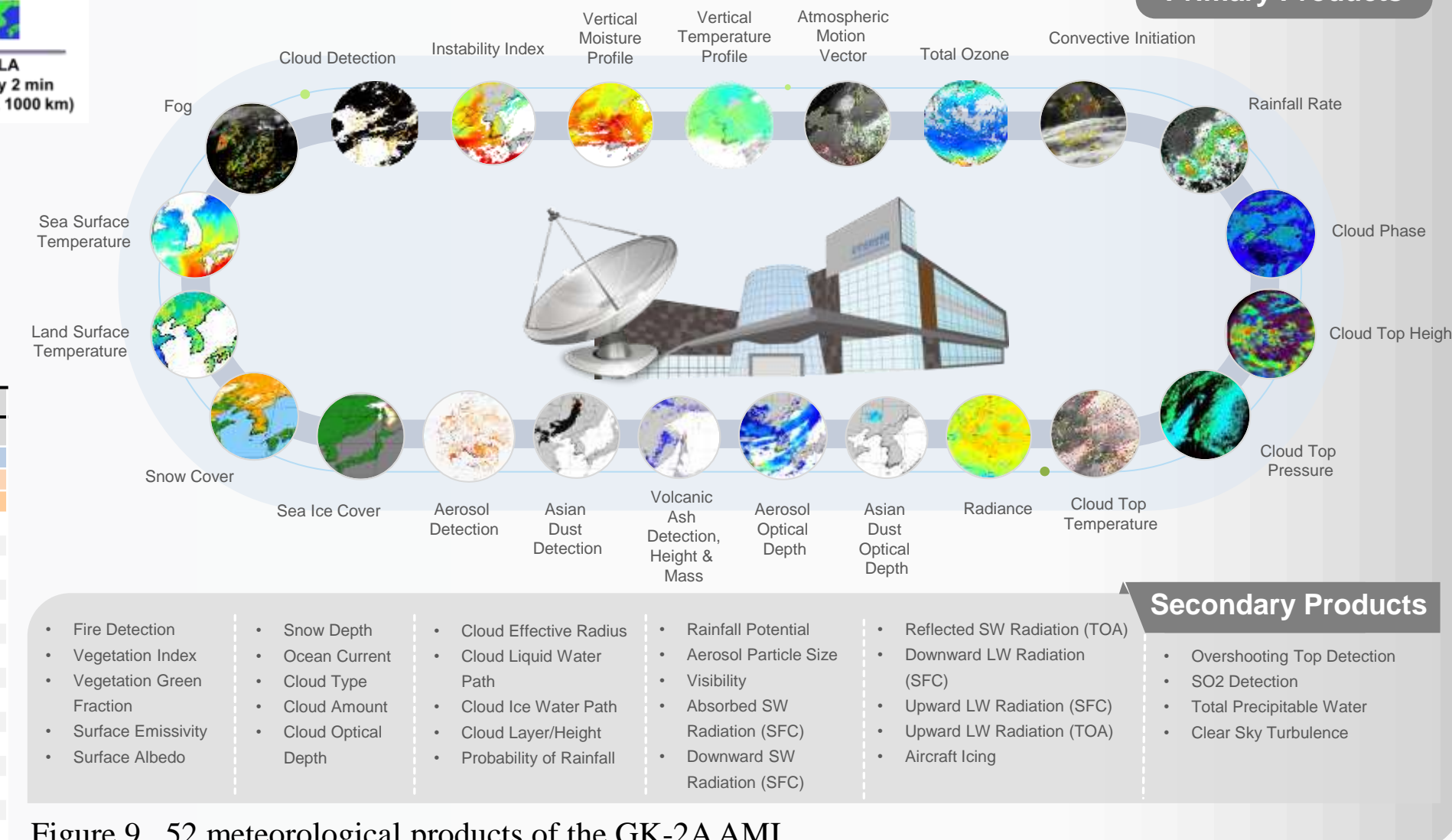


Figure 9. 52 meteorological products of the GK-2A AMI

II. COMS SST

KMA has been producing SST retrieval using the COMS observation data with MCSST method in operation since 2011. The MCSST algorithm uses different coefficient sets for daytime and nighttime.

COMS SST Algorithm: MCSST (Multi-Channel Sea Surface Temperature)

- Retrieval Formula

$$MCSST = a_1 T_{IR1} + a_2 (T_{IR1} - T_{IR2}) + a_3 (T_{IR1} - T_{IR2}) (\sec\theta - 1) + a_4$$

Where, a_1, a_2, a_3, a_4 : SST retrieval coefficients
 T_{IR1}, T_{IR2} : Brightness temperature of IR1 and IR2 channels
 θ : Satellite zenith angle

- Flow Chart of SST Calculation

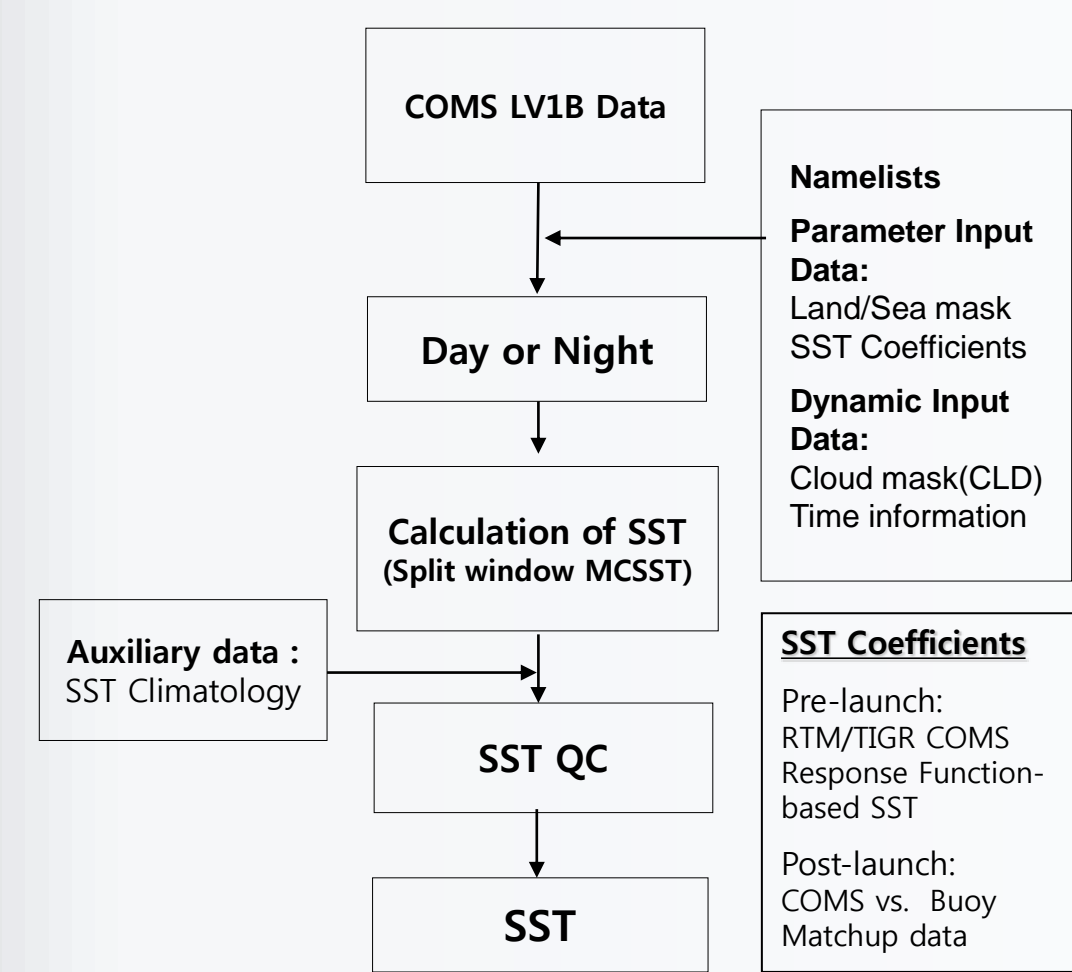


Figure 4. Flow chart of calculation of the COMS SST

COMS SST Products and Validation

- Composite Products using real-time products 1day, 5day, and 10days composite for Korean peninsula, east Asia, and Full Disk.
- Quality Monitoring
- Comparative analysis with in-situ data
- Bias: -0.9 K, RMSE: ~1.5 K

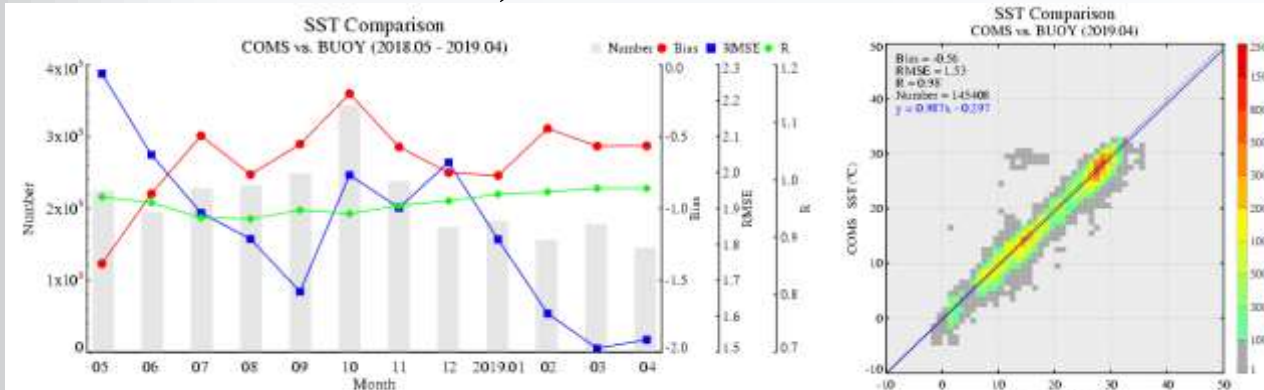


Figure 5. COMS SST statistical comparison with in-situ data

- SST Quality Control

- SST gross test:
 - $5^\circ\text{C} < \text{SST} < 37^\circ\text{C}$
- SST climatology test: using NASA JPL 9km pathfinder SST DB
 - $5^\circ\text{C} \leq \text{SST} - \text{SST}_{\text{clim}} \leq 5^\circ\text{C}$
- Thin cirrus test:
 - If $T_{IR1} < 20, T_{IR1} - T_{IR2} < 0.032 \times (T_{IR1})^2 + 0.0996 \times T_{IR1} + 1.6071$
 - If $T_{IR1} \geq 20, T_{IR1} - T_{IR2} < 6$
- SST spatial uniformity test:
 - remove SST if around 3×3 pixels' std > 1 & SST < SSTavg(3x3)

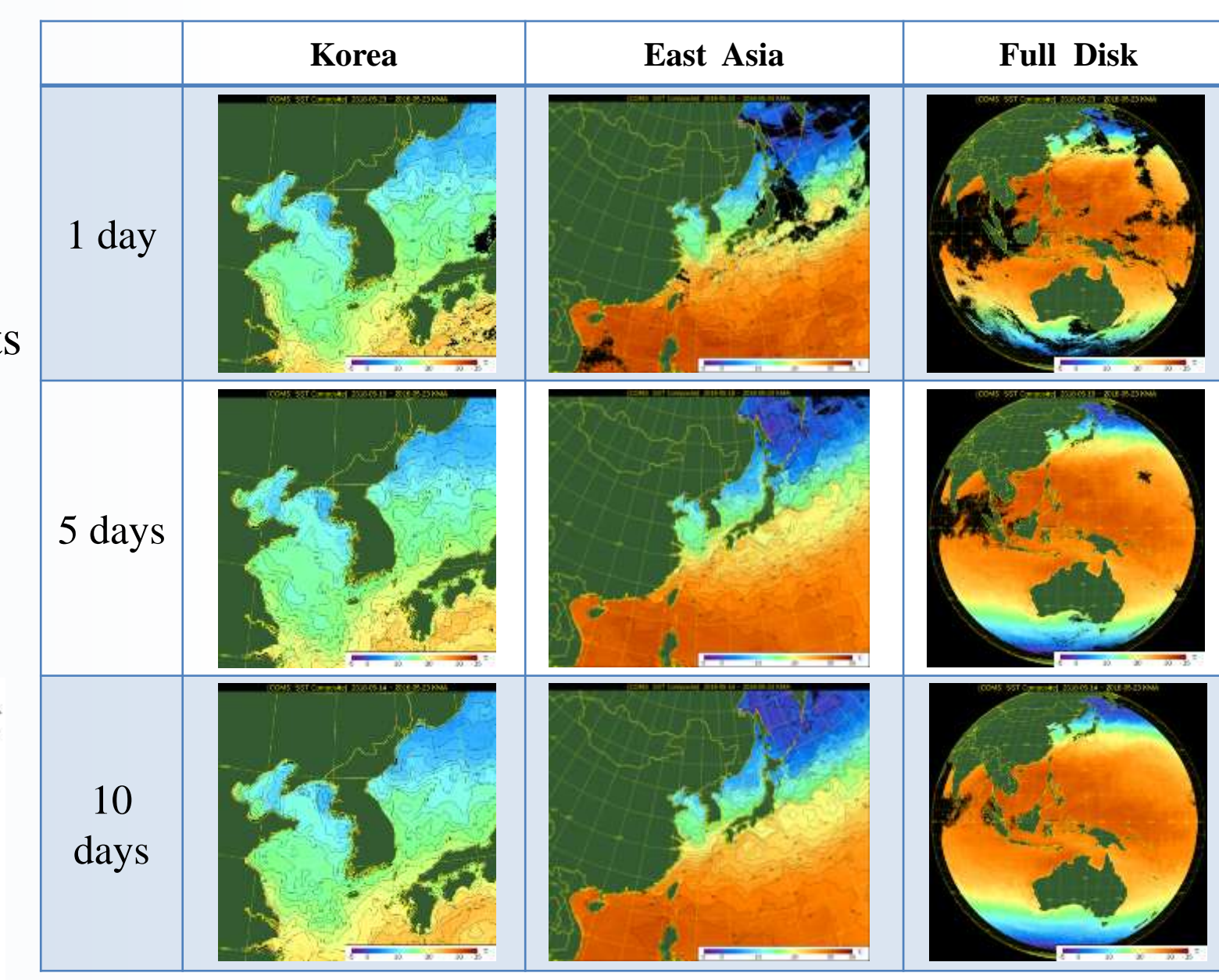


Figure 6. COMS SST composite images

III. GK-2A SST

KMA has developed SST algorithm for the GK-2A using 4 infrared channels (4-band algorithm). Now, we are in progress of In-Orbit Test (IOT) for tuning coefficients and qualifications until March 2020 before operation.

GK-2A SST Algorithm: Multi-band SST (a priority)

- 4 Retrieval Formulas
- MCSST Algorithm (Ch. 13 & 15)

$$SST = C_1 T_{10.4} + C_2 (T_{10.4} - T_{12.4}) + C_3 (T_{10.4} - T_{12.4}) (\sec\theta - 1) + C_0$$
- NLSST Algorithm (Ch. 13 & 15)

$$SST = C_1 T_{10.4} + C_2 TFG(T_{10.4} - T_{12.4}) + C_3 (T_{10.4} - T_{12.4}) (\sec\theta - 1) + C_0$$
- Hybrid Algorithm (Ch. 13 & 15)

$$T_s = T_{IR1} + a_0 + a_1 (T_{IR1} - T_{IR2}) + a_2 (T_{IR1} - T_{IR2}) (T_{12.4} - T_{10.4}) / T_{IR1} + a_3 (T_{IR1} - T_{IR2}) (T_{12.4} - T_{10.4}) / (\sec\theta - 1)$$
- Multi-band Algorithm (Ch. 11, 13, 14, & 15)

$$T_s = a_0 + a_1 T_{IR1} + a_2 (T_{IR1} - T_{IR2}) + [a_3 (T_{IR1} - T_{IR2}) + a_4 (T_{10.4} - T_{12.4})] \sec\theta + [a_5 (T_{10.4} - T_{12.4}) + a_6 (T_{10.4} - T_{12.4})] / T_{IR1}$$

- SST Quality Control

After Cloud Mask, SST Range Test / RTM Test / Static SST Test / Adaptive Test / Uniformity Test for non-cloudy pixels

GK-2A SST Products and Preliminary Result

- Test Operation System is running at NMSC of KMA for the GK-2A SST retrieval algorithm using Himawari-8 data.
- In addition, GK-2A SST retrieval also produced by L2 processing system without geometric correction and tuning coefficients because IOT is on going for data preprocessing.

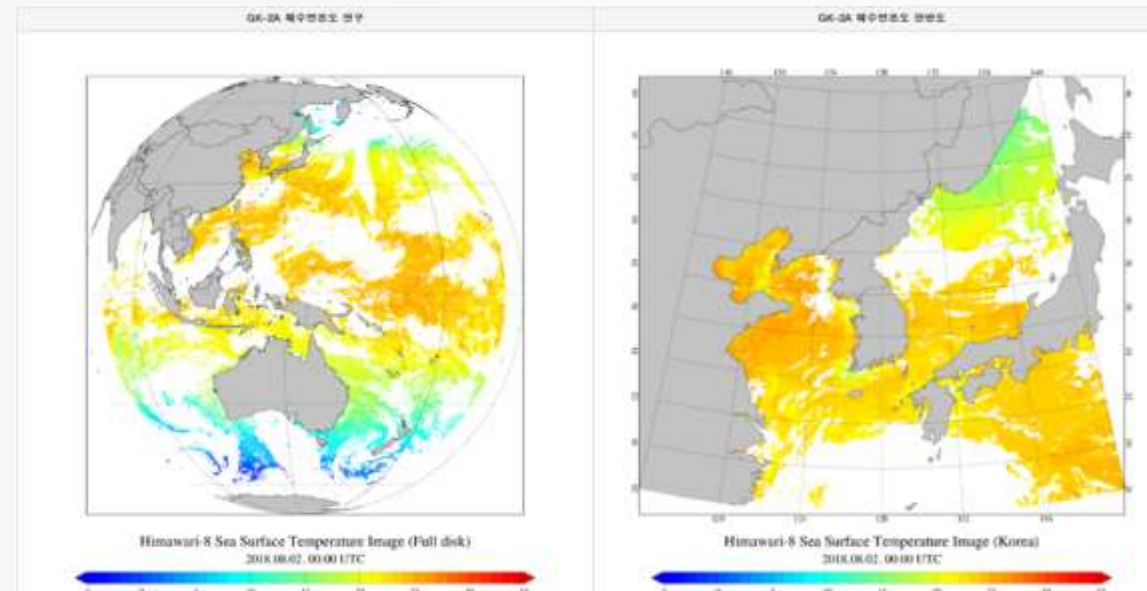


Figure 11. Test Operation for GK-2A SST algorithm using Himawari-8 data

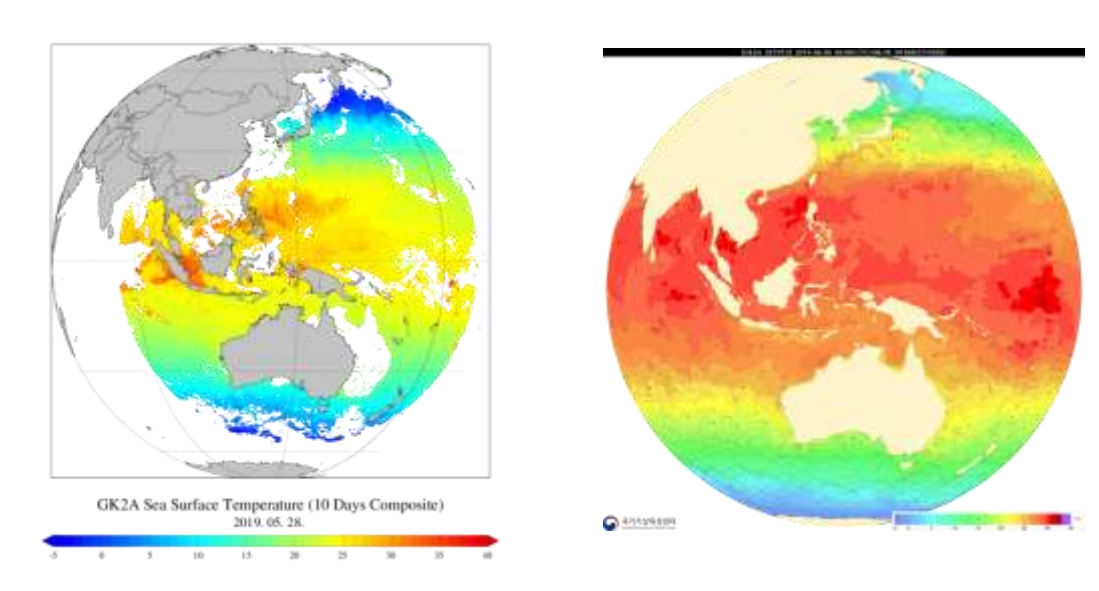


Figure 12. Preliminary produced images of GK-2A SST (without tuning coefficients and geometric correction)

Preliminary validation using Himawari-8 data shows a lot promising with the bias less than 0.2 K and RMSE less than 0.7 K.

Multi-sensor SST (MSST) with GK-2A

- NMSC also preparing SST retrieval using multi-sensor data.

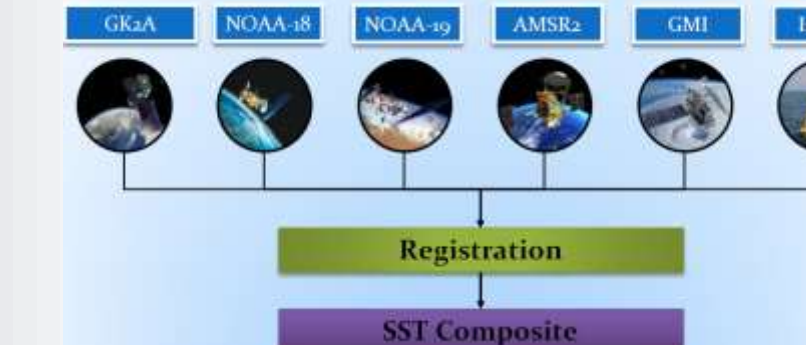


Table 3. Multi-sensors for MSST

| SST | GK2A (AMD) | NOAA-18/19 (AVHRR) | COMS-W1 (AMSR2) | GPM (GMI) | In-situ (Buoy) |
|------------|------------|--------------------|-----------------|-----------|----------------|
| Resolution | 2km | 1km or 4km | 25km | 25km | 60E-138W |

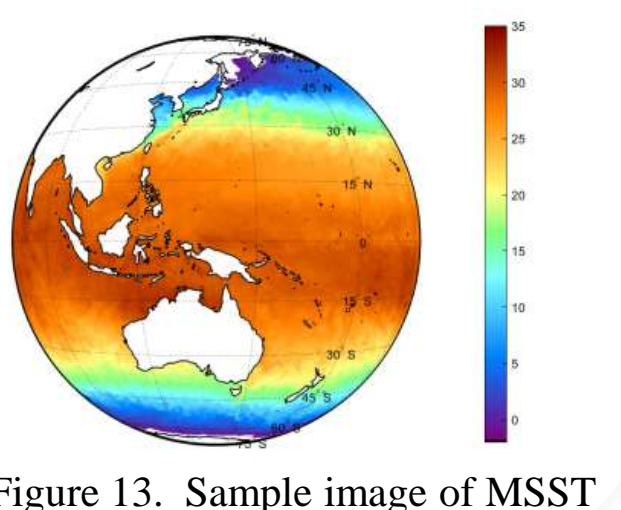


Figure 13. Sample image of MSST

Summary and Future Works

- National Meteorological Satellite Center of KMA has been operating Korean meteorological imager, MI onboard satellite COMS for 9 years.
 - One of the 16 baseline products, SST retrieval also operationally produced using MCSST algorithm in NMSC.
- NMSC (KMA) is getting ready for operating 2nd geostationary meteorological satellite of Korea, GK-2A with AMI in July 2019.
 - We have been developed SST algorithm using advanced method, multi-band SST with 4 infrared channels.
 - The bias and RMSE of GK-2A SST retrieval will be expected less than ± 0.2 K and less than 0.7K, respectively.
 - NMSC is preparing to provide official service of GK-2A SST data in March 2020.

