Improvement for Operational SST Observed by the COMS at KMA

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Abstract

Sea Surface Temperature (SST) is one of the sixteen baseline meteorological products of the Communication, Ocean, and Meteorological Satellite (COMS) which is the first Korean geostationary meteorological satellite. National Meteorological Satellite Center (NMSC) of Korea Meteorological Administration (KMA) has been operating the COMS and COMS Meteorological Data Processing System (CMDPS) officially since 2011. The operational SST Algorithm of KMA is based on Multi-Channel SST (MCSST) with split window channel. NMSC has been evaluating accuracy and performance of operational SST. In the statistics, it has a difference over 1 degree lower than in-situ data on global ocean area, Full Disk (FD). Therefore we have done experiments to improve the accuracy for the operational SST of KMA using coefficients of Essential Climate Variables (ECV), corrected data with Global Space-based Inter-Calibration System (GSICS), and Quality Control (QC). In consequence of experiments, SST bias and RMSE of COMS in comparison with in-situ data were reduced and then we are considering replacing operation mode with new mode of experiment.

I. COMS and CMDPS

The COMS is the first multi-purpose geostationary 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: June 27th, 2010
  - 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, Korea peninsula, 4 times a hour)

Figure 1. Structure and name of each parts of the COMS

- **CMDPS: COMS Meteorological Data Processing System**
  - L2 data processing system installed at ground station in NMSC
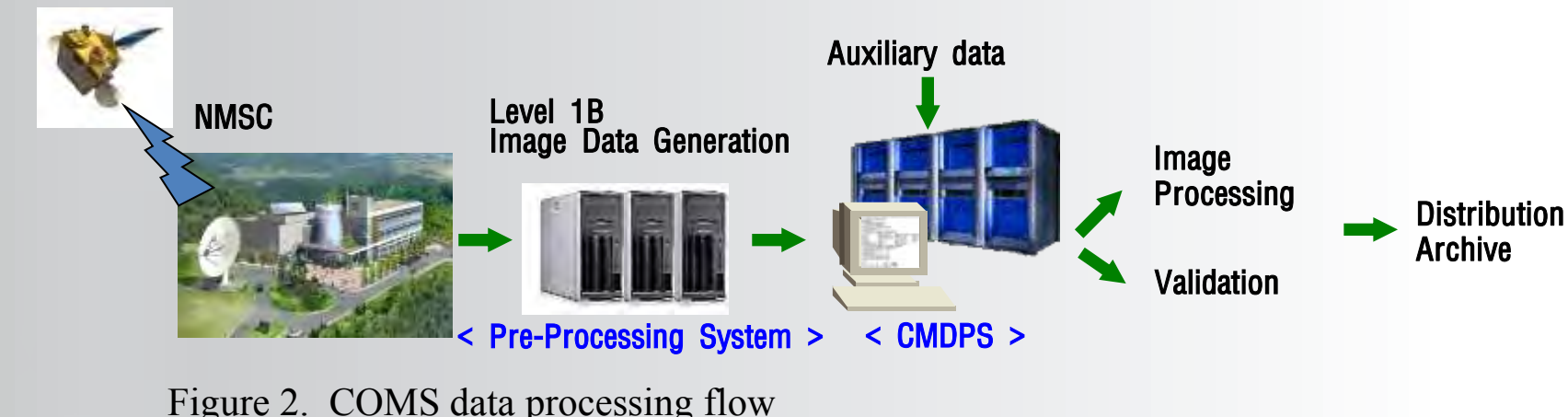 - CMDPS has produced 16 baseline products from the COMS MI observation
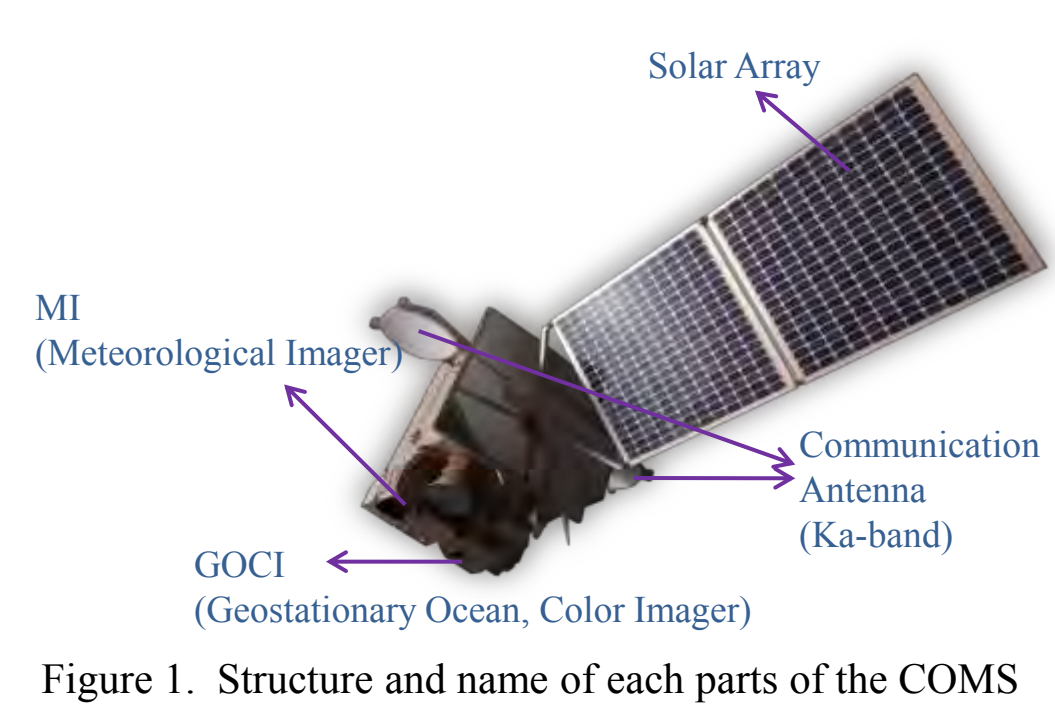
Figure 2. COMS data processing flow

Figure 3. 16 baseline products of the COMS MI

II. COMS SST

KMA uses MCSST method to derive SST products of the COMS in operation and different coefficient sets are used 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
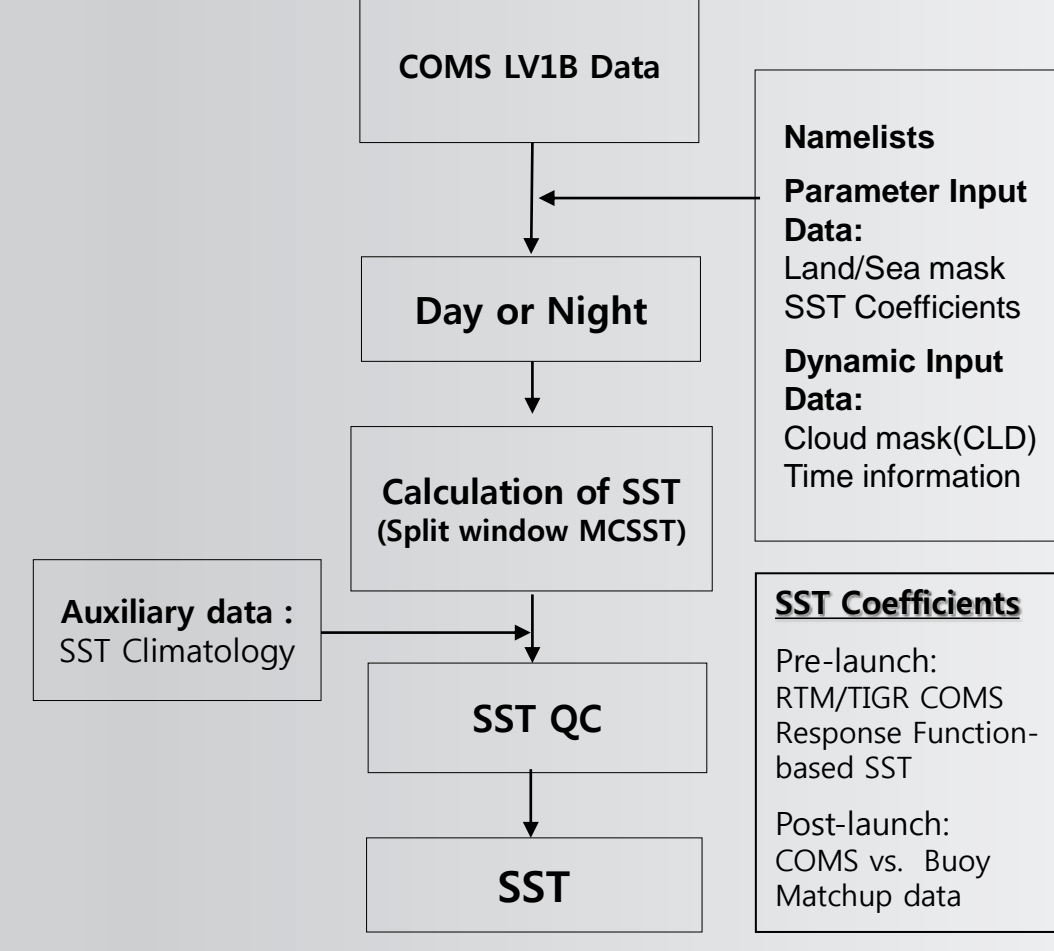
- Flow Chart of SST Calculation

COMS LV1B Data → Day or Night → Calculation of SST (Split window MCSST) → SST QC → SST

Auxiliary data : SST Climatology

Namelists Parameter Input Data: Land/Sea mask, SST Coefficients

Dynamic Input Data: Cloud mask(CLD), Time information

SST Coefficients
Pre-launch: RTM/TIGR COMS Response Function-based SST
Post-launch: COMS vs. Buoy Matchup data

- SST Quality Control

SST gross test:
- 5 ℃ < SST < 37 ℃

SST climatology test: using NASA JPL 9km pathfinder SST DB
- 5 ℃ ≤ SST − SST_{clim} ≤ 5 ℃

Thin cirrus test:
If T_{ir1} < 20, $T_{ir1} − T_{ir2}$ < 0.032 × (T_{ir1})2 + 0.0996 × T_{ir1} + 1.6071
If T_{ir1} ≥ 20, $T_{ir1} − T_{ir2}$ < 6

SST spatial uniformity test:
remove SST if around 3×3 pixels' std > 1 & SST < SSTavg(3×3)

Figure 4. Flow chart of calculation of the COMS SST

- **COMS SST Products**
  - Real-time Products (Observation data retrieval)
    FD / 3 hour
    ENH / 15 minutes
  - Composite Products
    1day, 5days, and 10days
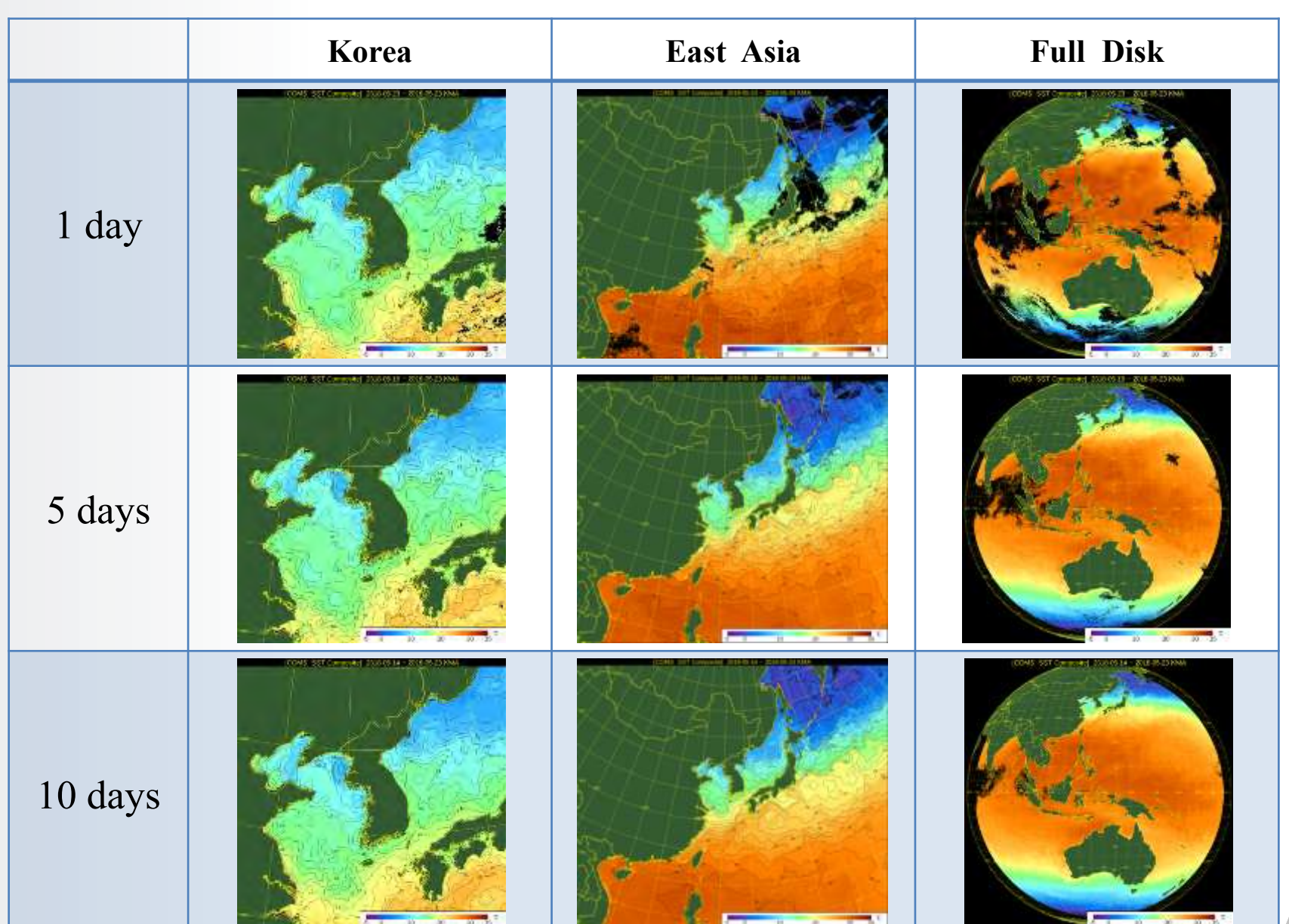   for Korean peninsula, east Asia, and Full Disk.

Figure 5. COMS SST composite images

III. COMS SST Improvement Experiments

- **Background and Test Objectives**
  - COMS existing operational SST product has a difference over 1.5 degree lower than in-situ data on global ocean area, full disk.
  - Existing operational MCSST retrieval coefficients used with value extracted in a short periods of time during 3 months (Apr. ~ Jun. 2011)
  - Retrieval coefficients extracted from long-term data need to be used.
  - Substitution the COMS SST operational processing for existing SST

- **Test Items**
  1. Retrieval Coefficient Substitution: **Essential Climate Variables (ECVs) coefficients**
     - Extracted from Long-term data (4 years from Apr. 2011 to Mar. 2015)

Table 1. MCSST coefficients for COMS SST

Coefficient	Day/Night	a1	a2	a3	a4	Remarks
ECVs	Day	0.923391	2.476857	-0.048561	1.458838	Sampling time: 2011. ~ 2015.
	Night	0.931688	2.647177	-0.000013	1.457544	Domain: Full Disk

※ Reference: NMSC, 2015, Development of Estimation Method for Essential Variables to Build Climate Standard Database using Satellite Data (II), pp. 15-155.

  2. LV1B Data Correction: **Global Space-based Inter-Calibration System (GSICS) correction**
     - Correction applied with Inter-calibration between COMS and IASI observation data
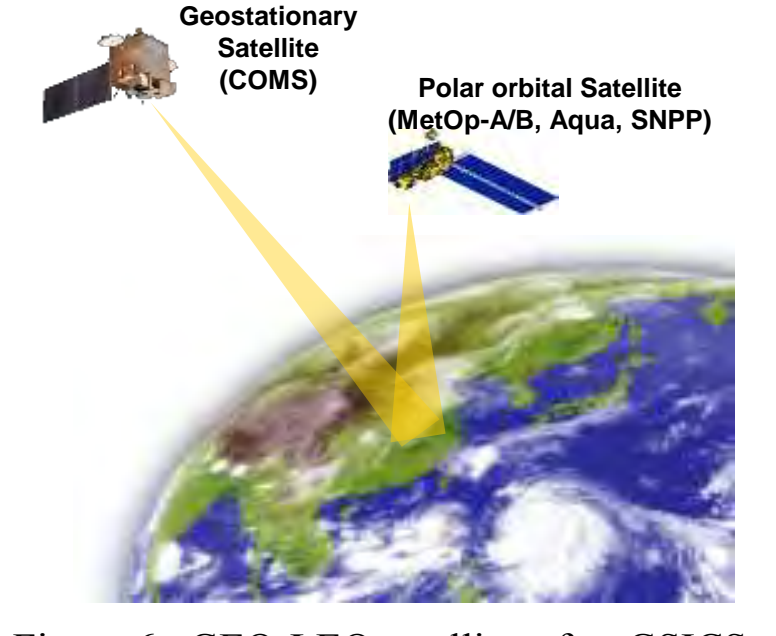   - Change the Brightness Temperature (T_B) value using GSICS coefficients

  3. Quality Control: **SST climatology comparison**
     - SST lower/upper limits modified wrt SST climatology
     - | SST − SST_{clim} | ≤ 5K → | SST − SST_{clim} | ≤ 3K

Figure 6. GEO-LEO satellites for GSICS
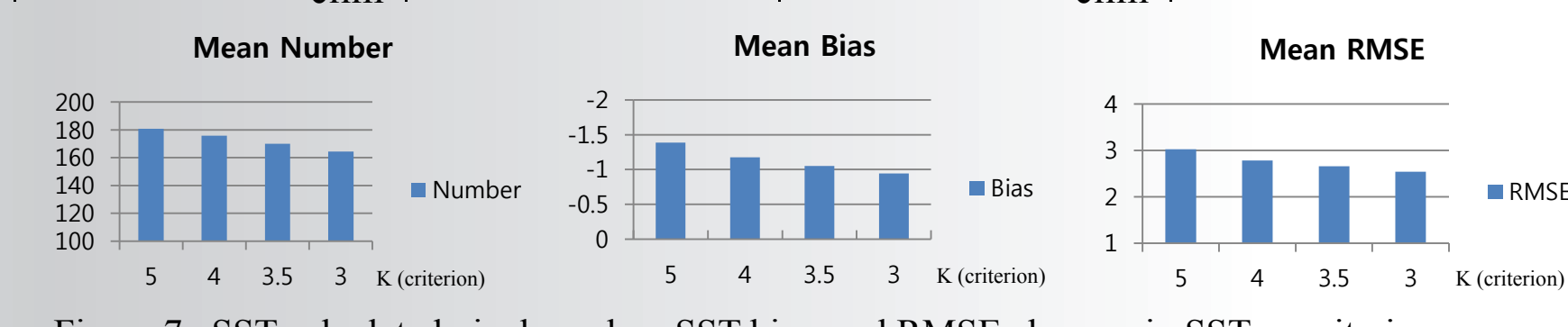
Figure 7. SST calculated pixel number, SST bias, and RMSE changes in SST_{clim} criteria

  - The criterion temperature wrt SST_{clim} has decided 3K in consideration of SST production
    (If the SST_{clim} is less than 3K, amount/region of SST decreases definitely.)

IV. Results

- **Image Comparison btw Existing and New operation**
  - SST calculated area decreases within 10% on the new operation products
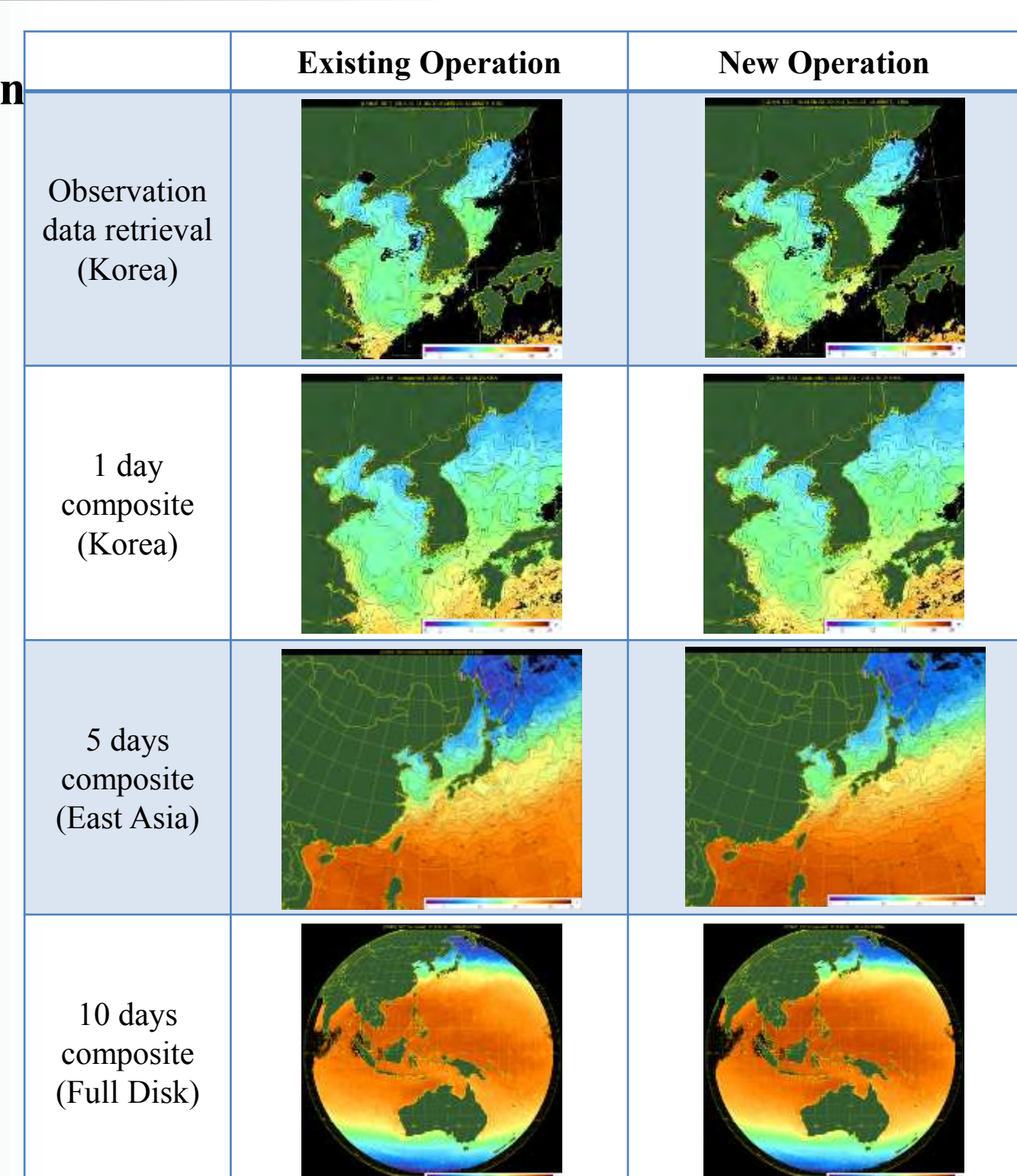 - SST got warmer on the new operation image

- **Scatter Plot Comparison**
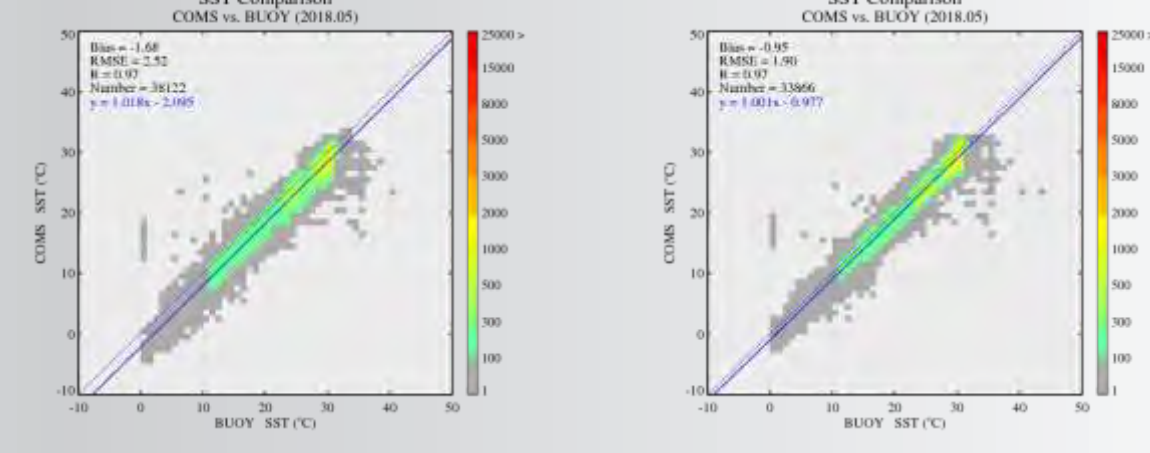 - The correlation between retrieval SST and Buoy has increased (for 1 month, i.e. May 2018)

Figure 8. COMS SST scatter plot comparison btw Existing and New operation data

- **Statistical Comparison**
  - Correlation has increased
  - Biases and RMSEs have been reduced

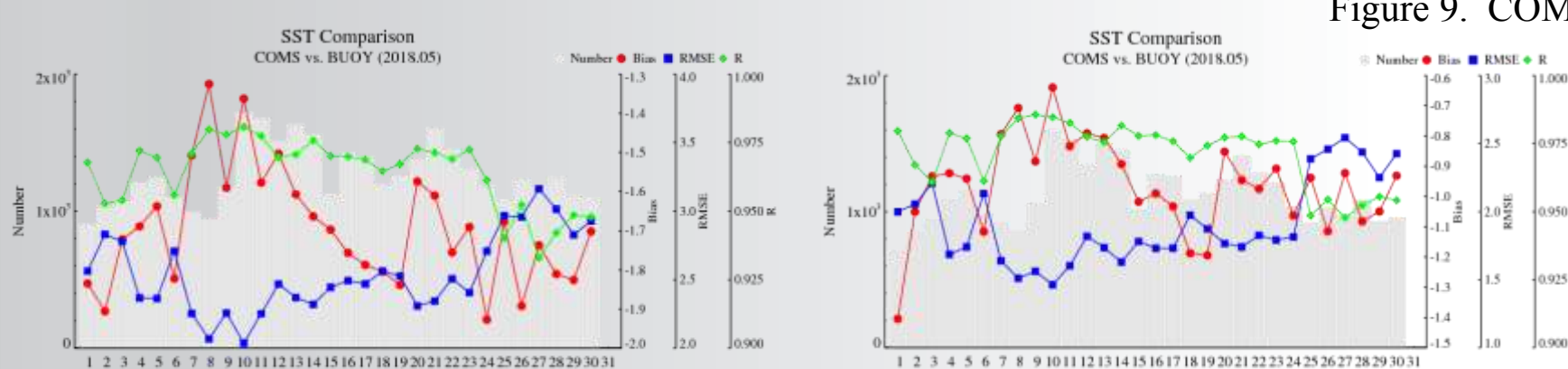Figure 9. COMS SST image comparison btw Existing and New operation data

Figure 10. COMS SST statistical comparison btw Existing and New operation data

Table 2. COMS SST comparison for operation during 1 month (May 2018)

	Existing Operation	New Operation	Improvement
Bias (K)	-1.683	-0.950	43.6 %
RMSE (K)	2.523	1.903	24.6 %
R	0.966	0.973	

Table 3. COMS SST comparison for 1year test (Jan. ~ Dec. 2017)

	Existing Operation	New Operation	Improvement
Bias (K)	-1.6	-1.0	35.6 %
RMSE (K)	2.4	1.9	19.2 %
R	0.96	0.97	

Summary and Future Works

- National Meteorological Satellite Center of KMA has been operating Korean meteorological imager, MI onboard satellite COMS.
  - One of the 16 baseline products, SST also operationally produced via CMDPS using MCSST algorithm in NMSC.
- We have done experiments to improve the accuracy for the operational SST of KMA using **coefficients of ECVs, corrected data with GSICS, and QC**.
  - In consequence of experiments, SST bias and RMSE of the COMS in comparison with in-situ data (Buoy) were reduced definitely (See the table 2 and 3).
- Now, KMA is changing operation mode with new operation based on result of the experiments.
- KMA is getting ready for launch and operating next meteorological satellite, GeoKOMPSAT-2A, and KMA has been developed SST algorithm using advanced method to do that.