International
Ocean Colour Science
Meeting 2025

Advancing Global Ocean Colour Observations

The sensor calibration of Geostationary Ocean Color Sensor-II (GOCI-II)

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Overview of GOCI-II

Overview of GOCI-II

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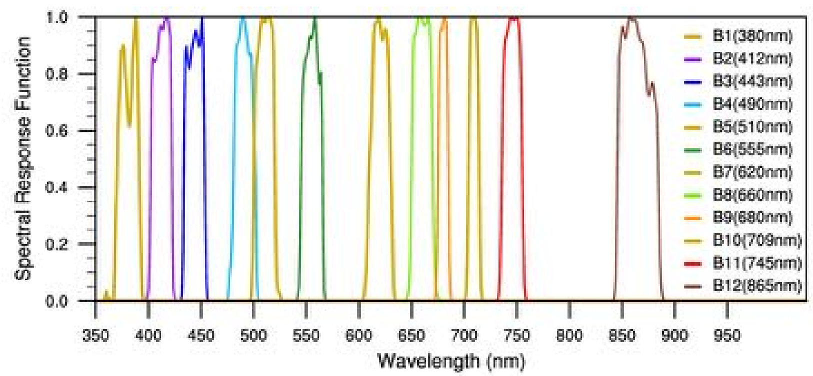
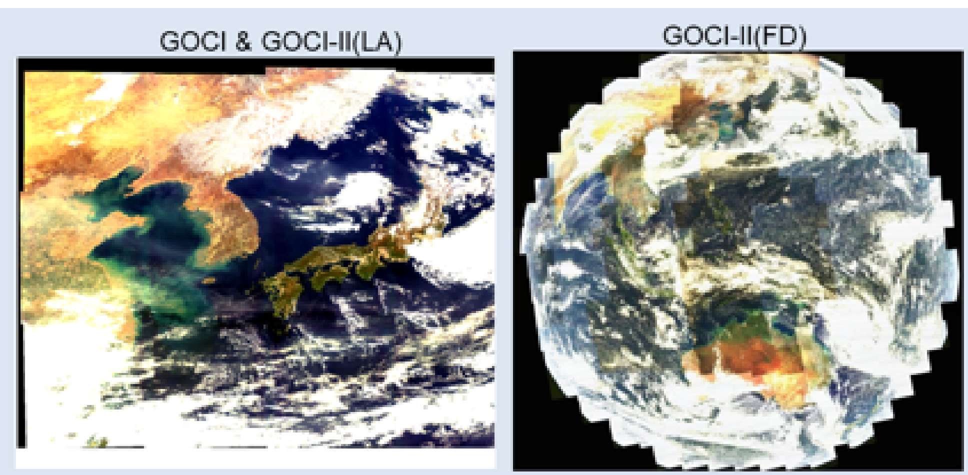
❖ Major objectives

- To monitor ocean biological and biogeochemical processes over the North-East Asia region
- To diagnose changes in marine ecosystems in a warming climate
- To maintain the continuity of the GOCI's missions in ocean color observations
- Adding Full Disk Imaging & Lunar Calibration (cf. GOCI: Local Area & Solar calibration)
- 12 spectral bands and one wide band





(13: 15(KST), March 23, 2020) (March 14, 2020)

	GOCI-II
Spectral resolution	13 bands
Spatial resolution	250m (at the equator)
Observations	10 times/day
Area	regional + global
Output	A total of 26 products - Remote-sensing reflectance - Chlorophyll concentration - Color Dissolved Organic Matter (CDOM) - Total Suspended Solids (TSS) - Aerosol - Land surface reflectance

GOCI-II On-board Radiometric Calibration Devices

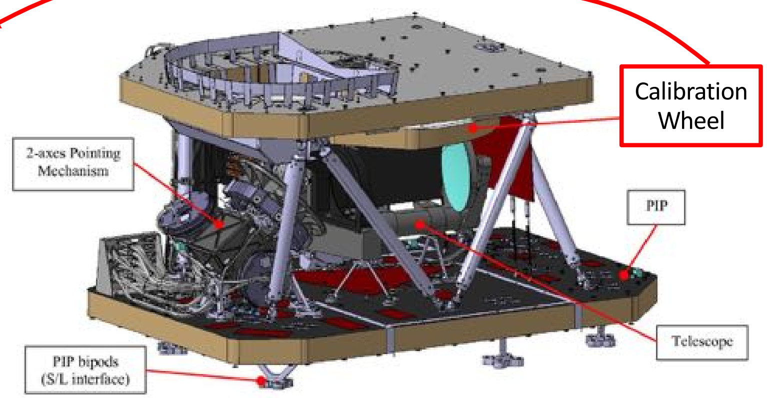
- ❑ Located in front of the pointing mirror to cover the whole optical path
- ❑ Two on-board calibration devices
  - SD (Solar Diffuser)
    - Observation once a week
  - DAMD (Diffuser Aging Monitoring Device)
    - Monthly observation for monitoring SD degradation

Pointing mechanism

(a) SD

(b) DAMD

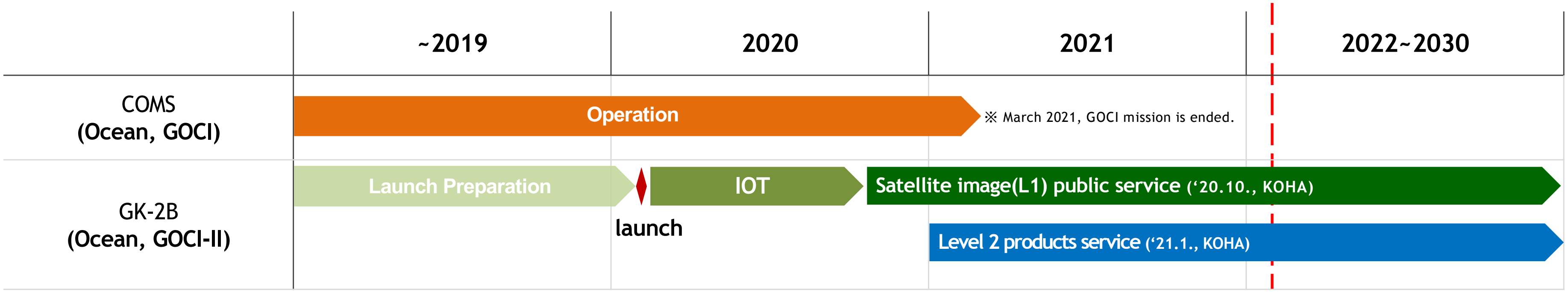
Dr. Yong (KARI)



GOCI-II instrument (Coste et al., 2016)

Filter wheel

Radiometric model development steps



Pre-launch	On-ground calibration (KARI)
IOT	In-orbit calibration (KARI)
Mission	In-orbit calibration updates Based on SD/DAMD observation (KIOST)

KARI: Korea Aerospace Research Institute

IOT: In-Orbit Test

- Pre-launch period, KARI worked on the characterization of on-board calibration devices.
- On-ground absolute gain has been used as the initial value for early orbit operation. $\rightarrow G_{prelaunch}(B)$
- In-orbit absolute gain has been calculated through solar calibration using SD. $\rightarrow G_{IOT}(B)$
- To improve the accuracy of ocean color data, we have improved the radiometric calibration model by utilizing SD monitoring observations. $\rightarrow G_{correct}(B,t)$

Scope of the this study

- ❑ The improvement of GOCI-II Radiometric Correction model using five years of SD stability observation (June 2020 – July 2025)
- ❑ Development of an iterative correction procedure for angle and temporal trend modeling
- ❑ Evaluation of updated GOCI-II ocean color product (e.g. TOA radiances)

Schematics of Radiometric Calibration System

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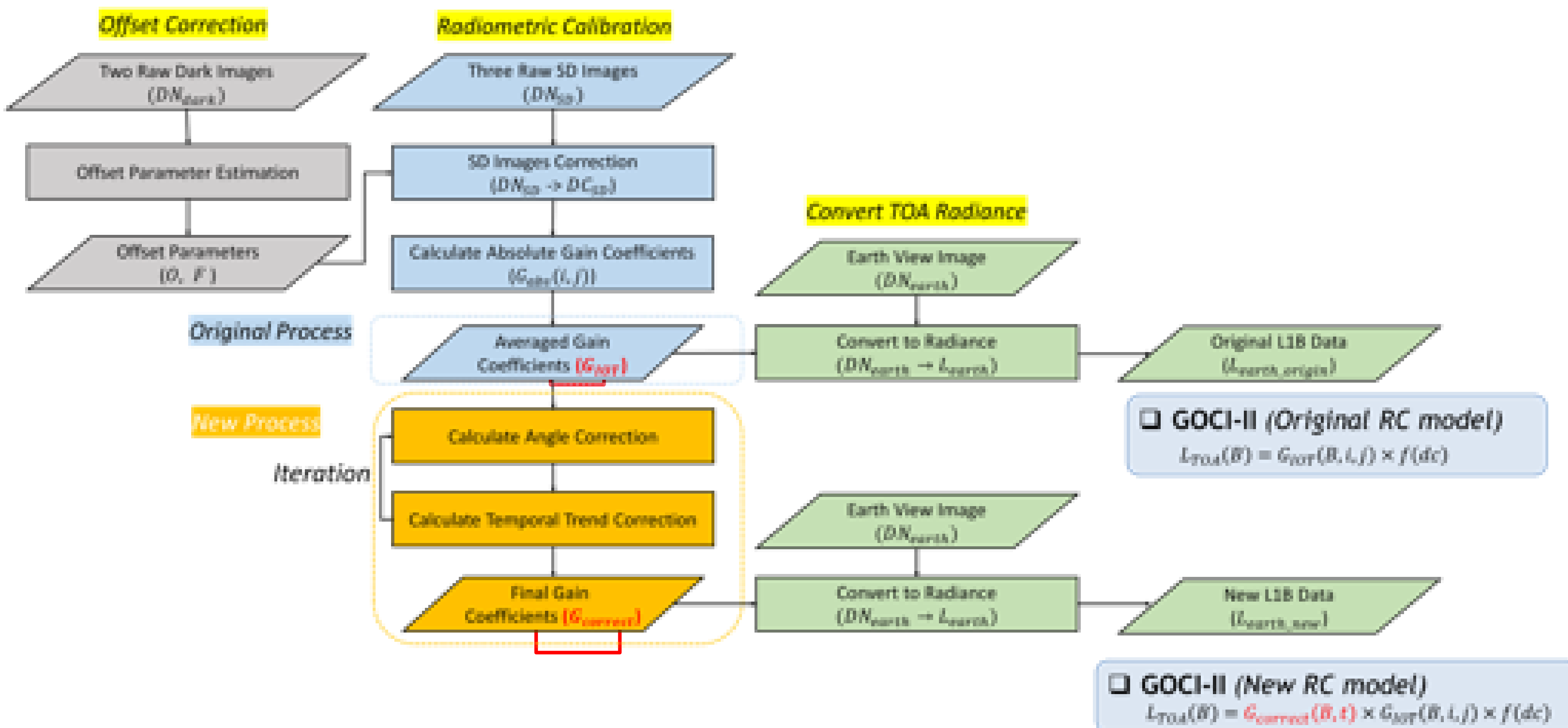

Comparison of Radiometric Correction models

Radiometric Correction model: $L_{TOA}(B) \sim f(dc)$

❑ GOCI-II *(Yong et al., 2021)*

$$L_{TOA}(B) = G_{IOT}(B) \times [c_0 dc + c_1 dc^2 + c_2 dc^4]$$

❑ GOCI-II *(New RC model)*

$$L_{TOA}(B,i,j) = G_{correct}(B,t) \times G_{IOT}(B) \times [c_0 dc + c_1 dc^2 + c_2 dc^4]$$

L_{TOA}: TOA radiance of Earth View
B: band number
c_x: calibration coefficients
dc: digital number after bias removed
$G_{IOT}(B)$: absolute gain of GOCI-II
$G_{inverse}(B,t)$:inverse gain coefficient of GOCI-II
$C_t^n(B)$: temporal correction coefficient
$C_\theta^n(B)$: angle correction coefficients
$F(B,t)$: calibration coefficient
$K_1(B,t)$: relative gain factor; K_2: absolute gain factor;
K_3: temperature dependence factor; K_4: scan modulation correction factor; K_5: nonlinearity factor; K_p: polarization
T: focal plane temperature during the measurement of $L_{SD_{MODIS}}$
T_{ref}: focal plane temperature at which K_2 was measured

❑ VIIRS *(Sun and Wang, 2015)*

$$L_{TOA}(B) = F(B,t) \times [c_0 + c_1 dc + c_2 dc^2]$$

❑ MODIS *(Meister et al., 2011)*

$$L_{TOA}(B) = K_1(t) \times K_2 \times \left(1 - K_3(T - T_{ref})\right) \times K_4(\theta) \times K_5(dc) \times dc$$

❑ OCI *(Meister et al., 2024)*

$$L_{TOA}(B) = K_1 \times K_2(t) \times \left(1 - K_3(T - T_{ref})\right) \times K_4(\theta) \times K_5(dc) \times \boldsymbol{K_p} \times dc$$

GOCI-II SD Gain Monitoring

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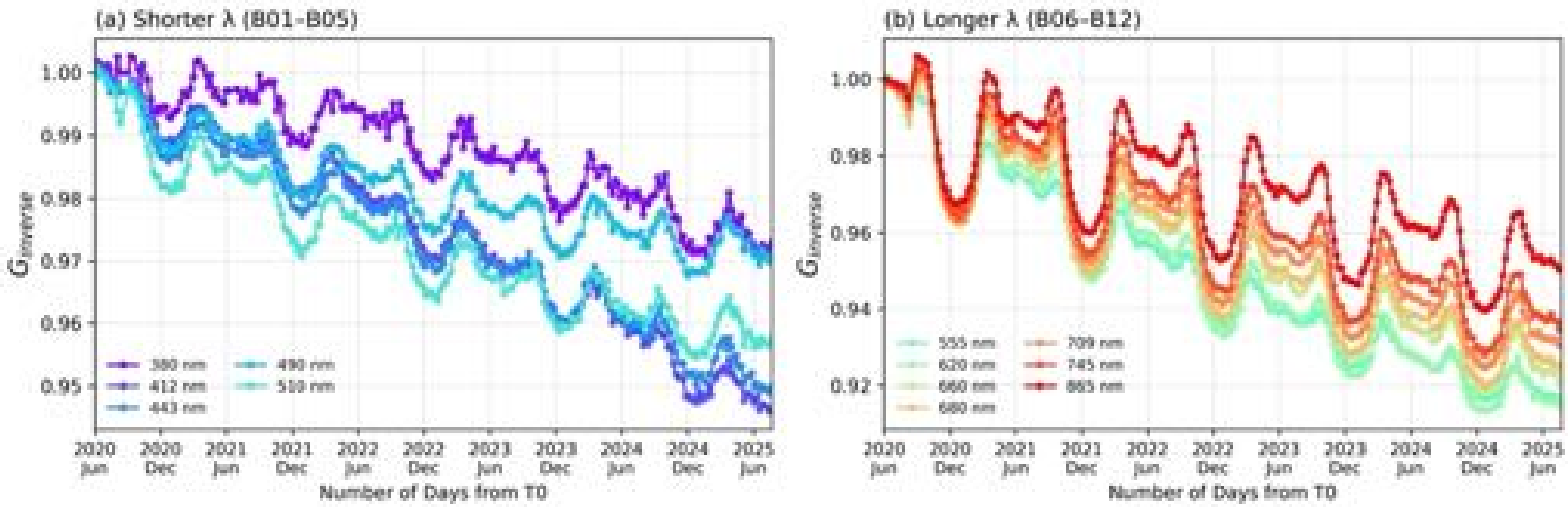
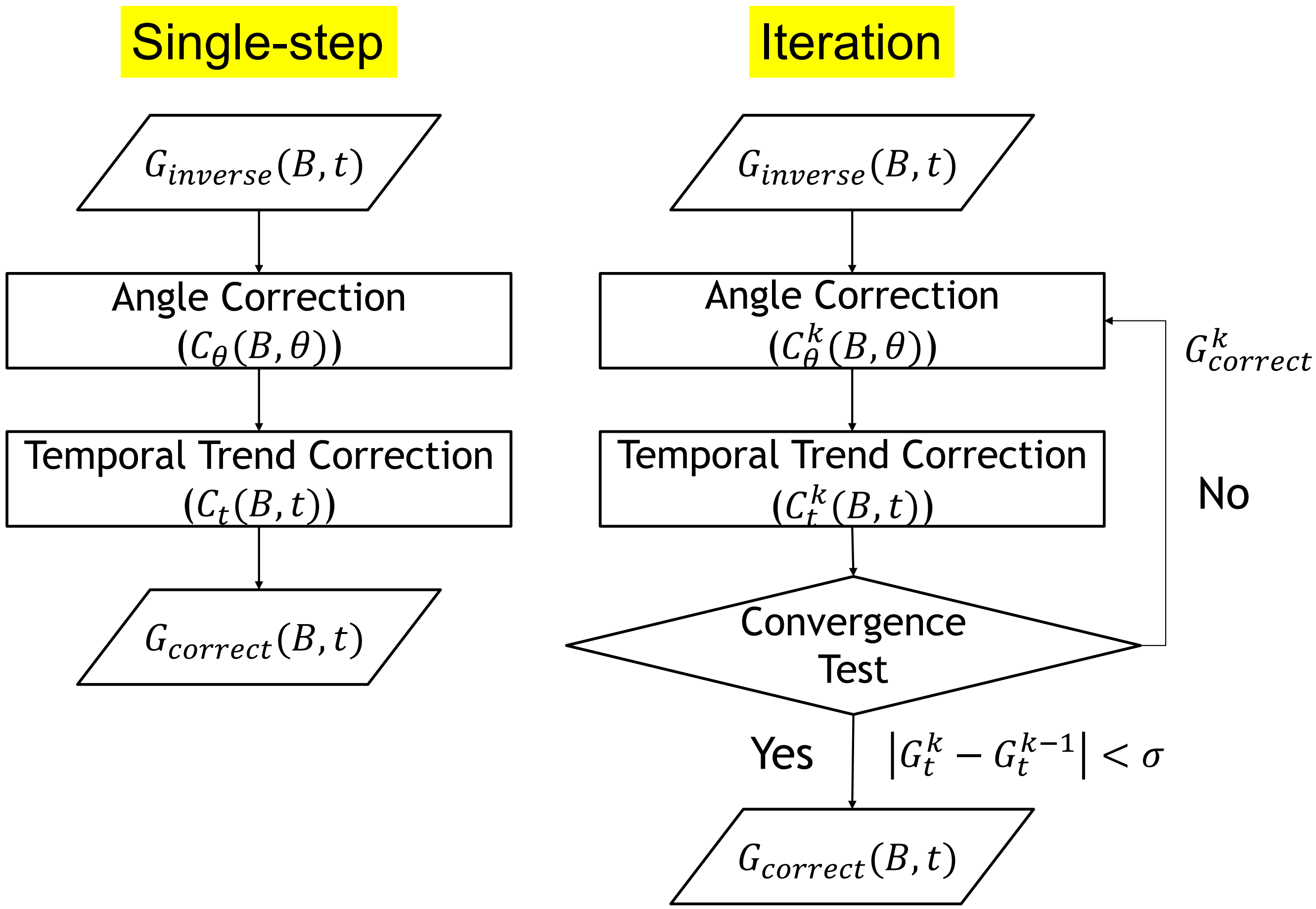
❑ Timeseries of Inverse Gain ($G_{inverse}(B,t) = \frac{\bar{G}(B,t_0)}{\bar{G}(B,t)}$) t0: 2020-06-01



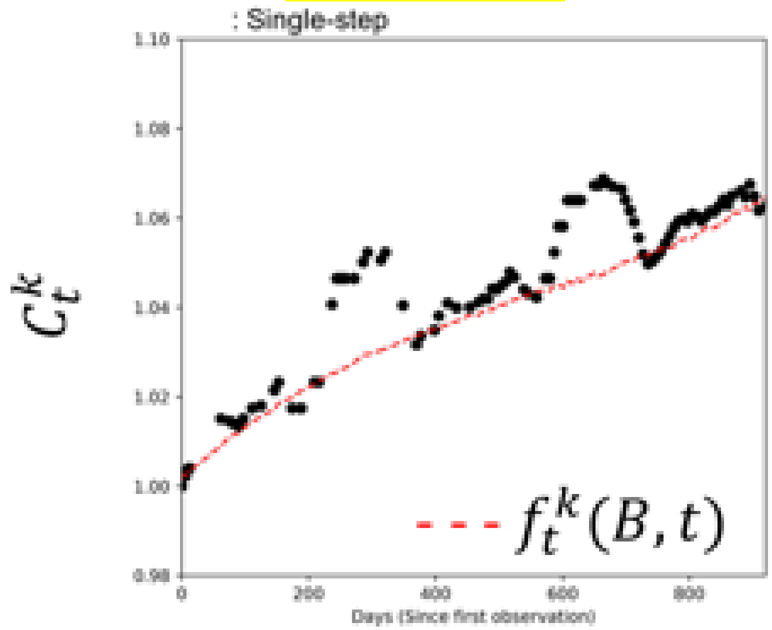
- Seasonal perturbation → Observational angle → Angle correction
- Long-term negative trend → Sensor long-term trend → Temporal trend correction
- Most changed band: 555 nm (GOCI-II) ↔ VIIRS, MODIS

Comparison Single-step vs. Iteration

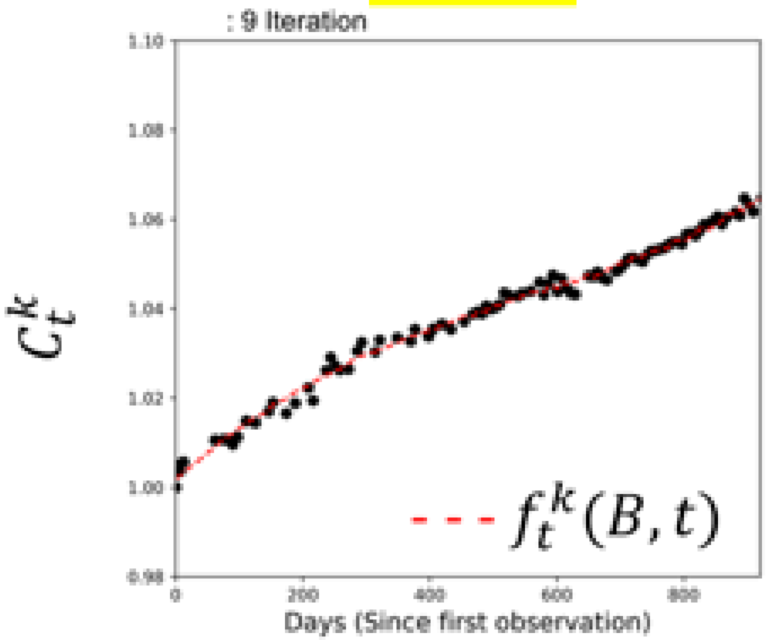


Comparison Single-step vs. Iteration

Single-step



Iteration



❑ Residual errors are minimized after iteration process

Obtained New Corrected Factor ($G_{correct}$)

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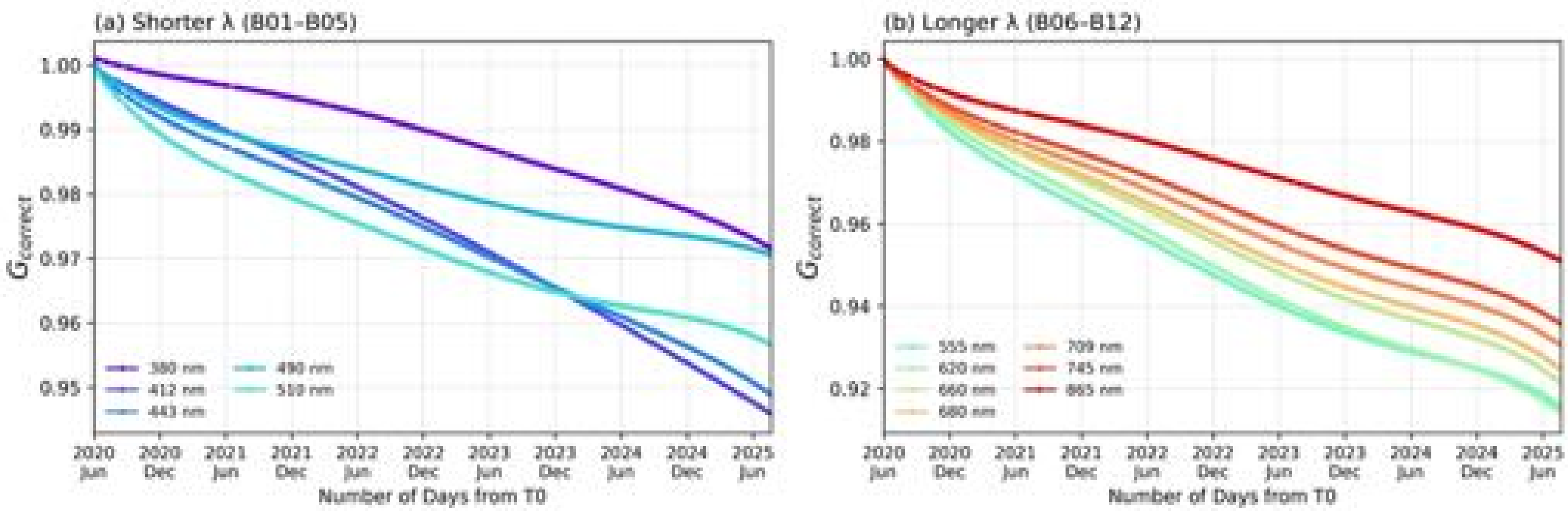
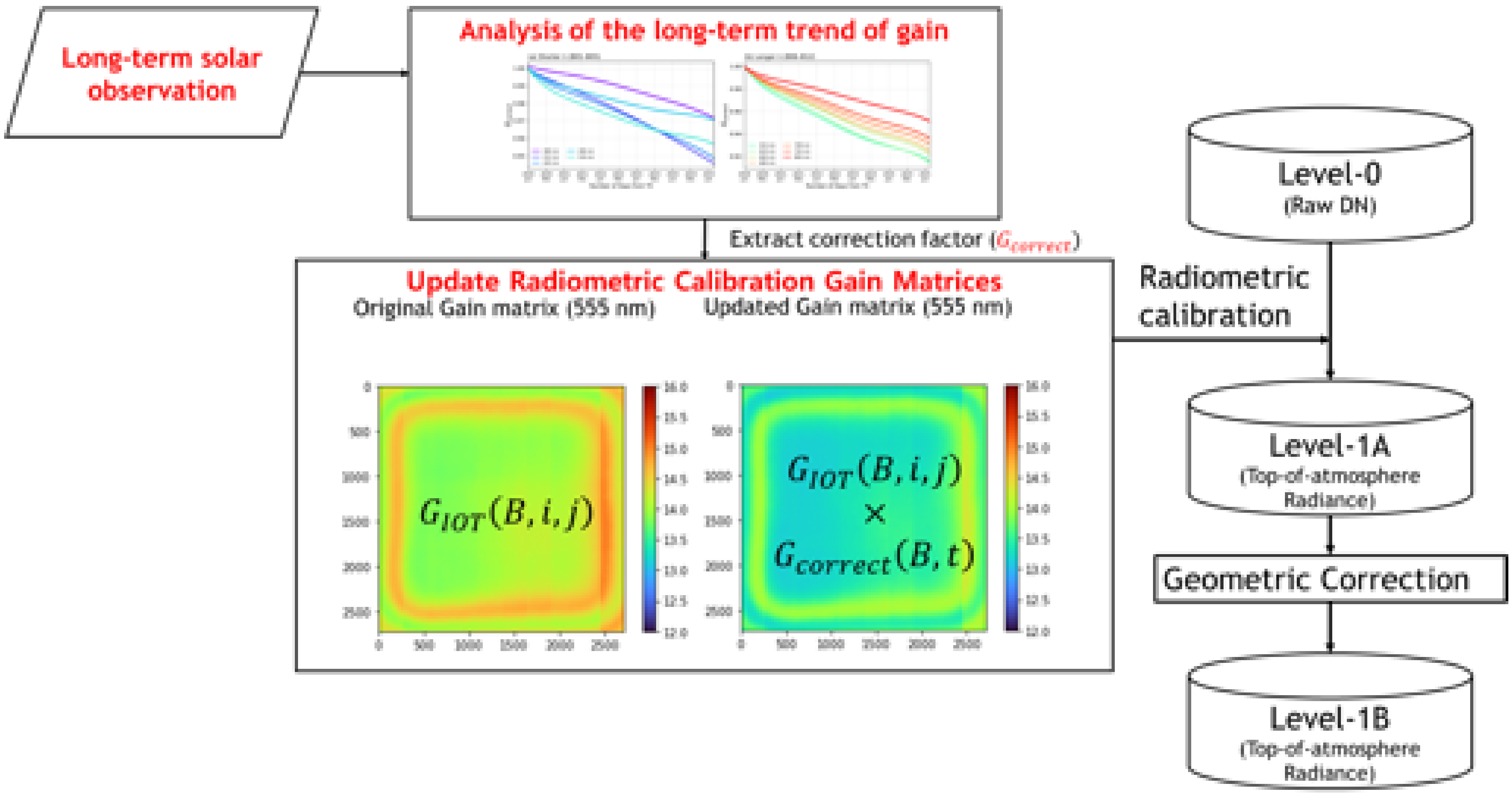
$$G_{correct}(B,t) = G_{inverse}(B,t) \times C_{\theta}^{n}(B,\theta) \times C_{t}^{n}(B,t)$$



- ❑ Reducing the residual signal of seasonality
- ❑ Band-specific chagne rate of 2 – 9 % over the five years

Improved GOCI-II Data Processing

DN: Digital Number



Effect of Updated RC on TOA Radiance

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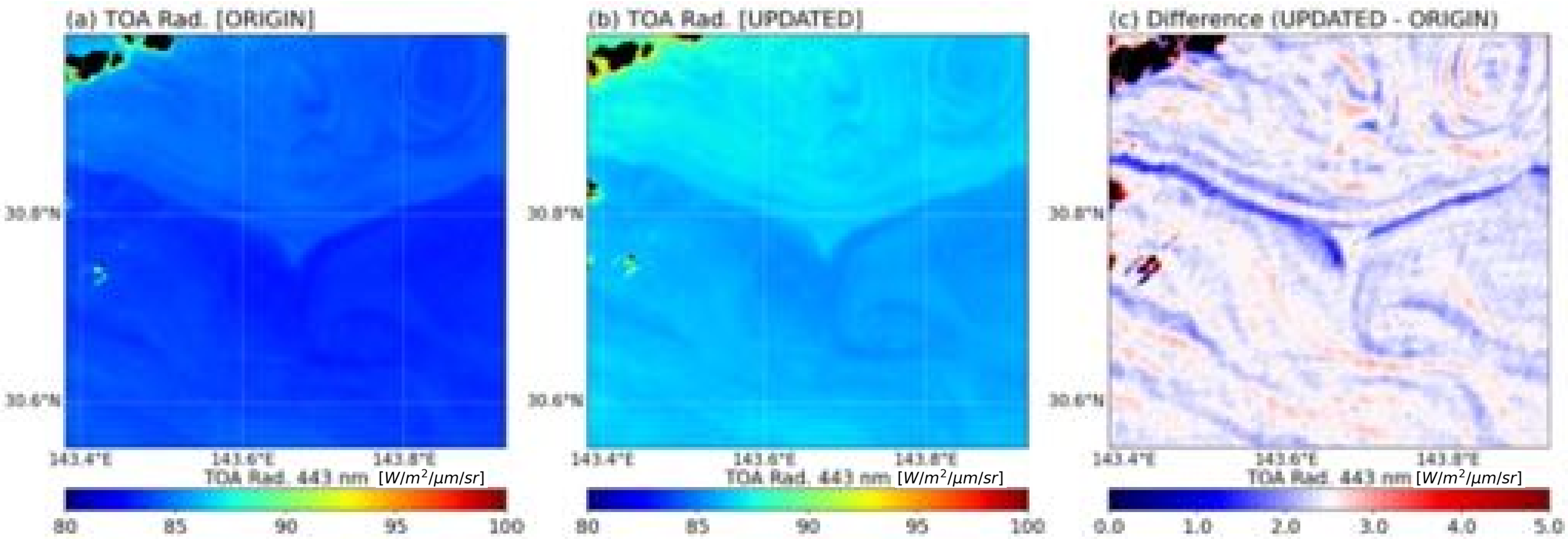

- The negative bias in the original TOA radiance is improved

Summary

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1. The radiometric correction model of GOCI-II, initially developed at the ground laboratory before launch and validated during the IOT period by KARI, was further improved using multi-year years of Solar Diffuser gain monitoring by KIOST.

2. The improvements are as follows: temporal correction factors were applied to obtain the angle correction and temporal trend model iteratively, which effectively reduced the seasonal residuals compared to the single-step model.

3. The derived correction factors were used to generate updated 2D gain matrices, which were applied during the reprocessing of GOCI-II. This update led to a noticeable improvement in the negative bias observed in the original TOA radiance.

4. The radiometric correction model based on the first three years of gain monitoring was applied to generate the updated Rrs for the GOCI-II 2024 reprocessing, and additionally, a new model based on the most recent data is planned to be implemented operationally next year.

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Questions and Answers

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Thank you!

Back-up: DAMD plan

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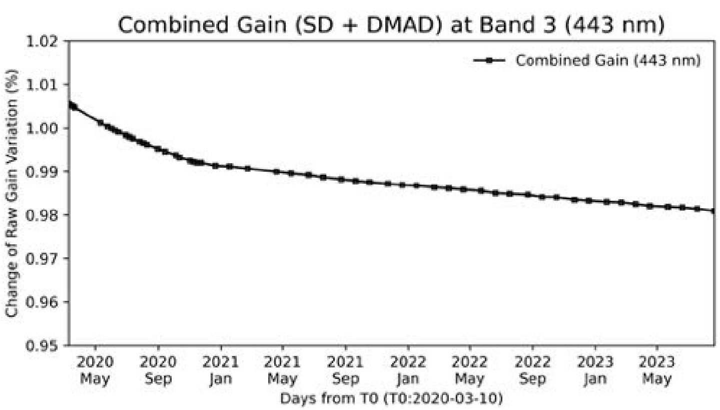
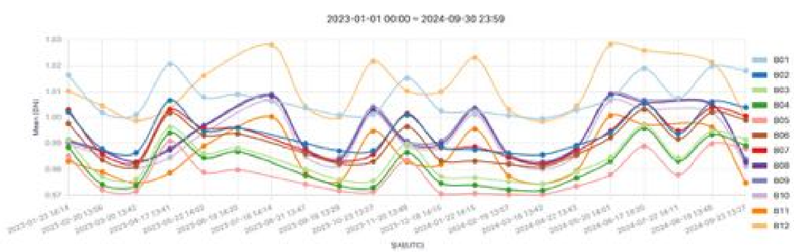
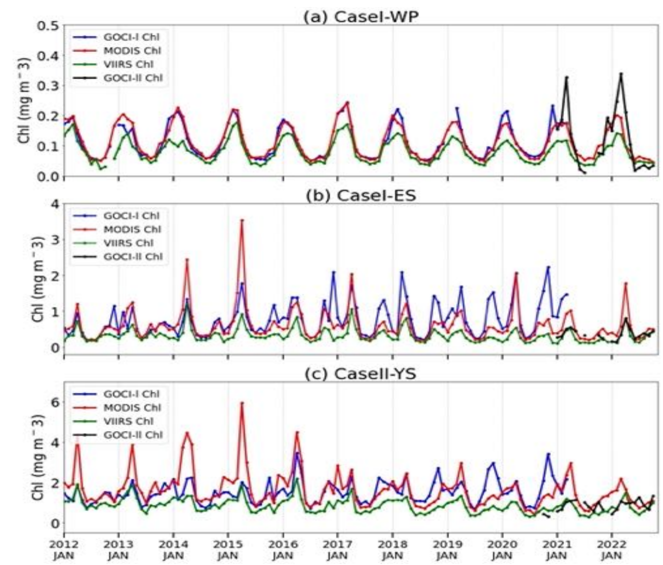
- ❑ To use DAMD for detecting SD's degradation $\rho_{SD}(\theta,\phi,i,j) = \Delta\rho \times \rho_{SD_o}(\theta,\phi,i,j)$
- ❑ To work on the lunar calibration model $\Delta\rho(\theta_{SD},\phi_{SD}) = \frac{\rho_{SD_o}(\theta_{MD},\phi_{MD})}{\rho_{SD_o}(\theta_{SD},\phi_{SD})} \times \frac{\cos\theta_{MD} T_{MD}}{\cos\theta_{SD} T_{SD}} \times \frac{1}{F_{MD}(\theta_{MD},\phi_{MD})} \times \frac{[\bar{Y}_{SD} + \alpha\bar{Y}_{SD}^2 + \beta\bar{Y}_{SD}^4]}{[\bar{Y}_{MD} + \alpha\bar{Y}_{MD}^2 + \beta\bar{Y}_{MD}^4]}$
- ❑ To reprocess GOCI L1b sensor data for continuity of GOCI and GOCI-II







Park, M.-S.*, S. Lee, J.-H. Ahn, S.-J. Lee, J.-K. Choi, J.-H. Ryu., 2021: Decadal observation of the first geostationary ocean color satellite (GOCI) compared with MODIS and VIIRS data, *Remote Sensing*, 14(1), 72

Back-up: Updated GOCI-II RC model and iterative procedure

B: Band number, i, j: pixel indices,
$dc(B,i,j)$: digital number after background correction
$G_{IOT}(B,i,j)$: original averaged absolute gain
θ_{RAA}: sine of relative azimuth angle
t: number of days since first observation

- Updated GOCI-II RC equation

$$L_{TOA}(B,i,j) = G_{inverse}(B,t)\times C_t^n(B,t)\times C_\theta^n(B,\theta)\times G_{IOT}(B,i,j)\times[a_0(B,i,j)dc(B,i,j) + a_1 dc^2(B,i,j) + a_2 dc^4(B,i,j)]$$

- Angle correction model: $f_\theta(B,\theta_{RAA}) = b_0 + \sum_i^5 b_i(B)\times \sin(\theta_{RAA})^i$
- Temporal trend correction model: $f_t(B,t) = c_0 + \sum_j^5 c_j(B)\times t^j$
- Iterative correction procedure

1. In the first iteration, the initial inverse gain, $G_{inverse}(B,t)$ are used.
2. At each iteration k, the angle-correction model is fitted to derive updated angle correction coefficient, $C_\theta^n(B,\theta)$.
3. The $C_\theta^n(B,\theta)$ are applied to $G_t^{k-1}(B,t)$ to obtain an angle corrected inverse gain, $G_\theta^k(B,\theta_i)$.
4. The angle-corrected values are then input to the temporal-trend model to generate the long-term trend-corrected coefficient, $C_t^n(B,t)$.
5. The $C_t^n(B,t)$ are applied to $G_t^{k-1}(B,t)$ to obtain temporal trend corrected gain, $G_t^k(t_i,\theta_i)$.
6. This process is repeated until the difference between iterations k and k-1 falls below a threshold.