International Ocean Colour Science Meeting 2023 | Advancing Global Ocean Colour Observations

Breakout session 6 | 15 November 2023

GOCI-II calibration for long-term data stability

Myung-Sook Park[1], Minsang Kim[1], Sunju Lee[1], Seonju Lee[1], Jaehyun Ahn[1], Jong-kuk Choi[1], and Gmsil Kang[2]

[1] KOSC/KIOST

[2] KARI

KOSC

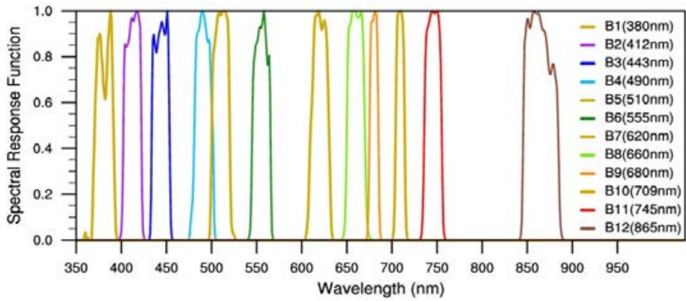
KIOST KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY

KARI Korea Aerospace Research Institute

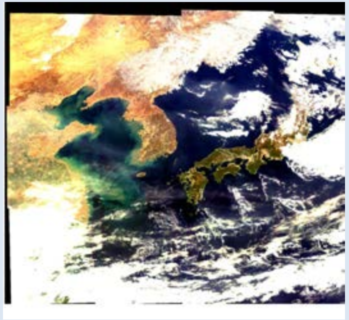
Korea Hydrographic and Oceanographic Agency

Overview of GOCI-II

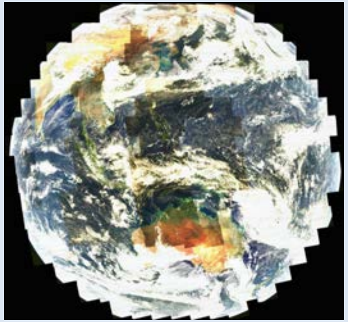
- Major objectives
  - ✓ To monitor ocean biological and biogeochemical processes over the North-East Asia region
  - ✓ To diagnose change in marine ecosystems in a warming climate
  - ✓ To maintain the continuity of the GOCI's missions in ocean color observations
  - ✓ Adding Full Disk Imaging & Lunar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



GOCI-II(LA)

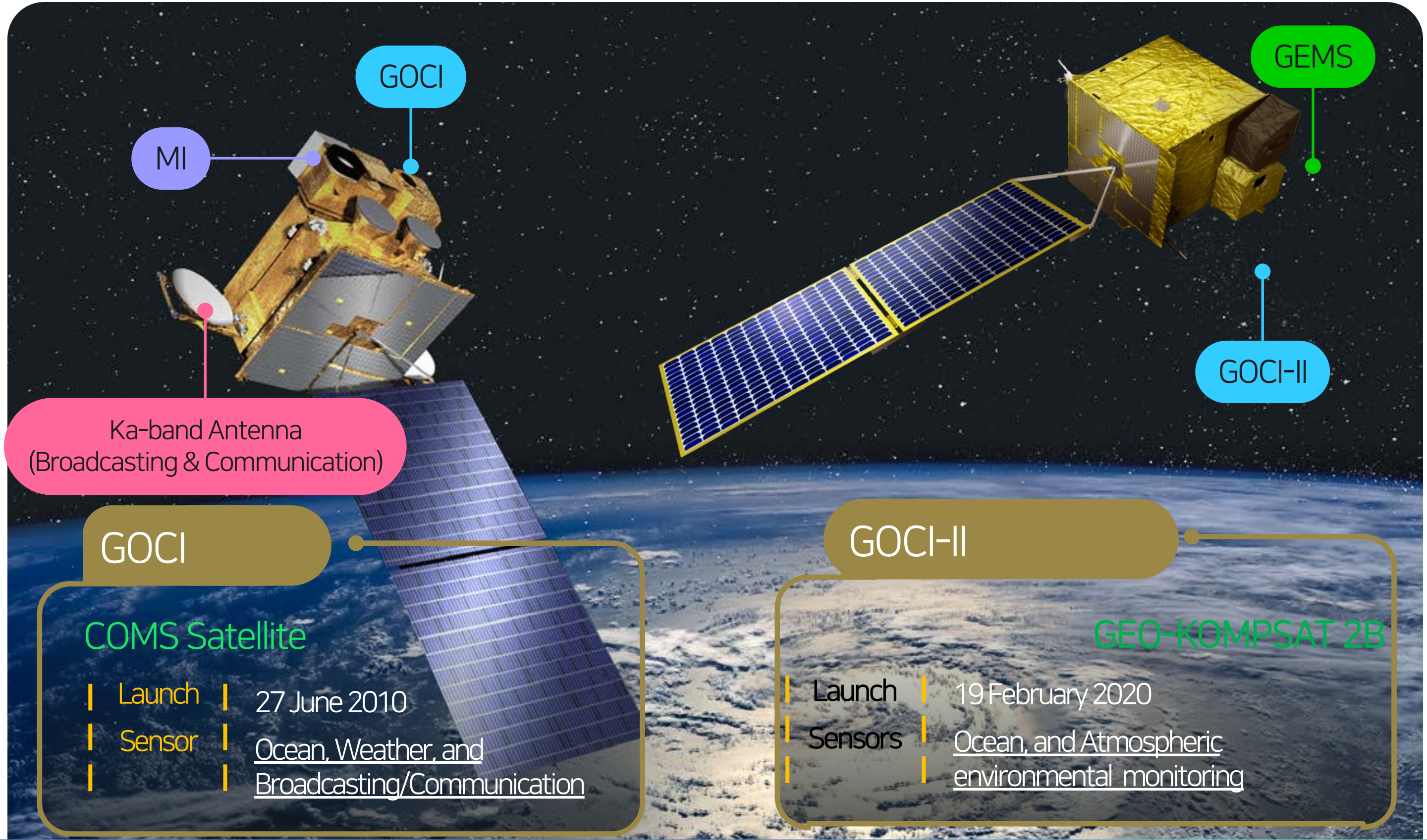


GOCI-II(FD)



	GOCI-II
Launching Date	19 Feb. 2020
Spatial Resolution	250 m (regional observation)
Imaging Area	Regional 2,500 km X 2,5 00 km (Center coordinate 130°E, 36°N)

GOCI & GOCI-II

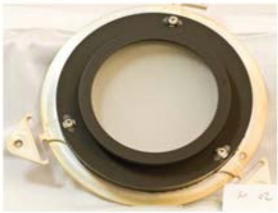


MI
GOCI
Ka-band Antenna
(Broadcasting & Communication)
GEMS
GOCI-II
GOCI
COMS Satellite
Launch
27 June 2010
Sensor
Ocean, Weather, and
Broadcasting/Communication
GOCI-II
GEO-KOMPSAT 2B
Launch
19 February 2020
Sensors
Ocean, and Atmospheric
environmental monitoring

GOCI-II On-board calibration devices

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

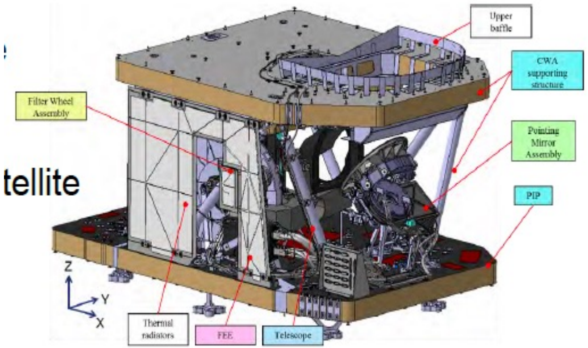
(a) SD



(b) DAMD

Dr. Yong (KARI)

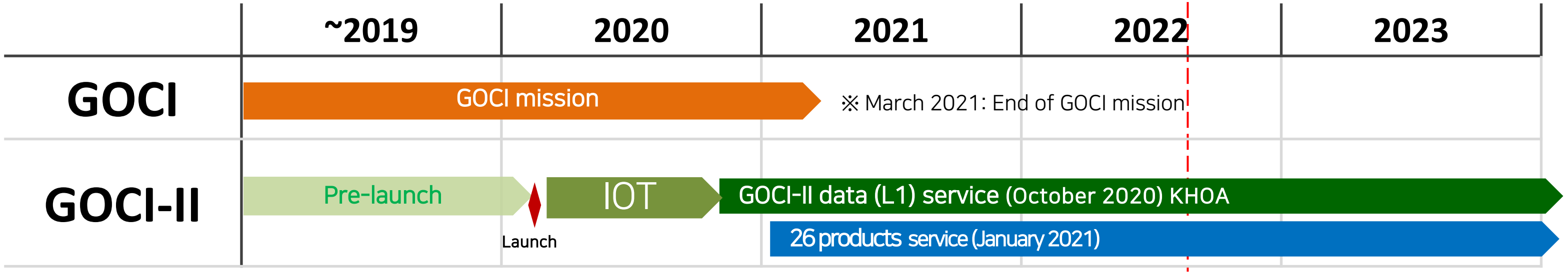
Sensor Unit



Pointing mirror mechanism

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)

- 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.
- In-orbit absolute gain has been calculated through solar calibration using SD.
- To improve the accuracy of ocean color data, we have improved the radiometric calibration model to use SD/DAMD observations for three years.

Scope of the current study

- The long-term geostationary ocean color data can resolve the ocean phenomenon with the diurnal, day-to-day, seasonal, and interannual variation.

- **The improvement of GOCI-II sensor calibration data using three years of SD stability observation (June 2020 – June 2023)**
- **Investigation as to how GOCI-II sensor calibration affects ocean color Data (two sets: original vs. improved L1B data)**

RC models

KOSC

Current RC model: $L_t(B) \sim f(Dc)$

❖ **GOCI-II** (*Yong et al, 2021)*

$$L_t = \boldsymbol{G(B)} \times [c_0 dc + c_1 dc^2 + c_2 dc^4]/Tint(B)$$

GOCI-II (new)

- $L_{Earth} = \boldsymbol{K_1} \times K_2 \times K_3 \times [a_0 \times dc_{Earth} + a_1 \times dc_{Earth}^2 + a_2 \times dc_{Earth}^4]$

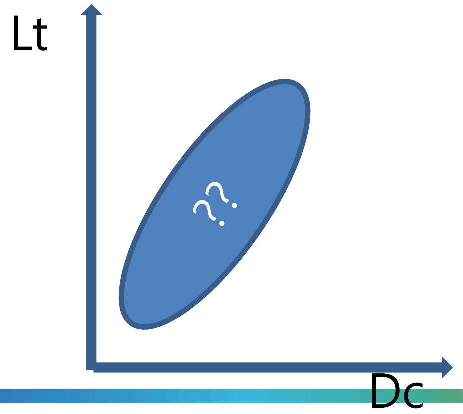
K1: absolute gain coefficient
K2: angle corrected model
K3: sensor degradation coefficient

❖ **MODIS** *(Meister et al., 2011)*

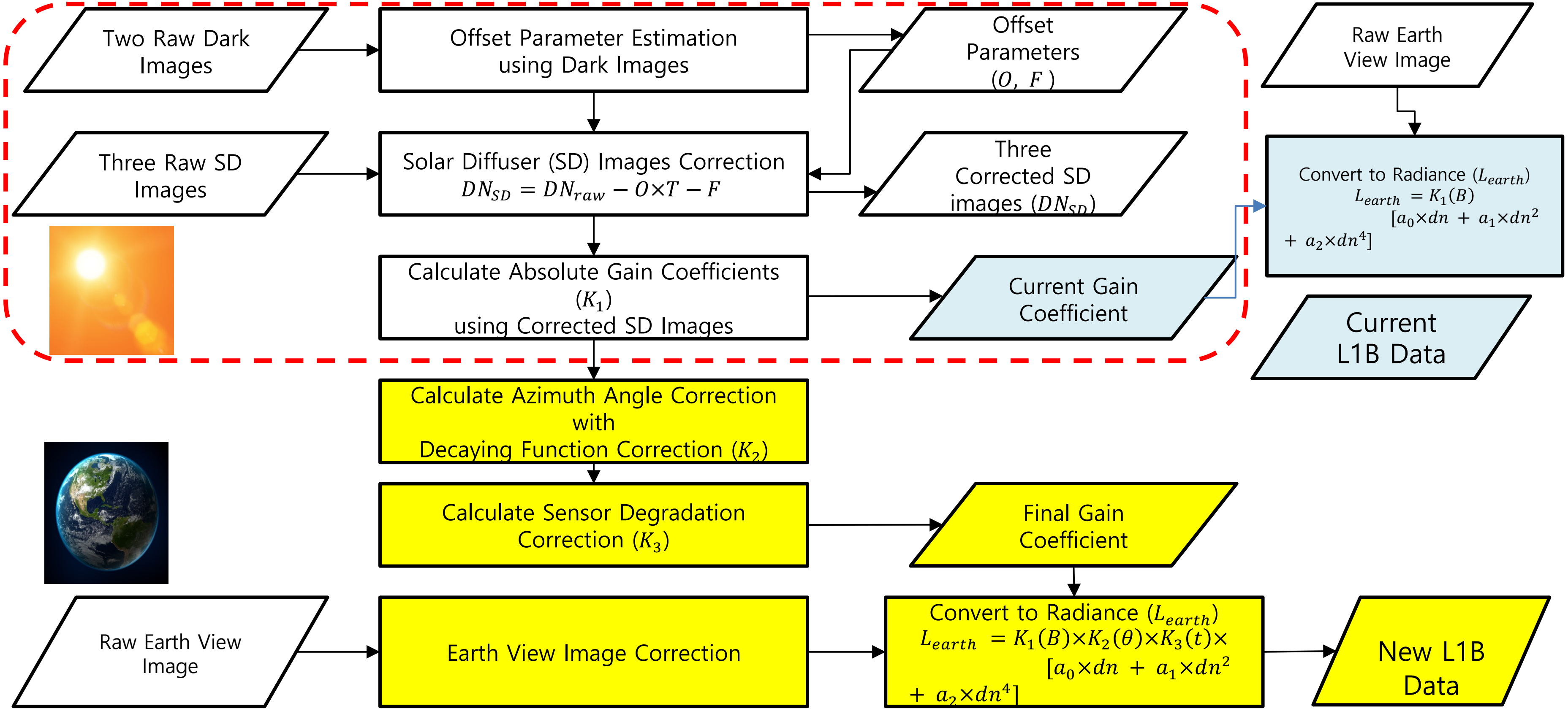
$$L_t(B) = \boldsymbol{K_1(t)} \times \boldsymbol{K_2} \times \left(1 - K_3\left(T - T_{ref}\right)\right) \times K_4(\theta) \times K_5(dn) \times dc$$

❖ **VIIRS** *(Sun and Wang, 2015)*

$$L_t(B) = \boldsymbol{F(B,t)} \times [dc + c_1 dc^1 + c_2 dc^2]$$

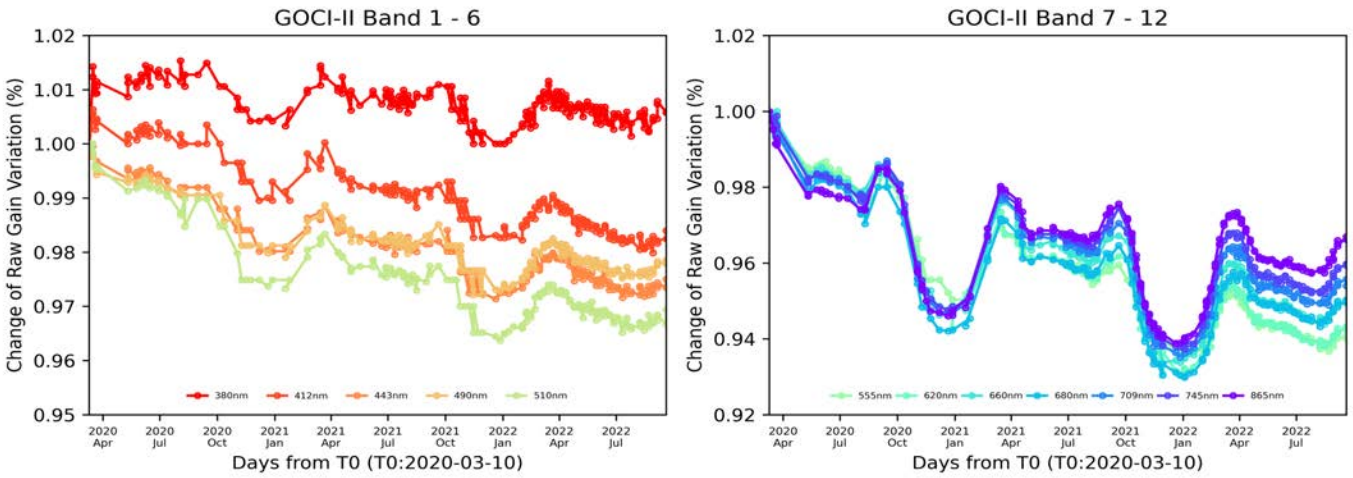


Schematics of RC model



GOCI-II SD gain monitoring

- Change of Gain variation [$\Delta G/G_0$]



Change of Gain variation shows the seasonality depending on RAA as well as a negative trend

- ✓ 412-510 nm: 2 % decreasing
- ✓ 555-865 nm: 4 % decreasing

Iteration of K_2 and K_3

$$\boldsymbol{L_{earth}} \\ = \boldsymbol{K_1(B,t)\times K_2(B,\theta_{SAA})\times K_3(B,t)\times\left[a_0(i,j)\times dc(i,j) + a_1(i,j)\times dc^2(i,j) + \ (i,j)\times dc^4(i,j)\right]}$$

Step 1. BTDF correction

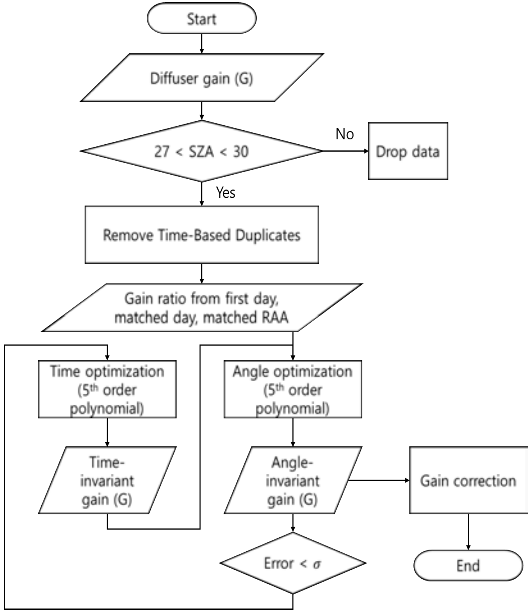
$$K_2(B,\theta_{SAA}) = b_0(B) + \sum_{i=1}^{5} b_i(\mathrm{B})\times\sin(\theta_{SAA})^i$$

Step 2. Trend correction (degradation)

$$K_3(B,t) = c_0(B) + \sum_{i=1}^{5} c_i(\mathrm{B})\times days(since\ first\ observation)$$

Step 3. BTDF iteration apply

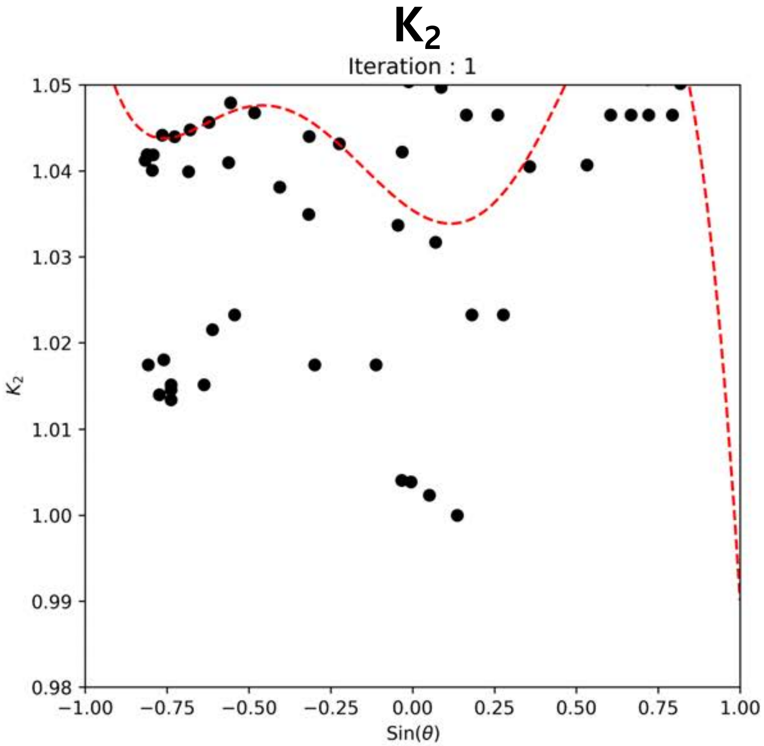
$$K_{2,3}(B,\theta_{SAA},t) = K_2\times K_3(iteration, optimization)$$

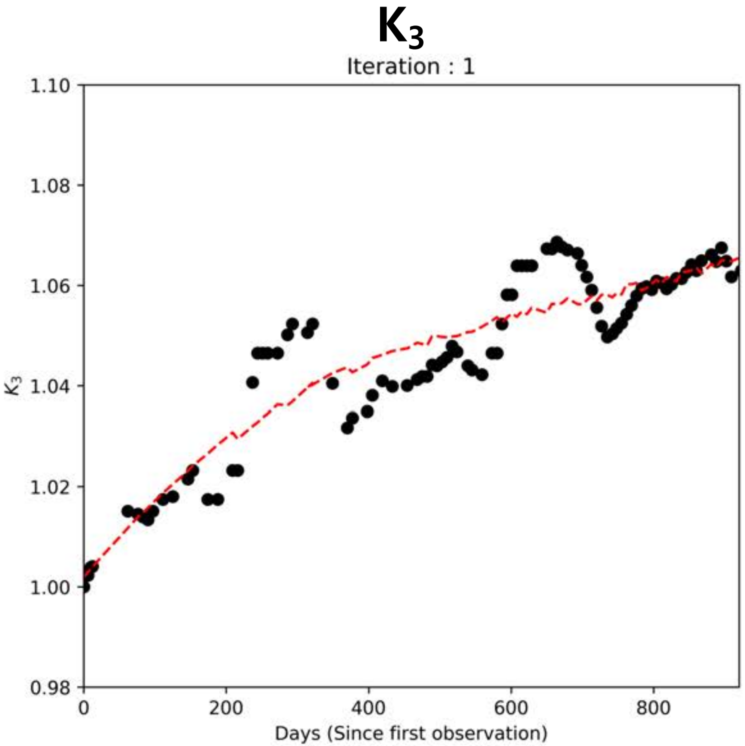


What is the best model for fitting?

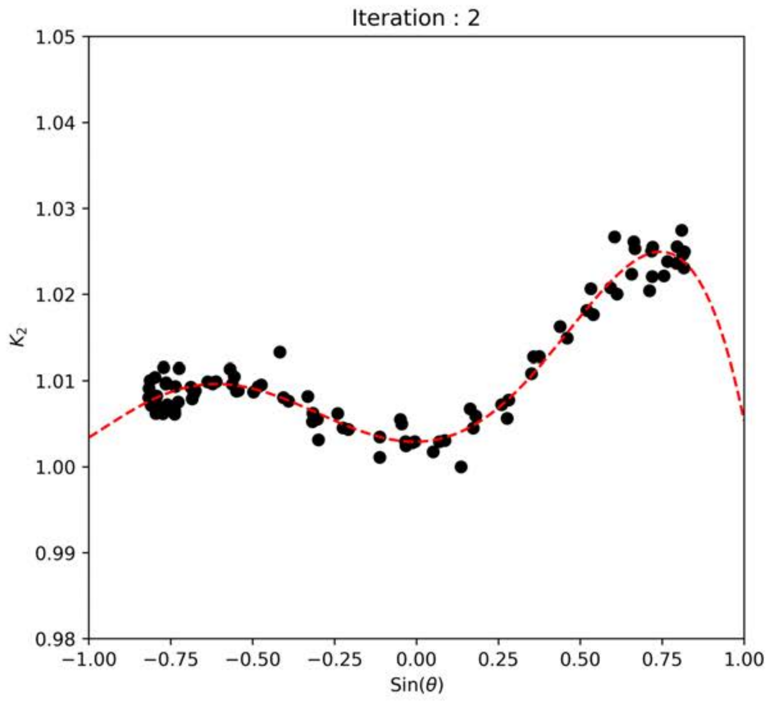
Time \ Angle	1st order polynomial	2nd order polynomial	3rd order polynomial	4th order polynomial	5th order polynomial	Exponential	Logarithm	Reciprocal
1st order polynomial	0.46156798	0.27275150	0.25456938	0.19902165	0.18740492	0.46157495	0.46157463	0.32759868
2nd order polynomial	0.43145902	0.23730758	0.21657386	0.15533781	0.14475499	0.43146295	0.43146409	0.30825954
3rd order polynomial	0.40317531	0.20594941	0.19464446	0.11366419	0.10535864	0.40317883	0.40317935	0.27341815
4th order polynomial	0.40238124	0.20548139	0.19529150	0.11376659	0.12416929	0.40238914	0.40238525	0.27339990
5th order polynomial	0.39861731	0.20403937	0.19389203	0.11319725	0.10357618	0.39861265	-	0.27328646
Exponential	0.38051160	0.21207295	0.19976878	0.13478526	0.12416929	0.38051551	-	0.26753250
Logarithm	0.40753789	0.22576512	0.20934874	0.14454272	0.13740719	0.40754181	0.40754196	0.29394255
Reciprocal	1.32171632	1.32470336	1.31116899	1.29512668	1.27161705	1.32171959	1.32172397	1.30938527

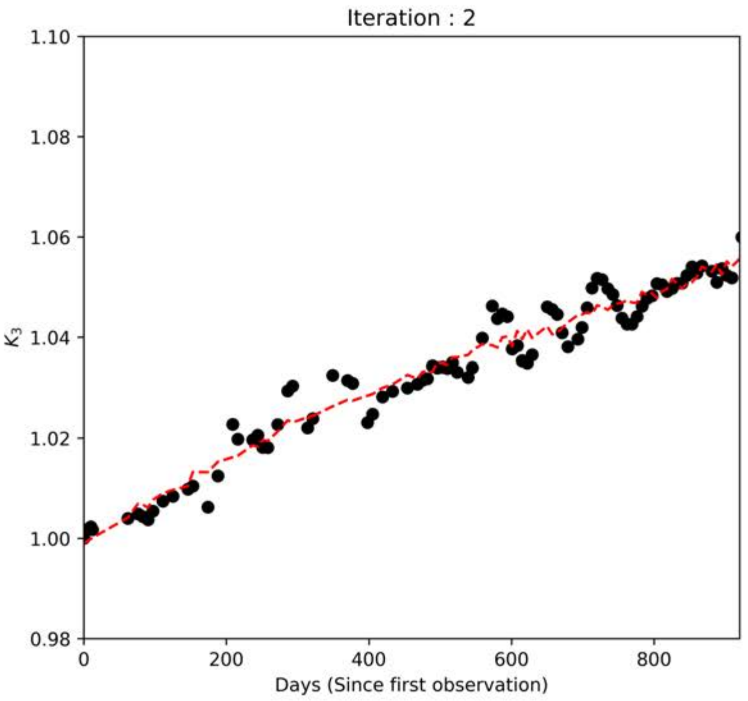
Iteration (1st step)



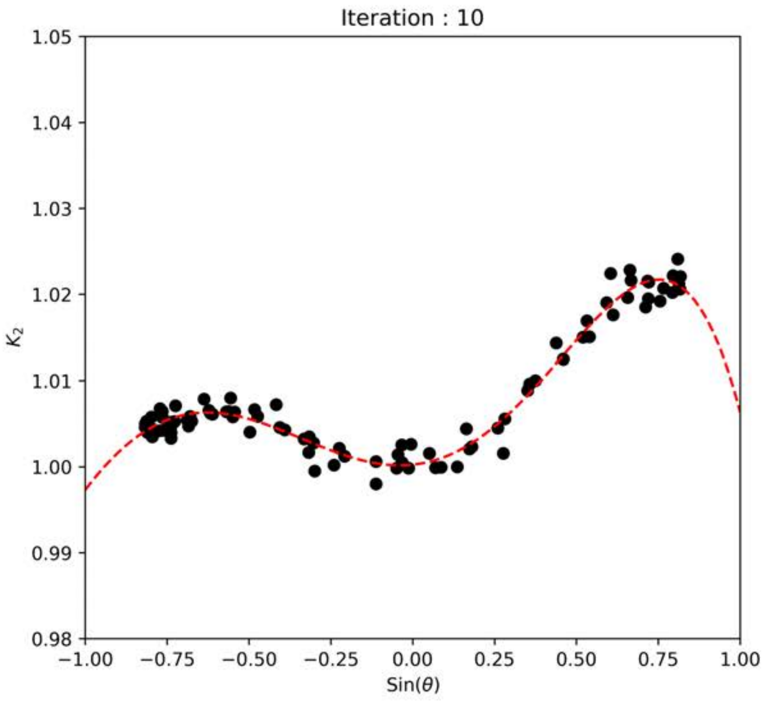


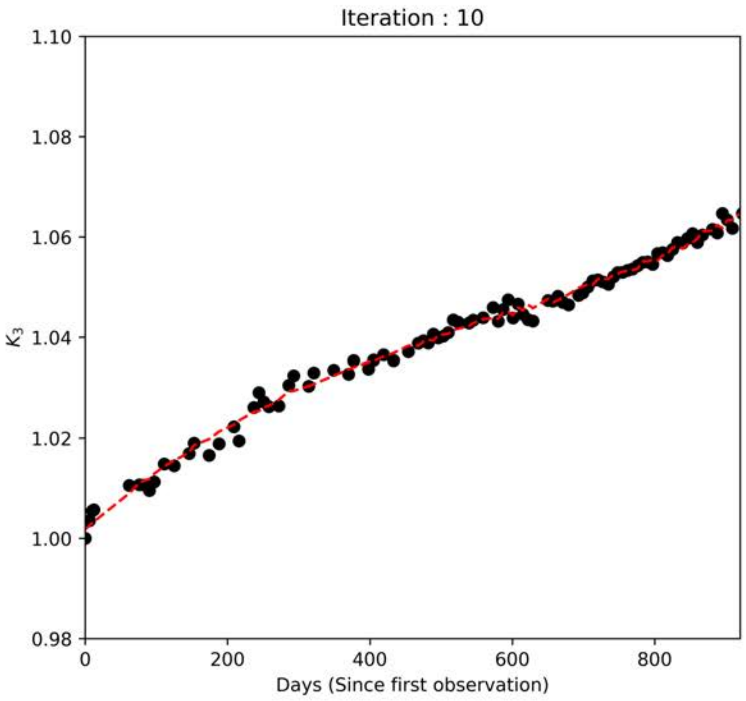
Iteration (2nd step)



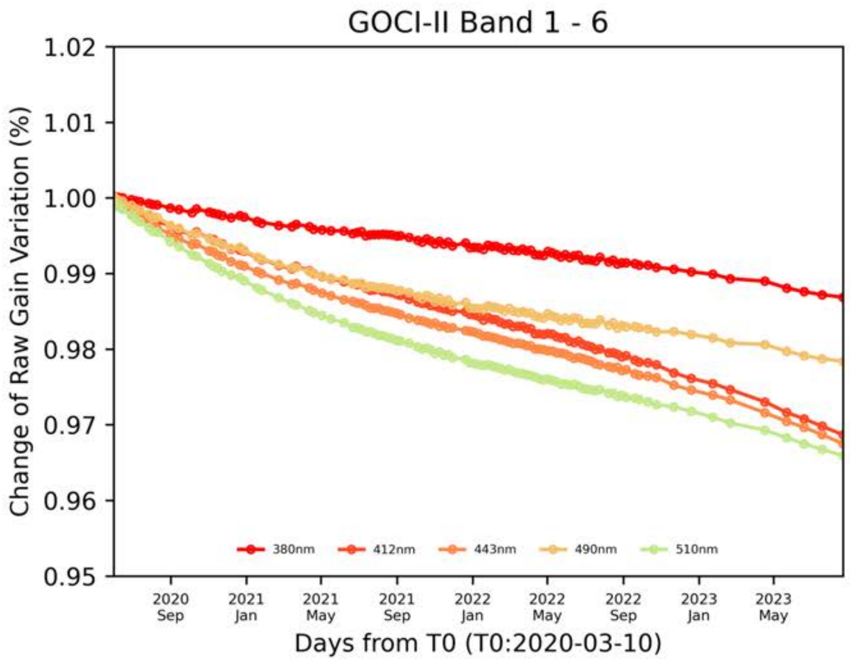


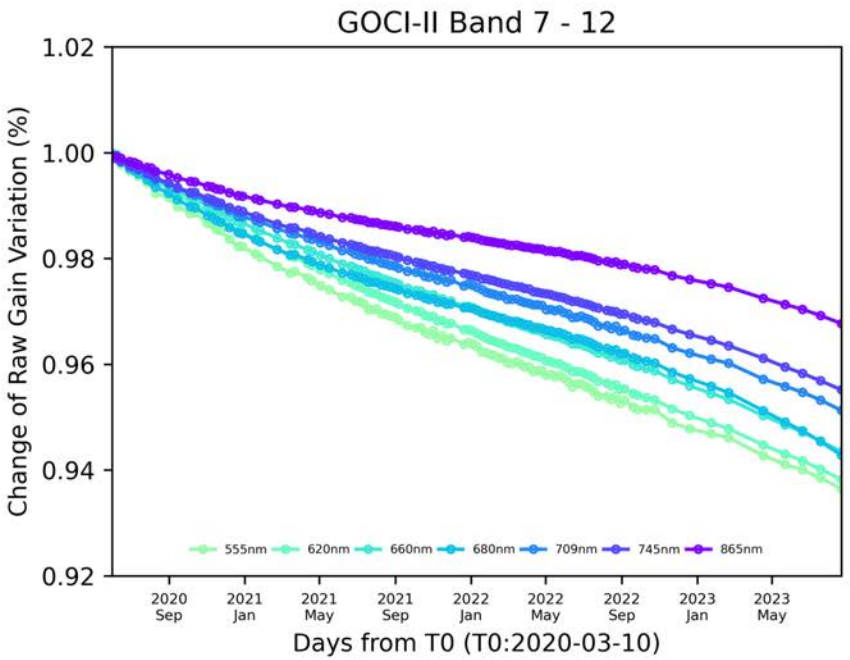
Iteration (3rd step)



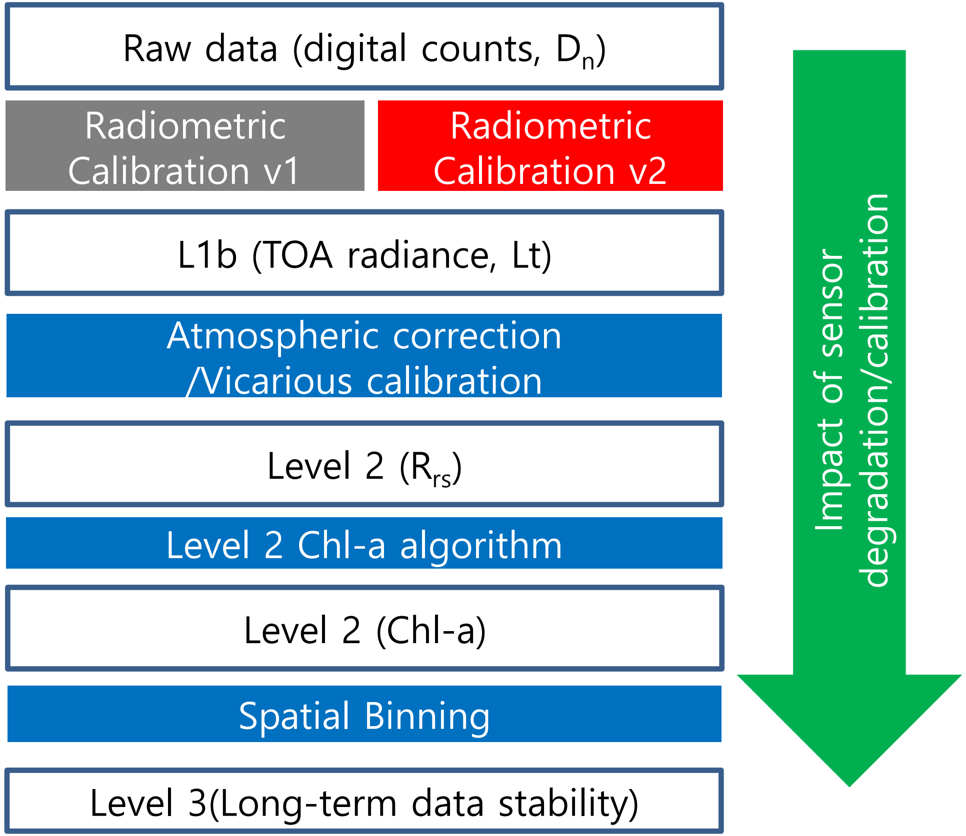


Updating sensor data

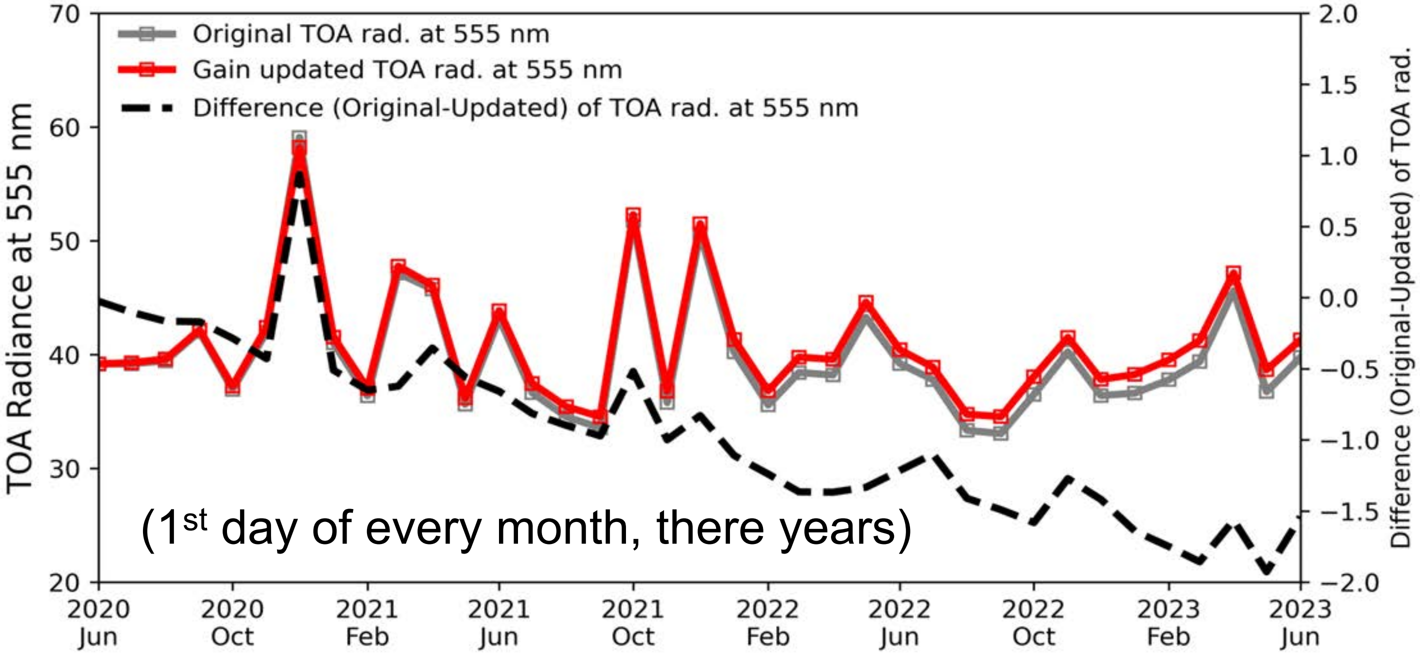




How does sensor calibration improve L3 data?



TOA radiance time series

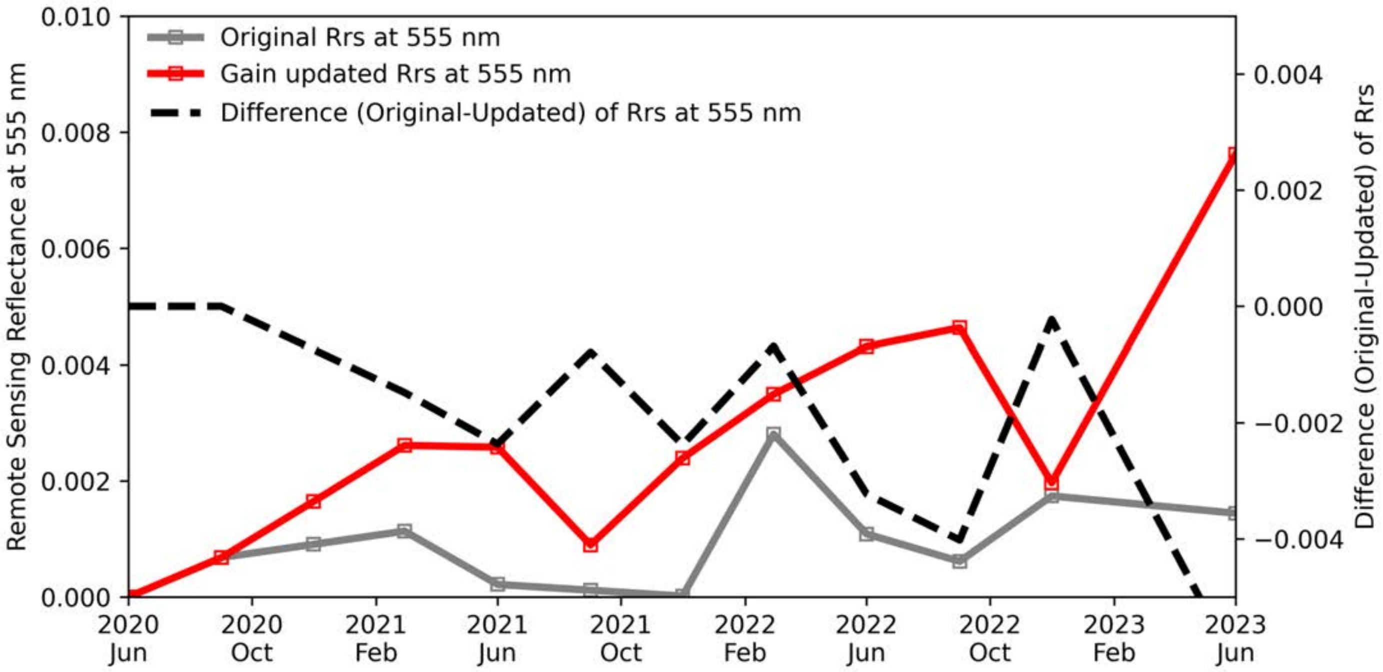


Sensor degradation induced the negative trends of TOA radiances.
The improved calibration will correct such biases in TOA radiances.

R_{rs} 555 nm time series

KOSC

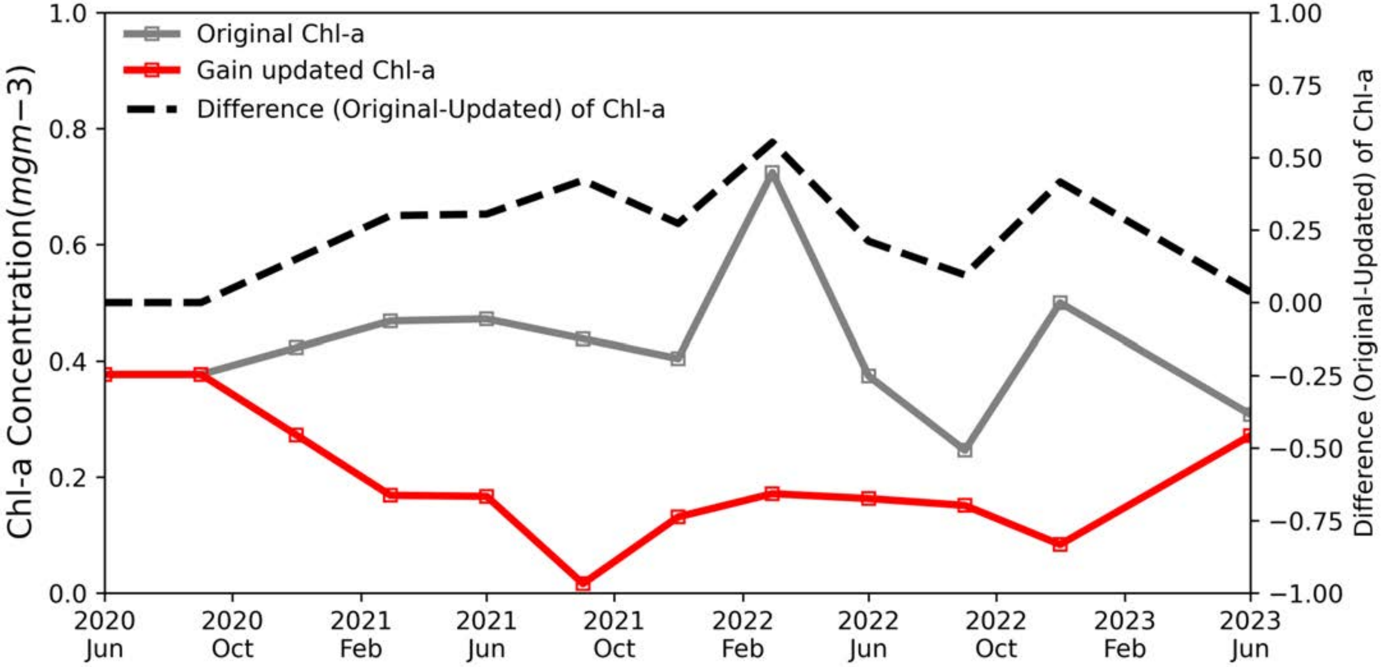
Negative trends TOA radiance biases by sensor degradation may be propagated to cause the negative trends in R_{rs} 555 nm after the atmospheric correction.



(1st day of every three month)

Chl-a time series

No significant trends in Chl-a → we need to investigate daily full-time series.



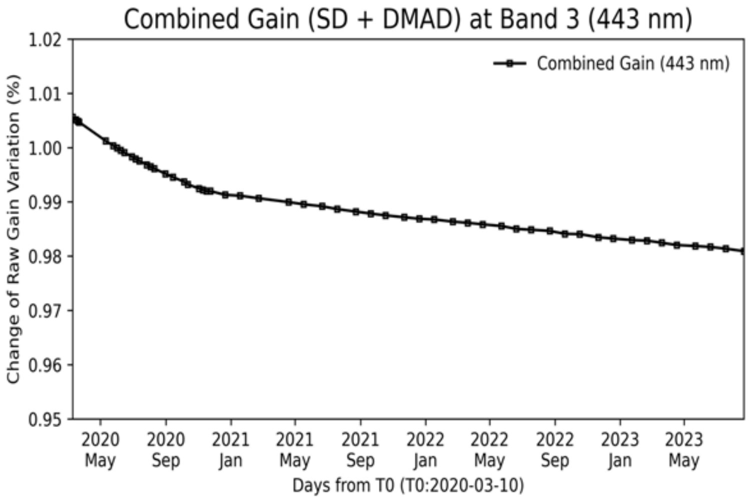
(1st day of every three month)

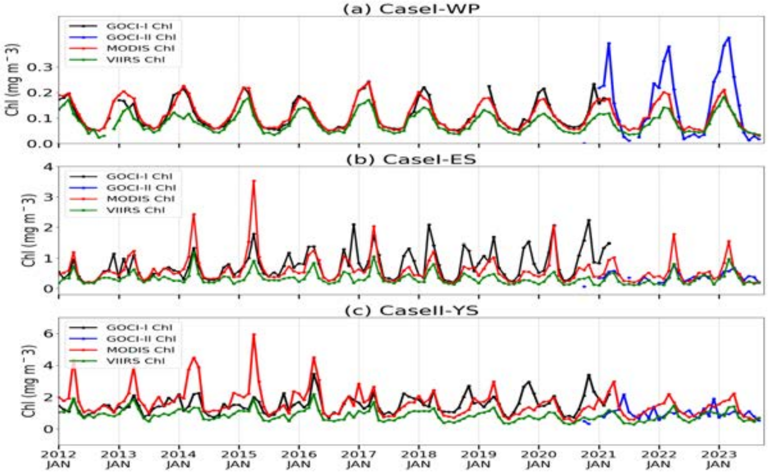
GOCI-II calibration summary

- The original radiometric model and absolute gain parameter of GOCI-II have been validated through on-ground and in-orbit calibration during the pre-launch and IOT period by KARI.
- Using SD Gain monitoring for 3 years, we developed the angle correction model (K2) and the sensor degradation model (K3). We found out that the 5th-order polynomial equations are best to minimize the errors. Adopting the iteration of K2 and K3 procedures contributes to reducing the residual signal of seasonality.
- Planned improvement to GOCI-II calibration for ocean color data reprocessing will eliminate this negative bias in TOA radiances and remote sensing reflectances at 555 nm that will finally affect the bio-geochemical ocean color variables.

Future plan

- To use DAMD for detecting SD's degradation
- To work on the lunar calibration model
- To reprocess GOCI L1b sensor data for continuity of GOCI and GOCI-I





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

Q & A

GOCI-II calibration for long-term data stability

Myung-Sook Park
mspark@kiost.ac.kr