Introduction to GOCI-II Radiometric Calibration

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2022. 02. 04
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Major missions of GOCI-II

- To maintain ocean color mission continuity of COMS in ocean color observations
- To improve monitoring capability of ocean biophysical phenomena and maritime disasters
- To estimate ocean climate change with monitoring global marine ecosystem
- Continuation and expansion of the GOCI mission
  - Local Area Imaging centered at 130°E, 36°N
  - Full Disk Imaging & Lunar Calibration
  - 12 spectral channels and one wideband channel for star imaging
Overview of GOCI-II (2/3)

- **Sensor Unit**
  - Shutter wheel: Shutter & Solar diffuser
  - Pointing Mirror: 2-D scan mechanism
  - Telescope: Three Mirror Anastigmat (TMA)
  - Filter wheel: 14 spectral filters and dark plate
  - Detector: 2-D CMOS array
  - FEE: Front End Electronics
  - PIP: Thermal & mechanical isolation from satellite

- **IEU (Instrument Electronics Unit)**
On-board Calibration Devices for in-orbit solar calibration

- Located in front of the pointing mirror to cover whole optical path
- Two on-board calibration devices
  - SD (Solar diffuser): full aperture
  - DAMD (Diffuser Aging Monitoring Device): partial aperture
Radiometric model for GOCI-II

\[
L(B,i,j) = \frac{G(B,i,j)}{T_{\text{int}}(B)} \times \left[ \bar{Y}(B,i,j) + \alpha(B,i,j)\bar{Y}^2(B,i,j) + \beta(B,i,j)\bar{Y}^4(B,i,j) \right]
\]

\[
\bar{Y}(B,i,j) = Y(B,i,j) - O(i,j)T_{\text{int}}(B) - F(i,j)
\]

Y(B,i,j): output digital count for each pixel for spectral channel B
G(B,i,j): linear radiometric gain of pixel (i, j) for spectral channel B
L(B,i,j): input radiance of pixel (i,j) for spectral band B
T_{\text{int}}(B): integration time for spectral band B
\alpha(B,i,j), \beta(B,i,j): nonlinearities of pixel (i,j) for spectral channel B
O(i,j), F(i,j): offset parameters

Radiometric model has been validated through pre-launch radiometric characterization.
GOCI-II Radiometric Calibration Plan

### On-ground calibration
- Absolute calibration
  - Gain parameter measurement
- Characterization of on-board calibration devices
  - SD (Solar Diffuser),
  - DAMD (Diffuser aging monitoring device)

### In-orbit solar calibration (absolute calibration)
- Gain parameter measurement
  (sun imaging using the SD)
- Aging parameter measurement of SD
  (sun imaging using the DAMD & moon imaging)

### In-orbit stability monitoring
- Relative gain variation monitoring
  - Sun imaging (using DAMD)
  - Moon imaging

- On-ground absolute gain has been used as initial value for early orbit operation.
- In-orbit absolute gain has been calculated through solar calibration by using the diffusion characteristics of on-board calibration devices.
- Monitoring of radiometric gain stability
• Radiometric model validation through on-ground characterization

→ Radiometric model is validated over full dynamic range.
→ Defective pixel list has been identified. (around 200 pixels for all spectral channels)
• Radiometric model shows similar performance (fitting error) for all spectral channels.
• PRNU pattern is different from spectral channel to channel.
• Non-linearity pattern due to PRNU

✓ Nonlinearity is expected to be the same for all spectral channels.
✓ Characterization results show similar level of nonlinearity over for spectral channels.
✓ But, there is a pattern in nonlinearity over matrix due to PRNU. → Channel to channel deviation
✓ This deviation will not degrade the fitting performance. However, nonlinearity has been characterized for each spectral channel.

When linear gain parameter is estimated with known nonlinear parameters (B1), fitting results show similar performance.

![Fitting error matrix](image1.png)

![Histogram](image2.png)
In-Orbit Solar Calibration (1/2)

- Radiometric model validation through In-orbit solar calibration: B1

Radiometric model is validated through in-orbit solar calibration.
- On-ground defective pixel list has been confirmed.
- PRNU pattern deviation from on-ground result has been observed.
- Radiometric model shows similar performance (fitting error) for all spectral channels.
- Nonlinear parameters have been estimated for each spectral channel.
Imaging Parameter Adjustment for Daily Radiance Variation

- Daily radiance variation (sample analysis using measurements acquired on 2020/03/19)

  - The daily radiance variation (mainly solar incident angle variation) is checked even though there are some error due to scene change.
  - Daily maximum ocean radiance (at around noon in KTC) shows smaller value than the specification except B2/B3/B4.
  - Cloud radiance measurements (max. measured at around noon in KTC) shows bigger value than the specification except B1.
  - Three sets of video parameters for a day are applied to keep SNR performance. (monthly)

Spot for ocean radiance monitoring: 200pixels x 200pixels, 8th slot
Discussions & Future Work

• GOCI-II radiometric model has been validated through on-ground and in-orbit solar calibration.

• Radiometric gain parameters for GOCI-II in-orbit operation have been determined based on;
  – On-ground calibration results
  – In-orbit solar calibration results
  – Comparison with GOCI-I radiance data

• Radiometric gain monitoring shows some degradation depending on spectral channels. The radiometric gain parameters will be updated to reflect these variation.

• Regarding spectral channel B1, the Earth calibration will be performed to acquire the PRNU corresponding to radiance from the Earth.