GLI early calibration results for oceanographic applications

GLI Calibration Team
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(A) Chlorophyll-a concentration by GLI, April 2003
1.1 Specification of NASDA Global Imager

- Cross track scan radiometer with 1600-km swath
- 36 bands from UV to Thermal IR
  - 380-865nm (VNIR 23 bands)
  - 1050-2210nm (SWIR 6 bands)
  - 3700-12000nm (MTIR 7 bands)
- Resolution (at Nadir): 1 km, 250 m (ch20-23, 28, 29)
- 12-bit digital resolution
- ADEOS-II orbit: Sun synchronous
  - Recurrent period: 4 days
  - Inclination: 98.6°
  - Descending local time: 10:30am
  - Altitude: 803 km, period: 101 min
- Along track tilt operation (±18.5°)
1.2 Example of observation coverage

Targets: Ocean, Atmosphere, Land, and Cryosphere
2. Characteristics of GLI bands  

(From GLI Mission Data Evaluation Test)

<table>
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<td>VNIR (1 km) (#p: piecewise linear band)</td>
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<tr>
<td>1</td>
<td>380.7</td>
<td>683</td>
<td>467 (59)</td>
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<td>233 (369)</td>
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<td>3</td>
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<td>8 (13)</td>
<td>1309 (5)</td>
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<td>661.3</td>
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<tr>
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<td>124 /769</td>
<td>880 (54)</td>
<td>19</td>
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<td>412 (8)</td>
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<td>235 (12)</td>
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<td>16 (24)</td>
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Many ocean bands

Saturation

Post launch SNR and NEΔT are almost consistent with the pre-launch ones.
3. Stripe-pattern noise

From OCTS and MODIS experiences, stripe patterns will remain in L1B. We have prepared following procedure to reduce the stripe-pattern noises.

The de-striping coefficients \( a_{k,l,j} \) are applied to radiometric corrected (by standard Level-1 processing) but not geometric corrected radiance, \( L_{k,l,j} \):

\[
L_{k,l,j}^{\text{corrected}} = a_{k,l,j} L_{k,l,j},
\]

(1)

\( k: \) pixels, \( l: \) lines, \( j: \) bands.

We assume \( a_{k,l,j} \) are related with input radiance \( L_{k,l,j} \) and scan-mirror incident angle \( \phi_{k,l} \), i.e,

\[
a_{k,l,j} = b_0 i,j + b_1 i,j \cdot L_{k,l,j} + b_2 i,j \cdot L_{k,l,j}^2 + b_3 i,j \cdot \phi_{k,l} + b_4 i,j \cdot \phi_{k,l}^2,
\]

(2)

\( i: \) detectors (1-12 or 48 \( \times \) scan-mirror sides), \( i=\text{mod}(l-1, 24 \text{ or } 96) + 1 \).

The \( b_{0-5,i,j} \) are estimated by followings.

1. Sampling relatively uniform areas \( n \) (size: normally 200\( \times \)200, number: \( N \)), \( L_{k,l,j,n} \).
2. Derive \( a_{i,j,n} \) minimizing \( E_n \) in (3) for each sub-image \( n \) (setting \( a_{6,j,n}=1.0 \)).

\[
E_n = \sum_{l=0}^{L-1} \left( \sum_{k=0}^{K-1} \left( a_{i,j,n} L_{k,l,j,n} - a_{i+1,j,n} L_{k,l+1,j,n} \right)^2 \right)
\]

(3)

3. Examine statistical significance of terms, \( b_{0-5,i,j} \) in polynomial expression (2) assuming

\( a_{k,l,j} \equiv a_{i,j,n}, L_{k,l,j} \equiv L_{i,j,n}^{\text{ave}}, \) and \( \phi_{k,l} \equiv \phi_{i,j,n}^{\text{ave}} \).

4. Derive \( b_{0-5,i,j} \) by fitting \( a_{i,j,n}, L_{i,j,n}^{\text{ave}} \) and \( \phi_{i,j,n}^{\text{ave}} \) to (2) excluding insignificant terms.
3. Stripe pattern noise

Examples of CH18 (865nm)
- Detector noise
- Mirror-side noise

need more investigations
3. Stripe pattern noise

Examples of stripe noise on CHLA images

Narrow-line noise ↓

Using original L1B

Original without along track registration (ATR)

Statistical de-striping with ATR

Statistical de-striping without ATR

Version 1.0

Along Track Registration ↓
Different mirror-side is used for different channels ↓
Enforces the line noise in CHLA image
On the MTIR images, detector and mirror noises can be corrected sufficiently by the statistical de-striping, but oblique lines remains. This is an electrical noise that might be caused by a combination of electric circulation noise and sample timing of 12 detectors.

3. Stripe pattern noise

Examples of stripe noise
Thermal infrared image (CH35, 11µm)
3. Stripe-pattern noise

**Summary of the stripe-pattern noises**

(1) Detector sensitivity normalization error
This is caused by calibration coefficients derived in the evaluation test on the ground, and relatively smaller than others, (2) and (3).

(2) Mirror reflectance normalization error
This looks striking in some areas. This is caused that the A/B-side difference in the pre-launch table did not represent the mirror-side difference on the real Earth view images. We are investigating the table values further, using Earth view and on-board calibrators.

(3) Electric system noise only on MTIR images
This appears as oblique lines at 1 to 2-pixel intervals and only on MTIR images. It also appeared in pre-launch evaluation tests, and we assumed that the reason might be a combination of electric circulation noise and sample timing of 12 detectors.

**Correction tables of stripe-pattern noises (1)-(2) will be tuned by statistics of uniform-area samples up to the next version 1.0.**
2. GLI post launch performance

In the early phase, we cannot obtain enough ground observations. As a provisional adjustment, we derived vicarious coefficients using global GLI, SeaWiFS, and GLI atmospheric correction look-up tables.

Fix two NIR bands for aerosol optical thickness ($\tau_a$) and model selection

Aerosol model selection by GLI atmos corr. Look Up Table ($\tau_a \rightarrow L_{TOA}$)

SeaWiFS 8-day binned nLw interpolated to GLI bands through an in-water model (Tanaka et al.)

Pressure and water vapor by JMA objective analysis

Column ozone by TOMS

Derive correction coefficients by comparison between GLI L1B and simulated $L_{TOA}$. 

4. Vicarious calibration coefficients by SeaWiFS nLw and radiative transfer simulation
Derived coefficients

4. Vicarious calibration by SeaWiFS and simulation
Derived coefficients

GLI vicarious calibration coefficients derived by JMA-ANAL and SeaWiFS data

wavelength distribution

Scan mirror incident-angle dependency

Temporal change

4. Vicarious calibration by SeaWiFS and simulation
Not apply the coefficients

→ We can adjust early-phase sensor data to well-calibrated sensor data.
Apply the coefficients

→ We can adjust early-phase sensor data to well-calibrated sensor data.

4. Vicarious calibration by SeaWiFS and simulation

Product evaluation
5. Plan for Level 1 Ver.1.0

5.1 Revision Items for Ver.1.0

<table>
<thead>
<tr>
<th>Item</th>
<th>Status</th>
<th>Revisions before Version 1.0</th>
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<tbody>
<tr>
<td>Code bugs</td>
<td>Some format errors: dimension size, VG name, parameter setting</td>
<td>Revised whenever they are found</td>
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<tr>
<td>Non-linearity tables</td>
<td>Pre launch values (CH10-19)</td>
<td>CH14, 16 and 18 tables by neighbor bands</td>
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<tr>
<td>Offset noise for nighttime MTIR</td>
<td>Using pre-launch test value</td>
<td>Using on orbit black-body calibration value</td>
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<tr>
<td>A/B mirror side difference</td>
<td>Using pre-launch test value</td>
<td>All 1.0 (from SCA and EV evaluations)</td>
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<tr>
<td>Stripe noise correction table</td>
<td>All 1.0</td>
<td>Set using Earth-observation images</td>
</tr>
<tr>
<td>Sensor alignment table</td>
<td>Using pre-launch test value</td>
<td>Set by GCP matching results</td>
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<tr>
<td>Vicarious calibration coefficients in L1B (gcal_coef)</td>
<td>All 1.0</td>
<td>Coding as a time-dependent function</td>
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<tr>
<td>Vicarious calibration in Level-2 pre-process</td>
<td>Comparison with simulation by SeaWiFS and OTSK1a LUT</td>
<td>Continue the comparison and evaluation with other satellite and MOBY data</td>
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</table>

- **Mirror-side difference** by solar diffuser and Earth view data
- **Sensor degradation** by solar diffuser, lamp, vicarious, (and lunar?) CALs
- **Non-linearity response**
- **Geometric accuracy** (satellite position and sensor alignment errors by GCP)

**Evaluations of on-board calibration and match up data are ongoing for Version 1.0 data release, December 2003.**
5. Plan for Level 1 Ver.1.0

Level-1 algorithm and calibration-table revisions are planned considering Level-2 algorithm and product developments.

5.2 Time table

Today

- ADEOS-II launch
- ADEOS-II evaluation for the next phase
- Evaluation for data release
- Operational phase
- Data release

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<th>Year/month</th>
<th>Dec-02</th>
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<th>Feb-03</th>
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<th>Aug-03</th>
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<td>months from launch</td>
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<td>L+11</td>
<td>L+12</td>
<td>L+13</td>
<td>L+14</td>
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**Milestone**

- Initial checkout phase
- ADEOS-II evaluation for the next phase
- Cal/Val phase
- Study for the next version 2.0

**Level 1 software & products**

- Δrevision (ToolkitV3.1)
- Δver1.0 α (ToolkitV2.2.1)
- Δver1.0 fix specifications
- Δdeadlines to reflect calibration results to L1 algorithm (alg.doc v6.0)

**L1B data version**

- Pre-launch version
- ver.1.0 α
- Δdeadlines of parameter table

**L2/L3 development**

- Development using ver.1.0 α in EORC
- Integration based on new specification
- ΔL2/L3 ver.1.0 α
- Δdeadlines of parameter table

**L2/L3 integration & operation**

- Reinforce L2/L3 operation system
- Δsystem check
- L2/L3 V1.0 α integration
- Additional integration and operational test
- Δdeadlines of parameter table

**Field observations**

- Atmosphere: AERONET
- Ocean: GTS, JFA
- Cryosphere: Nagasaki-Goto Islands, Tokyo Bay, Okhotsk, Sagami Bay, etc.
- Alaska

**Validation results**

- Anami Island
- CHOFI
- Activities around Japan
- Railroad Valley
- Alaska