1. Ocean products
2. Validation methods
3. Validation results
4. Summary and future plan

2003, December
H. Murakami,
K. Sasaoka,
K. Hosoda, and
Ocean PIs
1. Ocean products

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Overview of GLI ocean products (1)

Ocean atmospheric correction algorithm

Developer: Hajime Fukushima (Tokai Univ.)
R. Frouin (Scripps institution of oceanography)

Algorithm: Atmospheric correction (Fukushima)
and Photosynthetically available radiation (Frouin)

Algorithm code: OTSK1a (Fukushima), OTSK14 (Frouin)

Product code: NL (Level-2)
NW/LA (L2Map, L3Bin, L3STAMap)

3 type FR(1km)/LR(4km)/FR_NRT(near real time) for each

Parameters:

- normalized water-leaving radiance (nLw, 13 chs)
- aerosol radiance (4chs)
- aerosol optical thickness (Tau), angstrom exp.
- ocean color quality flag (Bit1-26: quality and cloud info.)
- photosynthetically available radiation (PAR) (Ein/m²/day)
Overview of GLI ocean products (2)

In-water algorithms

Developer: B.G. Mitchell (Scripps Institution of Oceanography)
Motoaki Kishino (Tokyo University of Marine Science and Technology)

Algorithm: In-water algorithms
Algorithm code: OTSK2,5,7 (Mitchell), OTSK6 (Kishino)
Product code: CS (Level-2)
CHLA, CDOM, K490, SS (L2Map, L3Bin, L3STAMap)
3 type FR(1km)/LR(4km)/FR_NRT(near real time) for each

Parameters:
- chlorophyll-a concentration (CHLA),
- colored dissolved organic matter absorption at 440nm (CDOM),
- attenuation coefficient at 490nm (K490),
- redtide flag,
- suspended solid concentration (SS),
- in-water quality flag (Bit27-32: Case-2 etc.)
Overview of GLI ocean products (3)

Sea surface temperature algorithm

Developer: Hiroshi Kawamura (Tohoku Univ.)
Algorithm: sea surface temperature
Algorithm code: OTSK13
Product code: ST (Level-2, 2Map, 3Bin)
  ST_daynight, ST_all (L3STAMap)
  3 type FR(1km)/LR(4km)/FR_NRT(near real time) for each
Parameters:
  Bulk sea surface temperature (SST) (K),
  SST quality flag (16bit: cloud information etc.)
  (cloud detection was improved by EORC and PI)
GLI ocean operation flow (1/2) (1-km Resolution)

1600×1600 km scene

Near real time operation at direct receiving station
GLI ocean operation flow (2/2)
(4 or 9-km Resolution)
Examples of ocean products (1/3)

*nLw380nm-nLw680* (26 May 2003, California)
Examples (2/3)

CHLA, SS, CDOM, K490, Tau, SST...

Research product:
Fluorescence line height
GLI neural network algorithm looks to present CHLA and SS characteristics well.
2. Validation methods

2003, December
H. Murakami,
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## 2.1 Validation methods for each product

<table>
<thead>
<tr>
<th>Products</th>
<th>Target accuracy (after 3 years)</th>
<th>Validation methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>normalized water-leaving radiance nLw (13 chs) [mW cm⁻² str⁻¹ μm⁻¹]</td>
<td>-35--+50% (offshore) -50--+100% (coastal)</td>
<td>● optical observations by radiometer above/under the sea surface</td>
</tr>
<tr>
<td>aerosol radiance (4 chs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>aerosol optical thickness at 865nm [ ]</td>
<td>Validated through nLw</td>
<td>● optical observations (same as above)</td>
</tr>
<tr>
<td>aerosol angstrom exp.749/865nm [ ]</td>
<td></td>
<td>● indirectly validated through nLw</td>
</tr>
<tr>
<td>photosynthetically available radiation [Ein m⁻² day]</td>
<td>-10--+10% (10km/ monthly)</td>
<td>● comparison with SeaWiFS or GMS products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● solar irradiance measurements at islands</td>
</tr>
<tr>
<td>chlorophyll-a concentration [mg m⁻³]</td>
<td>-35--+50% (offshore) -50--+100% (coastal)</td>
<td>● water sampling and measurement on ship</td>
</tr>
<tr>
<td>colored dissolved organic matter absorption at 440nm [m⁻¹]</td>
<td>-50--+100%</td>
<td>● indirectly validated through nLw; relations between in-water parameter and nLw have been investigated by ship measurements</td>
</tr>
<tr>
<td>attenuation coefficient at 490nm [m⁻¹]</td>
<td>-35--+50%</td>
<td>● comparison to SeaWiFS or MODIS products</td>
</tr>
<tr>
<td>suspended solid concentration [g m⁻³]</td>
<td>-50--+100%</td>
<td></td>
</tr>
<tr>
<td>bulk sea surface temperature [K]</td>
<td>0.6K</td>
<td>● comparison with ground SST measurements by mooring or drifting buoys distributed by GTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● comparison with other products e.g., Reynolds</td>
</tr>
</tbody>
</table>
## 2.2 observation instruments

<table>
<thead>
<tr>
<th>instruments</th>
<th>targets</th>
<th>wavelength nm</th>
<th>nLw</th>
</tr>
</thead>
</table>
| PRR600/610 under & above  | ● downward irradiance \((Ed^+\)) \  
● upward radiance \((Lu^-)\) \  
● sky irradiance \((Es^-)\) | 412, 443, 490, 520, 565, 670 and PAR | Calculate water leaving radiance \((Lw)\) by upward radiance profile \((Lu)\). nLw is normalized by \((Lw, Ed, F0)\). |
| MER2040/2041 under & above|                                                   | 412, 443, 465, 490, 510, 520, 555, 565, 625, 665, 670, 683 and PAR |                                          |
| Free Fall under & above   |                                                   | 380, 400, 412, 443, 455, 490, 520, 555, 565, 620, 665, 683, 705 and PAR | nLw is normalized by \((Lw, Ed, F0)\).                                          |
| TRIOS above only          | ● downward irradiance \((Ed^+\)) \  
● upward radiance \((Lu^-)\) \  
● downward radiance \((Ls^-)\) | 350-950nm 1nm intervals | normalize \((Lu)\) by \((Ed, F0)\) and sea surface reflection factor. 13 |
2.3 available match up data

<table>
<thead>
<tr>
<th>Cruise</th>
<th>Organization</th>
<th>MUD</th>
<th>avail</th>
<th>nLw</th>
<th>CHL</th>
<th>other</th>
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<td>CALCOFI</td>
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<td>MOBY</td>
<td>NOAA/MODIS</td>
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<td>YK0305</td>
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<tr>
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<td>ishysmpl</td>
<td></td>
<td>4</td>
<td>0</td>
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</tr>
</tbody>
</table>

Routine observations:
GTS (JMA), AERONET, SKYNET, MOBY (MODIS, NOAA)

Special observations:
2003.04.03-04.27
California Cooperative Oceanic Fisheries Investigations (CalCOFI)
Mitchell (SIO), Frouin (SIO), Hokkaido Univ.

2003.04-..
Ocean color obs. around Japan
Nagasaki Univ., Tokyo Ocean Univ., Nagoya Univ, Tokai Univ., NFRI, Hokkaido Univ, JAMSTEC etc.

Relatively many ground observations are provided from PI team and corroborative organizations in the early phase basing relationship until OCTS mission. The data is still increasing, and we continue the data collection and match-up processing now.
Global distribution can be evaluated by the following datasets.

- **SeaWiFS global dataset** (nLw, CHLA, Tau, PAR)
- **Reynolds global SST data**
- **Tohoku Univ. GMS solar irradiance dataset** (PAR is converted from SW)
3. Validation results

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3.1 vicarious calibration study

(1) candidates for the ocean color processing

We had many data source for the vicarious coefficients. Most of the results show the similar tendencies.

GLI $L_{TOA}$ is compared with simulated $L_{TOA}$ which is calculated using SeaWiFS nLw, pressure, ozone, water vapor, GLI geometry and GLI atmospheric correction look-up tables.
3.1 vical study (2) match-up processing tests

- Best choice is SeaWiFS Apr-Jun nLw base
- Possibly temporal change considering SeaWiFS Feb-Mar base coefs.
- MOBY coefs make lower nLw
- Cannot use Barrow and Railroad ones

Five Candidates of vical coefs:
- SeaWiFS Apr-Jun/Feb-Mar,
- Barrow Apr, MOBY 2Fix/Aeronet, Railroad

Test data: MOBY and Nagasaki ferry, CalCOFI200304 data

CalCOFI obs. are only at CH 4, 6, 9

![Graphs showing number, bias, RMSE, and ratio for different data sets.](image)
3.2 validation by ground observation match-ups

GLI products (nLw) derived using the selected vical coefs show high correlation with ground observations.

Figure: nLw380-545 x-axis: ground obs, y-axis: GLI products
3.2 validation by match-ups (in-water products)
3.2 validation by match-ups (SST)

Available data number: 4225

Bias: $-0.09$K (D: $-0.06$, N: $-0.17$)

RMSE: $0.67$K (D: 0.67, N: 0.69)

22days sample: 2003/ 3/19, 3/20, 4/8, 5/28, 6/4, 6/5, 6/10, 6/19, 6/20, 6/30 7/2, 7/5, 7/10, 7/15, 7/19, 7/20, 7/25, 7/30, 8/4, 8/10, 8/19, 9/19
3.3 comparison with other dataset (CHLA)

GLI monthly 200304

CHLA distribution agrees with SeaWiFS one

SeaWiFS monthly 200304
3.3 comparison with other dataset (PAR)

GLI v.s. SeaWiFS PAR

PAR distribution and data range agree well.
3.3 comparison with other dataset (PAR)

PAR distribution and data range agree well.
**3.3 comparison with other dataset (SST)**

- **AVHRR + buoys (one-degree grid)**

**GLI-SST Level-3 STA Map**

- Reynolds-SST

**4096x2048 (0.088-degree grid)**

- **2003/04/03-22 mean SST**

- Distribution and data range agree well.

- GLI describe fine structure of the ocean current.
4. Summary and future validation plan

2003, December
H. Murakami,
K. Sasaoka,
K. Hosoda, and
Ocean PIs
4.1 summary of GLI validation

→ all ocean products can be open today

<table>
<thead>
<tr>
<th>Param code</th>
<th>Param name</th>
<th>Final target</th>
<th>Today's accuracy</th>
<th>Notes</th>
<th>Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWLR</td>
<td>normalized water leaving radiance</td>
<td>−35−+50% (offshore)</td>
<td>16−47%</td>
<td>● Select vical coef. of SeaWiFS Apr-Jul base.</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−50−+100% (coastal area)</td>
<td>84−284%</td>
<td>● Bad results longer the 565nm are due to low (&lt;1/20) nLw over the ocean. ● looks better than the early OCTS ● problem under absorptive aerosol</td>
<td></td>
</tr>
<tr>
<td>PAR</td>
<td>photosynthetically available radiation</td>
<td>−10−+10% (10km/monthly)</td>
<td>11%</td>
<td>● agree well with SeaWiFS one</td>
<td>OK</td>
</tr>
<tr>
<td>CHLA</td>
<td>chlorophyll-a concentration</td>
<td>−35−+50% (offshore)</td>
<td>130%</td>
<td>● large scatter is caused by coastal points</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−50−+100% (coastal area)</td>
<td></td>
<td>● comparable quality to OCTS</td>
<td></td>
</tr>
<tr>
<td>CDOM</td>
<td>colored dissolved organic matter absorption at 440nm</td>
<td>−50−+100%</td>
<td>(82%)</td>
<td>● insufficient data number (now increasing)</td>
<td>OK</td>
</tr>
<tr>
<td>SS</td>
<td>suspended sediment concentration</td>
<td>−50−+100%</td>
<td>(34%)</td>
<td>● insufficient data number</td>
<td>OK</td>
</tr>
<tr>
<td>K490</td>
<td>attenuation at 490nm</td>
<td>−35−+50%</td>
<td>(78%)</td>
<td>● insufficient data number</td>
<td>OK</td>
</tr>
<tr>
<td>SST</td>
<td>bulk sea surface temperature</td>
<td>0.6K</td>
<td>0.67K</td>
<td>● cloud detection problem</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>● Electric noise on MTIR image</td>
<td></td>
</tr>
</tbody>
</table>
## 4.2 Future validation plan

<table>
<thead>
<tr>
<th>date</th>
<th>items</th>
</tr>
</thead>
</table>
| until GLI work shop (2003/03)       | ● Continue match-up process and analysis (all products)  
                                               ● Evaluation quality of each ground observation data (nLw and CHLA)  
                                               ● Compare with ground SW observations not only other satellite data (PAR)                                                                 |
| until Version 2 (2004/06)           | ● Reanalyze using reprocessed (geo/radiometric) L1B (all products)  
                                               ● Consider vical coefficients and their temporal change (Atmos.Corr.)  
                                               ● Improve absorptive aerosol frequently appeared over Japan (Atmos.Corr.)  
                                               ● Further study of in-water optical model in the coastal area (absorption, scattering, sea-surface reflection coefficients)  
                                               ● Improve cloud detection (SST)  
                                               ● Improve EORC MODIS processing applying the latest GLI code (all)  
                                               ● Improve sunglint correction using AMSR wind speed (Atmos.Corr.)  
                                               ● Switching saturation alternative bands, and try to use 710nm (Atmos.Corr.)  
                                               ● Consider diurnal cycle of cloud amount (PAR)  
                                               ● Evaluate SS and CDOM algorithm in global coastal area (in-water)  
                                               ● Improve water vapor correction for SST                                                                 |
| after 2004/06 for the mission goal  | ● Improve absorptive aerosol (Atmos.Corr.)  
                                               ● Investigate Atmos.Corr. and CHLA estimation using 250m data (Atmos.Corr. CHLA)  
                                               ● Further study of in-water optical model parameters in the coastal area  
                                               ● Coding Level-3 processing of PAR (PAR/research product)  
                                               ● Evaluate primary production algorithms (research product)  
                                               ● Study of fluorescence algorithm and its application (research product)                                                                 |