OBPG Status

Bryan Franz

and the
Ocean Biology Processing Group

OCRT Meeting
May 2014
Content

• Expanding mission support

• Reprocessing history and current product quality

• Sensor calibration issues (VIIRS & SeaWiFS)

• Changes for next reprocessing (R2014.0, starting now)
More than 8000 HICO scenes currently archived and available that were acquired since 15 October 2009. New files received generally within 3 days of acquisition.
HICO Support by OBPG

- Request and scheduling of data collection handled by OSU/NRL/ISS.
- Raw data acquired by NRL-DC via MSFC and transferred to OBPG within days of acquisition.
- HICO L1B products produced using standard software and calibrations supplied by NRL-DC.
- SeaDAS has been enhanced with HICO processing and display capabilities.
- Initial NASA Level-2 processing capability treats HICO as a 15-band MERIS-like instrument.
- Full hyperspectral processing capability is to be developed.
- Vicarious calibration to be developed.

- All past and future data collected by HICO is now openly available to anyone for research purposes, regardless of who requested it.
Korean Geostationary Ocean Color Imager (GOCI)
NASA Level-2 and Level-3 Processing Support

Daily Mean Chlorophyll

Chlorophyll a concentration (mg/m³)
Geostationary Ocean Color Imager (GOCI) Mirror Site Development
Landsat-8 Ocean Land Imager (OLI)

- Launch February 2013
- Operational April 2013
Ocean and Land Color Instrument (OLCI)

- ESA MERIS follow-on to fly on Sentinel-3, launch date June 2015
- Some additional bands relative to MERIS (e.g.: 400nm, 673.5nm)
- Westward roll to avoid sun glint
- Global 300-meter downlink
OLCI Support by OBPG

• OBPG staff (Gerhard Meister, Bryan Franz, Jeremy Werdell, Sean Bailey) participating in S3 validation team

• Agency-level data sharing effort, NASA/NOAA - ESA/EUMETSAT, to enable redistribution of Sentinel-1,-2,-3 data

• Tentative plan for OBPG to acquire full L0 (or L1B) and distribute L1B and NASA-derived L2 and L3 products (300-m or 1.2-km)
Reprocessing history and current data quality
Ocean Color Reprocessing History

2010-2011

**R2010.0:** multi-mission reprocessing using common algorithms.

MODISA, MODIST, SeaWiFS, OCTS, CZCS

2012 May

**R2012.0:** MODISA full-mission reprocessing to incorporate final MCST C6 calibration and OBPG RVS refinements. + MERIS

2013 February

**R2013.0:** MODISA partial-mission reprocessing (period 2011-2013) to incorporate refined MCST C6 calibration. + MODIST

2013 September & November

**R2013.1, R2013.1.1:** MODISA minor calib. updates (period 2013)
Clear-Water Rrs(547) Anomaly Trend

Anomaly in MODISA(AR2013.1M) Rrs(547)

± 2%, 2e-5 sr⁻¹

## MODISA (R2013.1) Rrs vs Field Measurements

<table>
<thead>
<tr>
<th>Product Name</th>
<th>MODIS Aqua Range</th>
<th>In situ Range</th>
<th>#</th>
<th>Best Fit Slope</th>
<th>Best Fit Intercept</th>
<th>$r^2$</th>
<th>Median Ratio</th>
<th>Abs % Difference</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rrs412</td>
<td>-0.00411, 0.01820</td>
<td>0.00000, 0.01964</td>
<td>1945</td>
<td>1.03539</td>
<td>-0.00065</td>
<td>0.90481</td>
<td>0.90307</td>
<td>22.21457</td>
<td>0.00147</td>
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<tr>
<td>Rrs443</td>
<td>-0.00065, 0.01950</td>
<td>0.00005, 0.01783</td>
<td>1774</td>
<td>1.04628</td>
<td>-0.00026</td>
<td>0.88967</td>
<td>1.00894</td>
<td>12.06771</td>
<td>0.00109</td>
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<tr>
<td>Rrs488</td>
<td>0.00033, 0.02513</td>
<td>0.00039, 0.02289</td>
<td>2127</td>
<td>0.94853</td>
<td>-0.00021</td>
<td>0.89894</td>
<td>0.91509</td>
<td>12.00520</td>
<td>0.00106</td>
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<tr>
<td>Rrs531</td>
<td>0.00092, 0.01682</td>
<td>0.00130, 0.02110</td>
<td>639</td>
<td>0.87525</td>
<td>0.000017</td>
<td>0.91346</td>
<td>0.97562</td>
<td>11.98040</td>
<td>0.00096</td>
</tr>
<tr>
<td>Rrs547</td>
<td>0.00088, 0.01590</td>
<td>0.00091, 0.01984</td>
<td>469</td>
<td>0.91611</td>
<td>0.00018</td>
<td>0.92442</td>
<td>1.04480</td>
<td>13.38668</td>
<td>0.00072</td>
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<tr>
<td>Rrs667</td>
<td>-0.00016, 0.01186</td>
<td>0.00002, 0.01100</td>
<td>709</td>
<td>0.98687</td>
<td>-0.00002</td>
<td>0.91982</td>
<td>0.94565</td>
<td>37.48856</td>
<td>0.00017</td>
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<tr>
<td>Rrs678</td>
<td>-0.00015, 0.00283</td>
<td>0.00004, 0.00295</td>
<td>373</td>
<td>0.94854</td>
<td>-0.00000</td>
<td>0.89380</td>
<td>1.00161</td>
<td>32.16394</td>
<td>0.00008</td>
</tr>
</tbody>
</table>

### Frequency Distribution

![Frequency Distribution](http://seabass.gsfc.nasa.gov/)
MODISA (R2013.1) Rrs vs Field Measurements

Mean APD 12-13%, Mean Bias < 10%, $R^2 > 0.9$
MODIST (R2013.0) Rrs vs Field Measurements

Rrs(443)  
Rrs(488)  
Rrs(547)

Mean APD 13-20%, Mean Bias < 10%, $R^2$ 0.8-0.9
MODIST (R2013.0) vs MODISA (R2013.1)

Rrs(443)  Rrs(488)  Rrs(547)

MODIS to MODIS scatter 1/2 the MODIS to in situ scatter!
SeaWiFS (R2010.0) Rrs vs Field Measurements

<table>
<thead>
<tr>
<th>Product Name</th>
<th>SeaWiFS Range</th>
<th>In situ Range</th>
<th>#</th>
<th>Best Fit Slope</th>
<th>Best Fit Intercept</th>
<th>R²</th>
<th>Median Ratio</th>
<th>Abs % Difference</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rrs412</td>
<td>-0.00425, 0.01773</td>
<td>0.00000, 0.02150</td>
<td>2323</td>
<td>1.03928</td>
<td>-0.00021</td>
<td>0.88622</td>
<td>1.00507</td>
<td>15.66889</td>
<td>0.00160</td>
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<tr>
<td>Rrs443</td>
<td>-0.00070, 0.02021</td>
<td>0.00022, 0.02227</td>
<td>2380</td>
<td>1.06826</td>
<td>-0.00019</td>
<td>0.84026</td>
<td>1.02870</td>
<td>12.62121</td>
<td>0.00132</td>
</tr>
<tr>
<td>Rrs490</td>
<td>0.00042, 0.02644</td>
<td>0.00074, 0.03020</td>
<td>2575</td>
<td>0.99072</td>
<td>-0.00024</td>
<td>0.82200</td>
<td>0.94335</td>
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<tr>
<td>Rrs510</td>
<td>0.00097, 0.02753</td>
<td>0.00065, 0.03023</td>
<td>1449</td>
<td>0.95042</td>
<td>0.00011</td>
<td>0.83939</td>
<td>0.98680</td>
<td>10.65210</td>
<td>0.00080</td>
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<tr>
<td>Rrs555</td>
<td>0.00088, 0.02600</td>
<td>0.00029, 0.03052</td>
<td>2261</td>
<td>0.94860</td>
<td>0.00002</td>
<td>0.88035</td>
<td>0.97217</td>
<td>13.33206</td>
<td>0.00115</td>
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<tr>
<td>Rrs670</td>
<td>-0.00037, 0.01223</td>
<td>0.00002, 0.01161</td>
<td>1203</td>
<td>0.88307</td>
<td>0.00002</td>
<td>0.86020</td>
<td>1.05347</td>
<td>41.03380</td>
<td>0.00039</td>
</tr>
</tbody>
</table>

**Frequency Distribution**

http://seabass.gsfc.nasa.gov/
SeaWiFS (R2010.0) Rrs vs Field Measurements

Mean APD < 13%, Mean Bias < 5%, $R^2$ 0.8-0.9
### MERIS (R2012.0) Rrs vs Field Measurements

<table>
<thead>
<tr>
<th>Product Name</th>
<th>MERIS Range</th>
<th>In situ Range</th>
<th>#</th>
<th>Best Fit Slope</th>
<th>Best Fit Intercept</th>
<th>$R^2$</th>
<th>Median Ratio</th>
<th>Abs % Difference</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rrs413</td>
<td>-0.01283, 0.01832</td>
<td>0.00001, 0.01550</td>
<td>1250</td>
<td>1.06363</td>
<td>-0.00097</td>
<td>0.87358</td>
<td>0.84771</td>
<td>28.28140</td>
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<tr>
<td>Rrs443</td>
<td>-0.00084, 0.01761</td>
<td>0.00014, 0.01557</td>
<td>1158</td>
<td>1.06040</td>
<td>-0.00067</td>
<td>0.87490</td>
<td>0.91770</td>
<td>16.55719</td>
<td>0.00127</td>
</tr>
<tr>
<td>Rrs490</td>
<td>0.00032, 0.02499</td>
<td>0.00054, 0.02442</td>
<td>1356</td>
<td>0.96946</td>
<td>-0.00042</td>
<td>0.86451</td>
<td>0.87365</td>
<td>14.98263</td>
<td>0.00125</td>
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<tr>
<td>Rrs510</td>
<td>0.00106, 0.02567</td>
<td>0.00131, 0.02538</td>
<td>582</td>
<td>1.08277</td>
<td>-0.00045</td>
<td>0.82955</td>
<td>0.94721</td>
<td>11.04571</td>
<td>0.00083</td>
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<tr>
<td>Rrs560</td>
<td>0.00087, 0.02889</td>
<td>0.00085, 0.02862</td>
<td>481</td>
<td>1.03390</td>
<td>-0.00017</td>
<td>0.91258</td>
<td>0.94987</td>
<td>13.62841</td>
<td>0.00076</td>
</tr>
<tr>
<td>Rrs665</td>
<td>-0.00071, 0.01217</td>
<td>0.00003, 0.01078</td>
<td>510</td>
<td>1.08306</td>
<td>-0.00007</td>
<td>0.92559</td>
<td>0.70893</td>
<td>47.51158</td>
<td>0.00029</td>
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<tr>
<td>Rrs681</td>
<td>-0.00022, 0.00235</td>
<td>0.00006, 0.00199</td>
<td>282</td>
<td>1.04185</td>
<td>-0.00004</td>
<td>0.83938</td>
<td>0.69642</td>
<td>42.98729</td>
<td>0.00009</td>
</tr>
</tbody>
</table>

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**http://seabass.gsfc.nasa.gov/**
Mean APD 11-17%, Mean Bias < 13%, $R^2$ 0.9
Chlorophyll vs Field Measurements

<table>
<thead>
<tr>
<th></th>
<th>SeaWiFS</th>
<th>MERIS</th>
<th>MODISA</th>
</tr>
</thead>
<tbody>
<tr>
<td>APD</td>
<td>36%</td>
<td>39%</td>
<td>38%</td>
</tr>
<tr>
<td>Bias</td>
<td>+4%</td>
<td>+7%</td>
<td>+12%</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.85</td>
<td>0.81</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Multi-Mission Chlorophyll Time-Series
Deep-Water Chlorophyll Anomaly

~5% month-to-month temporal precision
Multi-Mission Chlorophyll Time-Series

Deep-Water Chlorophyll Anomaly

there is a problem with VIIRS calibration after 2012
large degradation in NIR due to tungsten oxide contamination (but stabilizing!)

- impact to system spectral response

residual seasonal variability in solar time-series, likely due to error in solar vector

- likely source of blue calibration error

inconsistency in lunar and solar calibration time-series, due to above (and insufficient lunar samples, yet, to resolve and correct for residual lunar libration effects).
VIIRS Status

• Substantial radiometric degradation in NIR (> 35%) due to contamination of optical surfaces with tungsten oxides
  – a function of UV exposure, but impact is stabilizing

• Temporal calibration error starting in 2013
  – likely cause: solar vector error (reference frame inconsistency) in NOAA’s IDPS software, impact assessment in progress

• Significant detector striping artifacts
  – statistical solutions exist, but waiting on above before pursuing further

• OBPG is currently operating as the NPP Ocean PEATE, proposed to continue supporting VIIRS as the Ocean SIPS

• NASA redevelopment of Level-0 to Level-1B process and formats in progress (led by OBPG, w/ land, atmosphere PEATES and VCST).
Advancement in SeaWiFS Calibration

a story of less than one digital count
MODISA Clear-Water Rrs(547) Anomaly Trend
SeaWiFS Clear-Water Rrs(555) Anomaly Trend
SeaWiFS Aerosol Angstrom Anomaly Trend

R2010.0
SeaWiFS Radiometric Instability Issue
due to a 1-count shift in dark offset
SeaWiFS Radiometric Instability Issue

constant dark offset
SeaWiFS Status

• dark offsets are changing, by less than one digital count over 12 yrs. ... and it matters

• effort now to determine best way to estimate or model a continuous drift in the dark offsets

• also impacts lunar calibration measurements, which may have different offset behavior

• complicating factor is 1-2 count drift in lunar calibration gain relative to earth view gain
Changes for next reprocessing (R2014.0)
2014.0 Multi-Mission Reprocessing

Scope
- OC from CZCS, OCTS, SeaWiFS, MERIS, MODIS(A/T), and VIIRS
- SST from MODIS (and maybe VIIRS)

Motivation
1. incorporate knowledge gained in instrument-specific radiometric calibration and updates to vicarious calibration
2. incorporate algorithm updates and advances from community and last MODIS Science Team developed since 2010 (last reprocessing).
3. improve interoperability and sustainability of the product suite by adopting modern data formats, standards, and conventions
Data Format Change

Level-2 and Level-3 products moving from HDF4 to netCDF4 with
• Climate and Forecast (CF) meta-data conventions
• ISO19115 standards for geographic information
• Unidata’s Attribute Convention for Data Discovery (ACDD)

Why change?
• HDF4 is no longer being developed, and the current implementation is limiting for new missions (and current missions) – file size issues
• current OBPG format pre-dates development of international standards and is not recognized in many third-party software packages

Why netCDF?
• framework on which many international data standards are developed
• common use in physical oceanography (e.g., GHRSST), and adopted by our international partners (e.g., ESA Sentinel missions)
• widely supported by 3rd-party tools and applications
• netCDF4 is built on HDF5 – active support and development, backward compatibility

http://oceancolor.gsfc.nasa.gov/DOCS/FormatChange.html
## Current OC Standard Product Suite

<table>
<thead>
<tr>
<th>Level-2 OC Product</th>
<th>Algorithm Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( R_{rs}(\lambda) )</td>
<td>Gordon and Wang 1994, Ahmad et al 2010, etc.</td>
</tr>
<tr>
<td>2. Ångstrom</td>
<td>O'Reilly et al. 1998 (OC3) updated by Werdell</td>
</tr>
<tr>
<td>3. AOT</td>
<td>Mueller et al. 2000 (KD2) updated by Werdell</td>
</tr>
<tr>
<td>5. ( K_d(490) )</td>
<td>Mueller et al. 2000 (KD2) updated by Werdell</td>
</tr>
<tr>
<td>6. POC</td>
<td>Stramski et al. 2008</td>
</tr>
<tr>
<td>8. CDOM_index</td>
<td>Morel and Gentili 2009</td>
</tr>
<tr>
<td>9. PAR</td>
<td>Frouin, Franz, &amp; Werdell 2003</td>
</tr>
<tr>
<td>10. iPAR</td>
<td>Behrenfeld et al. 2009</td>
</tr>
<tr>
<td>11. nFLH</td>
<td>Behrenfeld et al. 2009</td>
</tr>
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</table>
## Proposed Changes to Standard Product Suite

<table>
<thead>
<tr>
<th>Level-2 OC Product</th>
<th>Algorithm Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( R_{rs}(\lambda) )</td>
<td>calibration updates, ancillary data updates, improved land/water masking, terrain height, other minor fixes</td>
</tr>
<tr>
<td>2. Ångstrom</td>
<td>merge OCx with Hu et al. 2012 CI</td>
</tr>
<tr>
<td>3. AOT</td>
<td>no change</td>
</tr>
<tr>
<td>4. Chlorophyll a</td>
<td>no change</td>
</tr>
<tr>
<td>5. ( K_d(490) )</td>
<td>updated ( b_b^* ) and two-band LUT (Balch)</td>
</tr>
<tr>
<td>6. POC</td>
<td>remove product</td>
</tr>
<tr>
<td>7. PIC</td>
<td>consolidated algorithm, minor fixes</td>
</tr>
<tr>
<td>8. CDOM_index</td>
<td>no change</td>
</tr>
<tr>
<td>9. PAR</td>
<td>flagging changes (allow negatives)</td>
</tr>
<tr>
<td>10. iPAR</td>
<td></td>
</tr>
<tr>
<td>11. nFLH</td>
<td></td>
</tr>
</tbody>
</table>
Chlorophyll algorithm refinement

Chlorophyll $a$ algorithms for oligotrophic oceans: A novel approach based on three-band reflectance difference

Chuanmin Hu, Zhongping Lee, and Bryan Franz

Chlorophyll Algorithm Refinement

a hybrid approach

New CI Line Height Algorithm

better at low chlorophyll

\[ \text{CI} = \frac{1}{4} R_{rs}(555) - \frac{1}{3} R_{rs}(443) \]
\[ \cdot \frac{\delta 555 - 443}{\delta 670 - 443} \cdot \frac{\delta R_{rs}(670)}{\delta R_{rs}(443)} \]
which is equivalent to

\[ \text{CI} \approx R_{rs}(555) - 0.55 \delta R_{rs}(443) \]
\[ \cdot \frac{\delta 555}{\delta 670} \]

Chl $\leq 0.25$ mg m\(^{-3}\)

Standard OCx Band Ratio Algorithm

better at mid to high chlorophyll

\[ \text{Chl}_{OC4} = 10^{y} \]
\[ y = a_0 + a_1 \chi + a_2 \chi^2 + a_3 \chi^3 + a_4 \chi^4 \]
\[ \chi = \log_{10}(R) \text{ and } R = \max(R_{rs}(443, 490, 510))/R_{rs}(555) \]

Chl $> 0.3$ mg m\(^{-3}\)

Proposed OCxI Algorithm

\[ \text{Chl}_{OCI} = \text{Chl}_{CI} \text{ [for Chl}_{CI} \leq 0.25 \text{ mg m}^{-3}] \]
\[ \text{Chl}_{OC4} \text{ [for Chl}_{CI} > 0.3 \text{ mg m}^{-3}] \]
\[ \alpha \times \text{Chl}_{OC4} + \beta \times \text{Chl}_{CI} \text{ [for } 0.25 < \text{Chl}_{CI} \leq 0.3 \text{ mg m}^{-3}] \]
MODISA Standard OC3 Chlorophyll

Chl_{OC3}
Flags off
MODISA Evaluation OCI Chlorophyll

Chl\textsubscript{Cl}
Flags off
SeaWiFS Standard OC4 Chlorophyll

Chl$_{OC4}$

mg/m$^3$

5.00
1.00
0.20
0.05
0.01
SeaWiFS Evaluation OCI Chlorophyll

\[ \text{Chl}_{\text{OCI}} \]
OCI Resistance to SeaWiFS Offset Issue

Anomaly in SeaWiFS(ST97) Chl$_a$(OC4) for Oligotrophic

OC4 – changing dark offset

Anomaly in SeaWiFS(ST99) Chl$_a$(OC4) for Oligotrophic

OC4 – fixed dark offset

Anomaly in SeaWiFS(ST97) Chl$_a$(OCI) for Oligotrophic

OCI – changing dark offset

Anomaly in SeaWiFS(ST99) Chl$_a$(OCI) for Oligotrophic

OCI – fixed dark offset
Improved Agreement in Chl Distribution
Deep-Water Monthly Mean, MODISA (red) & SeaWiFS (black)

Fall 2002

Fall 2010
SeaWiFS match-ups for OCI chl < 0.25 mg m\(^{-3}\)

*red line is best fit (Type II, RMA)*

\(r^2\), slope, and RMSE log-transformed statistics

sample size is 314

- **OC4**
  - \(r^2\): 0.35
  - Slope: 0.66
  - RMSE: 0.104
  - Ratio: 1.02
  - MPD: 36.4

- **OCI**
  - \(r^2\): 0.32
  - Slope: 0.52
  - RMSE: 0.085
  - Ratio: 0.99
  - MPD: 36.3

- **OCI vs OC4**
  - \(r^2\): 0.85
  - Slope: 0.83
  - RMSE: 0.074
  - Ratio: 0.96
  - MPD: 11.4

*results are inconclusive*
MODISA Evaluation OCI Chlorophyll

Fall 2002

Chlorophyll a concentration (mg / m³)
MODISA & SeaWiFS Chlorophyll Trends
Impact of OCI Algorithm – Elevated Chlorophyll

Global Mean Clear-Water Trend

Global Mean Deep-Water Trend

<table>
<thead>
<tr>
<th></th>
<th>Clear Water</th>
<th>Deep Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg m⁻³</td>
<td>SeaWiFS</td>
<td>MODIS</td>
</tr>
<tr>
<td>OCx</td>
<td>0.061</td>
<td>0.058</td>
</tr>
<tr>
<td>OCI</td>
<td>0.075</td>
<td>0.073</td>
</tr>
<tr>
<td>OCI - OCx</td>
<td>0.014</td>
<td>0.015</td>
</tr>
</tbody>
</table>
proceed with OCI?
Expanded Product Suite - IOPs

proposed IOP product suite
• $\text{aph}(\lambda)$  
  
  *all visible wavelengths*
• $\text{adg}(443) + \text{Sdg}$  
  
  *exponential spectral slope*
• $\text{bbp}(443) + \text{Sbp}$  
  
  *power-law spectral slope*
• uncertainties  
  
  *only at 443nm*

other potential products
• $\text{bbw}(443) + \text{Sbw}$  
  
  *power-law spectral slope; Zhang et al. 2009*
• chlorophyll

proposed distribution
• $\text{aph}(443)$, $\text{adg}(443)$, $\text{bbp}(443)$ included in standard OC Level-2
• full product suite included in new standard IOP Level-3

*what best serves the community?*
Next multi-mission OC reprocessing (R2014.0) in progress

OCTS ➔ SeaWiFS ➔ CZCS ➔ MERIS ➔ MODISA ➔ MODIST ➔ VIIRS

May 2014
June 2014

Includes instrument and vicarious calibration updates

Incorporates algorithm refinements since 2010

Expands standard product suite

Changes data formats

Looking for feedback on:

OCI chlorophyll algorithm refinement

IOP model and products to be included
Second-generation GLobal Imager (SGLI)

- JAXA SGLI follow-on to fly on GCOM-C1, launch date Dec 2015
- multi-spectral push-broom (380nm to 870nm) with multi-angle polarimeter in the red-NIR, married to a SWIR-IR scanner
- global 1-km with 250-m coastal
- no sun glint avoidance

### GCOM-C SGLI characteristics (Current baseline)

<table>
<thead>
<tr>
<th>Orbit</th>
<th>Sun-synchronous (descending local time: 10:30), Altitude: 798km, Inclination: 98.6deg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch Date</td>
<td>JFY 2016 (TBD)</td>
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<tr>
<td>Mission Life</td>
<td>5 years (3 satellites; total 13 years)</td>
</tr>
<tr>
<td>Scan</td>
<td>Push-broom electric scan (VNR: VN &amp; P) Wisk-broom mechanical scan (IRS: SW &amp; T)</td>
</tr>
<tr>
<td>Scan width</td>
<td>1150km cross track (VNR: VN &amp; P) 1400km cross track (IRS: SW &amp; T)</td>
</tr>
<tr>
<td>Digitalization</td>
<td>12bit</td>
</tr>
<tr>
<td>Polarization</td>
<td>3 polarization angles for POL</td>
</tr>
<tr>
<td>Along track tilt</td>
<td>Nadir for VN, SW and TIR, &amp; +/-45 deg for P</td>
</tr>
<tr>
<td>On-board calibration</td>
<td>VN: Solar diffuser, Internal lamp (LED, halogen), Lunar by pitch maneuvers (~once/month), and dark current by masked pixels and nighttime obs. SW: Solar diffuser, Internal lamp, Lunar, and dark current by deep space window TIR: Black body and dark current by deep space window All: Electric calibration</td>
</tr>
</tbody>
</table>

### Characteristics of SGLI spectral bands

<table>
<thead>
<tr>
<th>CH</th>
<th>(\lambda)</th>
<th>(\Delta\lambda)</th>
<th>(L_{\text{std}})</th>
<th>(L_{\text{max}})</th>
<th>SNR@(L_{\text{std}})</th>
<th>IFOV</th>
<th>Tilt</th>
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<tbody>
<tr>
<td></td>
<td>nm</td>
<td>W/m²/sr/μm·K: Kelvin</td>
<td></td>
<td></td>
<td>K: NEΔT</td>
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<tr>
<td>VN1</td>
<td>380</td>
<td>10</td>
<td>60</td>
<td>210</td>
<td>250</td>
<td>250 / 1000</td>
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<tr>
<td>VN2</td>
<td>412</td>
<td>10</td>
<td>75</td>
<td>250</td>
<td>400</td>
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<tr>
<td>VN3</td>
<td>443</td>
<td>10</td>
<td>64</td>
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<td>300</td>
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<tr>
<td>VN4</td>
<td>490</td>
<td>10</td>
<td>53</td>
<td>120</td>
<td>400</td>
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<td>VN5</td>
<td>530</td>
<td>20</td>
<td>41</td>
<td>350</td>
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<td>40</td>
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<td>1200*</td>
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<td>250</td>
<td>250</td>
<td>1000</td>
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<td>340K</td>
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</table>
Hyperspectral Imager for Coastal Oceans (HICO)
GOCI Analysis and Display in SeaDAS 7.1