MODIS Terra Ocean Color

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and the
NASA Ocean Biology Processing Group
Deep-Water nLw Trends
MODIS-Terra Collection 4.1 vs SeaWiFS Reprocessing 4

SeaWiFS & MODIST

MODIS / SeaWiFS

NASA discontinued MODIS-Terra Ocean Color processing and directed the OBPG to concentrate on MODIS-Aqua ....

ASLO-TOS, Feb 2004
Deep-Water nLw Trends
MODIS-Aqua Reprocessing 1.1 vs SeaWiFS Reprocessing 5.1

SeaWiFS & MODISA

MODISA / SeaWiFS

With lessons learned from MODIS-Aqua, NASA decided to revisit MODIS-Terra Ocean Color processing ....
Major Issues with MODIS-Terra for OC

- Instrument state changes introduce calibration epochs
- Substantial temporal degradation of instrument response in some spectral bands
- Overheating event in pre-launch testing "smoked" the mirror, subsequent to pre-launch characterization
Approach to MODIS-Terra OC Development

- Concentrate on forward stream (Jan 2005 to present)
- Review and revise pre-launch characterization (polarization)
- Work with MCST to develop and evaluate on-orbit calibration
- Apply common (MODIS-SeaWiFS) software and algorithms
- Apply common vicarious calibration approach
  - SIO/SPG, MOBY, mission averaged gain
- Test and evaluate changes on global scale
MODIS Temporal Degradation at 412 nm
Lunar and Solar Calibration Trends

MODIS Band 8 gains (Det. 5)

- Solar Diffuser (Pixel 989)
- Mirror-Side 1
- Mirror-Side 2
- Lunar Observations (Pixel 22)

Gain (norm.)

Terra

- Nov-99
- Mar-01
- Aug-02
- Dec-03
- May-05
- Sep-06

- 28%
- 7%
- 35%
- 40%
• Instrument response has degraded by as much as 40% (412nm), presumably due to changes in mirror coatings

• Mirror-sides degrading at significantly different rates, with larger changes in mirror side 2

• Change in mirror implies loss of characterization knowledge
  – response versus scan angle (RVS)
  – polarization sensitivity

• Need to quantify relative variability between mirror sides and with respect to scan angle
  – evaluate impact to derived products
Level-2 to Level-3 Match-up Analysis
Assessment of Residual RVS, Mirror-Side Differences, and Detector Striping

7-Day Composite Level-3 Bin Product

[L2, L3] nLw(λ), τa, ε, Ca
[L2] det #, m-side, scan pix
[L2] radiant path geometry

Central Day

Level-2 Granule

detector and mirror-side

scan pixel
Residual RVS - nLw(412)

MODIS/Terra TV02 nLw(412) Ratio for 2005 080 (M1 BLUE, M2 RED)

Scan Pixel

+10%

-10%

Mirror-Side 1

Mirror-Side 2
Residual RVS - nLw(412)
Residual RVS

2005 080

2005 173

2005 266
Residual RVS

<table>
<thead>
<tr>
<th>Year</th>
<th>nLw(412)</th>
<th>nLw(443)</th>
<th>nLw(488)</th>
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<td>2005 080</td>
<td><img src="image" alt="Graph" /></td>
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Residual RVS - nLw(412)

Due to error in instrument RVS characterization and/or polarization?
Residual RVS per Detector - nLw(412)
Detector Destriping Correction for Aqua statistical TOA analysis verified with lunar observations temporally constant, implemented in Level-1B LUT

Residual RVS per Detector - nLw(412)

MODIS/Terra TVC4 nLw(412) Ratio for 2005 080 (M1^{BLUE}, M2^{RED})

Destriped
All things being equal ... 

We require a method to derive MODIS-Terra instrument RVS and polarization sensitivities on-orbit ...
\[ L_m(\lambda) = M_{11} L_t(\lambda) + M_{12} (Q_t(\lambda) \cos 2\alpha - U_t(\lambda) \sin 2\alpha) + M_{13} (Q_t(\lambda) \sin 2\alpha + U_t(\lambda) \cos 2\alpha) \]
Vicarious Cross-Calibration Approach
on-orbit characterization of instrument RVS and polarization

\[ L_m(\lambda) = M_{11} L_t(\lambda) + M_{12} (Q_t(\lambda) \cos 2\alpha - U_t(\lambda) \sin 2\alpha) + M_{13} (Q_t(\lambda) \sin 2\alpha + U_t(\lambda) \cos 2\alpha) \]

SeaWiFS 7-Day Composite nLw(\(\lambda\))

Vicarious calibration:
given \(L_w(\lambda)\) and MODIS geometry, we can predict \(L_t(\lambda)\)

Global optimization:
find best fit \(M_{11}, M_{12}, M_{13}\) to relate \(L_m(\lambda)\) to \(L_t(\lambda)\)

where \(M_{xx} = fn(\text{mirror aoi})\)

per band, detector, and m-side
Residual RVS per Detector - nLw(412)

the depths of despair ...
Residual RVS per Detector - nLw(412)
after vicarious characterization
### Residual RVS (after vicarious characterization)

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Residual RVS (before vicarious characterization)

nLw(412)  nLw(443)  nLw(488)

2005 080

2005 173

2005 266
Residual RVS (after vicarious characterization)

- nLw(412)
- nLw(443)
- nLw(488)

2005 080

2005 173

2005 266
Future Plans

- Examine stability of vicarious on-orbit characterization with time
  - derive on annual or seasonal basis
- Are results physically realistic?
- Expand analysis to full-mission
  - full Terra L0 archive now in-house
- Begin detailed analysis of temporal trends
In parallel with OBPG cal/val efforts:

MODIS-Terra data is being distributed to the community via the ocean color web browsers, for qualitative use.

Full processing (L0-L3) and display support also provided in SeaDAS.

These products do not include recent OBPG characterization efforts (MCST characterization + vicarious calibration).
Thank You! 
Degree of polarization for Rayleigh atmosphere and sun-glint observed by the sensors
nLw only
operational polarization sensitivity and calibration for NIR bands and
no polarization correction for VIS bands (because it is to be derived)
Q and U polarization components included aerosol polarization
(aerosol polarization may not be particularly important)
derived M11, M12, and M13 approximated by 3rd deg. polynomial fit
along MODIS scan

\[ L_m = M_{11}L_t + M_{12}(Q_{t}\cos^2\alpha - U_{t}\sin^2\alpha) + M_{13}(Q_{t}\sin^2\alpha + U_{t}\cos^2\alpha) \]

where M are MODIS Mueller matrix components representing
instrument gain, M11, and polarization sensitivity, M12 and M13
Residual RVS - nLw(412)