Regional Vicarious Gain Adjustment for Coastal VIIRS Products

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ABSTRACT: As part of the Joint Polar Satellite System (JPSS) Ocean Cal/Val Team, Naval Research Lab - Stennis Space Center (JPLSSC) has been working to facilitate calibration and validation of the Visible Infrared Imaging Radiometer Suite (VIIRS) ocean color products. By relaxing the constraints of the NASA Ocean Biology Processing Group (OBPG) methodology for vicarious calibration of ocean color satellite and calibrating the Aerosol Robotic Network Ocean Color (AERONET-OCL) system to provide in situ data, we investigated differences between remotely sensed water leaving radiance and the expected in situ response in coastal areas and compare the results to traditional Marine Optical Buoy (MOBY) calibration/validation activities.

An evaluation of the Suomi National Polar-Orbiting Partnership (SNPP) VIIRS ocean color products was performed in coastal waters using the time series data obtained from the Northern Gulf of Mexico AERONET-OCL site, WaveCIS. The coastal site provides different water types with varying complexity of CDOM, sedimentary, and chlorophyll components. Time series data sets were used to develop a vicarious gain adjustment (VGA) at this site, which provides a regional top of the atmosphere (TOA) spectral offset to compare the standard MOBY spectral calibration gain in open ocean waters.

1. Accumulate coincident matchups (± 3 hrs) of satellite and in situ data (blue markers).
2. Apply screening criteria to coincident collections (green and yellow markers).
3. Calculate ratio of predicted (vLt) to observed LT radiance (R).
4. Plot spectral gains and remove anomalies.

5. Calculate an average gain for each site:
MOBY vicarious calibration and WCS VGA.

Although there is no statistical difference between the vicarious calibration and VGA gains, the MOBY site provides less uncertainty.

6. Apply Vicarious calibration and VGA using APS and look at effects on the nLw retrievals

7. Effects of Vicarious Calibration and VGA on chlorophyll products

8. Conclusions:
- The procedure addresses selection criteria for optimizing data quality in a near real-time setting, allowing for vicarious calibration and regional VGA to be established for each of the VIRS visible channels.
- Assembling an optimum data set for determining vicarious gains is time consuming and excluding considerale data: 69% for MOBY and 72% for WaveCIS site.
- The standard deviation of the adjustment gains was deemed acceptable and the screening procedure is critical for determining the adjustment.
- Due to the uncertainties in the vicarious calibration and VGA processes there was not a statistically significant difference in the blue water (410 nm) and green water (671 nm) gains, however, as expected, the blue water gains exhibit lower standard deviations per channel.
- Optimum selection of matchup points provides a strong relationship between satellite and in situ nLw and chi for both gain set, MOBY or WaveCIS.

**ABSTRACT WITH TABLES AND FIGURES:**

<table>
<thead>
<tr>
<th>WAVECIS AERONET-OCL (nLw 551 nm)</th>
<th>Vc</th>
<th>nLw 410 nm</th>
<th>y = 0.6151x + 0.1962 R² = 0.9612</th>
<th>WCIS Satellite retrieved nLw 551 nm</th>
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**SCREENING CRITERIA IS CRITICAL:**

As mission average calibrations have been shown to reach stability after 20 – 40 high quality calibration samples it is consideration is given to balance the strictness of removal criteria and preservation of sample size.

**Vicarious calibration**
MOBY (January 2012 to April 2013) Satellite criteria:
- Within 3 hours of over pass and 1000 ft below cloud base
- No clouds (pixel size: 450, 750, 1150, 1800, 2200)

**Regional VGA (revised constraints)**
WaveCIS AERONET-OCL (January 2013 to March 2014)
Satellite flags:
- Within 4 hours of overpass, atmospheric failure, failure, cloud/ice, high LT, snow, high solar zenith angle, epoloid out of range, high glint, max AER iteration, high polarization, moderate sun glint, and coastal ocean physics

**Exclusion criteria:**
- Wind speed must be less than 8 m/s, the maximum aerosol optical thickness (AOT) must be less than 0.2 as measured by the MOBY buoy, the nLw values must be between 0.001 and 3.0, the maximum solar zenith angle = 70 degrees and maximum sensor zenith angle = 56 degrees.

Extensively published by NASA's Ocean Biology Program Group (OBPG), the vicarious calibration is an inversion of the forward processing algorithm resulting in a ratio of predicted (vLt) to observed TOA radiance (R).

<table>
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<th>Gain = (vLt/Lt)</th>
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<td>MOBY gains nLw 671 nm y = 0.8689x + 0.0141 R² = 0.9337</td>
<td>WCIS gains nLw 671 nm y = 0.8853x + 0.0389 R² = 0.9433</td>
<td></td>
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<tr>
<td>MOBY gains nLw 551 nm y = 0.7745x + 0.0263 R² = 0.7199</td>
<td>WCIS gains nLw 551 nm y = 0.8012x + 0.0087 R² = 0.8761</td>
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**CRITICAL!**

Monitoring a Vicarious Regional matchup (Lt and nLw)

**Regional Bias of the Lt**
- Regional Blue/Red
- Ocean transect
- Water type
- Sea/land
- Pixels

**APS processing employs:**
- Standard atmospheric correction of Gordon/Wang
- Stumpf NIR Iteration
- Initial processing assumes perfect sensor calibration (unity gains)
- Save the atmospheric components (Lt, Sa, transmittance, polarization correction, etc.) and pointing-angles
- nLw from the in situ sensor is run through the inversion where the atmospheric components are added back creating an expected Lt from the view of the VIRS (vLt/Lt).

In a perfect system in which all components are computed accurately, the vLt and original Lt should have a ratio of 1.0.