Comparison of SeaWiFS On-Orbit Lunar and Vicarious Calibrations

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ABSTRACT

The NASA Ocean Biology Processing Group's Calibration and Validation Team has used monthly lunar calibrations of SeaWiFS to establish and maintain the on-orbit radiometric stability of instrument at the 0.1% level over its 9-year mission. The Cal/Val Team has compared the SeaWiFS lunar observations with the USGS ROLO photometric model of the Moon to verify the long-term stability of the SeaWiFS radiometric calibration. This stability has allowed the Team to apply a system-level vicarious calibration of the sensor/atmospheric calibration algorithm that is independent of time, yielding a single gain per band. SeaWiFS bands 1–6 (412–670 nm) are calibrated against water-leaving radiances measured by the Marine Optical Buoy (MOBY) that have been propagated to the top of the atmosphere. Band 7 (765 nm) is calibrated relative to band 8 (865 nm) so that the atmospheric correction algorithm selects maritime aerosol models over open ocean scenes. The long-term radiometric stability of SeaWiFS allows the Cal/Val Team to directly compare the mean residuals of the lunar observations from the ROLO model with the vicarious gains. A linear fit of the vicarious gains vs 1 - (mean ROLO residual) for bands 1–6 gives a slope of 1.084 with a correlation of 0.980. The predicted mean ROLO residual for band 7, computed from the observed mean residual for band 8 and the vicarious gain for band 7, agrees with the observed mean residual for band 7 to within 0.5%. The radiometric stability of SeaWiFS allows the comparison of the prelaunch calibration of SeaWiFS, the calibration of MOBY, and the calibration of the USGS ROLO model. Such a comparison is of interest to other Earth-observing instruments which use the Moon as a calibration reference, such as MODIS, VIIRS, and ABI.

Keywords: SeaWiFS, ocean color, lunar calibration, vicarious calibration

1. INTRODUCTION

One of the goals of climate change research is to discern small secular trends in geophysical processes that may have comparatively large daily, seasonal, or longer-scale periodic signals. This research requires remote sensing data from instruments with long-term radiometric stability, where the radiometric uncertainty in the data is less than the magnitude of the possible climate change signal. For ocean color data, the radiometric requirements are 5% absolute and 1% relative accuracies on the water-leaving radiances.[1] Because open-ocean reflectances are low, approximately 90% of the top-of-the-atmosphere (TOA) signal observed by ocean color satellite instruments is due to scattering of sunlight by gases and aerosols within the atmosphere. The ocean color atmospheric correction algorithm must remove this signal to yield the water-leaving radiances. Uncertainties in the sensor calibration and in the atmospheric correction algorithm require a vicarious calibration of the sensor/atmospheric correction algorithm system that is independent of time to achieve these accuracy requirements.[2] Because of the

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Table 1. SeaWiFS Bands. The nominal center wavelengths and bandwidths are in nanometers.

Band	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Wavelength	412	443	490	510	555	670	765	865
Bandwidth	20	20	20	20	20	20	40	40

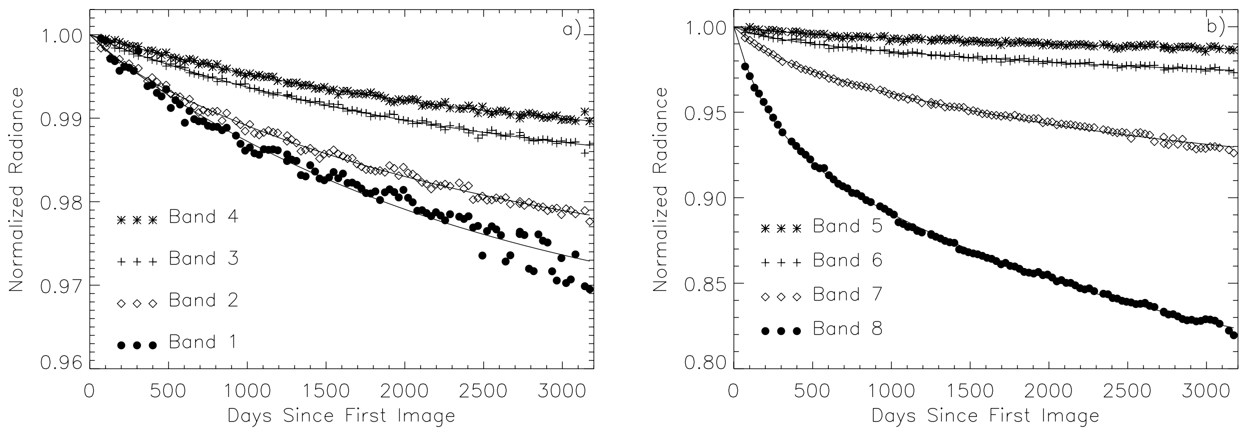

Figure 1. Lunar Calibration Time Series.

amplification of any errors in the sensor calibration by the atmospheric correction process, the 1% relative accuracy requirement on water-leaving radiances translates into a 0.1% long-term radiometric stability requirement for TOA radiances. This paper uses SeaWiFS as a case study for the long-term radiometric stability of ocean color instruments.

SeaWiFS is an eight-band visible and near-infrared scanning radiometer designed to have high radiometric sensitivity over oceans without saturating over bright clouds. The bands are provided in Table 1. The NASA Ocean Biology Processing Group's Calibration and Validation (Cal/Val) Team has implemented monthly lunar calibrations to monitor the radiometric stability of the instrument over its mission lifetime.[3–5] The Cal/Val Team has also used data from the NASA/NOAA Marine Optical Buoy (MOBY)[6,7] deployed 15 km west of Lanai, Hawaii, for the vicarious calibration of SeaWiFS.[8,9] The comparison of the lunar and vicarious calibration results for SeaWiFS are presented in this paper.

5. DISCUSSION

This study demonstrates the level of radiometric stability that can be obtained for remote sensing satellite instruments with a sufficiently rigorous on-orbit calibration program. For most satellite instrument, systematic noise sources eventually limit the long-term stability. For SeaWiFS, that limit is the oversampling correction for the lunar images in the lunar calibration time series. The long-term radiometric stability of the SeaWiFS calibration allows a single-point vicarious calibration to be performed for each band using in-water measurements from MOBY. The stability of SeaWiFS also allows the calibration of the U.S. Geological Survey photometric model of the Moon to be compared directly with the calibration of MOBY. This comparison would be useful in refining the absolute calibration of the lunar model and should be of interest to other Earth-observing instruments which use the Moon as a calibration reference, such as MODIS, VIIRS, and ABI.