SeaWiFS Long-Term Solar Diffuser Reflectance Trend Analysis

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ABSTRACT

The NASA Ocean Biology Processing Group's Calibration and Validation (Cal/Val) Team implemented daily solar calibrations of SeaWiFS to look for step-function changes in the instrument response and has used these calibrations to supplement the monthly lunar calibrations in monitoring the radiometric stability of SeaWiFS during its first year of on-orbit operations. The Team has undertaken an analysis of the mission-long solar calibration time series, with the lunar-derived radiometric corrections over time applied, to assess the long-term degradation of the solar diffuser reflectance over nine years on orbit. The SeaWiFS diffuser is an aluminum plate coated with YB71 paint. The bidirectional reflectance distribution function of the diffuser was not fully characterized before launch, so the Cal/Val Team has implemented a regression of the solar incidence angles and the drift in the node of the satellite's orbit against the diffuser time series to correct for solar incidence angle effects. An exponential function with a time constant of 200 days yields the best fit to the diffuser time series. The decrease in diffuser reflectance over the mission is wavelength-dependent, ranging from 9% in the blue (412 nm) to 5% in the red and near infrared (670–865 nm). The degradation of diffuser reflectance is similar to that observed for SeaWiFS radiometric response itself from lunar calibration time series for bands 1–5 (412–555 nm), though the magnitude of the change is four times larger for the diffuser. Evidently, the same optical degradation process has affected both the telescope optics and the solar diffuser in the blue and green. The Cal/Val Team has developed a methodology for computing the signal-to-noise ratio (SNR) for SeaWiFS on orbit from the diffuser time series. The on-orbit change in the SNR for each band over the nine-year mission is less than 7%. The on-orbit performance of the SeaWiFS solar diffuser should offer insight into the long-term on-orbit performance of solar diffusers on other instruments, such as MODIS, VIIRS, and ABI.

Keywords: SeaWiFS, ocean color, calibration, solar diffuser, signal-to-noise ratio

1. INTRODUCTION

The NASA Ocean Biology Processing Group's Calibration and Validation (Cal/Val) Team implemented daily solar calibrations of SeaWiFS to look for step-function changes in the instrument response and has used these calibrations to supplement the monthly lunar calibrations in monitoring the radiometric stability of SeaWiFS during its first year of on-orbit operations. The Cal/Val Team has undertaken an analysis of the mission-long solar calibration time series, with the lunar-derived radiometric corrections over time applied, to assess the long-term degradation in the solar diffuser reflectance over nine years on orbit. The diffuser reflectance analysis allows the Team to compute the SeaWiFS signal-to-noise ratio (SNR) on orbit and monitor changes in the SNR over time.

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6. DISCUSSION

The residual effects of the azimuthal angle variation in the SeaWiFS diffuser time series (Fig 6–Fig 9) show the necessity of accurately determining the BRDF of solar diffusers prior to launch and monitoring the changes in the diffuser BRDF on orbit. The long-term degradation of the reflectance of solar diffusers on orbit, and the monitoring and modeling of that degradation, is a critical concern for Earth remote sensing instruments that employ solar diffusers as the primary on-orbit radiometric calibration standard for the visible and near-infrared bands. The fits to the SeaWiFS solar diffuser reflectance trends (Fig 10), show that diffusers made from YB71-coated aluminum exhibit an exponential decrease in reflectance with a relatively short time constant (200 days for SeaWiFS). The degradation is wavelength dependent, with the blue bands degrading 9% while the red bands degrade 5%. For all of the bands, the degradation levels off after the first thousand days of the mission. Despite the degradation in diffuser reflectance, the solar diffuser time series show the the on-orbit change in the SNR for each SeaWiFS band is less than 7% (Table 2).

One flight instrument other than SeaWiFS, the Landsat-7 ETM+, uses a YB71-coated solar diffuser. The SeaWiFS diffuser results are difficult to compare with those reported for the ETM+ FASC, since estimates of the FASC reflectance on orbit are only provided for a limited number of observations.[9]

The SeaWiFS diffuser results are qualitatively similar to those observed for the Terra MODIS solar diffuser,[13] which is made from space-grade Spectralon. The complicated on-orbit history of the Terra MODIS instrument and the poor characterization of the SeaWiFS diffuser BRDF makes detailed comparisons of the SeaWiFS and MODIS diffusers difficult. However, comparisons of the long-term degradation trends of the SeaWiFS diffuser with the Terra and Aqua MODIS diffusers should provide insight into the on-orbit performance of solar diffusers on future Earth remote sensing instruments, such as VIIRS and ABI.