Results and Lessons Learned from MODIS Polarization Sensitivity Characterization

J. Sun[a], X. Xiong[b], X. Wang[c], S. Qiu[c], S. Xiong[a], and E. Waluschka[d]
[a]Science Systems and Applications, Inc., 10210 Greenbelt Road, Lanham, MD 20706
[b]Code 614.4, NASA/GSFC, 8800 Greenbelt Road, Greenbelt, MD 20771
[c]New Century Applied Science, Inc., Ellicott City, MD 21042
[d]Code 551.0, NASA/GSFC, 8800 Greenbelt Road, Greenbelt, MD 20771

ABSTRACT

In addition to radiometric, spatial, and spectral calibration requirements, MODIS design specifications include polarization sensitivity requirements of less than 2% for all Reflective Solar Bands (RSB) except for the band centered at 412nm. To the best of our knowledge, MODIS was the first imaging radiometer that went through comprehensive system level (end-to-end) polarization characterization. MODIS polarization sensitivity was measured pre-launch at a number of sensor view angles using a laboratory Polarization Source Assembly (PSA) that consists of a rotatable source, a polarizer (Ahrens prism design), and a collimator. This paper describes MODIS polarization characterization approaches used by MODIS Characterization Support Team (MCST) at NASA/GSFC and addresses issues and concerns in the measurements. Results (polarization factor and phase angle) using different analyzing methods are discussed. Also included in this paper is a polarization characterization comparison between Terra and Aqua MODIS. Our previous and recent analysis of MODIS RSB polarization sensitivity could provide useful information for future Earth-observing sensor design, development, and characterization.

Keywords: MODIS, reflective solar bands, polarization, Terra, Aqua

1. INTRODUCTION

The MODerate Resolution Imaging Spectroradiometer (MODIS) is a cross-track scanning radiometer and one of the key instruments of the NASA Earth Observing System (EOS).[1-3] Currently two MODIS instruments are in orbit, one on the Terra spacecraft launched on December 18, 1999 and the other on Aqua launched on May 4, 2002.[4] Each MODIS instrument views the entire Earth surface approximately daily and provides information on many different biological and physical processes within the Earth/atmosphere system through visible and infrared measurements. MODIS data is used to study ocean, atmosphere, land, and global primary productivity.[5-8] It is also used to provide alerts for and monitor natural disasters such as volcanoes, earthquakes, tsunamis, and forest fires.

MODIS has 36 spectral bands covering the wavelength range from 0.4 to 14.1 μm and 490 detectors distributed on the VIS, NIR, SWIR/MWIR, and LWIR Focal Plane Assemblies (FPAs).[9,10] Twenty bands are Reflective Solar Bands (RSB). They are calibrated on-orbit through the use of an on-board Solar Diffuser (SD) panel (made of Spectralon™), the Moon, and an on-board Spectro-Radiometric Calibration Assembly (SRCA).[11-13] The RSB calibration procedure is based on measurements of unpolarized light from the Sun, the Moon, and the SRCA. The radiance reflected from the earth surface-atmosphere system can be strongly polarized[14,15] and the MODIS RSB are sensitive to the polarization of the incident light.[16] Therefore, it is essential to precisely characterize this sensitivity, in term of a polarization factor and phase angle, in order to obtain accurate top of atmosphere (TOA) radiances. These radiances are the basis of the MODIS high-level products for ocean, land, atmosphere, and other earth science studies.[1-3]

MODIS polarization sensitivity was measured by Santa Barbara Remote Sensing (SBRS).[17] The polarized light was provided by a Polarization Source Assemblies (PSA) consisting of a collimator with a rotatable Ahrens polarizer. The measured data show that there was an unexpected one-cycle oscillation and a four-cycle anomaly per 360 degree prism rotation. The four-cycle anomaly was explained as the result of the retro-reflectance of the FPAs.[17,18] In this report, we

Earth Observing Systems XI, edited by James J. Butler, Jack Xiong,
Proc. of SPIE Vol. 6296, 629605, (2006) · 0277-786X/06/$15 · doi: 10.1117/12.679080

analyze the measured data and derive the polarization parameters for visible and near infrared bands of both instruments. In section 2, we give a brief description for the methods used in this analysis. In section 3, we analyze the data and derive the polarization parameters. We also analyze and discuss the impact of the non-uniformity of the light source and the retro-reflectance of the MODIS optical elements on the derived parameters. In section 4, we analyze the derived parameters and compare the polarization performance of the two instruments. In section 5, we address the lessons learned from the MODIS polarization characterization.

6. SUMMARY

The polarization performance of the visible and near infrared bands for both Aqua and Terra MODIS is analyzed using the data of the pre-launch MODIS polarization sensitivity measurements with an approach equivalent to Fourier analysis. The derived polarization parameters depend on both the wavelength and the AOI of the scan mirror. Among these bands, band 8 has largest polarization factor, which is approximately 0.049 for Aqua and 0.055 for Terra at large AOI. The unexpected one-cycle pattern and four-cycle anomaly are analyzed and their impacts on the derived parameters are discussed. It is also shown that the polarization factors of the two instruments agree each other reasonably well.