Tracking VIRS/TRMM On-Orbit Calibration with MODIS

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ABSTRACT

The Visible and Infrared Scanner (VIRS) aboard the Tropical Rainfall Measuring Mission (TRMM), launched on 28 November 1997, has two reflected solar bands and three thermal infrared bands. The solar bands are calibrated using an onboard solar diffuser (SD) and the thermal bands are calibrated using an onboard blackbody (BB). Since launch, VIRS has provided more than eight years of on-orbit observations. The five VIRS bands have a close spectral match with corresponding Moderate Resolution Imaging Spectroradiometer (MODIS) bands. MODIS was launched on 18 December 1999 and 4 May 2002 aboard the NASA EOS Terra and Aqua spacecrafts, respectively. In this study, six years of VIRS and MODIS overlapping data are used to examine VIRS long-term calibration stability and consistency. This is particularly useful for the VIRS solar band calibration due to a lack of capability to track the on-orbit SD degradation. To reduce impacts due to scene variations, measurements from simultaneous nadir overpasses (SNOs) for VIRS and MODIS are co-located and aggregated to 30-by-30km areas for inter-comparison. Results show that the VIRS thermal bands maintain a stable calibration. For the two VIRS solar bands at 0.62µm and 1.62µm, the calibrated reflectance values gradually drift higher over the six-year period. The 0.62µm band increases at a rate of 1.1%/yr over the period, compared to an increase of 0.4%/yr for the 1.62µm band.

Keywords: VIRS, MODIS, reflected solar bands, thermal bands, calibration stability, onboard calibration

1. INTRODUCTION

Launched on 28 November 1997, the Visible and Infrared Scanner (VIRS) aboard the Tropical Rainfall Measuring Mission (TRMM) produces radiometrically calibrated global data sets at five spectral bands (two reflected solar bands at 0.62 and 1.61µm and three thermal emissive bands at 3.78, 10.83 and 12.03µm). The calibration of the two VIRS reflected solar bands depends on periodic measurements of reflected sunlight by an onboard solar diffuser (SD)[1,2]. The calibration of the three thermal emissive bands uses an onboard temperature-controlled blackbody.

VIRS on-orbit calibration data show that only the visible band at 0.62µm has a noticeable degradation change[2]. These results are obtained from on-orbit SD reflectance measurements with the bidirectional reflectance distribution function (BRDF) determined from prelaunch measurements. Because there are no means to determine possible on-orbit changes in the SD reflectance, it is assumed that any observed degradation changes in the two VIRS reflected solar bands are solely due to the sensor. As the instrument ages, it is likely that the on-orbit SD BRDF may be different from that determined from the prelaunch and this could affect the calibration and data quality of the two bands.

The Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the NASA Earth Observing System (EOS) Terra spacecraft, launched on 18 December 2000, has 36 spectral bands, covering a spectral wavelength range from 0.41 to 14.5µm[3,4]. Aqua MODIS was launched on 4 May 2002. MODIS uses a SD and a solar diffuser stability monitor (SDSM) to perform the calibration of the reflective solar bands (RSB)[5,6]. The use of the SD and SDSM separates degradation

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changes between the sensor and the SD. For calibration of the thermal emissive bands (TEB), a temperature-controlled blackbody (BB) is used.

This study uses measurements from well-calibrated MODIS bands to track the calibration stability and consistency of VIRS. Data sets over a six-year overlap period (2000 to 2006) between VIRS and MODIS are used. This gives a direct assessment of the VIRS calibration for the six-year period, which is particularly important for the two VIRS reflected solar bands, since there is no data on its SD condition.

In order to achieve high quality comparable data sets, VIRS and MODIS co-located simultaneous nadir observations (SNO) of spectrally matched bands at orbital intersections are used to conduct an inter-comparison of VIRS and MODIS. Co-located SNO measurements from the Aqua MODIS and VIRS are also included in this study although there is only a four-year overlap.

The approach applied in this study to obtain SNO observations between MODIS and VIRS is the same as the approach used in previous studies[7-10] for the purpose of Terra and Aqua MODIS inter-comparison. These studies showed that the SNO approach could produce high-quality comparable cross-instrument data sets between MODIS and AVHRR (Advanced Very High Resolution Radiometer aboard NOAA satellites) (2002) and between MODIS and GLI (GLobal Imaging) aboard the Advanced Earth Observing Satellite-II (ADEOS-II, launched on 14 December 2002). Section 2 gives a brief description of the VIRS and MODIS instruments and calibration. Section 3 describes the approach to obtain SNO observations and is followed by sections on results and conclusions.

5. SUMMARY

This study uses MODIS to track VIRS calibration consistency based on observations over a six-year overlap of the two instruments. Co-located observations from simultaneous VIRS and MODIS nadir overpasses are used to reduce impacts of scene variations. This study is useful to examine the overall VIRS calibration, particularly for the two reflected solar bands, since there is no on-orbit data to track the conditions of the SD plate used for solar band calibration. Results show that there is a gradual increase in reflectance obtained from the two VIRS solar bands at 0.62μm and 1.62μm, respectively. More increase occurs at the 0.62μm band with a total of 7% over the six-year period (1.1%/yr), compared with an increase of only 3% (0.4%/yr) for the 1.62μm band. Recent VIRS lunar observational data also show that reflectances of the 0.62μm band are drifting higher by about 1.0%/yr and no significant drift is found for the 1.62μm band. The results of this study indicate that not accounting for VIRS SD on-orbit degradation has significant impacts on the calibration of the reflected solar bands and future data processing should use alternative sources such as the Moon to allocate any on-orbit changes between the SD and the sensor.