

PROCEEDINGS OF SPIE REPRINT



SPIE—The International Society for Optical Engineering

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Reprinted from

Earth Observing Systems X

31 July–2 August 2005
San Diego, California, USA



The International Society
for Optical Engineering

Volume 5882

SPIE paper # 5882-43

Use of the Moon as a calibration reference for NPP VIIRS

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ABSTRACT

The Moon has served as a reference for several satellite instruments including SeaWiFS and MODIS, both of which provide design innovations for NPP VIIRS. However, as yet, the Moon is not a formal part of the calibration baseline for NPP VIIRS. In particular, the lunar measurements by the MODIS instruments require on-orbit maneuvers (spacecraft rolls of up to 20°) to maintain a constant lunar phase angle. Here, we use a simulated set of NPP VIIRS lunar measurements to demonstrate the quality of the Moon as a reference for long-term measurements by VIIRS. With nine lunar comparisons (1 year of VIIRS measurements), it is possible to detect linear changes over time in the calibration of the VIIRS reflective solar bands at the 0.1% per year level or better. In addition, the surface of the Moon does not change over periods of a million years or more. As a result, the Moon can act as a cross-calibration reference for NPP VIIRS and the Terra MODIS instrument that precedes it, even with a time gap between the operation of the two sensors. The quality of this cross-calibration reference is estimated to be significantly better than 1%. However, to accomplish both of these functions, NPP VIIRS must make measurements at the same lunar phase angle as Terra MODIS, that is, at 55° after full phase. This requires periodic spacecraft maneuvers.

Keywords: VIIRS, NPP, Moon, on-orbit calibration

1. INTRODUCTION

The Visible Infrared Imaging Radiometer Suite (VIIRS) is an all-reflective 22-band Earth-imaging spectroradiometer¹. VIIRS will replace three currently operating sensors: the Defense Meteorological Satellite Program (DMSP) Operational Line-scanning System (OLS), the NOAA Polar-orbiting Operational Environmental Satellite (POES) Advanced Very High Resolution Radiometer (AVHRR), and the Earth Observing System (EOS) MODerate-resolution Imaging Spectroradiometer (MODIS)¹. VIIRS has been designed to fulfill the varied requirements of the civil, military, and science communities². Currently, work is underway to determine if the VIIRS Environmental Data Records (EDRs) will be satisfactory for climate change research.

There are several factors necessary to provide a long-term climate data set³. Among these are the long-term stability of the Earth measurements from each satellite instrument and the cross-calibration of the individual instruments as each follows its predecessor. Optimally, the data sets from the series of satellite instruments will overlap in time. However, the possibility exists that such an overlap may not occur, causing gaps in the long-term data sets along with possible discontinuities between instruments across those gaps. Here, we examine the use of lunar measurements as a reference for both of these factors – the long-term stability of individual Earth-imaging satellite instruments and the cross-calibration of those instruments for long-term continuity in their Climate Data Records (CDRs).

This examination is performed for the VIIRS instrument onboard the National Polar-Orbiting Environmental Environmental Satellite System (NPOESS) Preparatory Project (NPP) mission. For NASA, NPP is a continuity mission for Earth observation⁴. NPP VIIRS is a bridge between Terra MODIS instrument and the VIIRS instrument onboard the first (C1) NPOESS platform. NPP VIIRS is a test bed for the development of consistent multi-sensor climate data sets. It is a crucial step in long-term climate change measurements.

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