Improvement of Visible Infrared Imaging Radiometer Suite Day/Night Band Image Quality


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Abstract

The Day/Night Band (DNB) is a panchromatic visible and near-infrared band of the Visible Infrared Imaging Radiometer Suite (VIIRS) on board the Suomi National Polar-Orbiting Partnership (S-NPP) and NOAA-20 satellites. Because of its three gain stage design, i.e., Low-Gain Stage (LGS) for daytime scenes, the Mid-Gain Stage (MGS) for twilight scenes, and the High-Gain Stage (HGS) for nighttime low light scenes, the DNB is capable of quantitative measurement of light radiances from $3 \times 10^{-2}$ W cm$^{-2}$sr$^{-1}$ to $2 \times 10^{-1}$ W cm$^{-2}$sr$^{-1}$. The extreme sensitivity to low light enables numerous applications of environmental remote sensing and anthropogenic activities monitoring in nighttime. However, the three gain stage design makes radiometric calibration of the DNB’s nighttime image complicated. Artifacts like striping are shown in the calibrated nighttime images. In this paper, we present our efforts for improving image quality of VIIRS DNB onboard both S-NPP and NOAA-20 by updating radiometric calibration algorithms. Our work is beneficial for applications that require high quality of DNB nighttime images.

Introduction

The VIIRS DNB onboard S-NPP and NOAA-20 is a panchromatic visible and near-infrared band (0.5 – 0.9 µm) for Earth observation both day and night. The DNB is effectively an integration of three separate bands, i.e., Low-Gain Stage (LGS) for daytime scenes, Mid-Gain Stage (MGS) for twilight scenes and High-Gain Stage (HGS) for nighttime scenes. The HGS is able to detect lunar illuminated Earth surface, clouds and artificial lights such as city light, boat, ships, street light etc. The extreme sensitivity to low light enables many image based applications, including monitoring of power outages after natural disasters and automated fishing boat detection. The three gain stage design makes radiometric calibration of the HGS complicated. Artifacts like striping are shown in the calibrated nighttime images. The HGS is calibrated by two key parameters that is dark offset and gain. The HGS dark offset is determined by tracking on-offset change on top of the baseline HGS dark offset by the DNB observation of deep space collected during the spacecraft pitch maneuver early in the mission. The HGS gain is obtained by transferring LGS gain through multiplying the MGS/LGS and HGS/LGS gain ratios evaluated in the twilight region. The HGS dark offset, MGS/LGS and HGS/MGS gain ratios are updated monthly using data collected during new moon nights.

Correlation of Stripping due to Detector Nonlinearity

• Striping has been found in many aggregation zones of both the S-NPP and NOAA-20 VIIRS DNB nighttime imagery.
• Aggregation zone 21 of NOAA-20 VIIRS DNB is a typical example, shown in Figure 1.
• Because of the special aggregation option known as Option 21, about 30% pixels of a NOAA-20 VIIRS DNB image are in aggregation zone 21.
• Striping severely degrades the quality of the NOAA-20 VIIRS DNB nighttime imagery.

Improvement of Visible Infrared Imaging Radiometer Suite Day/Night Band Image Quality after Reprocessing

Reprocessed SNPP VIIRS DNB SDRs from early mission to March 2017 accommodate calibration updates since launch

• Continuous DNB LGS gain degradation using modulated relative spectral response (RSR) function, benefiting application of nightlight time series for study of socioeconomic changes (Figure 5).

Summary

• This study summarized radiometric calibration updates for improving image quality of VIIRS DNB onboard both S-NPP and NOAA-20 satellites.
• Major improvements include:
  • Correction of stripping due to detector nonlinearity
  • Continuous DNB LGS gain degradation correction by modulated RSRs
  • DNB data collected during early mission calibrated with the postlaunch LUTs
  • Straylight corrected DNB data available since early mission
  • Enhanced low light detection by the deep space based HGS dark offset
• Reprocessed SNPP VIIRS SDR data including DNB from early mission to March 2017 are available at https://ncc.nesdis.noaa.gov/VIIRS/index.php

References:

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