SNPP and NOAA-20 VIIRS Day/Night Band Calibration Performance Monitoring and Applications

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Abstract

- The VIIRS Day/Night Band (DNB) sensors onboard NOAA-20 and SNPP satellites, being 50 minutes apart along the same orbit, provide nighttime imagery of clouds, nocturnal lights, aurora etc., and have been used for a variety of studies involving both geophysical and socio-economic activities.
- Recent SNPP and NOAA-20 DNB calibration algorithm updates focused improving imagery quality of DNB by addressing the striping in high aggregation zones due to residual nonlinearity.
- To synchronize with the improved DNB calibration algorithm, monthly DNB stray light correction LUTs for SNPP and NOAA-20 have also been updated. This poster reports updates that have been performed for SNPP and NOAA-20 DNB stray light correction and evaluates the improvements in DNB imagery product.
- Examples of applications of DNB data products in observations of aurora activities during severe solar storms, deep convective cloud monitoring, observation of light emission from lava flow during volcano eruption and monitoring of impacts of global event on social activities are also given.

SNPP and NOAA-20 DNB Calibration Update and Stray Light Correction

- Details on recent updates and development of SNPP and NOAA-20 DNB calibration can be found in the poster by Gu et al. presented in this session. The calibration algorithm improvements are mainly to reduce strong striping at the end aggregation zone.
- DNB stray light has been observed over both the Northern and the Southern Hemisphere. Origin of the DNB stray light may be due to the leaking of solar light near the extended zone and through the VIIRS Earth view and solar diffuser view aperture. To maintain consistency between DNB stray light correction and calibration algorithm update, monthly DNB stray light correction LUTs have been routinely generated by NOAA/STAR for operational DNB data production.

SNPP DNB Stray Light Correction

- There were remnant stray light of the magnitude ~1 nW/cm^2-sr in the SNPP DNB image over the southern hemisphere resulting from the use of static yearly-recycled stray light correction LUTs (twelve sets) generated during 2014 and 2015. To address this issue, the stray light correction algorithm was improved to support operational SNPP DNB calibration since May, 2019.

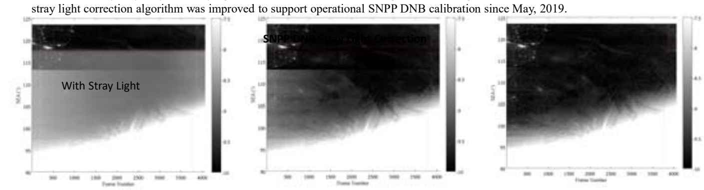

Figure 1. SNPP DNB image over Southern Hemisphere (Left) corrected with recycled stray light correction LUT (Middle) and corrected with improved stray light correction LUT (Right) developed by NOAA/STAR. City lights are better revealed with the improved stray light correction LUT.

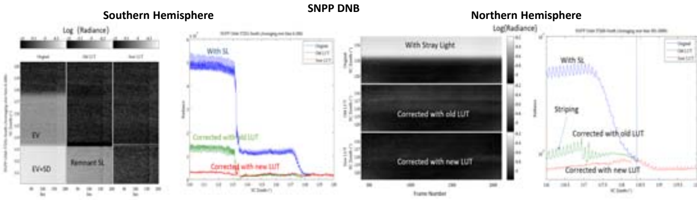

Figure 2: Comparison of stray light correction with recycled and new stray light correction LUT over northern and southern hemisphere indicates the remnant stray light magnitude is ~1 nW/cm^2-sr which were significantly reduced with improved stray light correction.

NOAA-20 DNB Stray Light Correction

- For NOAA-20 DNB, to synchronize with the improved DNB calibration algorithm and maintain consistency between DNB stray light correction and calibration algorithm update, monthly DNB stray light correction LUTs have been routinely generated for one additional full year until November, 2019.

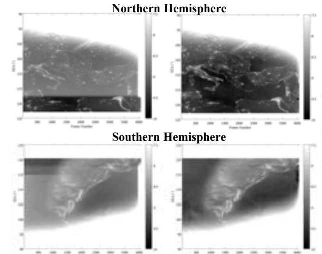

Figure 3: Example of NOAA-20 DNB correction over northern and southern hemisphere. Spatial distribution and radiometric features of nocturnal lights and aurora are better revealed after stray light correction.

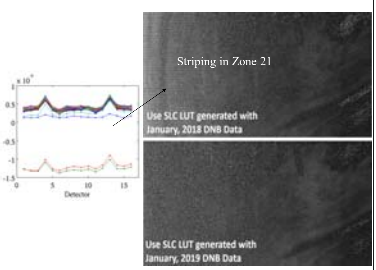

Figure 4: Example of updating stray light correction LUT for NOAA-20 DNB to remove the strong striping in aggregation zone 21 after the update of calibration algorithm to address issues of detector nonlinearity in high aggregation zone.

Inter-Comparison of Radiometric Performance between SNPP and NOAA-20 DNB

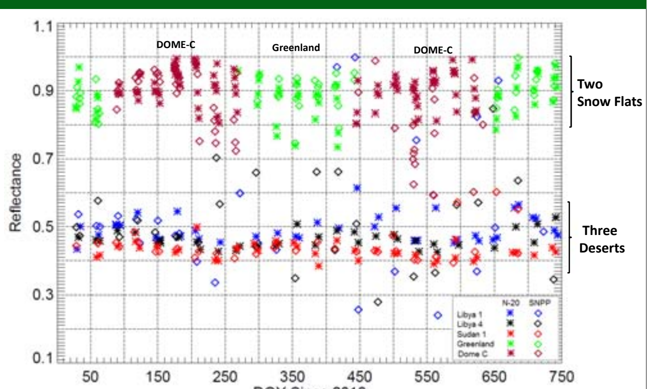

Figure 5: Radiometric consistency (within 3-5% over ~2 years) between SNPP and NOAA-20 DNB are demonstrated through long term monitoring of TOA reflectance derived from vicarious measurements over various pseudo-invariant calibration sites: two snow flats (~0.9 TOA Reflectance) and three desert sites, being illuminated by Moon Light. Lunar irradiance model from Miller and Turner, 2009 has been used to derive the TOA reflectance.

Applications of Day/Night Band

Aurora Activities during Severe Solar Storm Observed by SNPP DNB

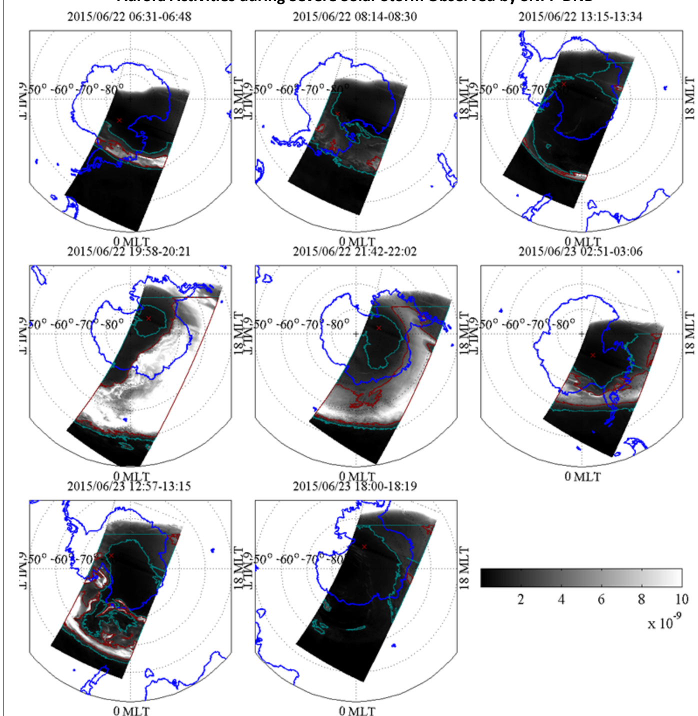

Figure 6: The DNB radiance map over southern hemisphere in solar-magnetic (SM) coordinates from UT 6:31 on June 22 to UT 18:19 on June 23, 2015. Two coronal mass ejections (CME) occurred on June 19 and 21, 2015 and had made their way to Earth to cause a G4 (severe) geomagnetic storm on June 22, 2015. Overall evolution of aurora such as initial appearance, growth, expansion and decay phases were observed in successive DNB overpasses. DNB observations monitored spatial and temporal variation of aurora activities and help understand particle/plasma flow and electromagnetic energy coupling in Sun-Magnetosphere-Ionosphere system during geomagnetic storms.

Deep Convective Cloud Observation under Moon Light

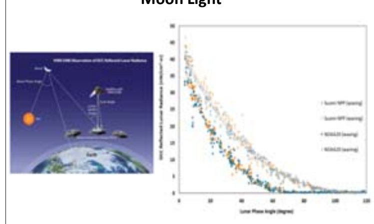

Figure 7: Night light observation of Deep Convective Cloud under moon light by DNB provides unique opportunity to perform inter-calibration of VIIRS DNB between SNPP and NOAA-20 using lunar radiances. (Cao et al., 2019)

DNB Observation of Lava Flow during Hawaii Kilauea Volcano Eruption

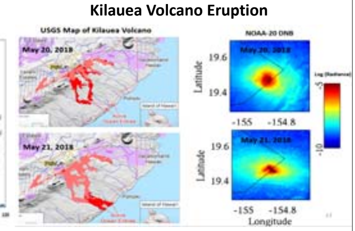

Figure 8: DNB data enable night time monitoring of natural disaster events. The observation of light emission from high temperature lava flow during Hawaii Kilauea volcano eruption by DNB shows the entry of lava into ocean on May 21, 2018, which is consistent with the in-situ measurements by USGS.

Global Event Impact Monitoring: Nocturnal Light Variation before and after Wuhan City Lockdown due to Coronavirus Outbreak

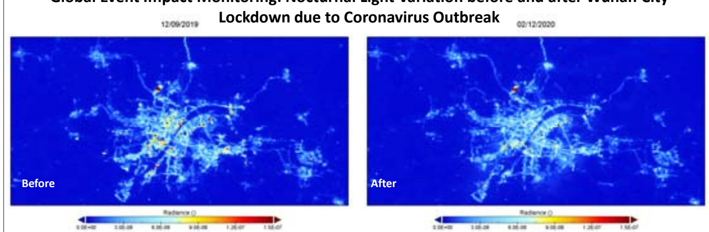

Figure 9: Comparison of night light distribution around Wuhan city, China observed by SNPP DNB before and after the coronavirus outbreak. City light reduction in both magnitude and spatial distribution after one third of city population left the city and with reduced socio-economical activities due to city lockdown on Jan. 23, 2020 can be clearly seen. DNB data provide unique capability for monitoring night light variation during global events.

Summary

- Maintained consistency between SNPP/NOAA-20 DNB stray light correction and recent DNB calibration algorithm update.
- Improved DNB data quality with updated stray light correction for SNPP by removing remnant stray light.
- Radiometric bias trending of SNPP and NOAA-20 DNB over pseudo-invariant calibration sites under moon light shows the radiometric consistency between SNPP and NOAA-20 DNB is within 3-5% with SNPP being higher. Part of the bias is due to the spectral response differences and the use of different solar irradiance spectra for DNB calibration. The rest may be from the calibration uncertainties.
- DNB observation of Deep Convective Cloud enables inter-calibration between SNPP and NOAA-20 DNB using lunar radiances.
- SNPP and NOAA-20 DNB data enable applications in monitoring large spatial scale and temporal variation of aurora light during severe solar storms, nocturnal light variation during global social event, and monitoring light emission variation during global natural disaster events such as lava flow due to volcano eruption.

References:

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