Land of the Rising Moon: The VIIRS Day/Night Band as a Path to Nocturnal Enlightenment

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Daytime measurements of reflected sunlight have been a mainstay of Earth-viewing environmental satellites observing systems, dating back to the first 'vidicon' cameras of the TIROS series. These observations enable detection and characterization of numerous surface and atmospheric parameters whose optical properties, defined by their intrinsic physical properties, respond in strong and diverse ways to the visible light spectrum. In the absence of sunlight (at night), optical-spectrum radiometers traditionally are limited to measurements of thermal infrared emission. While useful in their own right, the thermal bands suffer from relatively poor sensitivity and hence information content for many important weather and climate parameters. These deficiencies have, in turn, limited our ability to monitor and characterize the full diurnal behavior of parameters relevant to the improved, understanding and modeling of weather and climate processes. The challenges are particularly intense at high latitudes, where the dearth of sunlight in the polar winter may render conventional visible-band measurements obsolete for extended periods of time.

Visible-spectrum light information exists at night, originating from a wide variety of sources both natural and anthropogenic, but its detection requires specialized technology in order to achieve sensitivity to signals that typically are several orders of magnitude less than solar reflectance. Such a refined measurement technology has existed for many decades on U.S. Department of Defense satellite constellation, but the historically restricted access of those observations combined with the inherent limitations of the sensor's 1960-heritage spatial and radiometric resolution has precluded the full exploitation of the nocturnal light sources. This all changed with the launch of the Suomi National Polar-orbiting Partnership (S-NPP) satellite on 28 October, 2011. Suomi carries a Visible/Infrared Imaging Radiometer Suite (VIIRS), which includes a Day/Night Band (DNB) radiometer offering the first quantitative, highly advanced measurements of nocturnal visible light.

Here, we review through striking examples the paradigm shift in nocturnal low-light visible applications enabled by the S-NPP VIIRS/DNB. Via a combination of terrestrial and extraterrestrial light sources, we show that visible observations are indeed always available. These novel low-light measurements expand many currently daytime-relegated applications while at the same time illuminating a wealth of heretofore untrodden interdisciplinary research pathways (Miller et al., 2012) and enabling a suite of new operational applications (Miller et al., 2013). Even as the DNB expands our current world-view of what is possible, it provides key insight for the optimized design of next-generation low light visible sensors.

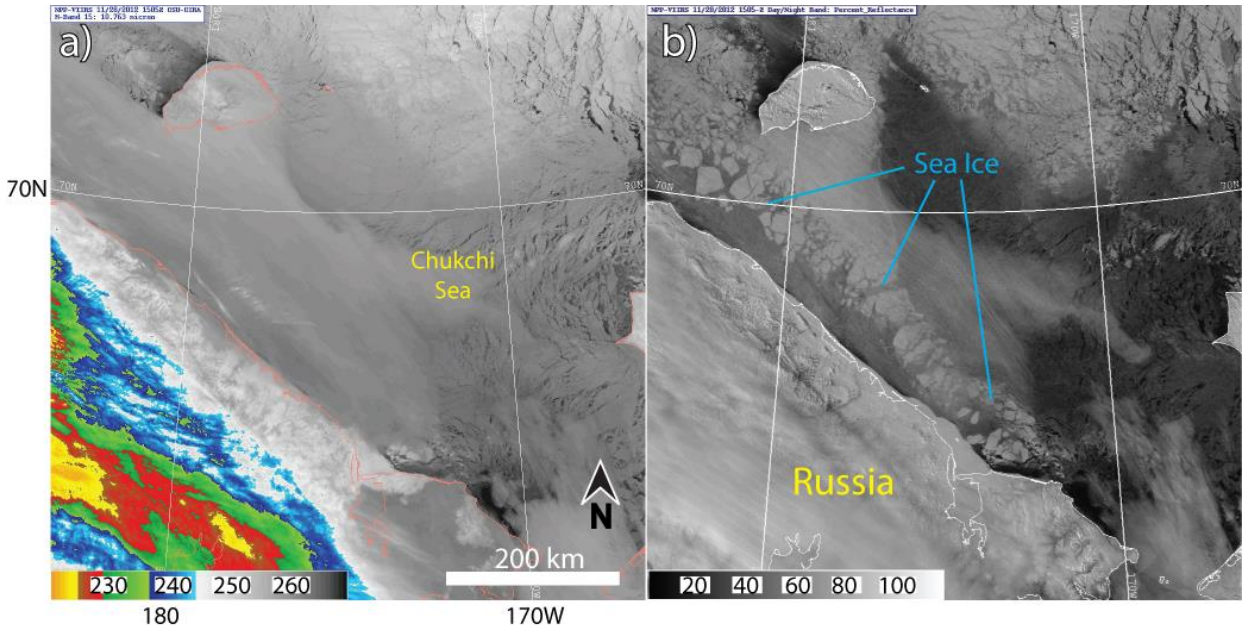

Figure 1. Comparison between (a) VIIRS/M15 thermal infrared imagery (kelvins) and (b) VIIRS/DNB lunar reflectance (%) imagery of sea ice in the Chukchi Sea on 28 November 2012, 1505 UTC. The DNB lunar reflectance imagery offers the unique ability to peer through semi-transparent clouds that are opaque at thermal infrared wavelengths, revealing the sea ice structures residing below them. (Miller et al., 2013)

References

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