Consistency of reflected moonlight based nighttime precipitation product with its daytime equivalent.

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Introduction

- Rain rate can be estimated with empirical methods from cloud optical properties derived by VIS/NIR measurements. Several publications show examples for daytime techniques to derive rain rate.
- The Daytime Cloud Optical and Microphysical Properties (DCOMP) is the official NOAA retrieval for GOES-ABI and VIIRS developed at University of Wisconsin.
- The Nighttime Lunar Cloud Optical and Microphysical Properties (NLCOMP) algorithm is a reflected-moonlight based retrieval for cloud optical properties Cloud Optical Thickness, Effective Radiative and Cloud Water path which measures first time also at night by VIIRS Day/Night band channel.
- This paper intends to demonstrate consistency between daytime and nighttime cloud and precipitation products.

Lunar Reflection in VIIRS Day/Night Band

- Moonlight is about 250,000 times dimmer than sunlight (approx. 10⁻¹⁴ W/m²sr). Current sensors (e.g. MODIS, VIIRS) are only able to detect signals around 10⁻¹⁰ W/m²sr.
- Day/Night band onboard NPP Suomi is the first sensor which is both sensitive to low-light in visible spectrum and providing a sufficient data depth with a 14-bit resolution.
- Steven Miller (CIRA, Fort Collins) developed a lunar irradiance model from which we can derive for the first time visible reflectance at night if illuminated by moon.
- Lunar reflectance is more complex than solar due to many components to consider (lunar phase, lunar spectral surface albedo, Moon-Sun-Earth geometry, lunar zenith angle etc.). Thus, we expect overall uncertainty from 5-12% depending on lunar phase.

Validation studies and global assessment shows good agreement between daytime (solar) reflectance and nighttime (lunar) reflectance. We sufficient global lunar reflectance coverage at about 60% of time for cloud property retrievals.

Nighttime Lunar Cloud Optical and Microphysical Properties retrieval (NLCOMP): The nighttime equivalent of DCOMP

- Standard approach for DCOMP simultaneous measurements in a visible and in an absorbing Near-IR channel (VIIRS M-12 channel at 3.75 micron)
- Use of solar reflectance, solar irradiance is known very accurately.
- NIR channel is in mixed solar/terrestrial region of spectrum around 3.8 micron.
- Forward model equation set for a given geometrical constellation is:

  \[ R_{\text{VIS}} = \frac{R_{\text{LS}}}{1 + R_{\text{LS}} - 1} \]

  \[ R_{\text{LS}} = \frac{c_{\text{LS}}}{c_{\text{LS}} + 1} \cdot \frac{c_{\text{LS}} + 1}{c_{\text{LS}} + 1 + \frac{c_{\text{LS}}}{c_{\text{LS}} + 1} - 1} \]

- Standard approach for NLCOMP simultaneous measurements in a visible (DNB) and in an absorbing Near-IR channel (VIIRS M-12 channel at 3.75 micron).
- Use of lunar reflectance. Lunar irradiance is not known accurately.
- NIR channel is in mixed solar/terrestrial region of spectrum around 3.8 micron.
- Forward model equation set for a given geometrical constellation is:

  \[ R_{\text{VIS}} = \frac{R_{\text{LS}}}{1 + R_{\text{LS}} - 1} \]

  \[ R_{\text{LS}} = \frac{c_{\text{LS}}}{c_{\text{LS}} + 1} \cdot \frac{c_{\text{LS}} + 1}{c_{\text{LS}} + 1 + \frac{c_{\text{LS}}}{c_{\text{LS}} + 1} - 1} \]

- NLCOMP retrieval lacks on the reflectance term in the forward model of the Near infrared channel.
- NLCOMP is implemented in CIMSS processing system CLAVR-x and provides routine results.
- Current version is limited to non-urban regions.

Conclusions and Outlook

- The new DNB channel of VIIRS offers observations of low-light signals in a visible channel during night.
- A lunar down-welling irradiance predictor was developed which enables us to use DNB lunar reflectance as an input of quantitative cloud retrievals.
- DNB products are a part of CLAVR-x output.
- Comparisons to daytime results demonstrates consistency between day and nighttime observations of COD.
- NLCOMP will help to close the nighttime observation gap of cloud optical properties and precipitation estimates. This will be especially valuable in high latitudes winter where cloud observations are missed for longer periods (example: clouds, icing and rain rate for Alaska).

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