Progress in Developing a Ground-Based Polarimetric Spectroradiometer to Support J1 VIIRS Validation
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Abstract

J1 VIIRS pre-launch testing showed polarimetric sensitivity that could lead to radiometric corrections on-orbit, which would rely on understanding the polarization states in the atmosphere. To aid in understanding this phenomenology, we developed a ground-based spectroradiometer for polarization measurements by combining an off-the-shelf spectroradiometer with a rotatable standard camera lens polarizer to allow polarized light into the spectroradiometer. Since these pieces do not combine easily, we built a customized adapter in-house - designed using open source software and built with a 3D printer. Preliminary measurements of the atmosphere using the spectroradiometer show stronger linear polarization (350 nm to ~650 nm) viewing 90º to the sun than towards the sun, which is consistent with polarization dominated by Rayleigh scattering. We plan to further improve the instrument and characterize the atmosphere over a larger range of sun and sensor positions and analyze the measurement uncertainties. This will improve our understanding of polarization states in the atmosphere and contribute to validation efforts of radiative transfer models used in any on-orbit corrections for J1 VIIRS.

Background

Pre-launch Polarization Sensitivity Measurements

- Rayleigh scattering linearly polarizes the sun's radiation according to its scattering angle, α:

\[
\text{DOLP} = \frac{1 - \cos^2(\alpha)}{1 + \cos^2(\alpha) - 2 \cos(\delta) \cos(\delta + \delta)}
\]

where DOLP is a degree of linear polarization and \(\delta\) is a depolarization factor.

- With the sensor viewing up and the sun on the horizon, the photons detected have been scattered at 90º, so are highly polarized.

Fig. 1: Un-DOLP image at 780 nm (© A. Pearlman, 2011)

Example of ground measurements of the full sky taken in the early morning on October 22, 2011.

-景象中的DOLP: 0.06

- Solar altitude: 23º

- Solar azimuth: 123º

- Sun at horizon, photons detected toward the sun

- Built the customized adapter in-house using a 3D printer

- Printed back to mitigate reflections

- Added threads to connect to fiber holder

- Assembled spectroradiometer for measuring polarization

Taking Measurements of the Atmosphere

- Used polarized sunglasses to locate direction of high and low polarization

- Sensor 90º to Sun

- Pointed sensor at 90º to the sun

- Measurement time: 5 minutes

- Sensor Towards Sun

- Pointed sensor towards sun but not in the field of view

- Measurement time: 4 minutes

Summary and Future Work

Summary:

- Designed and built a customized ASD-based polarimeter that provides a new capability for NOAA to investigate polarization phenomenology in support of J1 VIIRS.

- Preliminary sky measurements established confidence in the prototype design, which will act as a baseline for advancing atmospheric polarization research and development.

Future work:

- Improve the polarimeter design:
  - Add 3D printed part to decrease uncertainty in angle.
  - Add more control to stabilize polarization to increase efficiency.
- Conduct measurements to gain better understanding of polarization states and assess uncertainties:
  - Continuously measuring atmospheric parameters from sun angles.
  - Measure polarization of reflected Earth surfaces.
- Work with NIST to calibrate polarimeter.
- Validate atmospheric radiative transfer models.