Improved Ground-Based Polarization Sensitivity Measurement Capability for Next-Generation Environmental Remote Sensing Systems

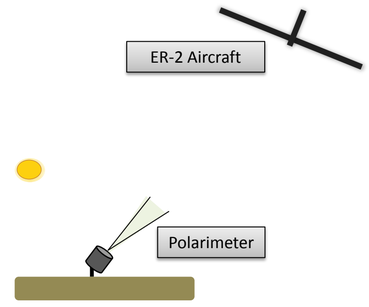
Aaron Pearlman[1], Francis Padula[2], Raju Datla[1], Changyong Cao[3], & Xiangqian Wu[3]

[1]ERT Inc., [2]GeoThinkTank LLC, [3]NOAA/NESDIS/STAR

Both the J1 Visible Infrared Imaging Radiometer that will be onboard the Joint Polar Satellite System (JPSS) spacecraft and the Advanced Baseline Imager that will be onboard GOES-R spacecraft showed polarization sensitivity in their pre-launch testing. This sensitivity influences retrievals of aerosol and ocean color products. In order to characterize performance impacts that could arise from polarization sensitivity effects on-orbit, an understanding of polarization phenomenology is necessary. Radiative transfer codes are typically used to evaluate polarization impacts, but further measurements are needed to validate such codes. We are continuing to develop a ground-based spectroradiometer for polarization measurements by combining an off-the-shelf spectroradiometer with an enhanced front-end design to measure varying linear polarization states. This improves our original design by extending the wavelength range and reducing measurement uncertainties. We plan on employing this instrument to support GOES-R and other field campaigns. Our progress in developing this new capability for NOAA/STAR is discussed through its phase 1 & 2 stages and will extend to phase 3 by conducting field measurements with the upgraded polarimeter.

Validation Efforts During Intensive Field Campaigns

- This instrument will be deployed in support of GOES-R intensive field campaign efforts to validate SI traceability of ABI observations and validate geophysical parameters for product retrievals.
- Supports L1b validation for improving the ability to retrieve ground and atmospheric properties that can then be used to generate L1b radiances for comparison to ABI.
- Diagnosing satellite instrument anomalies related to their polarization sensitivity requires an understanding of the polarized scenes.
- There are limitations in polarization modeling in radiative transfer codes. The measurement with the polarimeter will aid in understanding these limitations and perhaps lead to improvements in the models.



Phase 1 NOAA/STAR Capability Development: Proto-type Spectral Polarimeter

- The preliminary sky measurements acted as a baseline for advancing atmospheric polarization research and development.
- It used an ASD spectroradiometer with a customized polarizing filter adapter made in-house using a 3D printer.

<u>Issues found during proto-type testing:</u>

1. Suffered from high uncertainties due to the polarization sensitivity of the ASD spectroradiometer
2. Polarizing filter had low extinction and limited wavelength range
3. Did not include motor control of the polarizer rotation

3-D Printed Adapter

Initial Field Measurements

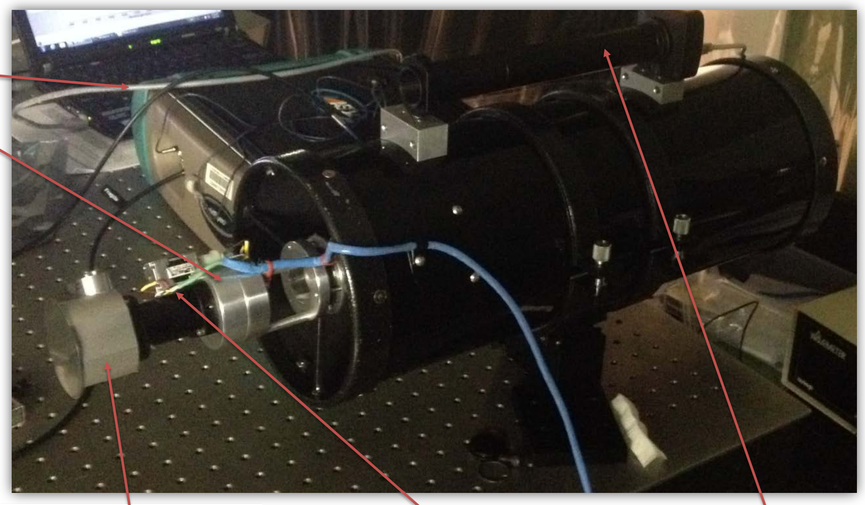
Phase 2 NOAA/STAR Capability Development: Upgrade of Spectral Polarimeter

ASD Spectroradiometer

Channels	Range (nm)	Resolution (nm)	Sampling (nm)	Detector Type	Detector Cooling
Visible Near IR	350-1000	1.4 @ 700 nm	1.4	Silicon Detector Array	None
Short Wave IR #1	1000-1830	10 @ 1400 nm	2	InGaAs Detector	TE-Cooled
Short Wave IR #2	1830-2500	10 @ 2100 nm	2	InGaAs Detector	TE-Cooled

Polarizer

manufacturer	Thor Labs
model	WP25M-UB
transmission range (nm)	250 - 4000



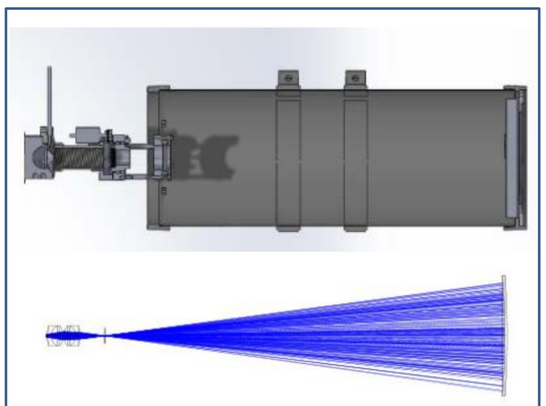
Integrating Sphere

manufacturer	Gigahertz-Optik
model	UPK-30-L
aperture diameter (mm)	5
interior diameter (mm)	30
material	ODM98

Stepper Motor

Guide Scope

clear aperture (mm)	21
focal length (mm)	200
field of view (10^{-3} radians)	25x35
sensor size (pixels)	1536x2048

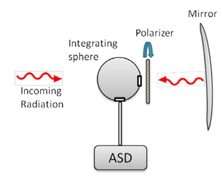


Polarimeter	
collection area (m^2)	0.015
primary focal length (mm)	500
field of view (10^{-3} radians)	25

The upgrade addresses the issues found in the proto-type design:

1. The integrating sphere randomizes the polarization after passing through the polarizer; this mitigates the polarization sensitivity issue of the proto-type model.
2. The high quality polarizer extends the wavelength range to cover the spectroradiometer's range (350-2500 nm).
3. The stepper motor allows for automation of the polarizer's rotation.

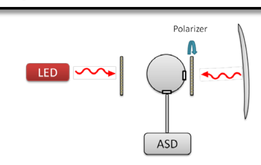
Incident radiation reflects off the mirror and propagates through the polarizer, integrating sphere, and collected by the ASD's fiber bundle.

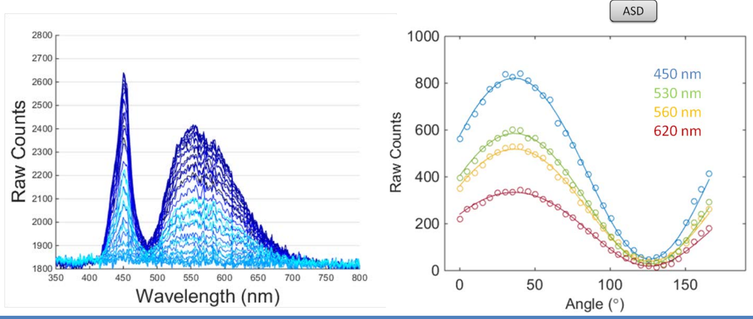


Phase 2 NOAA/STAR Capability Development: Lab characterization

Proof of Principle

Shows that the polarization state of incoming light is detected across the LED spectrum

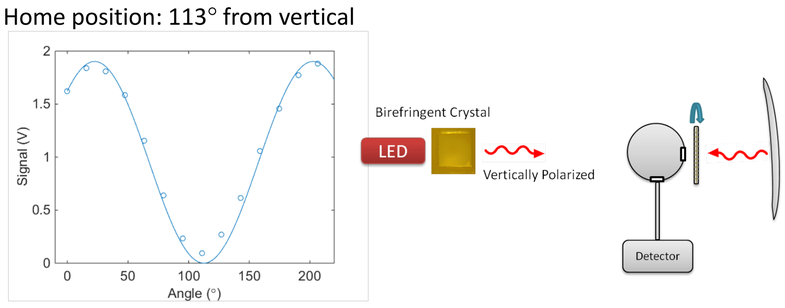




Orientation

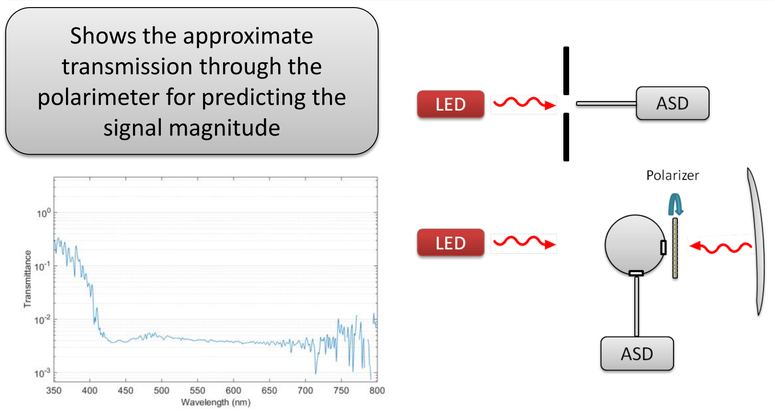
Shows the phase offset between the homing position of the polarimeter & vertical polarization

Home position: 113° from vertical



Transmittance

Shows the approximate transmission through the polarimeter for predicting the signal magnitude



Acknowledgments: S. Lorentz & A. Long at L-1 Standards & Technology, Inc.