Feasibility of Measuring Albedo with the Multifilter Rotating Shadowband Radiometer

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NOAA COOPERATIVE SCIENCE CENTER IN ATMOSPHERIC SCIENCES & METEOROLOGY
EDUCATION RESEARCH IMPACT

Abstract

Quantifying albedo is important as albedo provides the fraction of solar energy reflected from the surface back into the atmosphere. The ratio of diffuse and total irradiance provides measurable data on the earth's energy budget and changes within the climate. Increased levels of albedo cause a cooling effect on the earth due to a higher percentage of short-wave energy is reflected to space. The use of space-based instrumentation such as Moderate Resolution Imaging Spectroradiometer (MODIS) provides scientists with data that help determine the impact of clouds and aerosols on the Earth's energy budget. (NASA TERRA, 2020) We intend to use the Multi-Filter Rotating Shadowband Radiometer (MFRSR) to quantify surface albedo, which can be used for small scale validation of satellite inversions of albedo. The MFRSR is a sun photometer instrument that measures diffuse, direct, and total irradiance levels of solar radiation. Prior to using the MFRSR to quantify albedo, this study will examine the various influences on the measurement of albedo and gain a better understanding of how well the MFRSR can quantify albedo. Retrievals of aerosol and cloud optical depth, total column water vapor, and ozone can be quantified from these measurements. The ratio of diffuse and total irradiance carries information about the albedo of the surface surrounding the instrument.

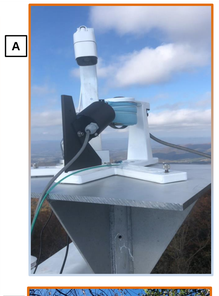
Introduction

- This study analyzed the feasibility of retrieving albedo with the MFRSR using NASA's Planetary Spectrum Generator (PSG) to simulate the ratio of diffuse and total irradiance. Additionally, the PSG measurements examined the sensitivity of this ratio to various parameters. These parameters include the uncertainty in the atmospheric profile of aerosols, water vapor and the potential contamination due to the mounting structure of the MFRSR.
- Our goal is to establish acceptable uncertainty levels for these and other parameters to acquire useful measurements of albedo from MFRSR measurements.

Methods

- 27SEP19 Emplaced Equipment (MFRSR, grounding rods, fiber, power source, and webcam)
- 22OCT19 completed MFRSR emplacement
- 07DEC19 First time webcam removed to test changes in Diff to Tot ratios
- 19DEC19 Clear Day measurements selected to use in Diff/Tot ratio comparison
- 08AUG20 Second time webcam removed to test changes in retrieval due to reflectivity from webcam surface

A



B

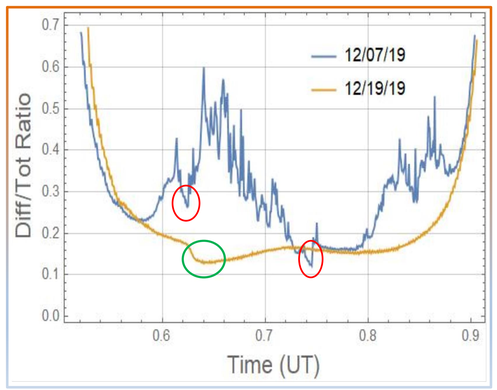
- Modeled MFRSR retrievals from SEP19-DEC20 using Wolfram Mathematica
- Modeled NASA's PSG retrievals at f range 300nm, resolution 2nm, albedo 0.30/0.80, emissivity 0.90, and Zenith angles at Looking up (Diffuse) and Looking Solar (Total)
- PSG Config files created; PSG Output files modeled in Mathematica to compare MFRSR sensitivity to albedo

C

Pinnacles Research Site, Shenandoah National Park

A. MFRSR and Webcam
B. Tower at 3000ft where components mounted
C. Base Station

Results



https://www.wolfram.com/mathematica

- Clear Day 12/19/19 vs Cloudy day 12/07/19 ratio
- Ratio indicates increased scattering due to cloud cover
- Effects on 12/19/19 indicates potential interference from surroundings (metal, webcam reflectivity, and other instruments) on tower
- MFRSR Diff/Tot ratios indicate correlation with PSG Diff/Tot radiative transfer model

Data and Graphs

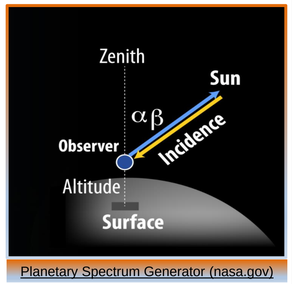
	414	500	614	673	869
Alb-0.3	0.158845	0.0689409	0.0294663	0.00724407	0.00724407
Alb-0.8	0.211085	0.0915085	0.0390702	0.00966699	0.00966699
R0.3/R0.8	0.752518	0.752725	0.75419	0.749361	0.749361

https://www.wolfram.com/mathematica

- Diffuse and Total irradiance ratio measurements for clear day samples
- Results show sensitivity to albedo across Nasa's Planetary Spectrum Generator to that of MFRSR
- Ratios indicate albedo is spectrally independent

Research Questions

- What is the minimum albedo that can be measured by the MFRSR?
- How well do aerosols need to be characterized to provide accurate albedo?
- What is the most suitable installation location for MFRSR to reduce interference (metal, other instruments, reflection)?
- What simulations need to be run to accurately match MFRSR measurements?



Planetary Spectrum Generator (nasa.gov)

Conclusion

- The MFRSR effectively retrieved direct and diffuse irradiance values through narrowband channels (414, 500, 614, 673, and 869 nm) and provided, through inner-calibration, total global irradiance measurements. These measurements were compared to the retrievals provided by NASA's PSG.
- The PSG provided a radiative transfer models of synthesized planetary and atmospheric spectra. The results indicate that the retrieved albedo ratios are spectrally independent.
- Future simulations will test the PSG zenith angle to ensure it properly correlates with the MFRSR surface albedo

References

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