Polarization of Skylight

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Randomly polarized sunlight becomes partially polarized by scattering from the gas molecules of the atmosphere. This scattered skylight exhibits a spatial polarization pattern with maximum Degree of Linear Polarization (DoLP) forming an arc 90° from the sun. The example shown in Figure 1 is an all-sky image of DoLP, or percentage of polarization measured at each point in the sky. This image is from an all-sky polarization imager developed at Montana State University in Bozeman, Montana USA. The colors indicate the DoLP, ranging from zero for random polarization and one for complete (100%) linear polarization (the sun is located on the right side, behind the occulting band shown here as a blue arc). Although Rayleigh scattering theory predicts a maximum DoLP of 1.0, the maximum rarely rises higher than 0.7 because of multiple scattering by gas molecules, aerosols (particles suspended in the air), the ground, and clouds.

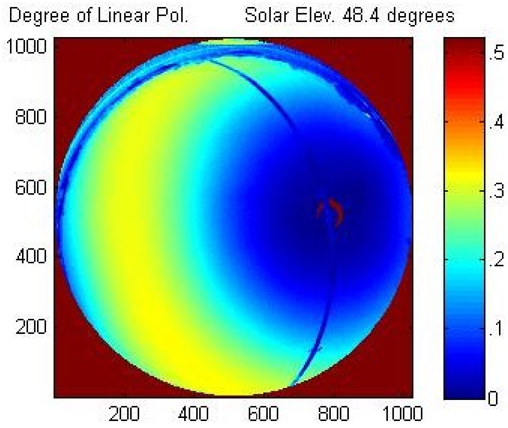

Figure 1. All-sky image of the Degree of Linear Polarization (DoLP) for a cloud-free sky.

The Montana State University all-sky polarization imaging system uses a pair of liquid crystal variable retarders with a fixed linear polarizer to electronically record images at four different polarization states at a wavelength selected with a rotating filter wheel. Measurements from this system have been combined with measurements of aerosols and ground reflectance to create a model, which allows us to numerically explore the variation of polarization with atmospheric and ground optical properties. This model has revealed an intriguing spectrum of skylight polarization that behaves quite differently in the visible-near-infrared (VNIR) spectral range of 400-1000 nm and the shortwave-infrared (SWIR) spectral range of 1000-2500 nm. Skylight polarization tends to increase slowly at longer VNIR wavelengths and then decrease at SWIR wavelengths beyond about 1000 nm. The dominant physical parameter for predicting the spectrum of skylight polarization is the aerosol optical depth for VNIR wavelengths and the aerosol size distribution for SWIR wavelengths, but ground reflectance is also a major influence at all of these wavelengths.