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Monitoring Earth's Climate with Shortwave Hyperspectral Reflectance

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The Sun provides nearly all the energy that fuels the dynamical, chemical, and biological processes in the Earth system. Absorbed solar radiation, the difference between incoming and reflected sunlight, defines Earth's equilibrium temperature and, along with the emitted infrared radiation, determines the climate state of the planet. The transfer of solar radiation through the atmosphere is modulated by wavelength-specific interactions that are unique for a given surface type and the intervening atmospheric gases and condensed species. Reflected radiation that exits the Earth's atmosphere carries with it the complex fingerprint of the Earth system state. How this signal varies temporally, spatially, and spectrally is a measure of those processes within the Earth system that affect climate change. Despite its importance to the basic energy balance between Earth and the solar-terrestrial environment in which it resides, a precise record of the nature of reflected solar spectral radiation over all climate-relevant time scales remains elusive.

A primary goal of a climate observing system is to obtain climate benchmark data records with sufficient accuracy for identifying climate variability on decadal time scales and longer, and with sufficient information content to attribute change to underlying causes. Until recently, detecting climate change signatures in reflected solar radiance has been hindered by instrument accuracy and stability, insufficient spectral coverage and resolution, and inherent sampling limitations from low-Earth orbit observations. This paper discusses the challenges to monitoring the shortwave energy budget from space. We will present new studies on methods to separate the various contributions in the top-of-atmosphere outgoing shortwave radiance using existing satellite data and we explore methods to enhance trend detection in hyperspectral reflectance time series. Finally, we look ahead to the requirements for a climate observing system for monitoring shortwave hyperspectral reflectance.