Title: Is There Ecological Information in Optical Polarization Data?

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Abstract

Optical linear polarization? In remote sensing it's due to specular reflection. The first surface that incident light encounters – a smooth water surface or the waxy first surface of a leaf's cuticle, if it's even somewhat smooth (i.e. shiny) – will specularly reflect and linearly polarize the incident light. We provide three examples of the types of ecological information contained in remotely sensed optical linear polarization measurements.

Remove the surface reflection to better see the interior. The linearly polarized light reflected by leaf surfaces contains no information about cellular pigments, metabolites, or water contained in the leaf interiors of a plant canopy, because it never enters the leaf interior to interact with them. Thus, for purposes of remotely sensing the leaf interiors of a plant canopy, the linearly polarized light should be subtracted from the total reflected light, because including it would add noise to the measurement. In particular 'minus specular' vegetation indices should allow improved monitoring of a plant canopy's physiological processes.

Estimate plant development stage and yield. Wheat and sorghum grain heads, following emergence, rapidly extend upward and very quickly tower over nearby leaves, partially blocking our view of the sunlight reflected by those leaf surfaces. The resulting decrease in the amount of surface reflected and polarized sunlight, if monitored over time, potentially allows per-field estimates of the dates of the heading and flowering development stages to be interleaved with weather data in models, which is key to better estimating per-field grain yield. Similar polarization changes may occur in other grasses, such as oats, barley, corn and rice, each a crop so widely grown that it potentially affects climate at the regional scale.

Wetlands Mapping. The sunlight specularly reflected by surface waters is blindingly bright, spectrally flat and polarized – all of which telegraphs that the ground area is inundated. Inundated soils exchange methane with the atmosphere; non-inundated soils, carbon dioxide. Aquatic plants growing through the water surface pipe the soil-produced methane via the stomata to the atmosphere, enhancing exchanges rates by factors of 10-20 compared to ebullition (bubbling) or diffusion through the water column to the atmosphere. Thus, mapping wetland areas into three community types - inundated areas with emergent vegetation, open water and uplands - provides potentially key information to water, carbon and energy budgets at landscape to global scales.