Interpreting vegetation condition from satellite observations: accounting for the influence of water availability

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Abstract: Vegetation condition is important in landscape dynamics with implications for the state of ecosystems and carbon, energy and water fluxes in the landscape. Understanding the state of vegetation condition through time and space is valuable for assessing the health of ecosystems, informing planning and conservation. Vegetation closely interacts with the water cycle and climate system, both by modulating water, energy and carbon fluxes as well as by being impacted by water availability and climate. Vegetation condition can be expressed using a range of attributes depending on the intended use and the information available. Relevant attributes include; species richness (e.g. species count or genetic diversity), vertical (strata) and lateral (patches, variation) structure, and material stocks (e.g. biomass or carbon) and fluxes (carbon, water, energy). Selecting relevant attributes is dependent on of the question at hand, and which specific ecosystem function or services are being investigated. The quality of selected ecosystem attributes is typically assessed by comparison against benchmark or reference sites. These benchmark sites are selected as "undisturbed" analogue ecosystems, pre-disturbance conditions, natural climax condition based on ecological succession theory or optimal resource use based on ecohydrological principles.

Here we propose an approach to measure vegetation condition using remote sensing and satellite observations. Previous efforts to map vegetation condition using image data exploit regionally derived statistical relationships between field observations and spatial vegetation metrics derived from the imagery. The reliance on field data and moderate to high resolution imagery that is not systematically acquired makes these techniques unsuitable for routine assessments. Our intention is to develop a framework that provides systematic and accurate measures of native vegetation condition with the eventual aim of applying the methodology to a system of national environmental accounts.

Numerous studies, including those that exploit satellite observations, have demonstrate the fundamental relationship between precipitation and a range of vegetation properties including leaf area index, fractional cover, evapotranspiration, and primary productivity. These relationships are curvilinear with thresholds in the response of vegetation to ever increasing precipitation. These relationships have been exploited by recent advances in understanding the interaction of precipitation, vegetative cover, evapotranspiration and runoff. These advances typically build upon the Budyko framework, an established and simple approach for understanding mean annual evapotranspiration (ET) and runoff within large catchments. The framework is useful in predicting fractions of ET and runoff but does not provide insight into how vegetation impacts on these discrete partitions or vice versa. Developing the Budyko framework further, researchers have attempted to account for the impact of vegetation (e.g. Zhang Curves and Budyko-Choudhury-Porporato model) and also to overcome some of the steady state assumptions that restrict the framework to broad spatial and large temporal scales. Many of these advancements also rely on the principles of ecohydrology that dictate an evolutionary drive to optimize the exploitation of available resources.

We propose that the recent revisions to the Budyko framework, developed to understand the impact of vegetation on evapotranspiration and runoff, can also offer an insight into the impact of resource availability and other environmental pressures, on vegetation condition. The ability to examine the relationship between precipitation and vegetative properties using satellite observations and other spatial datasets offer the ability for comparisons and benchmarking across increasing spatial and temporal resolutions. This will enable tends in vegetation conditions to be observed and hopefully measured across space and time with the eventual aim that this information can inform environmental accounts at a national scale.

Keywords: *Vegetation condition, remote sensing*