Scaling plant physiology for Earth System Models (ESMs)

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Abstract

Ecosystem and Earth System Models (EESMs) require detailed information on ecosystem states and canopy properties in order to properly represent the carbon (C) cycle and simulate the fluxes of C, water and energy from the land to the atmosphere as well as address the vulnerability of ecosystems to environmental and other perturbations. Moreover, EESM uncertainty is currently dominated by model parameter uncertainty stemming from inadequate representation of plant traits. Over the last several decades the amount of available data to constrain ecological predictions has increased substantially, resulting in a increasingly data-rich era for global change research. Remote sensing approaches, particularly spectroscopy, imaging spectroscopy (IS) and thermal infrared (TIR) data, represent a synoptic observational dataset capable of capturing broad-scale spatial and temporal dynamics in many important vegetation properties related to terrestrial ecosystem functioning, offering a an important and direct data constraint on ecosystem model projections.

Here we highlight ongoing work as part of the Next Generation Ecosystem Experiment (NGEE) Arctic (NGEE-Arctic) and developing Tropics (NGEE-Tropics) projects, as well as the ongoing NASA HyspIRI Airborne Campaign (http://hyspiri.jpl.nasa.gov/airborne), to develop a generalized framework for scaling and mapping plant physiological traits with remote sensing approaches including the quantification of uncertainties in trait estimates. Specifically, we are focusing on key vegetation properties related to C uptake, water and energy fluxes,

as well as nutrient cycling, including biochemical (e.g. leaf N, lingo-cellulose), morphological (e.g. leaf mass area, LMA), and physiological (e.g. $V_{c,max}$ and J_{max}) traits that drive model representation of gross and net primary productivity For example, preliminary results, at the leaf level, indicate a strong capacity to generalize the relationship between spectral optical properties and LMA across global biomes from the Arctic to the Tropics. In general our results, across a range of scales, highlight the potential to develop general algorithms for a number of key traits needed for EESM model parameterization or initialization, as well as for capturing broad-scale responses of ecosystems to environmental perturbations. This approach provides the data products necessary to enable a transformational change in representation of plant traits in next generation EESMs.