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The contribution of soil, topographic, and vegetation traits to plant-water sensitivity

Alexandra Konings[1], Krishna Rao[1], Meng Zhao[1], A. Park Williams[2], Noah Diffenbaugh[1], and Marta Yebra[3]

[1]Stanford University, Stanford, CA, United States of America (konings@stanford.edu)
[2]University of California, Los Angeles, Los Angeles, CA, United States of America
[3]The Australian National Universty, Acton, Australian Capital Territory, Australia

Spatio-temporal patterns of plant water uptake, loss, and storage are a first-order control on photosynthesis, evapotranspiration dynamics, and thus, land-atmosphere interactions. These patterns depend on temporally variable hydrometeorological conditions but also on geographically varying characteristics. These include, but are not limited to, topographic and soil properties that influence rainfall infiltration and water distribution in the unsaturated zone and vegetation properties, such as rooting depth, stomatal and xylem properties, leaf area, and more. Understanding how these different factors interact to control the overall dynamics of plant water uptake is fundamental to understanding the response of vegetation to hydrologic variations, but has traditionally been hindered by data limitations. In situ measurements are too sparse to sufficiently span the range of possible variations across different geographic factors. Remote sensing estimates of plant water uptake either are not available or (in the case of ET estimates) are sufficiently indirect that they are unlikely to correctly account for all of the factors above. Here, we study the effects of different geographic factors on plant-water interactions by analyzing the dynamics of live fuel moisture content (LFMC, defined as the vegetation water content divided by dry biomass) determined from Sentinel-1 synthetic aperture radar and Landsat multispectral observations. LFMC directly reflects vegetation water content and therefore patterns of plant water uptake and evapotranspiration. We quantify the "plant-water sensitivity" by using an auto-regressive model comparing LFMC to climate and analyze the spatial patterns of plant water sensitivity at 4 km resolution across the Western United States. No individual factor explains a majority of the spatial patterns in plant-water sensitivity. With the exception of the maximum soil conductance, no soil, topographic, or vegetation traits exerts a dominant control on plant water sensitivity. However, when aggregated, soil characteristics explain about twice as much variability in plant water sensitivity as topographic or plant characteristics do, despite little previous recognition of the influence of soil hydraulic properties on plant-water interactions.