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A Global Picture of the Depth and Origin of Soil Water Uptake by Vegetation

Gonzalo Miguez-Macho[1] and Ying Fan[2]
[1]Fac. de Física, Universidade de Santiago de Compostela, Santiago de Compostela, Galicia, Spain (gonzalo.miguez@usc.es)
[2]Dep. of Earth and Planetary Sciences, Rutgers University, Piscataway, NJ, USA

Plants play a fundamental role in the climate system, not only as important components of the global water and carbon cycles, but because they provide a key link between water stores in the deep soil and the atmosphere. Vegetation has evolved strategies to cope with droughts, such as the existence of deep roots allowing for the shifting of water uptake to deeper layers storing past precipitation, as water from more recent precipitation on top is depleted and not replenished. Here we ask the following question: To what extent is the soil water uptake source for vegetation the recent rain reaching shallow soils, or past wet-season rain stored in deep soils, or past rain that reached the water table, which sends the water back up through capillary flux, or past rain that flowed down the topographic gradient from ridges to valleys (i.e. upland to lowland subsidy)? We address this question through (a) a synthesis of 528 observations of stable isotopes of O/H in plant xylem and source waters, compiled from the literature, and (b) a dynamic high-resolution (1km) model representing the global soil-plant-atmosphere continuum at the global scale by explicitly coupling land surface-groundwater and root uptake, driven by reanalysis atmosphere and observed leaf area. Both model and isotope methods reveal that plant use of past precipitation is globally widespread and particularly significant in semi-arid or seasonally dry climates and lowland ecosystems. Seasonal shifting to deeper uptake tapping past precipitation in dry periods is common even in wetter climates. The model results allow us to further distinguish among past precipitation stored as deep soil water or from local or remote groundwater sources. Our findings shed critical lights on the depth and origin of the water supporting global photosynthesis, hence their resilience or vulnerability to seasonal-interannual droughts across the globe and vegetation response to climate change.