Soil moisture plays crucial role in delineating and forecasting agricultural and meteorological drought

Sumanta Chatterjee[1,2], Ankur R. Desai[3], Jun Zhu[4], Philip A. Townsend[5], Jingyi Huang[1,*]

[1]Department of Soil Science, University of Wisconsin-Madison, Madison, WI 53706, USA

[2]ICAR-National Rice Research Institute, Cuttack 753006, India, ORCID ID: 0000-0003-4805-5732

[3]Department of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison, Madison, WI 53706, USA

[4]Departments of Statistics and Entomology, University of Wisconsin-Madison, Madison, WI 53706, USA

[5]Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, Madison, WI 53706, USA

Abstract

Drought is a recurring and extreme hydroclimatic hazard with serious impacts on agriculture and overall society. Delineation and forecasting of agricultural and meteorological drought are essential for water resource management and sustainable crop production. Agricultural drought assessment is defined as the deficit of root-zone soil moisture (RZSM) during active crop growing season, whereas meteorological drought is defined as subnormal precipitation over months to years. Several indices have been used to characterize droughts, however, there is a lack of study focusing on comprehensive comparison among different agricultural and meteorological drought indices for their ability to delineate and forecast drought across major climate regimes and land cover types. This study evaluates the role of RZSM from Soil Moisture Active Passive (SMAP) mission along with two other soil moisture (SM) based indices (e.g., Palmer Z and SWDI) for agricultural and meteorological drought monitoring in comparison with two popular meteorological drought indices (e.g., SPEI and SPI) and a hybrid (Comprehensive Drought Index, CDI) drought index. Results demonstrate that SM-based indices (e.g., Palmer Z, SMAP, SWDI) delineated agricultural drought events better than meteorological (e.g., SPI, SPEI) and hybrid (CDI) drought indices, whereas the latter three performed better in delineating meteorological drought across the contiguous USA during 2015–2019. SM-based indices showed skills for forecasting agricultural drought (represented by end-of-growing season gross primary productivity) in the early growing seasons. The results further confirm the key role of SM on ecosystem dryness and corroborate the SM-memory in land-atmosphere coupling.

Keywords: SMAP; aridity index; gross primary productivity; soil moisture memory; climate regimes; land cover types;