scientific data

OPEN

DATA DESCRIPTOR

SMAP-HydroBlocks, a 30-m satellite-based soil moisture dataset for the conterminous US

Noemi Vergopolan[1] ✉, Nathaniel W. Chaney[2], Ming Pan[1,3], Justin Sheffield[4], Hylke E. Beck[5], Craig R. Ferguson[6], Laura Torres-Rojas[2], Sara Sadri[7] & Eric F. Wood[1]

Soil moisture plays a key role in controlling land-atmosphere interactions, with implications for water resources, agriculture, climate, and ecosystem dynamics. Although soil moisture varies strongly across the landscape, current monitoring capabilities are limited to coarse-scale satellite retrievals and a few regional *in-situ* networks. Here, we introduce SMAP-HydroBlocks (SMAP-HB), a high-resolution satellite-based surface soil moisture dataset at an unprecedented 30-m resolution (2015–2019) across the conterminous United States. SMAP-HB was produced by using a scalable cluster-based merging scheme that combines high-resolution land surface modeling, radiative transfer modeling, machine learning, SMAP satellite microwave data, and *in-situ* observations. We evaluated the resulting dataset over 1,192 observational sites. SMAP-HB performed substantially better than the current state-of-the-art SMAP products, showing a median temporal correlation of 0.73 ± 0.13 and a median Kling-Gupta Efficiency of 0.52 ± 0.20. The largest benefit of SMAP-HB is, however, the high spatial detail and improved representation of the soil moisture spatial variability and spatial accuracy with respect to SMAP products. The SMAP-HB dataset is available via zenodo and at https://waterai.earth/smaphb.

Background & Summary

Detailed and accurate information on the spatiotemporal distribution of soil moisture is important for numerous applications, such as monitoring of drought[1–3] and crop irrigation demands[4–6]; mapping antecedent conditions that trigger wildfires[7,8], landslides[9,10], and flooding[11,12]; and quantifying water, energy, and carbon fluxes between the land and atmosphere[13–15]. Depending on the landscape heterogeneity, such physical processes can occur at the 1–100 m spatial scale, at which *in-situ* sensors could provide detailed information. However, *in-situ* observations' representativeness can be limited to only a few meters from the sensors, they are costly to deploy and maintain, and therefore are not widely available at continental extents.

With satellite observations increasingly available[16], optical and near-infrared satellite sensors (e.g., MODIS, Landsat, and Sentinel-2) can provide proxies for estimating soil moisture at high spatial resolution (10–250 m)[17–19]. However, estimates from these sensors can suffer attenuation from the atmosphere, high cloud coverage, dense vegetation, and infrequent revisit time (~1–2 weeks). Alternatively, passive microwave sensors were designed to penetrate through clouds and dense vegetation to retrieve surface soil moisture with a 25–50-km spatial resolution and 2–3-days revisit time[20–25]. NASA's Soil Moisture Active-Passive mission[22] (SMAP), for example, has a 36-km spatial resolution (or 9 km via the resampled SMAP L3 Enhanced[23,26] product). Combining such passive sensors with a active sensor (e.g., Sentinel-1) and/or assimilating them into physical models can provide estimates with a 1–3-km[27,28] and 9–25-km[29–32] spatial resolution, respectively. These capabilities critically contributed for aiding regional- to global-scale water resources applications[33,34]. However, they still lack the spatial detail and accuracy necessary for local-scale (1–100 m) applications[3,35,36]. Thus, despite the increased demand, obtaining high-resolution data at continental extents remains a challenge.

[1]Princeton University, Department of Civil and Environmental Engineering, Princeton, NJ, United States. [2]Duke University, Department of Civil and Environmental Engineering, Durham, NC, United States. [3]Center for Western Weather and Water Extremes, Scripps Institution of Oceanography, University of California, San Diego, CA, United States. [4]Southampton University, School of Geography and Environmental Science, Southampton, United Kingdom. [5]GloH2O, Almere, the Netherlands. [6]University at Albany, State University of New York, Atmospheric Sciences Research Center, Albany, NY, United States. [7]University of Saskatchewan, Global Institute for Water Security, Saskatoon, Canada. ✉e-mail: noemi@princeton.edu