Montana Mesonet and SMAP Products Support Multi-Layer Soil Moisture and Drought Forecasts

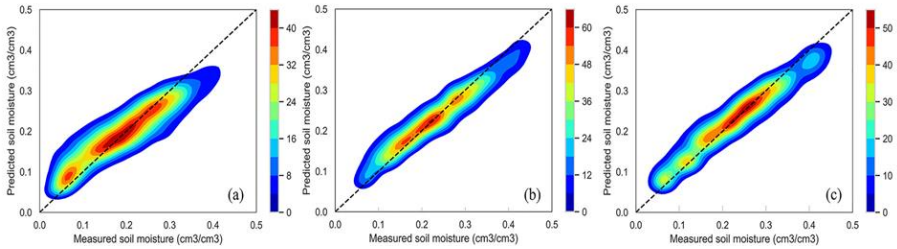
Motivation: Despite the substantial agricultural and economic losses that flash droughts can cause, operational forecasts of these types of events are not currently available. Timely forecasts of soil moisture (SM) spatial distribution and vertical profiles are essential for early detection and prediction of flash droughts.

Methods: Satellite-driven machine-learning used to build relationships between in-situ multi-layer SM measurements from the Montana Mesonet, a regionally dense environmental station network in the US upper Missouri and Columbia basins, and geospatial predictors, including (a) SMAP soil moisture (SPL3SMP_E), (b) satellite radar and optical-infrared observations, and (d) NWP forecasts.

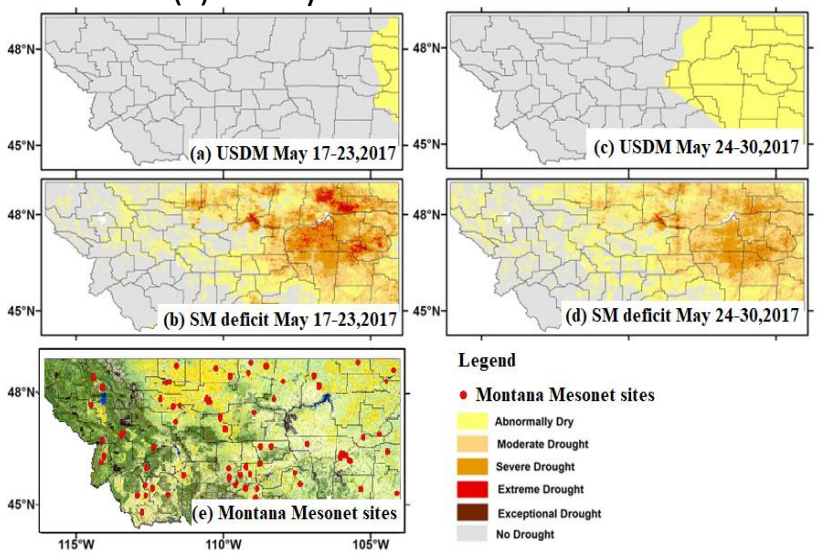
Findings: The resulting 30-m daily SM predictions showed high consistency with in-situ measurements at 4-, 8- and 20-inch depths, and with 1- to 2-week forecast lead times (R> 0.91; RMSE≤0.047 cm^3/cm^3).

The SM deficit forecasts successfully depicted the onset, progression, and termination of the 2017 Montana flash drought.

Impact: New capacity for local-scale flash drought forecast enabled from SMAP and machine-learning.



Comparisons between in-situ SM measurements and predictions at 1-week lead time for 4-inch (a), 8-inch (b), and 20-inch (c) soil layers.



USDM drought severity for May 17–23, 2017 (a) compared with 1-week lead time forecasts of 4-inch SM deficit (b); and USDM maps for 24–30 May 2017 (c) compared with 2-week lead time forecasts of 4-inch SM deficit(d) derived using machine-learning and Montana Mesonet (e) .

Du et al., 2024: Machine-Learning Based Multi-Layer Soil Moisture Forecasts—An Application Case Study of the Montana 2017 Flash Drought, *WRR*.