Estimating Soil Moisture in Semiarid Sagebrush Steppe Utilizing NASA Earth Observations

Abstract

Soil moisture is a critical component of ecosystem health, particularly in semi-arid landscapes where seasonal and infrequent precipitation is one of the primary controls on vegetative health. Current land management practices of soil moisture data collection rely on costly and time-consuming field sampling or on extensive modeling. The introduction of remotely sensed soil moisture measurements from NASA Earth observations (EO) will provide low-effort, high spatio-temporal coverage datasets for management agencies such as our primary partners at the US Fish and Wildlife Service (USFWS). Validating remotely-sensed data with field observations from Reynolds Critical Experimental Watershed (RCEW) in Idaho will increase the confidence in remotely sensed soil moisture data. This project evaluated methods for monitoring soil moisture in semi-arid ecosystems using data from NASA Soil Moisture Active Passive (SMAP) sharpened with European Space Agency (ESA) Sentinel-1 C-Band Synthetic Aperture Radar (C-SAR) backscatter, Global Precipitation Measurement (GPM), Terra Moderate Resolution Imaging Spectroradiometer (MODIS) derived Normalized Difference Vegetation Index (NDVI), and modeled soil moisture from TopoFire for the period between December 2016 to July 2018. The Idaho NASA DEVELOP team created useful maps and established a workflow to allow land managers to easily access and visualize soil moisture in their area of interest. Linear regression analysis was used to quantify correlations between soil moisture, precipitation, and vegetation health. Preliminary correlation between SMAP and *in situ* soil moisture were positive at all sites, but results fell into three categories: 60% had a moderate correlation at good confidence, 25% had a high correlation at high confidence, and 15% had a low correlation at low confidence.
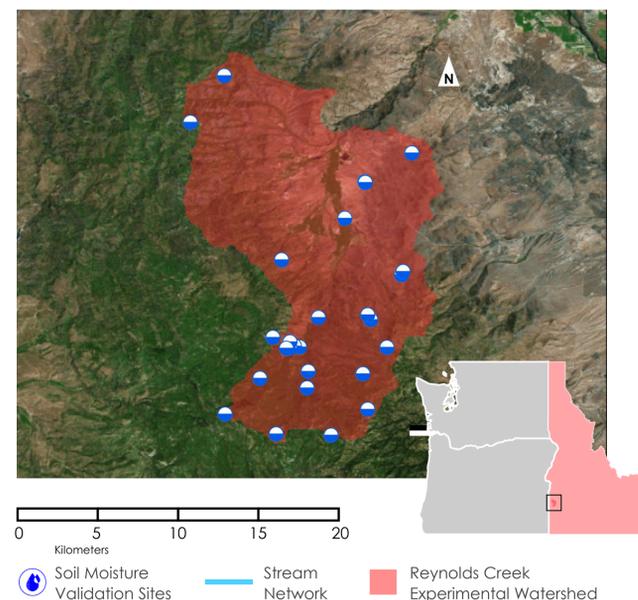
Objectives

- **Evaluate** the application of enhanced SMAP soil moisture estimates for semi-arid sagebrush steppe in the Intermountain West

- **Validate** Sentinel-1 enhanced SMAP maps against *in situ* soil moisture measurements, precipitation maps, and vegetation indices

- **Develop** a replicable workflow/methodology to access SMAP measurements, perform comparisons to other indices, and output useful maps and statistics

Study Area
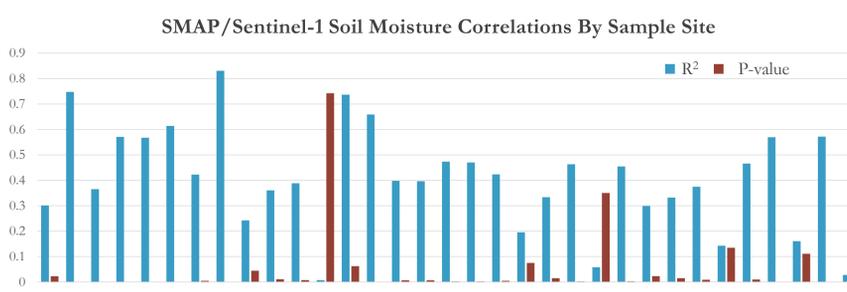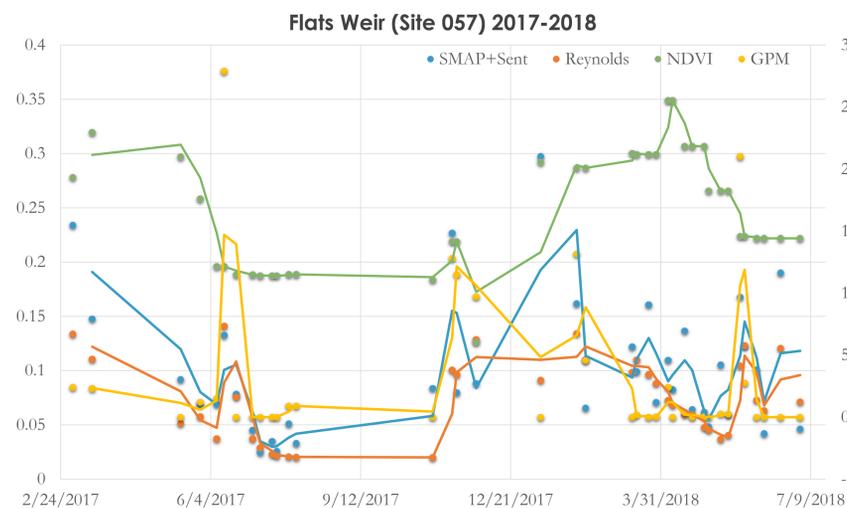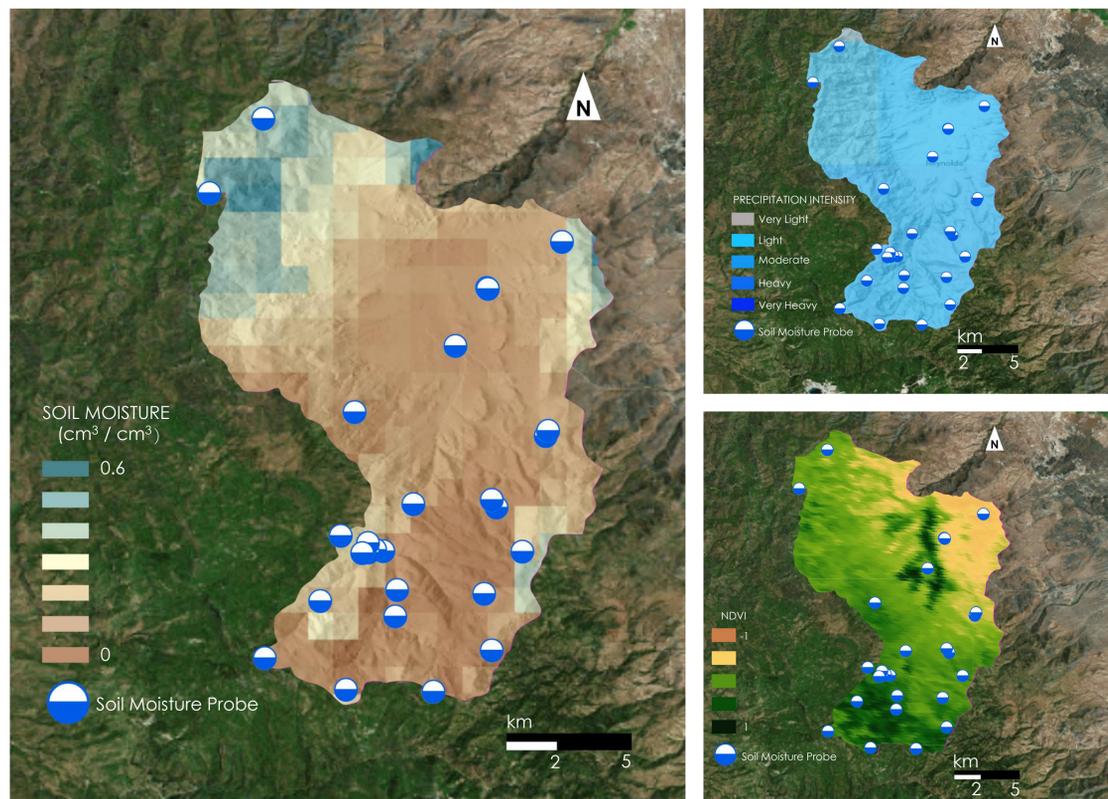

- Soil Moisture Validation Sites
- Stream Network
- Reynolds Creek Experimental Watershed

Earth Observations

SMAP • Terra MODIS • GPM • Sentinel-1 C-SAR

Methodology

In situ soil moisture, GPM, NDVI →

Google Earth Engine: Combine GEE and *in situ* data; extract values at RCEW sites →

SMAP/Sentinel-1 Soil Moisture →

ArcPro: Clip to study area, extract point data for RCEW sites →

Compare *in situ* soil moisture and precipitation, NDVI, and GPM precipitation to SMAP soil moisture estimates →

Produce soil moisture maps and correlation plots

Results

SOIL MOISTURE (cm³ / cm³): 0.6 — 0 · Soil Moisture Probe

PRECIPITATION INTENSITY: Very Light, Light, Moderate, Heavy, Very Heavy · Soil Moisture Probe

NDVI: -1 to 1 · Soil Moisture Probe

Flats Weir (Site 057) 2017-2018 — SMAP+Sent, Reynolds, NDVI, GPM

SMAP/Sentinel-1 Soil Moisture Correlations By Sample Site — R², P-value

Conclusions

- SMAP and Sentinel-1 1 km soil moisture data products and *in situ* soil moisture measurements show a moderate to high positive correlation in 85% of sample sites.

- The sample sites with high uncertainty (P-values above 0.05; representing 15% of all observations) may be due to intrapixel variability, slope and elevational differences, or other regional variations.

- Future studies can use these methods and incorporate evapotranspiration estimates for improved hydrologic modelling.

Team Members

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