Early Results of the Soil Moisture Active Passive Marena Oklahoma In Situ Sensor Testbed (SMAP-MOISST)

Michael H. Cosh[1]and Tyson Ochsner[2]
USDA-ARS-Hydrology and Remote Sensing Laboratory, Beltsville, MD
Dept of Plant and Soil Science, Oklahoma State University, Stillwater, OK

Abstract

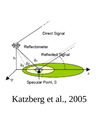
The Soil Moisture Active Passive Mission (SMAP) is an upcoming NASA mission to monitor surface soil mositure. Key to the success of this mission is the calibration and validation of the resulting product. As part of the calibration and validation program for SMAP, an ambitious intercomparison study was initiated to determine how soil moisture sensors vary with respect to measuring a long term in situ time series. The Marena Oklahoma In Situ Sensor Testbed (MOISST) was installed in May of 2010, with other instrumentation added more recently. There are more than 200 sensors installed over an approximately 64 hectare pasture in Central Oklahoma. There are 4 main stations with multiple sensors installed in a profile. Sensors located at the site include a COSMOS system, GPS reflectometers, and a passive DTS system. Additional sensor systems are also installed which represent the Oklahoma Mesonet and the NOAA Climate Reference Network stations. This diverse set of sensors will provide guidance on the aggregation of soil moisture networks worldwide into a single soil moisture data record. In support of the time series, regular sampling of gravimetric soil moisture and vegetation water content were conducted to determine an absolute ground truth. A full year of data is available for study which has yielded several conclusions regarding how different sensors perform in space and time. Early conclusions will be presented, including accuracy, calibration, reliability, and scalability.

Project Team

- Lead Scientist: Michael Cosh (USDA-ARS-Beltsville)
- Local Lead: Tyson Ochsner (Oklahoma State Univ.)
- Field Managers: Chris Stansbury (OSU) and Lynn McKee (ARS)
- Sensor Leads
  - Base Stations: Michael Cosh
  - COSMOS: Marek Zreda (U.Ariz)
  - GPS Reflectometers: Eric Small/John Braun (UCAR)
  - Mesonet/Flux: Jeff Basara (OU-OCS)
  - CRN: Michael Palecki (NOAA)
  - Passive DTS: John Selker (OSU), Susan Steele-Dunne (Delft Univ.)
  - TDR: Steve Evett (USDA-ARS-Bushland) and Tyson Ochsner (OSU)

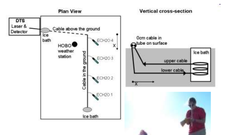
New Sensors/Networks

COSMOS – COsmic ray Soil Moisture Observing System uses a neutron counting system to measure broken down water molecules as a proxy for moisture at the surface and root zone (~30 cm).



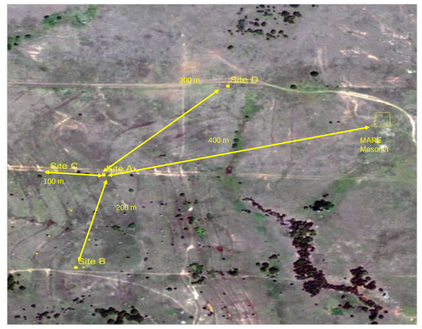
Katzberg et al., 2005

GPS Reflectometry - Using full GPS stations which measure tectonic movement and taking the reflections at the horizon to estimate soil moisture in the foreground.



Passive Distributed Temperature Sensor Systems (PDTS) – Long buried cabling at various depths can estimate on a high spatial scale, the moisture content immediately surrounding the wire.

Testbed Design: Marena, Oklahoma



The initial criteria for the site was a 700 m short grass area to accommodate the COSMOS sensor. Long term access to a short grassland site was the goal to maintain the site until SMAP launches.

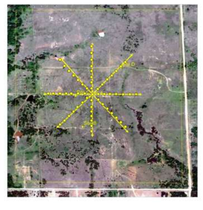
The testbed was organized around Base Sites which would hold a variety of sensors at different depths. There are 4 Base Sites, and additional instrumenation was added to these facilities.

Site A	Site B	Site C	Site D
Base	Base	Base	Base
GPS	ASSH	GPS	GPS
COSMOS	Passive DTS		CRN
ASSH			
TDR systems			

- Common depths of 5, 10, 20, 50, 100 cm, with some sampling at 2.5 cm with Hydra.
- Base station sensors
  - Stevens Water Hydra Probes (6)
  - Delta-T Theta Probes (5)
  - Decagon EC-TM probes (5)
  - Sentek EnviroSMART Capacitance Probes (4)
  - Campbell CS615/CS616 TDRs (5)
  - CS 229-L heat dissipation sensors (OK Mesonet) (5)
  - Acclima Sensor (5)

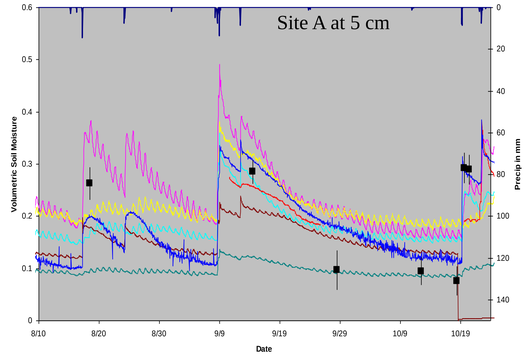
Validation Sampling Campaigns

Satellite programs for soil moisture require that the product be validated to a physically collected soil moisture standard. These electronic proxy measurements must therefore also be validated with physically collected samples. A series of campaigns were developed to provide adequate information for validation and calibration of the sensors. In addition to soil moisture, vegetation samples were collected to help in modeling the information from the COSMOS and GPS sensors.



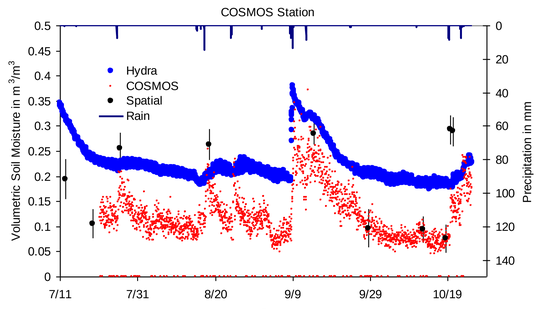
- Monthly Sampling
  - Vegetation Collection
  - Gravimetric Sampling
  - Theta Probe Sampling
- Intensive Observations
  - High Density Sampling
  - Soil Profiles

Preliminary Results

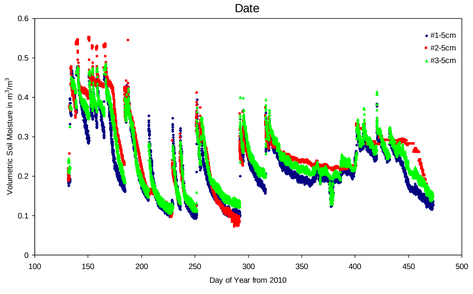


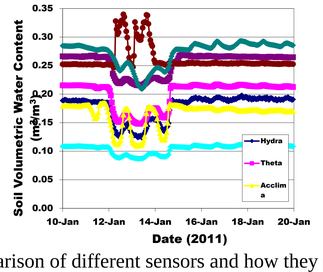
A comparison of the sensors at a depth of 5cm. There are dramatic variations in sensor response, but these are un-calibrated and improvement is expected when calibrations are completed in the spring of 2011. Validation samples are plotted with standard deviations

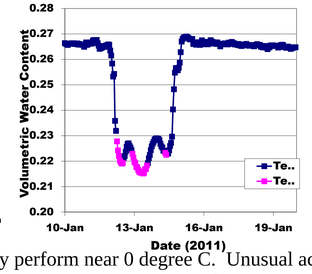
Early results of the COSMOS sensor to gravimetric collections demonstrate that there is a response to precipitation events. Also plotted is the Site A uncalibrated surface Hydra probe soil mositure for reference.



Early results of the co-located Climate Reference Network Hydra probe installation.







A comparison of different sensors and how they perform near 0 degree C. Unusual activity occurs prior to 0, which means a high resolution time series is important for accurate monitoring.