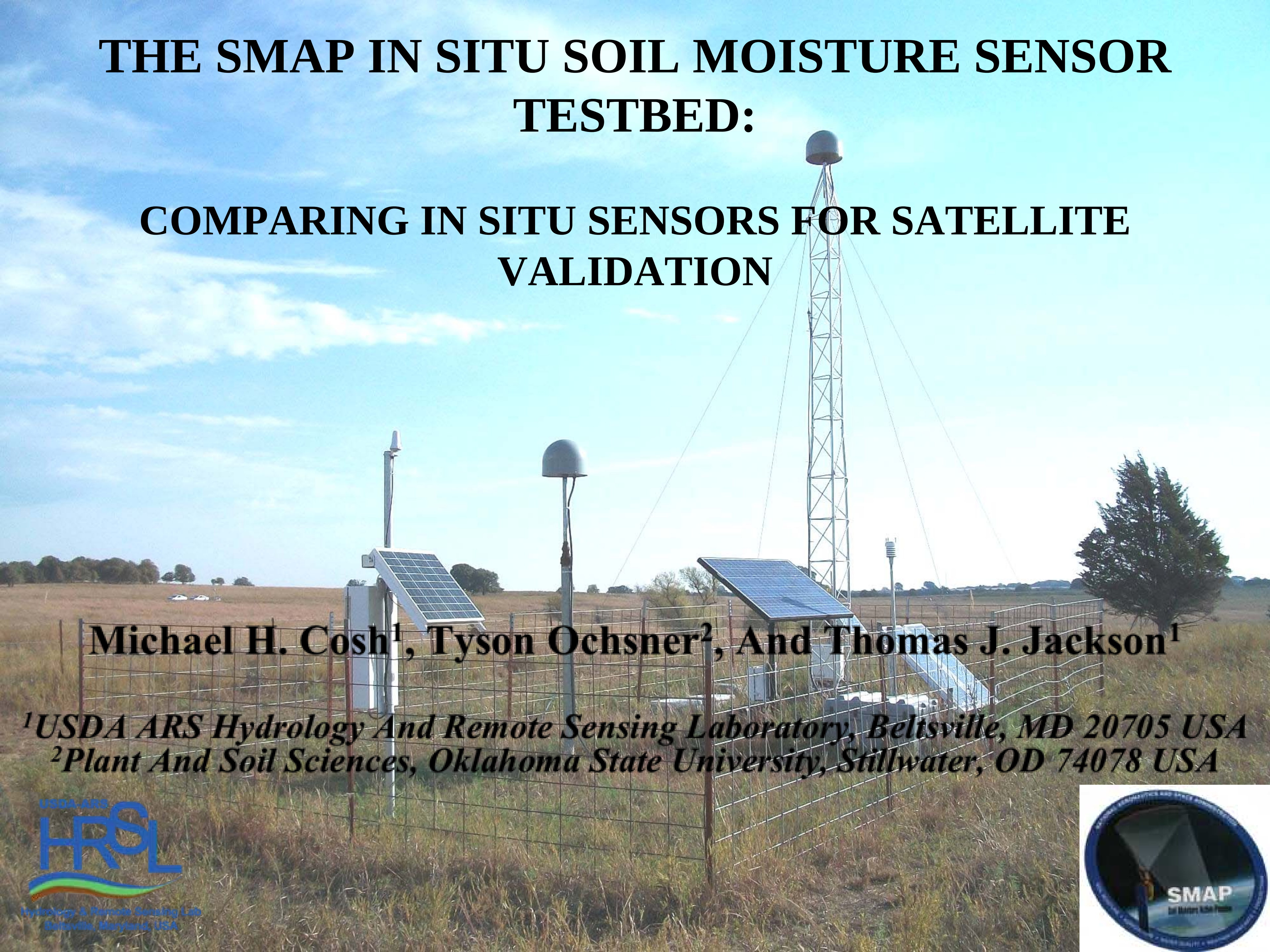

THE SMAP IN SITU SOIL MOISTURE SENSOR TESTBED:

COMPARING IN SITU SENSORS FOR SATELLITE VALIDATION

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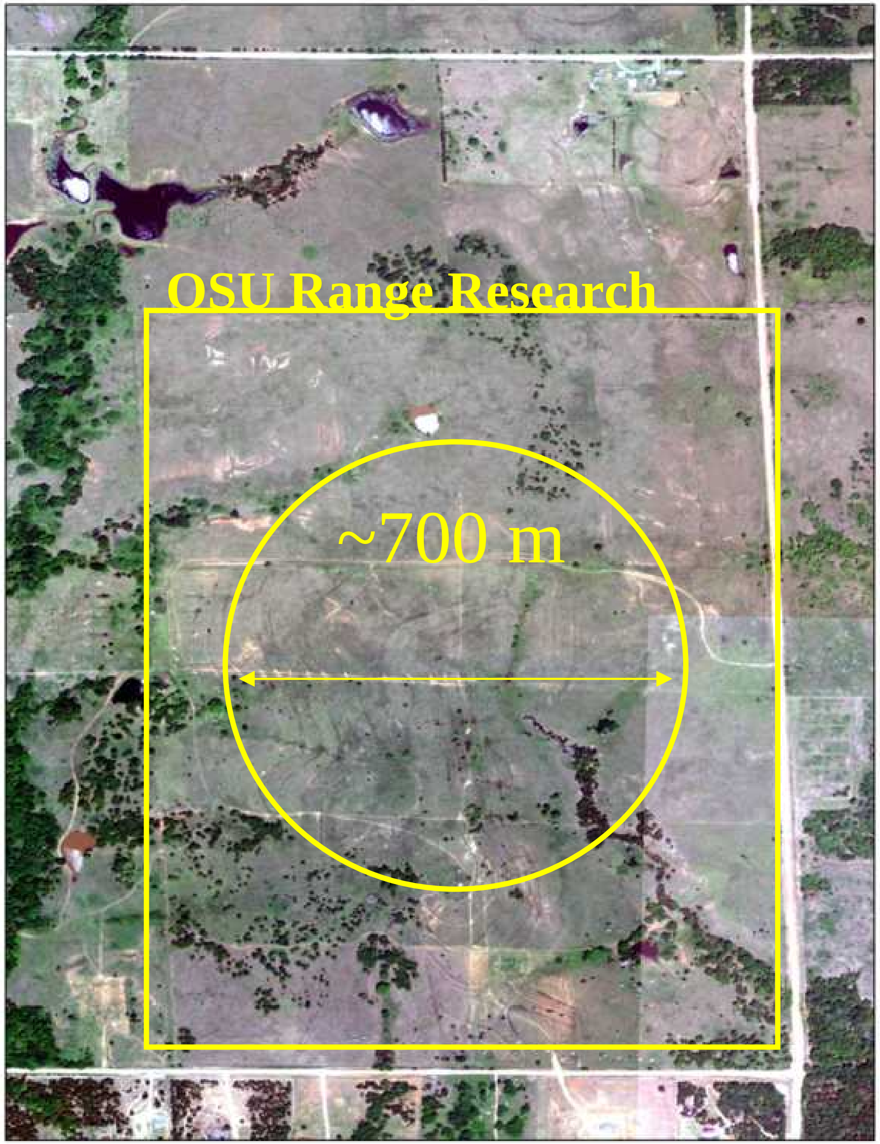
[2]Plant And Soil Sciences, Oklahoma State University, Stillwater, OD 74078 USA

Testbed Team

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

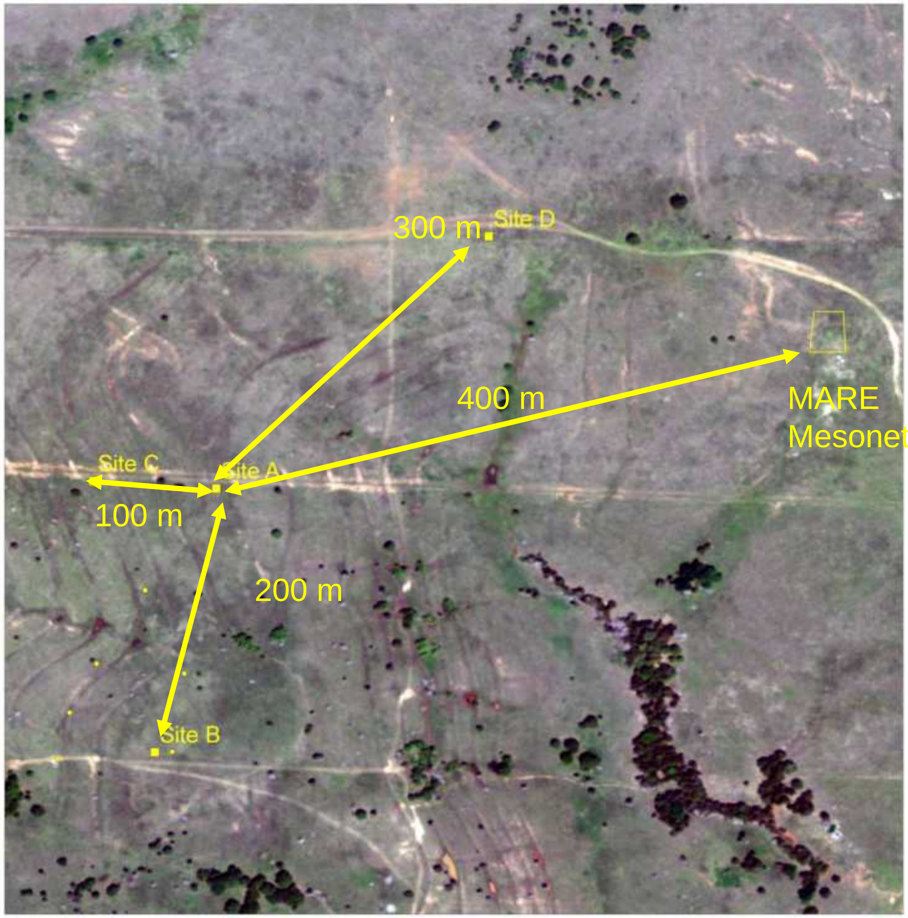
Site Selection

- Managed by OSU Range Research Station
- Local support from OSU Dept. Plant and Soil Science
- Rangeland/Pasture
- Co-located with Oklahoma Mesonet MARE site
- Two NOAA CRN stations nearby (1 additional installed on site)
- Long Term Access ~ 6 years
- >700 m Domain for COSMOS



SMAP In Situ Sensor Testbed
Marena Site Design

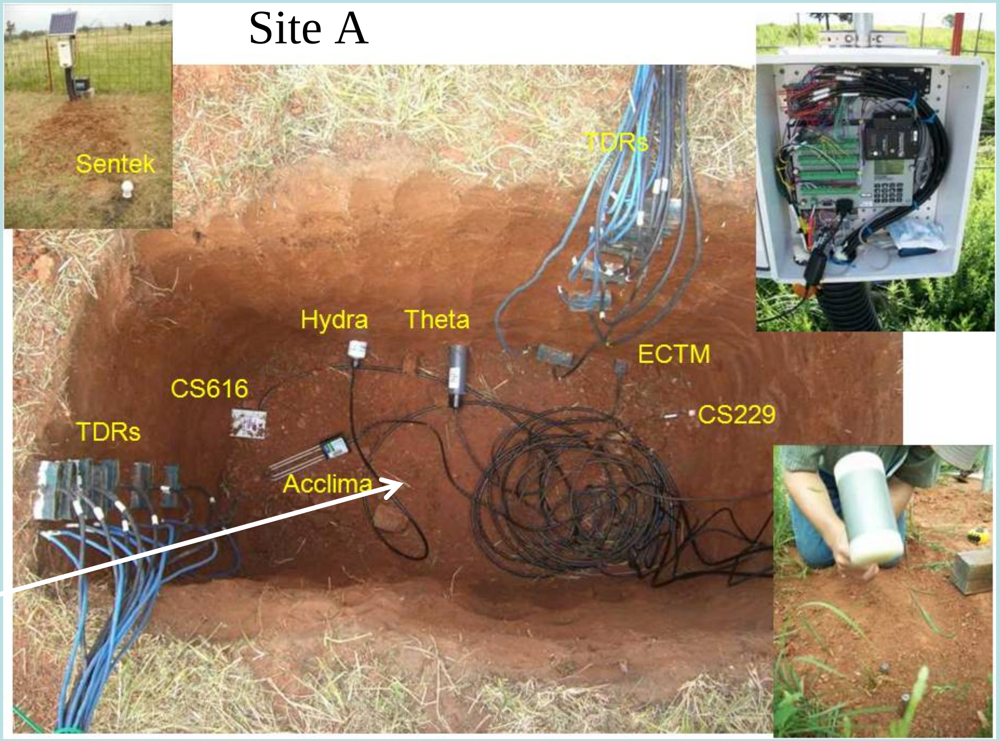
- Tradeoff between replication and resources
- 4 base stations with the same set of instruments plus some site specific sensors.
- Common depths of 5, 10, 20, 50, 100 cm, with some sampling at 2.5 cm with Hydra.
- Base station sensors
  - Stevens Water Hydra Probes (6)
  - Delta-T Theta Probes (5)
  - 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)



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

Installation

- Installation in May 2010



Site Management

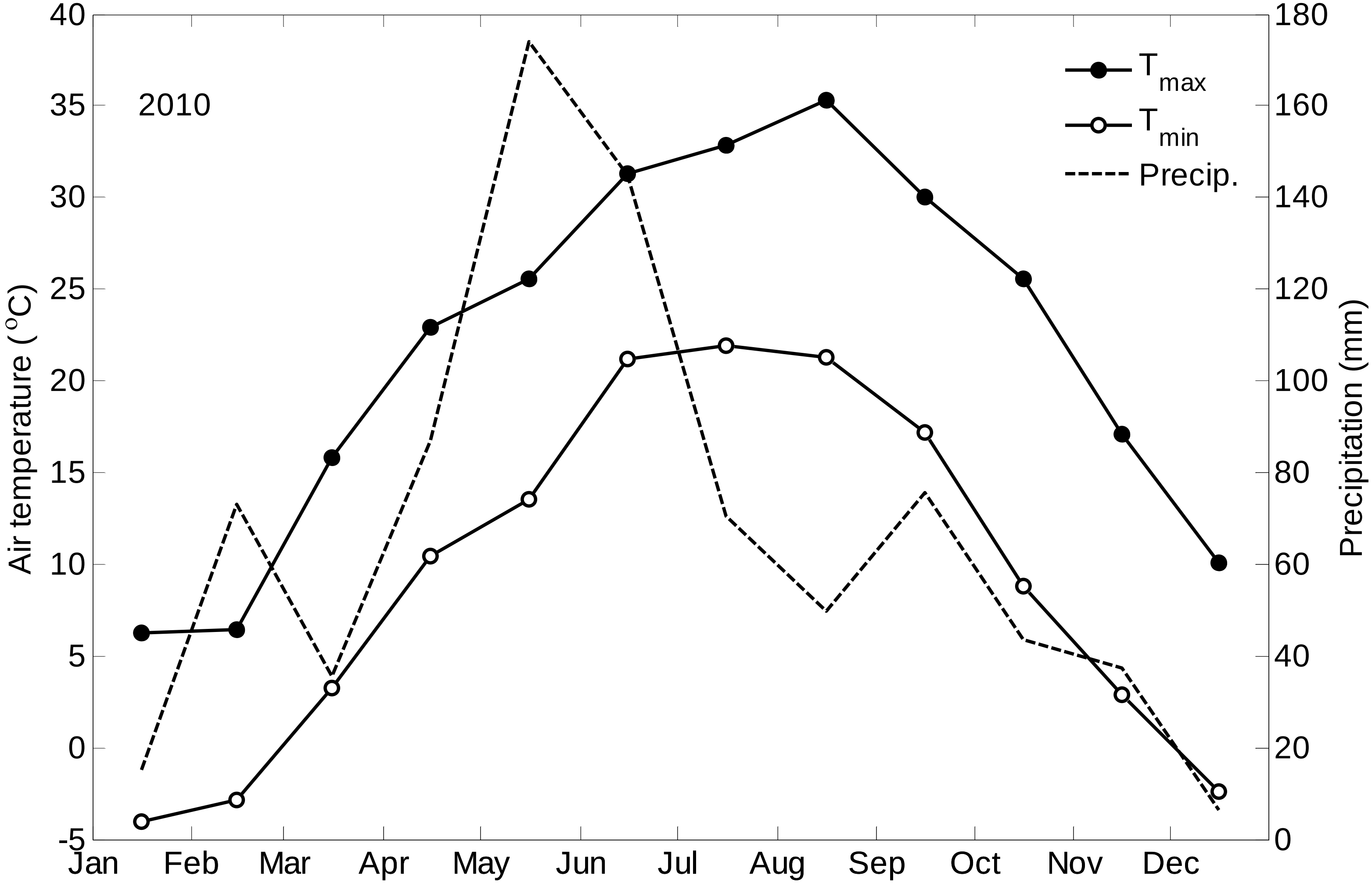
OSU Range Research Station

Chris Stansberry
Station Superintendent

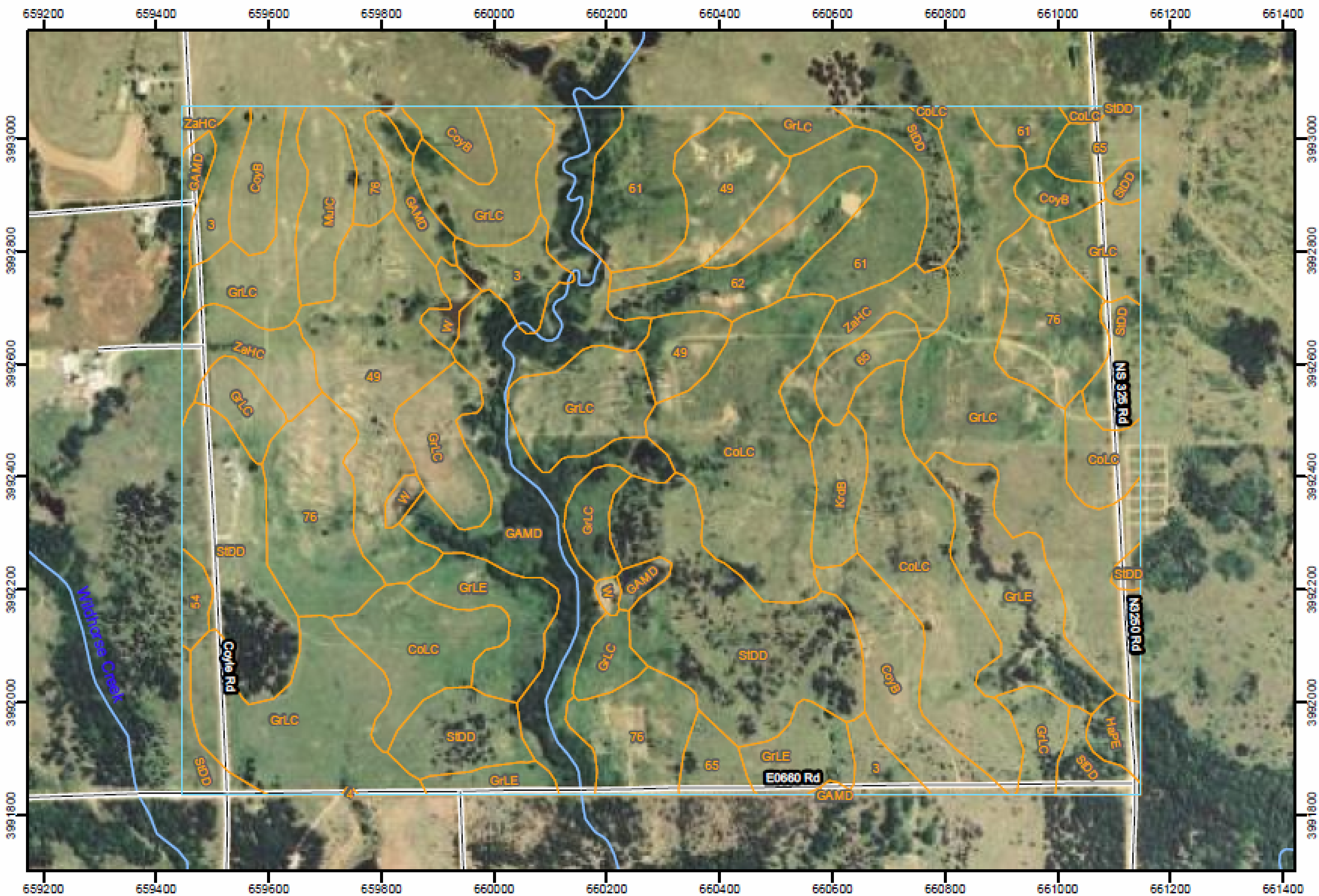
Grazed at moderate stocking rate
3 ha animal^{-1}

Controlled burns for ecological function
3 year return interval

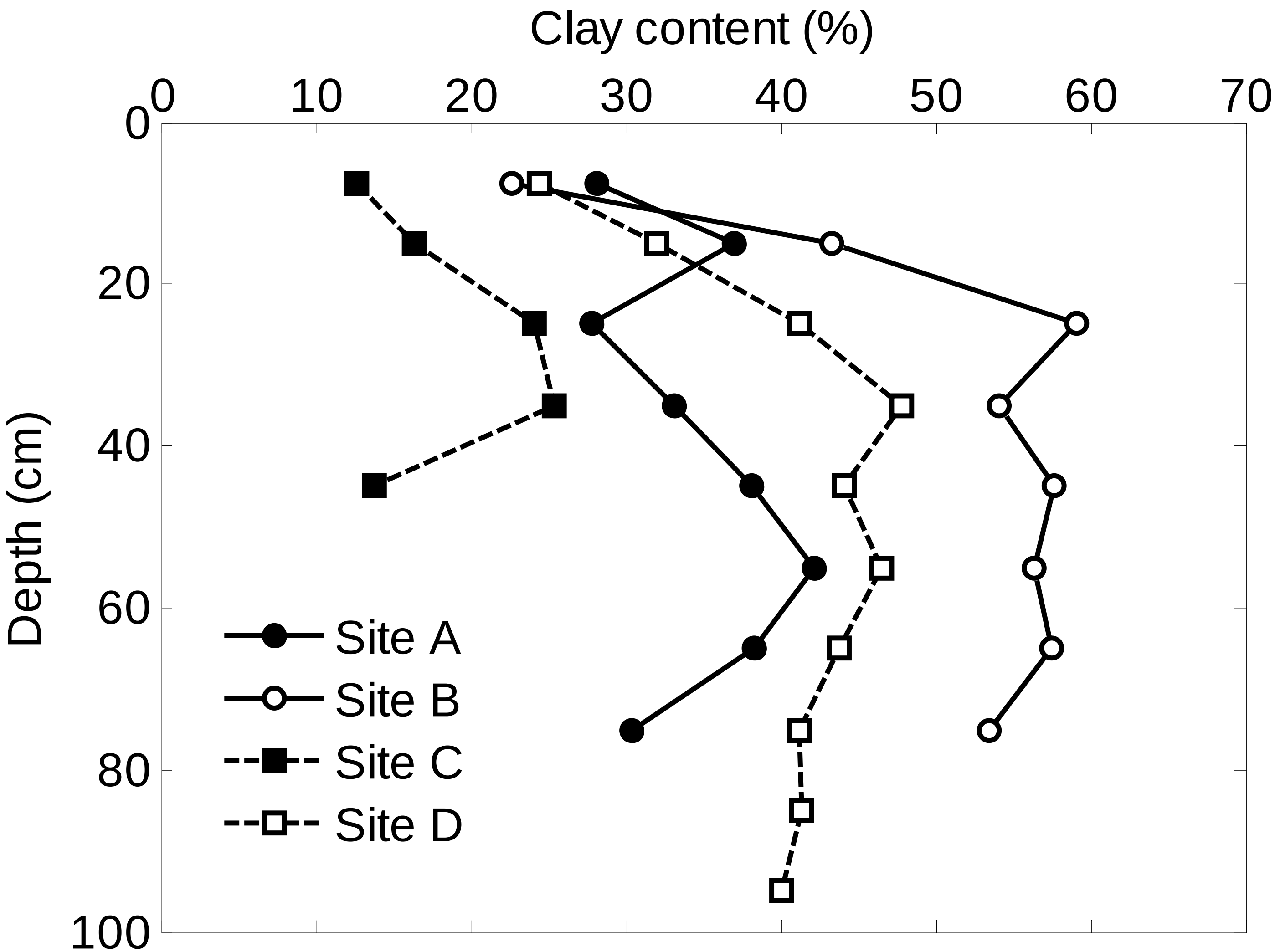
Continental Climate



Heterogeneous Soil



Spatial Variability in Soil Texture



Tallgrass Prairie Vegetation

Little bluestem
Schizachyrium scoparium (Michx.) Nash

Indiangrass
Sorghastrum nutans (L.) Nash

Big bluestem
Andropogon gerardii Vitman

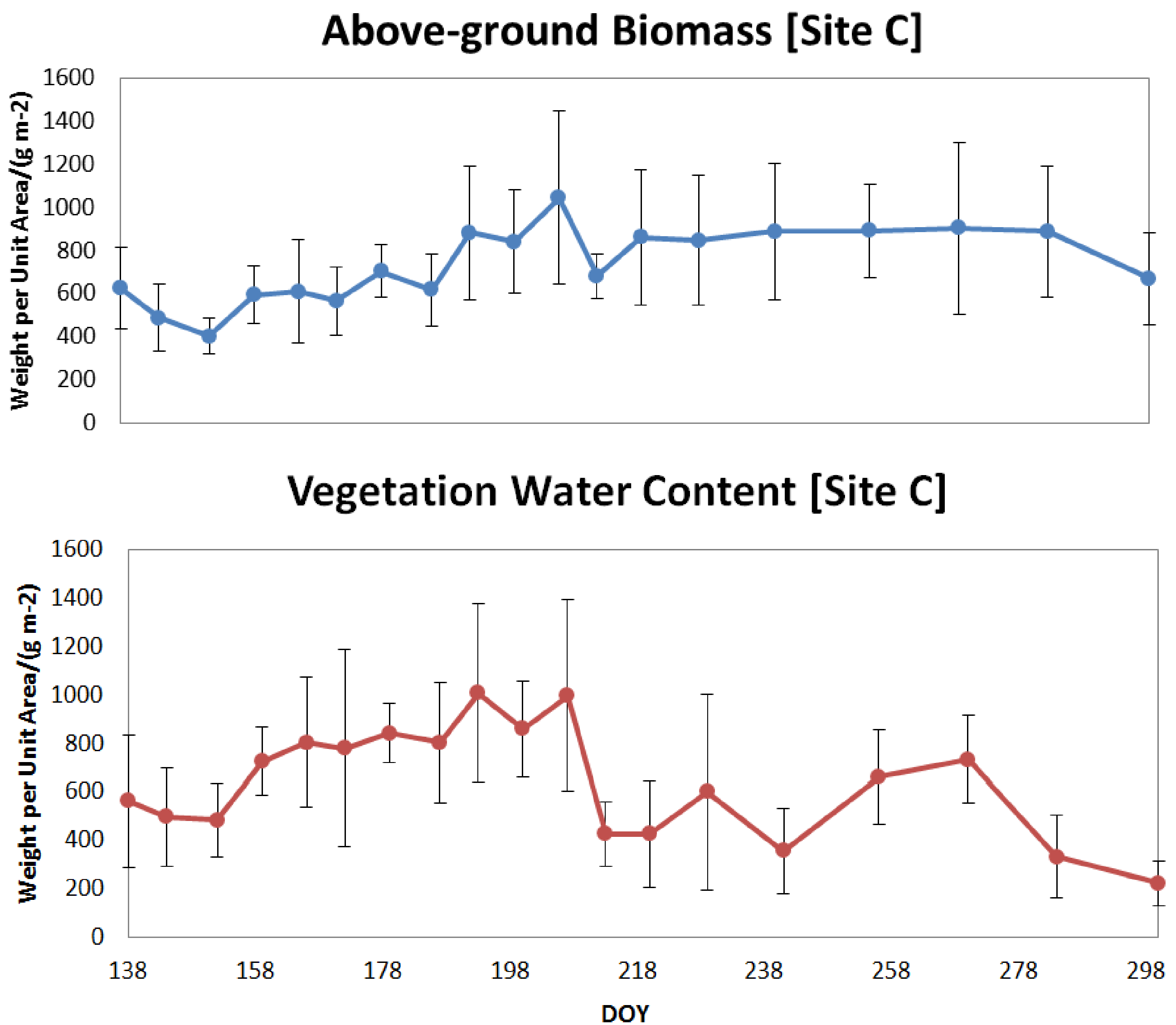
Post oak
Quercus stellata Wang

Eastern redcedar
Juniperus virginiana L.

Routine Vegetation Sampling

- Every 2 weeks April-Oct.
- Measuring
  - vegetation height
  - above-ground biomass
  - vegetation water content
  - soil water content, 0-6 cm

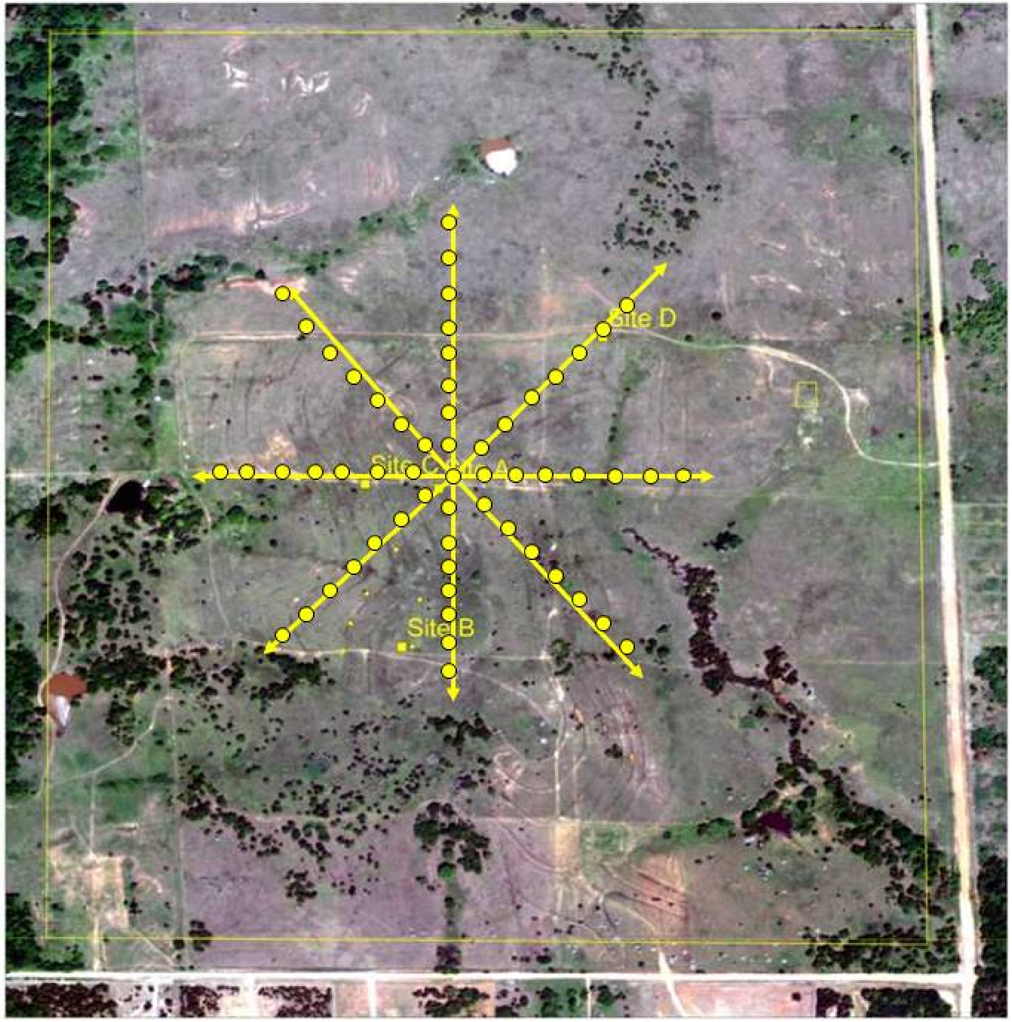
Example Vegetation Data



Routine Soil Moisture Surveys

- Theta probe measurements of volumetric water content, 0-6 cm
- 8 radial transects out from Site A
- 8 points per transect
- 50 m between points

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



Example Soil Moisture Survey Data

October 18, 2010

$\bar{\theta} = 5.9\%$

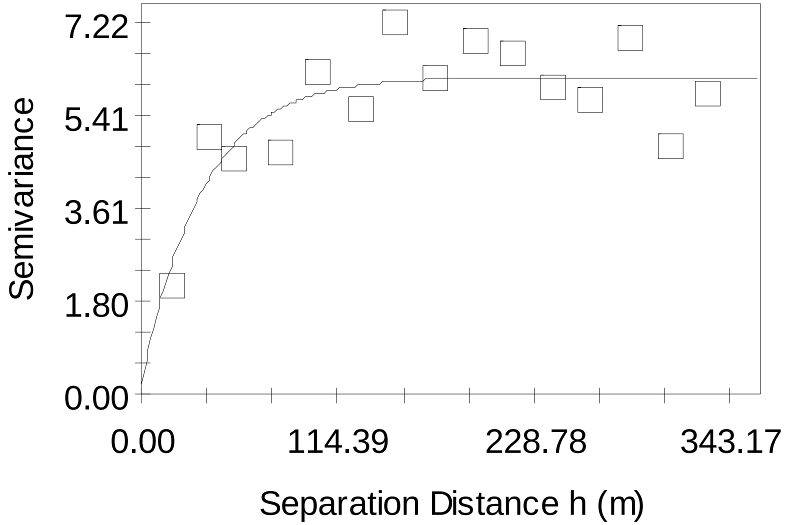
Rainfall 2.94 cm

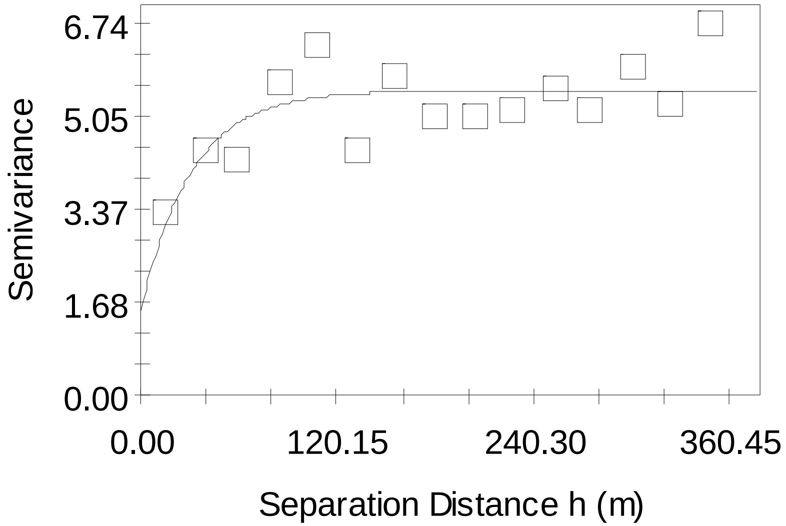
October 19, 2010

$\bar{\theta} = 24.2\%$

<u>Exponential semivariogram</u>
Nugget: 0.19
Sill: 6.2
Range: 36 m

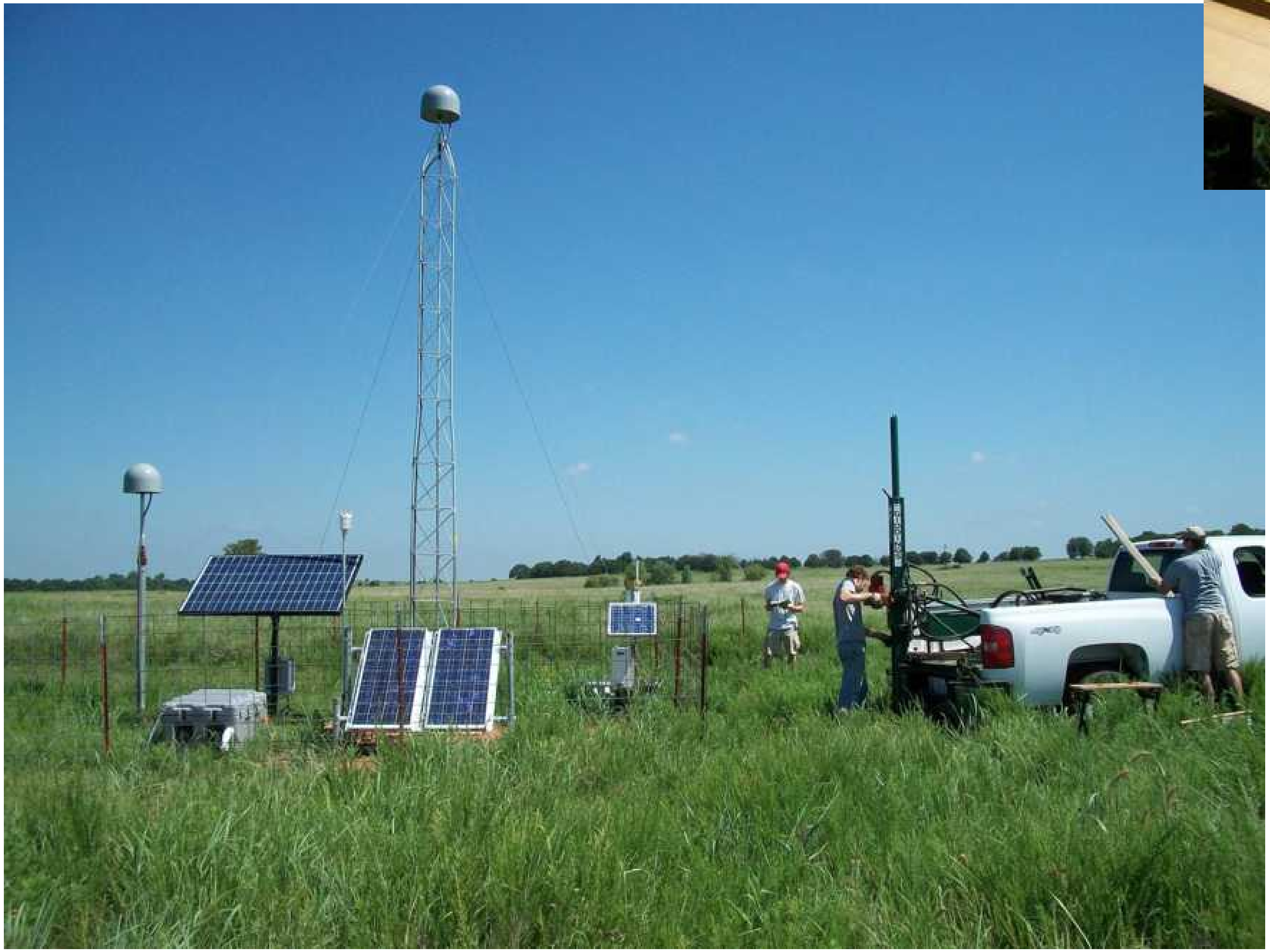
<u>Exponential semivariogram</u>
Nugget: 1.53
Sill: 5.52
Range: 31 m





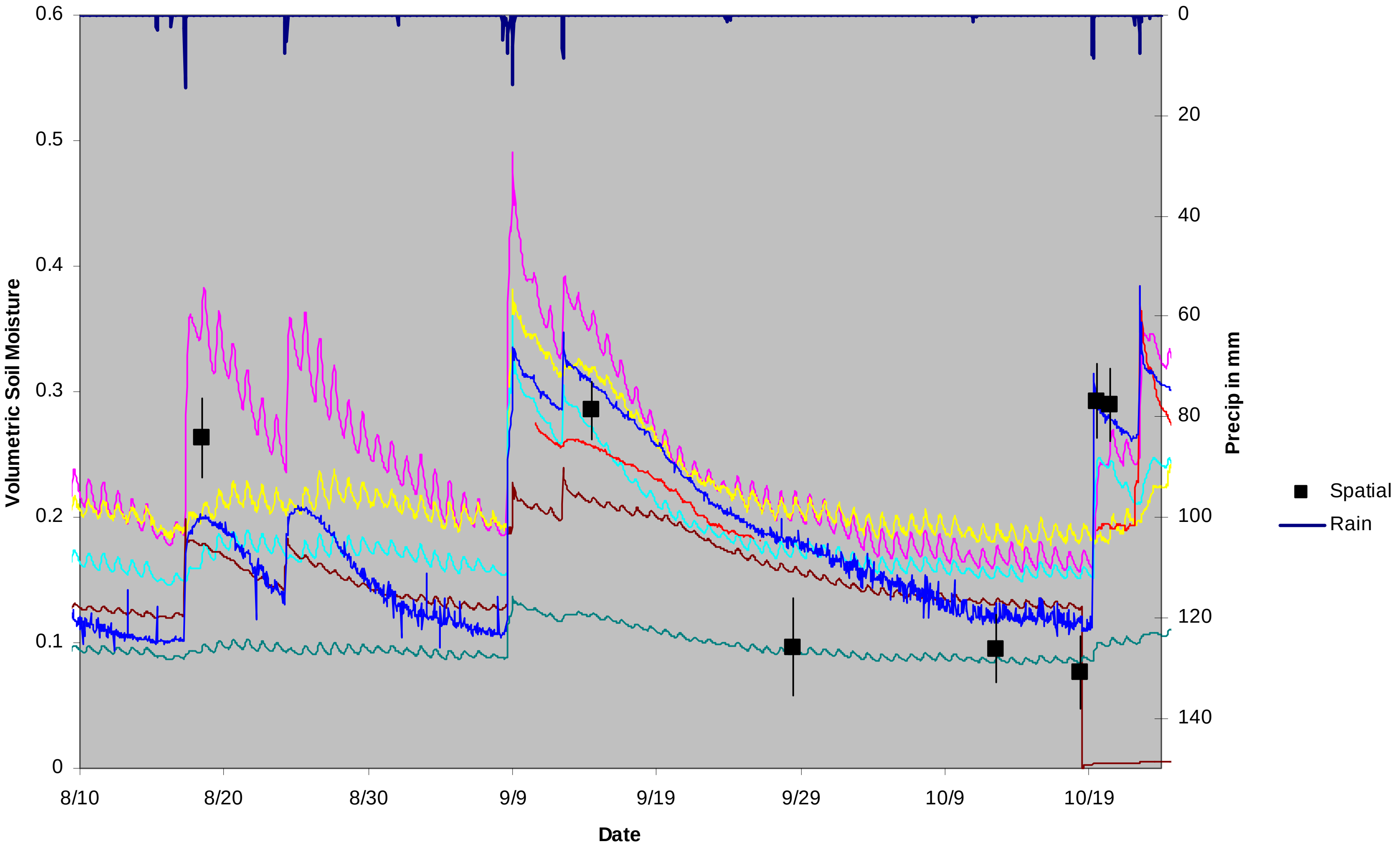
Site A – Main Station

Provide replicate sampling of gravimetric soil moisture at sites and over domain

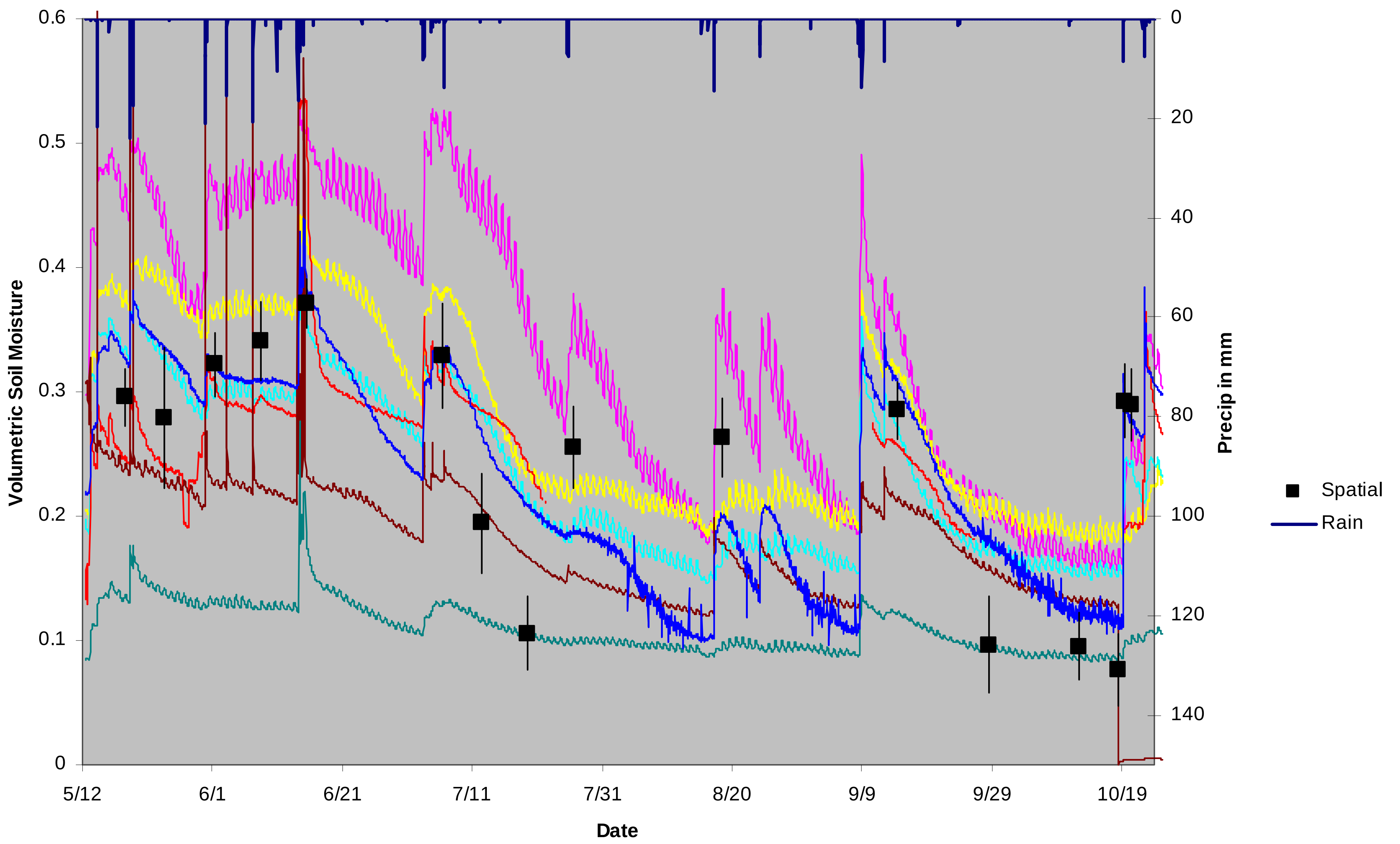


All soil moisture validation is referenced to physically collected soil moisture estimates.

SMAP In Situ Sensor Testbed
Preliminary Data: Site A 5 cm depth



SMAP In Situ Sensor Testbed



Early Conclusions

- Installation practices and procedures should be standardized, vertical versus horizontal orientation
- Temperature sensors necessary to correct for low temperature errors in soil moisture signals
- Raingage records are important for erroneous readings and troubleshooting.
- Calibration is critical for all sensors.
- Diurnal patterns can be significant for some surface sensors (~4%) depending on temperature range

Still to be Finished

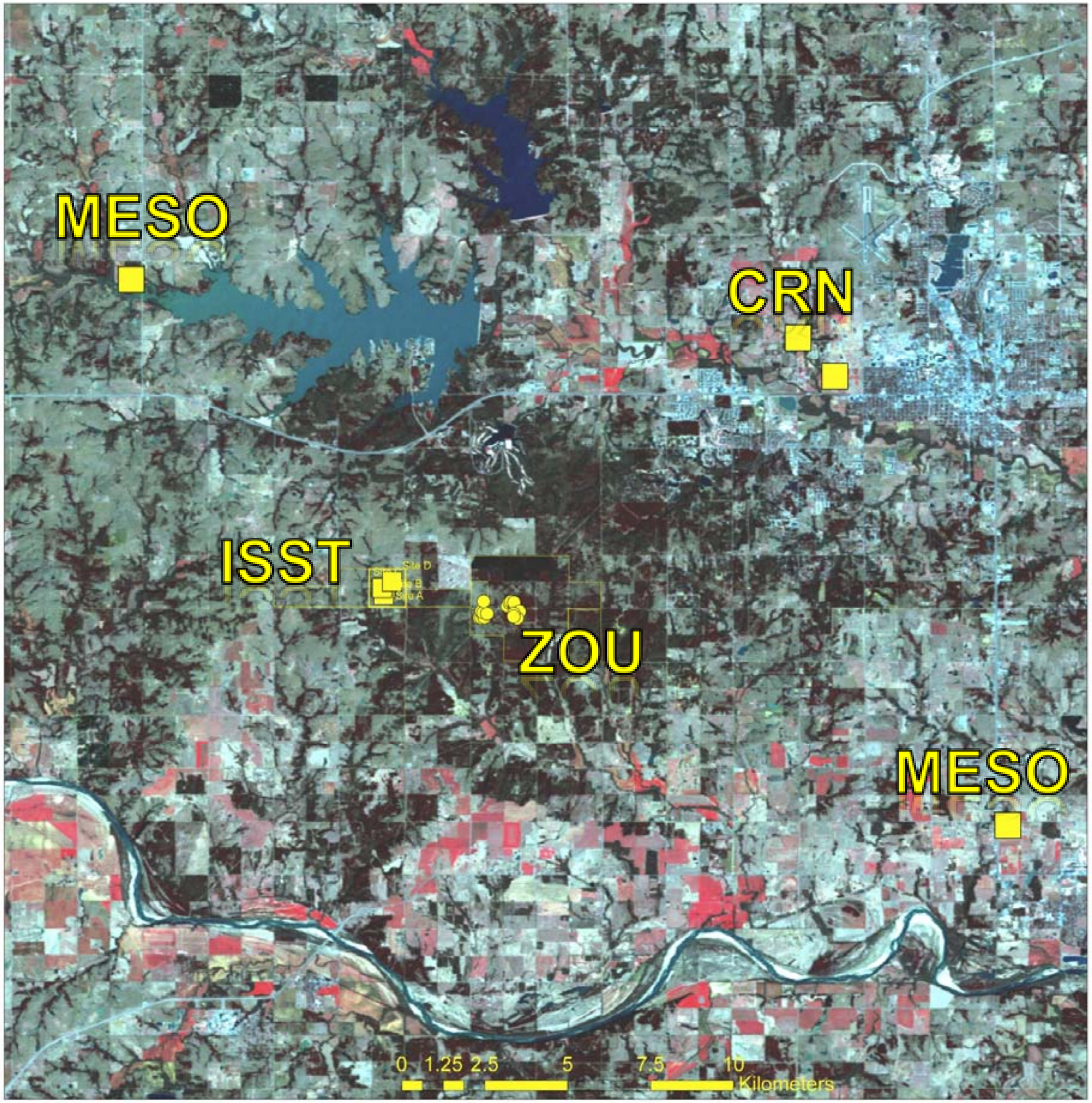
- Calibrations
- Quality Assurance development

Future Plans

- Installation and deployments
  - COSMOS Rover (June 2011)
  - Assess Replacement Needs
  - Sensor Calibrations
  - Flux and Scintillometer?
- Experiments
  - Cosmos Rover (future visits)
  - Intensive Campaigns (ongoing 4 month rotation)
  - Burn Study (Spring 2012)
  - Incorporation into large scale field experimentation?
- Additional Testbeds
  - Regional Network (pending resources)
  - Sterling (VA) site with Node network
  - Workshop – Spring 2011

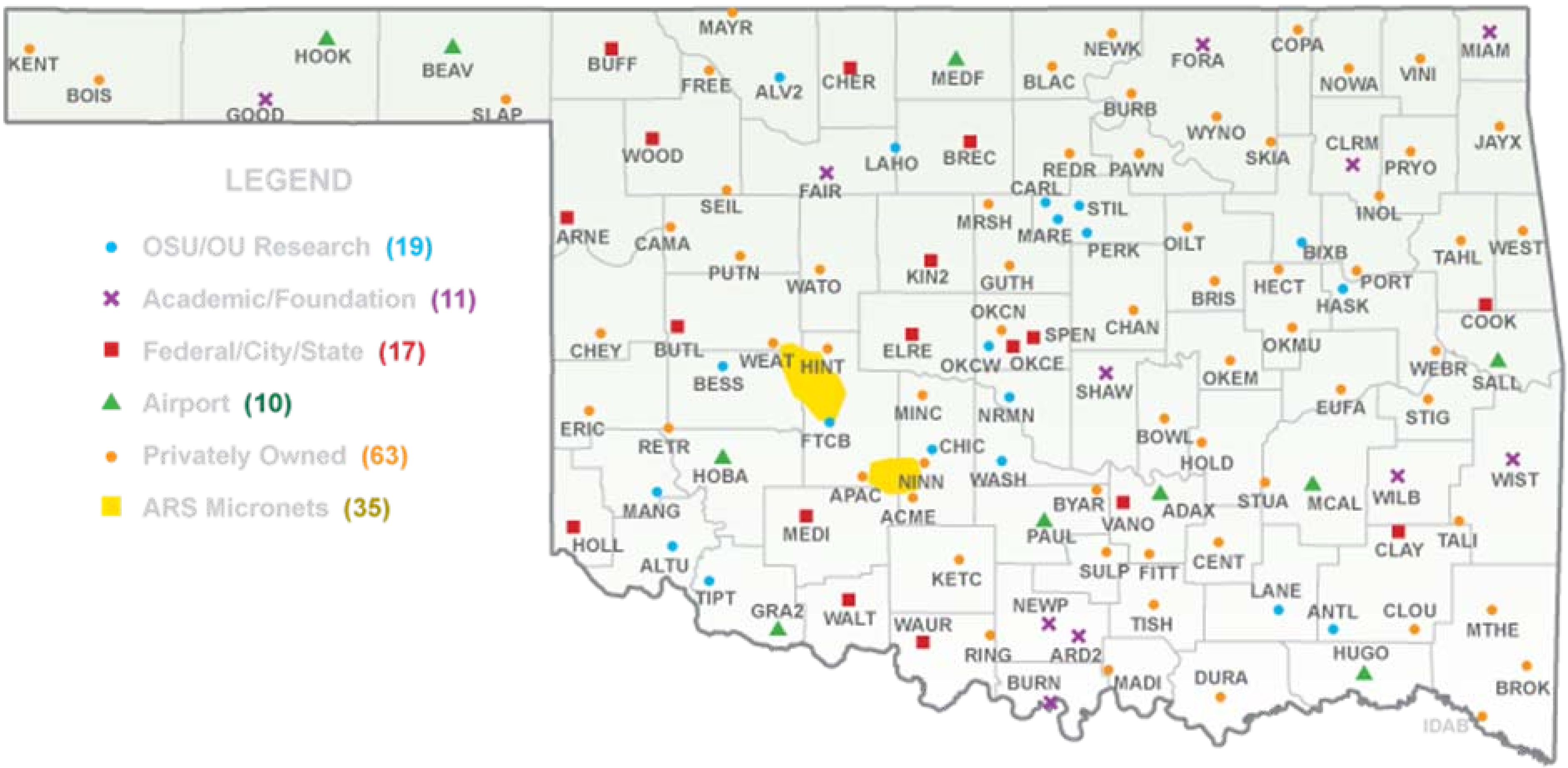
Additional Intensive θ Monitoring Nearby

SMAP In Situ Sensor Testbed Surrounding Area



Extensive θ Monitoring Across the State

Oklahoma Mesonet



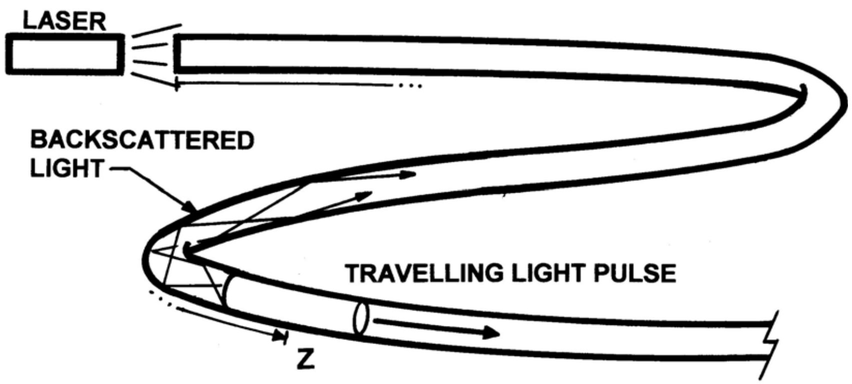
Soil Moisture Monitoring Using Distributed Temperature Sensing

TU Delft: Susan Steele-Dunne, Nick van de Giesen, Jop Jansen

UNR: Christine E. Hatch, Scott Tyler, Lucas Williamson

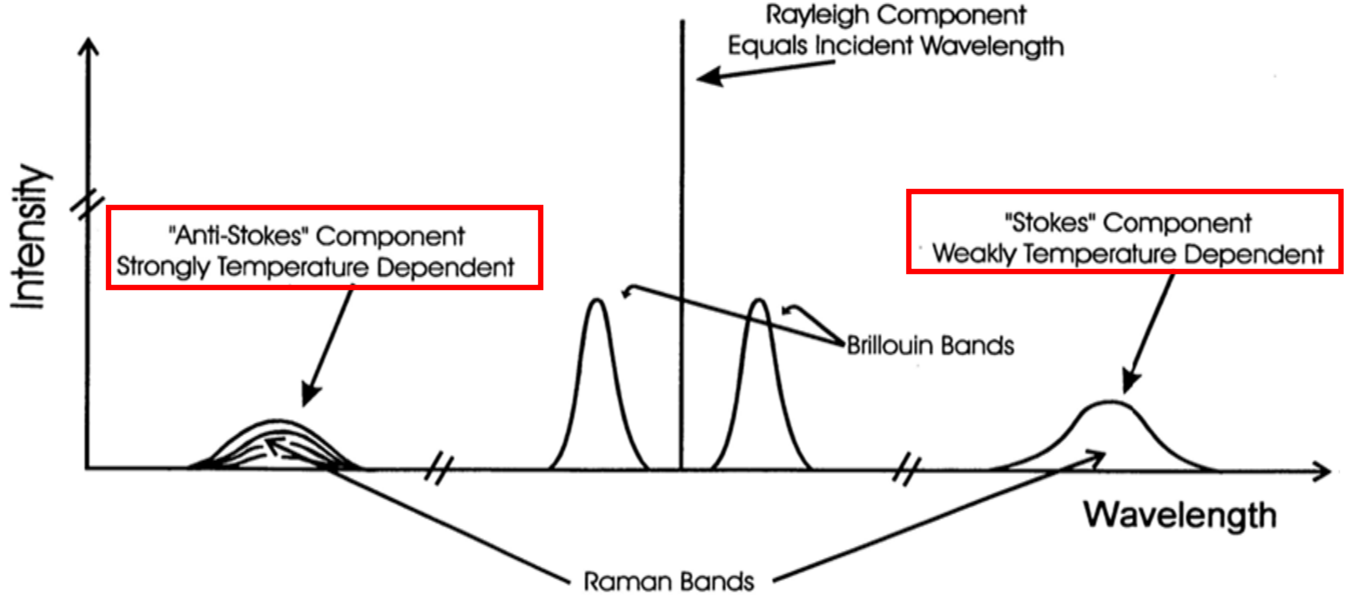
OSU: John Selker, Jim Wagner, Chadi Sayde

Distributed Temperature Sensing



Use fiber-optic cables as thermal sensors.

Measure temperature every 0.25m-2m along cables 5km in length.

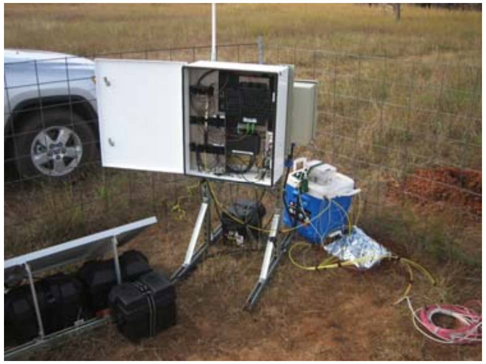


Soil moisture monitoring using Active DTS at ISST

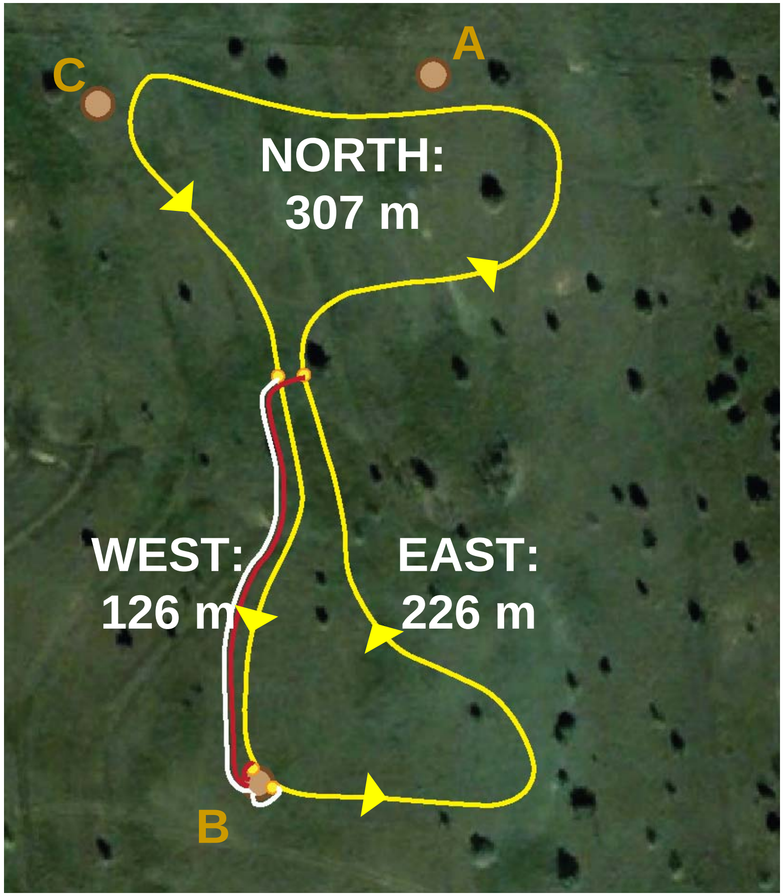
Cables installed
October 2010

5cm
Active/Passive

10cm, 15cm
Passive



Oryx DTS system,
solar panels,
calibration baths
at Enclosure B



Pulse length=20 minutes

Current, I=3.875A

Resistance, R= 0.18 Ω/m

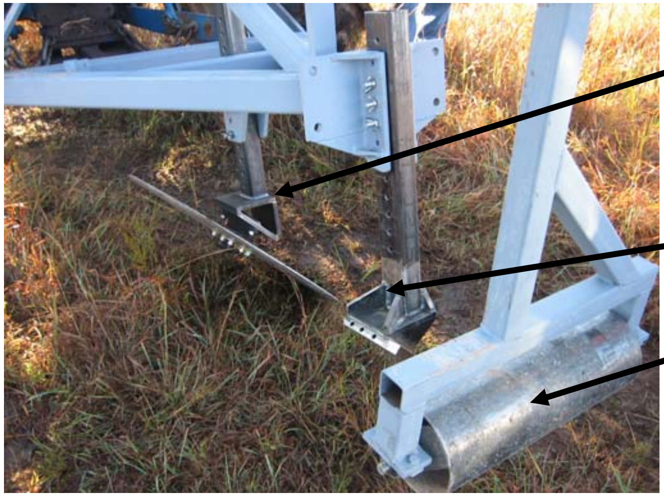
Soil Moisture using Distributed Temperature Sensing

Cable Depths

5cm (Active,Passive)

10cm (Passive),

15cm (Passive)



Minimizing disturbance:

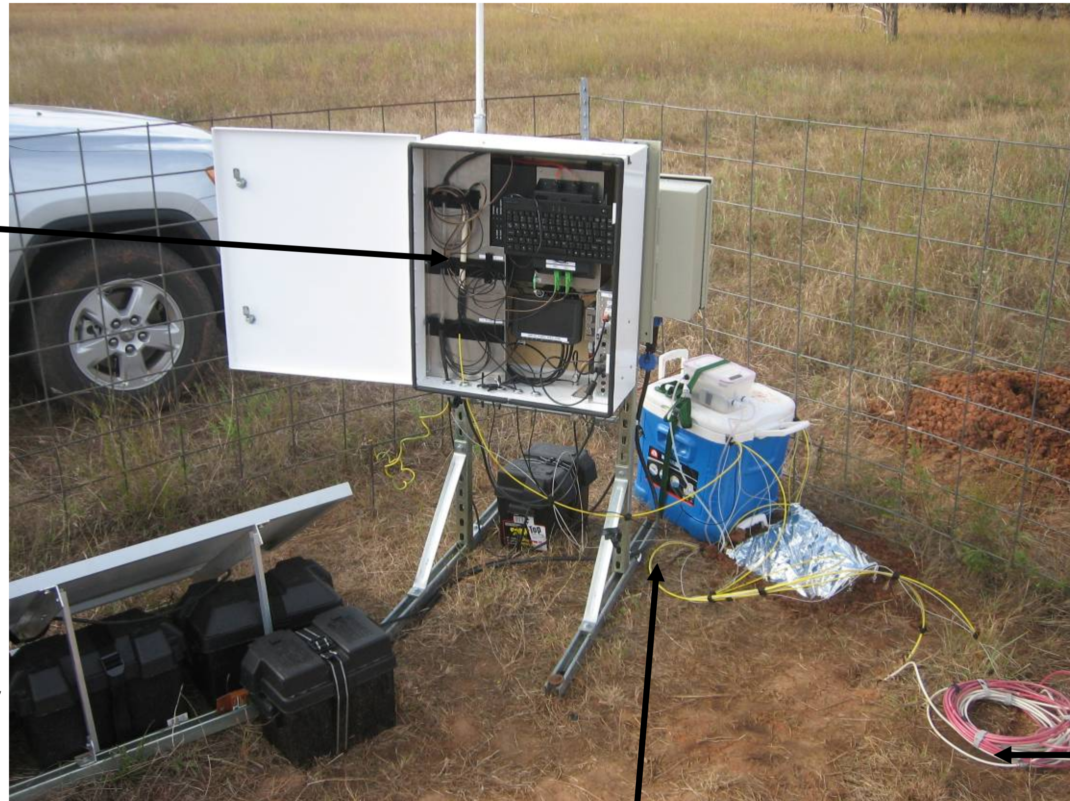
Wheel: Cuts through roots, scores surface

Blade: installs cable

Roller: Flattens surface after cable installed

Equipment at Enclosure

DTS Unit &
Computer



Jumper cables
for Active
Measurements

Solar panels & batteries

Calibration baths

(~60m each cable,
compare to Pt100)