Early Results of the SMAP Marena Oklahoma In Situ Sensor Testbed SMAP-MOISST

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and
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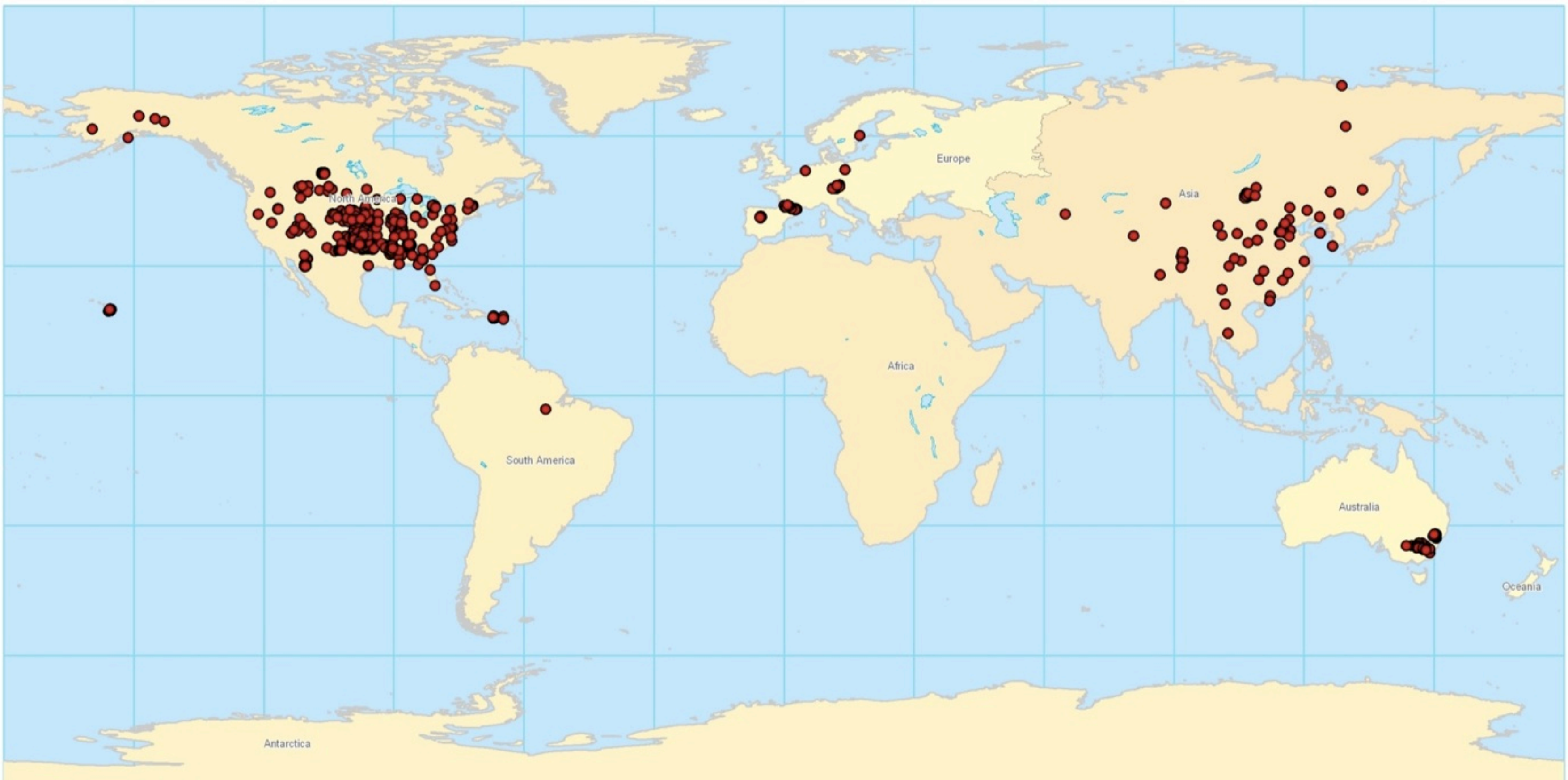
Many in situ networks in the world, with a variety of sensors/methods



How do you establish a consistent, quality data record for SMAP cal/val?

Compare and contrast in situ sensors to ground truth data.

Questions:

What are the limitations of these sensors?

What are the errors associated with the measurement?

What types of calibration should be conducted? (there are 2 types)

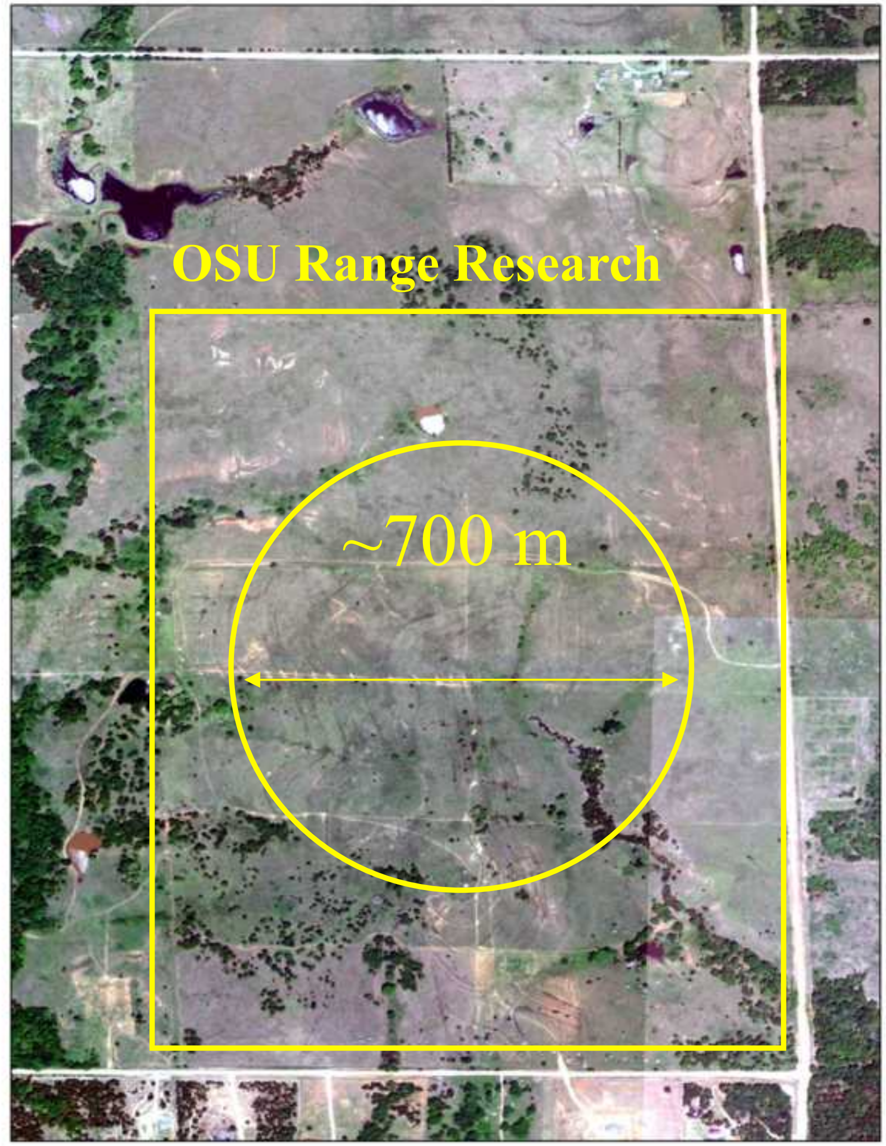
Moving forward with network development, what are key lessons to keep in mind?

SMAP Marena Oklahoma In Situ Sensor Testbed
Testbed Team

- Lead Scientist: Michael Cosh (USDA-ARS-Beltsville)
- Local Lead: Tyson Ochsner (Oklahoma State Univ.), Geano Dong
- 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)
  - CRN: Michael Palecki and John Kochendorfer (NOAA)
  - Passive DTS: Susan Steele-Dunne (Delft Univ.), John Selker (Oregon State), Christine Hatch (Umass Amherst), Chadi Sayde (Oregon State), Nick van de Geisen (Delft Univ.)
  - TDR: Steve Evett (USDA-ARS-Bushland) and Tyson Ochsner (OSU)
  - Flux: Jeff Basara (Univ. of Oklahoma) and John Prueger (USD-ARS-Ames)

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



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Marena Site Design

- Four Base Installations
- 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			
Flux System			

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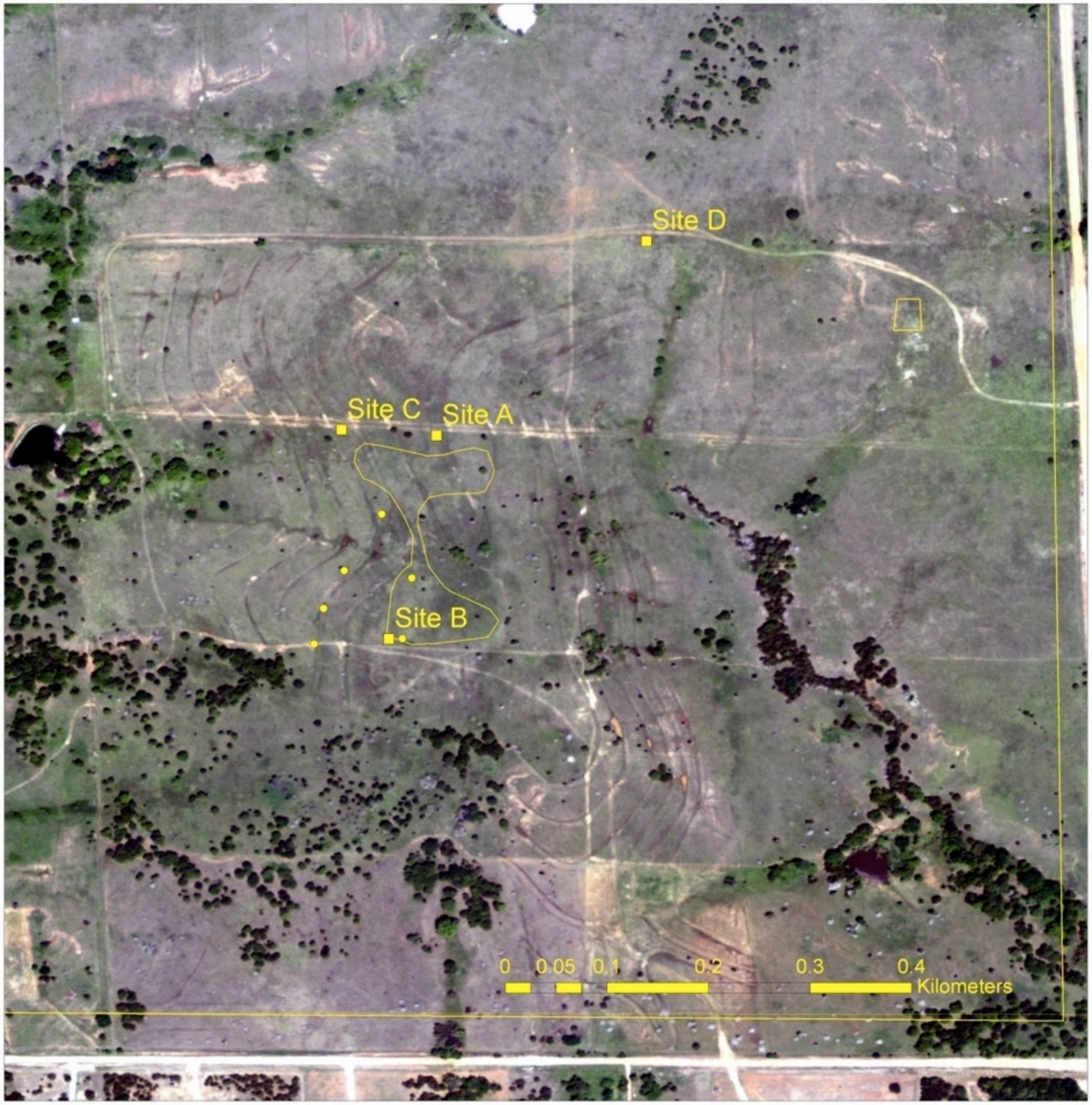
Site Design



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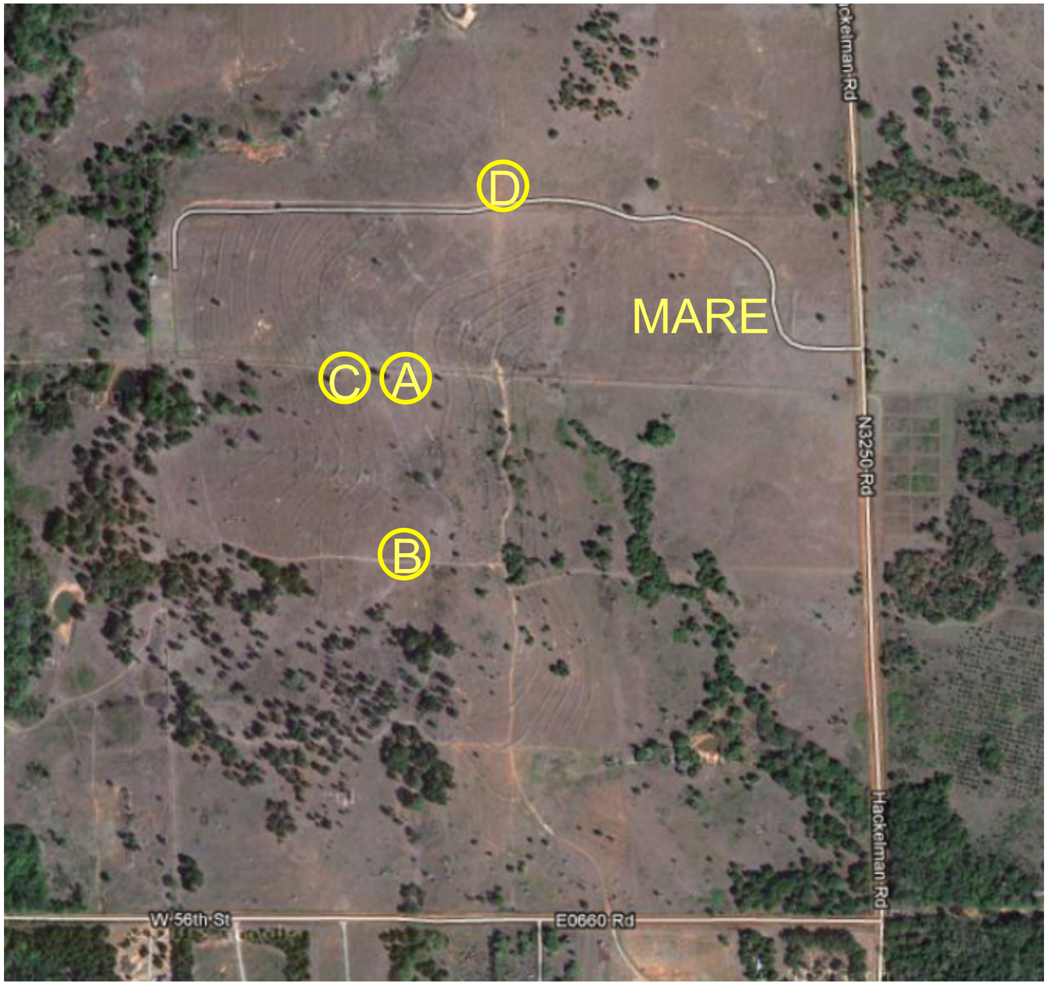
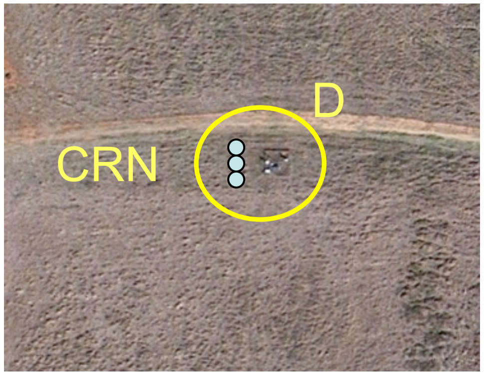
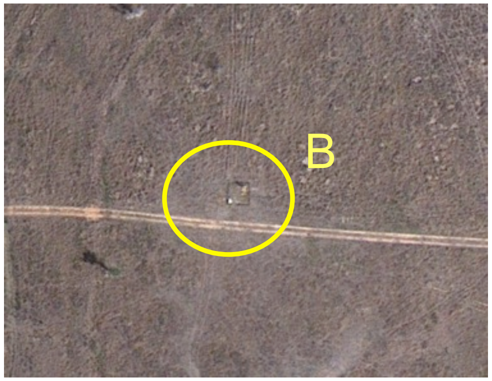
Site Design

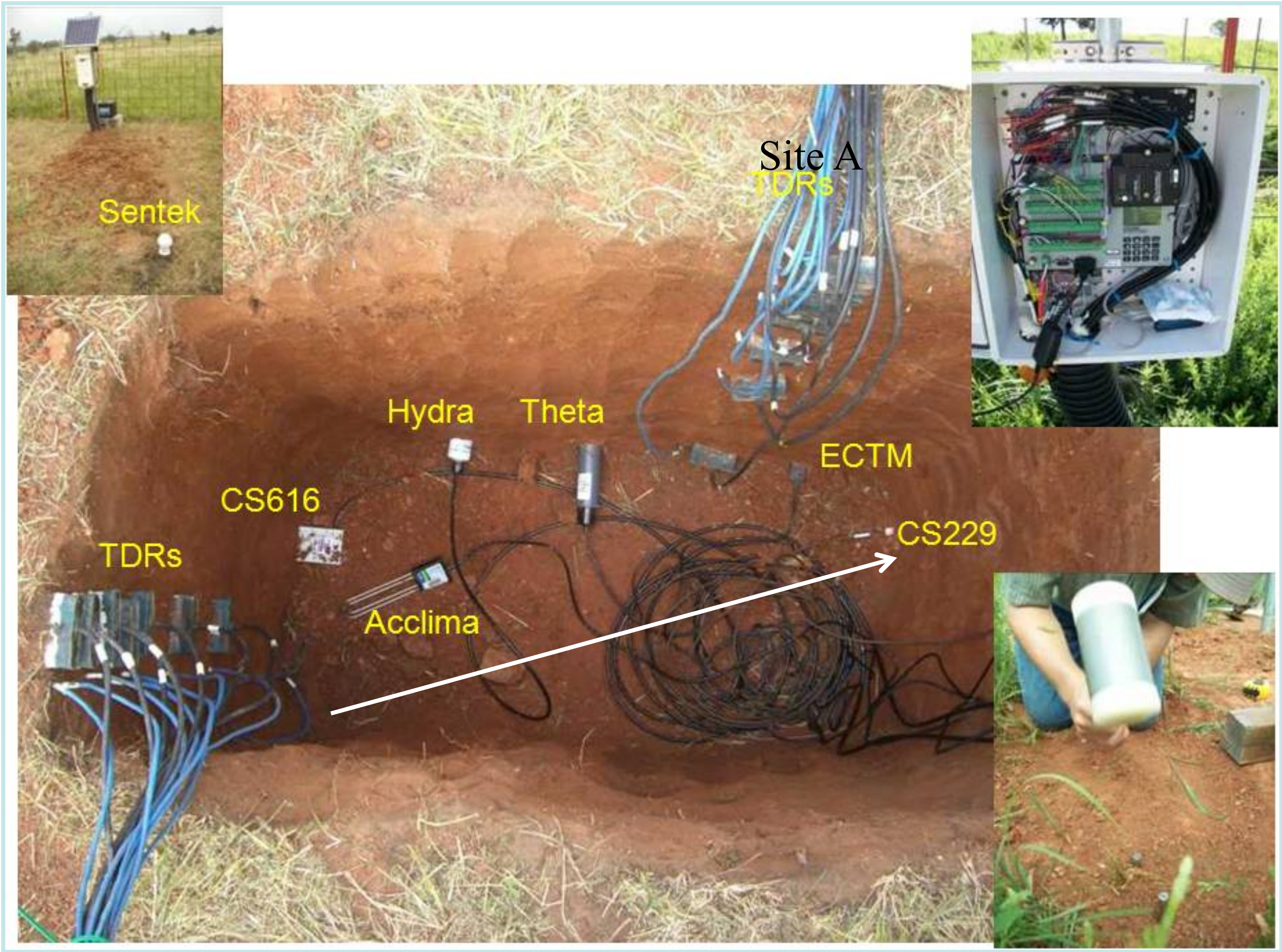






Installation

- Installation in May 2010



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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).

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.

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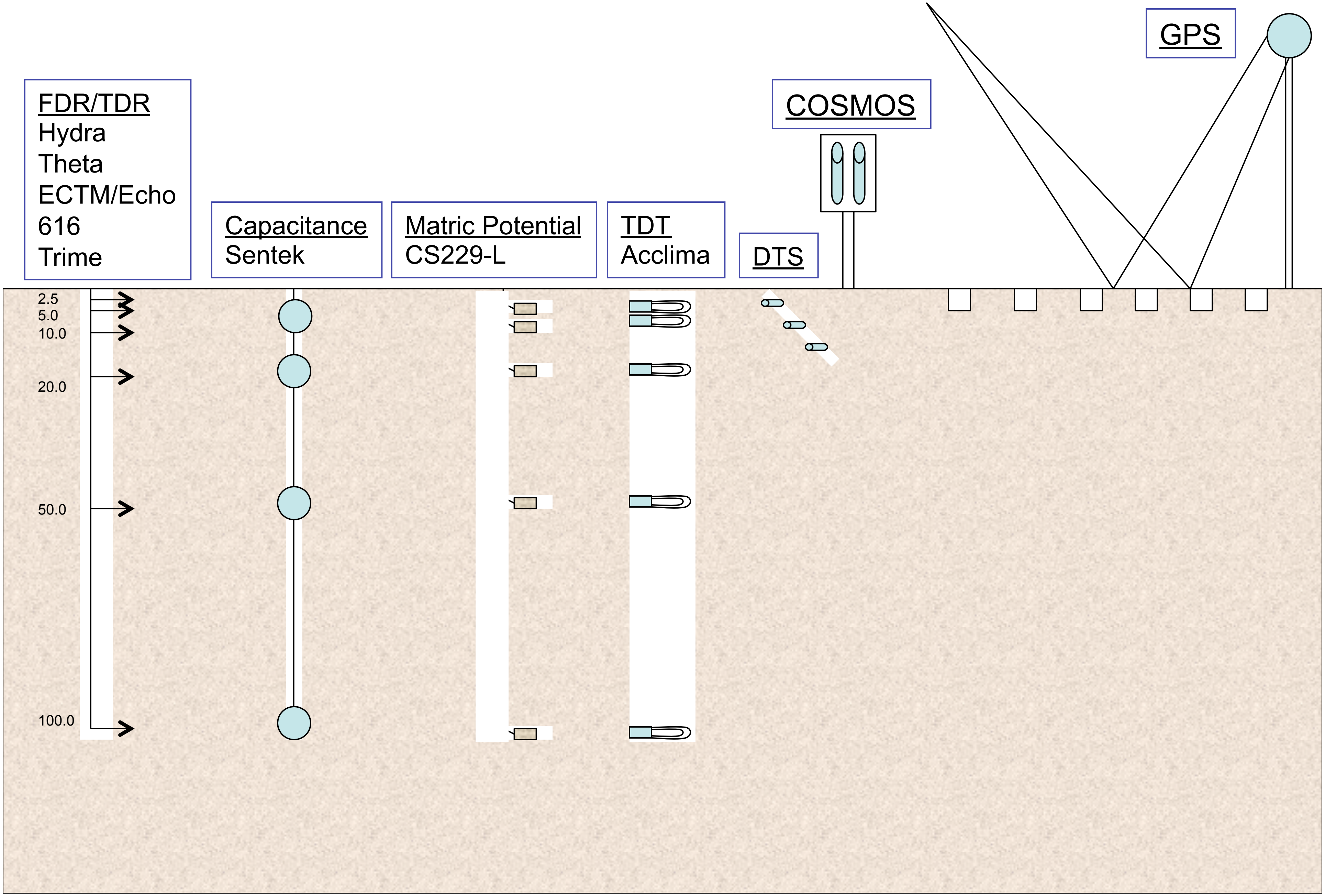
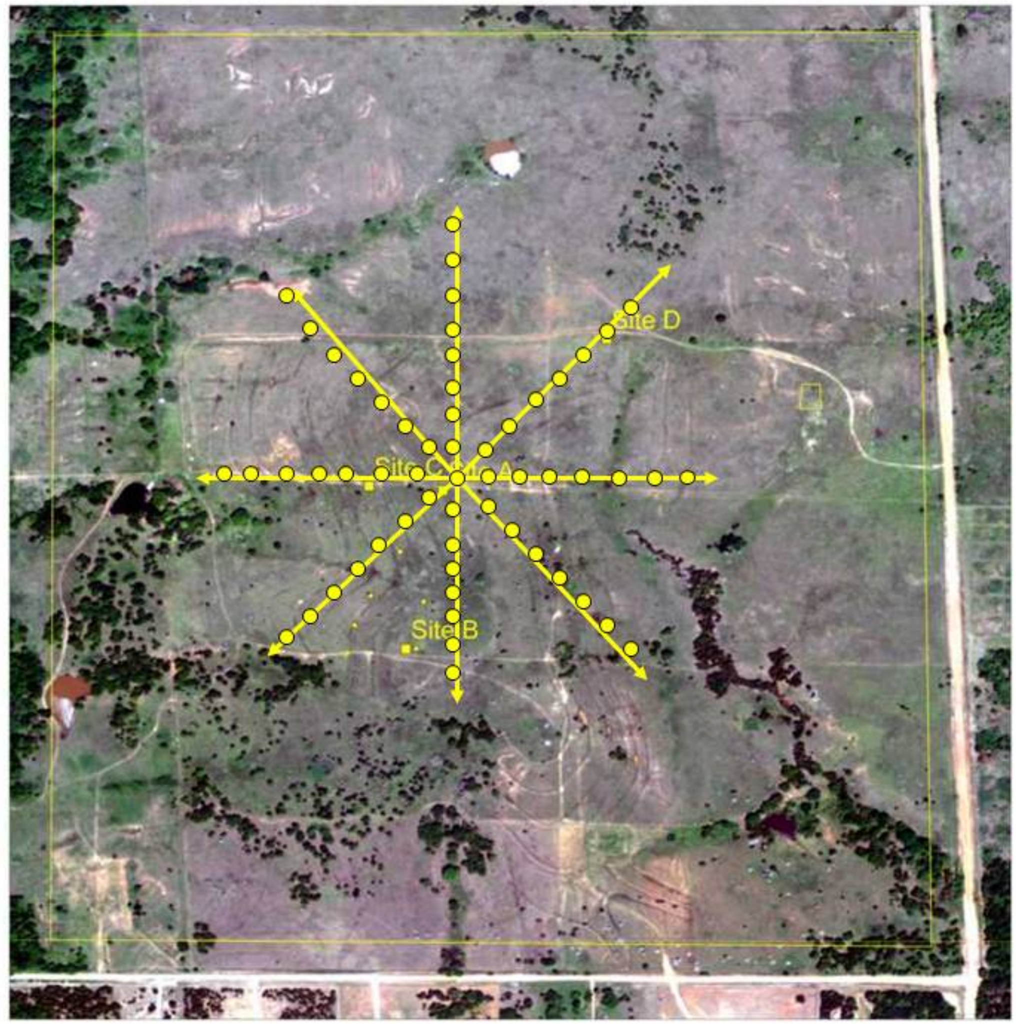
Sensor Methods



Validation Sampling Campaigns

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



Timeline

- Project Planning begins October 2009
- Installation and deployments
  - Base Stations installed May 2010
  - GPS installed in June 2010
  - COSMOS installed July 2010
  - Passive DTS installed October 2011
  - SMAPVEX11, June 2011, PALS flights/COSMOS rover.
  - Flux Tower installed October 2011
  - NASA Funds received October 2011
  - Burn Study Winter 2012
  - Additional UAVSAR flights October 2012
  - AirMoss Validation October 2012

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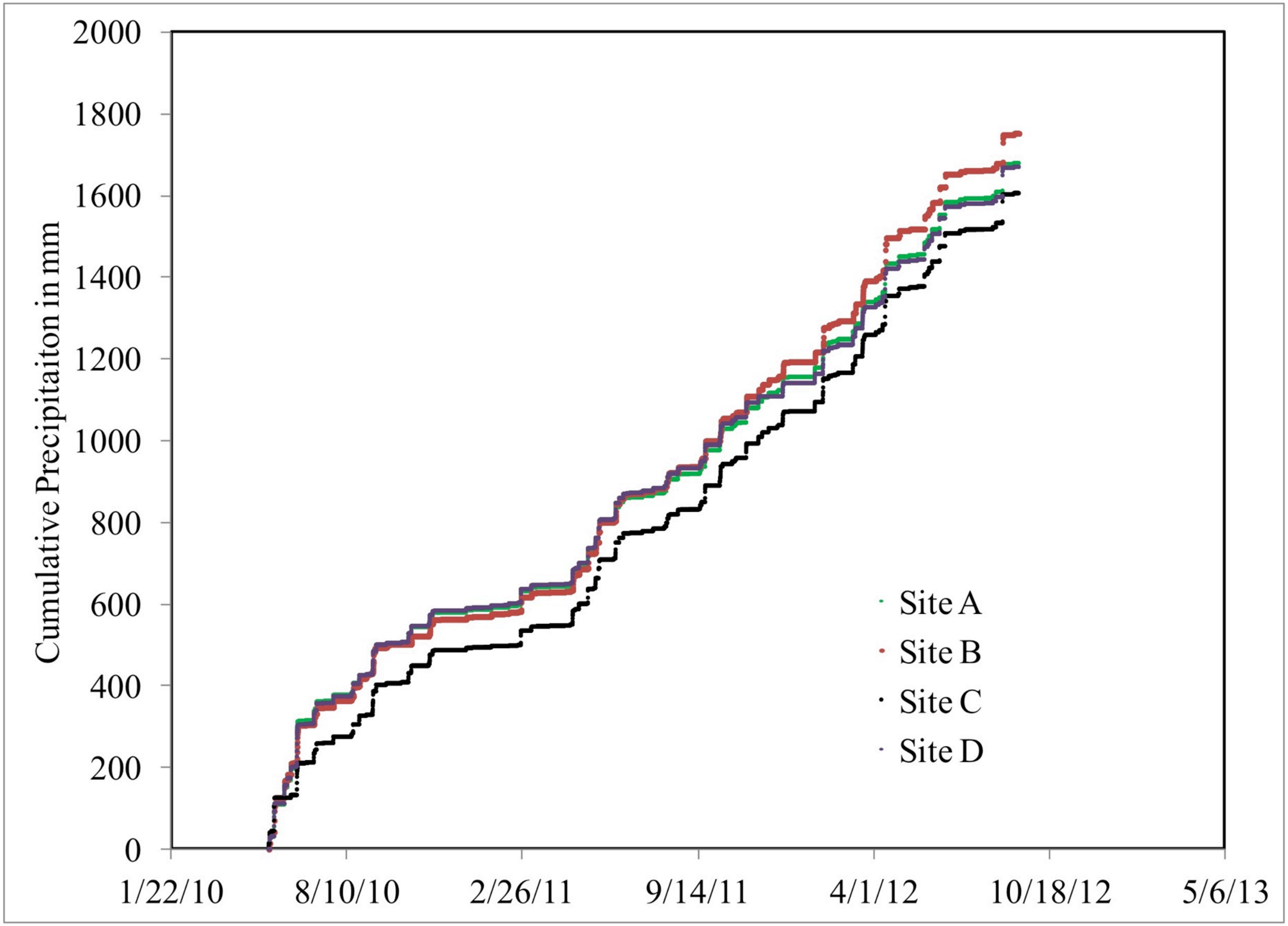
Precipitation Record



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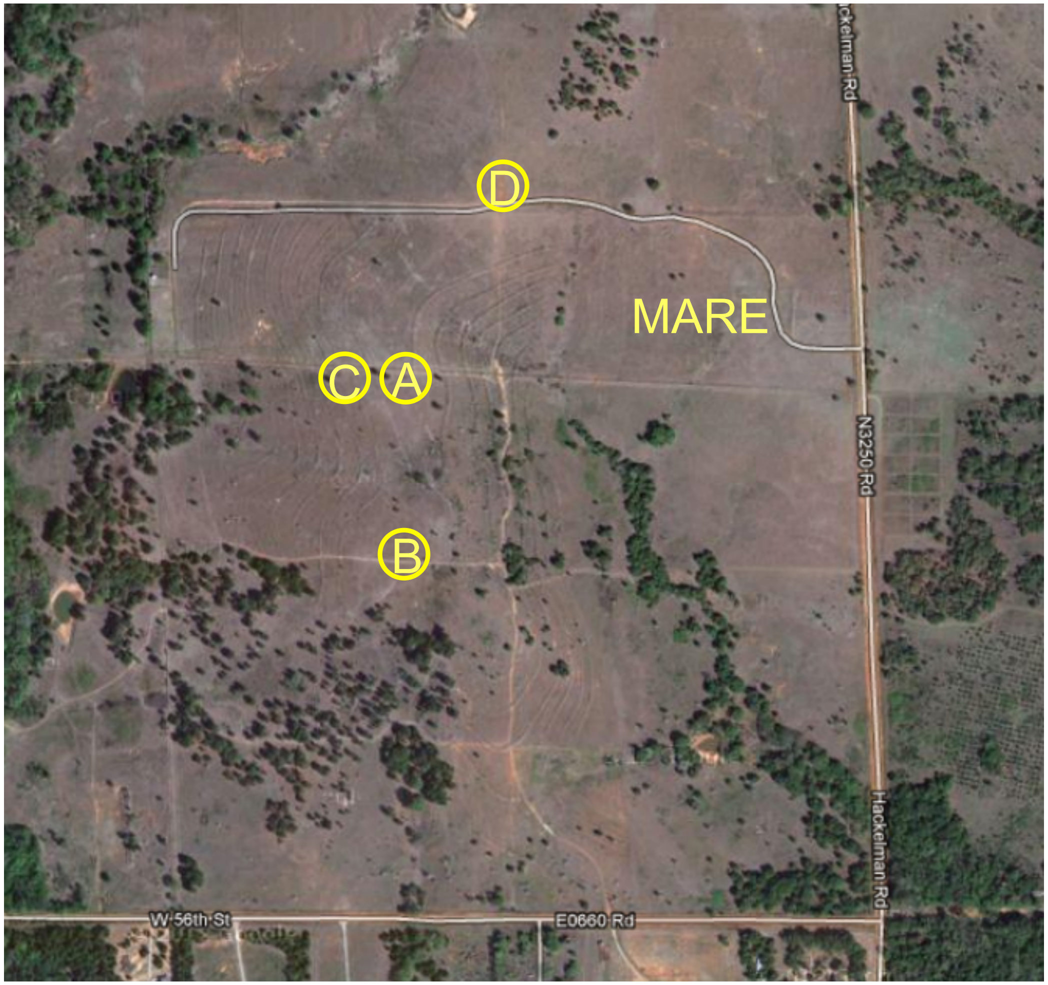
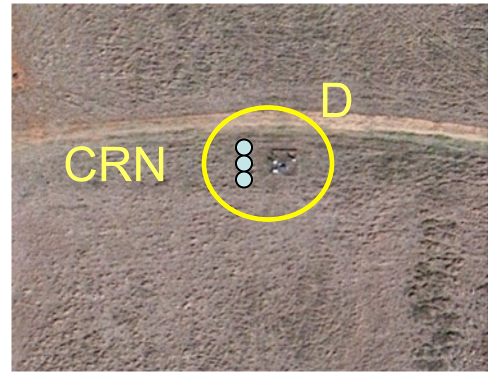
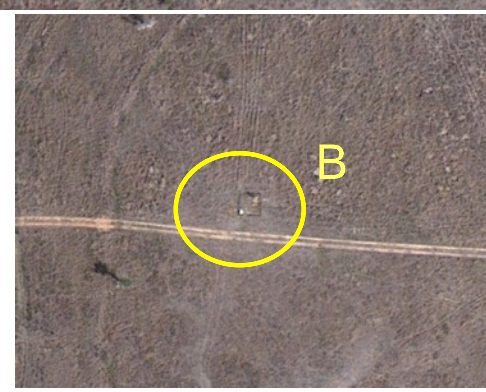
Site Design







Calibration and Scaling

Soil Calibration

Every sensor can be calibrated to each specific soil to be installed in.

- Soil specific Calibration, in field or in lab with replication of soil bulk density
- Variety of soil moisture conditions necessary for accurate calibration.

Installation Scaling

Each installation should be scaled to determine how it represents the domain in which it is installed.

- Each installation or set of installations is one data series to be calibrated
- Scaling is against the satellite metric, 0-5 cm gravimetrically based volumetric soil moisture.

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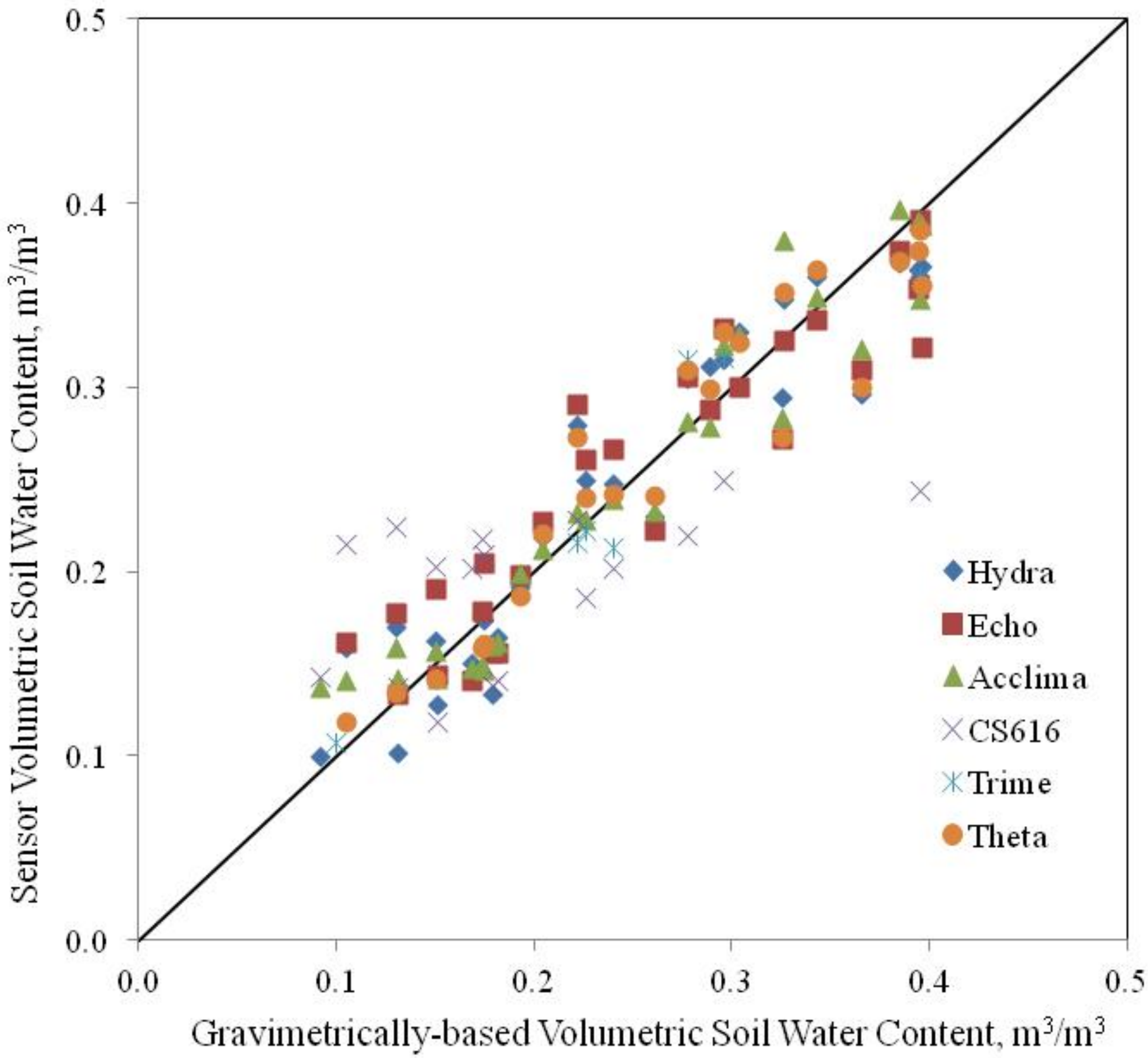
Sensor Calibration



Calibration Accuracy

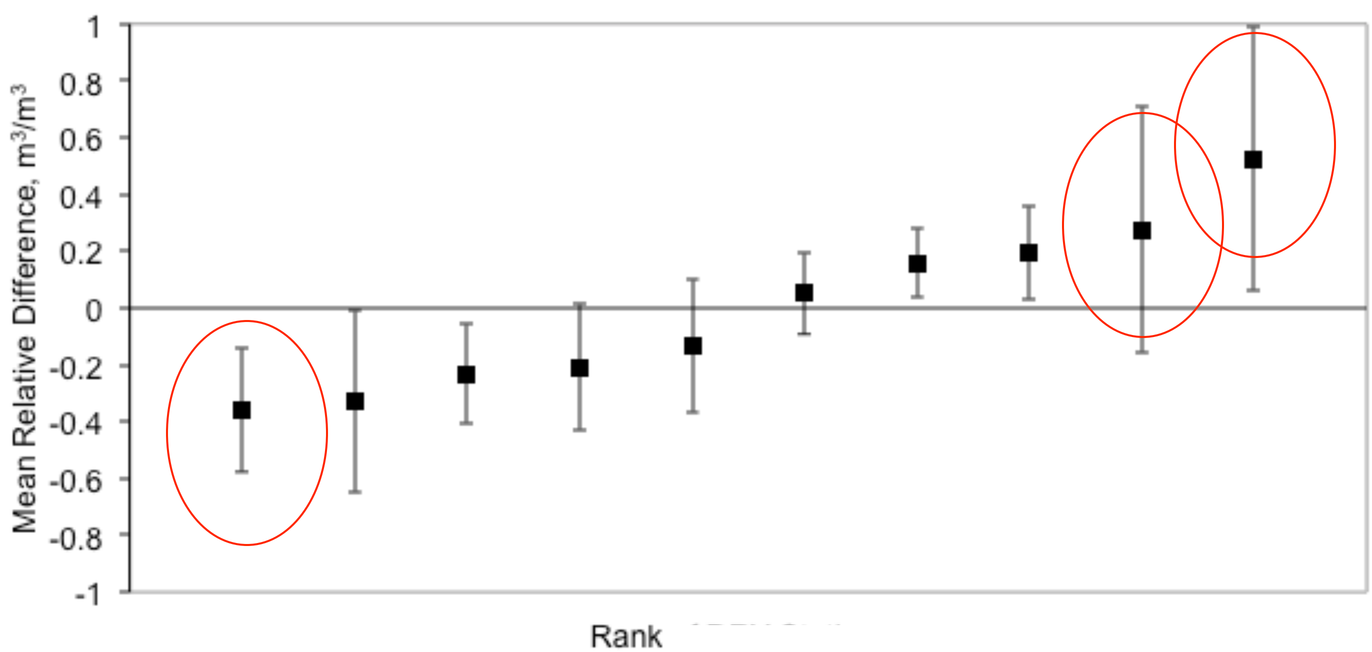
Sensor	RMSE Factory Calibration	RMSE Site Calibration	Failure Rate
Theta	0.0300	0.0276	0% (0/20)
Hydra	0.0401	0.0299	0% (0/24)
ECTM(Echo)	0.0811	0.0361	10% (2/20)
CS616	0.0726	0.0626	5% (1/20)
Acclima	0.0796	0.0253	40% (8/20)
Trime	0.0422	0.0233	12.5% (1/6)
CS229	-	-	5% (1/20)
EnviroSMART/ Sentek	-	-	0% (0/16)

RMSE in m^3/m^3

Field Scaling

Sensor Calibration is not the final step.

Even is a sensor is calibrated, the installed sensor may be in
An unrepresentative location, or have a faulty installation.



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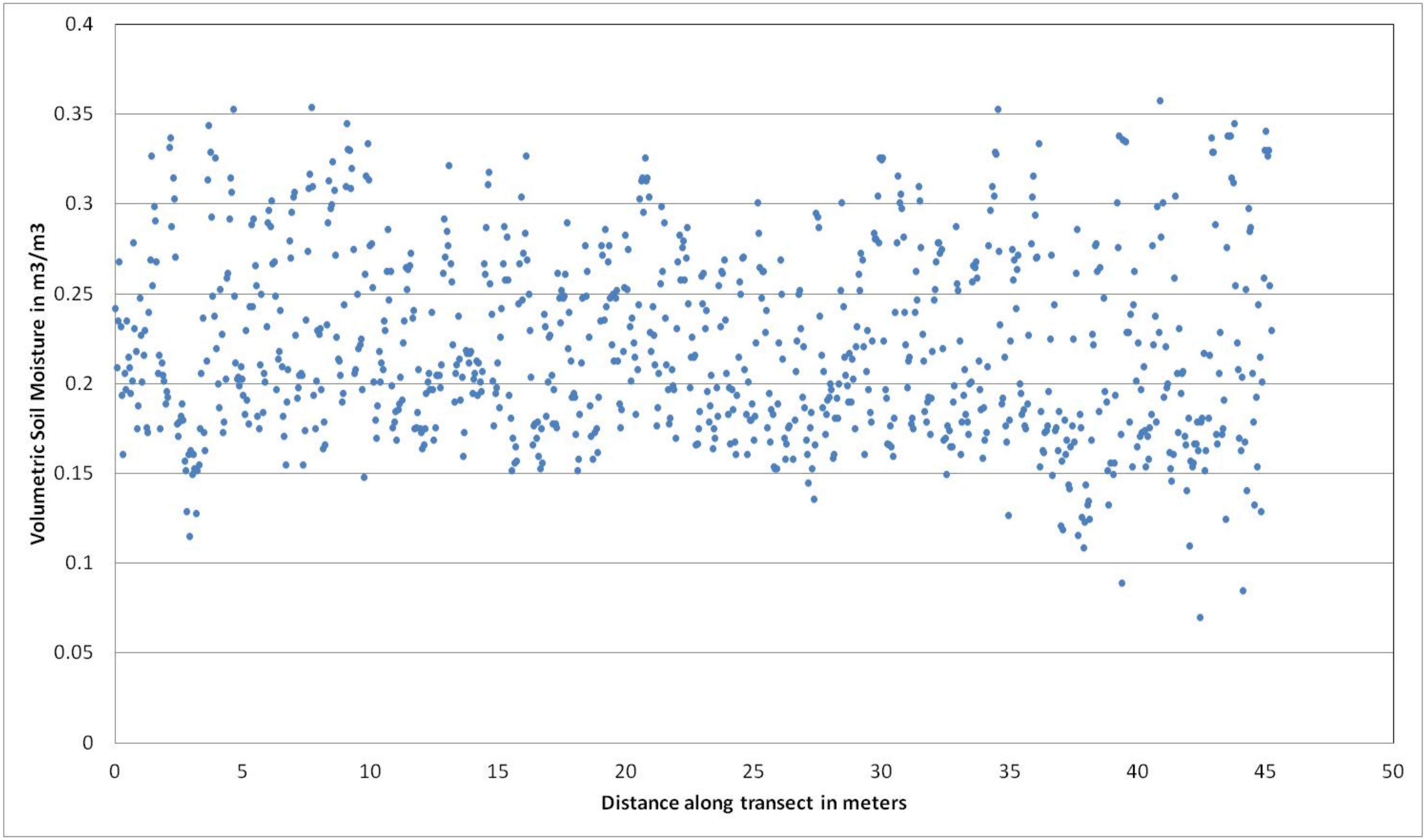
Variability at the Surface 0-5 cm



*BEAREX08 Transect Data
Cosh et al., 2012

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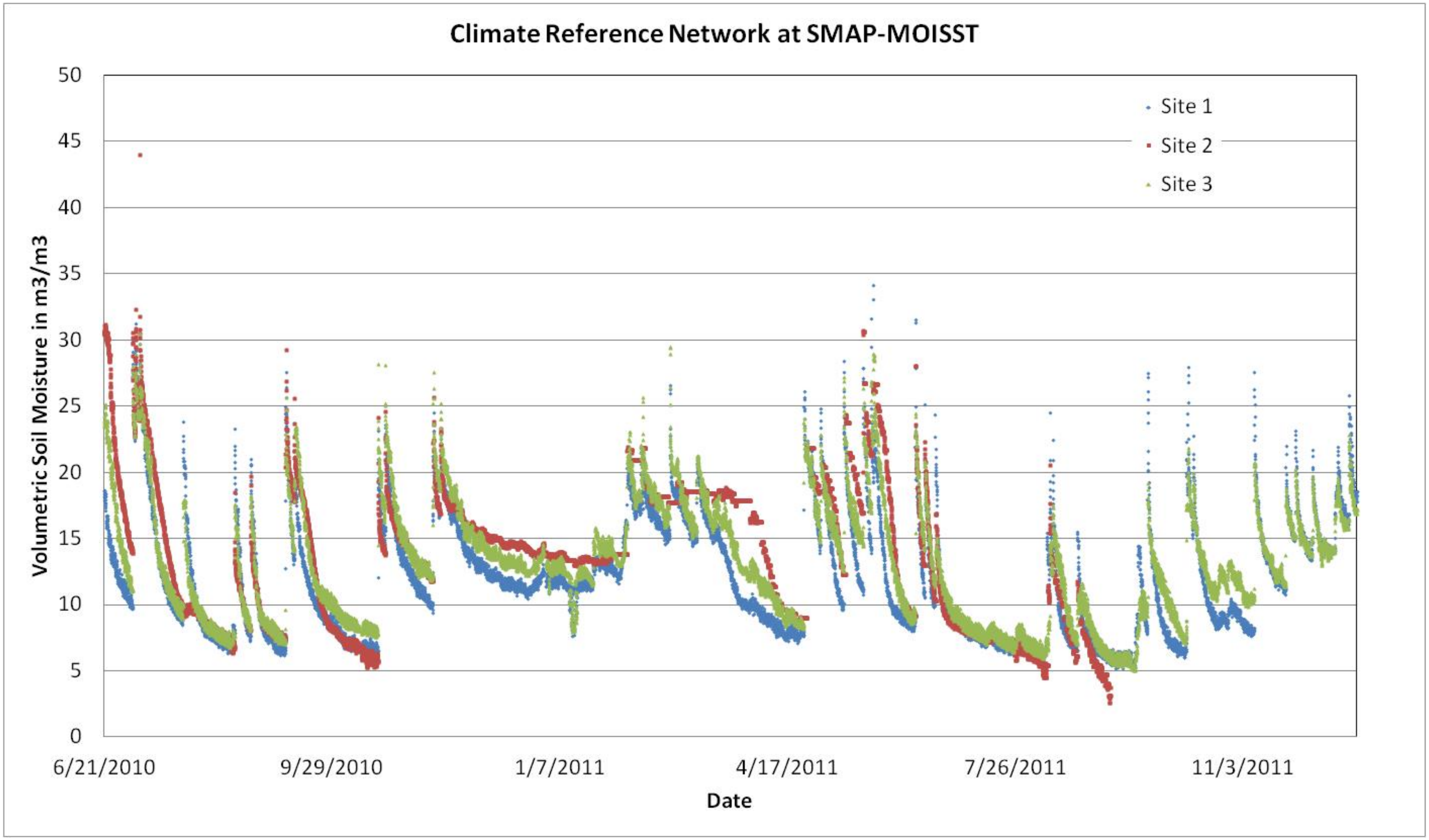
CRN 5 cm



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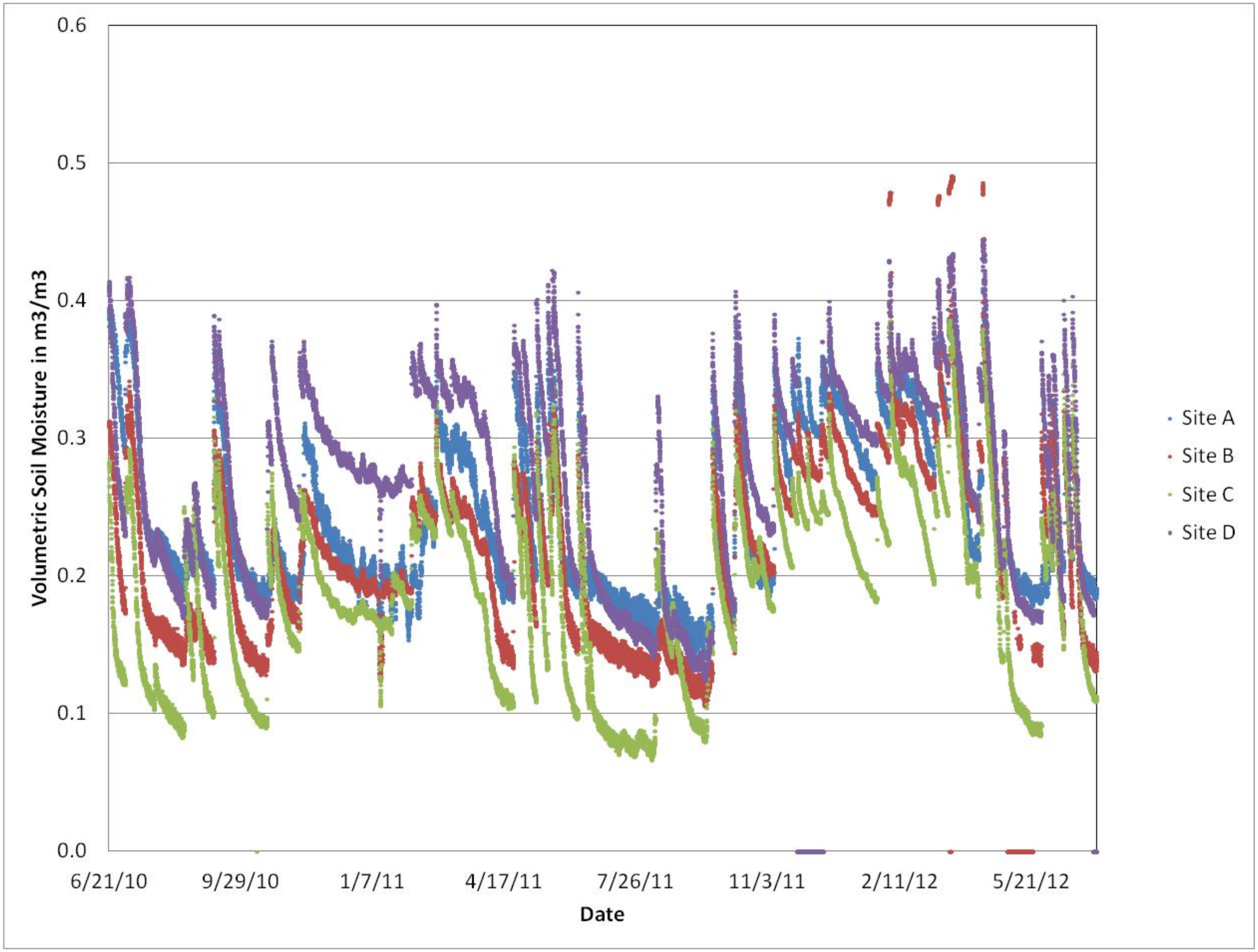
Sites A-D Hydras at 5 cm depth



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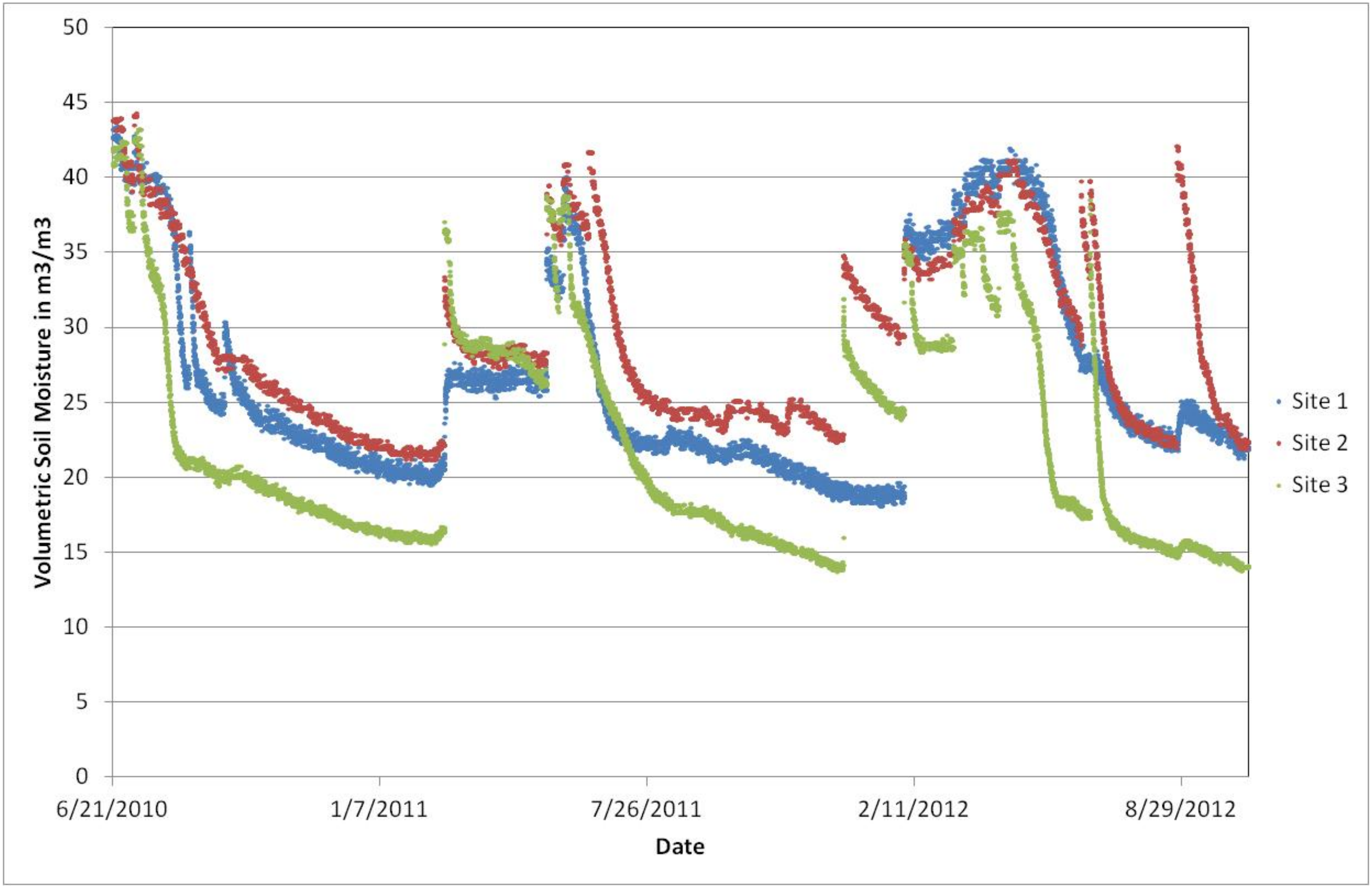
CRN Hydras at 100 cm depth



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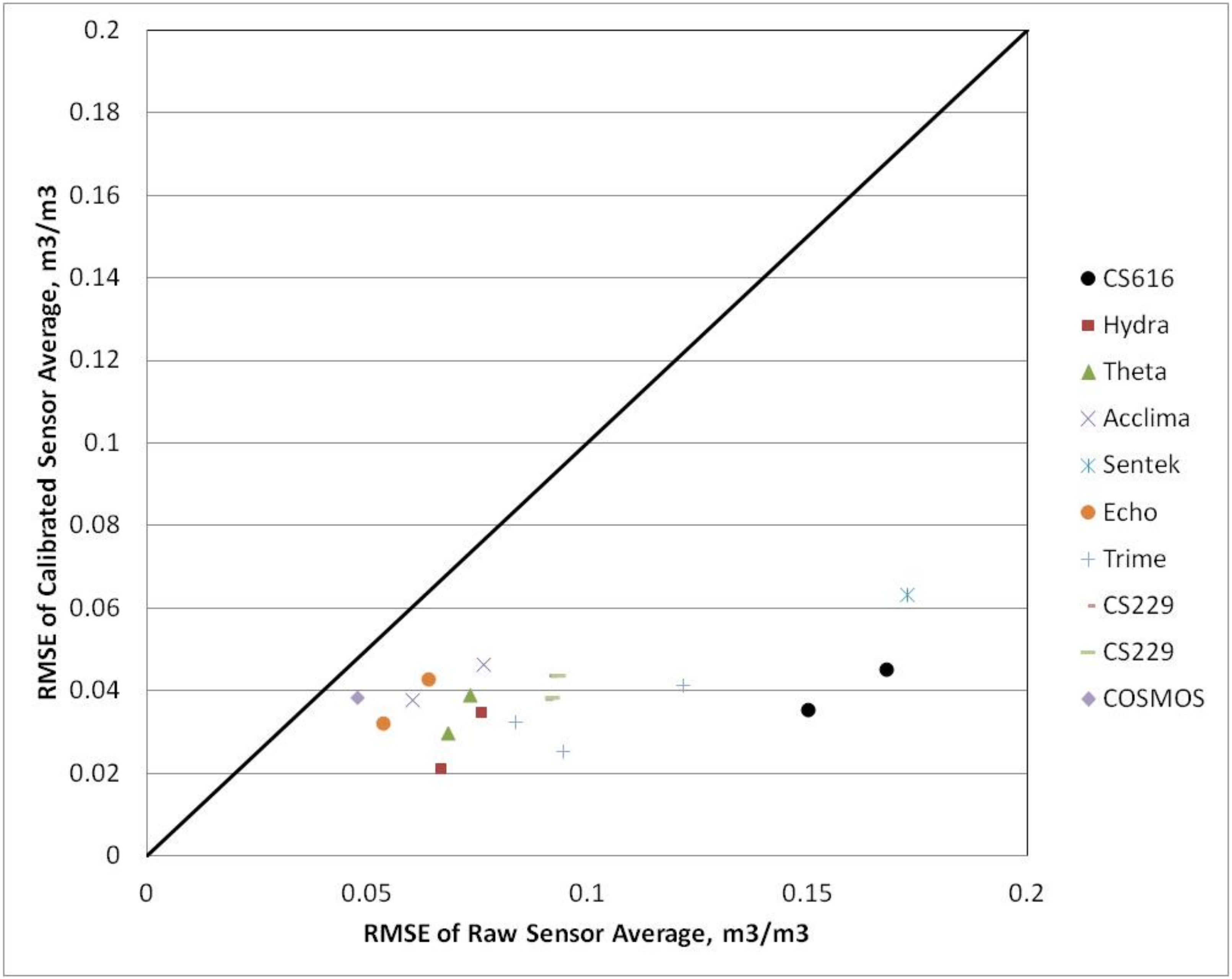
Uniform conditions in the testbed



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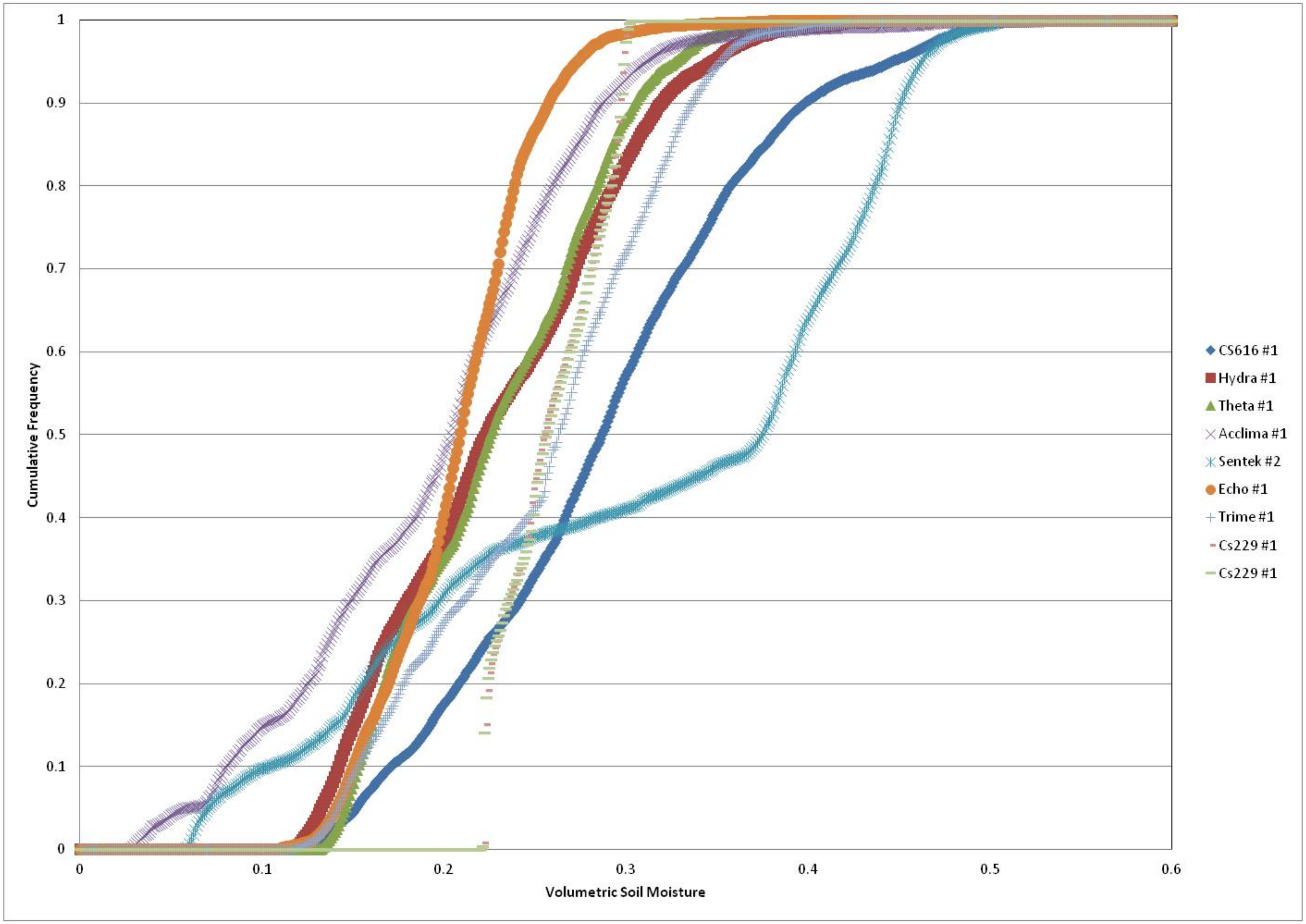
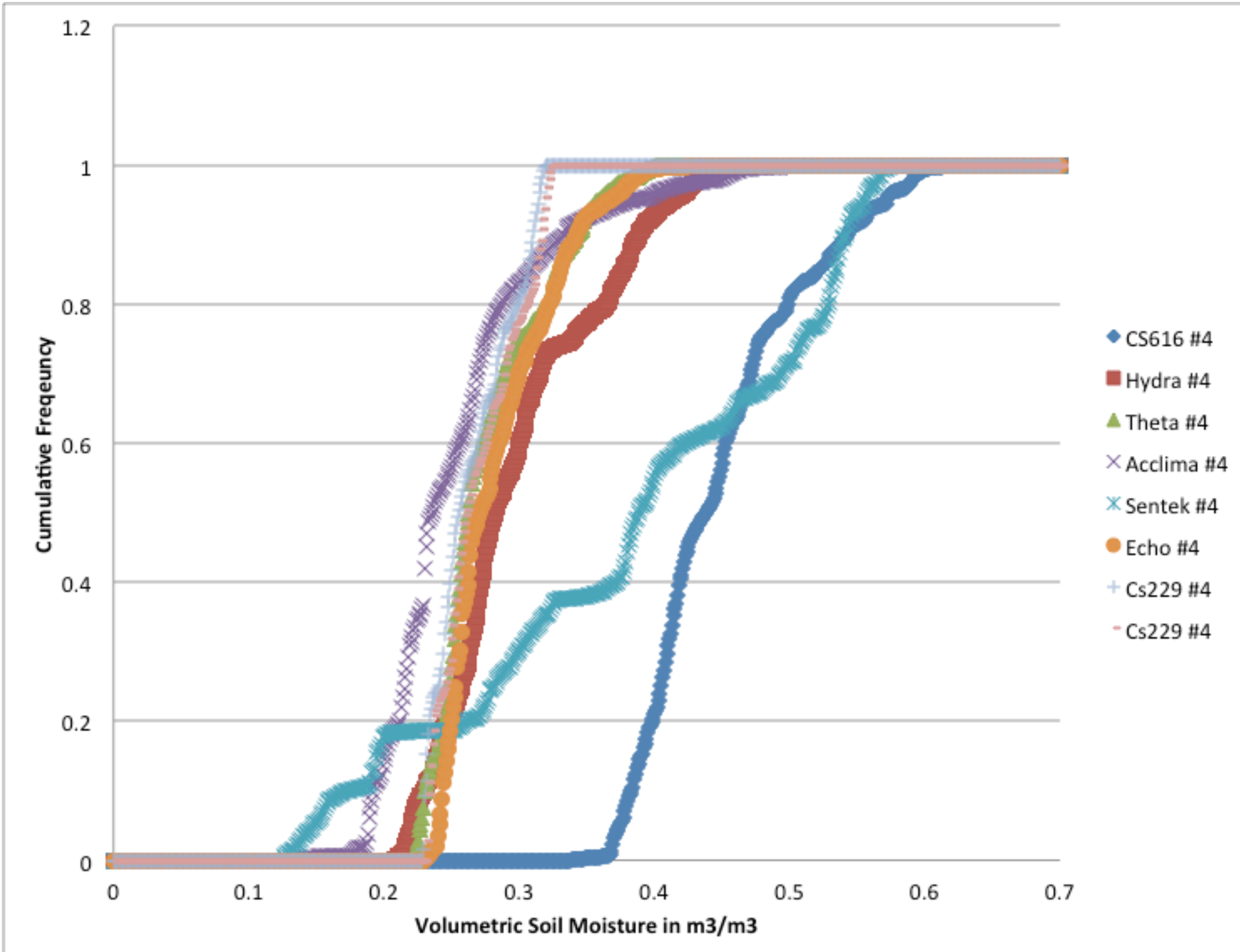
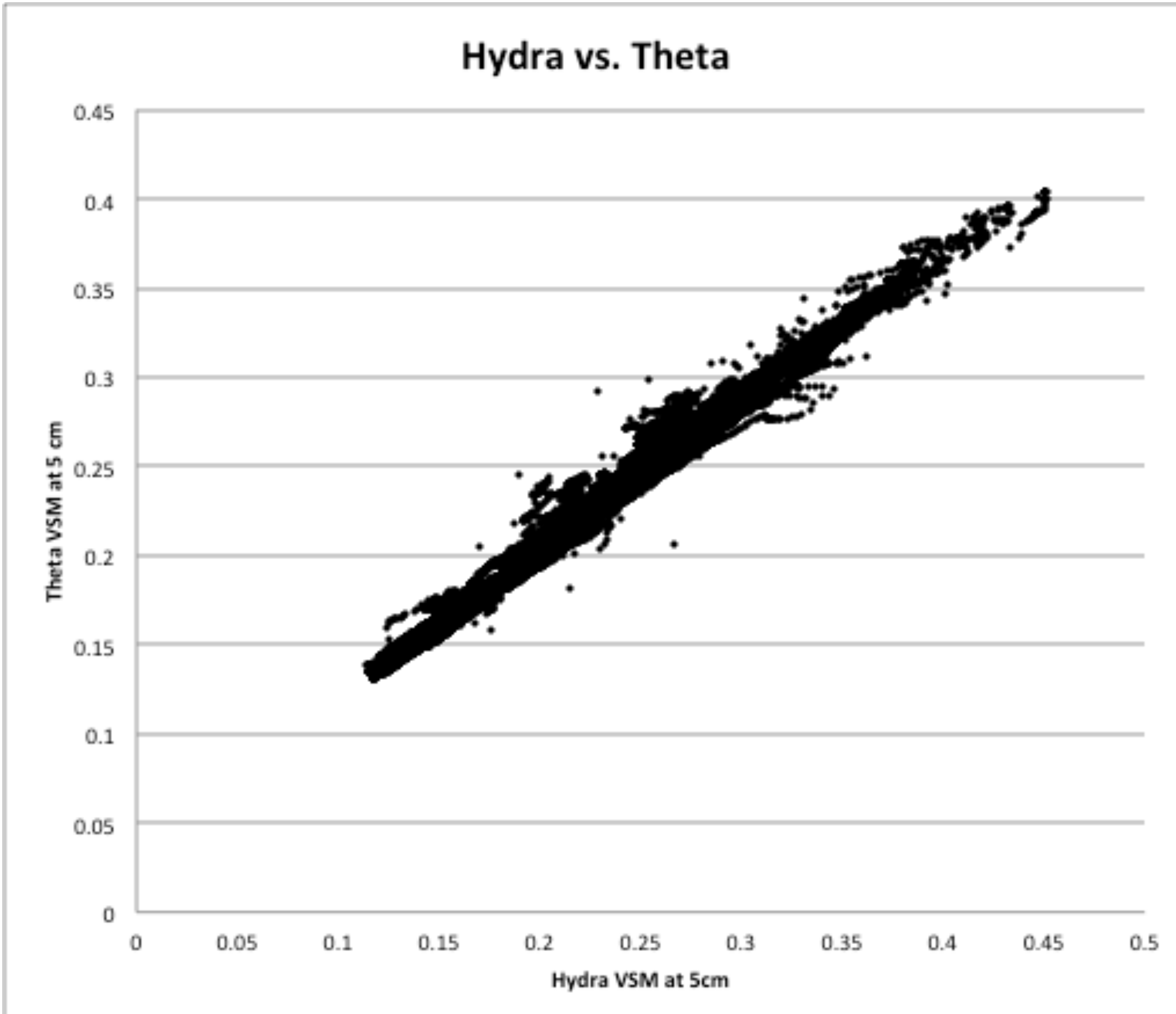
CDFs of Site Averages by Sensor at 5 cm



SMAP Marena Oklahoma In Situ Sensor Testbed
CDFs of Site Averages by Sensor at 50 cm



SMAP Marena Oklahoma In Situ Sensor Testbed
Sensor to Sensor Average Comparison



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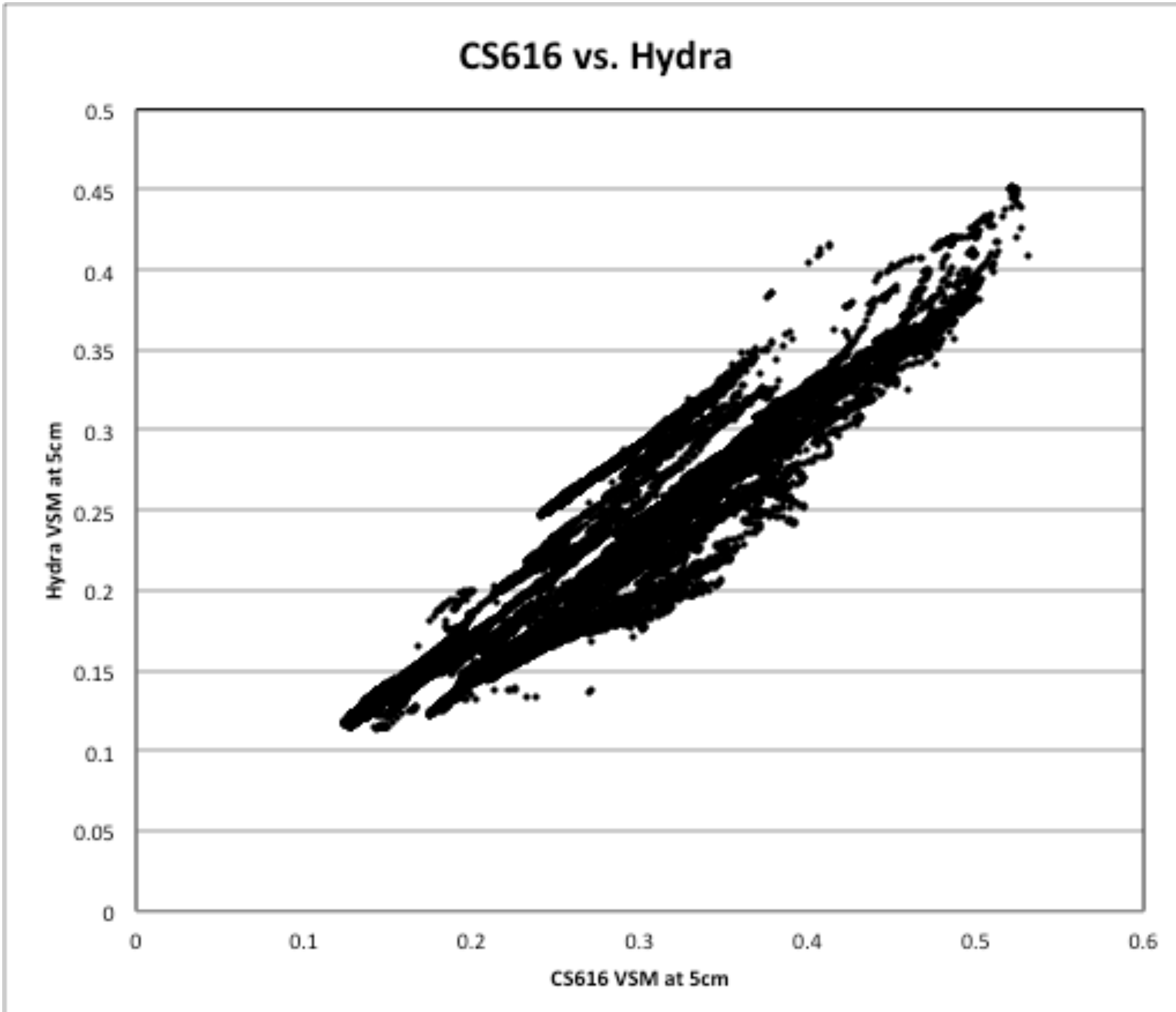

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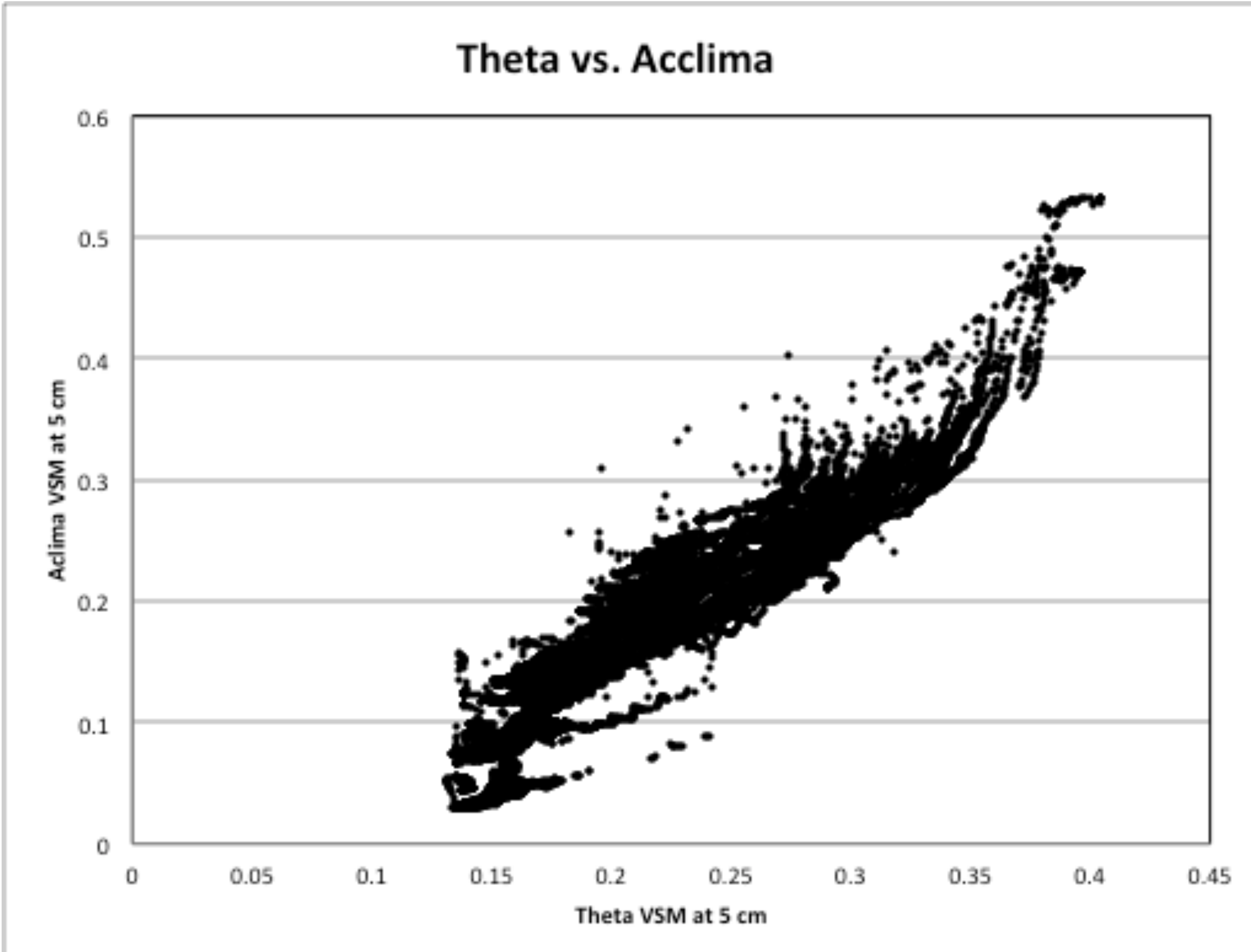

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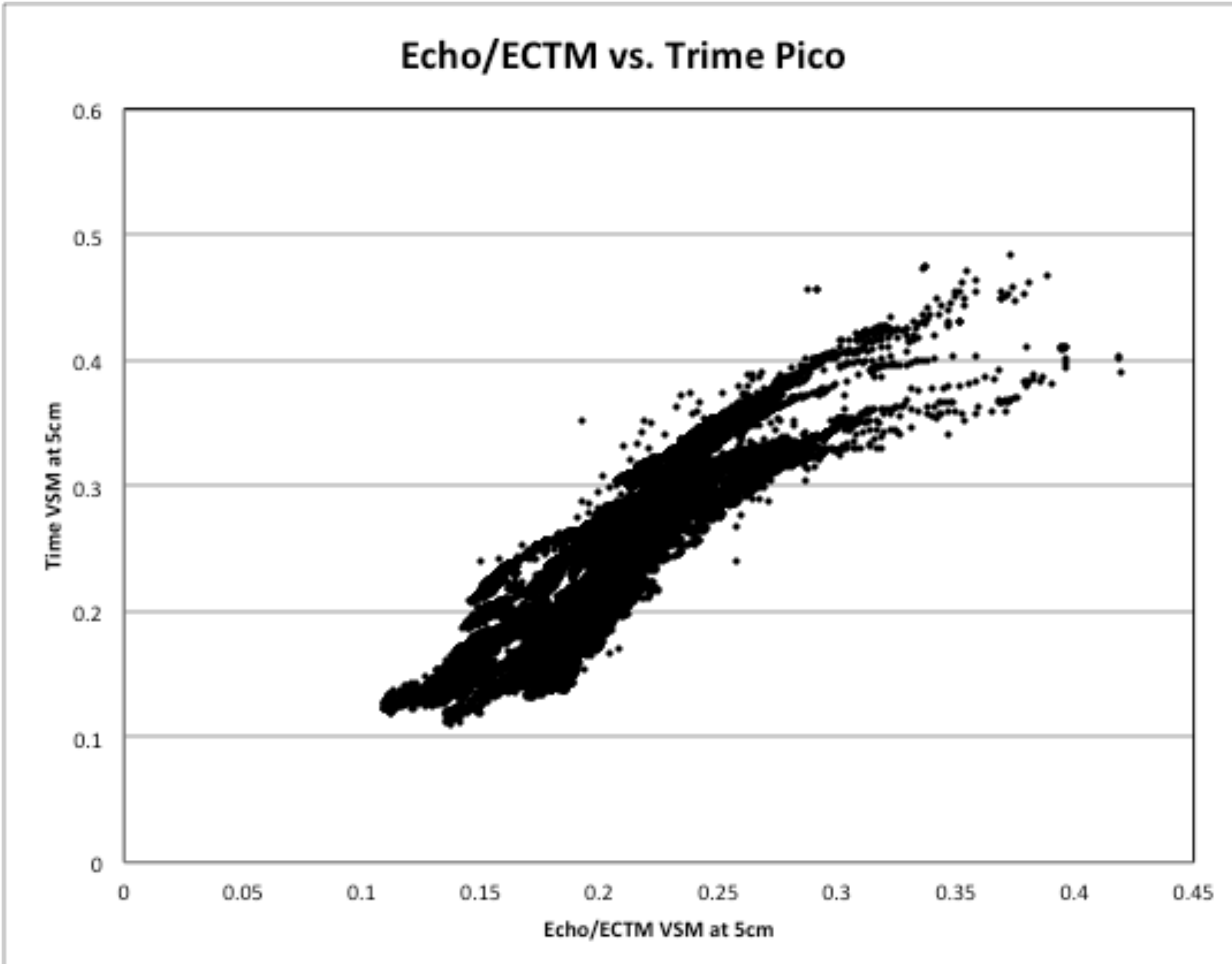

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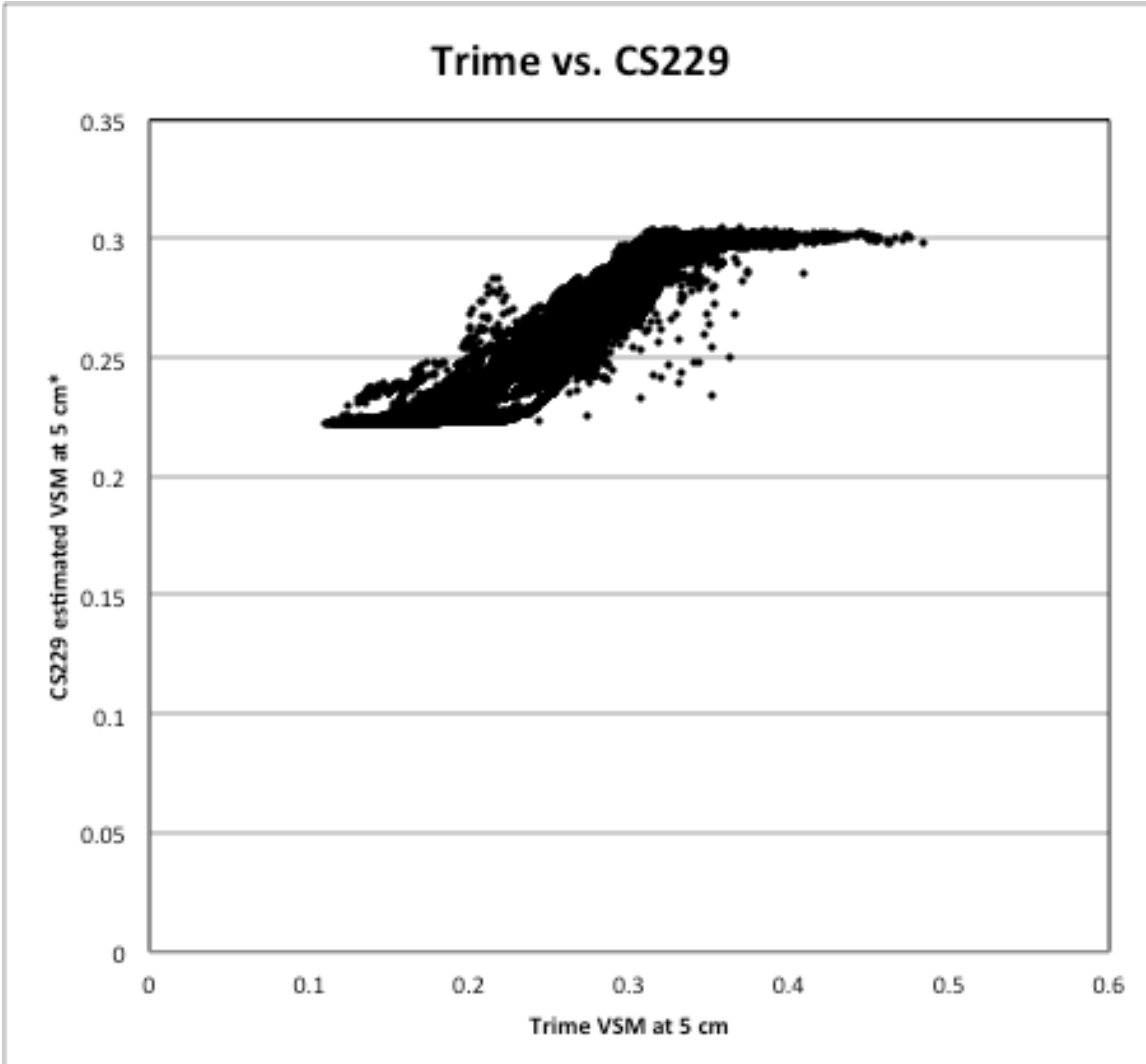

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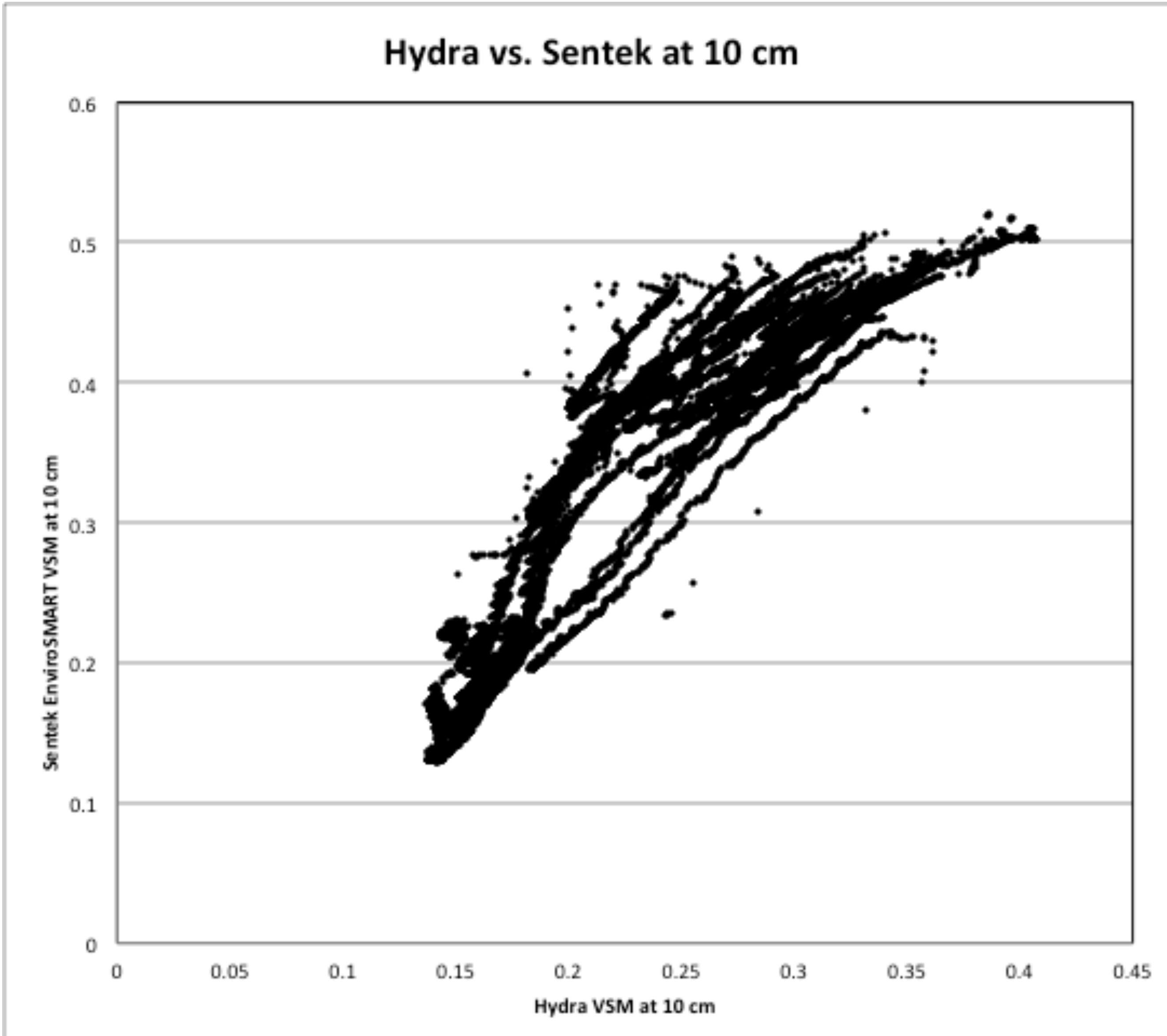

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Some Conclusions

- Installation practices and procedures should be standardized
- 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.
- Scaling also critical for all sensors.
- Diurnal patterns can be significant for some surface sensors (~4%) depending on temperature range

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What is freezing?