# The Soil Moisture Active Passive Marena Oklahoma In Situ Sensor Testbed (SMAP-MOISST): Design and Initial Results

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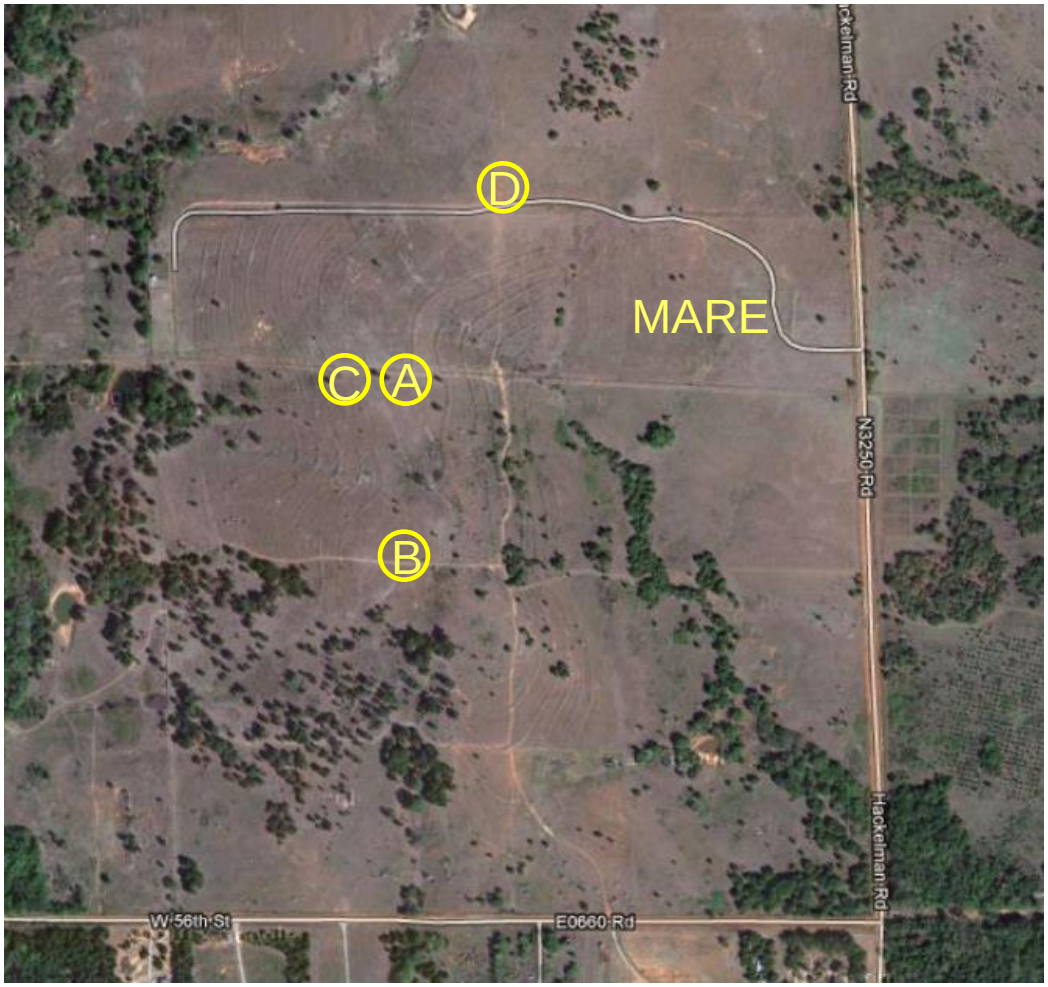
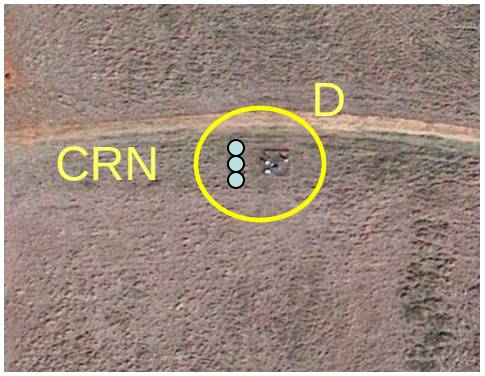
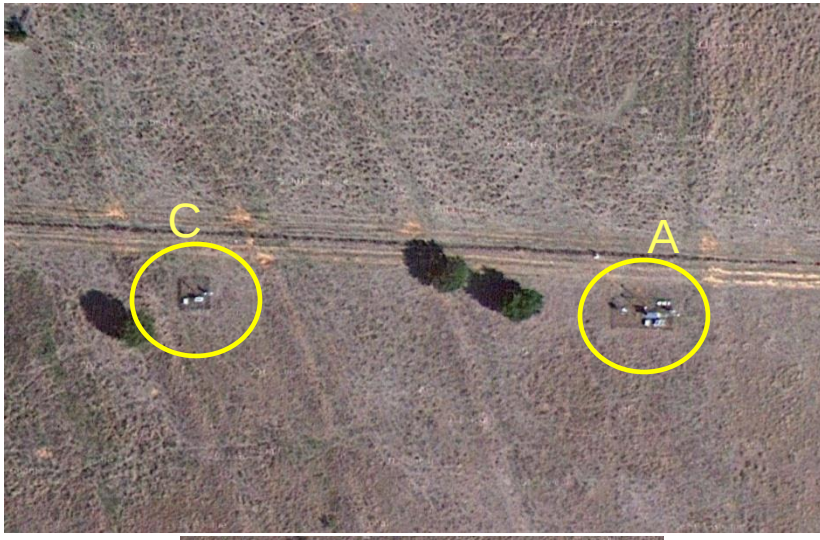
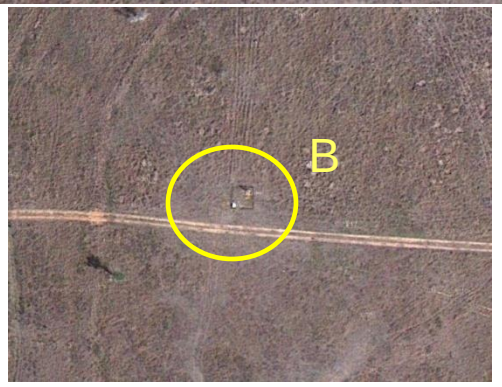
# SMAP Marena Oklahoma In Situ Sensor Testbed
## Site Design



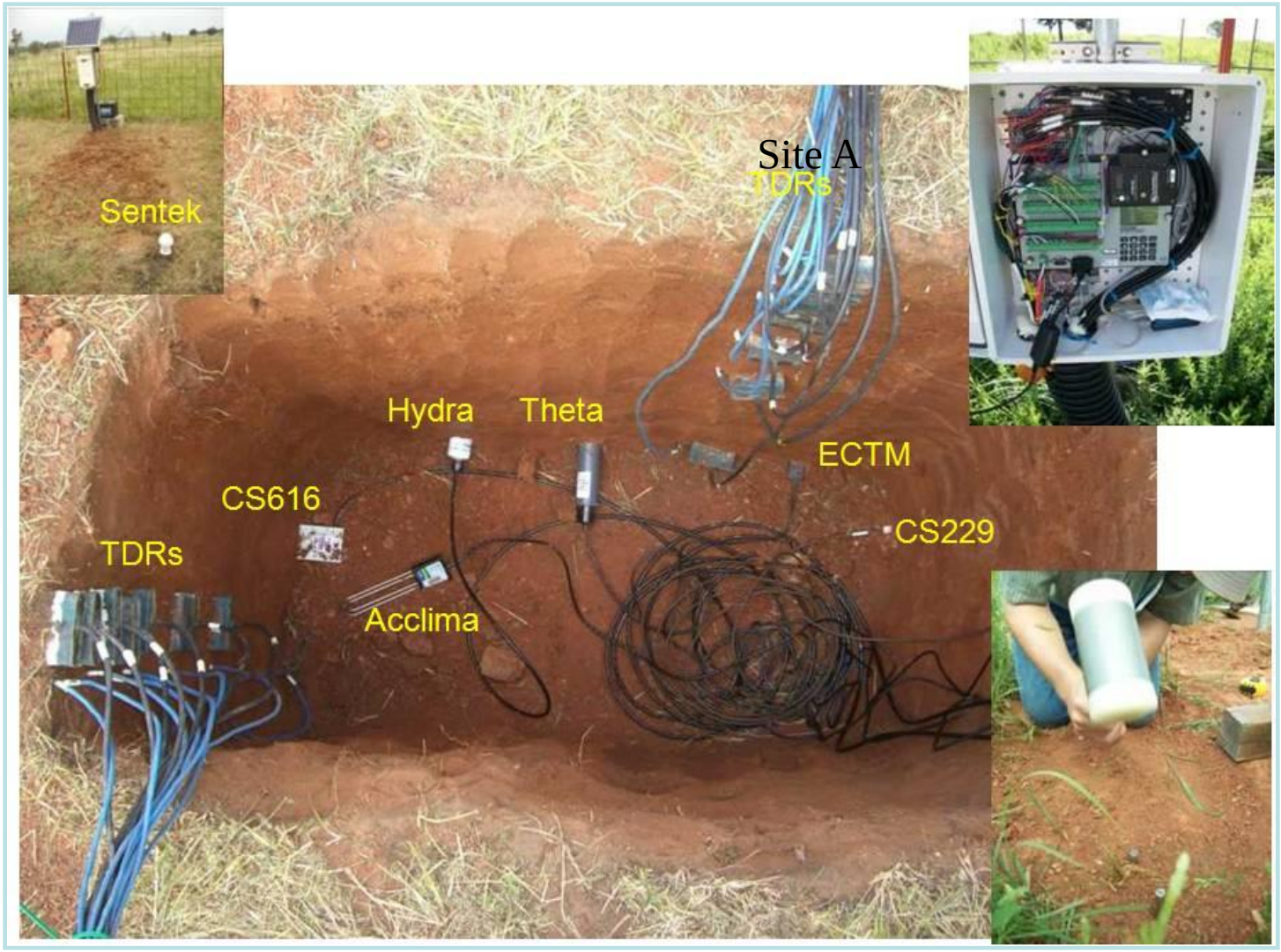
# SMAP Marena Oklahoma In Situ Sensor Testbed
## Marena Site Design

- 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 | | | |

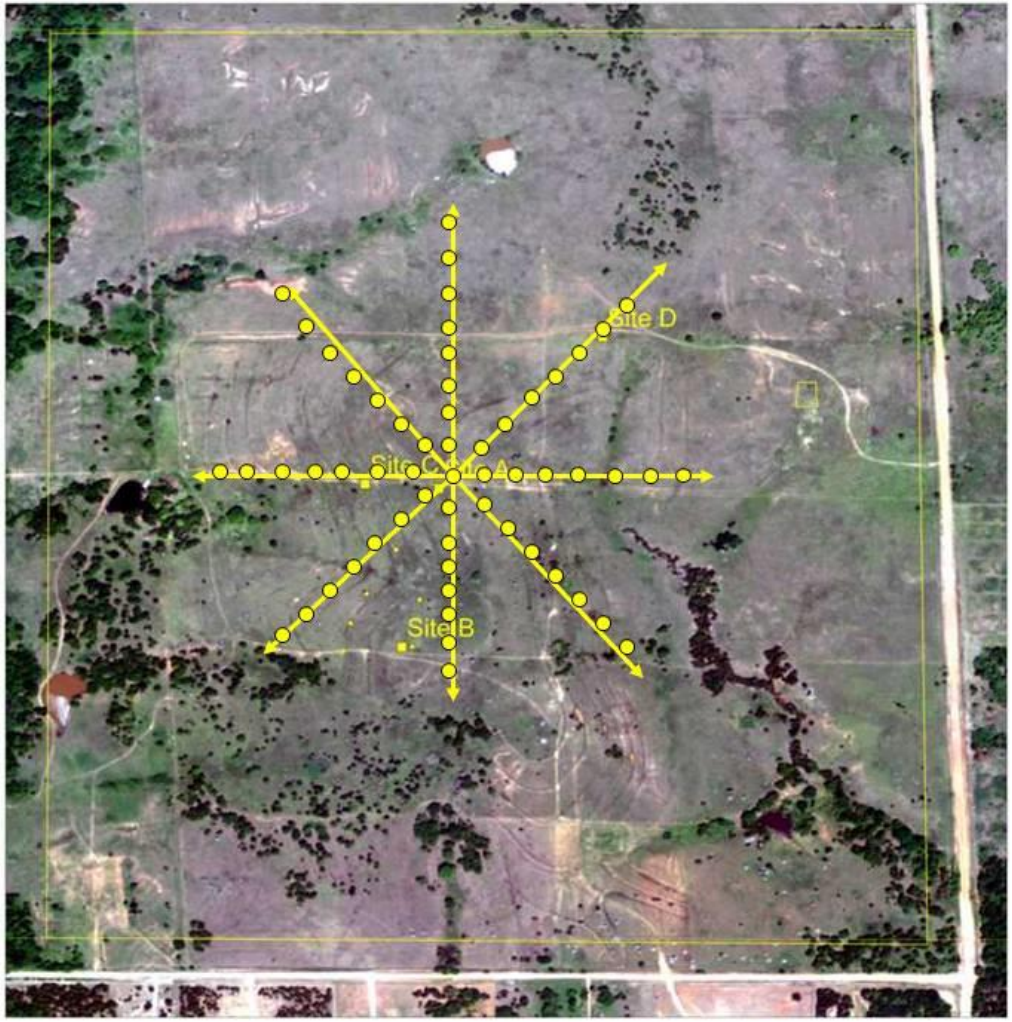
# SMAP Marena Oklahoma In Situ Sensor Testbed Installation

- Installation in May 2010



# SMAP Marena Oklahoma In Situ Sensor Testbed
## Validation Sampling Campaigns

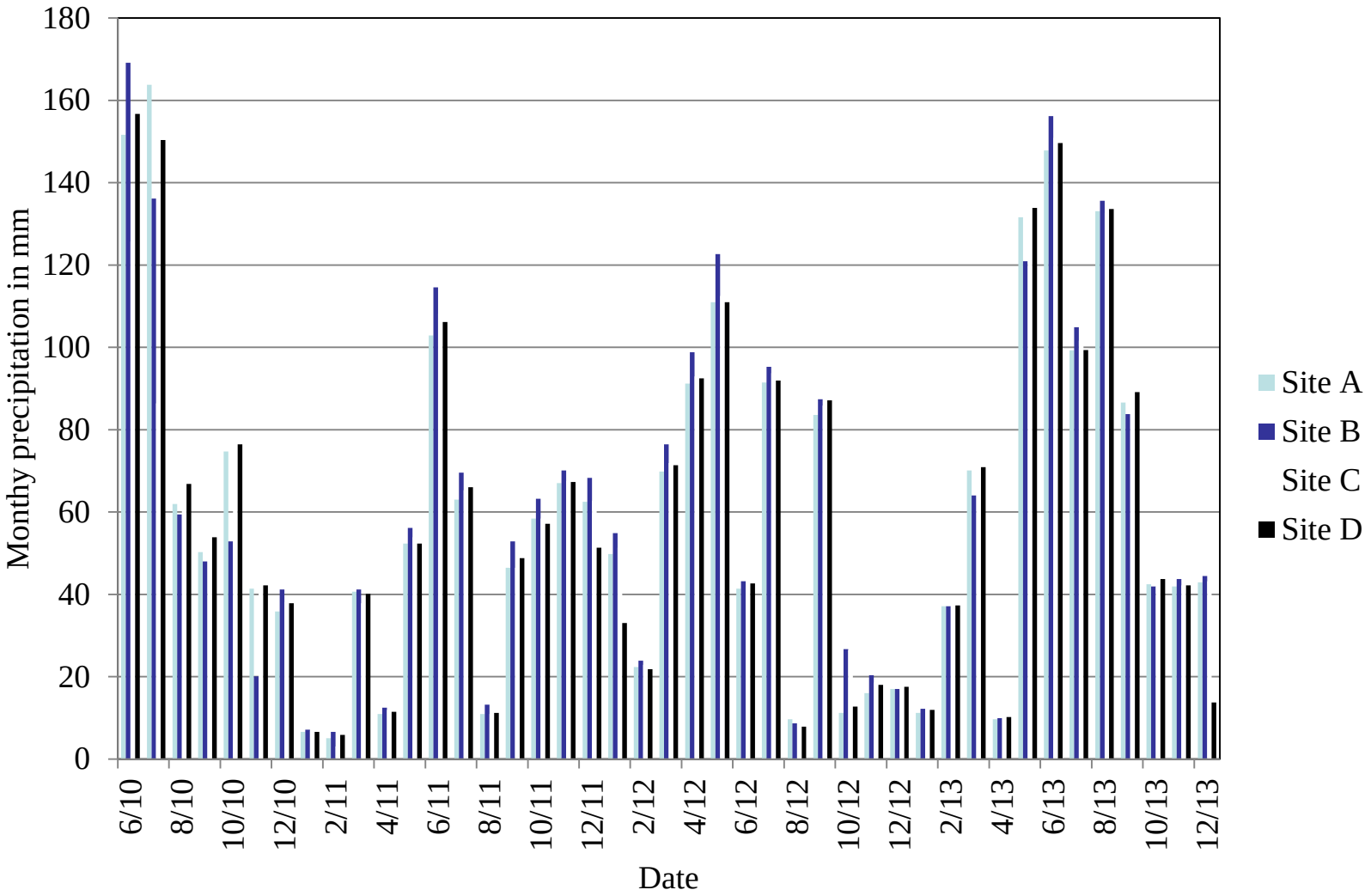
- Monthly Sampling
  - Vegetation Collection
  - Gravimetric Sampling
  - Theta Probe Sampling
- Intensive Observations
  - High Density Sampling
  - Soil Profiles



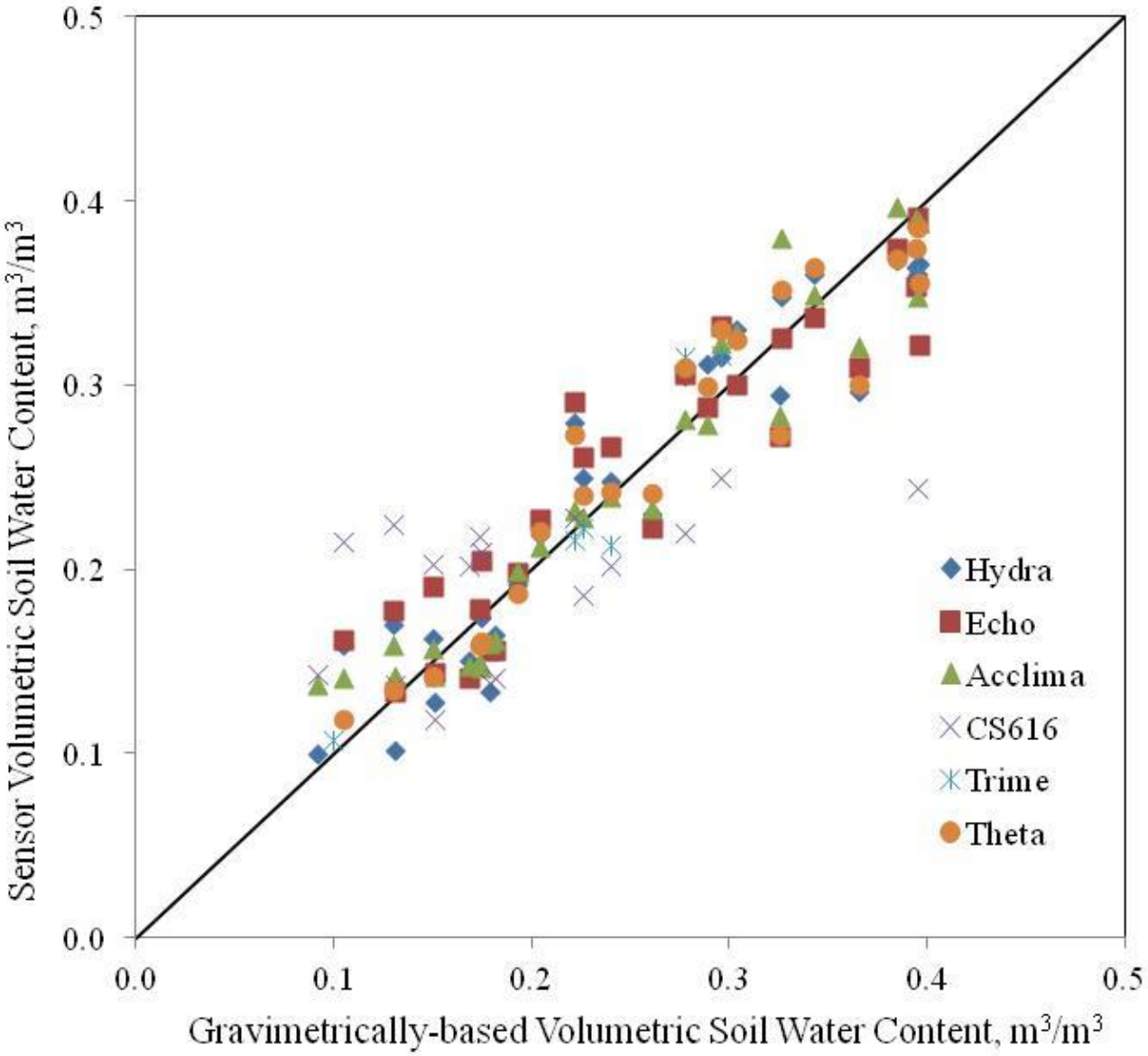
# SMAP Marena Oklahoma In Situ Sensor Testbed
## Timeline

- 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
  - Burn Study Winter 2012
  - Additional UAVSAR flights October 2012
  - AirMoss Validation October 2012

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



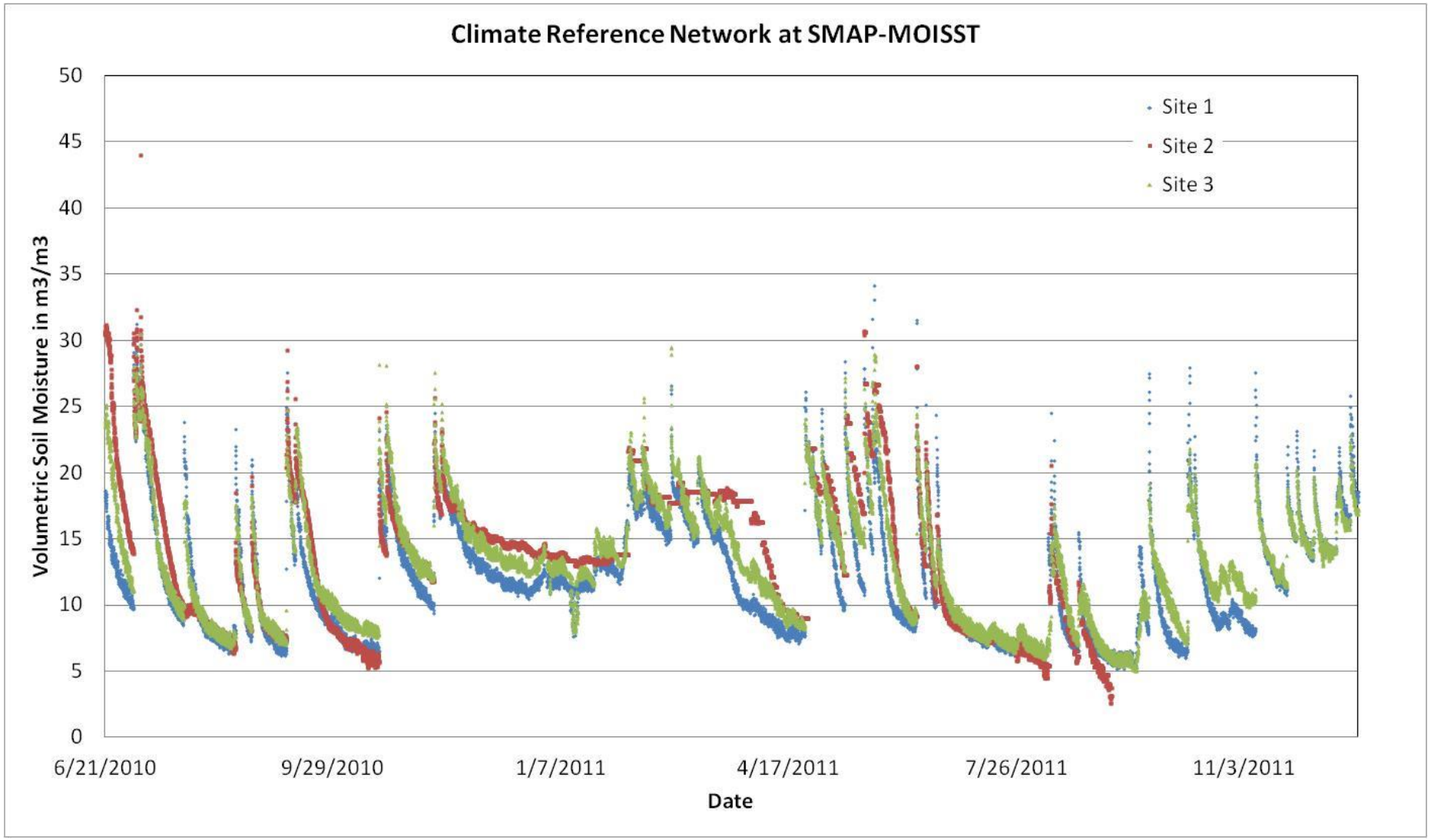
# SMAP Marena Oklahoma In Situ Sensor Testbed
## Sensor Calibration



# SMAP Marena Oklahoma In Situ Sensor Testbed
## Sensor Calibration

| Sensor | Factory Listed Accuracy | Bias w/ factory calibration | RMSE factory calibration | RMSE soil specific calibration | Failure Rate over 3 years |
|---|---|---|---|---|---|
| Theta | 0.01 | 0.014 | 0.030 | 0.028 | 0 out of 20 |
| Hydra | 0.01-0.03 | 0.020 | 0.040 | 0.032 | 0 out of 24 |
| ECTM | 0.03 | 0.076 | 0.081 | 0.036 | 8 out of 20 |
| CS-616 | 0.025 | -0.023 | 0.073 | 0.063 | 1 out of 20 |
| Trime | 0.01-0.03 | 0.005 | 0.042 | 0.023 | 0 out of 6 |
| Acclima | 0.01 | 0.074 | 0.080 | 0.025 | 9 out of 20 |
| CS-229 | N/A | - | - | - | 2 out of 20* |
| Enviro-SMART | N/A | - | - | - | 4 out 15** |

# SMAP Marena Oklahoma In Situ Sensor Testbed
## CRN 5 cm

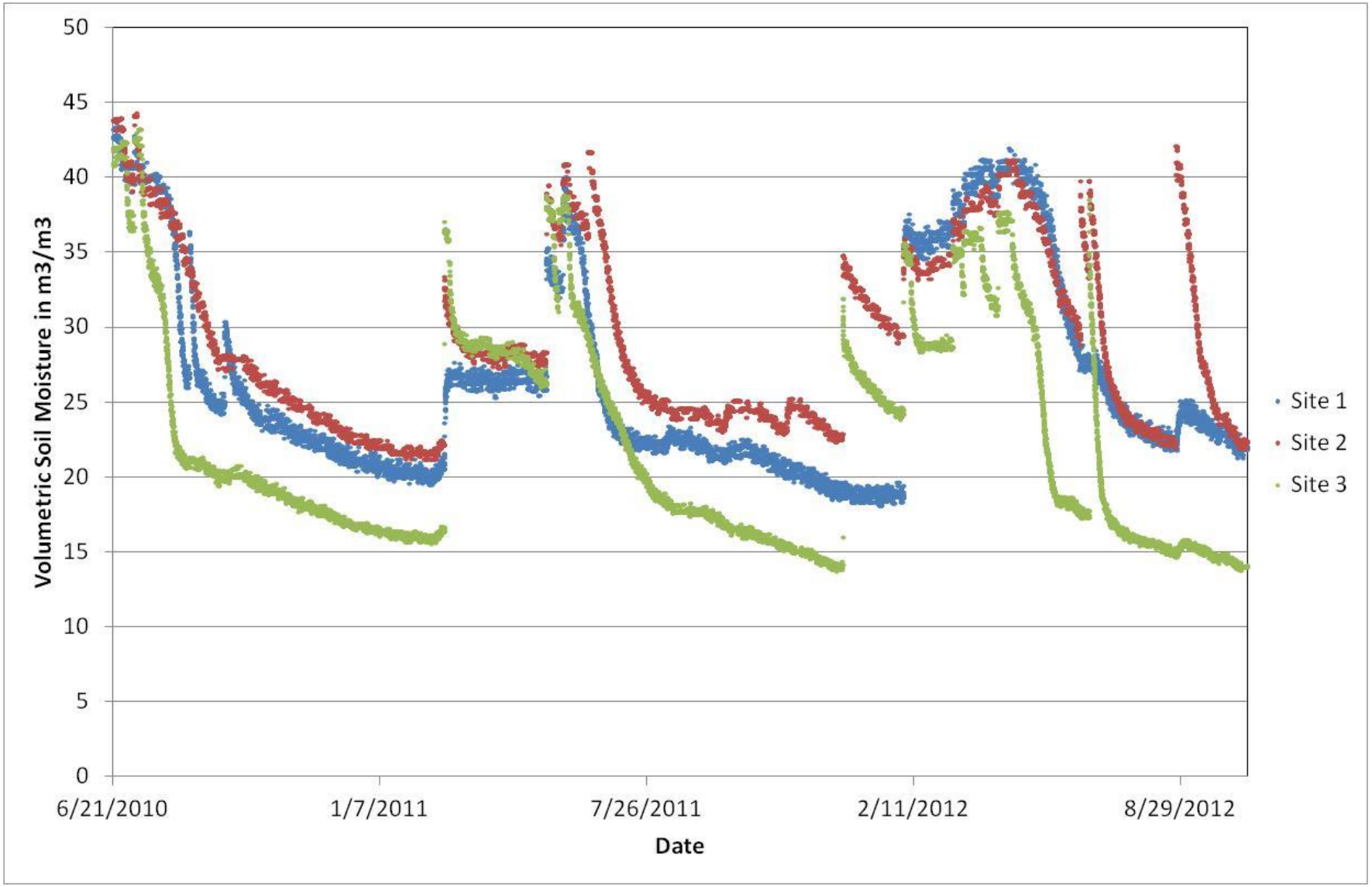


# SMAP Marena Oklahoma In Situ Sensor Testbed
## CRN 5 cm

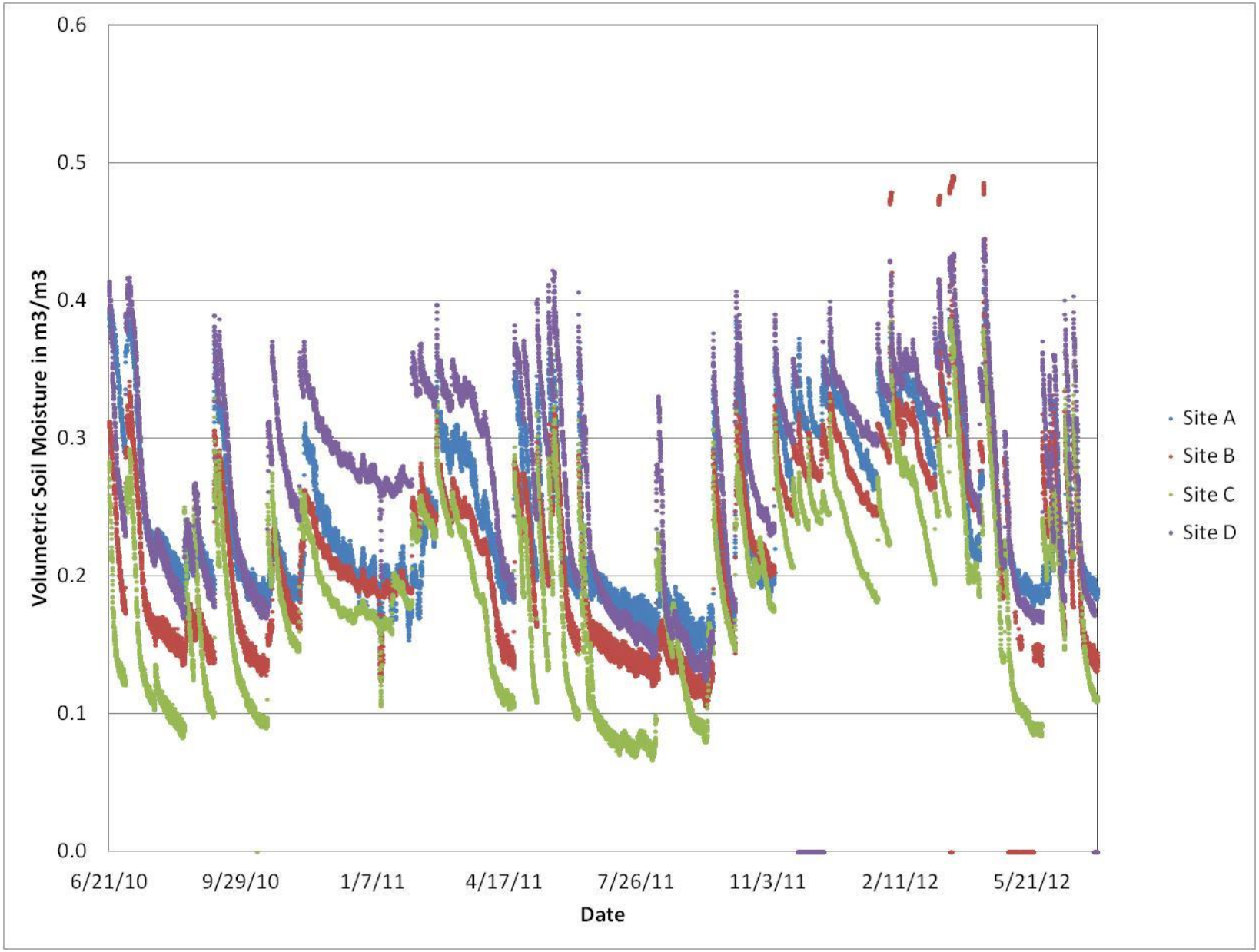
Comparison of the three CRN 5 cm installations which are in close proximity

| | 5 cm | Site 1 | Site 2 | Site 3 |
|---|---|---|---|---|
| RMSD | Site 1 | 0 | 0.054 | 0.028 |
| | Site 2 | | 0 | 0.039 |
| | Site 3 | | | 0 |
| r | Site 1 | 1 | 0.855 | 0.964 |
| | Site 2 | | 1 | 0.922 |
| | Site 3 | | | 1 |

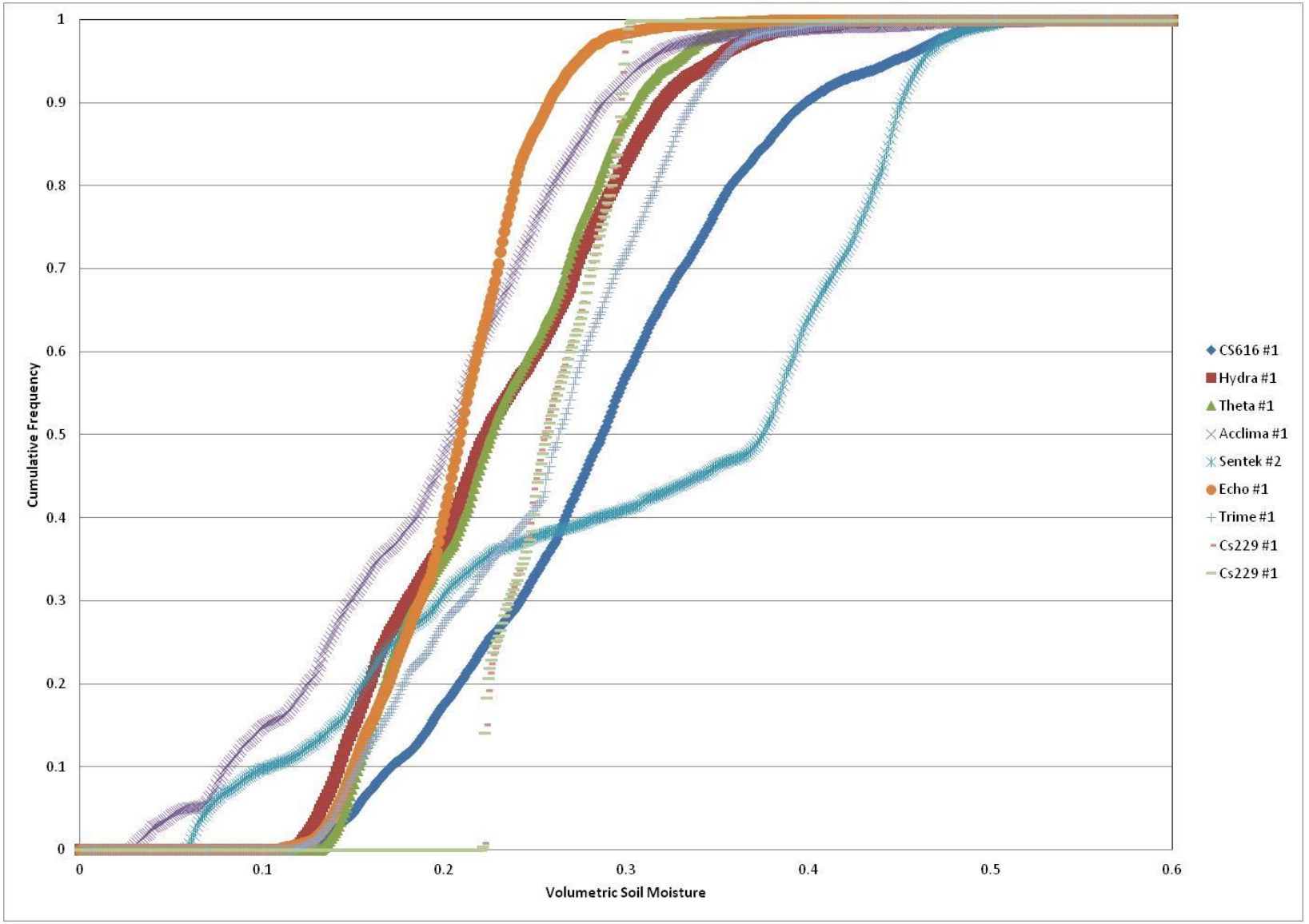
# SMAP Marena Oklahoma In Situ Sensor Testbed
## CRN Hydras at 100 cm depth



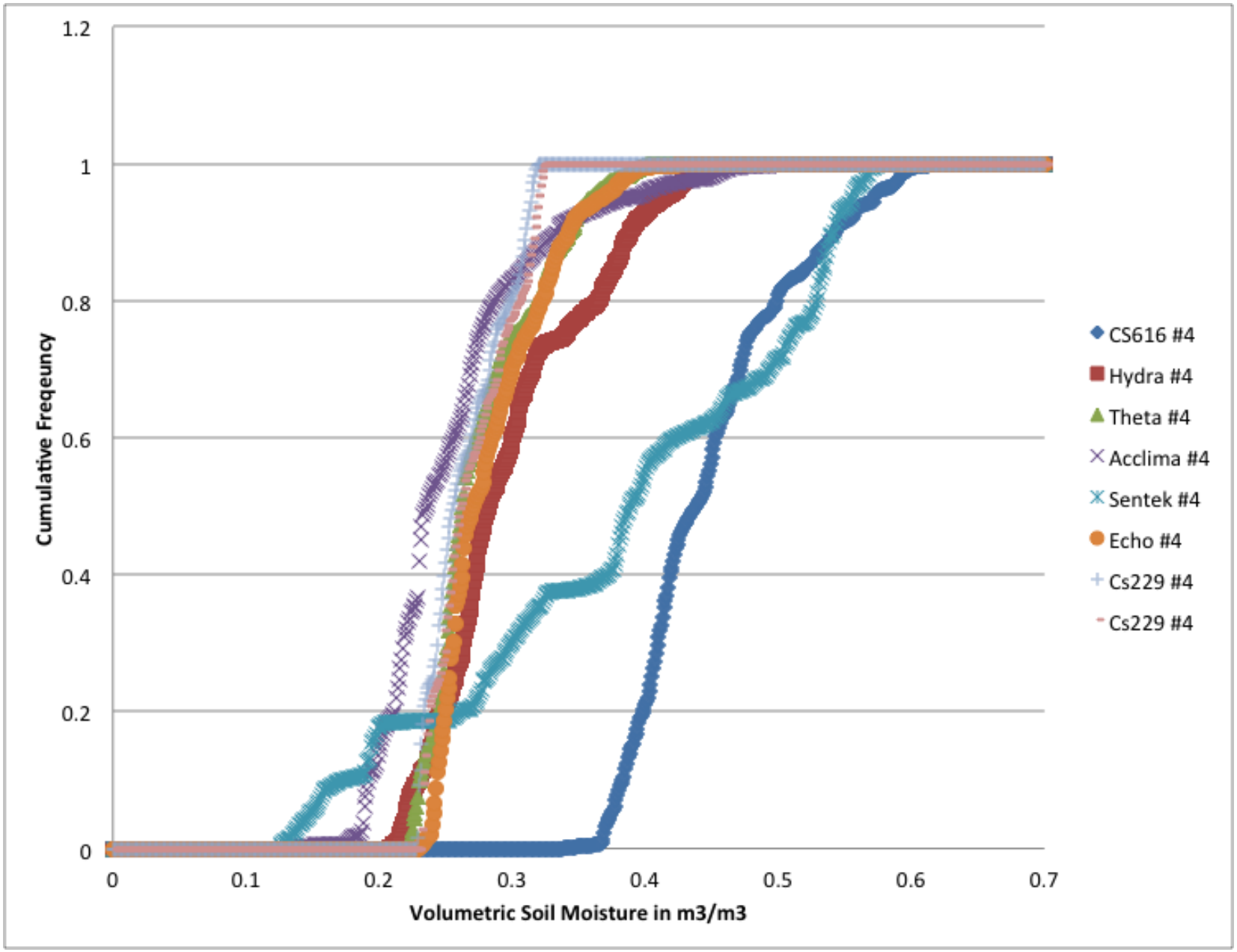
# SMAP Marena Oklahoma In Situ Sensor Testbed
## Sites A-D Hydras at 5 cm depth



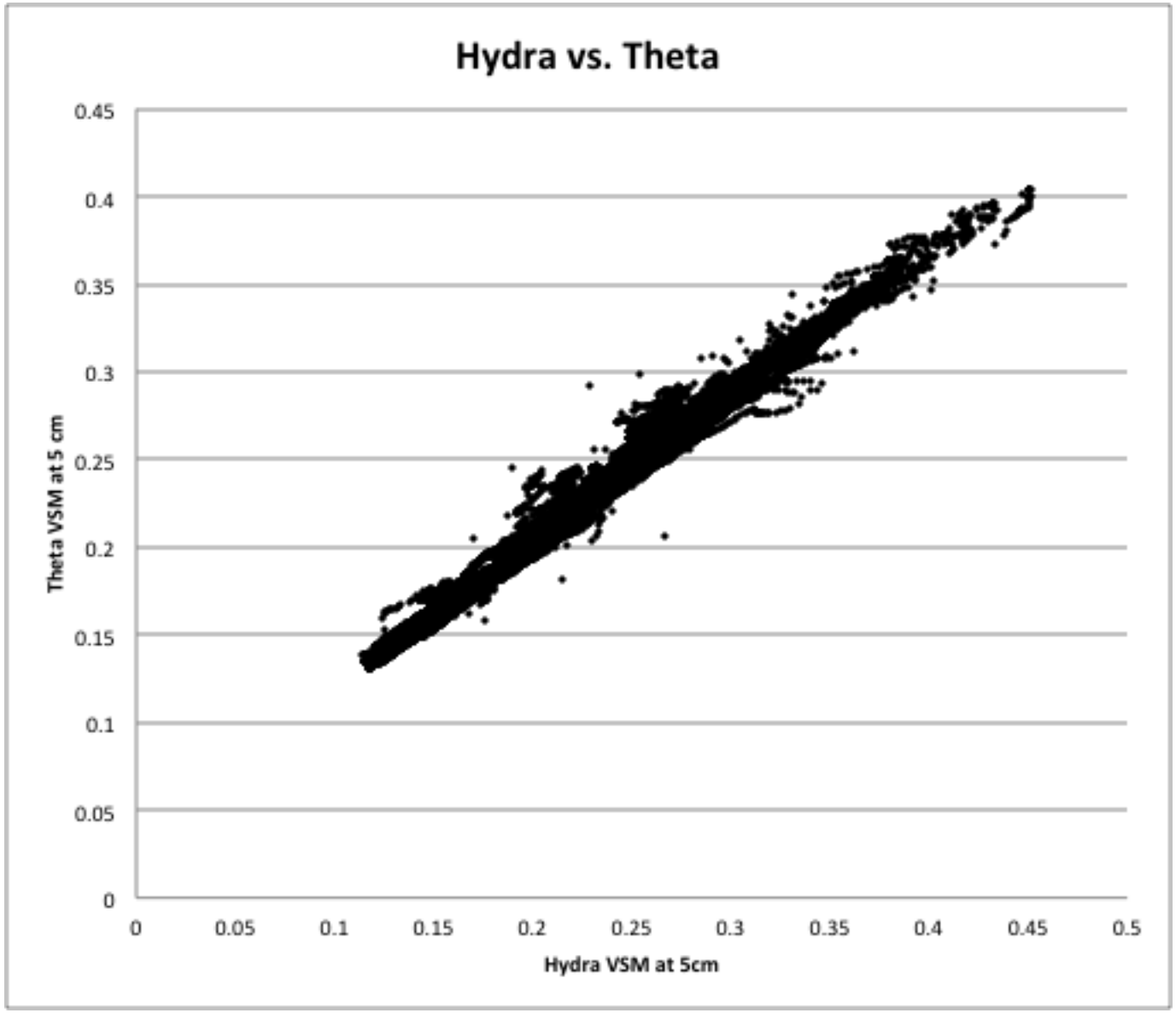
# SMAP Marena Oklahoma In Situ Sensor Testbed
## CDFs of Site Averages by Sensor at 5 cm



# 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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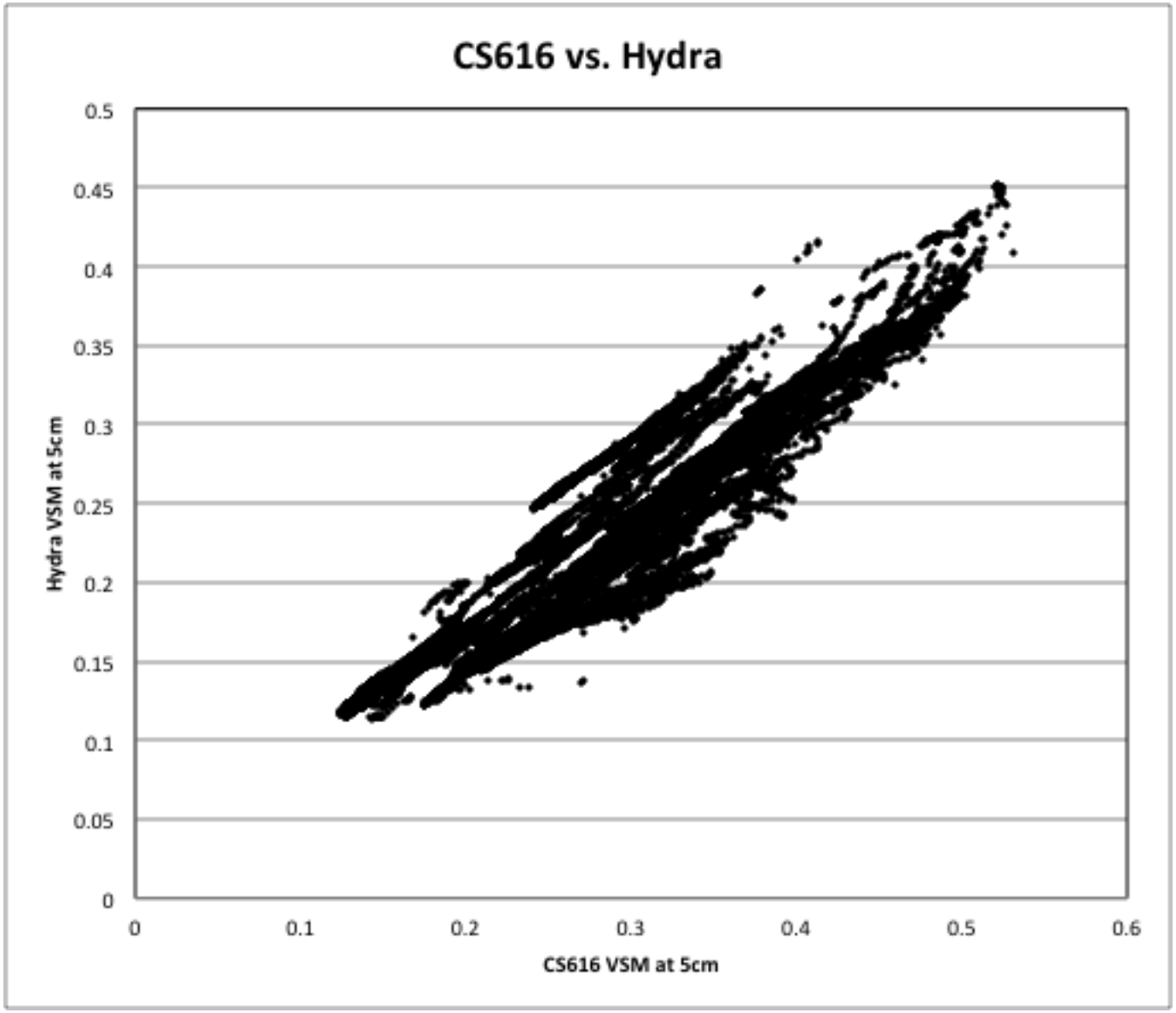
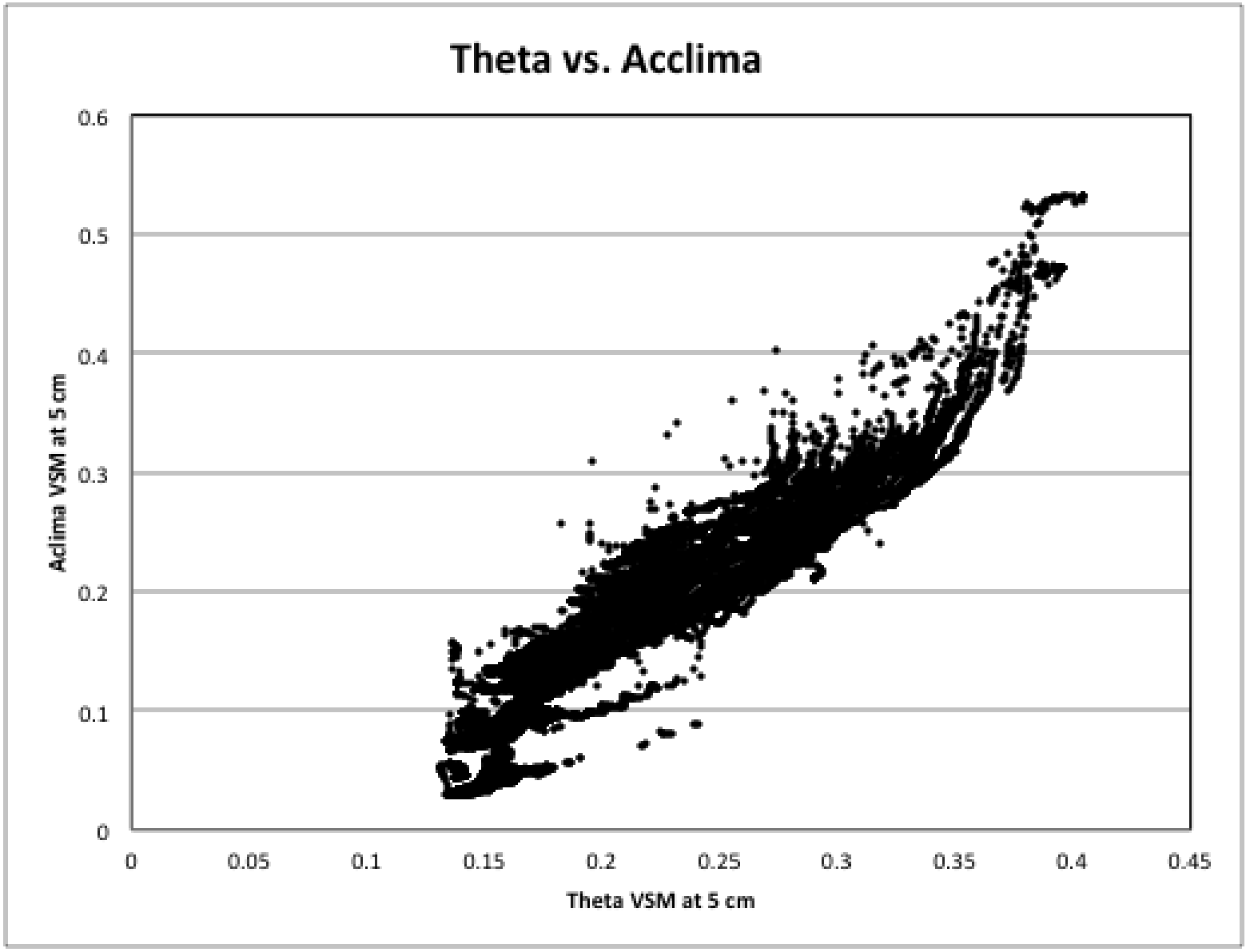


# SMAP Marena Oklahoma In Situ Sensor Testbed
## Sensor to Sensor Average Comparison



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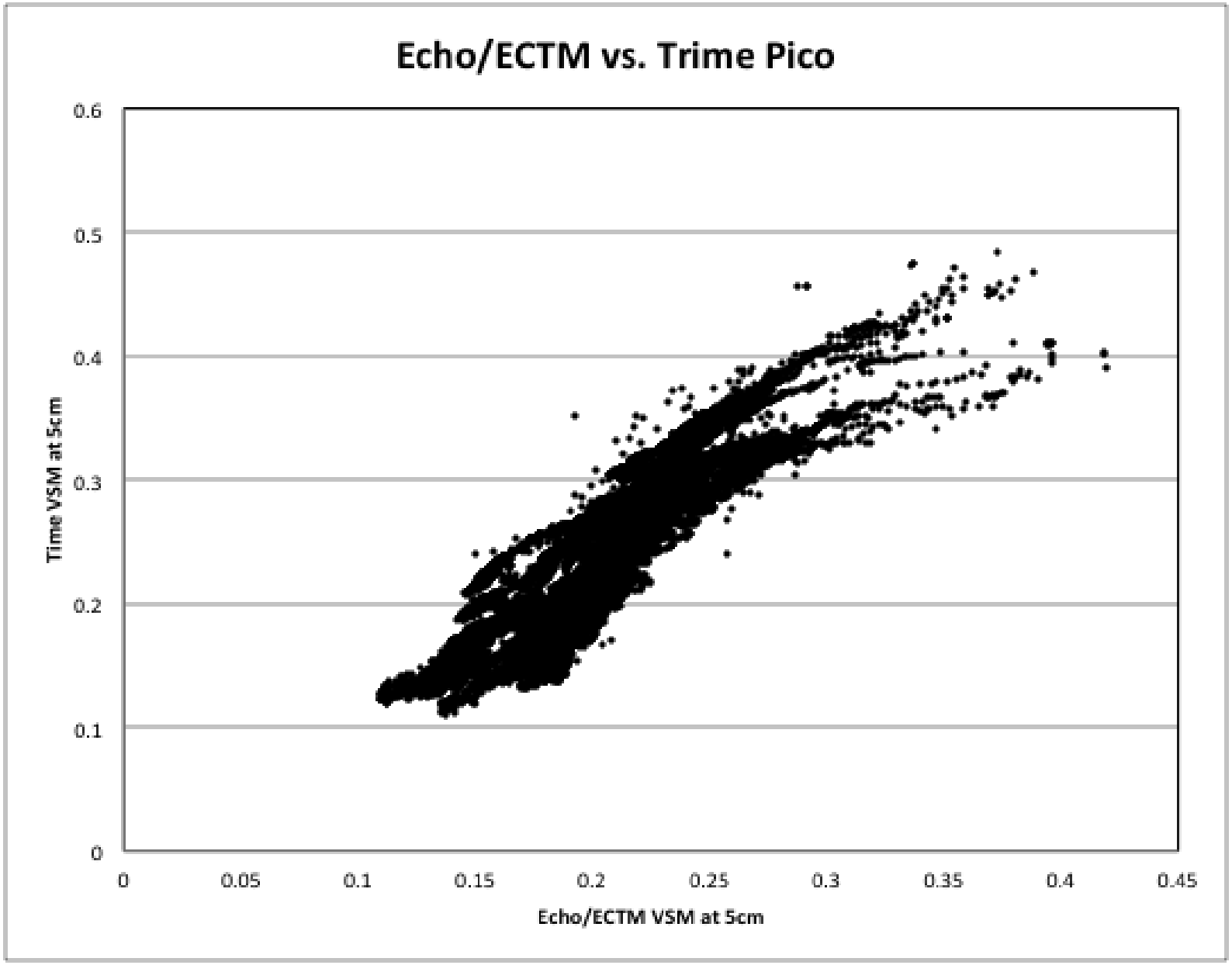
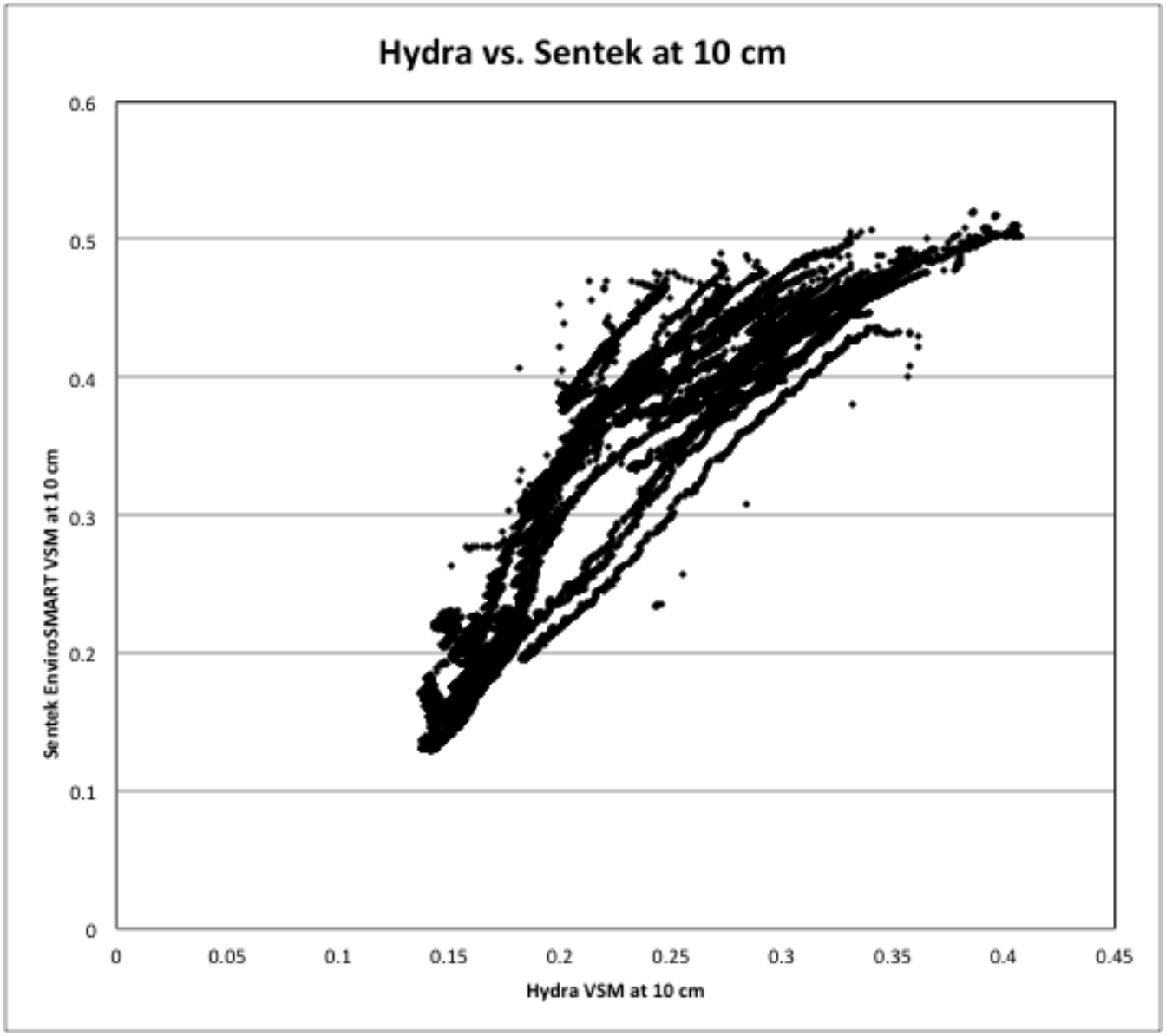


# SMAP Marena Oklahoma In Situ Sensor Testbed
## Sensor to Sensor Average Comparison



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

| Sensor | UnScaled | | | | Scaled | | | |
|---|---|---|---|---|---|---|---|---|
| | 2.5 cm | 5 cm | 10 cm | Variable Depth | 2.5 cm | 5 cm | 10 cm | Variable Depth |
| CS-616 | | 0.110 | 0.140 | | | 0.036 | 0.046 | |
| Hydra | 0.048 | 0.062 | 0.079 | | 0.021 | 0.035 | 0.047 | |
| Theta | | 0.058 | 0.063 | | | 0.030 | 0.039 | |
| Acclima | | 0.027 | 0.053 | | | 0.030 | 0.047 | |
| Sentek | | | 0.178 | | | | 0.064 | |
| ECTM | | 0.047 | 0.055 | | | 0.032 | 0.043 | |
| Trime | 0.083 | 0.085 | 0.110 | | 0.026 | 0.032 | 0.042 | |
| CS229 | | 0.089 | 0.091 | | | 0.038 | 0.044 | |
| GPSR | | | | 0.050 | | | | 0.036 |
| COSMOS | | | | 0.048 | | | | 0.035 |

# SMAP Marena Oklahoma In Situ Sensor Testbed
## Some Conclusions

- Installation practices and procedures should be standardized
- Calibration is critical for all sensors.
- Scaling (representativeness) also critical for all sensors.
- Raingage records are important for erroneous readings and troubleshooting.
- Accuracies of < 0.04 $m^3/m^3$ are achievable with a variety of sensors to field scales.
- Mixing of sensors within or between domains will cause variation at the fringes of the moisture conditions.

# SMAP Marena Oklahoma In Situ Sensor Testbed
## Future Plans

Install/Replace Acclima sensors

Install Campbell Scientific CS655/625

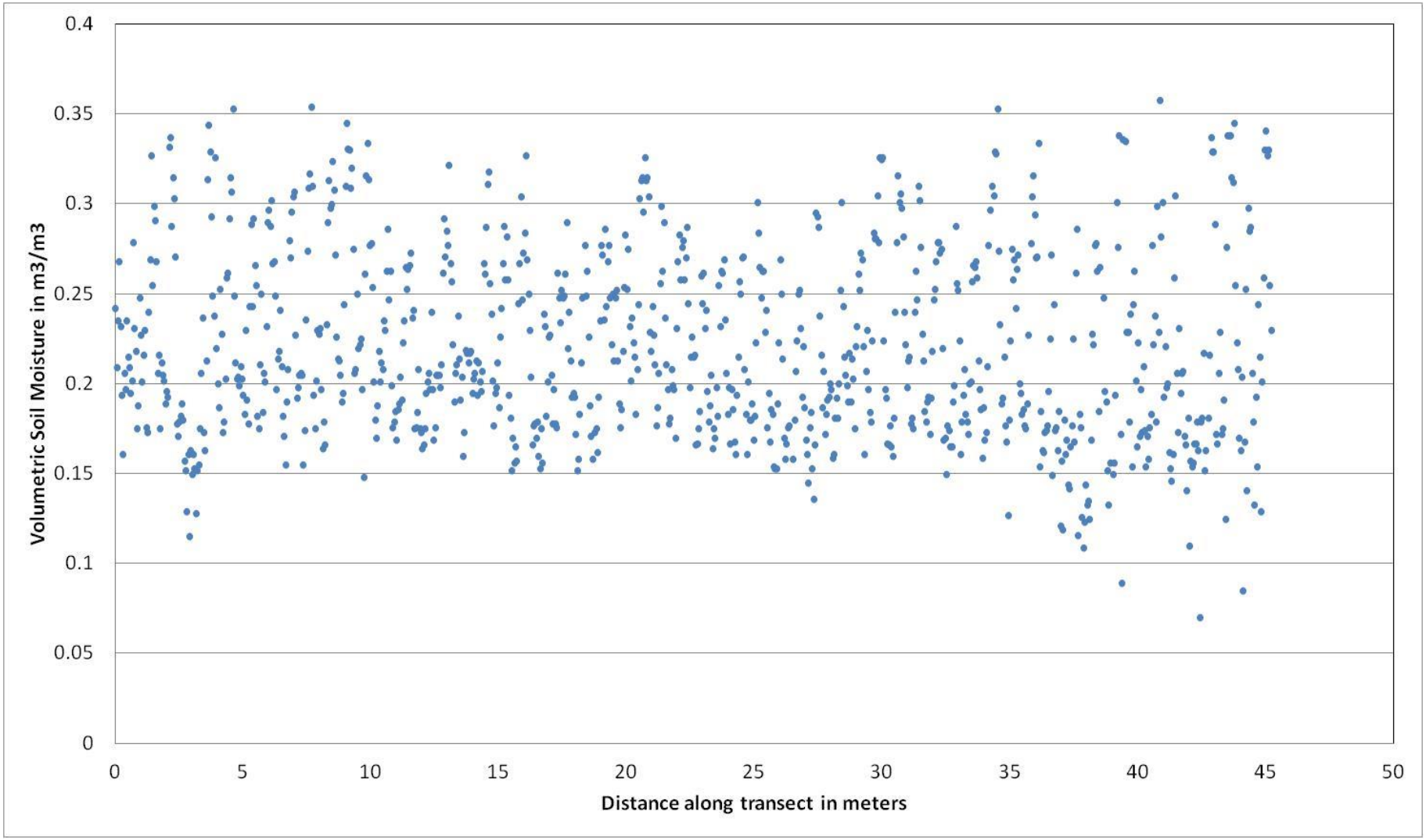
Perform temperature tests for Hydra sensors

Perform a study on portable soil moisture sensors

Continue with AIRMOSS cooperation


HAPPY
Birthday

# SMAP Marena Oklahoma In Situ Sensor Testbed
# Variability at the Surface 0-5 cm




*BEAREX08 Transect Data
Cosh et al., 2012