Soil Moisture Active Passive (SMAP)

and Marena Oklahoma In Situ Sensor Testbed (MOISST)

Past, Present, and Future

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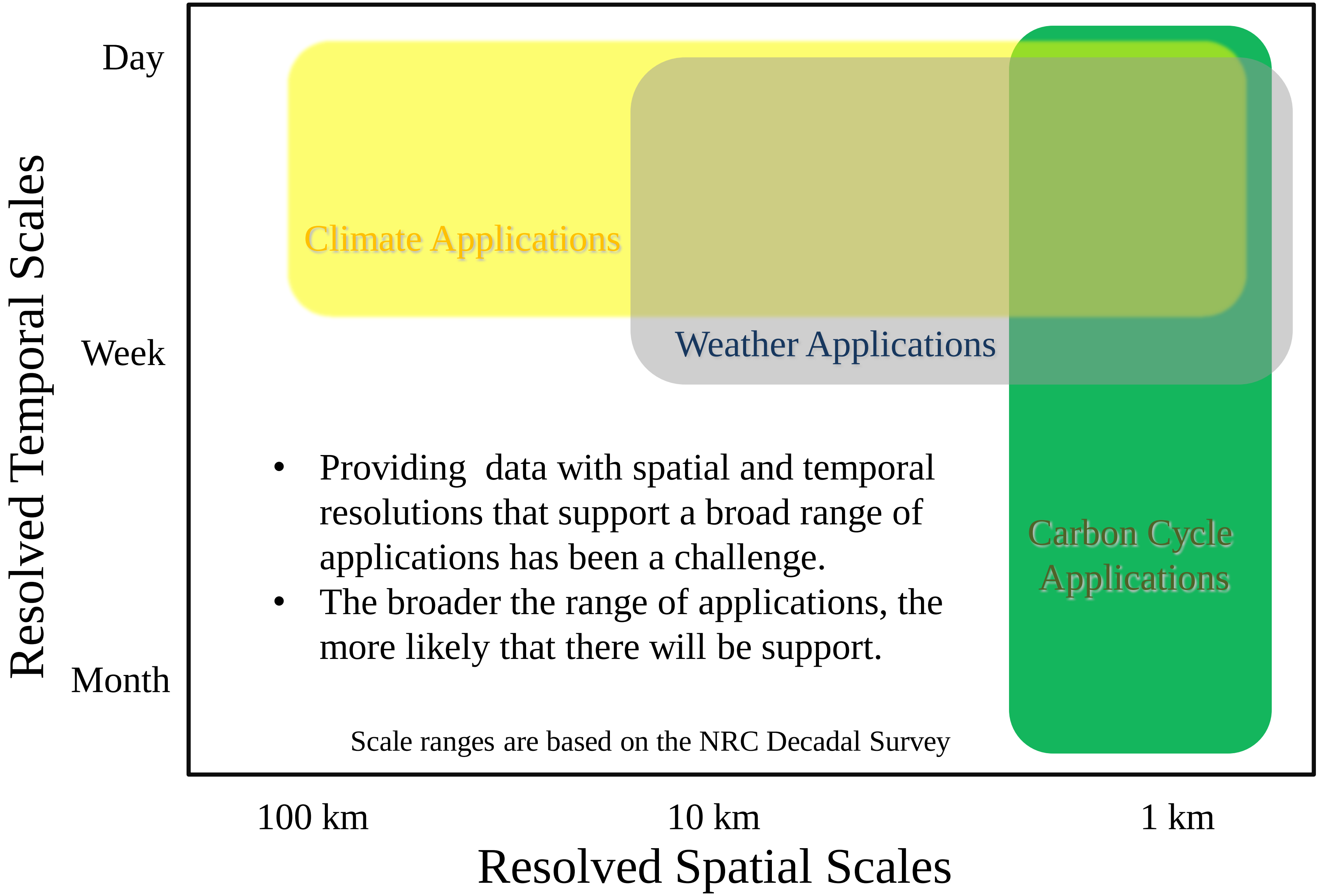
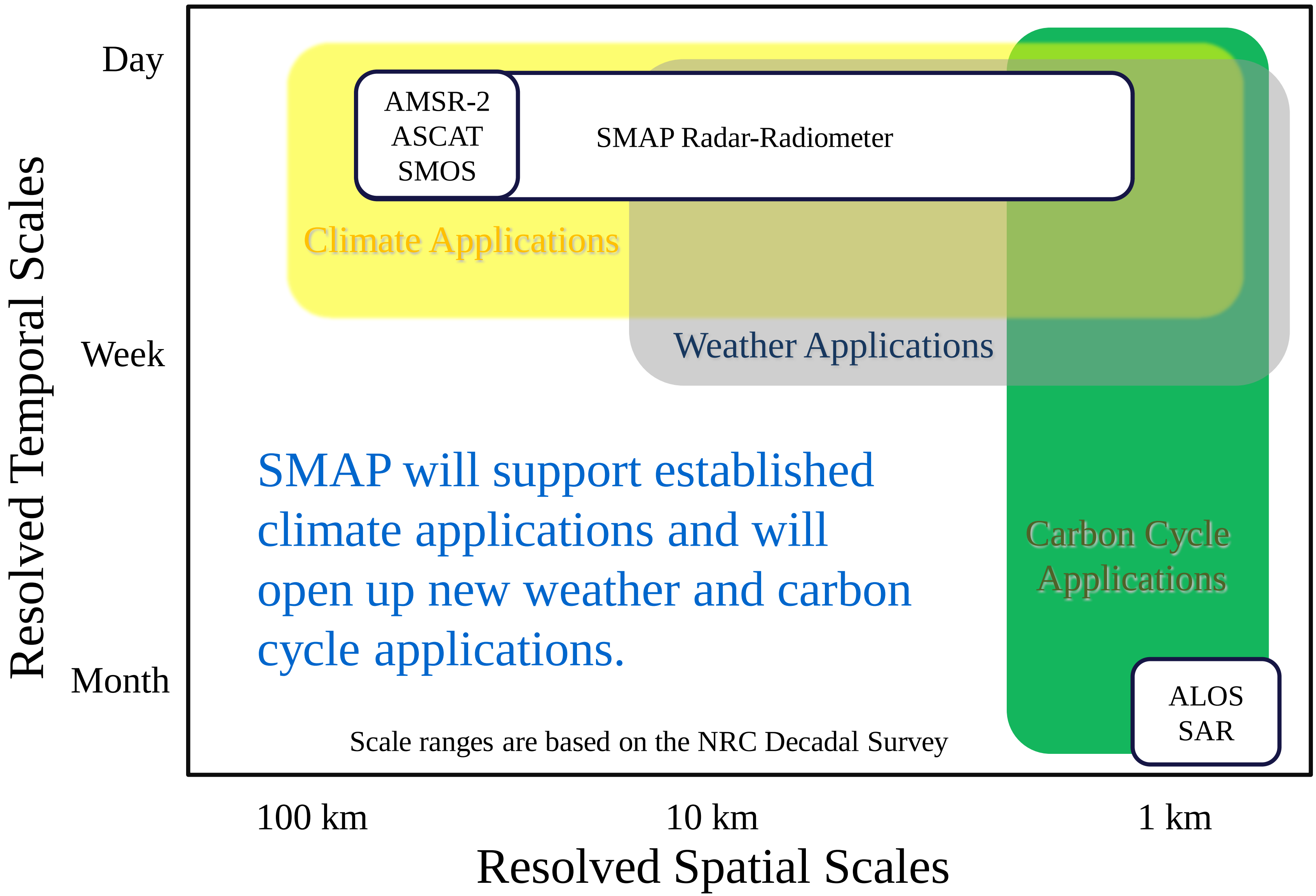
Evolution of Microwave Remote Sensing (Land)

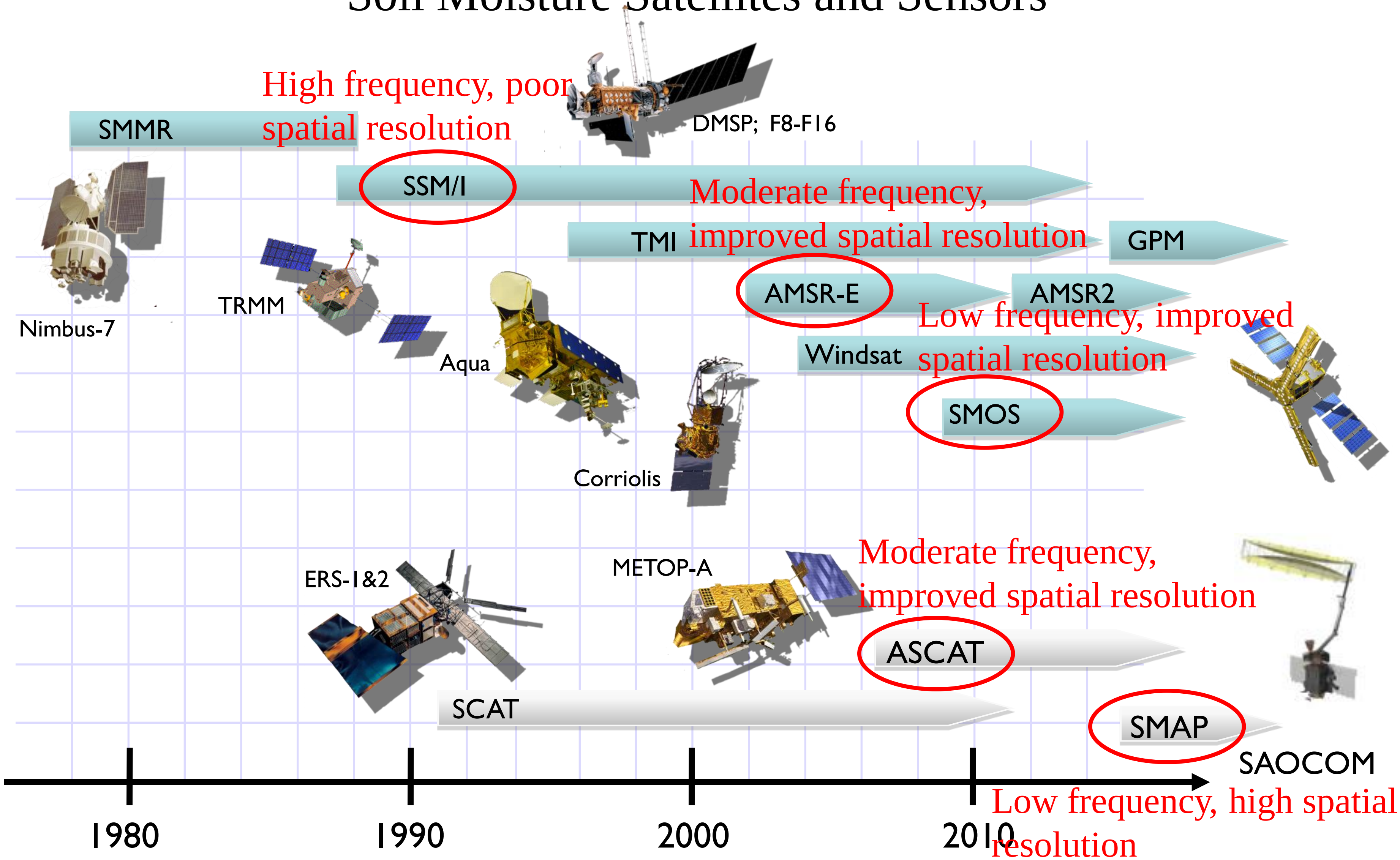


- Providing data with spatial and temporal resolutions that support a broad range of applications has been a challenge.
- The broader the range of applications, the more likely that there will be support.

Evolution of Microwave Remote Sensing (Land)



Soil Moisture Satellites and Sensors



Source: W. Wagner with some additions

SMAP Applications

<u>NRC Earth Science Decadal Survey Report (Chapter 1):</u>

"*It is necessary now to build on the paradigm of Earth system science and strengthen its dual role of science and applications. This duality has always been an element of Earth science, but it must be leveraged more effectively than in the past*".


Agricultural Productivity


Weather Forecasting


Drought Early Warning


Flood Prediction


Human and Animal Health

SMAP measurements of soil moisture and freeze/thaw state address a wide range of Earth science <u>applications</u>


Insurance Sector


Famine Warning


Dust Storms


Trafficability

Application requirements were assessed for spatial resolution, temporal frequency and accuracy.

January 31st Launch

SMAP Launch: January 31, 2015

SMAP Products

Product	Description	Gridding (Resolution)	Latency**	
L1A_Radiometer	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_Radar	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer T_B in Time-Order	(36x47 km)	12 hrs	
L1B_S0_LoRes	Low Resolution Radar σ_o in Time-Order	(5x30 km)	12 hrs	
L1C_S0_HiRes	High Resolution Radar σ_o in Half-Orbits	1 km (1-3 km)*	12 hrs	
L1C_TB	Radiometer T_B in Half-Orbits	36 km	12 hrs	
L2_SM_A	Soil Moisture (Radar)	3 km	24 hrs	Science Data (Half-Orbit)
L2_SM_P	Soil Moisture (Radiometer)	36 km	24 hrs	
L2_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	
L3_FT_A	Freeze/Thaw State (Radar)	3 km	50 hrs	Science Data (Daily Composite)
L3_SM_A	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P	Soil Moisture (Radiometer)	36 km	50 hrs	
L3_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	50 hrs	
L4_SM	Soil Moisture (Surface and Root Zone)	9 km	7 days	Science Value-Added
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	14 days	

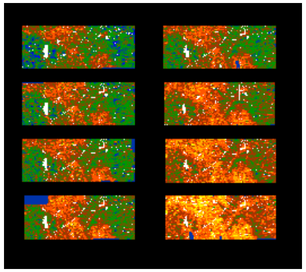
But how do you assess the quality of the data being produced.

Field Experiments

Modeling

In Situ Networks

USDA-Agricultural Research Service Soil Moisture Experiments



Washita 92/94
Oklahoma

SGP97/99
Oklahoma

SMEX02
Iowa

SMEX03
Oklahoma
Georgia
Alabama

SMEX04
Arizona
Sonora, Mexico

SMEX05
Iowa

NAFE05/6
SMAPEX
Australia

CLASIC07
Oklahoma

SMAPVEX08
Maryland

CANEX-SM10
Saskatchewan
Canada

SMAPVEX12
Winnipeg
Canada

SMAPVEX15
Arizona

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.

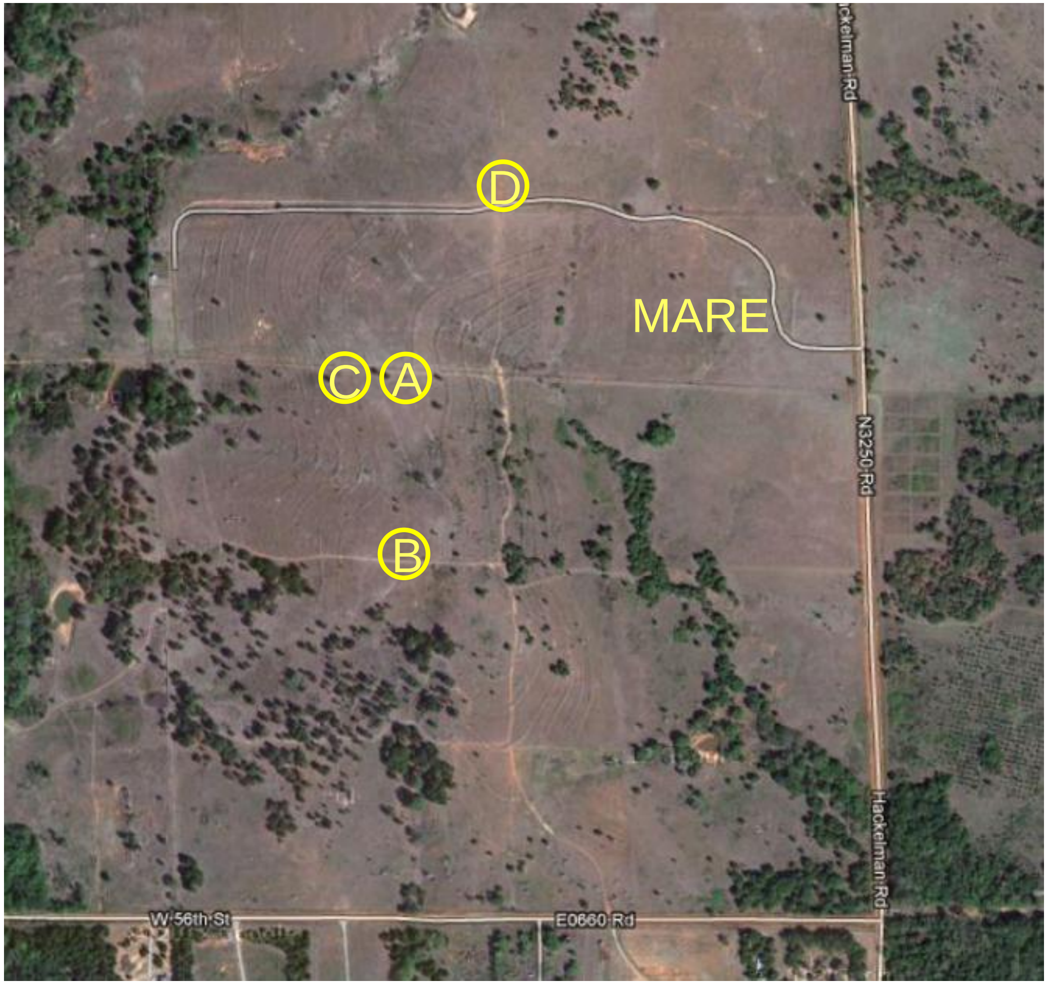
Installation Scaling

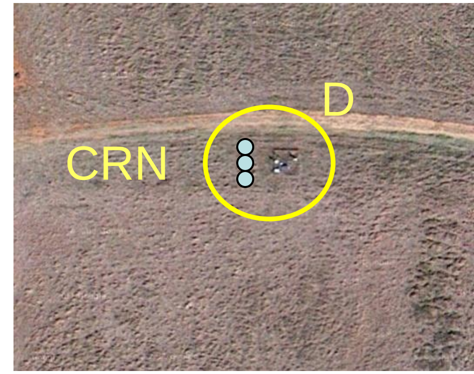
Each installation should be scaled to determine how it represents the domain in which it is installed.

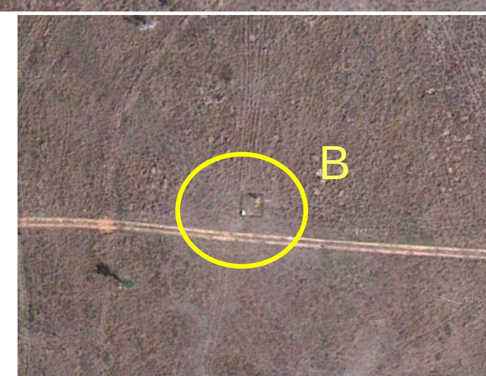
- Each installation or set of installations is one data series to be calibrated
- Scaling is against the satellite metric, 0-5 cm gravimetrically based volumetric soil moisture.

Marena Oklahoma In Situ Sensor Testbed
MOISST

SMAP Marena Oklahoma In Situ Sensor Testbed
Site Design







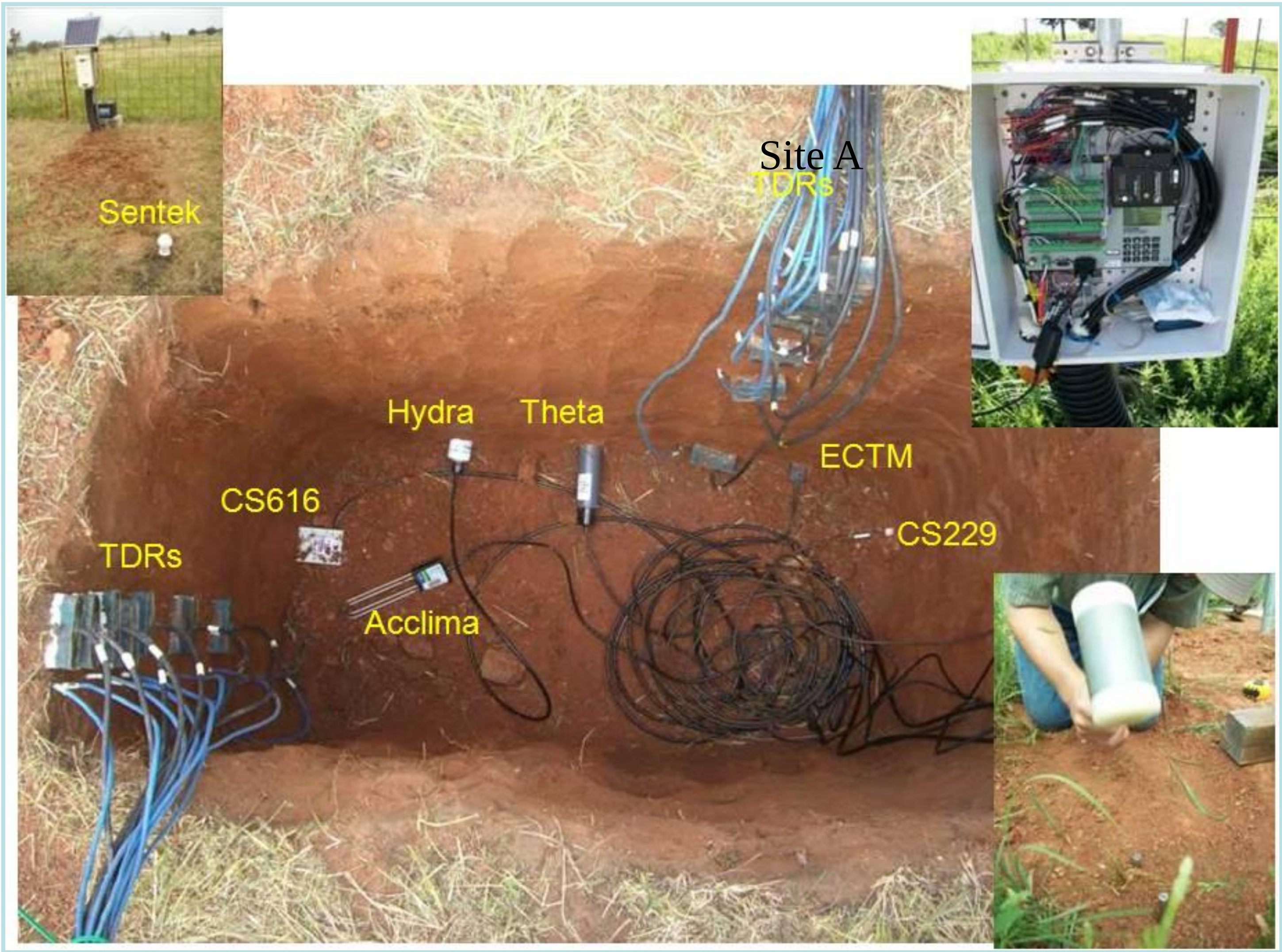
Marena Site Design

- 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)

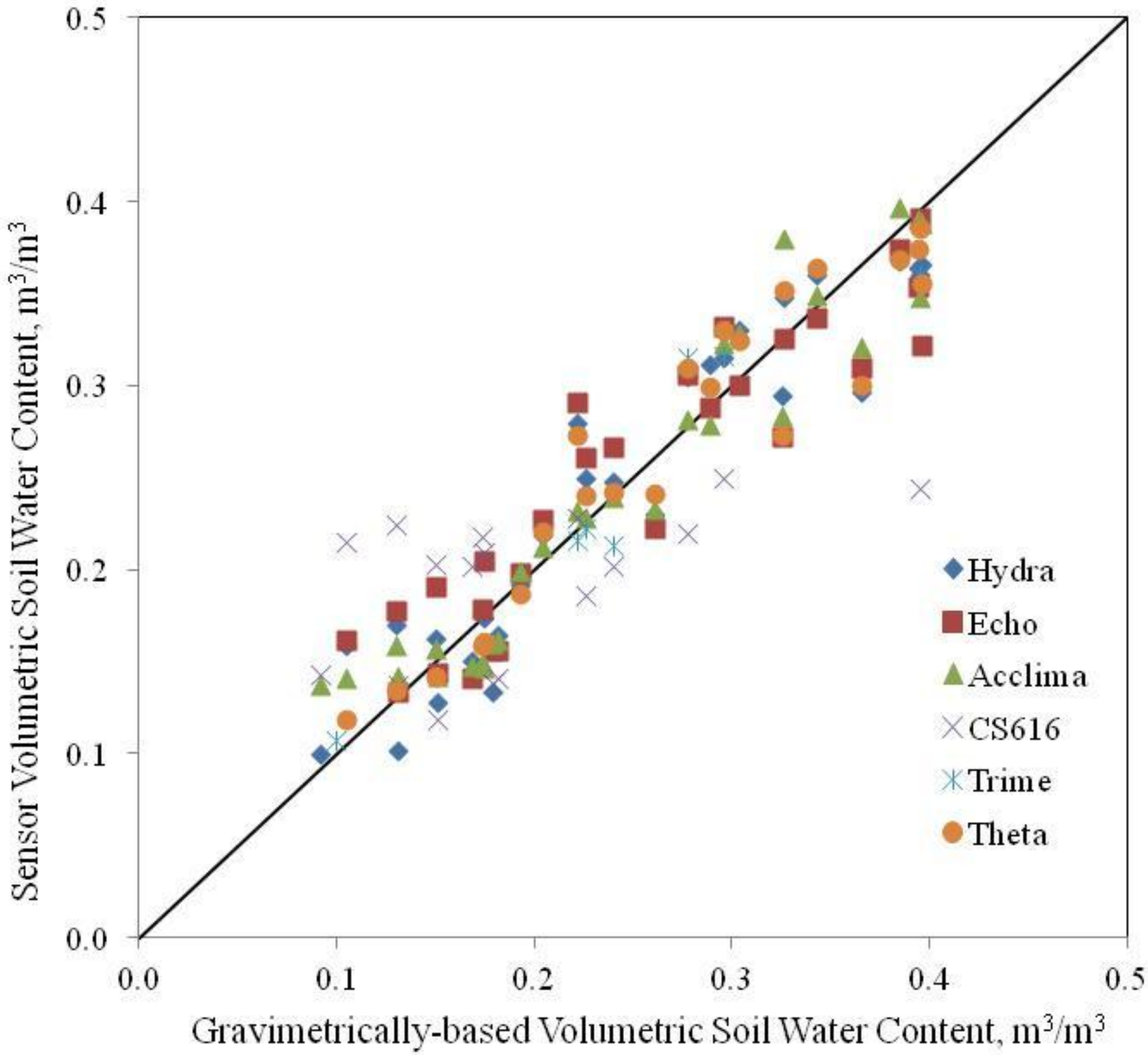
Site A	Site B	Site C	Site D
Base	Base	Base	Base
GPS	ASSH	GPS	GPS
COSMOS	Passive DTS		CRN
ASSH			
TDR systems			
Flux System			

SMAP Marena Oklahoma In Situ Sensor Testbed Installation

- Installation in May 2010



SMAP Marena Oklahoma In Situ Sensor Testbed
Sensor Calibration

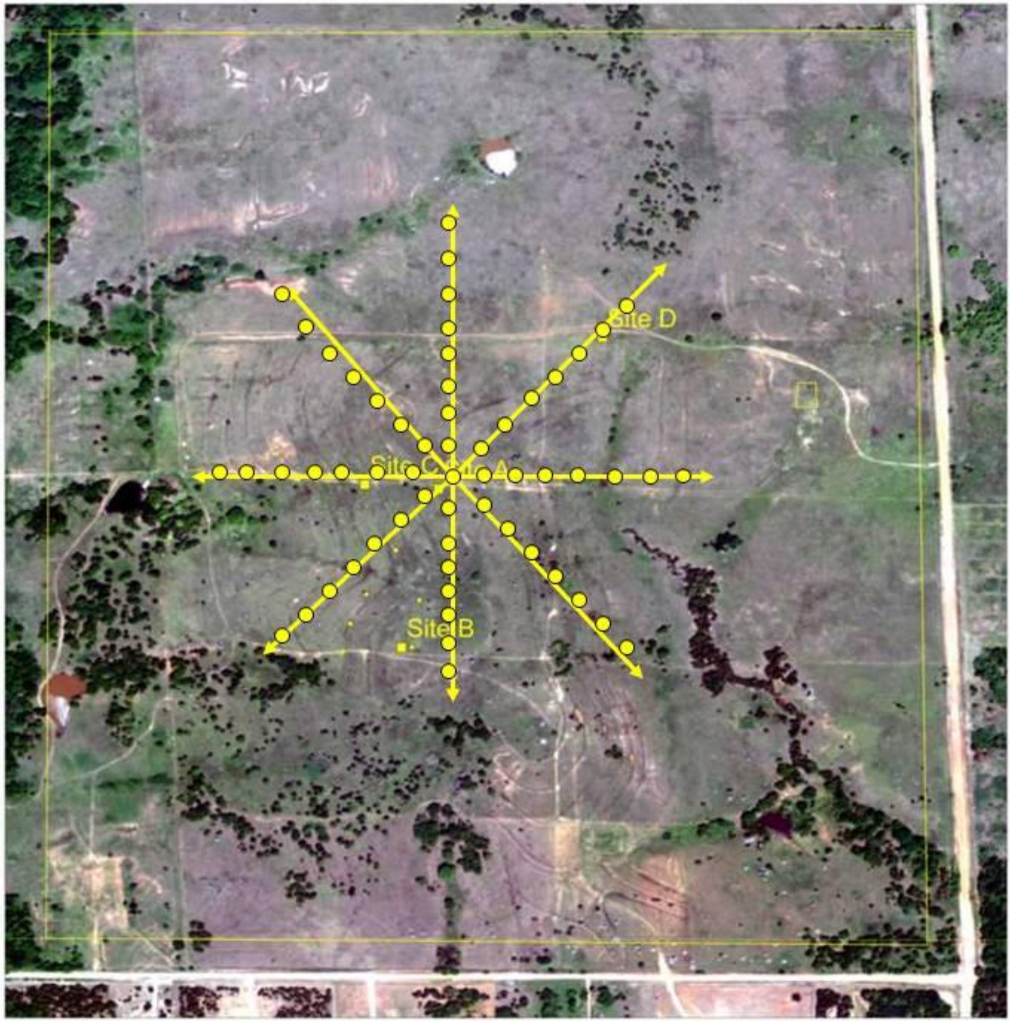


SMAP Marena Oklahoma In Situ Sensor Testbed
Sensor Calibration

Sensor	Factory Listed Accuracy	Bias w/ factory calibration	RMSE factory calibration	RMSE soil specific calibration
Theta	0.01	0.014	0.030	0.028
Hydra	0.01-0.03	0.020	0.040	0.032
ECTM	0.03	0.076	0.081	0.036
CS-616	0.025	-0.023	0.073	0.063
Trime	0.01-0.03	0.005	0.042	0.023
Acclima	0.01	0.074	0.080	0.025
CS-229	N/A	-	-	-
Enviro-SMART	N/A	-	-	-

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



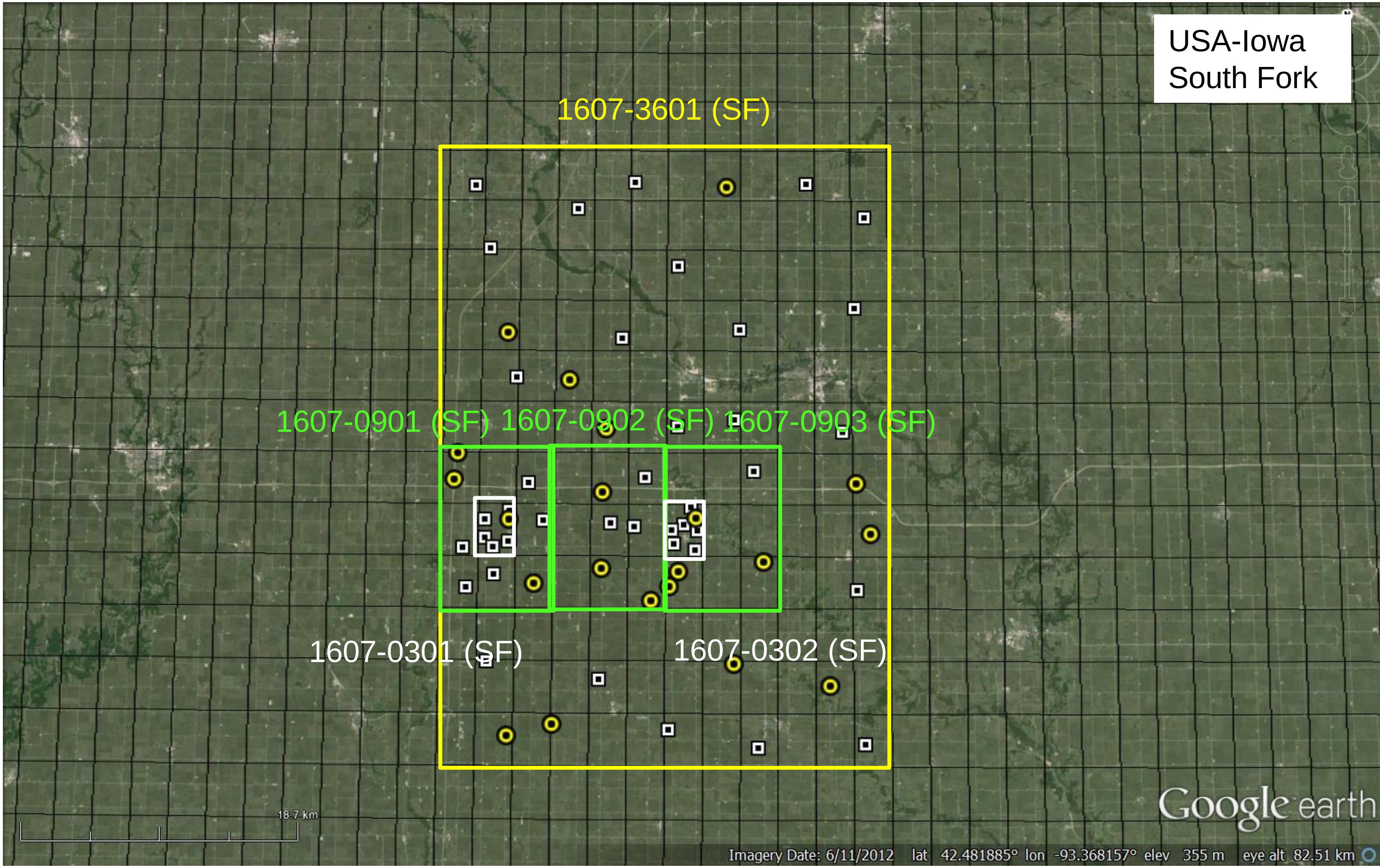
SMAP Marena Oklahoma In Situ Sensor Testbed
Sensor to Sensor Average Comparison

Sensor	UnScaled 2.5 cm	UnScaled 5 cm	UnScaled 10 cm	UnScaled Variable Depth	Scaled 2.5 cm	Scaled 5 cm	Scaled 10 cm	Scaled 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	
TDR	0.020	0.045	0.070		0.013	0.039	0.053	
GPSR	→	→	→	0.050	→	→	→	0.036
COSMOS	→	→	→	0.048	→	→	→	0.035

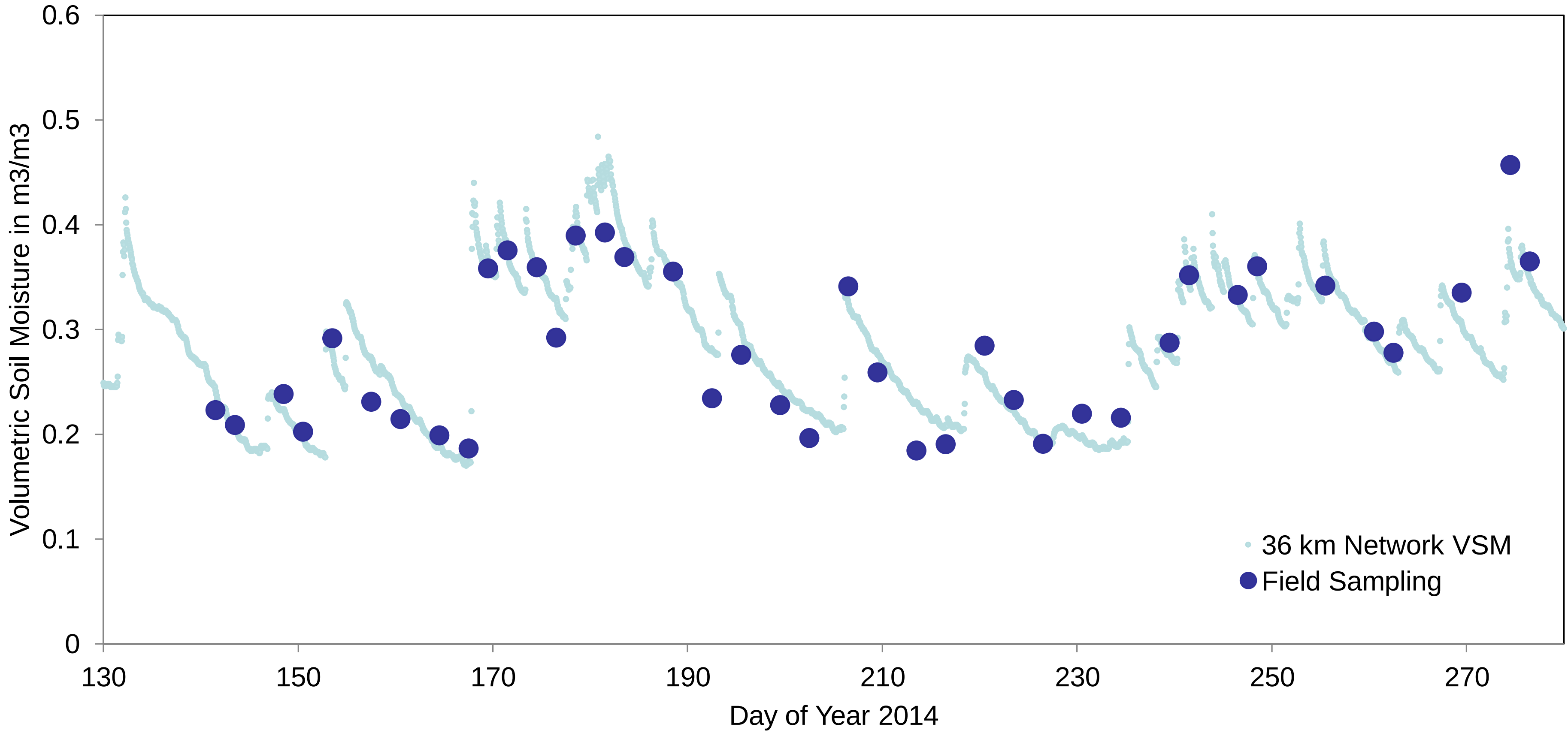
SMAP Marena Oklahoma In Situ Sensor Testbed
Some Conclusions

- 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.

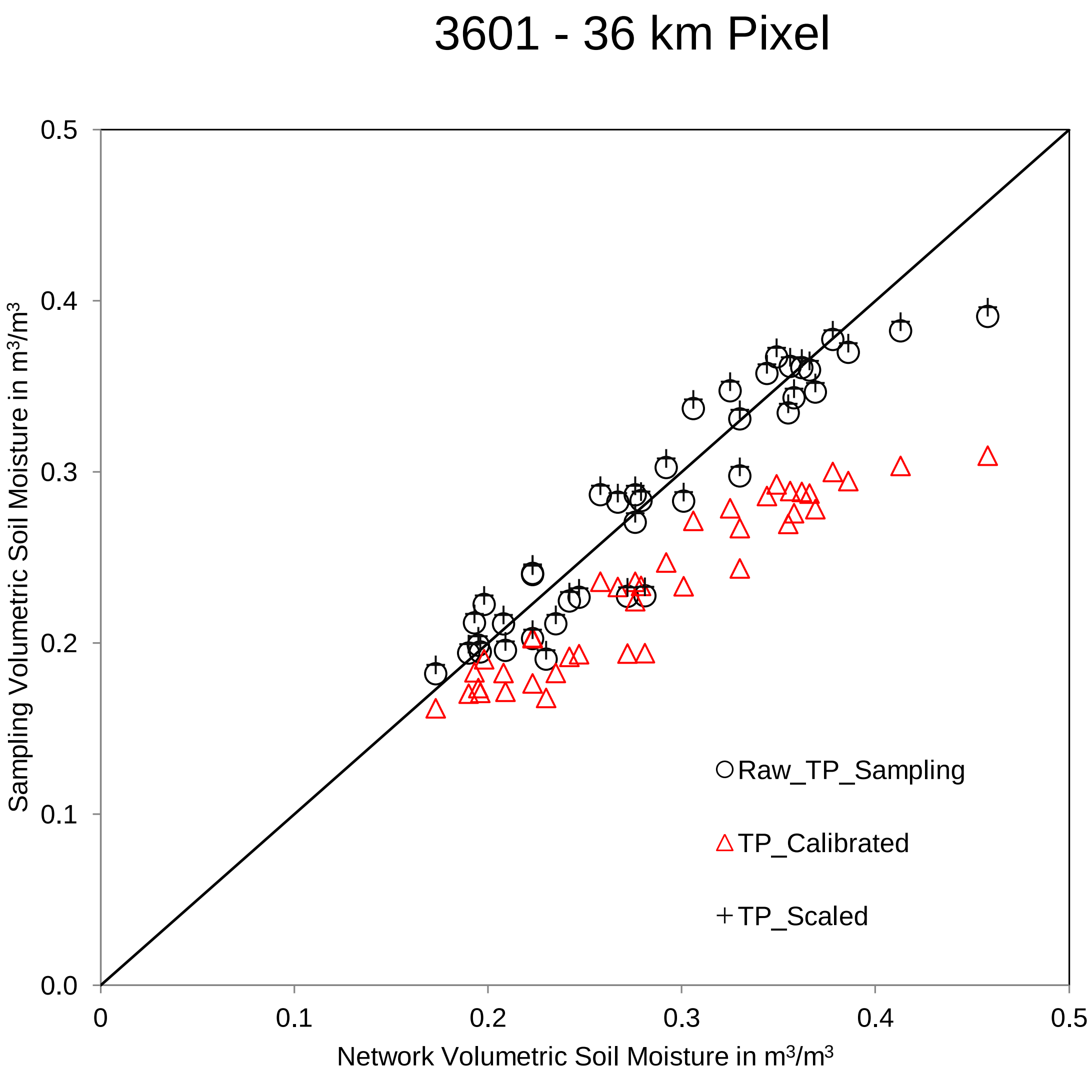
Extending in situ resources to the SMAP Cal/Val program

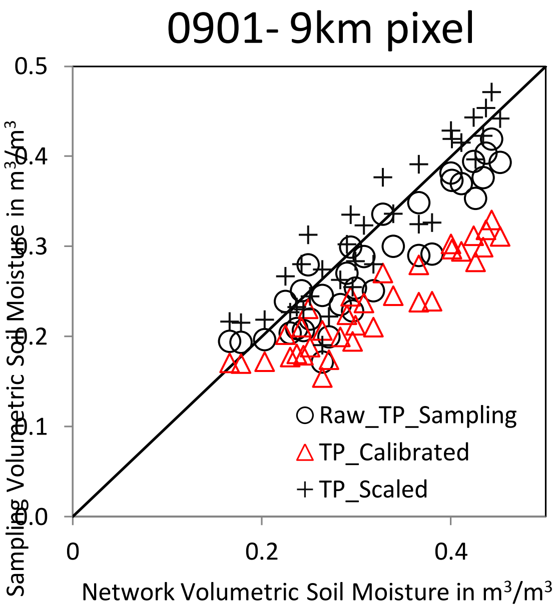


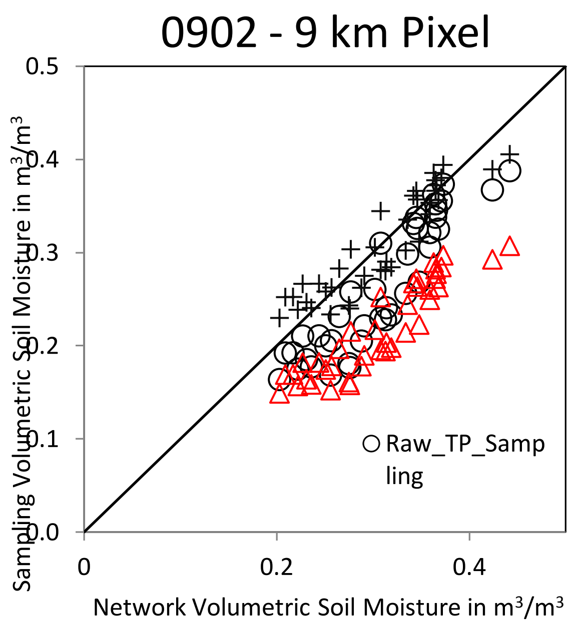
USA-Iowa
South Fork
1607-3601 (SF)
1607-0901 (SF)
1607-0902 (SF)
1607-0903 (SF)
1607-0301 (SF)
1607-0302 (SF)
18.7 km
Google earth
Imagery Date: 6/11/2012 lat 42.481885° lon -93.368157° elev 355 m eye alt 82.51 km

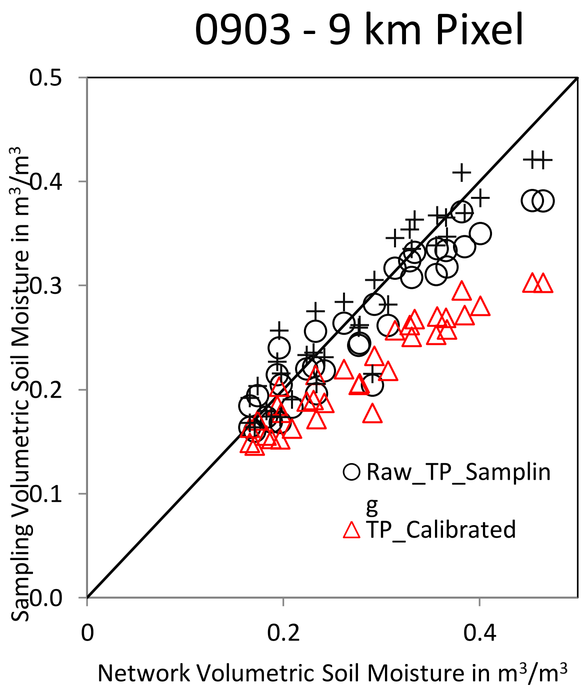


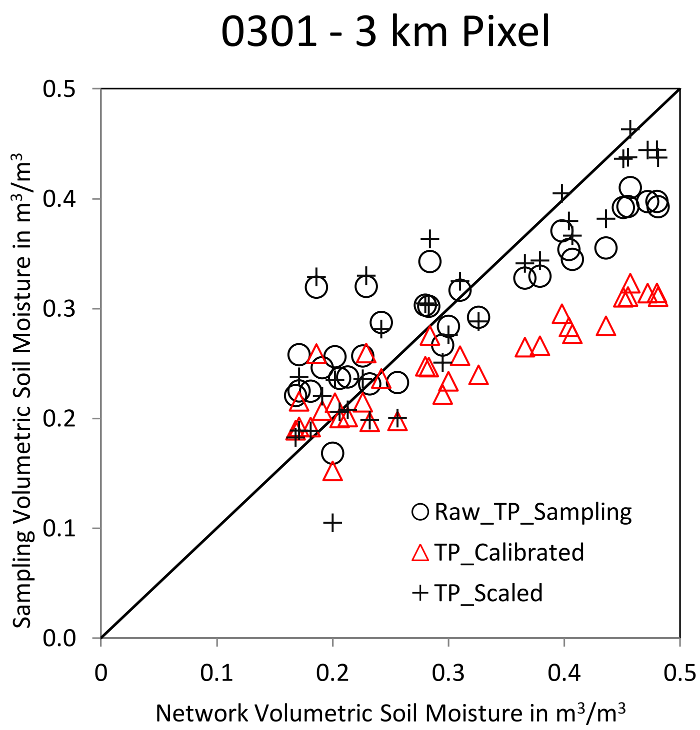
0.6
0.5
0.4
0.3
0.2
0.1
0
Volumetric Soil Moisture in m3/m3
130
150
170
190
210
230
250
270
Day of Year 2014
36 km Network VSM
Field Sampling

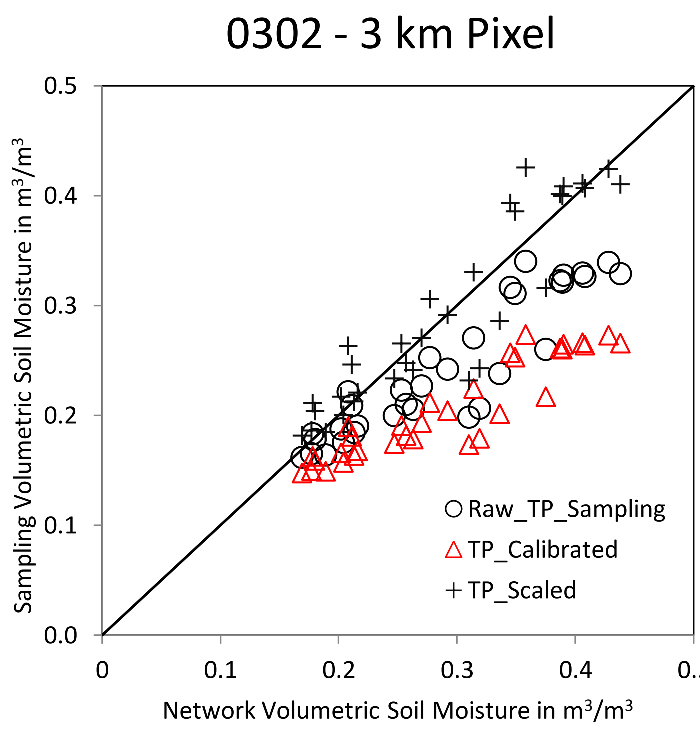

3601 - 36 km Pixel
0.5
0.4
0.3
0.2
0.1
0.0
0
0.1
0.2
0.3
0.4
0.5
Sampling Volumetric Soil Moisture in m3/m3
Network Volumetric Soil Moisture in m3/m3
Raw_TP_Sampling
TP_Calibrated
TP_Scaled


0901- 9km pixel
Sampling Volumetric Soil Moisture in m³/m³
Network Volumetric Soil Moisture in m³/m³
Raw_TP_Sampling
TP_Calibrated
TP_Scaled
0.5
0.4
0.3
0.2
0.1
0.0
0
0.2
0.4


0902 - 9 km Pixel
Sampling Volumetric Soil Moisture in m³/m³
Network Volumetric Soil Moisture in m³/m³
Raw_TP_Samp
ling
0.5
0.4
0.3
0.2
0.1
0.0
0
0.2
0.4

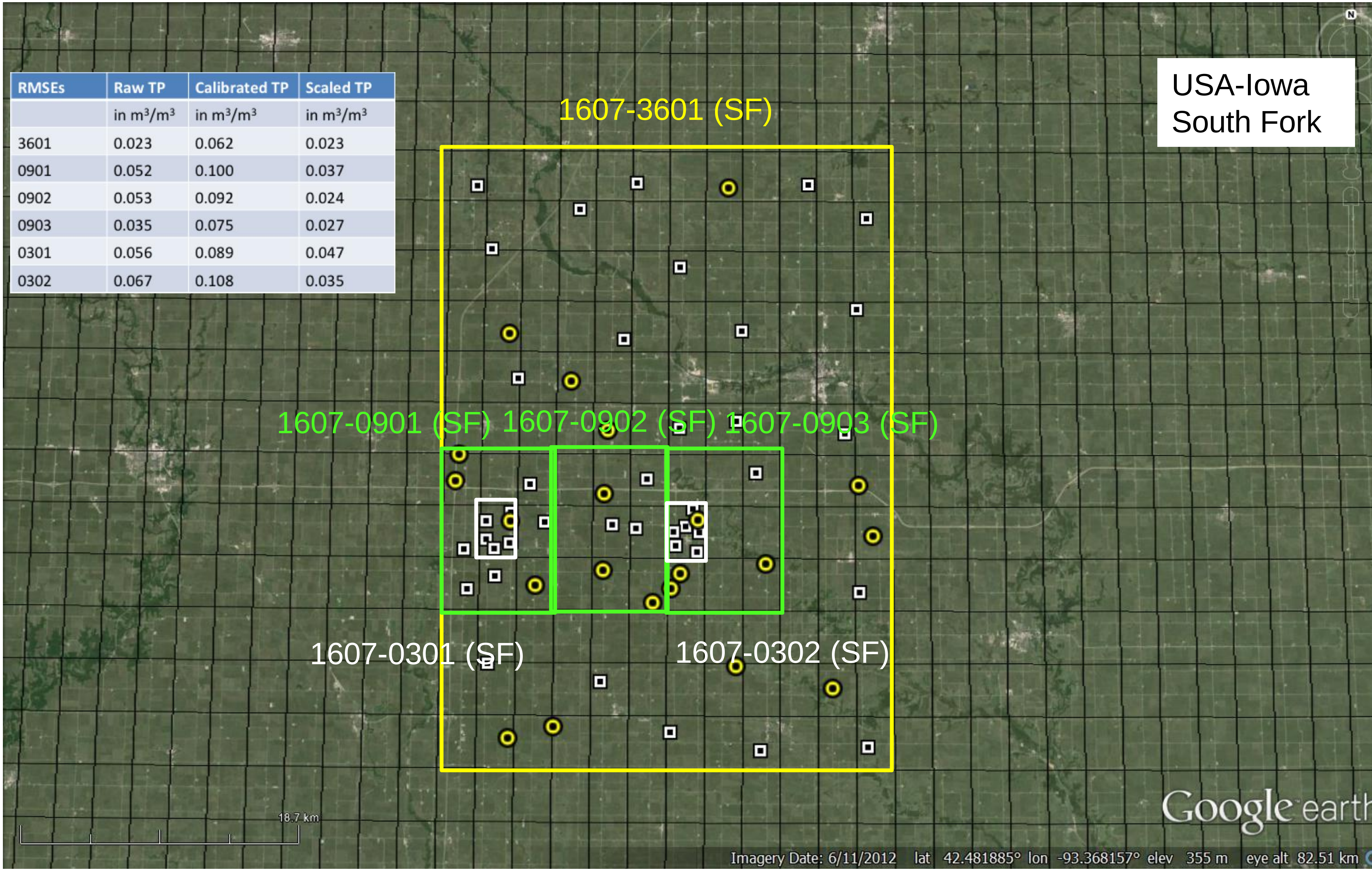

0903 - 9 km Pixel
Sampling Volumetric Soil Moisture in m³/m³
Network Volumetric Soil Moisture in m³/m³
Raw_TP_Samplin
g
TP_Calibrated
0.5
0.4
0.3
0.2
0.1
0.0
0
0.2
0.4


0301 - 3 km Pixel
0.5
0.4
0.3
0.2
0.1
0.0
0
0.1
0.2
0.3
0.4
0.5
Sampling Volumetric Soil Moisture in m3/m3
Network Volumetric Soil Moisture in m3/m3
Raw_TP_Sampling
TP_Calibrated
TP_Scaled


0302 - 3 km Pixel
0.5
0.4
0.3
0.2
0.1
0.0
0
0.1
0.2
0.3
0.4
0.5
Sampling Volumetric Soil Moisture in m3/m3
Network Volumetric Soil Moisture in m3/m3
Raw_TP_Sampling
TP_Calibrated
TP_Scaled

RMSEs	Raw TP	Calibrated TP	Scaled TP
	in m^3/m^3	in m^3/m^3	in m^3/m^3
3601	0.023	0.062	0.023
0901	0.052	0.100	0.037
0902	0.053	0.092	0.024
0903	0.035	0.075	0.027
0301	0.056	0.089	0.047
0302	0.067	0.108	0.035

RMSEs	Raw TP	Calibrated TP	Scaled TP
	in m³/m³	in m³/m³	in m³/m³
3601	0.023	0.062	0.023
0901	0.052	0.100	0.037
0902	0.053	0.092	0.024
0903	0.035	0.075	0.027
0301	0.056	0.089	0.047
0302	0.067	0.108	0.035



Next for SMAP

SMAPEX – Wagga Wagga, Australia

SMAPVEX15 – Upper San Pedro Basin, August 2015

SMAPVEX16 – TBD

SMAPVEX15 (Aug 2-18)