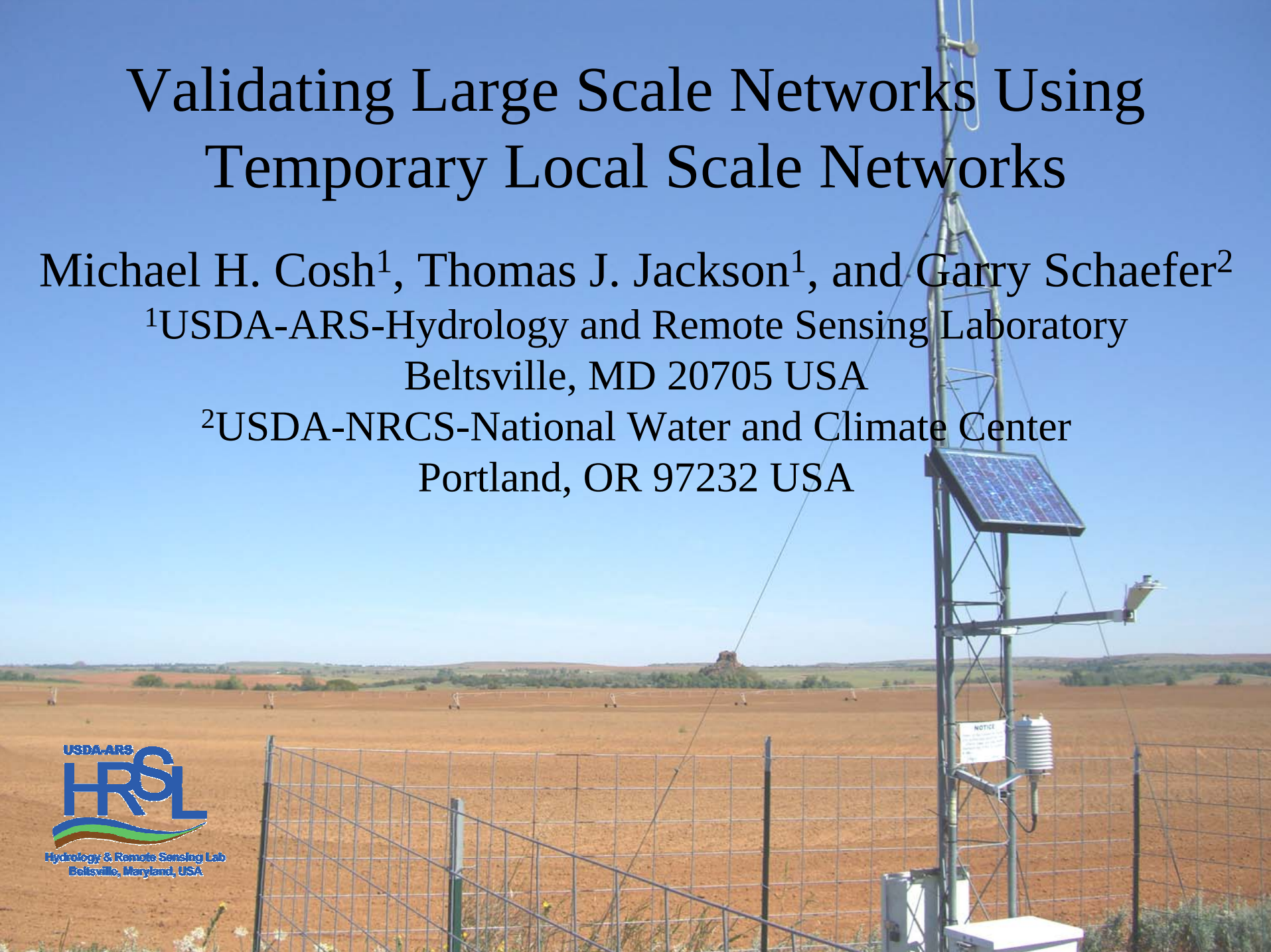
Validating Large Scale Networks Using Temporary Local Scale Networks

Michael H. Cosh[1], Thomas J. Jackson[1], and Garry Schaefer[2]

[1]USDA-ARS-Hydrology and Remote Sensing Laboratory
Beltsville, MD 20705 USA

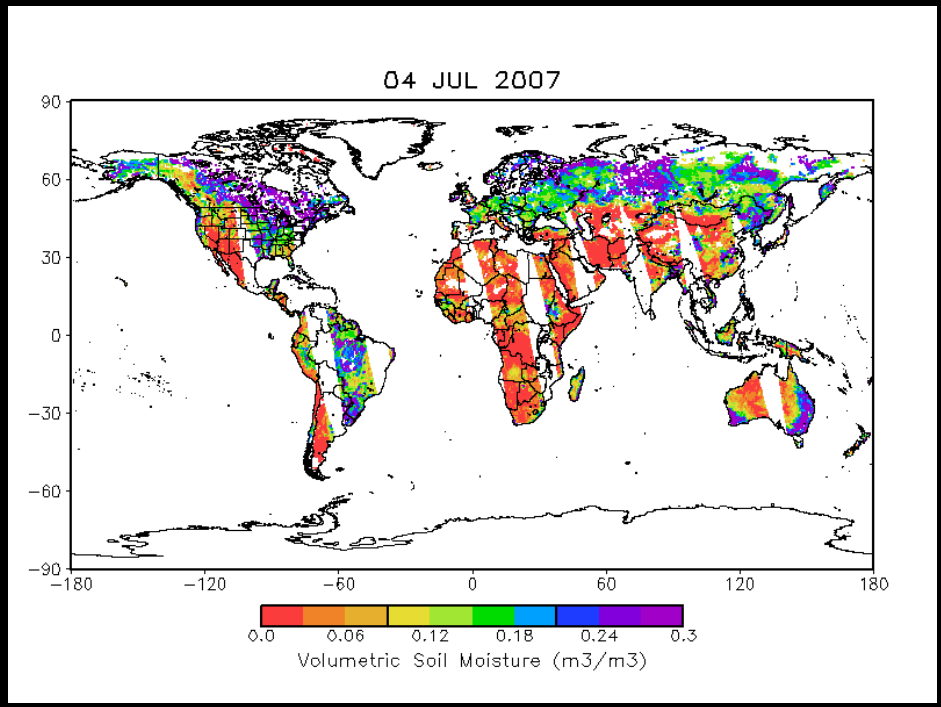
[2]USDA-NRCS-National Water and Climate Center
Portland, OR 97232 USA



Specific USDA-ARS Goal

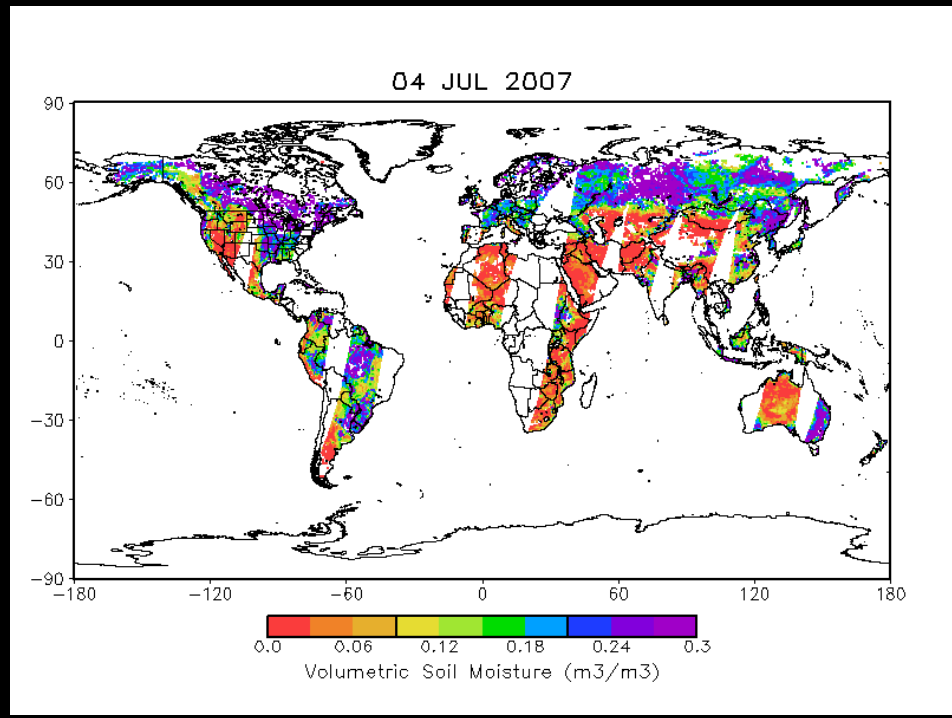
Provide a *close approximation* of soil moisture within the area and depth measured by low frequency passive microwave sensors that would result in a robust data set for validating retrieval algorithms as well as models for the AMSR-E Soil Moisture Products.

AMSR-E Soil Moisture



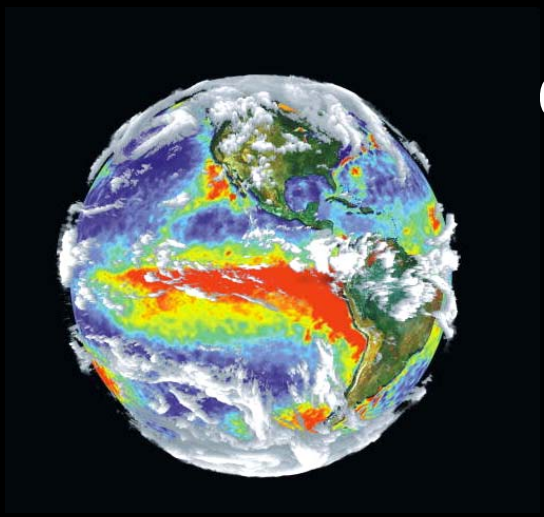
Ascending

Descending



AMSR-E ~50 km footprint
SMAP ~ 10 km footprint

Applications

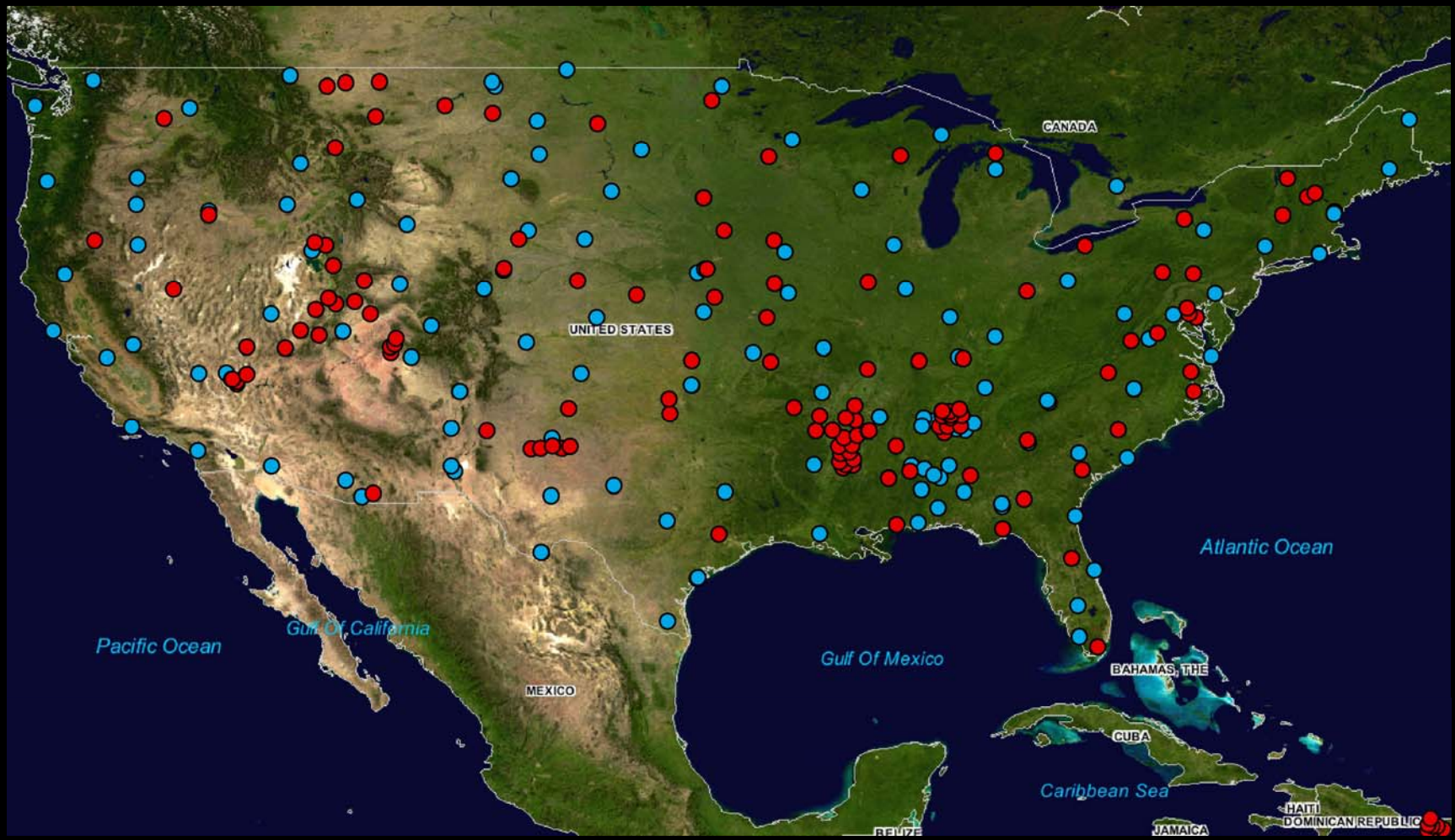


Climate Modeling

Satellite Validation

Watershed Management

SCAN and CRN



800 km

400 km

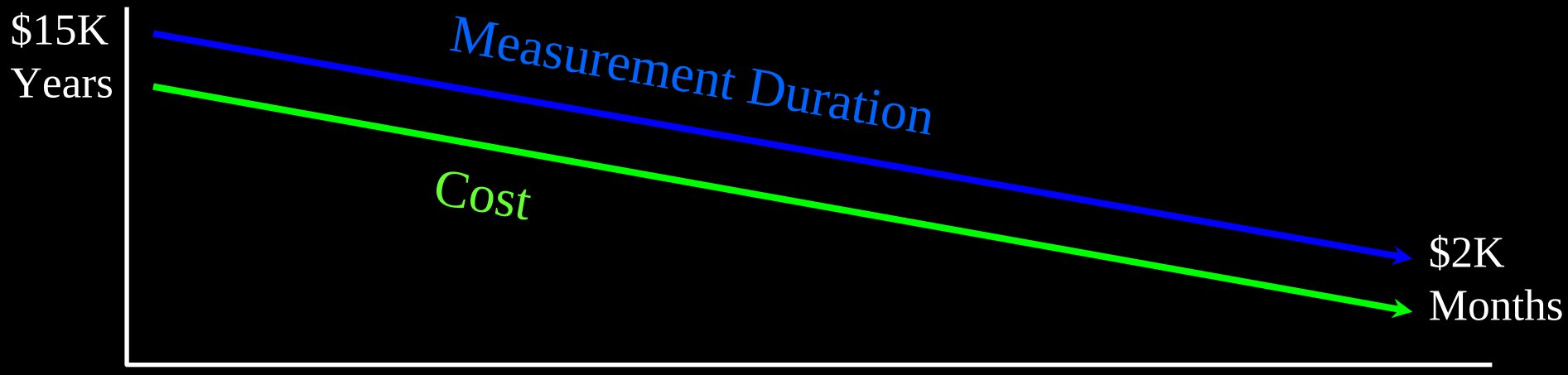
80 km

Permanent, Semi-Permanent, and Temporary Sites

Permanent

Semi-Permanent

Temporary



Outline

1. Overview of AMSR-E Validation Sites

2. Validation of Networks
    1. Little Washita, OK
    2. Walnut Gulch, AZ

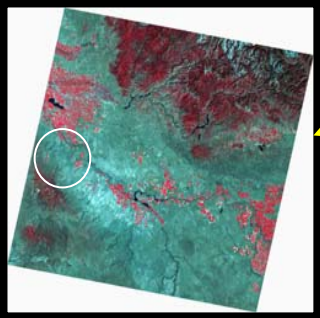
3. Expanding the Networks
   Walnut Creek, IA

4. Outstanding Issues

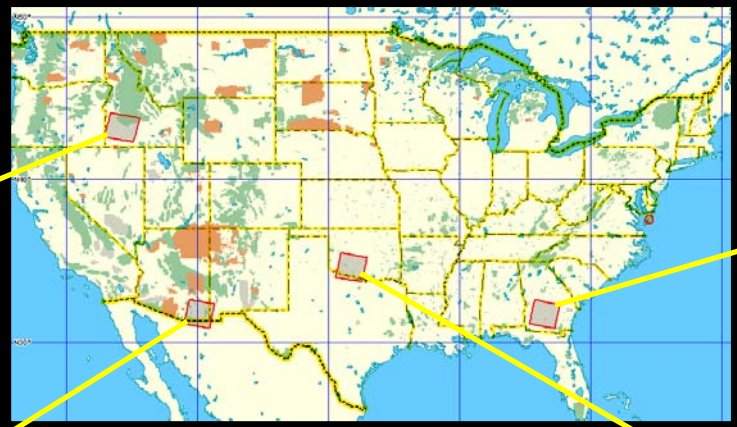
In situ Soil Moisture Networks Dimensions to Consider

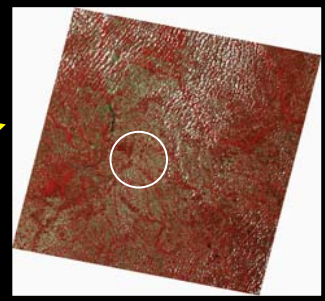
- Scale of network (AMSR-E footprint)
- Density (Replication)
- Temporal Frequency of Measurement
- Data Availability
- Measurement Technique
- Other: 5 cm, profile station

USDA-ARS Semi-Permanent Soil Moisture Networks

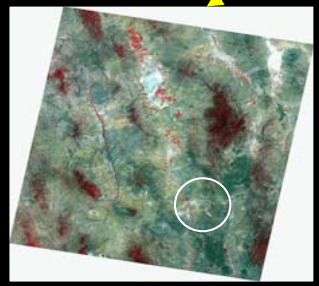


Reynolds Creek, ID

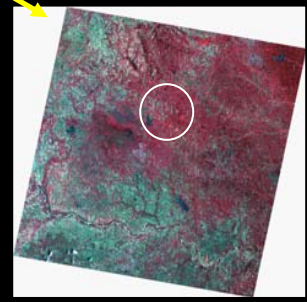




Little River, GA



Walnut Gulch, AZ



Little Washita, OK

Description and Status of Watershed and Other Networks

Watershed	Type	# Sensors	Reporting
Little Washita, OK	Grazingland	20	30 min
Little River, GA	Forest	19	30 min
Walnut Gulch, AZ	Semi-Arid	19	20 min
Reynolds Creek, ID	Mountainous	16	1 hour

Installed in summer of 2002 and continuing

Validation of Networks

Two methods:

1. Verify installations are accurate of immediate vacinity, usually done on install.

2. Compare local installations to the large scale average with increased sampling densities. (Field Experimentation)

Timeline of validation activities

Installation of Networks

SMEX02
Iowa

SMEX03
Oklahoma
Georgia
Alabama

SMEX04
Arizona
Sonora, MX

SMEX05
Iowa

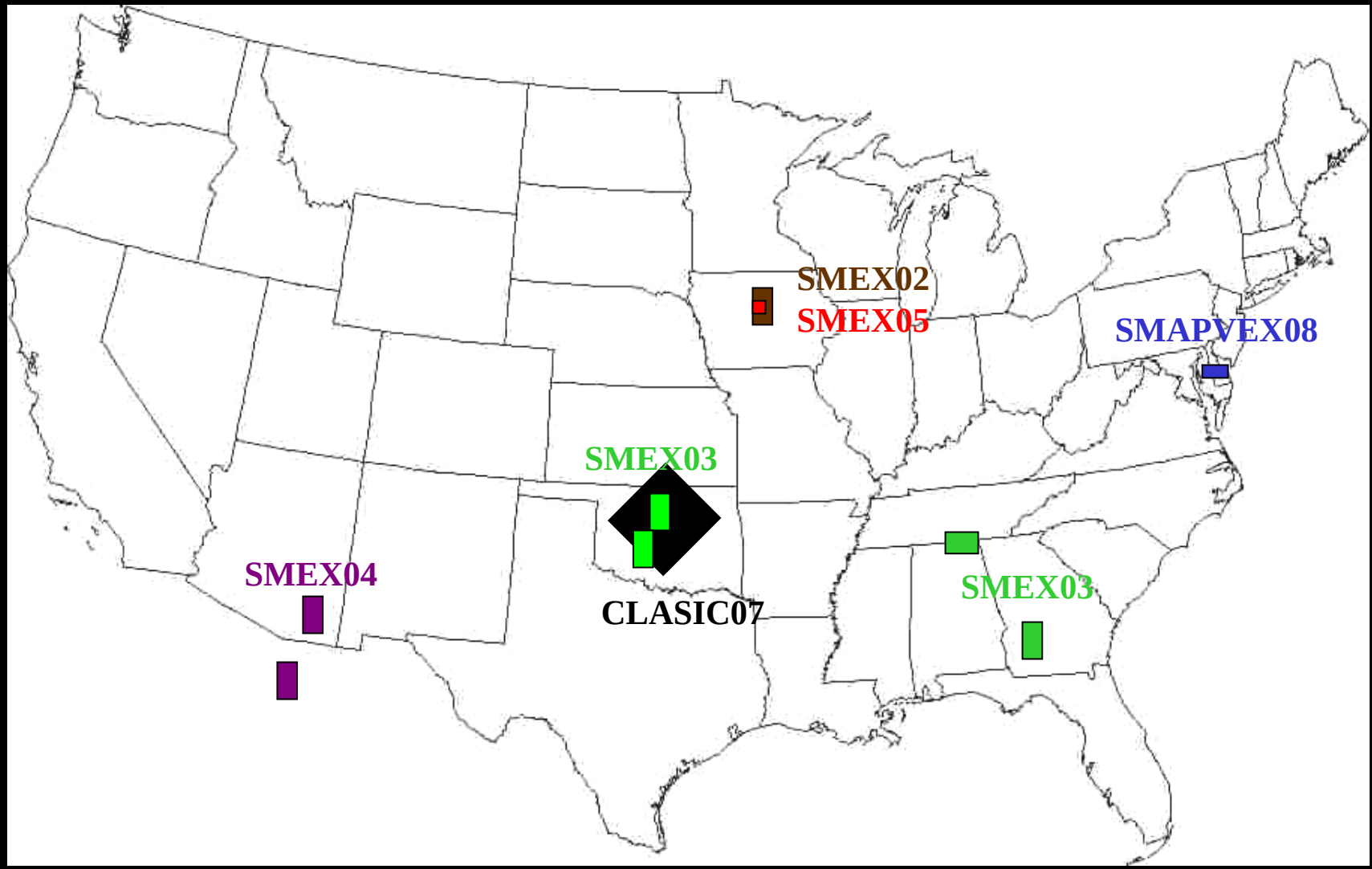
CLASIC
Oklahoma

SMAPVEX
Maryland

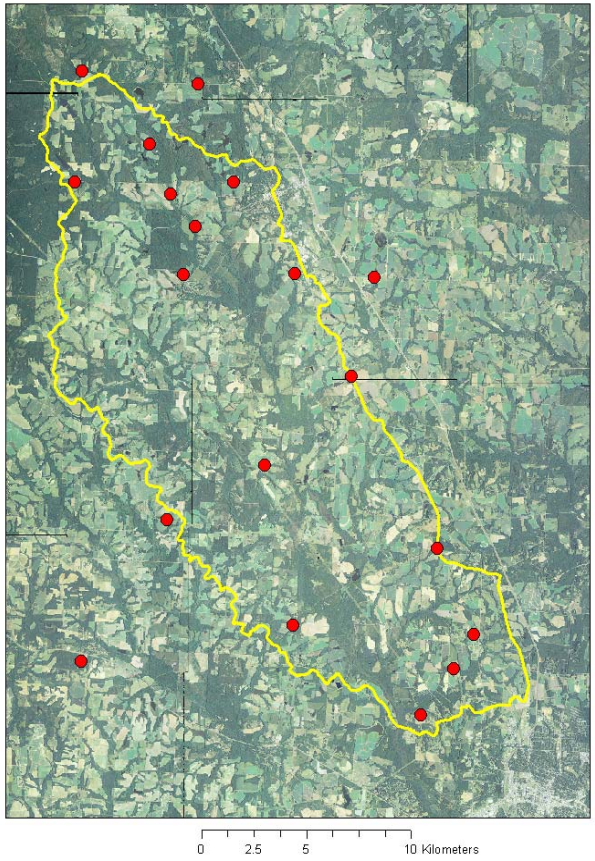
AMSR-E Validation Dataset

2002 2003 2004 2005 2006 2007 2008 2009

Assorted Validation Experiments

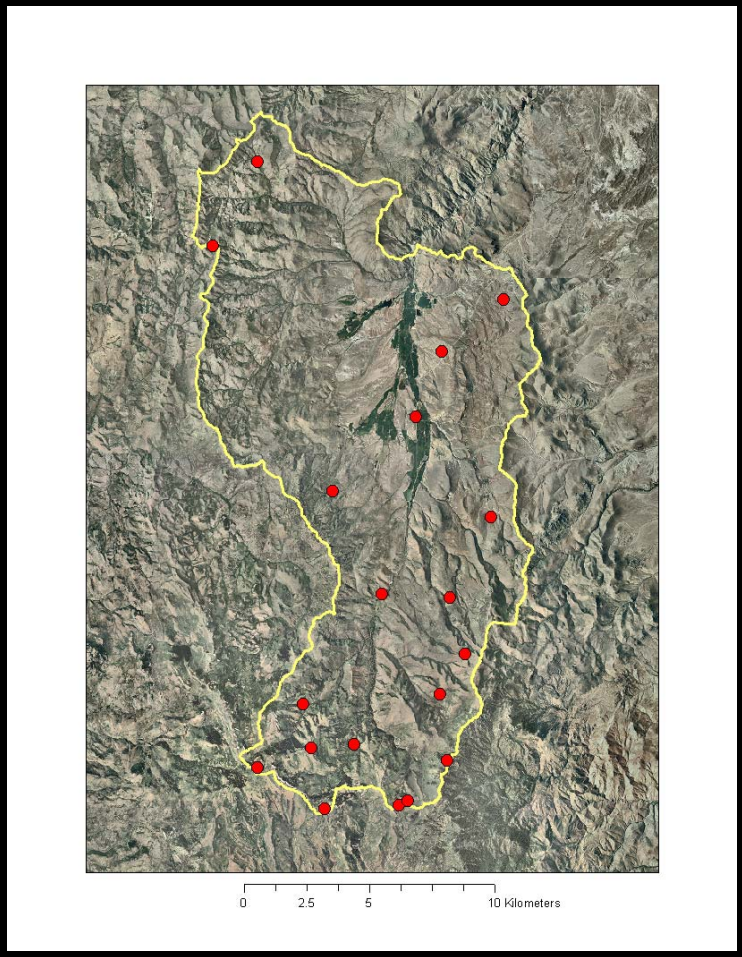


Little River, GA



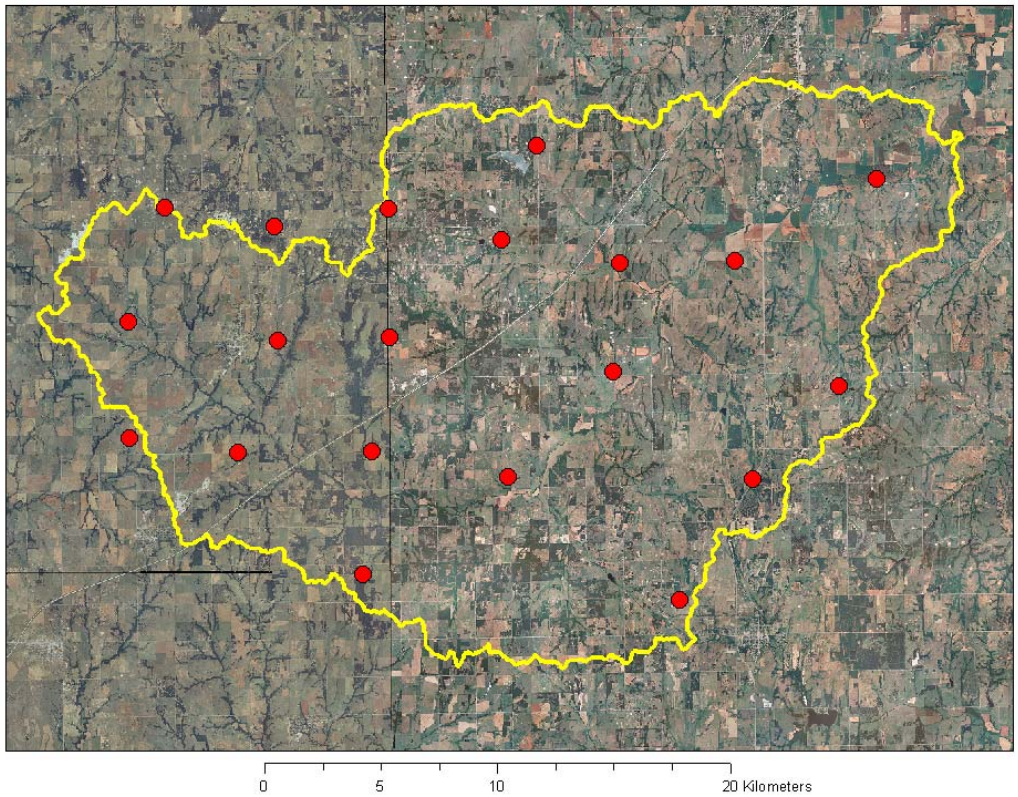
Watershed	Type	# Sensors	Reporting
Little River, GA	Forest	19	30 min

Reynolds Creek, ID



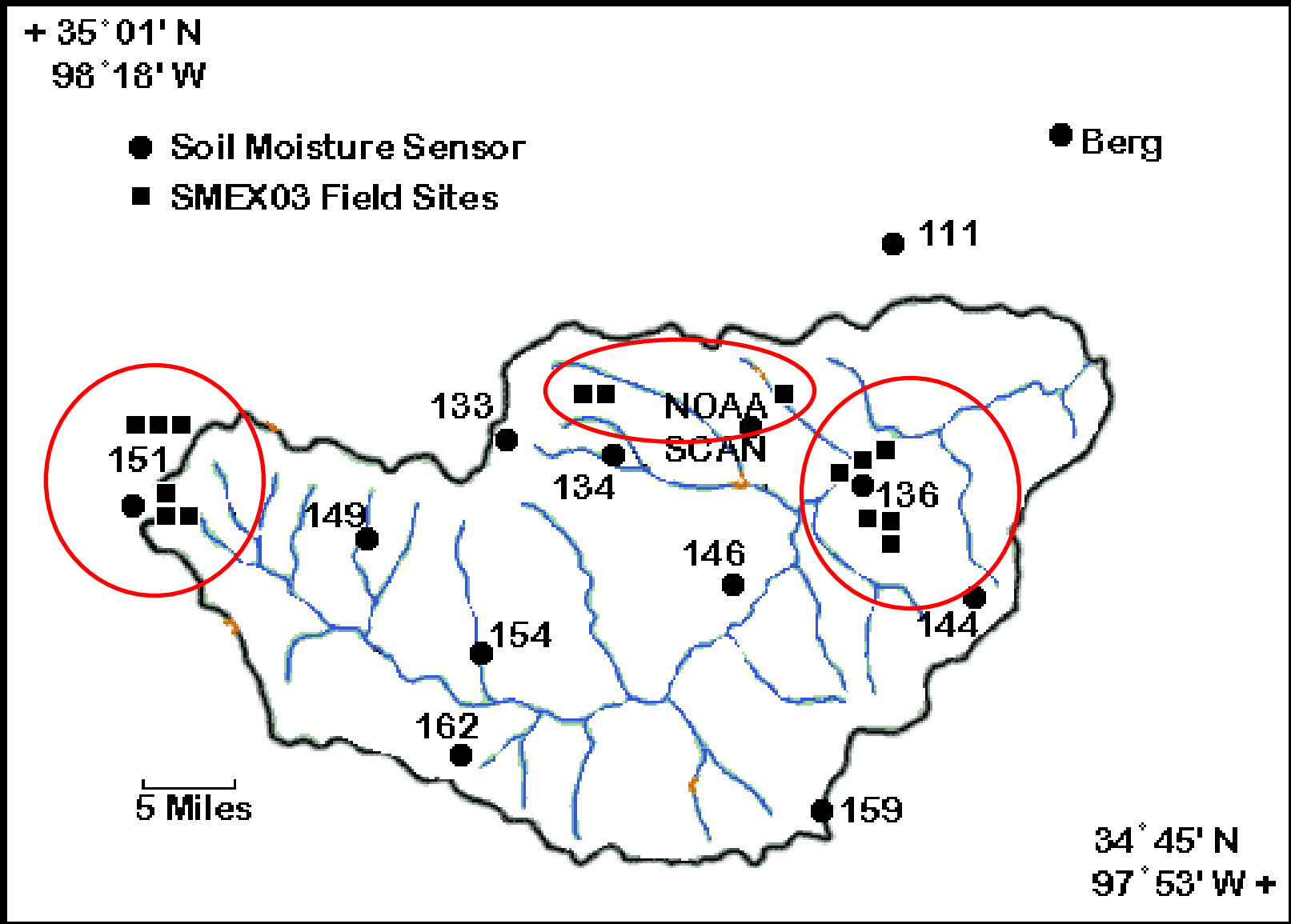
Watershed	Type	# Sensors	Reporting
Reynolds Creek, ID	Mountainous	16	1 hour

Little Washita, OK

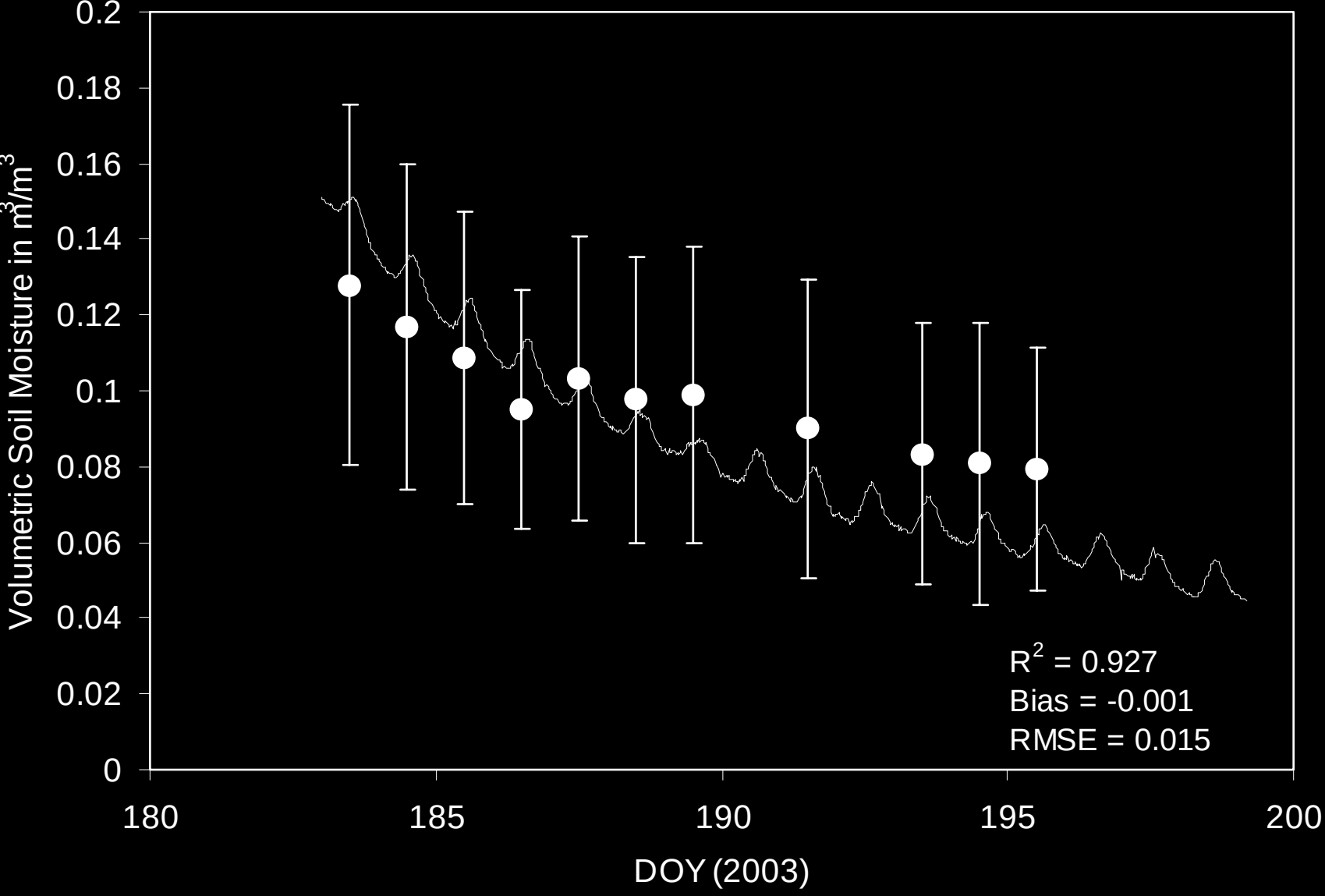


Watershed	Type	# Sensors	Reporting
Little Washita, OK	Grazingland	20	30 min

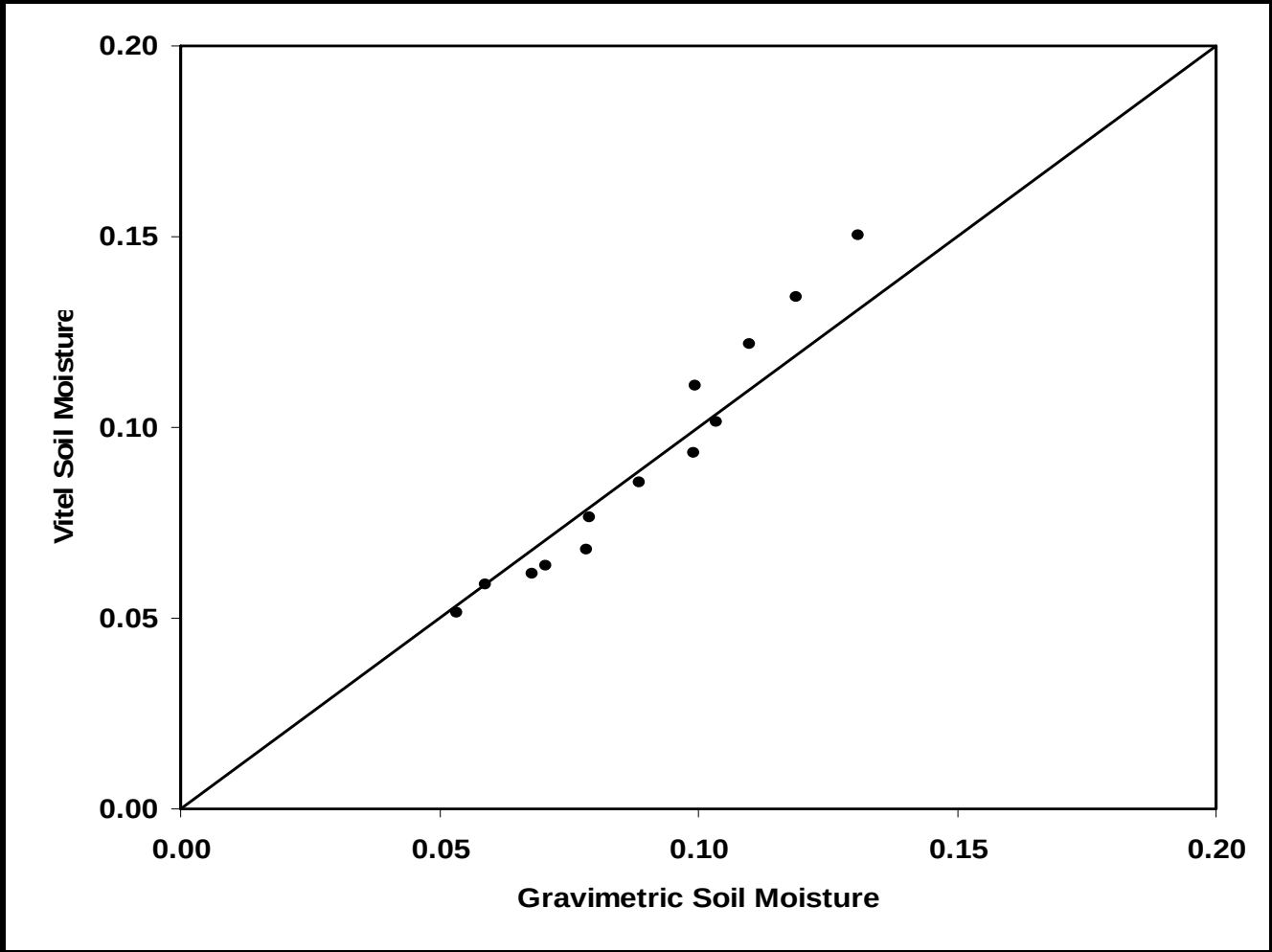
SMEX03 Soil Moisture Sampling Scheme



Micronet Average vs Field Sampling



Little Washita Validation



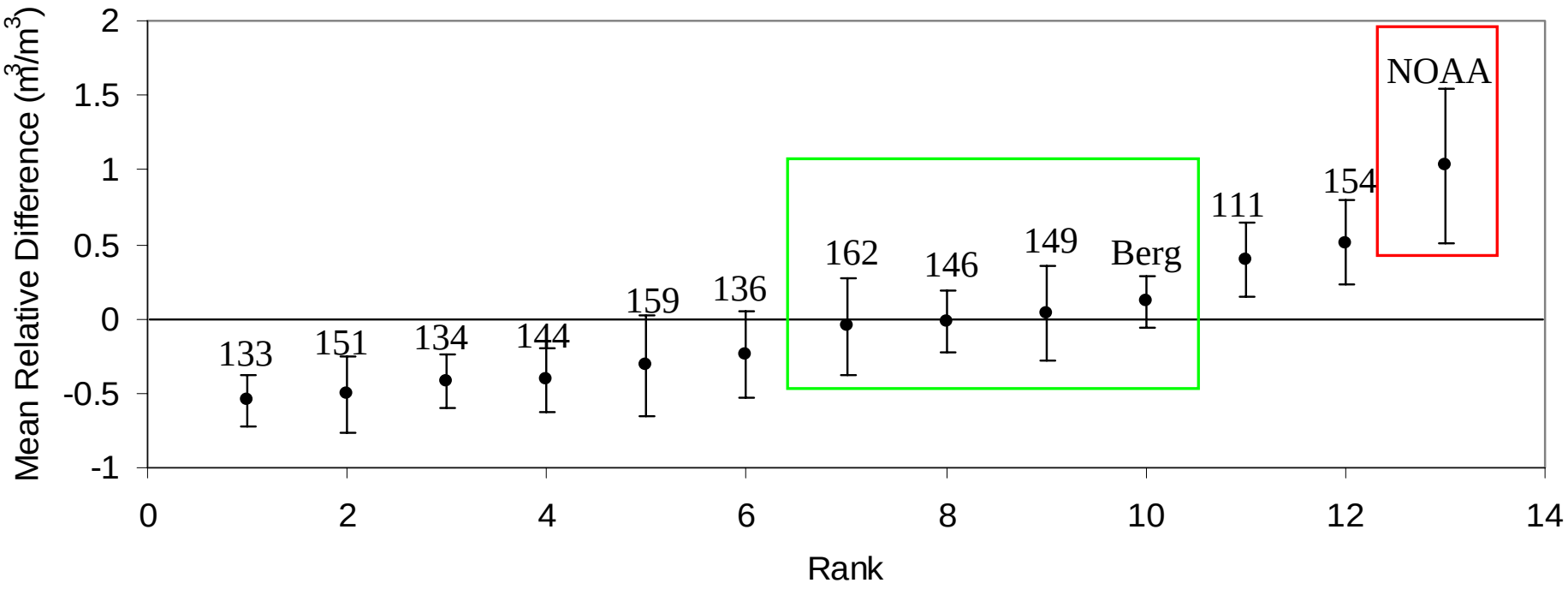
SMEX03 comparison of the average of 13 automated *in situ* sensors and 13 field sites sampled using a gravimetric method (not the same locations). The example demonstrates that reliable area average soil moisture can be obtained using the automated sensors.

Mean Relative Difference Plot

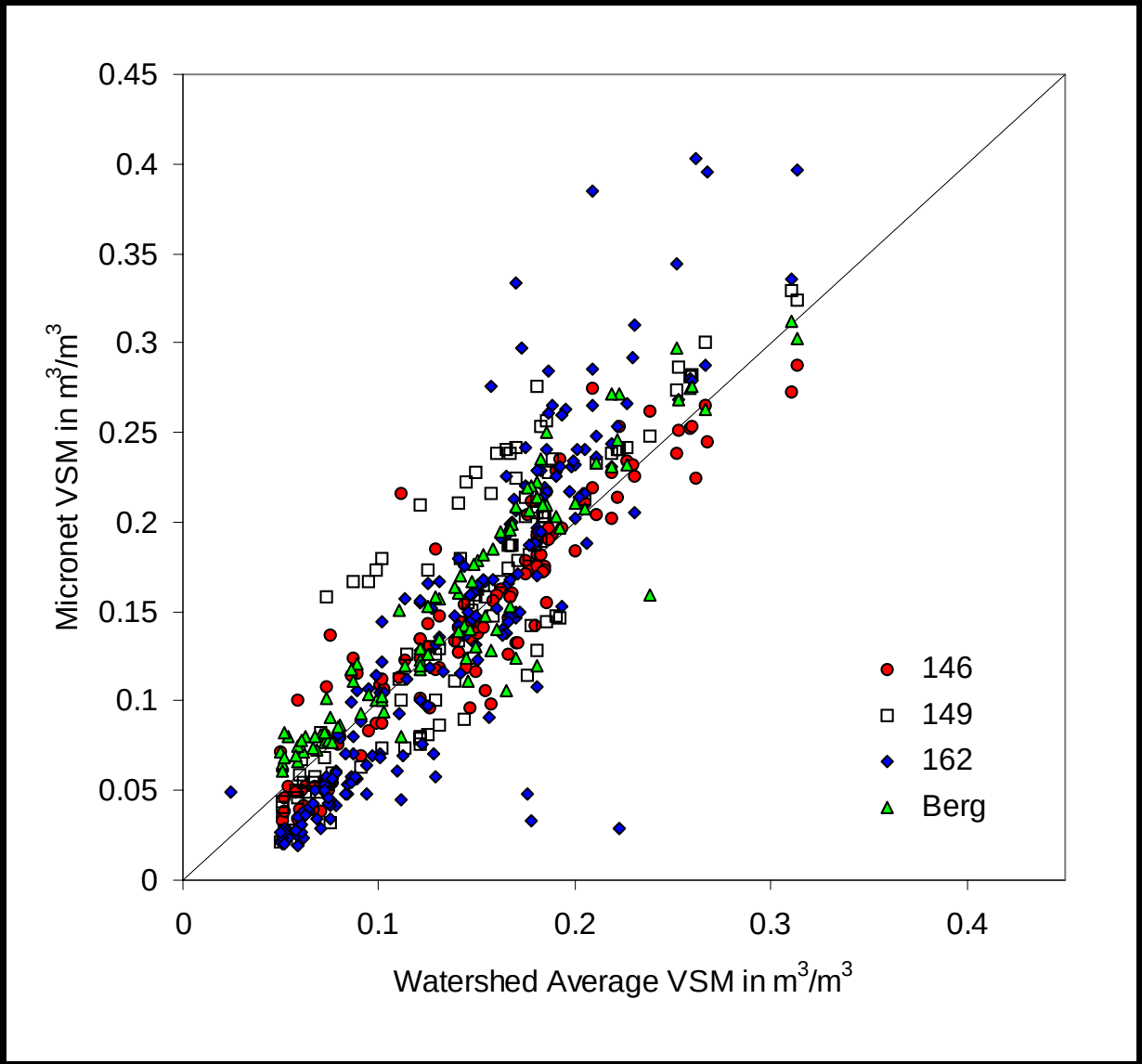
Time stability is established by the mean relative difference plot. The mean relative difference is defined by

$$\bar{\delta}_i = \frac{1}{t}\sum_{j=1}^{t}\frac{S_{i,j} - \bar{S}_j}{\bar{S}_j}$$

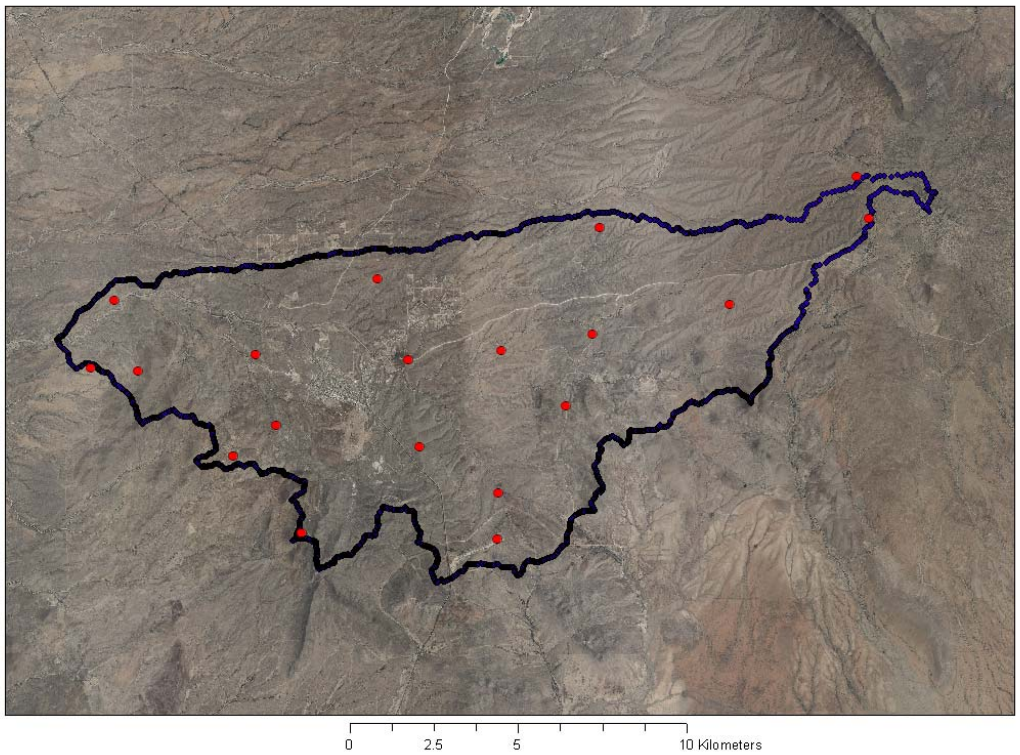
$S_{i,j}$ is the jth sample at the ith site of n sites within the study region.



Representative Sites

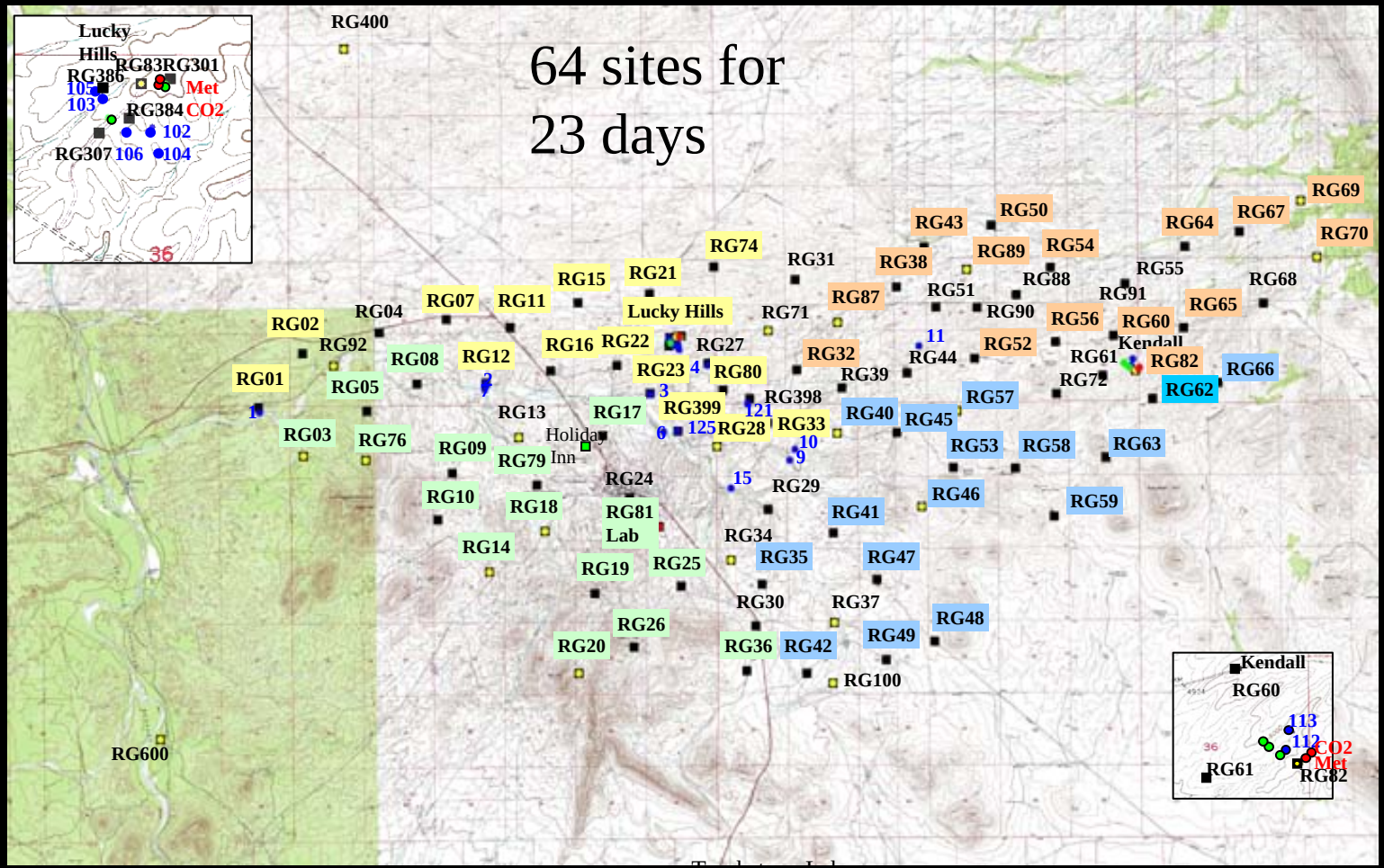


Walnut Gulch, AZ



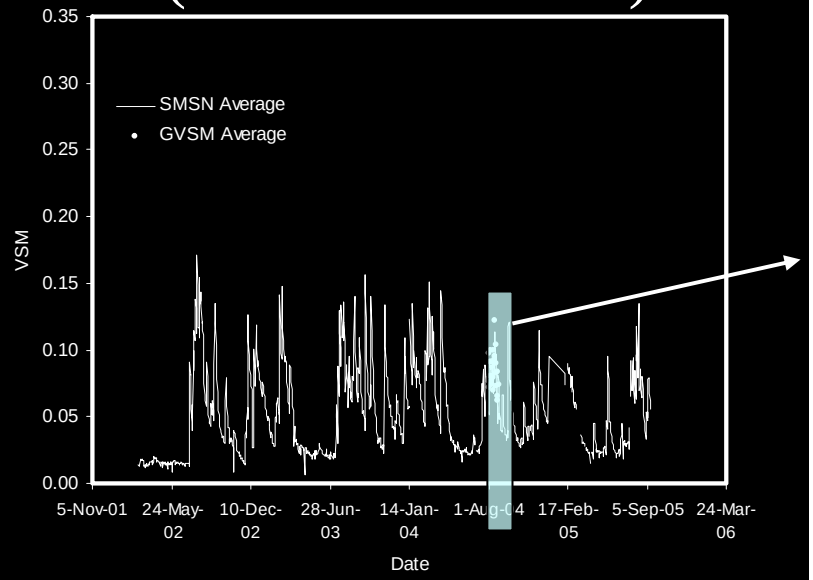
Watershed	Type	# Sensors	Reporting
Walnut Gulch, AZ	Semi-Arid	19	20 min

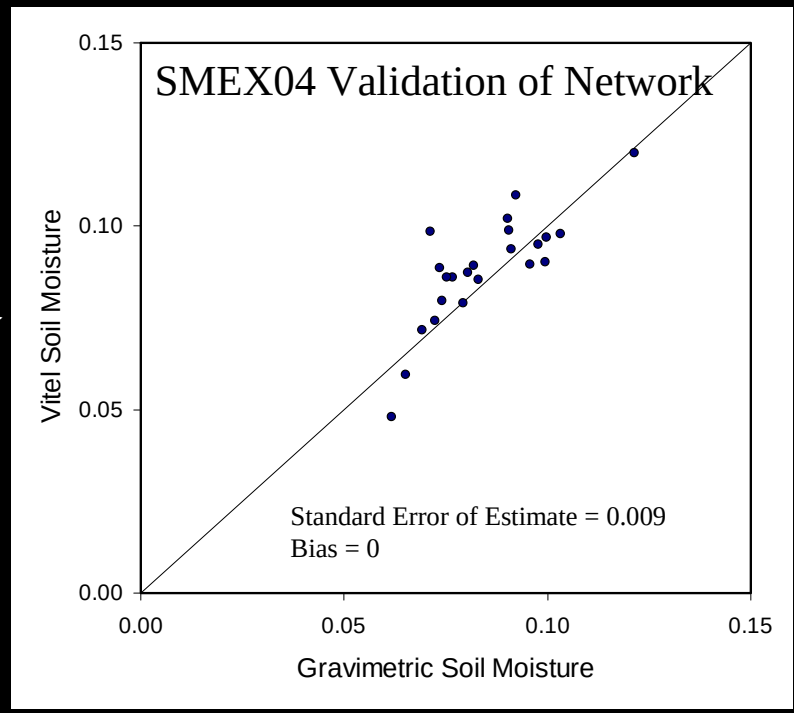
SMEX04 Sampling Scheme



SMEX04

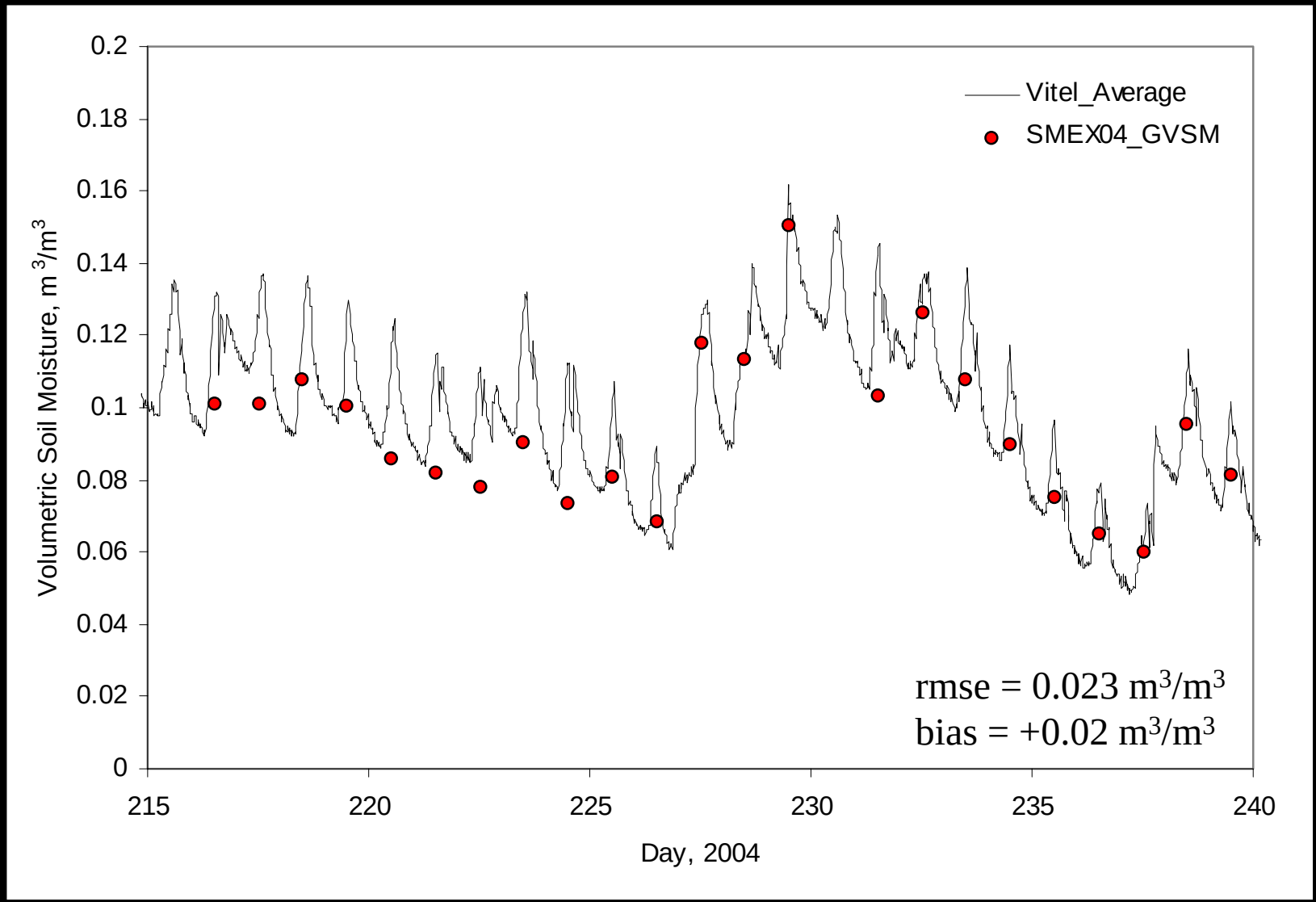
(noon observation)



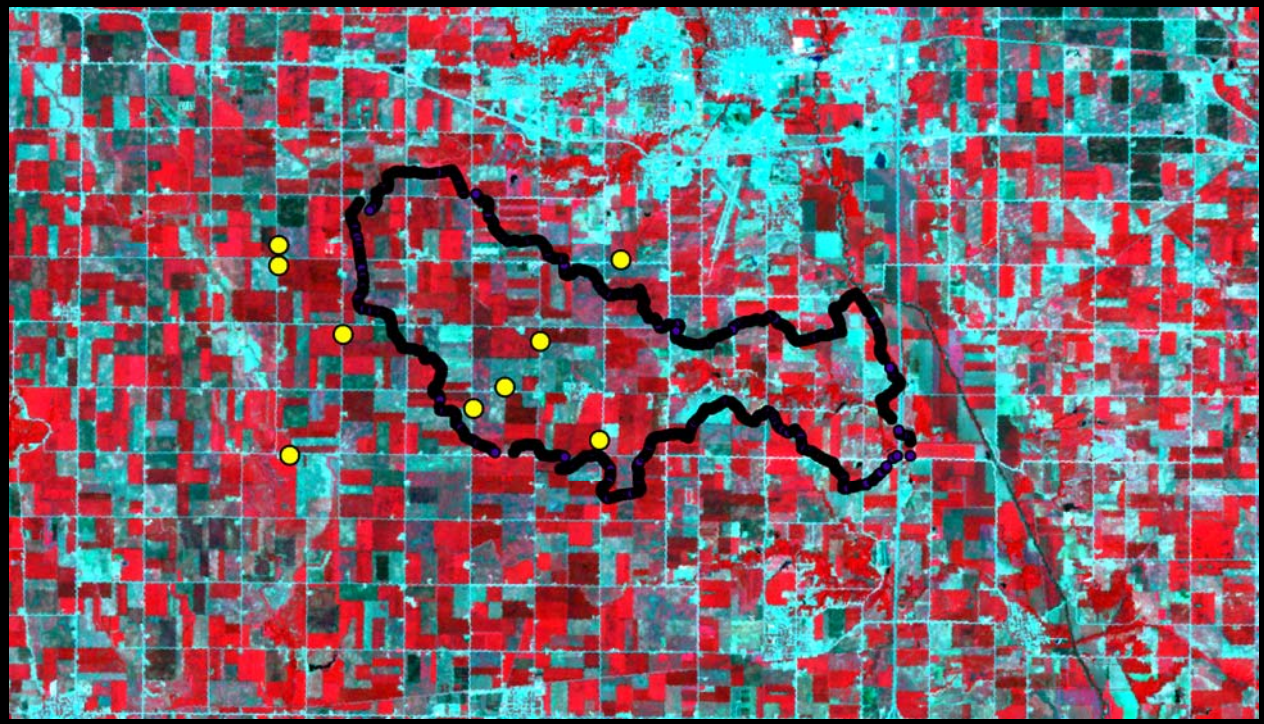


SMEX04 comparison of the average of 19 automated *in situ* sensors (solid-line time-series) and 69 sites sampled using a gravimetric method (red symbols). The example demonstrates that reliable area average soil moisture can be obtained using the automated sensors.

Time Series of Soil Moisture during SMEX04



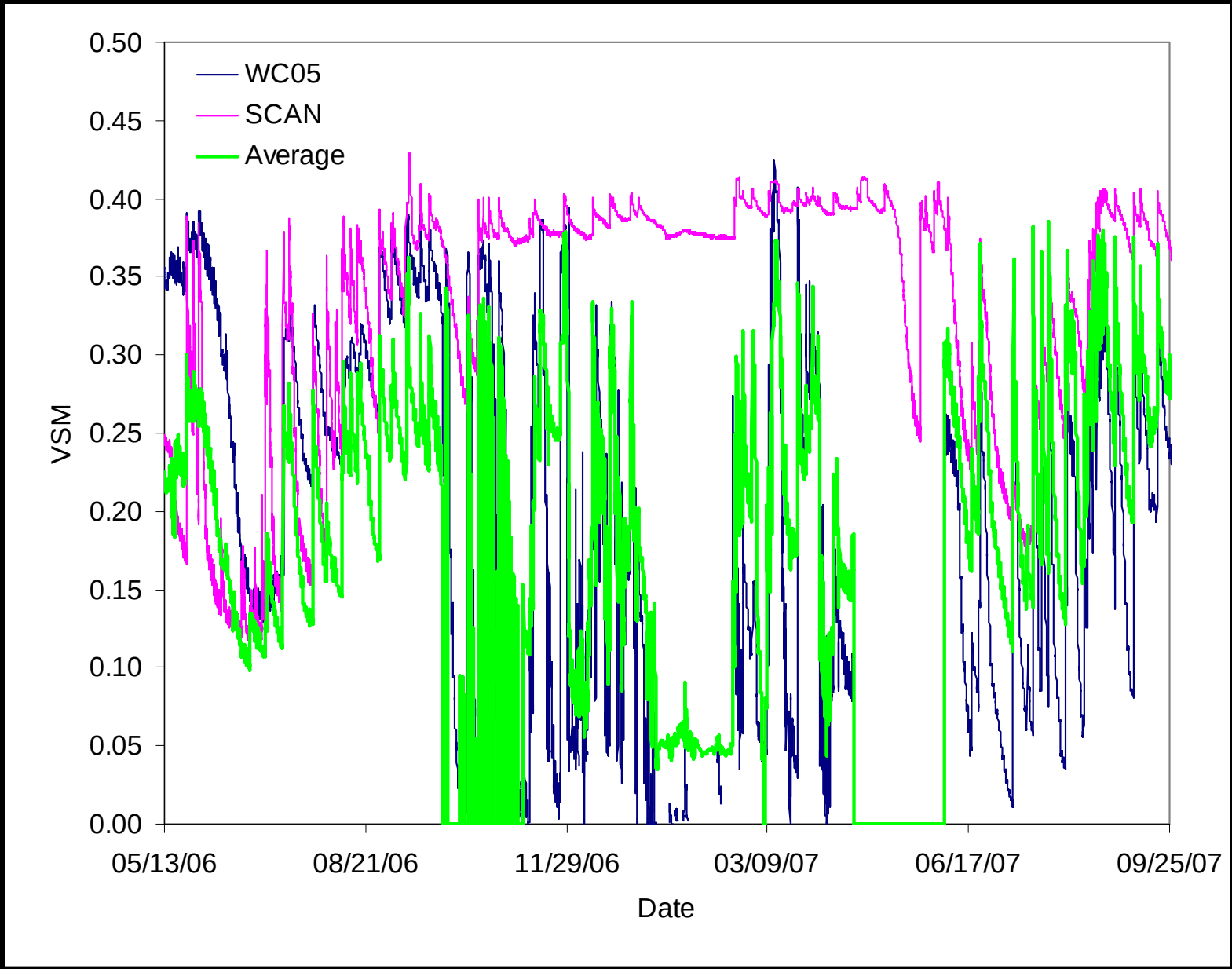
5th Temporary Network : Walnut Creek, IA



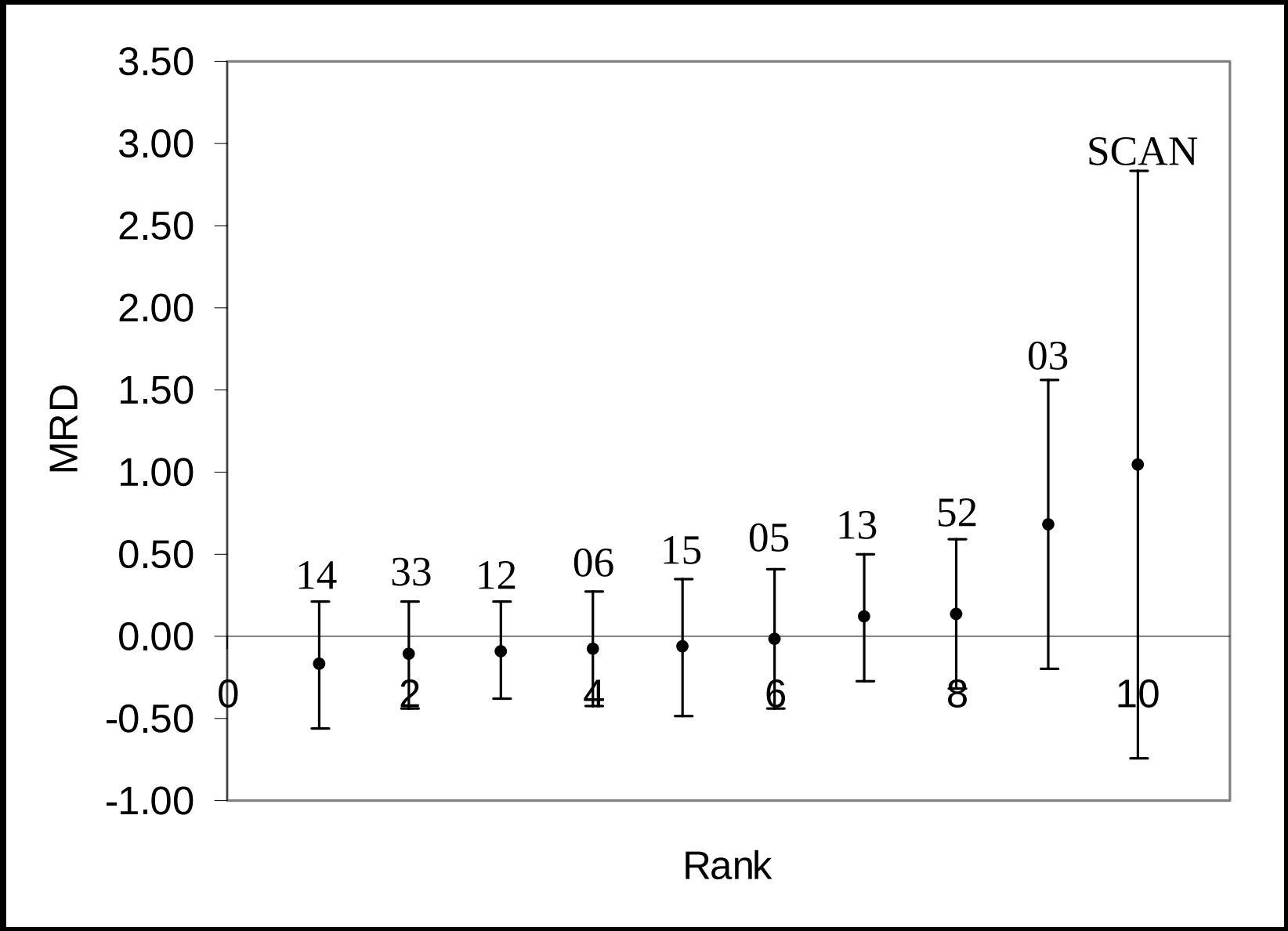
Watershed	Type	# Sensors	Reporting
Walnut Creek, IA	Plains	9	30 min

Since 2006

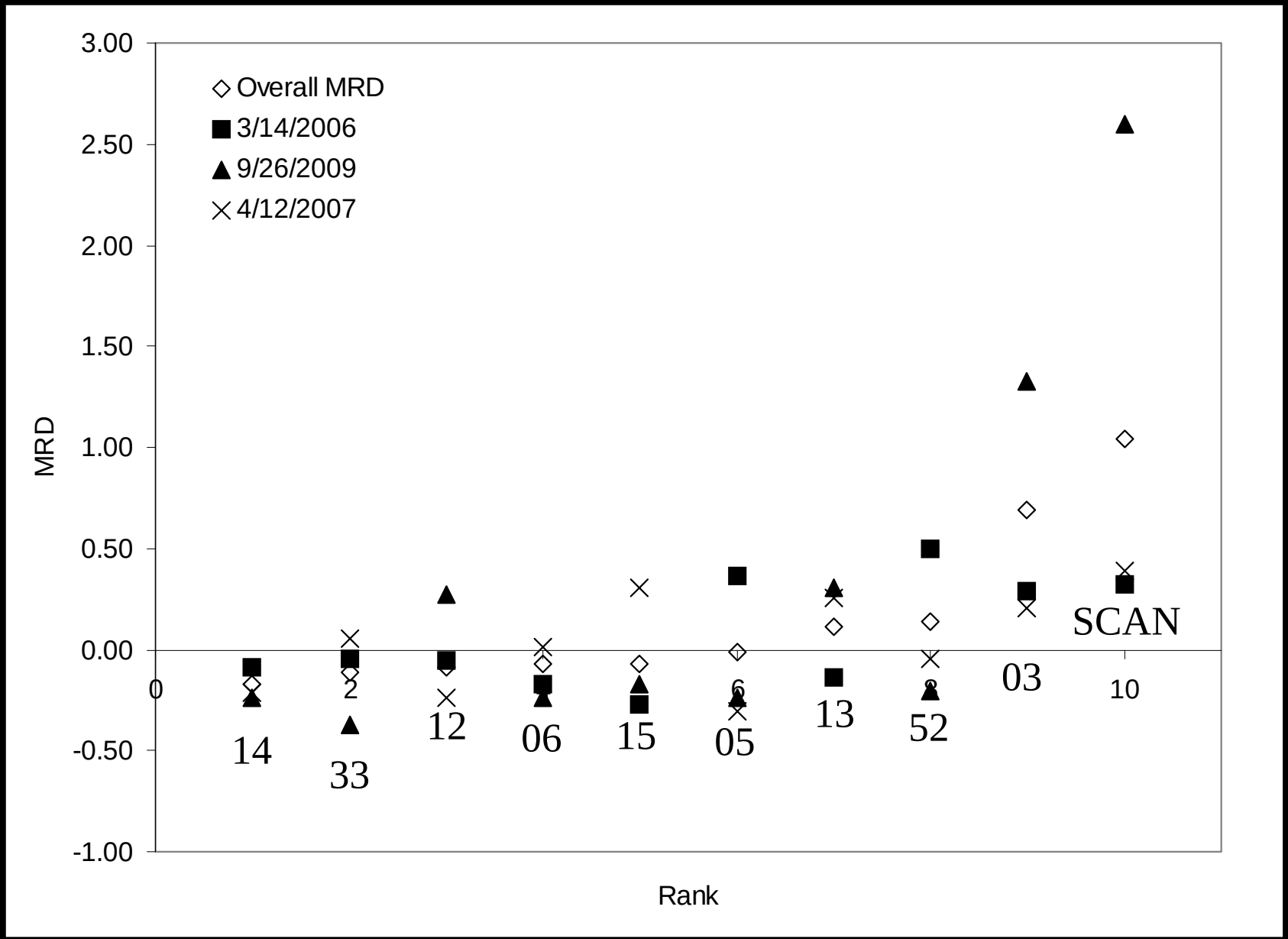
Walnut Creek, Iowa



Overall MRD


3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
MRD
Rank
0
14
33
12
06
15
05
13
52
03
SCAN
2
4
6
8
10

Temporal Stability

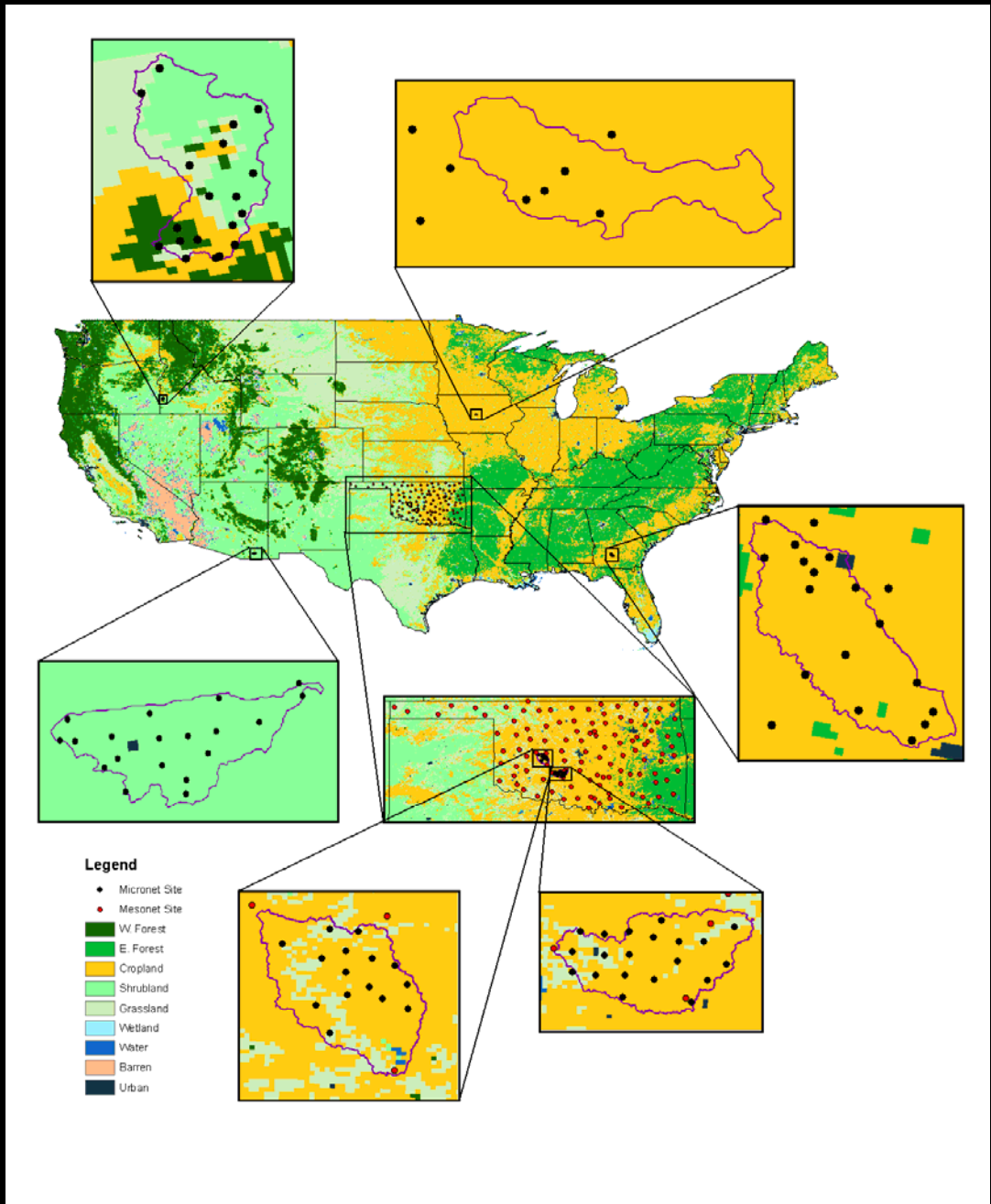


Expanding the Networks

Watershed	Type	# Sensors	Reporting
Walnut Gulch, AZ	Semi-Arid	19 (21)	20 min
Reynolds Creek, ID	Mountainous	16	1 hour
Little River, GA	Forest	19 (++)	30 min
Little Washita, OK	Grazingland	20	30 min
Developing Watersheds			
Walnut Creek, IA	*Cropland*	*9*	*30 min*
Fort Cobb, OK	*Cropland*	*15*	*30 min*
Salamanca, Spain	*Cropland*	*23*	*60 min*
Sonora. Mexico	*Semi-Arid*	*12*	*60 min*

Walnut Creek and Salamanca Design: Addresses the issue of sampling within the field to represent agricultural regions

U.S. Small Networks



Outstanding Issues

Diurnal variations in dielectric sensor readings an effect of temperature

• Representativeness of long term installations and agricultural fields with soil tillage practices (Walnut Creek)

Comments

It has been established in these examples that small networks are capable of accurately estimating large scale soil moisture averages using intensive short term field campaigns and temporal stability analysis. It also identifies suspicious soil moisture stations and representative stations for eventual reduction of networks to single points.