

Soil Moisture Validation Activities

T. J. Jackson and M. Cosh

USDA ARS Hydrology and Remote Sensing Lab

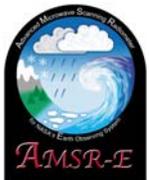
Sept. 2005

Topics

- **Watershed validation networks**
- **Temporal stability of Arizona**
- **New sites**
- **SMEX04**
- **SMEX05**
- **SMEX data sets and archive**
- **Plans**

ARS Watershed Soil Moisture Validation Sites

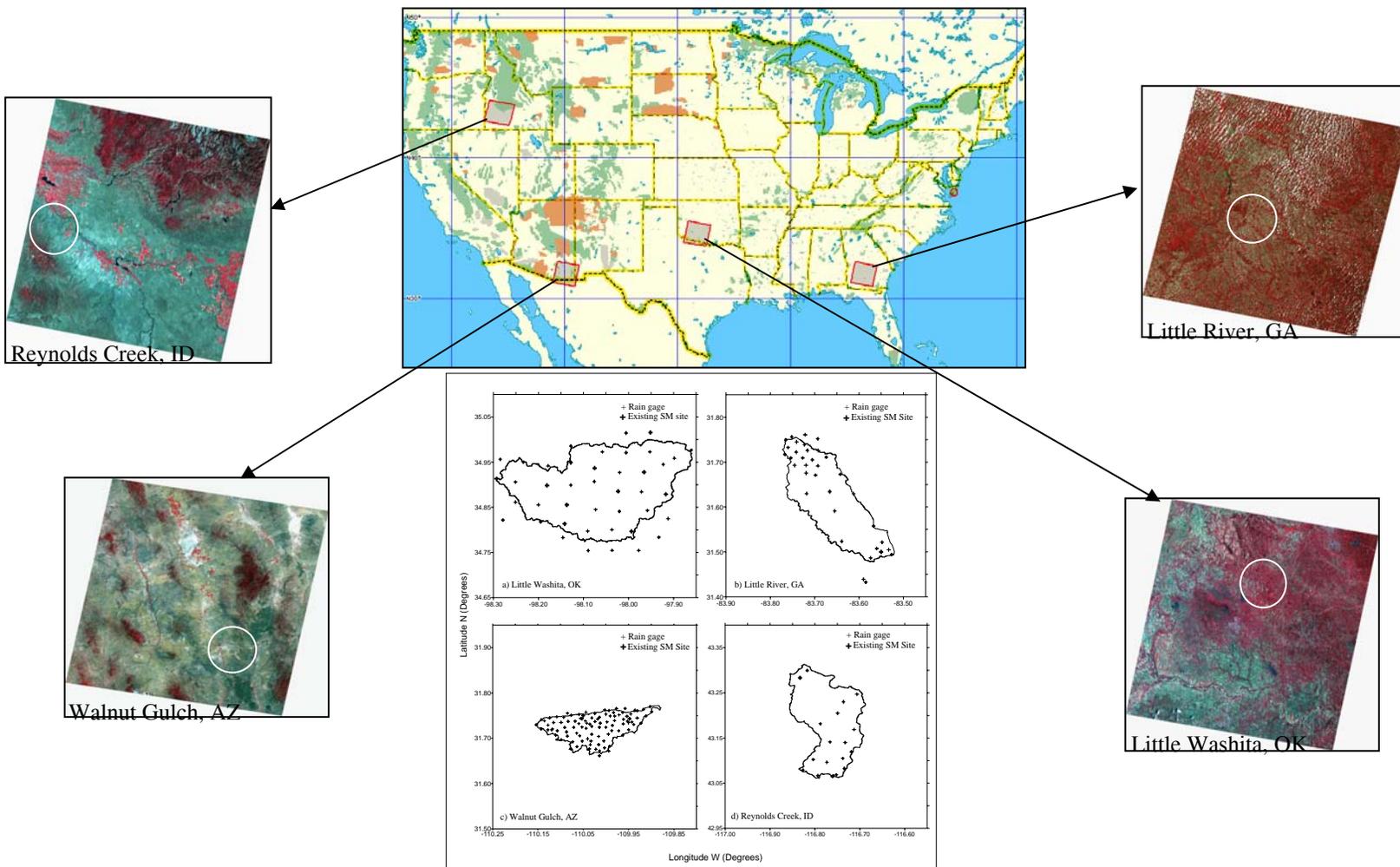
- ✓ Install**
- ✓ Calibration**
- ✓ Scaling (almost)**
- Access and Archive**



AMSR-E Soil Moisture Validation



AMSR-E U.S. Soil Moisture Validation Sites

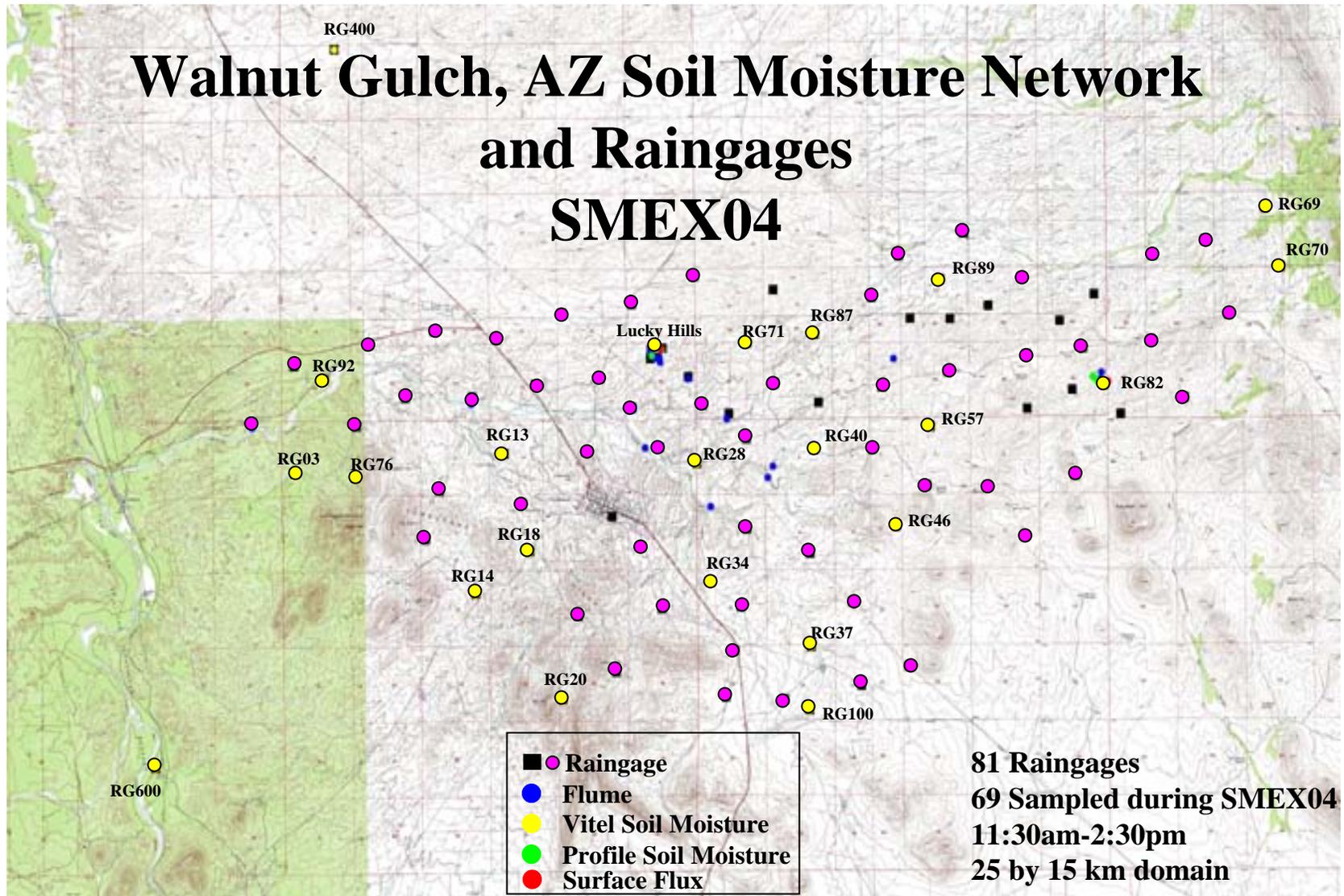


Description and Status of Watershed Networks

<u>Watershed</u>	<u>Type</u>	<u># Sensors</u>	<u>Reporting</u>
Walnut Gulch, AZ	Semi-Arid	21	20 min
Reynolds Creek, ID	Mountainous	16	1 hour
Little River, GA	Forest	19	30 min
Little Washita, OK	Grazingland	19	30 min

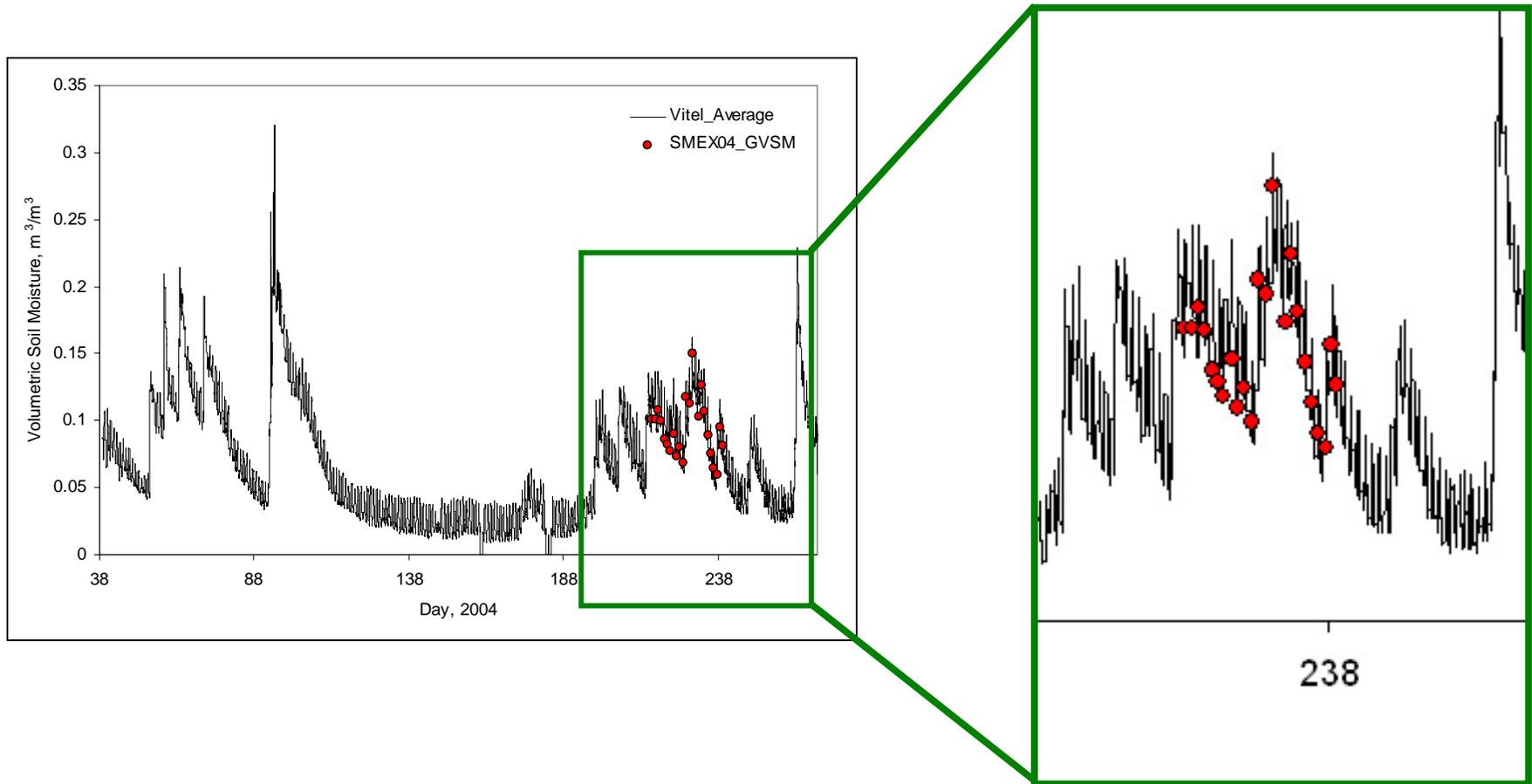
***All watersheds currently downloading daily.**

Walnut Gulch, AZ Soil Moisture Network and Raingages SMEX04



Daily sampling during SMEX04 = ● + ●

Walnut Gulch Time Series of Soil Moisture February to September, 2004



SMEX04 comparison 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.

Plans for Data access and Archival

- **Web page interface with monthly files available.**
- **Scheduled Beta-testing October 15, 2005**
- **Full release November 30, 2005**

Web-Address:

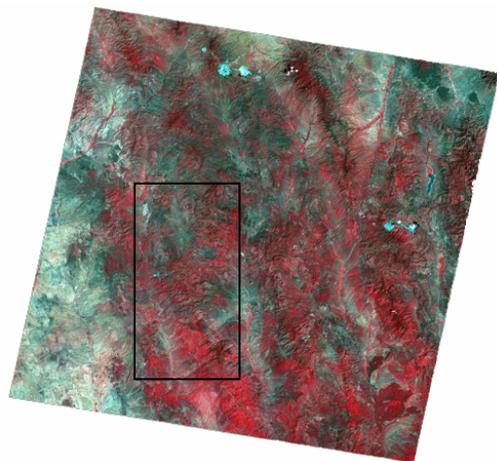
http://hydrolab.arsusda.gov/ARS_Soil_Moisture/

Insitu Soil Moisture Supporting Modeling and Remote Sensing

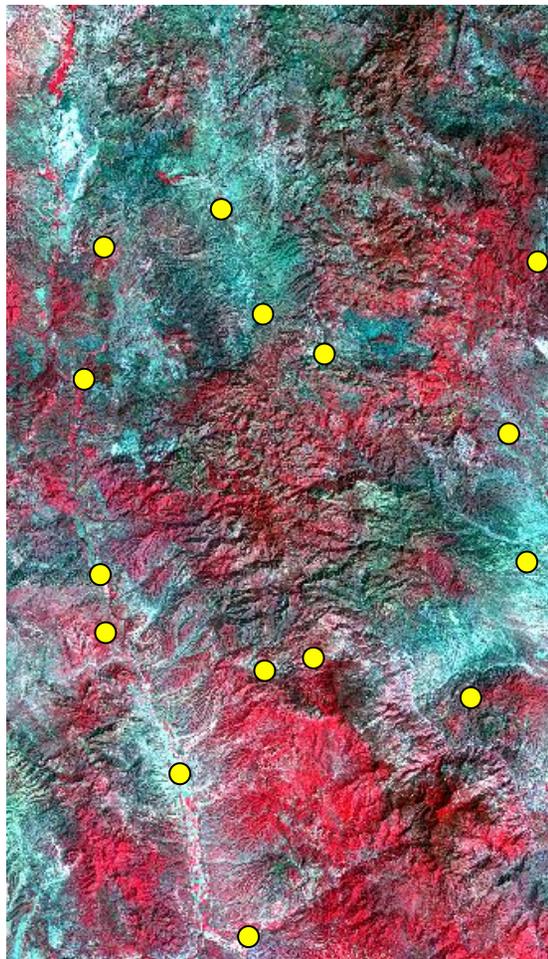
- **Take advantage of existing infrastructure**
- **Strive for consistency and standardization**
- **Link long term points to short term spatial**
- **Exploit temporal stability**
- **Consistent measurements**
- **Expand what we can (Sonora, Salamanca,..)**
- **5 cm!**

Sonora, MX Soil Moisture and Precipitation Network (50 x 85 km)

University of Sonora, Mexico

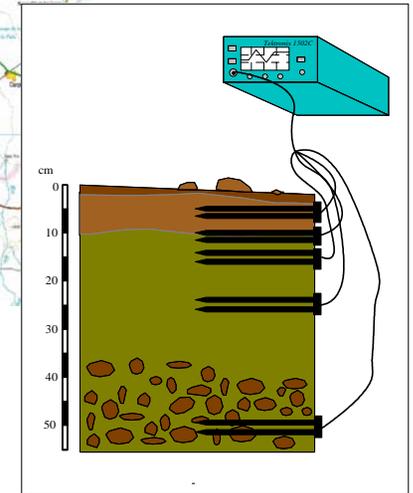
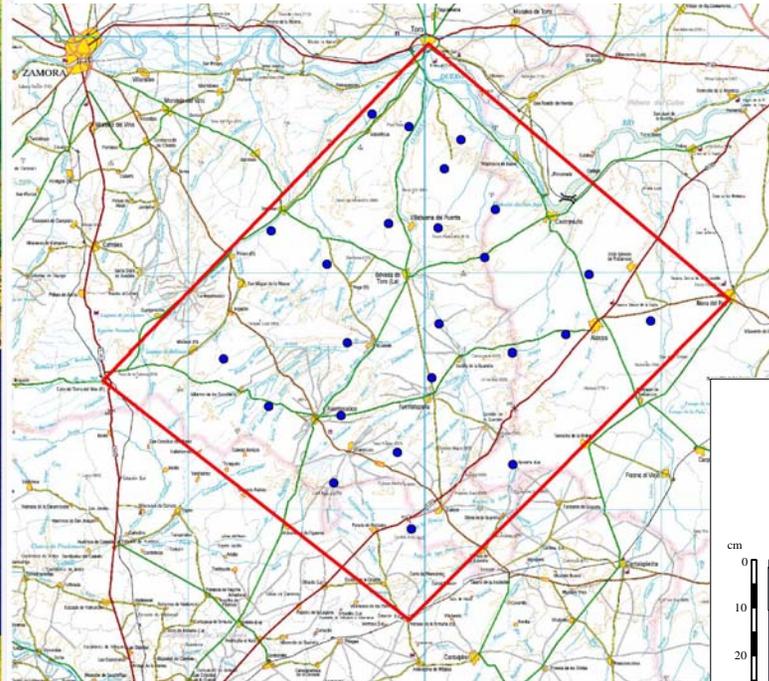


Landsat false color image
August 30, 2004



Network has been operating since June 2004 measuring soil moisture at a depth of 5 cm for 14-locations using Vitel probes. Each site has a rain gauge and two site have additional soil moisture depths. Data are recorded every 20 minutes to data loggers.

REMEDHUS* *Soil Moisture Stations Network (33 x 38 km)* University of Salamanca, Spain



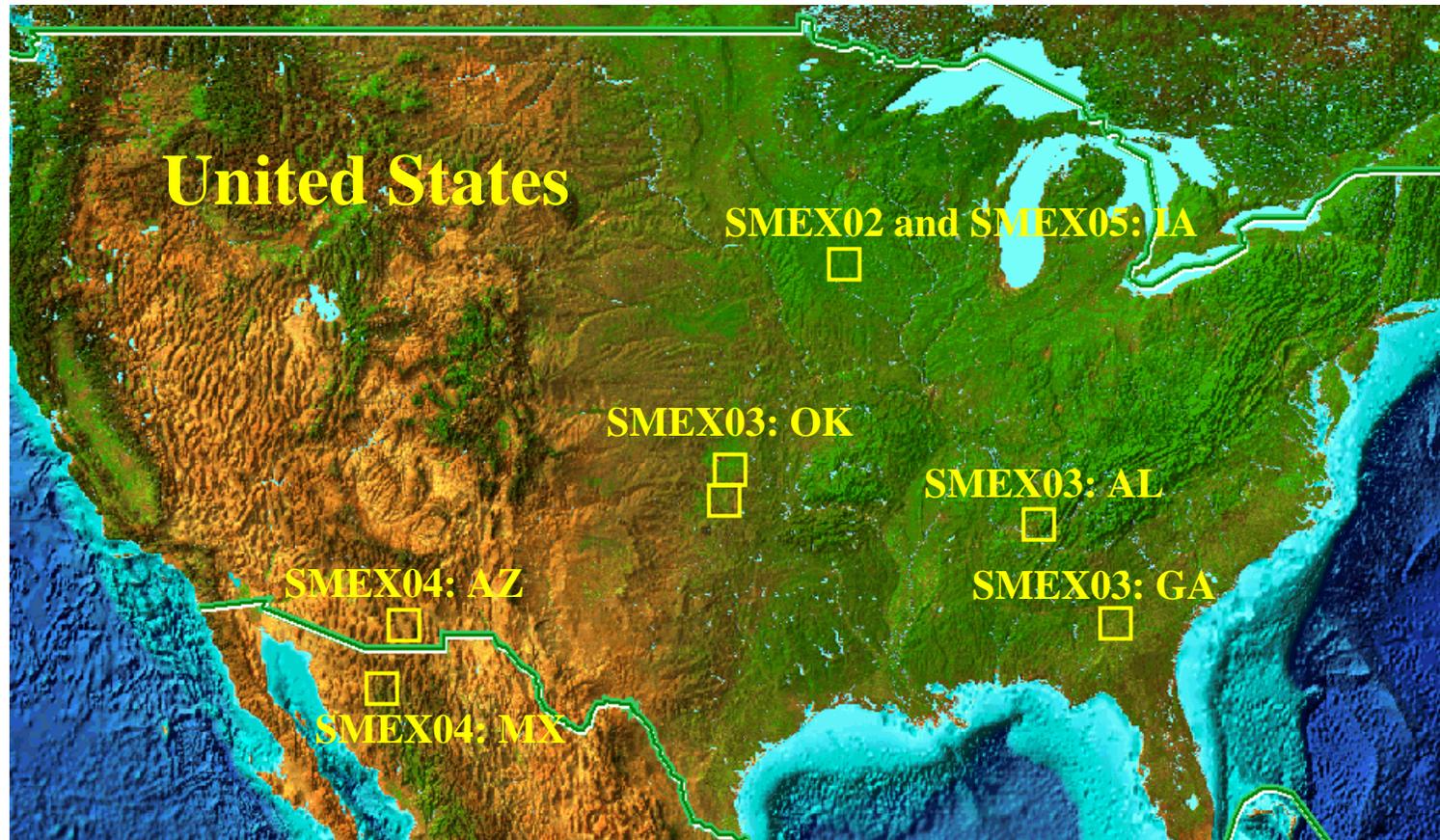
Network (23 sites) has been operating since June 1999 measuring soil moisture at depths of 5, 25, 50 and 100 cm at 14-days intervals using TDR probes. Vitel probes were added for 5 cm data every 20 min.

*Red de Estaciones de Medición de la Humedad del Suelo

SMEX Science Objectives

- ***Validation*** of Aqua AMSR-E T_B and soil moisture products for a range of land cover types
- Development and verification of soil moisture retrieval ***algorithms*** for a range of biomass levels for current (C Band) and future (L Band) passive microwave missions and Envisat ASAR
- Soil moisture sampling-scaling, calibration and method, establishing ***insitu networks***
- Demonstration of new soil moisture retrieval concepts and ***technologies*** (GPS, PALS, 2DSTAR)
- Robust ***data sets*** for follow-on modeling including land atmosphere interactions

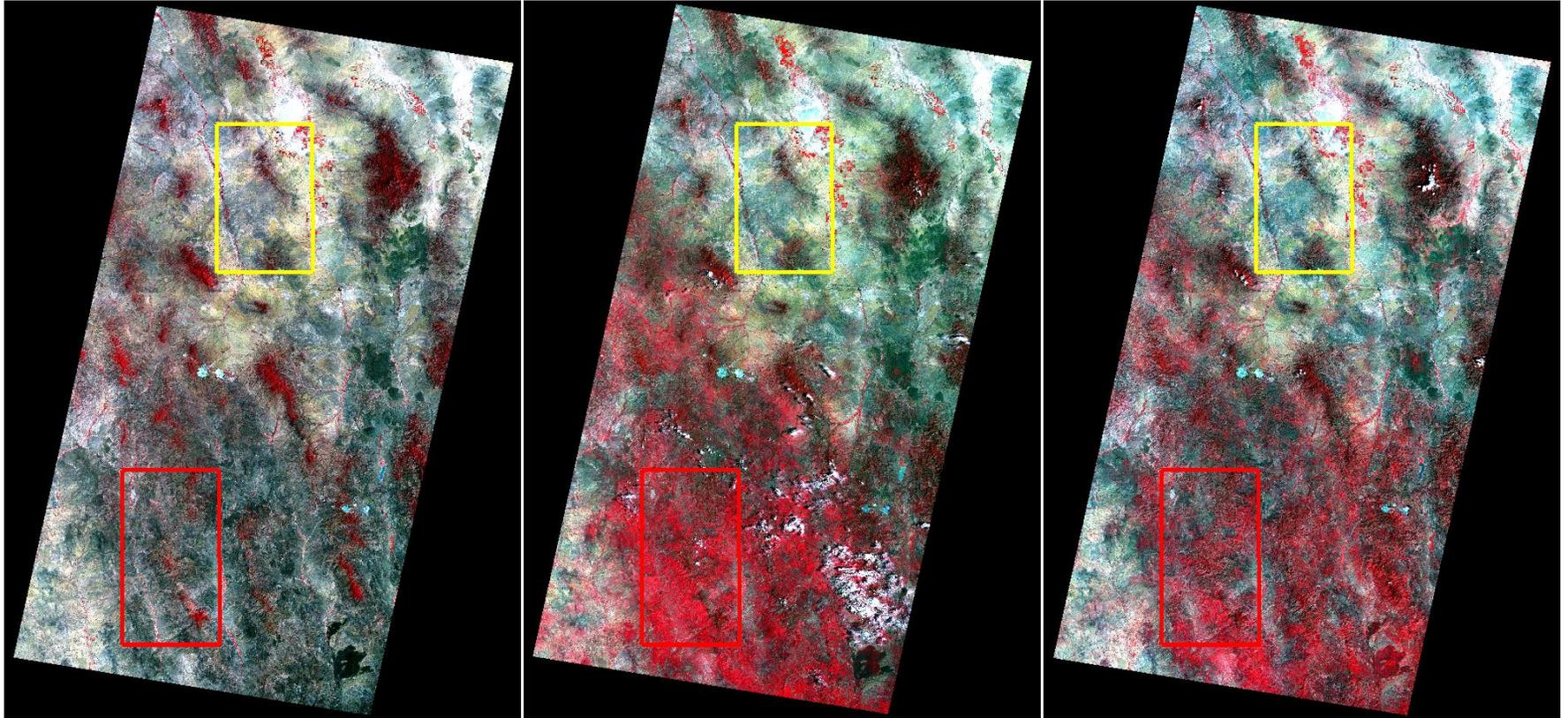
SMEX: A Series of Intensive Field Campaigns Incorporating Diverse Land Covers and Climates



SMEX04 Elements

- **Two regional study sites, Arizona and Sonora provide diverse vegetation and topographic variations**
- **In situ networks in each region provide long term soil moisture**
- **Field campaign August 2-August 27, 2004 with intensive ground sampling concurrent with aircraft and Aqua AMSR-E**
- **Aircraft mapping**
- **Satellite retrievals**

Landsat TM Coverage of the SMEX04 Region in 2004



June 11, 2004

July 29, 2004 ←SMEX04→ August 30, 2004

These are false color composites of two images. Study areas are outlined

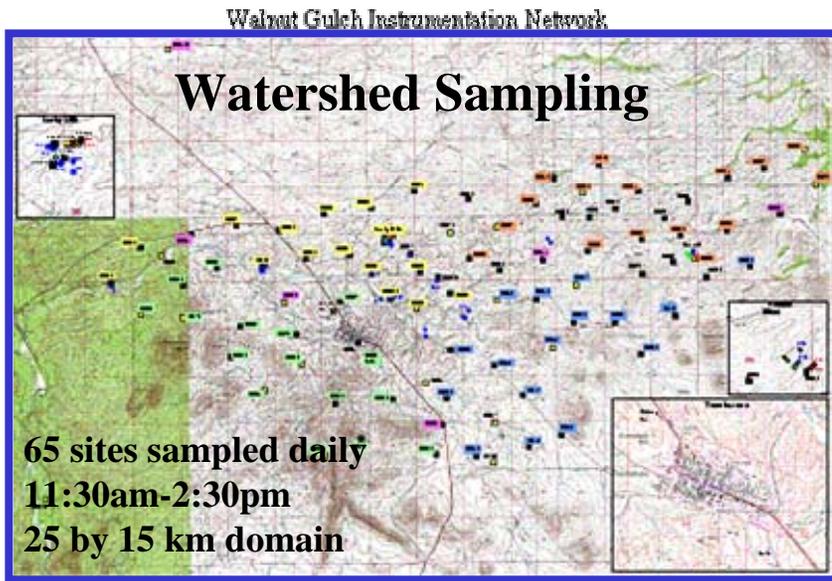
SMEX04 Elements

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SMEX04 AZ Intensive Sampling

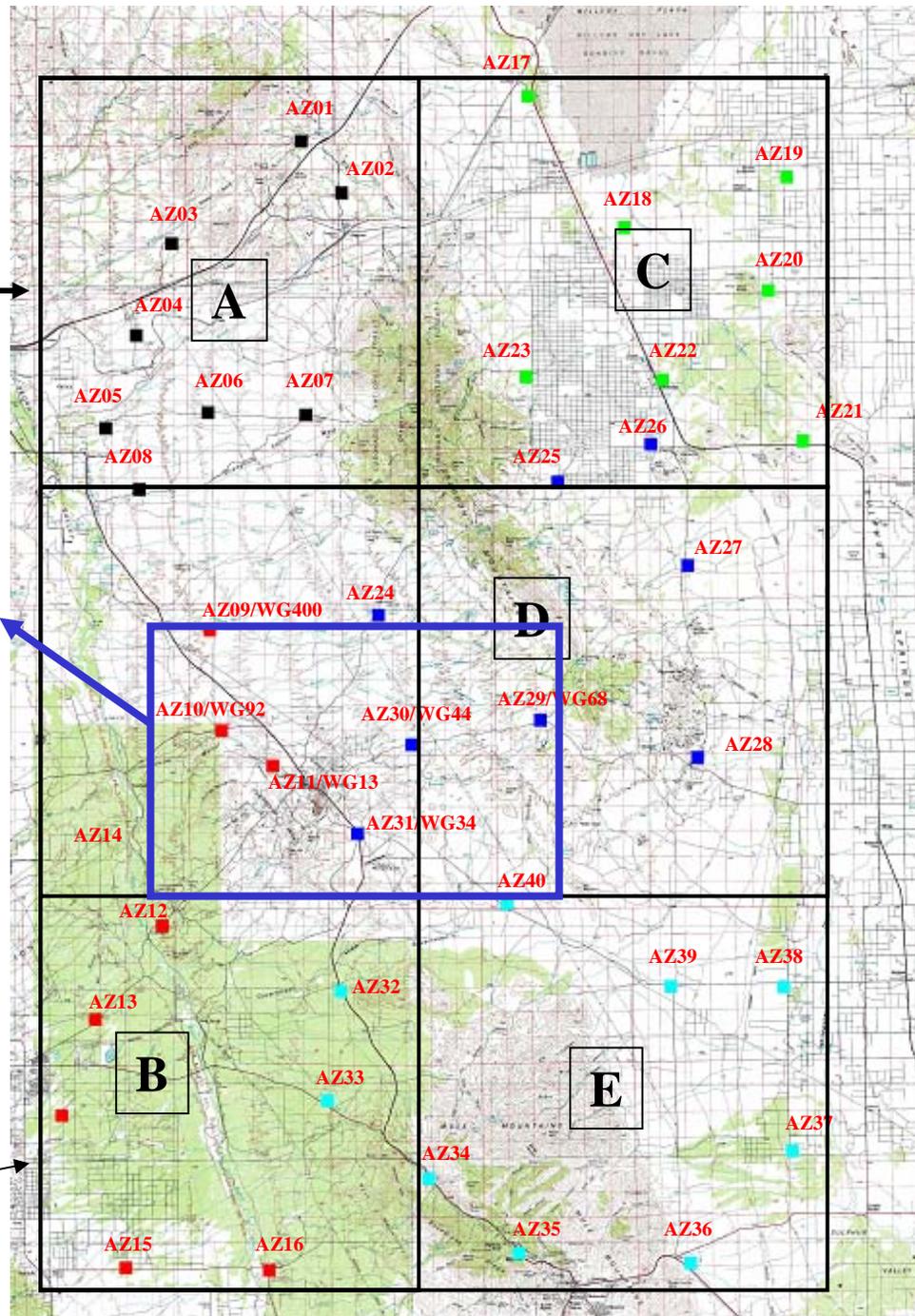
Regional Sampling

40 sites sampled daily
11:30am-2:30pm
50 by 75 km domain



- Runways
- Mill
- Wind Sources
- Transportation
- Airport
- Profit to Soil Interaction
- Intensity of Use

Ease-Grid



SMEX04 Elements

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- **Aircraft mapping**
- **Satellite retrievals**

SMEX04 PSR/CX and AMSR-E/WindSat Coverage

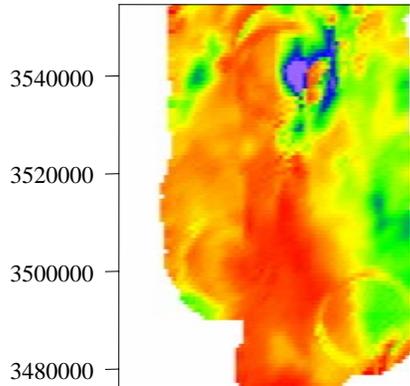
August	Aircraft Mission		Satellites		Antecedent Precipitation	
	AZ	SO	AMSR-E	WindSat	AZ	SO
5	X	X	X	X	X	T
6					T	X
7		X	X			
8	X	X			X	X
9	X	X	X	X		X
10	X	X	X	X	X	T
11				X		
12	X	X	X		T	X
13	X	X				T
14		X	X	X	X	X
15				X	X	X
16			X	X	X	X
17						X
18			X			X
19			X		T	T
20				X		
21			X	X		
22				X		
23			X			
24	X	X				
25	X	X	X		X	X
26	X	X	X	X		

PSR Data Sets and Processing

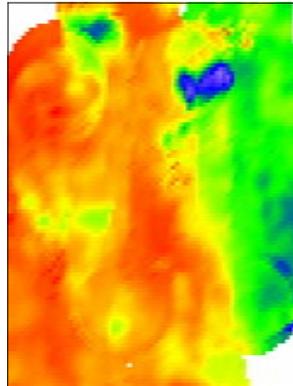
- **84 high altitude flightlines resulting in 21 mapping domains (10 – AZ and 11 - SO)**
- **RFI analysis: best channels 7.32 GHz and 10.7 GHz**
- **RFI removal**
- **Temporal normalization of multiple flightlines**
- **800 m grid mapping (high altitude nominal beam position spacing is 300 m)**

SMEX04 PSR 7.32H (Arizona)

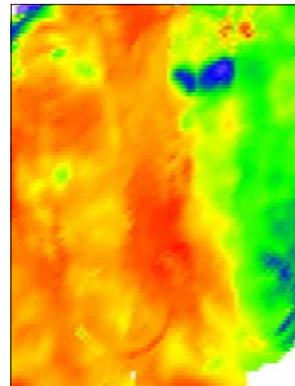
08/05/04



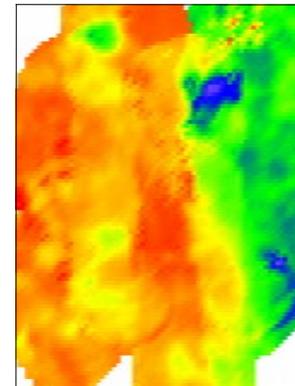
08/08/04



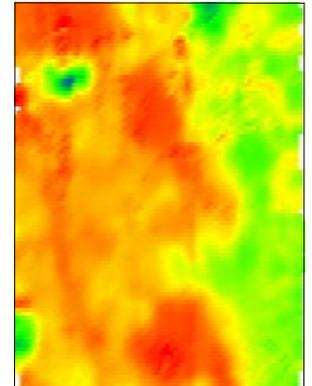
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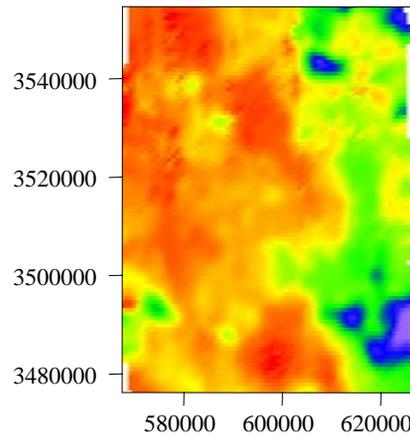
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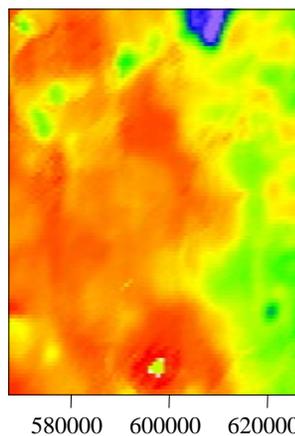
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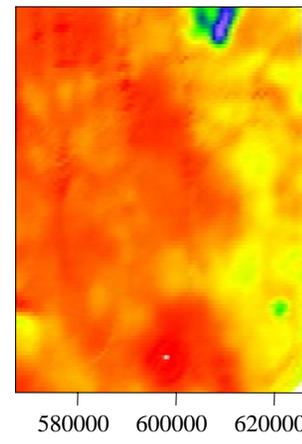
08/13/04



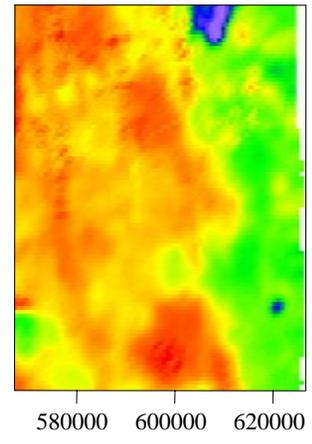
08/24/04



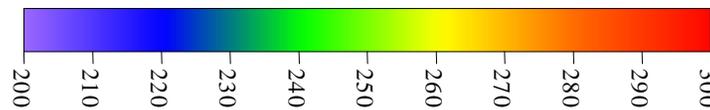
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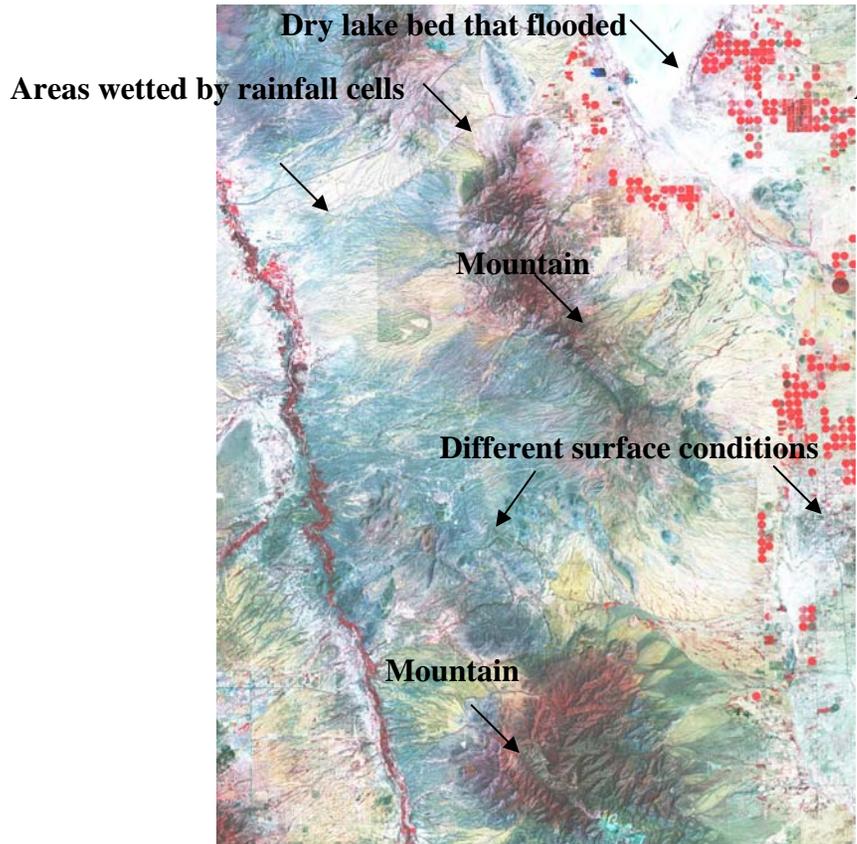
08/26/04



Brightness Temperature (K)

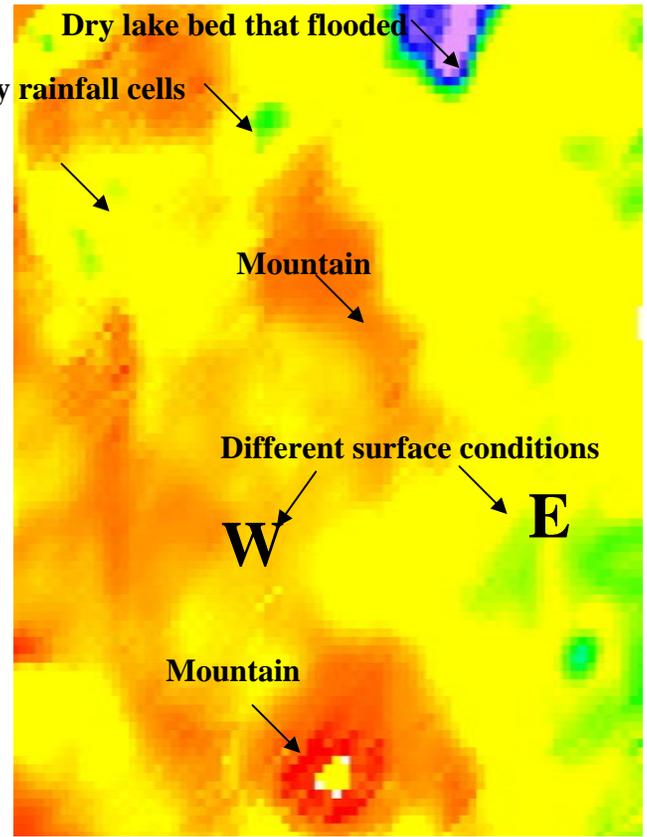


Arizona Landsat 5 (July 29)

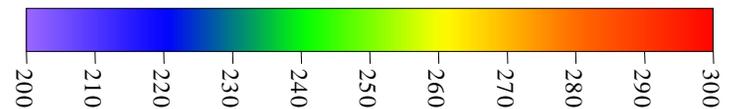


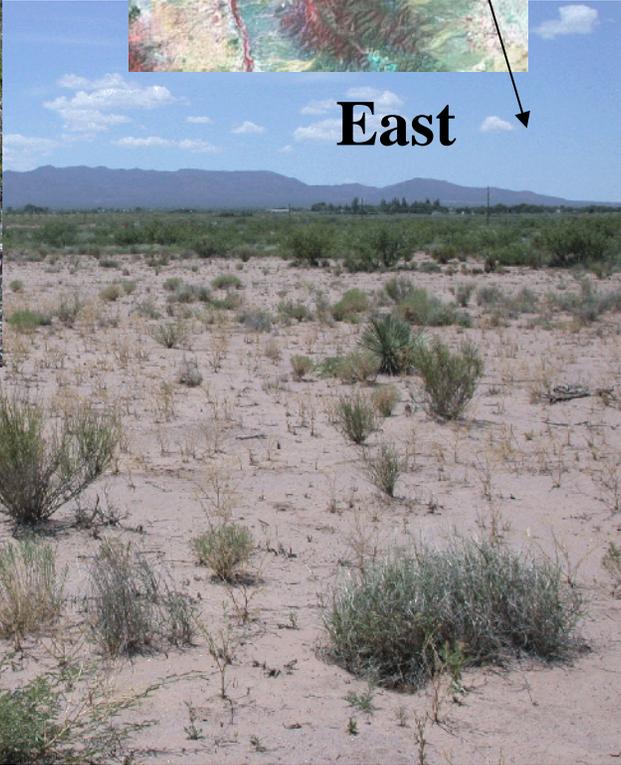
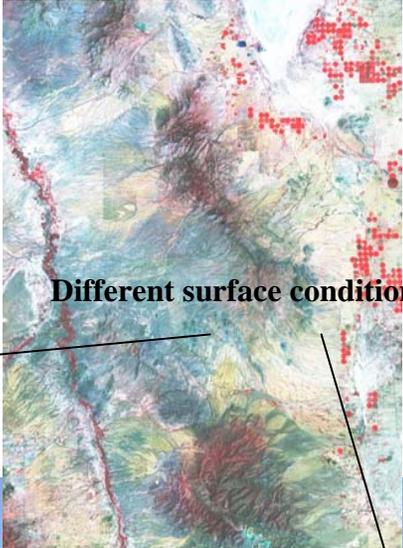
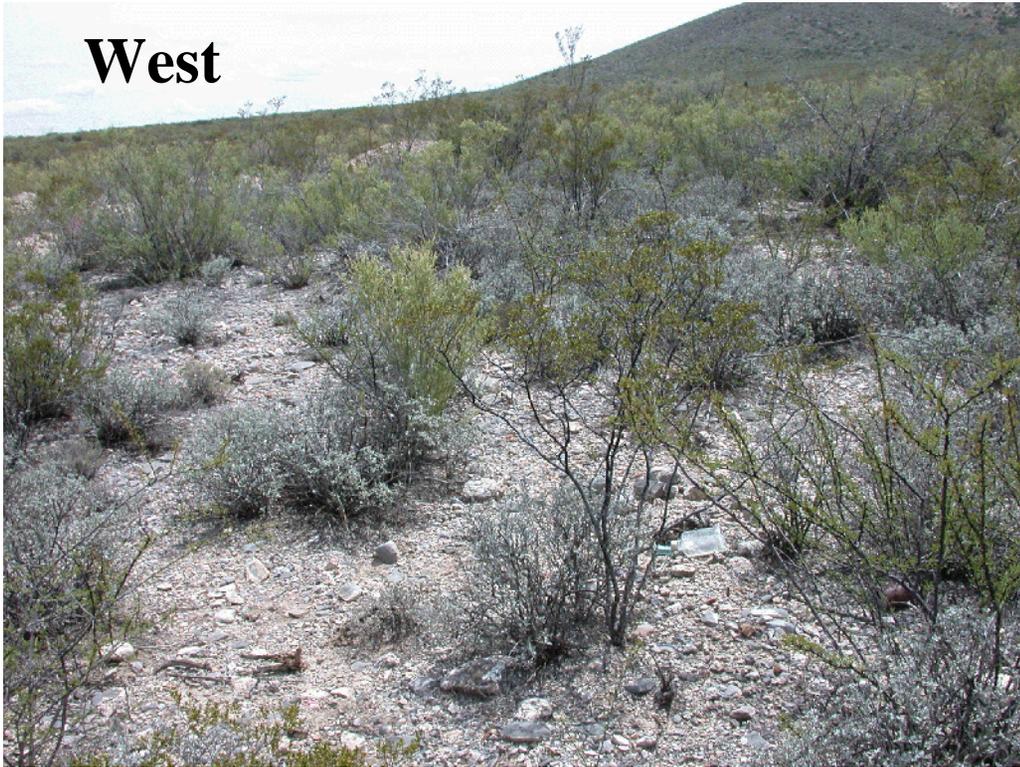
Arizona PSR (August 24)

C Band H

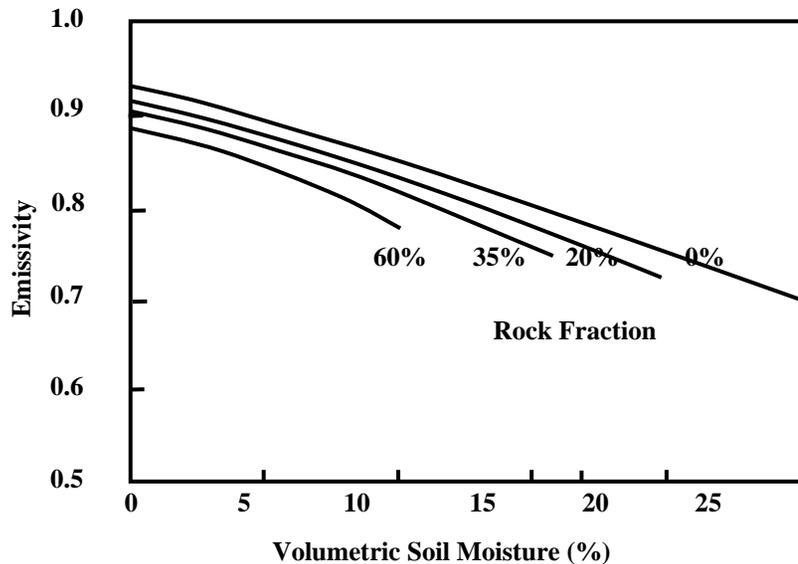


Brightness Temperature (K)





Potential Effects of Surface Rocks on Microwave Remote Sensing of Soil Moisture

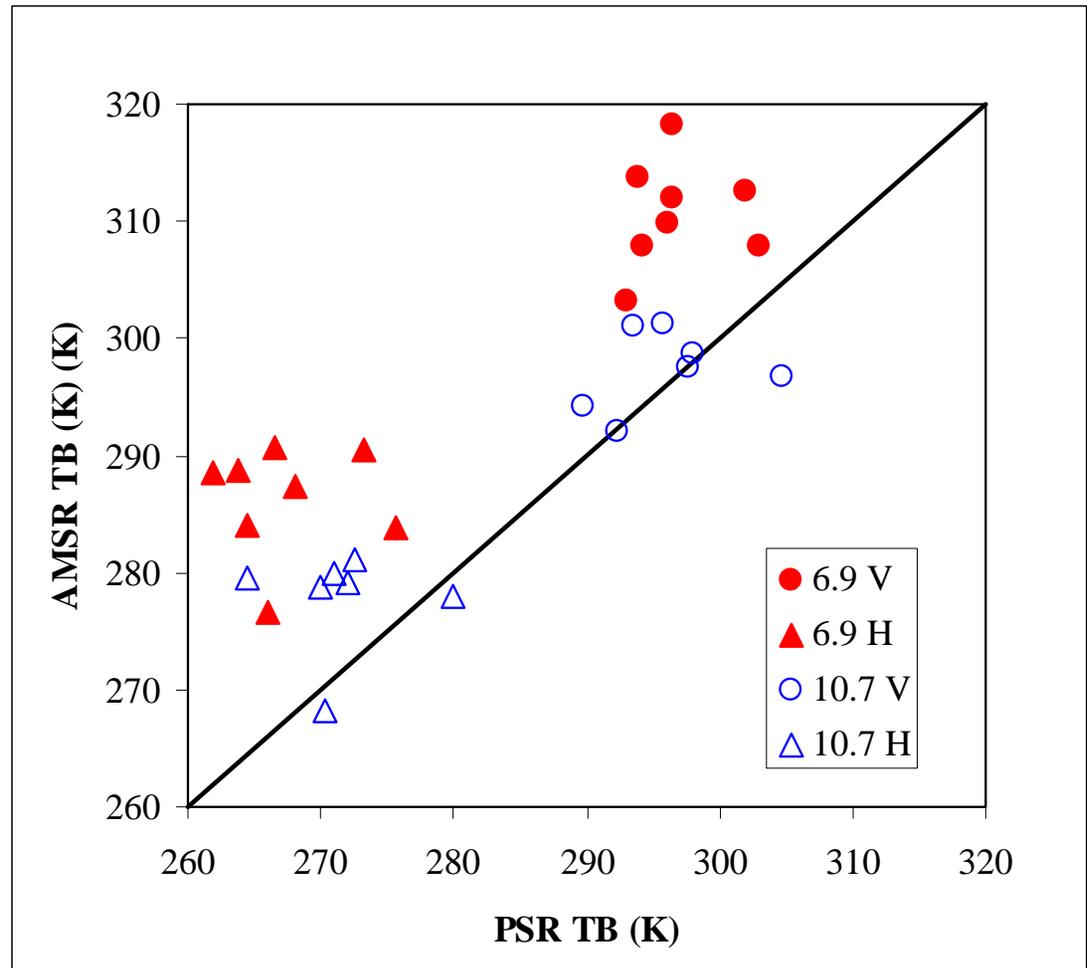


- Rocks occupy volume but do not hold water: the range of possible soil moisture as well as that of T_B will decrease as RF increases
- Surface rocks contribute to roughness
- Thermal features of rocks will be different than soils
- All of these factors will contribute to generally high T_B (emissivity) that shows little variability (roughness and temperature may have a frequency component)

Brightness Temperature Comparisons

Arizona (AZ) Domain

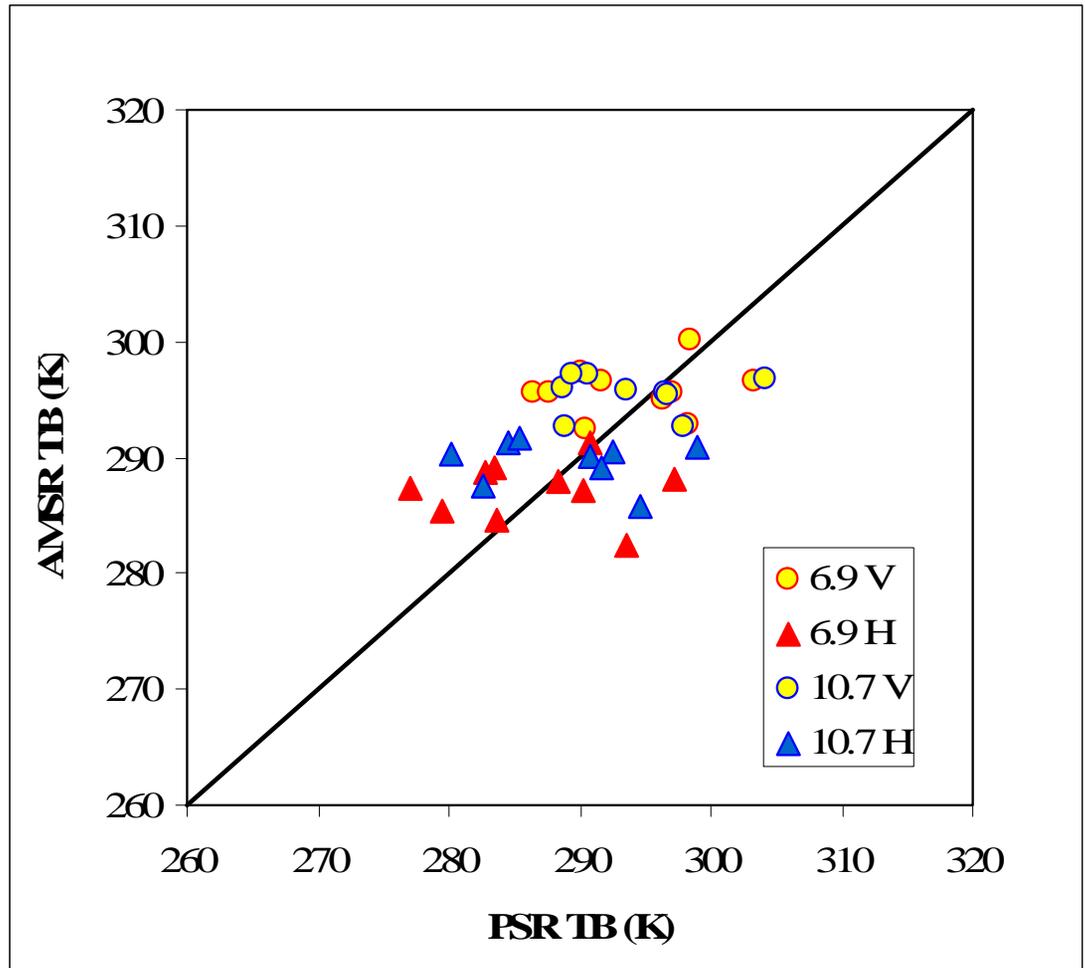
- **10.7 GHz**
PSR~AMSR
(H&V)
- **V>H** (typical low
vegetation result)
- **6.9 GHz**
AMSR>PSR
(H&V)
- **Problem: RFI**
- **PSR observed**
earlier in day



Brightness Temperature Comparisons

Sonora (SO) Domain

- **10.7 GHz**
PSR~AMSR
(H&V)
- **6.9 GHz**
PSR~AMSR
(H&V)
- **V~H (typical of**
increasing
vegetation)
- **Limited range for**
AMSR-E T_B



Unresolved issues

- **Topography: incidence angle**
- **Rocks: dielectric properties, interpretation of VSM, surface roughness**
- **Observation time: PSR observations were made earlier in the morning than AMSR-E**
- **Spatial scale: dynamic range of AMSR observations is much smaller than PSR observations**

Summary

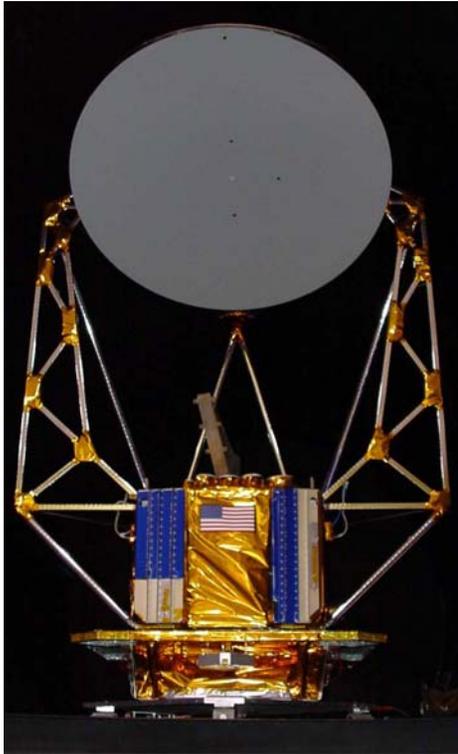
- PSR is a **proven airborne radiometer system** which has performed well during a number of SMEX experiments (SGP99, SMEX02, SMEX03, SMEX04)
- There is **RFI contamination over the AZ domain for C-band** observations. C-band observations over SO and for X-band do not exhibit obvious RFI effects
- Spatial patterns of PSR observations over AZ and SO are consistent **to geophysical features and weather events**
- **Rock fraction** may reduce the utility of high frequency channels in soil moisture retrieval, even if it is essentially bare soil
- **Work continues** on topography and soil moisture products

SMEX05 Objectives

- **Controlled condition data to understand polarimetric signatures of structured vegetation, tillage, and soil moisture at CMIS frequencies**
- **Define the effects of dew on microwave emission and explore techniques for the screening and/or correction (*Hydros relevance)**
- **Forest sites observations**
- **Evaluation and testing of RFI suppression techniques**
- **Follow on AMSR-E validation**

NRL WindSat Radiometer

**WindSat is the first spaceborne
Polarimetric Microwave Radiometer**



Frequency (GHz)	SSM/I	AMSR-E	WindSat	CMIS	SMOS	Hydros
85/91	V, H	V, H	-	TBD	-	-
37	V, H	V, H	V, H, U, F	TBD	-	-
22/23	V, H	V, H	V, H	TBD	-	-
19	V, H	V, H	V, H, U, F	TBD	-	-
10.8	-	V, H	V, H, U, F	TBD	-	-
6.8	-	V, H	V, H	TBD	-	-
1.4	-	-	-	-	V, H	V, H, U
37 IFOV, km	27x38	8x14	8x13	TBD	*50@1.4 Ghz	*10-40@1.4 GHz
Observing Time	Various	1:30 pm	6:00 am	6:00 am	6:00 am	6:00 am
Period of Record	1985-	2002-	2003-	2009-	2007-	2010-

NRL Airborne Polarimetric Microwave Imaging Radiometer (APMIR) in SMEX05

- Fully polarimetric channels
- Only C and X available
- Can mimic space-borne sensor conical scan
- Fixed beam selected to provide fixed target/sensor geometry
- Scan in elevation angle (0 to 60 degrees) and spin in azimuth (0 to 360 degrees)
- Spatial resolution selected to provide adequate within field sampling

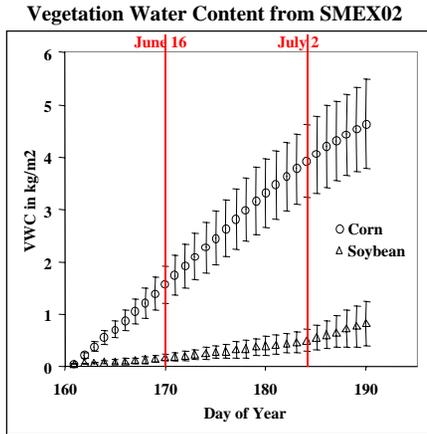


APMIR Frequencies and Coverage (based on a 53 degree incidence angle)				
Channel (GHz)	Beam width (Deg)	Altitude = 7.6 km		Altitude = 0.9 km
		Footprint (km)	Swath (km)	Footprint (km)
6.6, 6.8, 7.2	9.4	2.1 x 3.5	20	0.24 x 0.42
10.7	5.9	1.3 x 2.2	20	0.15 x 0.27
18.7 / 19.35	6.8	1.5 x 2.5	20	0.18 x 0.30
22.235 / 23.8	5.3	1.2 x 1.9	20	0.15 x 0.24
37	6	1.3 x 2.2	20	0.15 x 0.27

SMEX05/POLEX Summary of Aircraft and Satellite Coverage (Daytime Passes of W=Windsat, A=AMSR, L5=Landsat 5)

June 12 A	13 W	14 W A Briefings	15 W A L5	16 P3 Transit	17 A Flight	18 Flight
19 W A Flight	20 W Flight	21 W A ASAR Flight	22 L5 Flight	23	24 A ASAR	25 W
26 W A Flight	27 Flight	28 A	29	30 W A Flight	July 1 W A L5 Flight	2 W Flight
3 A P3 Transit	4 ASAR	5 A	6 W	7 W A	8 W L5	9

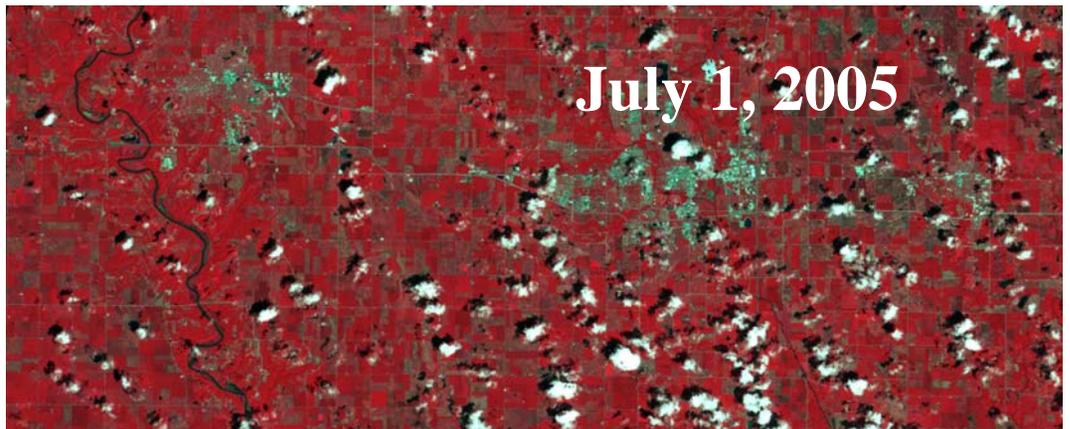
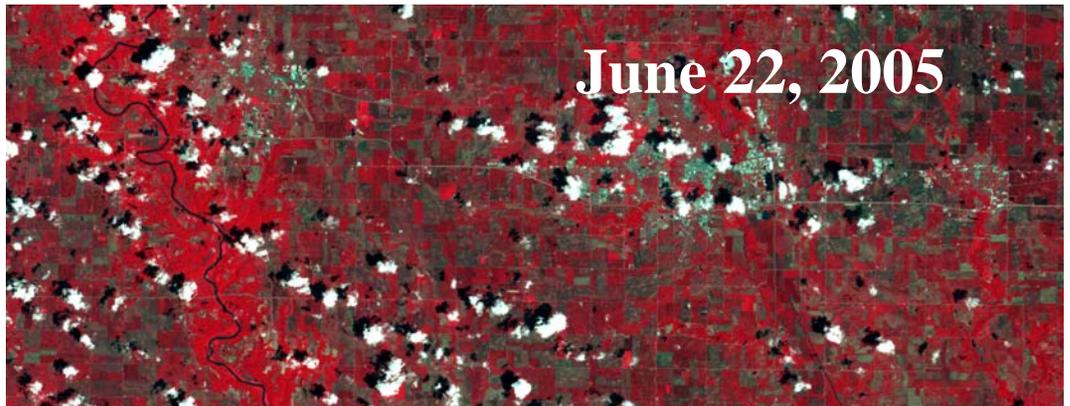
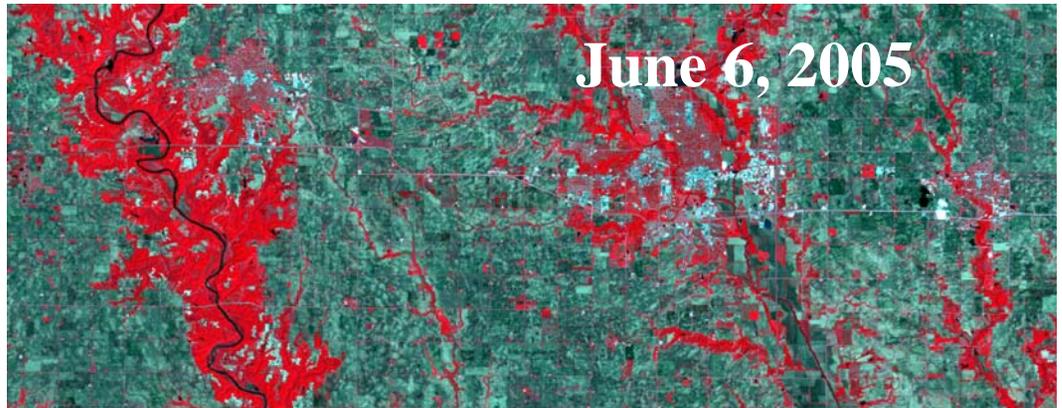
Walnut Creek Watershed Vegetation Conditions



Red indicates expected SMEX05 study period



**SMEX05
Landsat 5 TM
Images of the
Walnut Creek
Watershed Area**







SMEX DATA SETS

(08/15/05)

- SMEX02-complete
- SMEX03-loose ends
- SMEX04-June 2006
- SMEX05-TBD

Group	Data Set	SMEX02	SMEX03					SMEX04		SMEX05
		IA	GA	AL	OS/ON	BZ	AZ	SO	IA	
Aircraft	PSR	☐	☐	☐	☐	--	■	■	☐	
	ESTAR/2DSTAR	☐	☐	☐	☐	--	☐	☐	--	
	GPS	☐	☐	☐	☐	--	--	--	☐	
	AIRSAR	☐	--	--	☐	--	--	--	--	
	AVIRIS	--	--	--	--	--	☐	☐	--	
Ancillary	Land Cover	☐	☐	☐	☐	☐	☐	☐	☐	
	Geolocation	☐	☐	☐	☐	■	■	■	☐	
	Soils	☐	☐	☐	☐	☐	■	■	☐	
	Photographs	☐	☐	☐	☐	■	☐	■	☐	
	Surface Roughness	☐	☐	☐	☐	☐	☐	☐	☐	
Soil Moisture	Regional	☐	☐	☐	☐	■	☐	■	--	
	Watershed/Transect	☐	--	--	☐	--	☐	■	☐	
	Vitel Network	☐	■	☐	☐	■	☐	■	☐	
	SCAN	☐	☐	☐	☐	--	☐	--	☐	
Meteorological	Sunphotometer	☐	--	--	☐	--	☐	--	☐	
	Precipitation	☐	☐	☐	☐	■	■	■	☐	
	Apogee Network	☐	--	--	☐	--	--	■	--	
	Mesonet	--	--	--	☐	--	--	--	--	
	ARM	--	--	--	☐	--	--	--	--	
	SCAN	☐	☐	☐	☐	--	☐	--	☐	
	Flux Measurements	☐	--	--	--	--	☐	☐	☐	
Satellite	AMSR	☐	☐	☐	☐	☐	☐	☐	☐	
	WINDSat	--	☐	☐	☐	☐	☐	☐	☐	
	ASAR Imagery	--	☐	☐	☐	--	☐	☐	☐	
	ASTER	☐	--	--	☐	☐	☐	☐	☐	
	AVHRR	--	☐	☐	☐	--	■	■	☐	
	GOES	☐	☐	☐	☐	--	■	■	☐	
	NDVI/NDWI	☐	☐	☐	☐	--	☐	☐	☐	
	Quickscat	☐	■	■	■	■	■	■	☐	
	SSM/I	☐	☐	☐	☐	☐	■	■	☐	
	TERRA-MODIS	☐	--	--	--	--	☐	☐	☐	
	TM Imagery	☐	■	■	☐	■	☐	☐	☐	
	TMI	--	☐	☐	☐	☐	■	■	--	
Vegetation	Regional	☐	☐	☐	☐	☐	■	■	--	
	Watershed/Transect	☐	--	--	☐	--	--	--	☐	
	MSR/LAI	--	--	--	☐	--	☐	--	☐	
	VWC Maps	☐	☐	☐	☐	--	☐	☐	☐	

Plans

- **Idaho watershed data**
- **Watershed archive**
- **New sites?**
- **SMEX03 archive (ASAP)**
- **SMEX04 special issue of RSE**
- **SMEX04 archive (June 2006)**
- **SMEX05 processing**