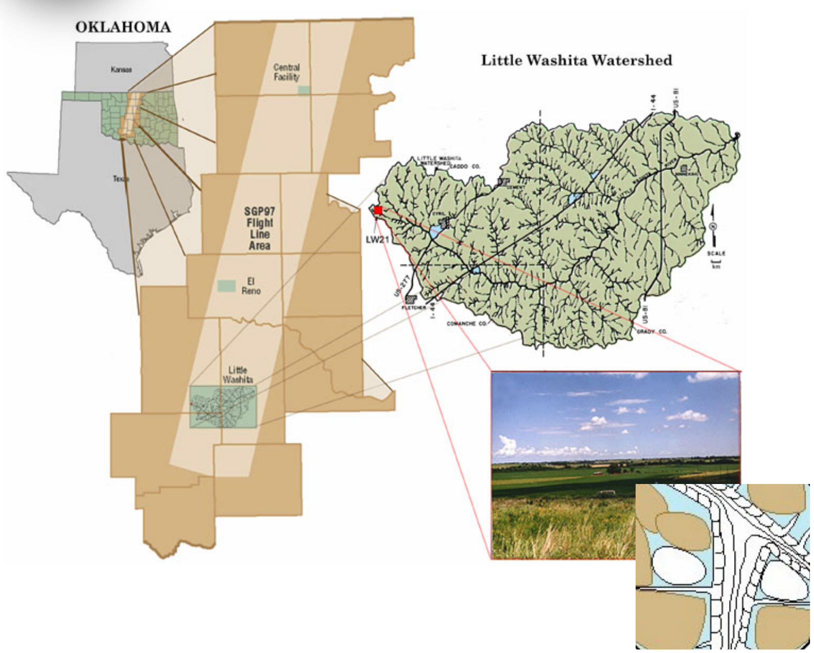
supported by:

Soil Moisture Physical Controls Across Scales



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Champa Joshi
Nandita Gaur
Texas A&M University
SMAP cal/val workshop
May 04, 2011

Overarching Objectives

- **Evaluate the dominant physical controls** (soil properties, vegetation types, topographic indexes, and precipitation intensity/duration) for soil moisture evolution and resultant vadose zone fluxes (evapotranspiration, infiltration, shallow ground water recharge) at different spatial scales (hill-slope, remote sensing footprint, landscape, watershed, region) in the selected hydro-climatic conditions.

- **Develop aggregation/disaggregation rule(s)** for determining scaled soil moisture and "effective" hydrologic parameters (related to the physical control representing the ensemble vadose zone flux behavior) at different spatial scales (hill-slope, remote sensing footprint, landscape, watershed, region) and platforms in the selected watersheds/hydro-climatic regions and test their mutual transferability for SMAP cal/val and various applications.

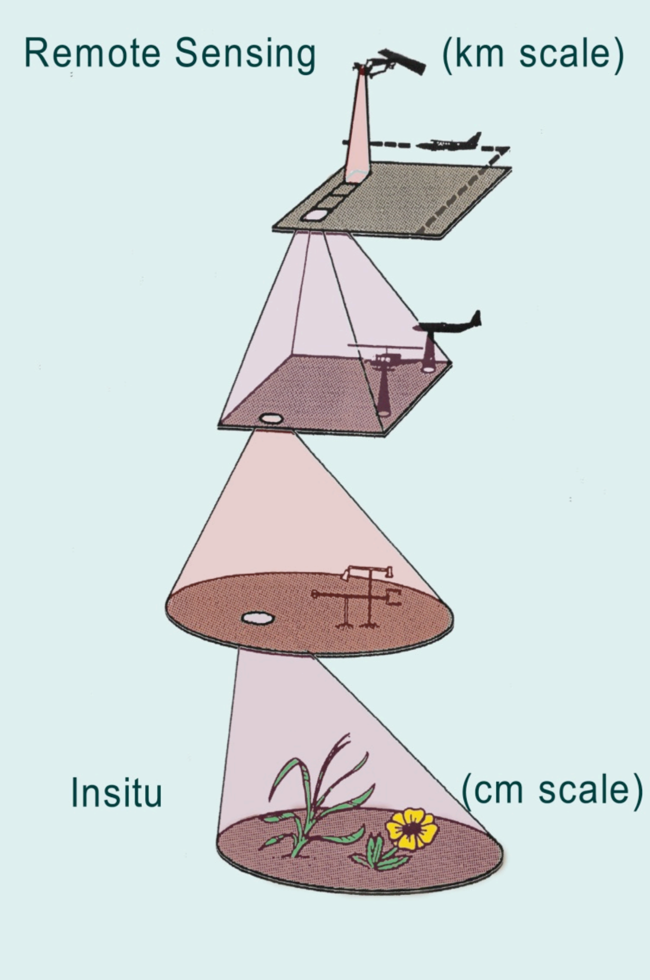
Soil Moisture / Brightness Temperature Measurement Platforms and Scales

Space-borne

Air-borne

Ground-based

In situ



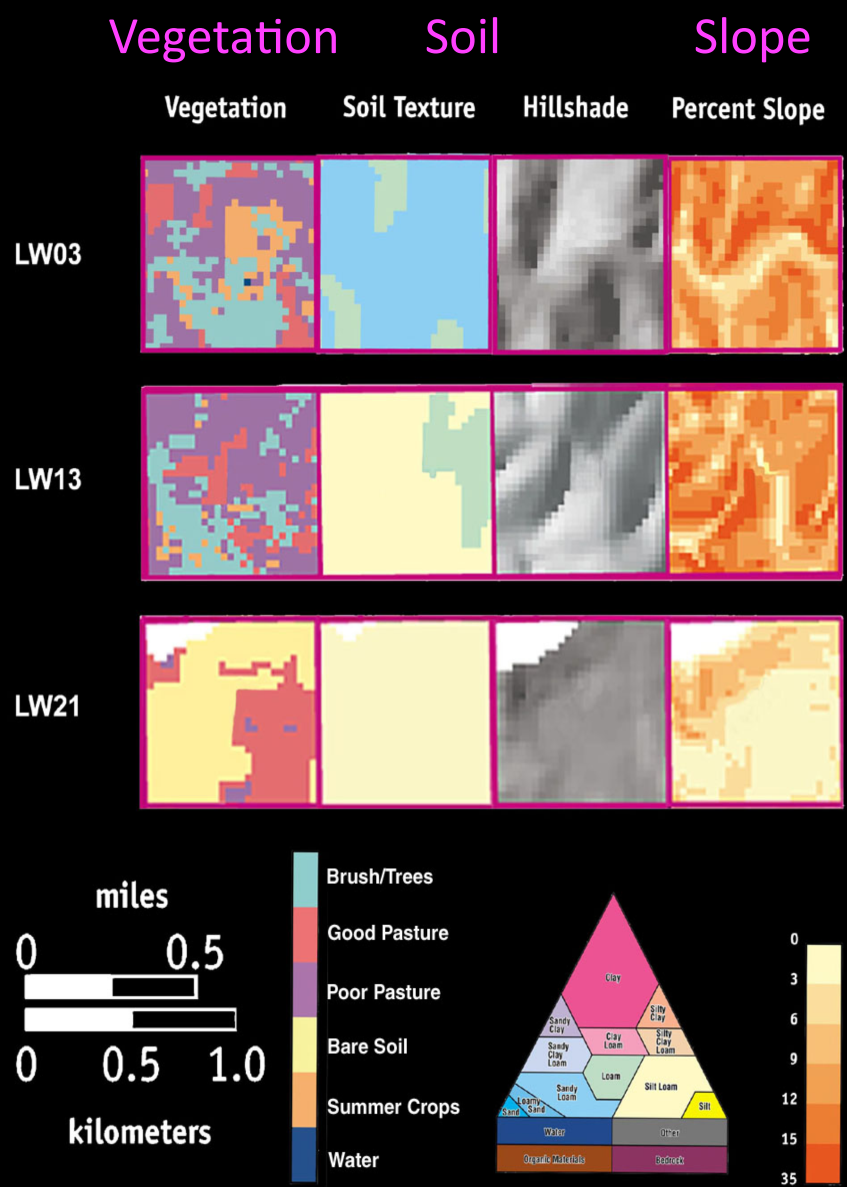
AMSR-E/ SMAP

ESTAR/ PSR

TOWER/ Truck

TDR/ Gravimetric

Soil Moisture & Landscape Heterogeneity

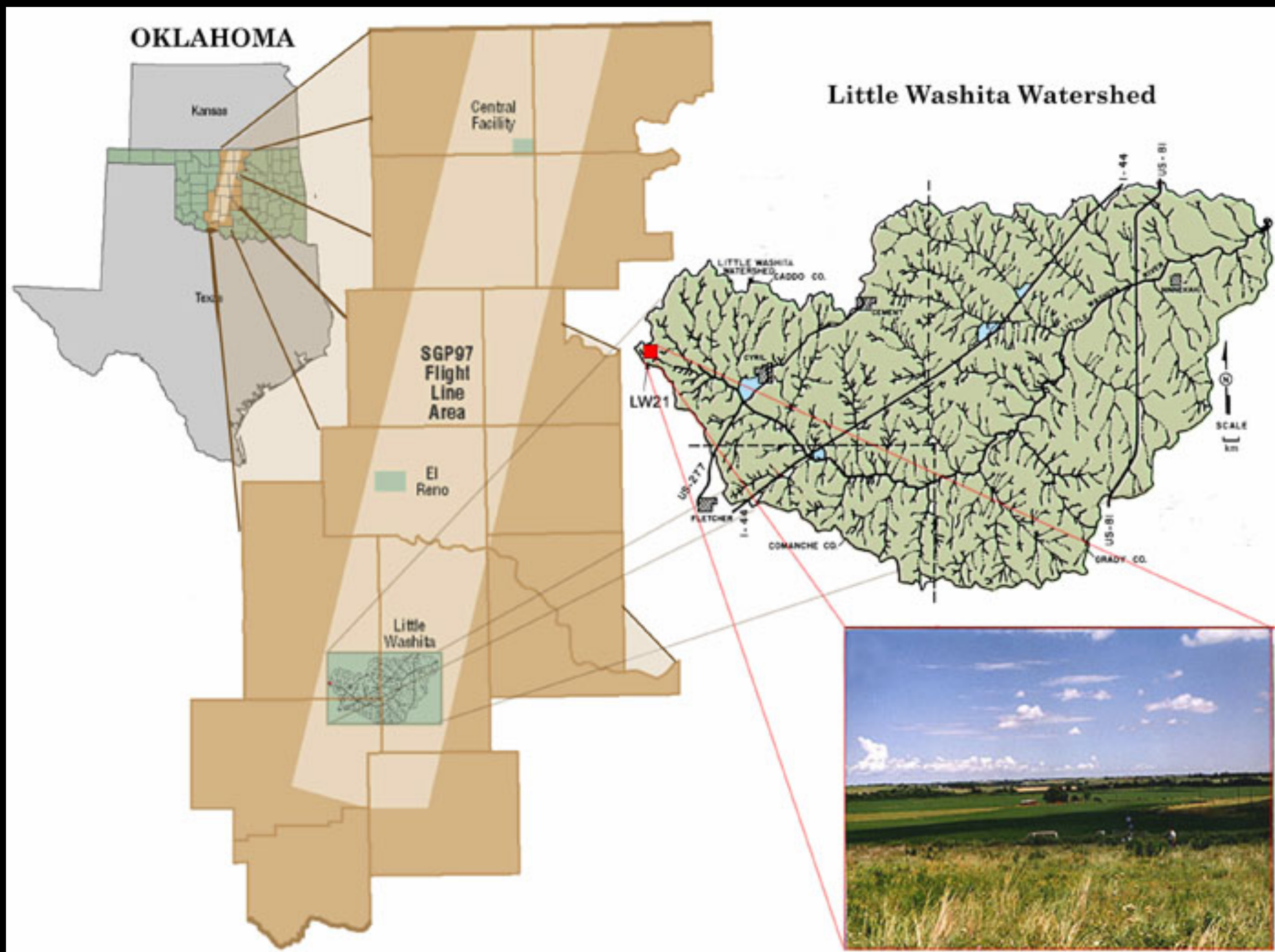


Soil Moisture Physical Controls at Different Scales

Region

Watershed

Field

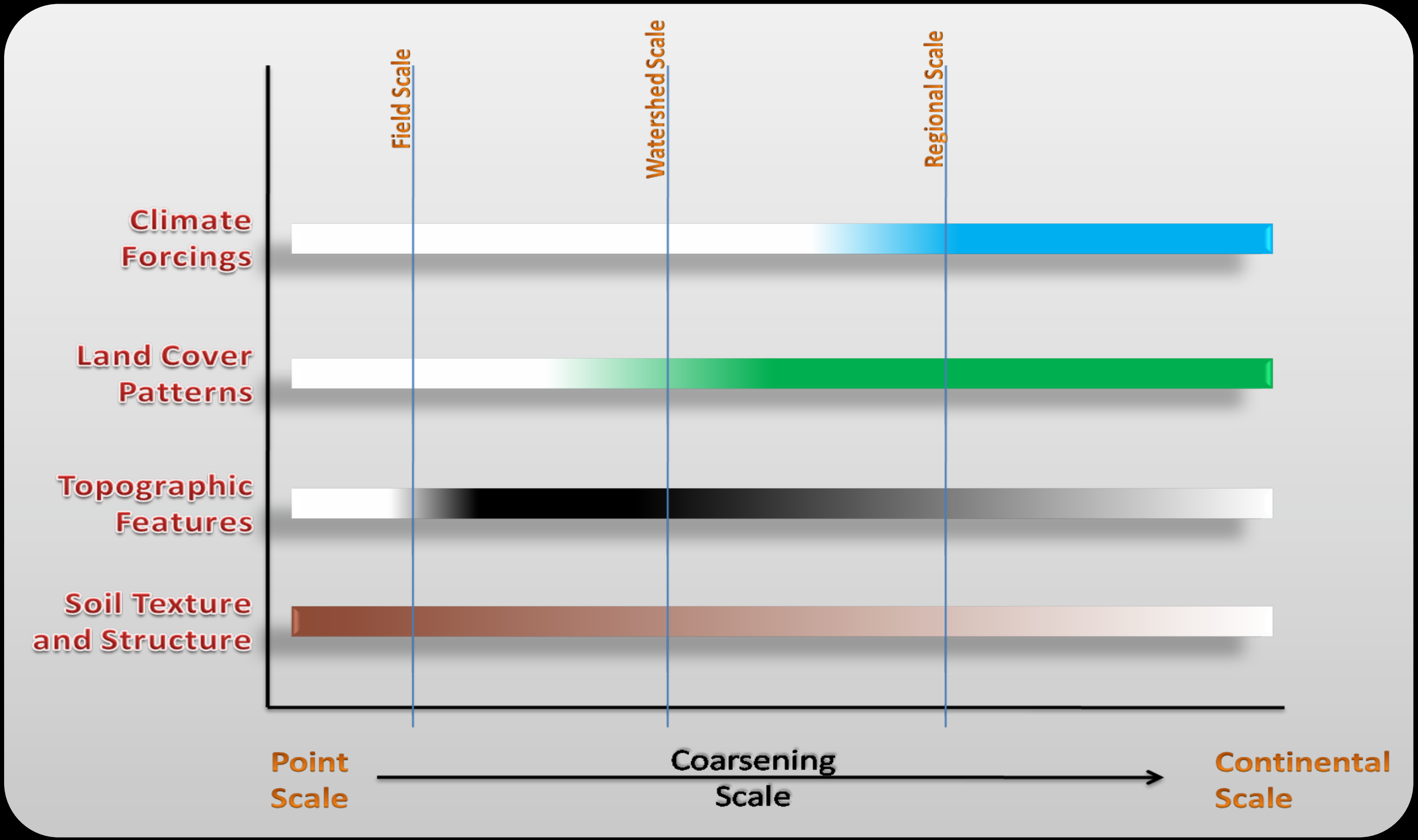


Vegetation/ Precipitation

Topography

Soil

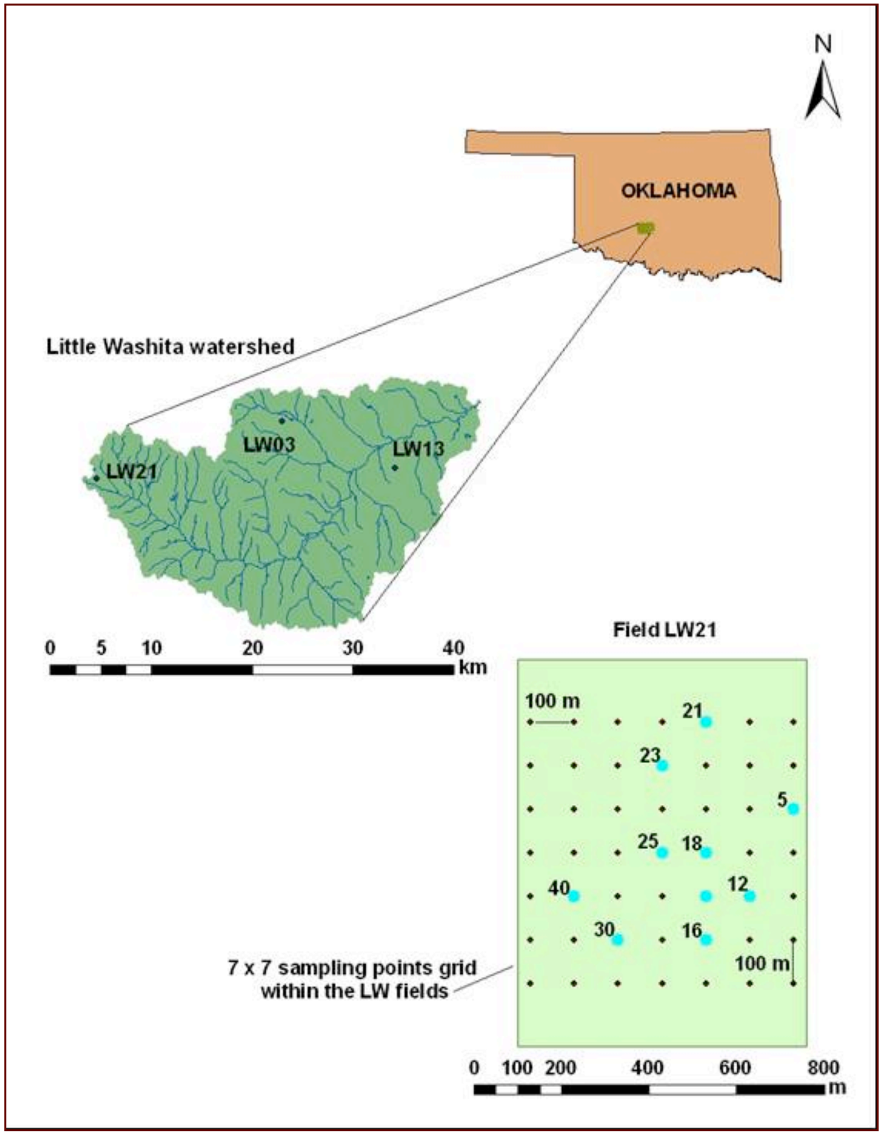
Soil moisture variability is dominated by

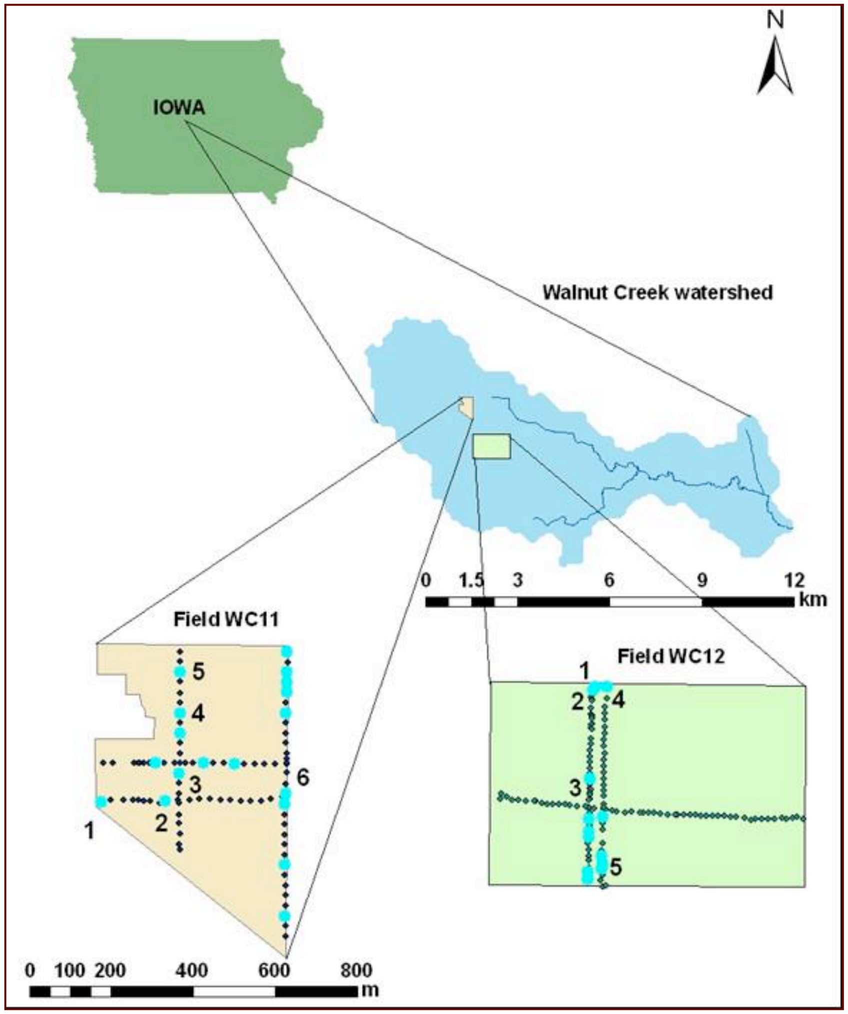


– Modified sampling strategies to better assist development of algorithms for scaling of land surface parameters (e.g., soil hydraulic parameters) and soil moisture state is necessary

Jana and Mohanty, 2010

Study Areas

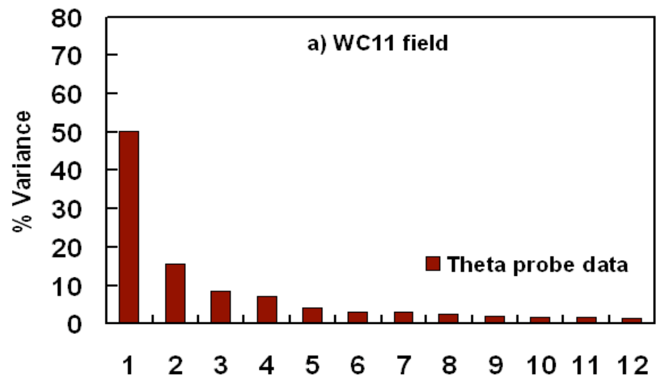


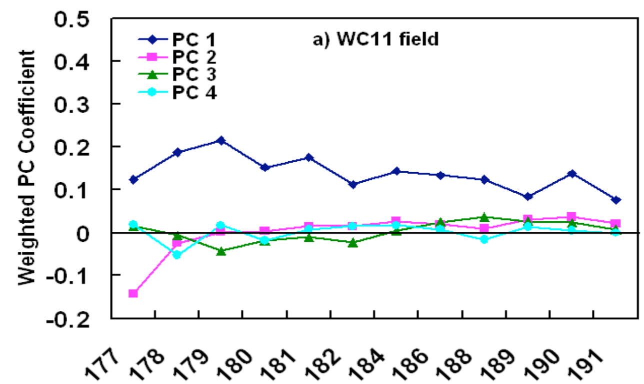


Joshi and Mohanty, 2010 WRR

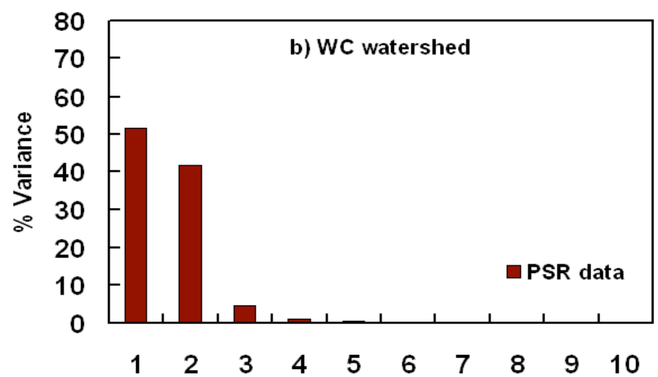
EOF Analyses

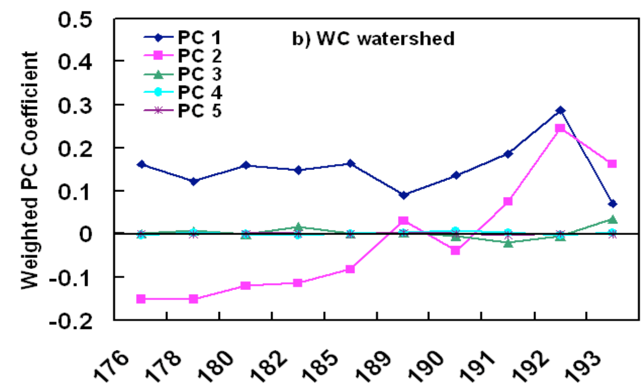
Field-scale



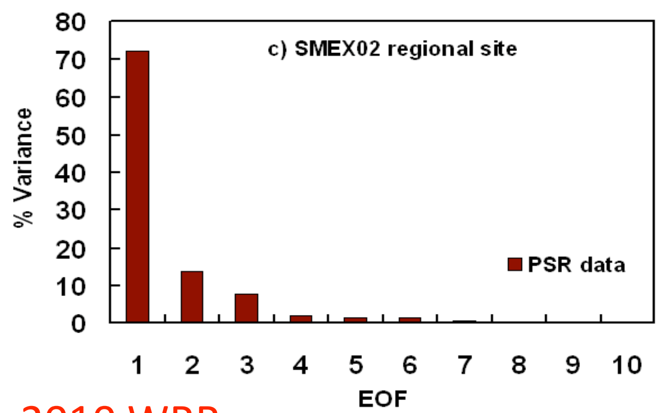


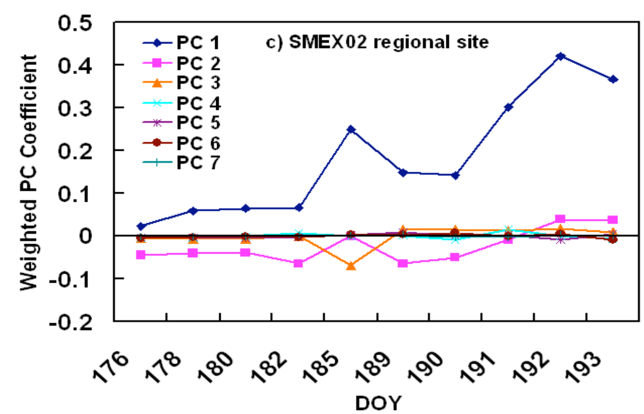
Watershed-scale





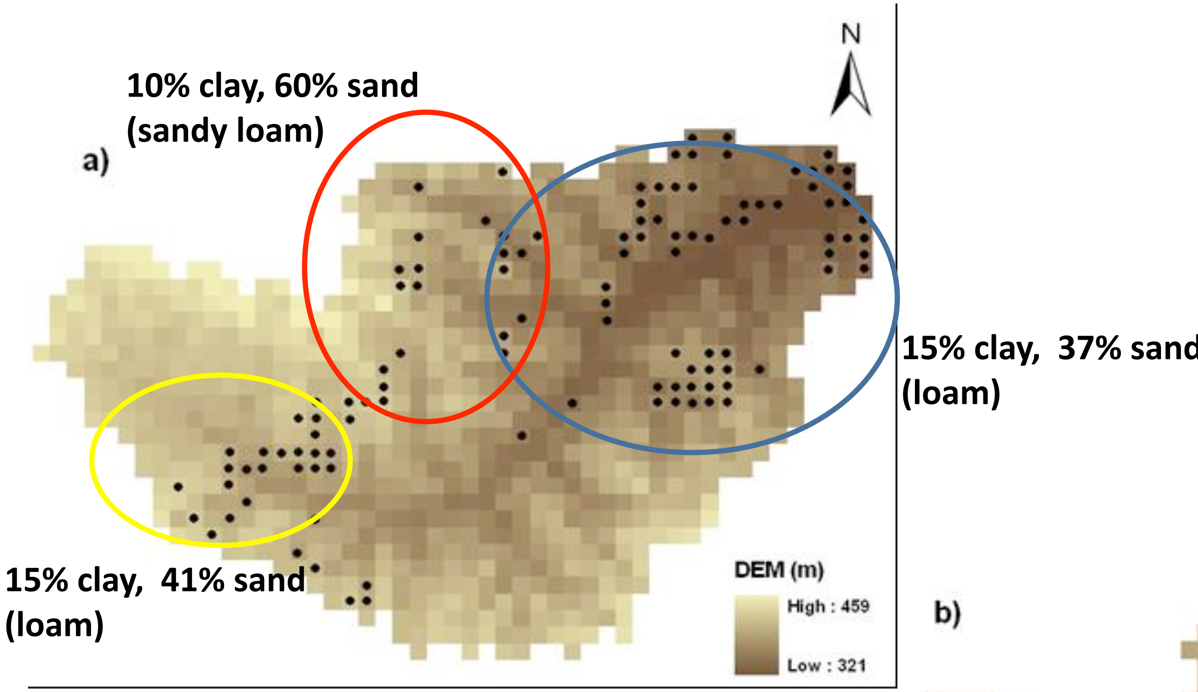
Regional-scale

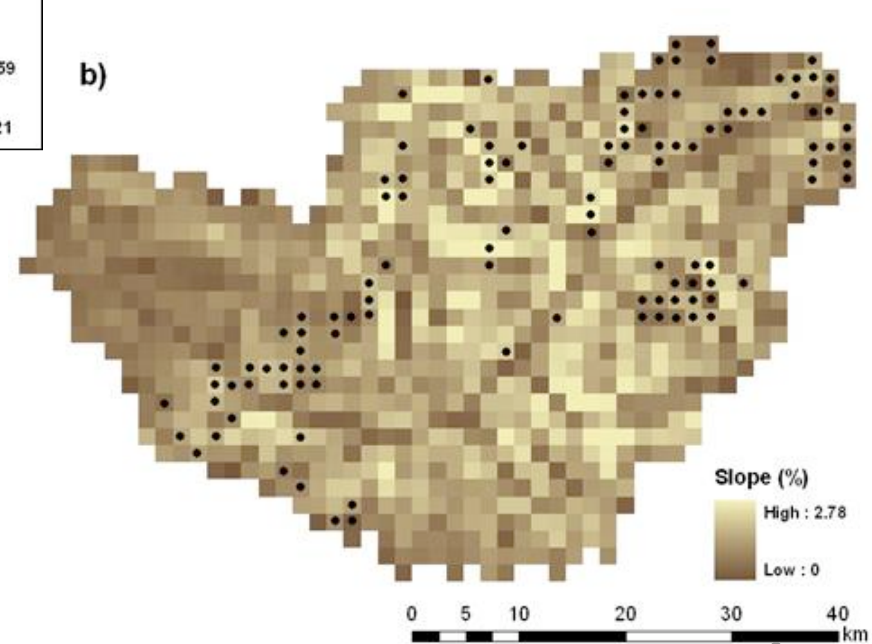




Joshi and Mohanty, 2010 WRR

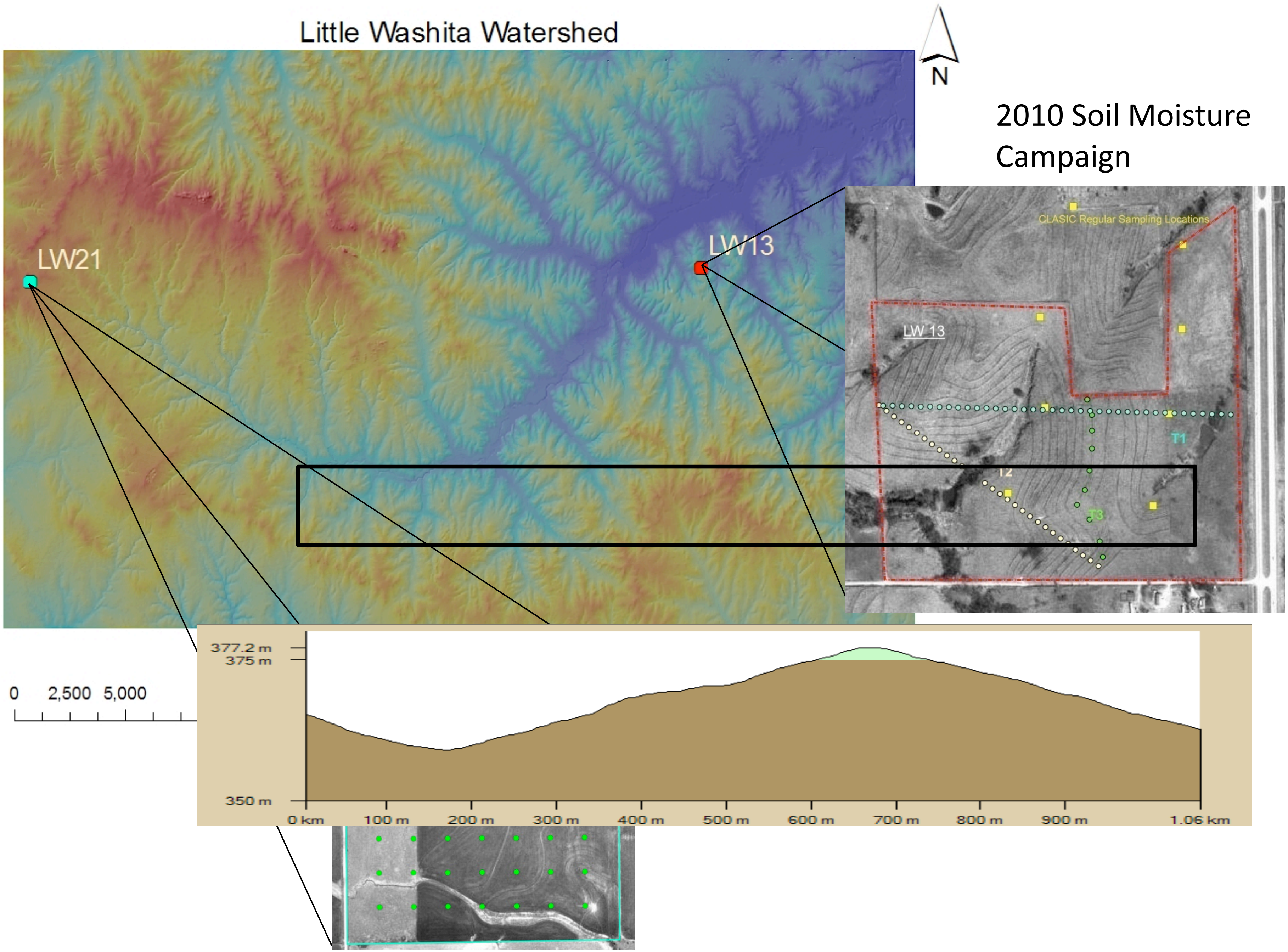
Temporal Stability (Watershed-scale)



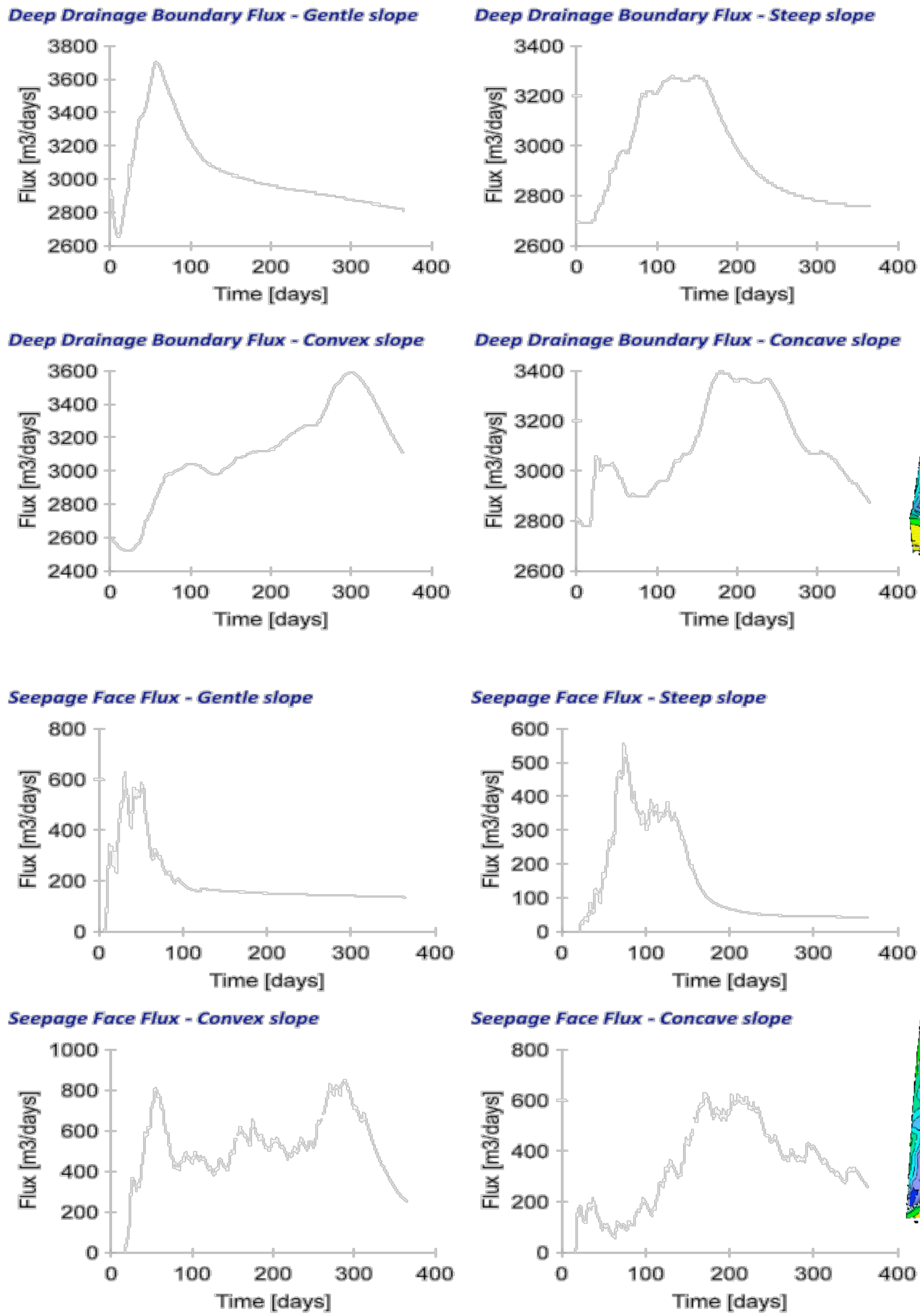


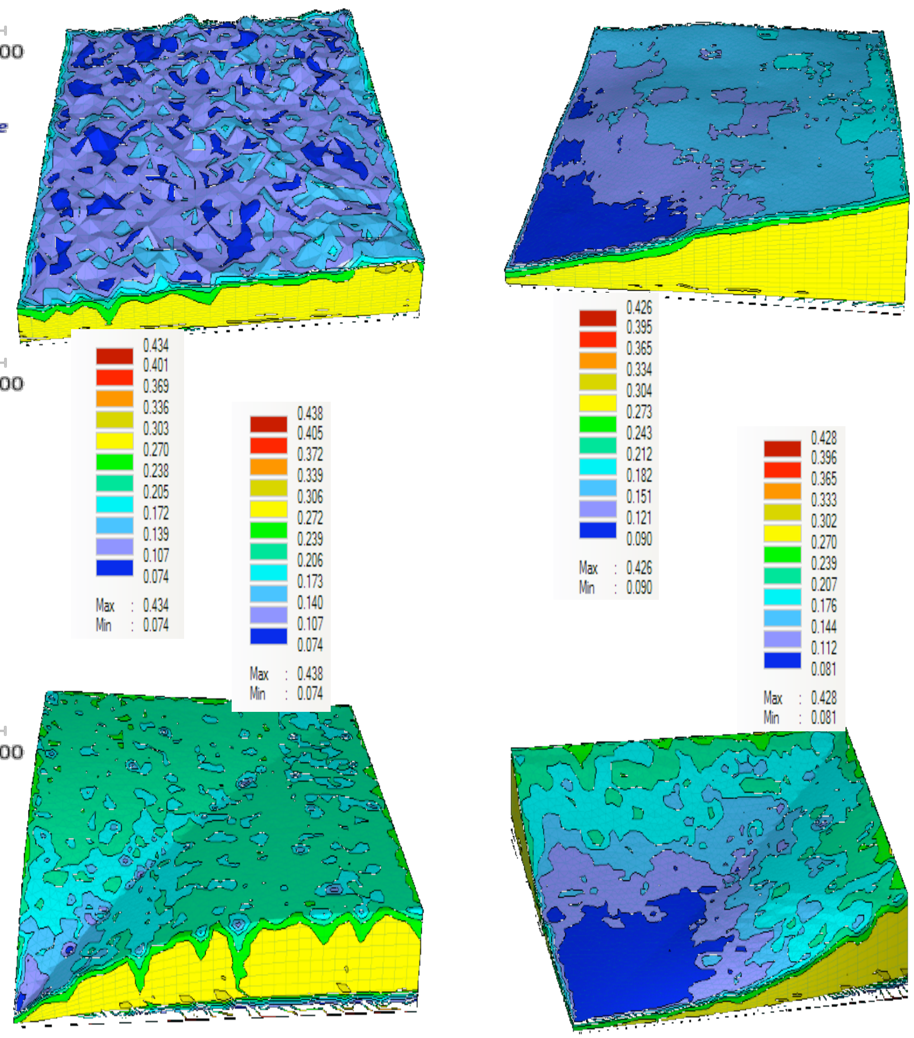
TS footprints (ESTAR) within ± 10% VSM during SGP97 & SGP99 in LW watershed, OK.

Joshi et al, 2011 WRR


Little Washita Watershed
N
2010 Soil Moisture Campaign
LW21
LW13
CLASIC Regular Sampling Locations
LW 13
T1
T2
T3
0 2,500 5,000
377.2 m
375 m
350 m
0 km
100 m
200 m
300 m
400 m
500 m
600 m
700 m
800 m
900 m
1.06 km

Topographic Control





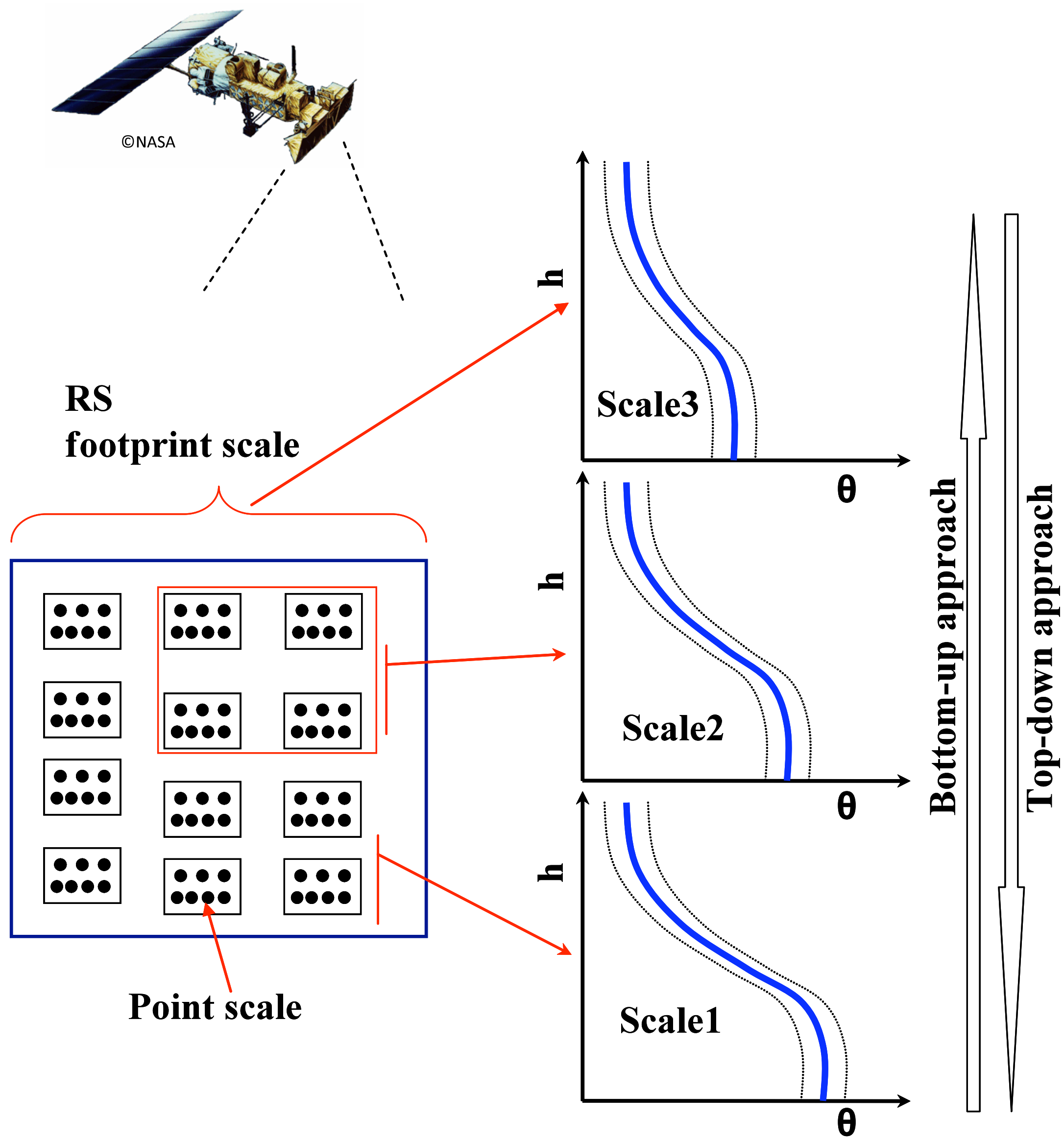
Jana and Mohanty, 2010

Effective Root Zone Soil Hydraulic Functions at Multiple Scales

Using the information content of the soil moisture data collected at that particular SCALE, we can estimate the scale dependent soil hydraulic properties

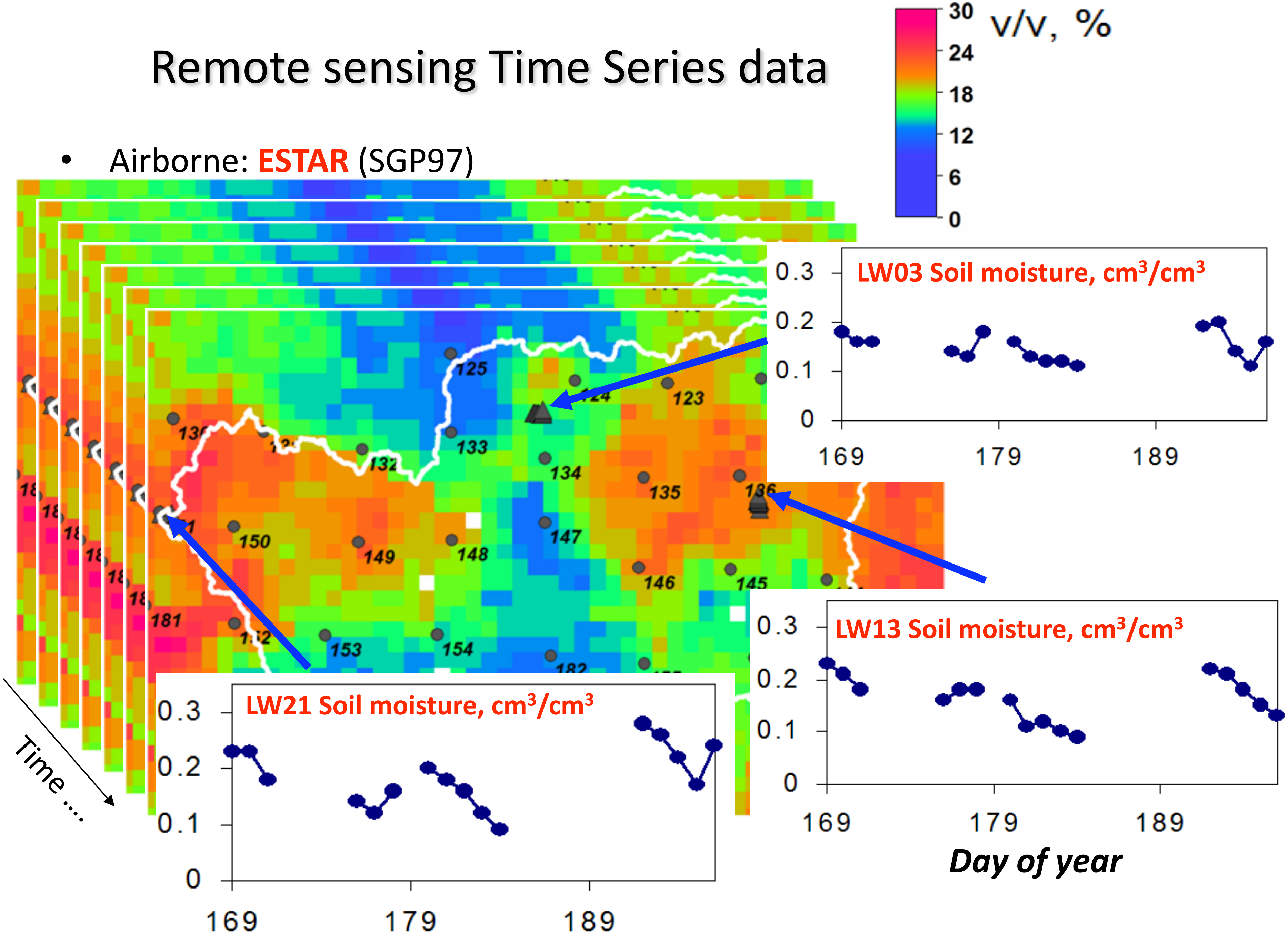
$$S_e = \frac{\theta(h)-\theta_{res}}{\theta_{sat}-\theta_{res}} = \left[\frac{1}{1+|\alpha h|^n}\right]^m$$

$$K(h)=K_{sat}S_e^{\lambda}\left[1-\left(1-S_e^{1/m}\right)^m\right]^2$$

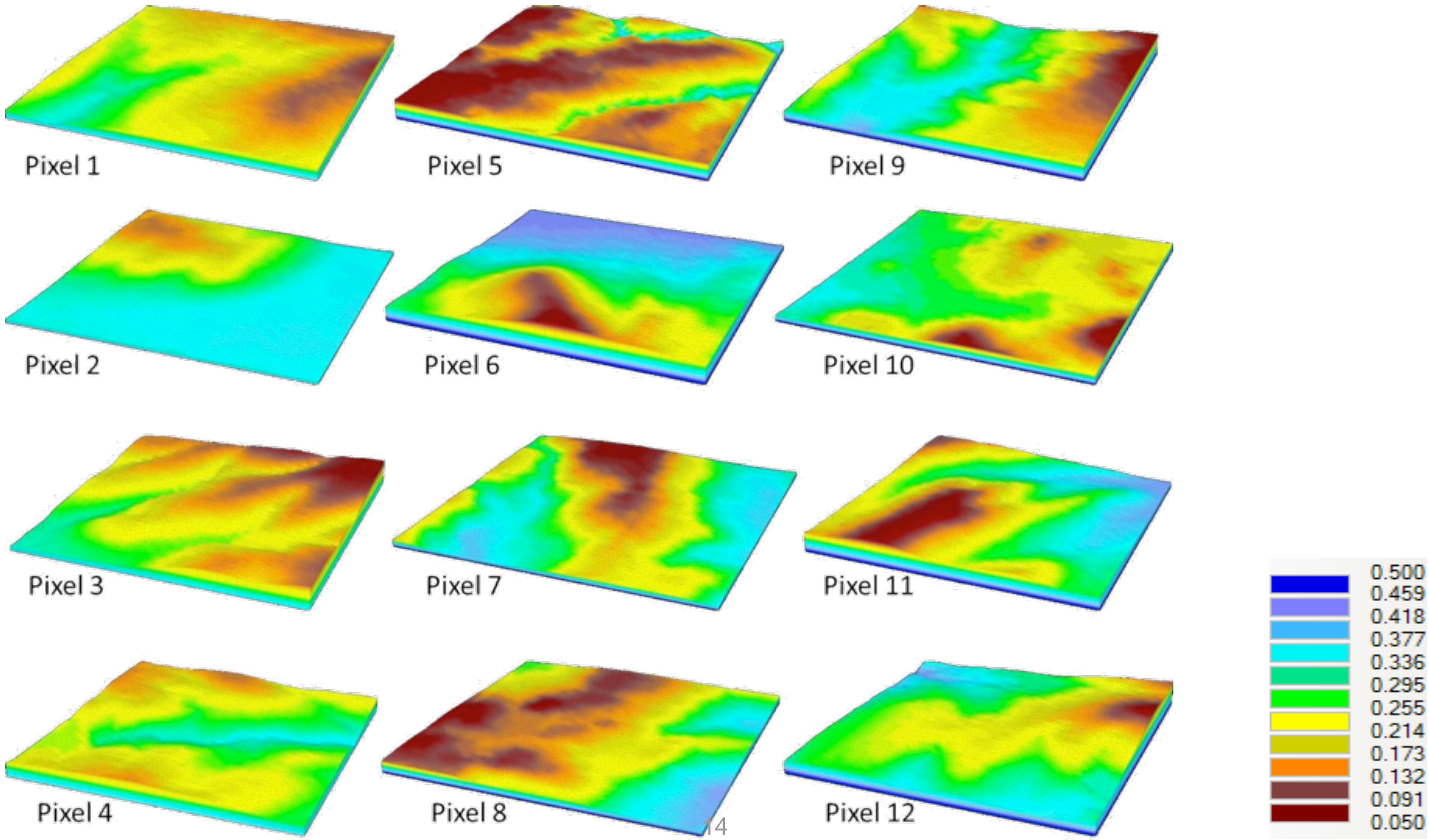


Remote sensing Time Series data

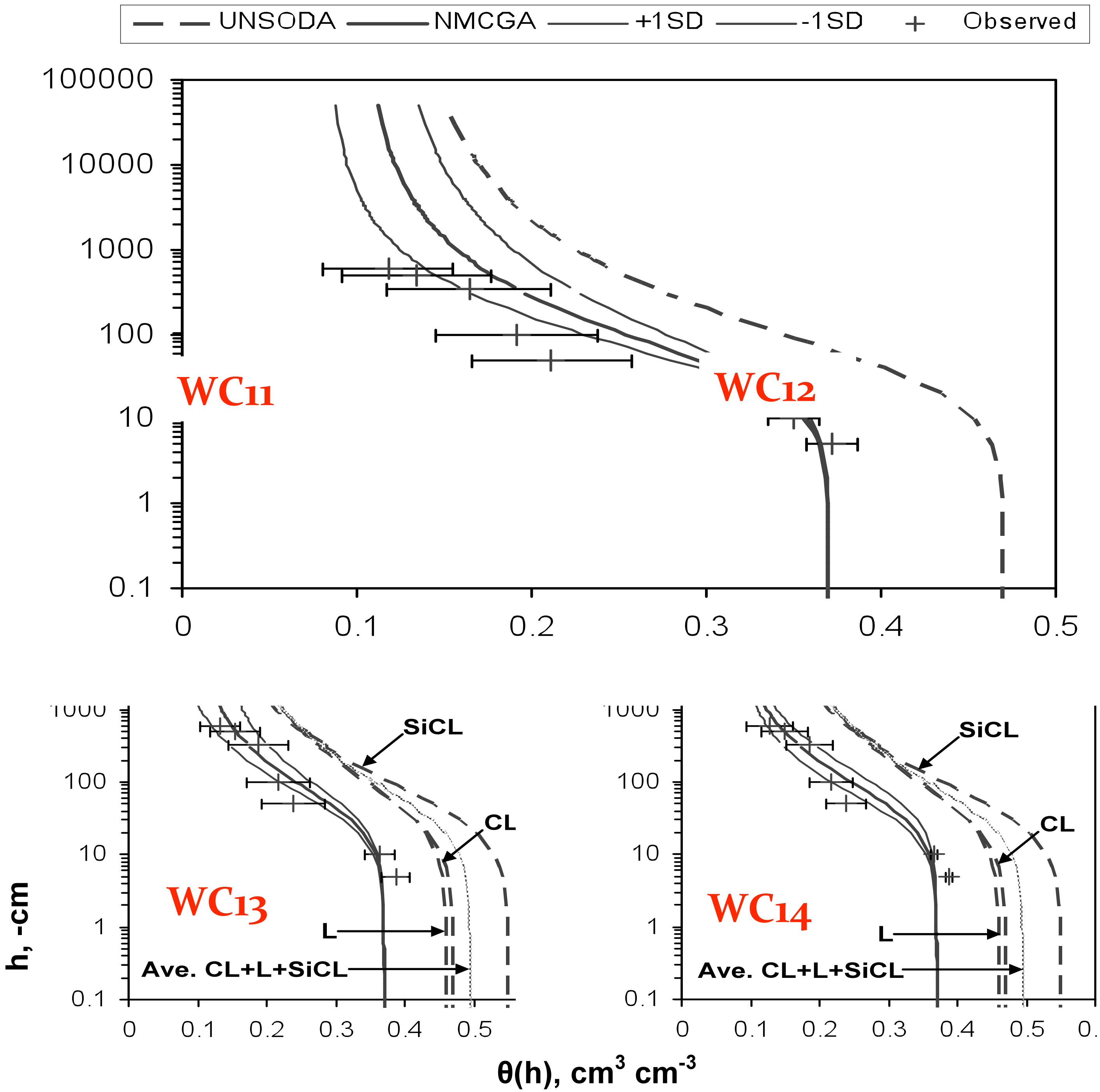
- Airborne: **ESTAR** (SGP97)



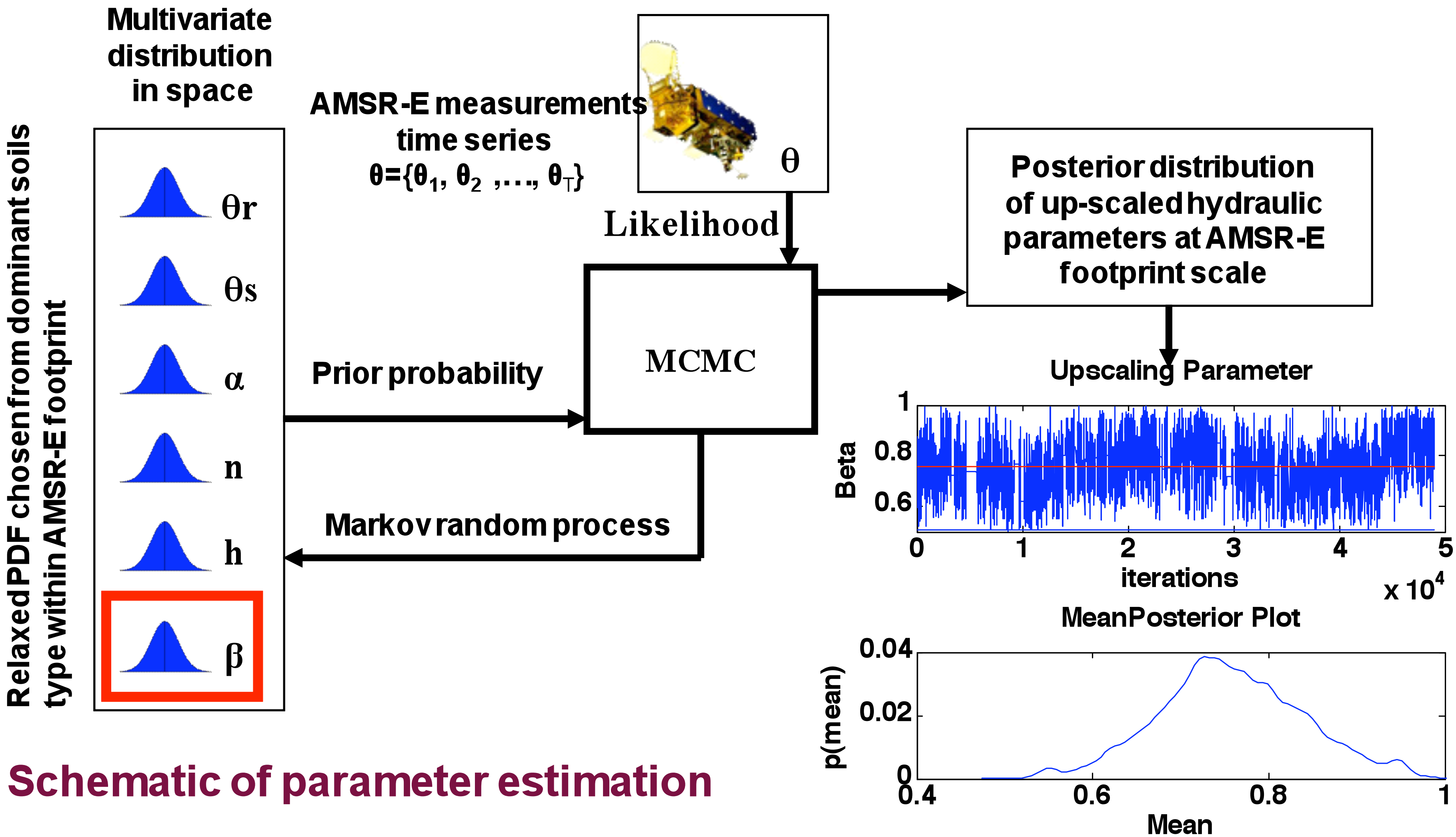
Pixels Selected for Analysis



Air-borne RS scale (Polarimetric Scanning Radiometer: PSR)



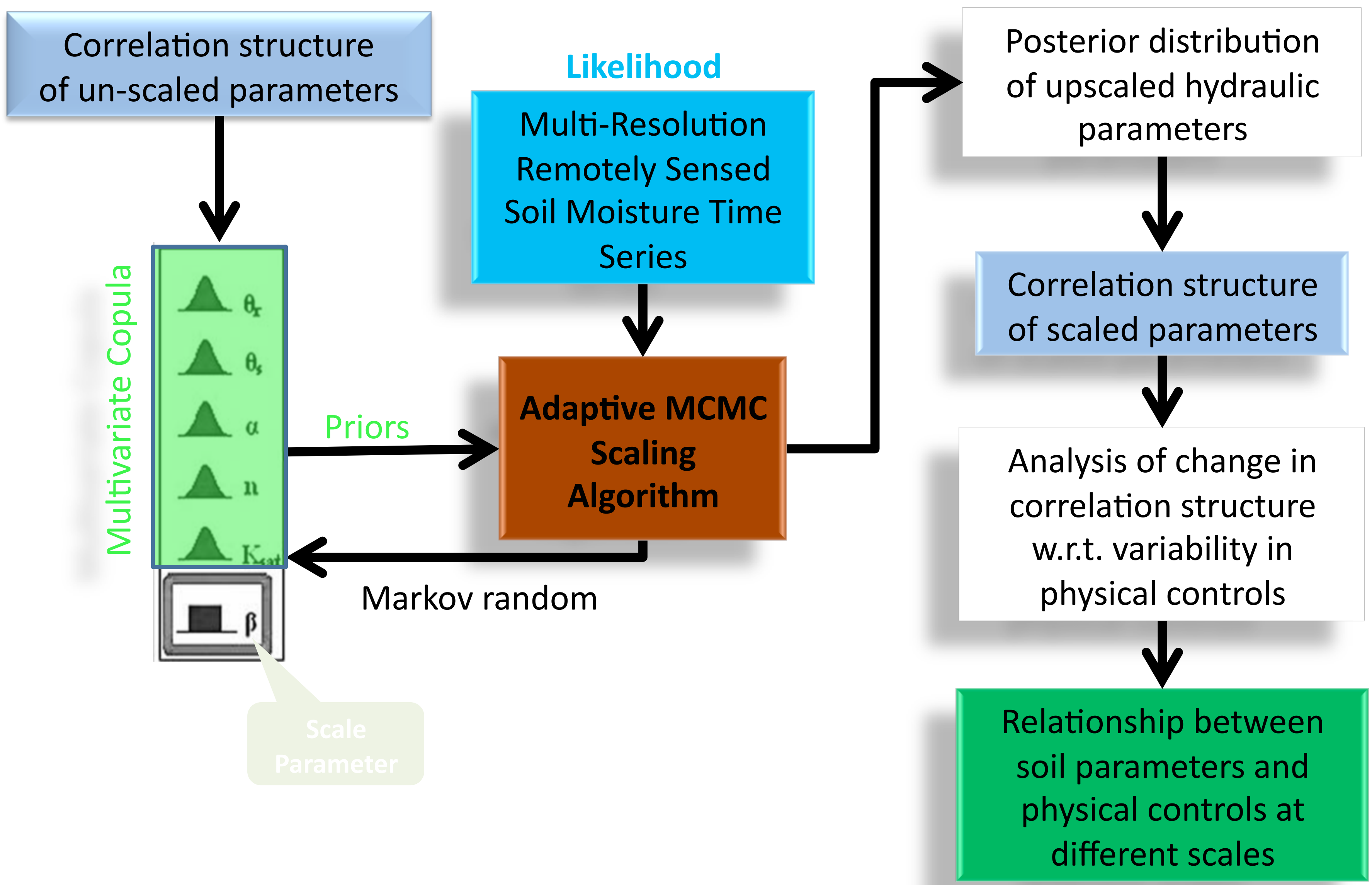
Markov Chain Monte Carlo approach



Schematic of parameter estimation

Das et al., 2008 WRR

MCMC Scaling Algorithm

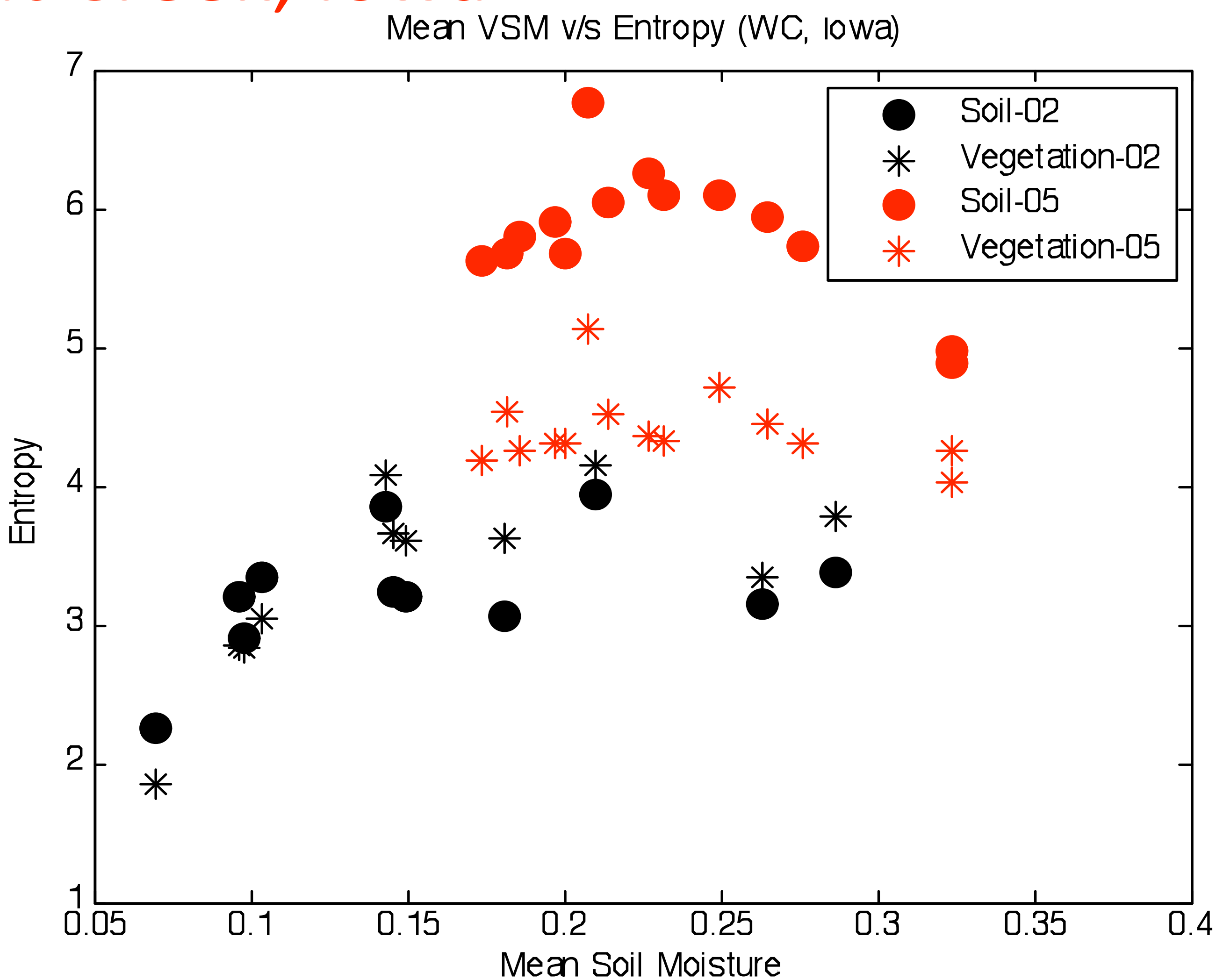


Entropy

- Shannon Entropy- Also known as informational entropy
- Concept- Higher the entropy of a random variable, higher the 'information content'
- Maximum entropy = Maximum uncertainty

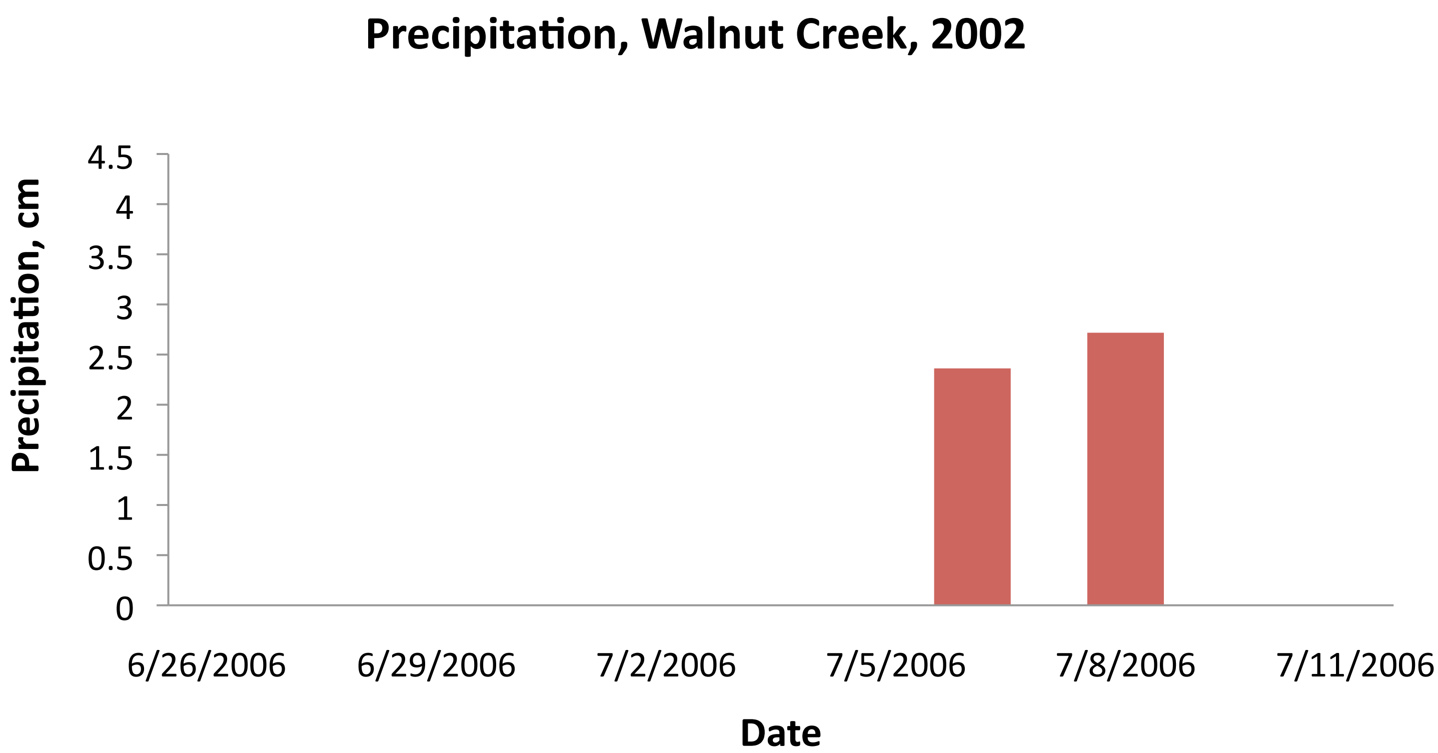
$$H(p_1, p_2, ...p_N) = -\sum_{i=1}^{N} p_i \log_2 p_i \quad , \qquad \text{where} \qquad \sum_{i=1}^{N} p_i = 1$$

Walnut Creek, Iowa



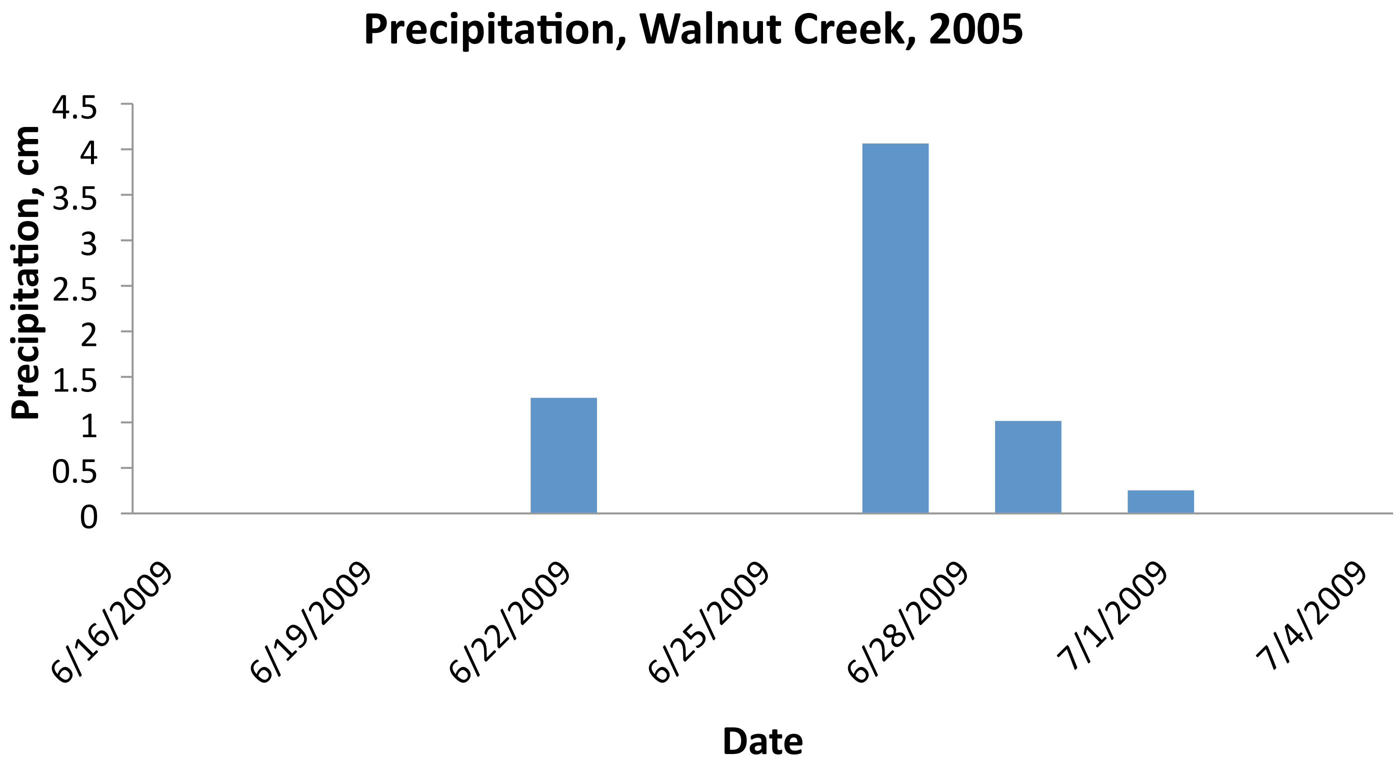
Walnut Creek Watershed

Precipitation, 2002



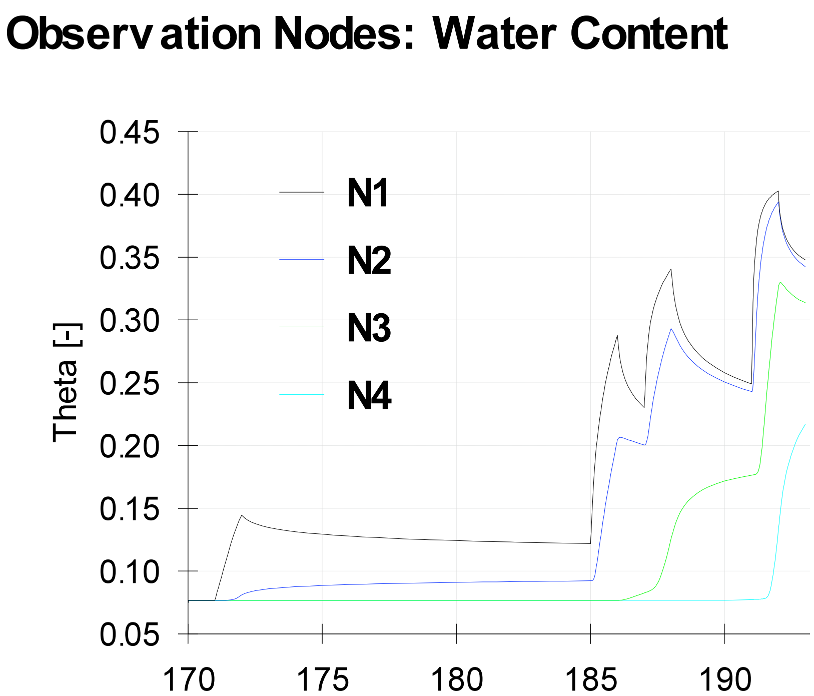
Total Precipitation = 5.077 cm

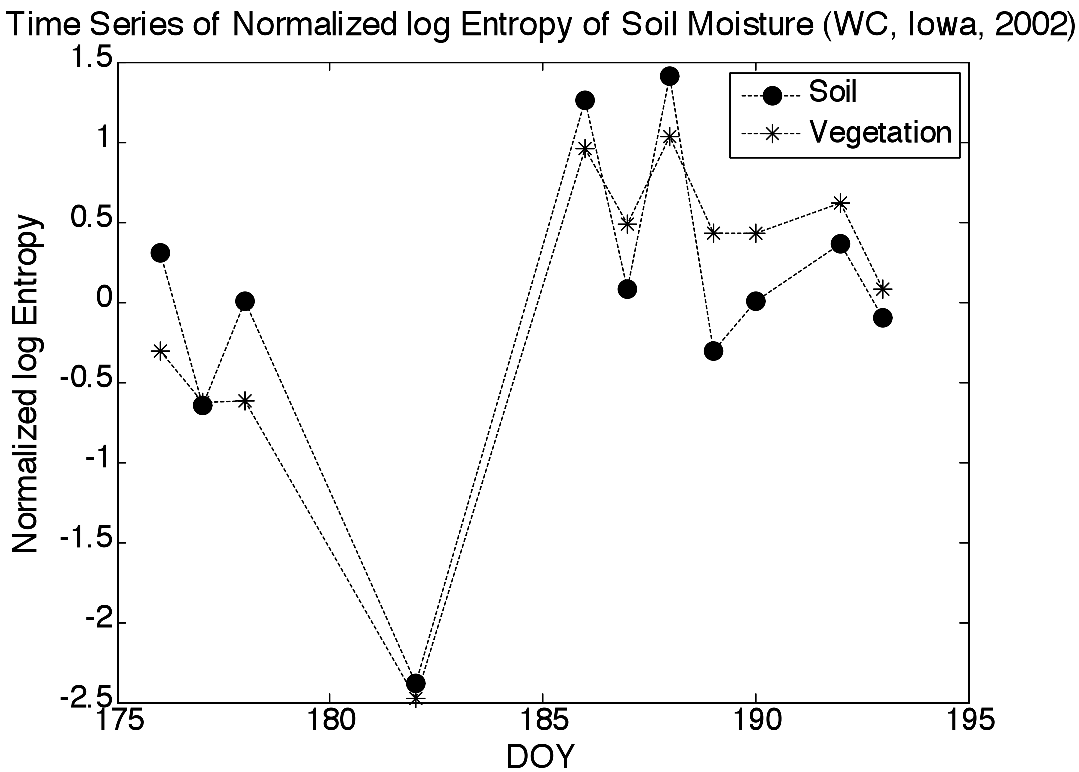
Precipitation, 2005



Total Precipitation = 6.6 cm

Time Series of Entropy

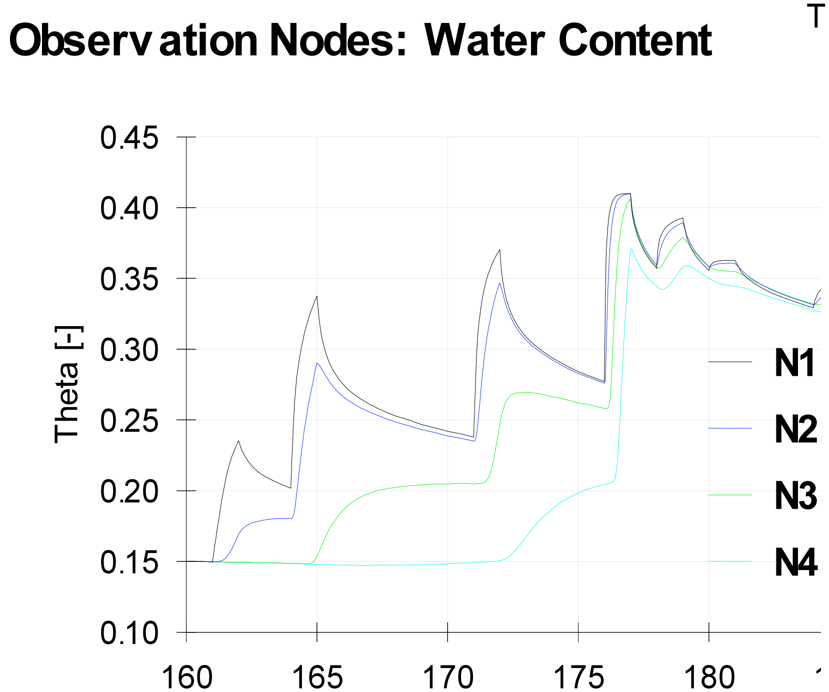


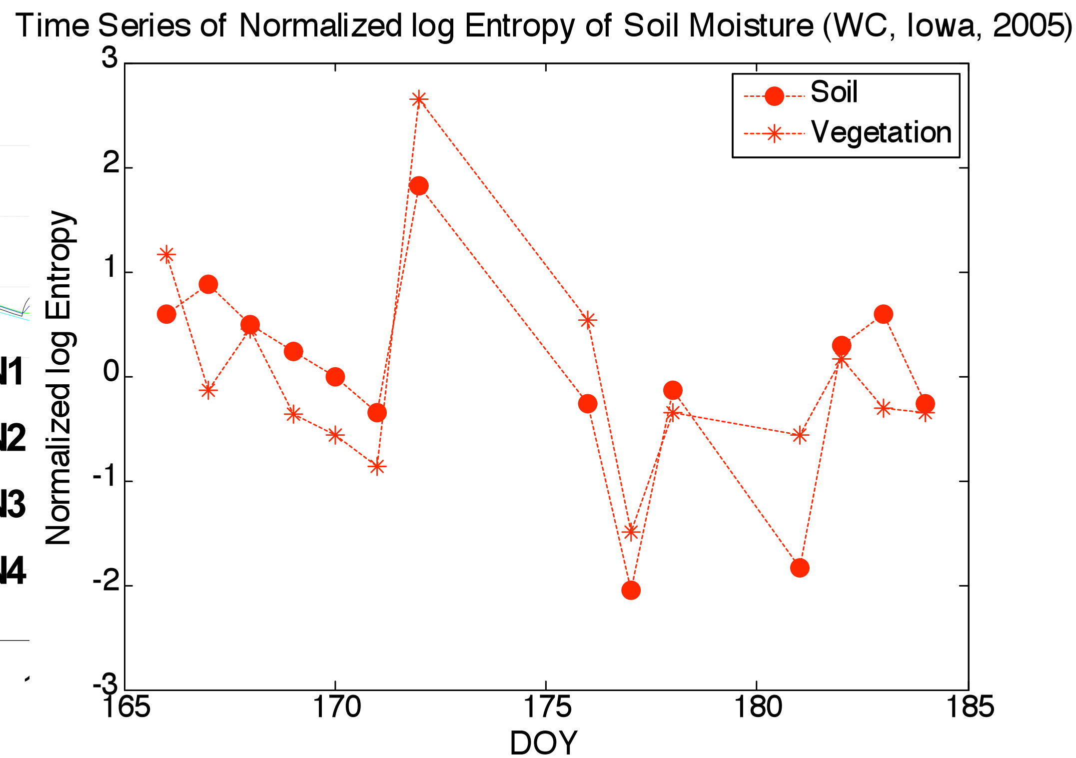


N1 – surface
N2 – 4 cm (Theta Probe Reading)
N3 – 12 cm (Max density of roots, starting point)
N4 – 20 cm

SMEX 02

Time Series of Entropy





N1 – surface

N2 – 4 cm (Theta Probe Reading)

N3 – 12 cm (Max density of roots, starting point)

N4 – 20 cm

Evolution of physical controls

- *Iowa:*

  - Soil type and Vegetation were 'equally' heterogeneous

  - Higher root zone soil moisture leads to reduced effect of vegetation on surface soil moisture

  - Towards saturation of all layers competing dominance of vegetation and soil moisture

  - Entropy of surface soil moisture may serve as an indicator of root zone soil moisture status

Ongoing work!

- Analyze across different hydro-climatic regions in USA and worldwide
  - w.r.t. soil, topography, vegetation,

    climatic patterns