COSMOS Rover Measurements in SMAPVEX11

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COSMOS rover

- Detectors:
  - Four ^{3}He-filled proportional counters (LND, Inc. and GE, Inc.)
  - Moderated by 2.5 cm thick polyethylene
  - Interfaced by neutron pulse modules (Q-NPM-1000, Questa Instruments, LLC)
- Logger:
  - Q-DL-2100 (Questa Instruments, LLC)
  - Integrated barometric pressure sensor
  - Integrated GPS receiver
  - SDI-12 communications
  - Removable SD card
  - Set to one minute integration and output

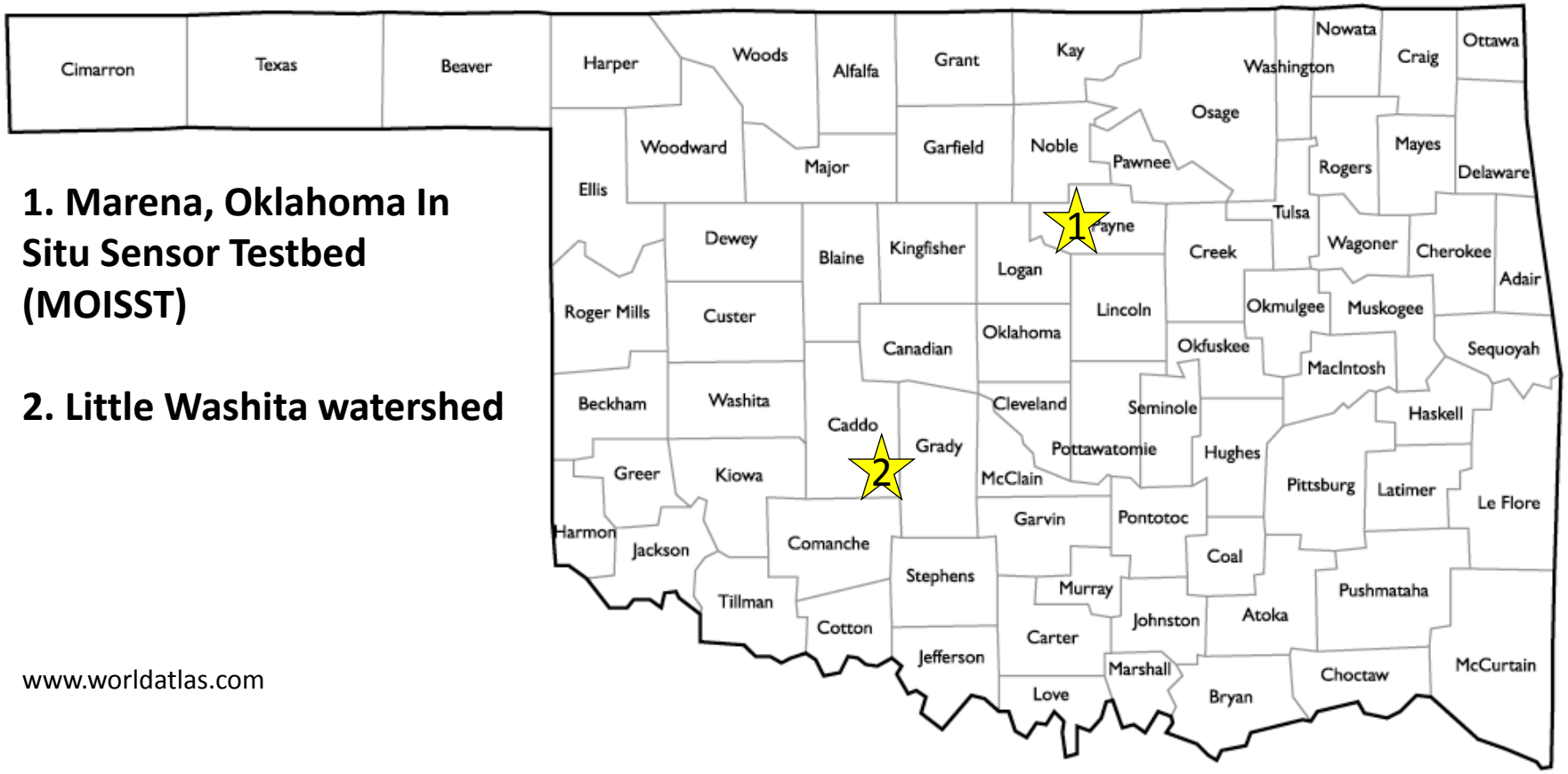
Research Questions

- How efficiently can the rover be calibrated in a footprint with heterogeneous soils and vegetation?
- How does the accuracy of the COSMOS rover compare with that required for satellite cal/val?
- What are the relationships between soil moisture patterns observed with COSMOS and those observed with the PALS instrument?

SMAP Validation Experiment 2011 (SMAPVEX11)

1. Marena, Oklahoma In Situ Sensor Testbed (MOISST)

2. Little Washita watershed



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COSMOS rover calibration method

- Raw count rates normalized to a reference pressure, P_0, of 972 mbar using an exponential model with attenuation coefficient, β, 0.0077 $mbar^{-1}$.

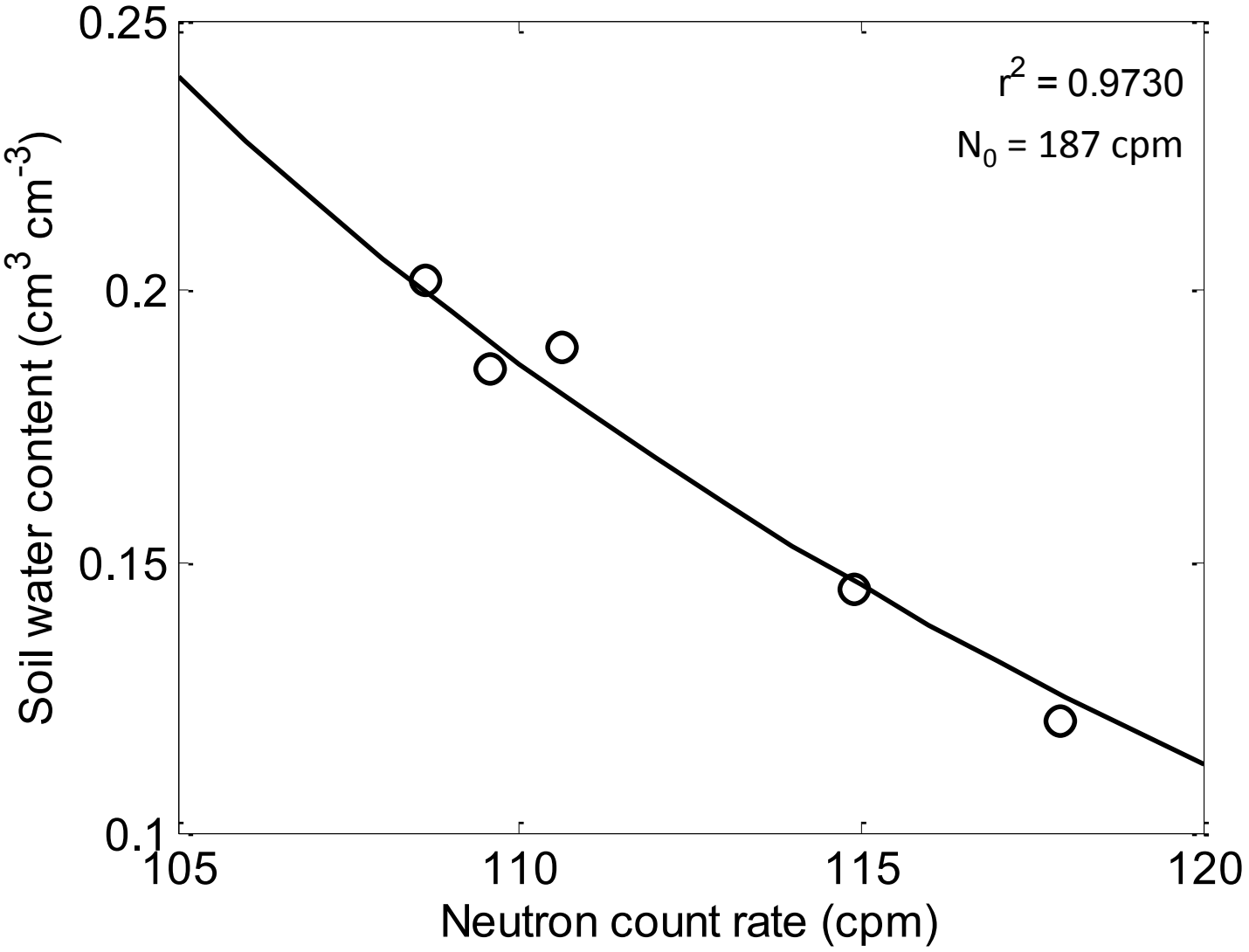
- Sum of normalized count rates from detectors 1 and 2 (*N*) calibrated to ground truth soil moisture on June 3 (5 fields) by the following equation with one fitting parameter (N_0):

$$\theta = \frac{0.808}{\left(\frac{N}{N_0}\right) - 0.372} - \left(0.115 + \theta_{lat}\right)$$

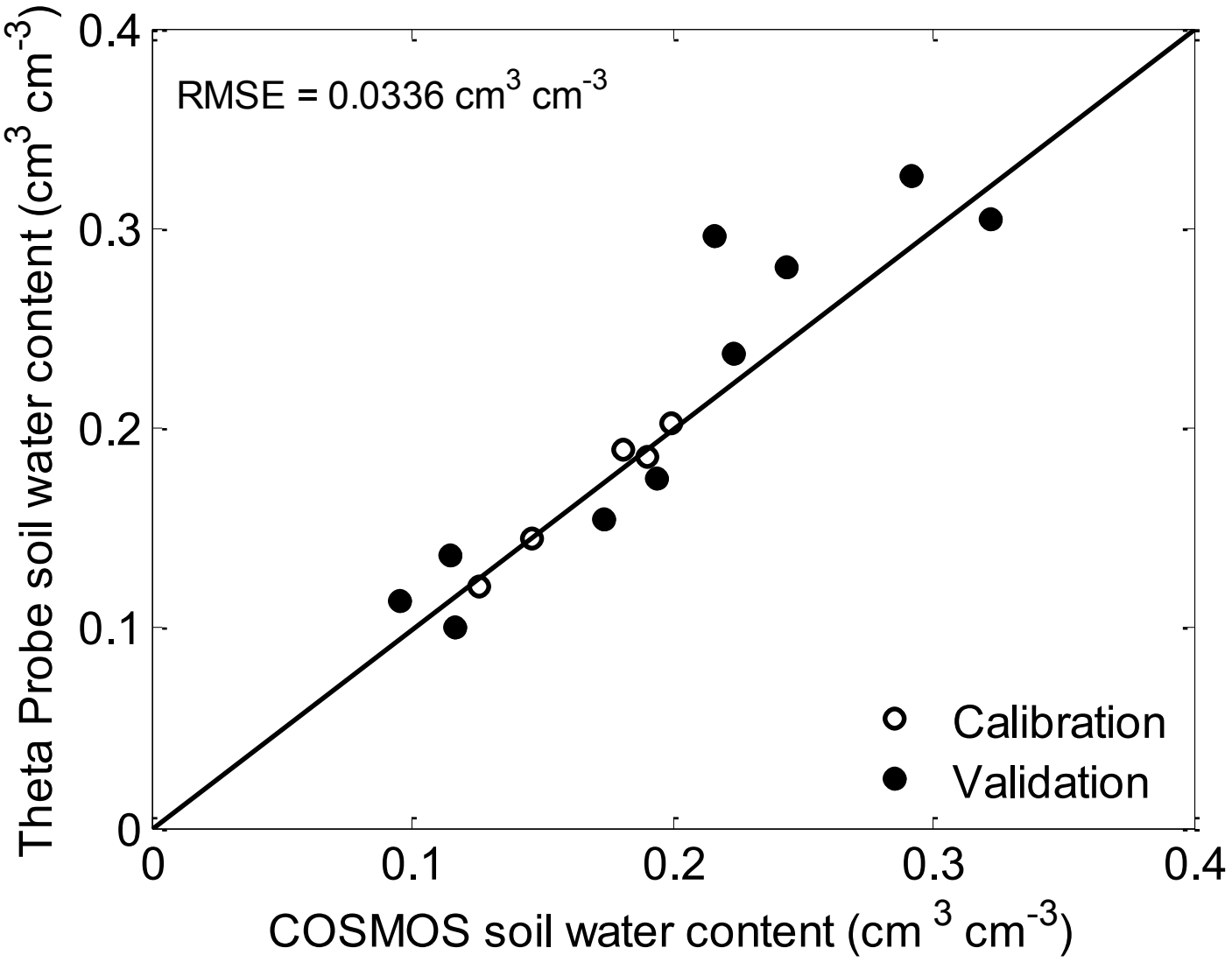
- "Lattice" water content, θ_{lat},set to 0.072 $cm^3\ cm^{-3}$ for MOISST

Target Fields

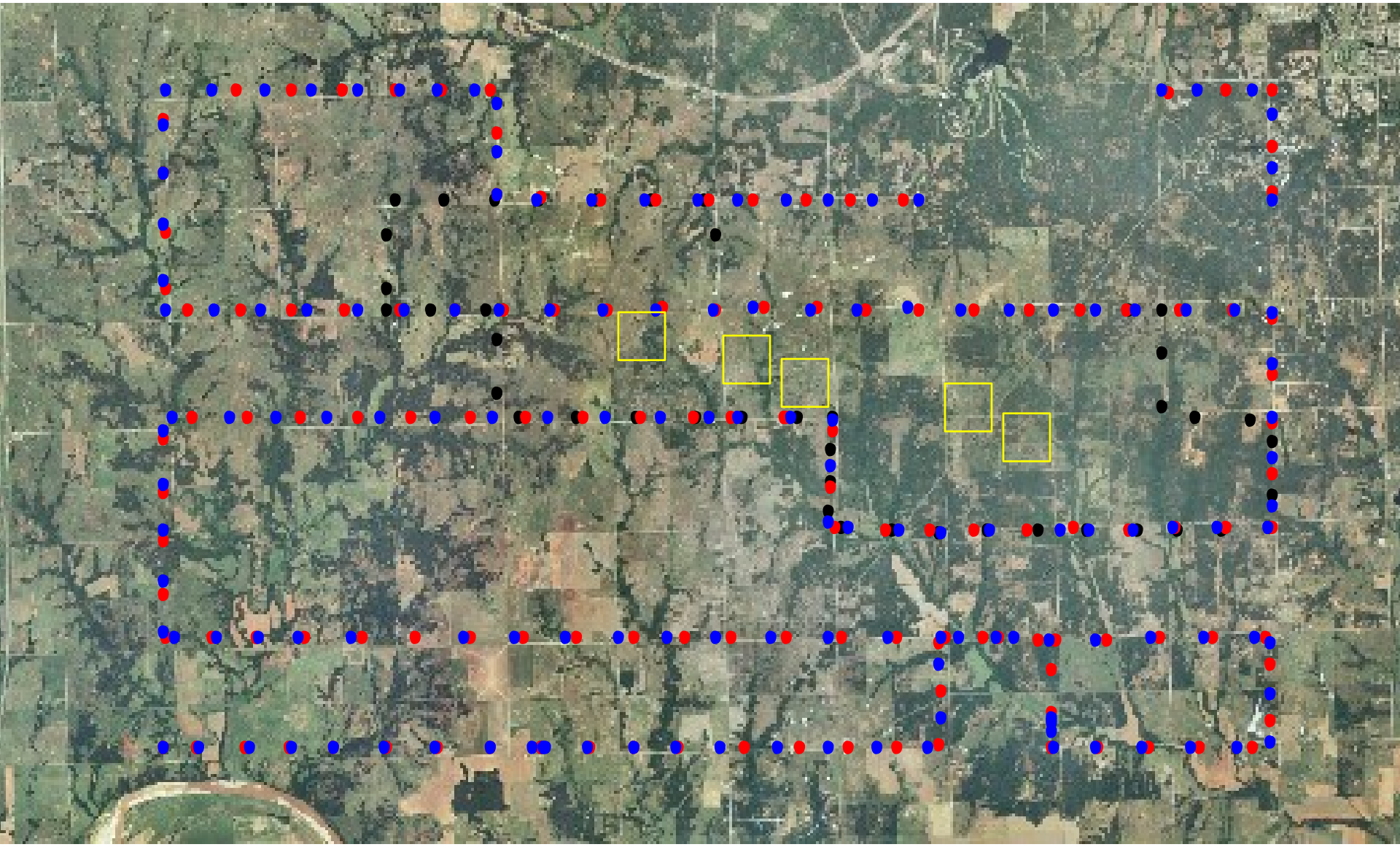
COSMOS rover calibration (stationary)



COSMOS rover validation (stationary)



MOISST Surveys, 16x10 km

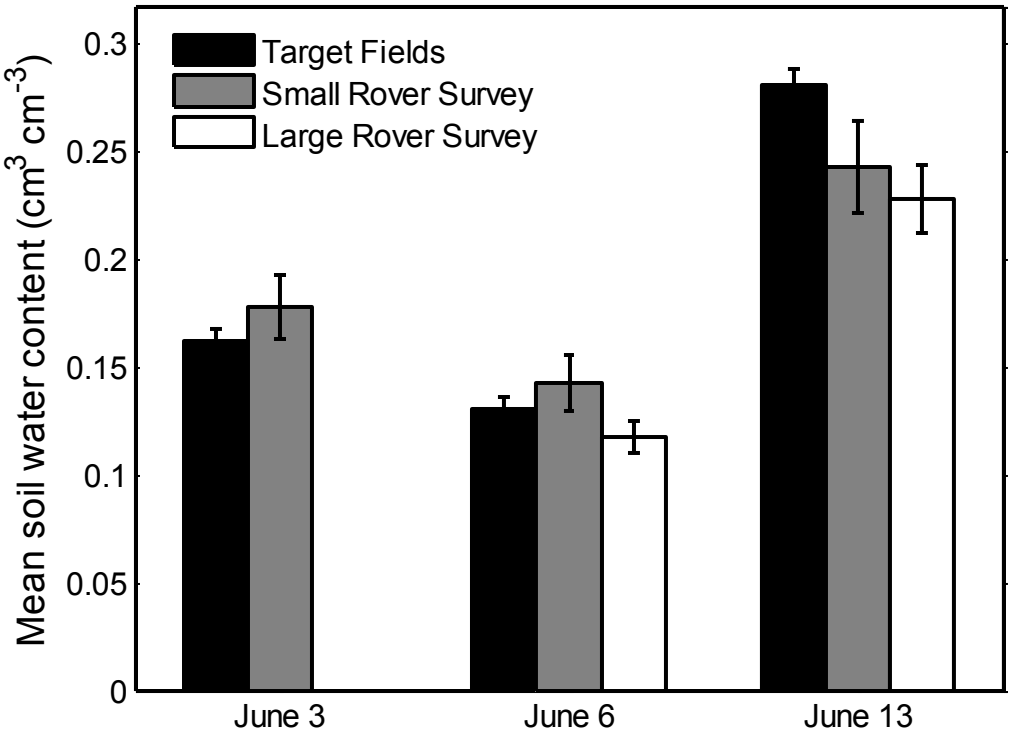


Black = June 3, small survey; Red = June 6, large survey; Blue = June 13, large survey

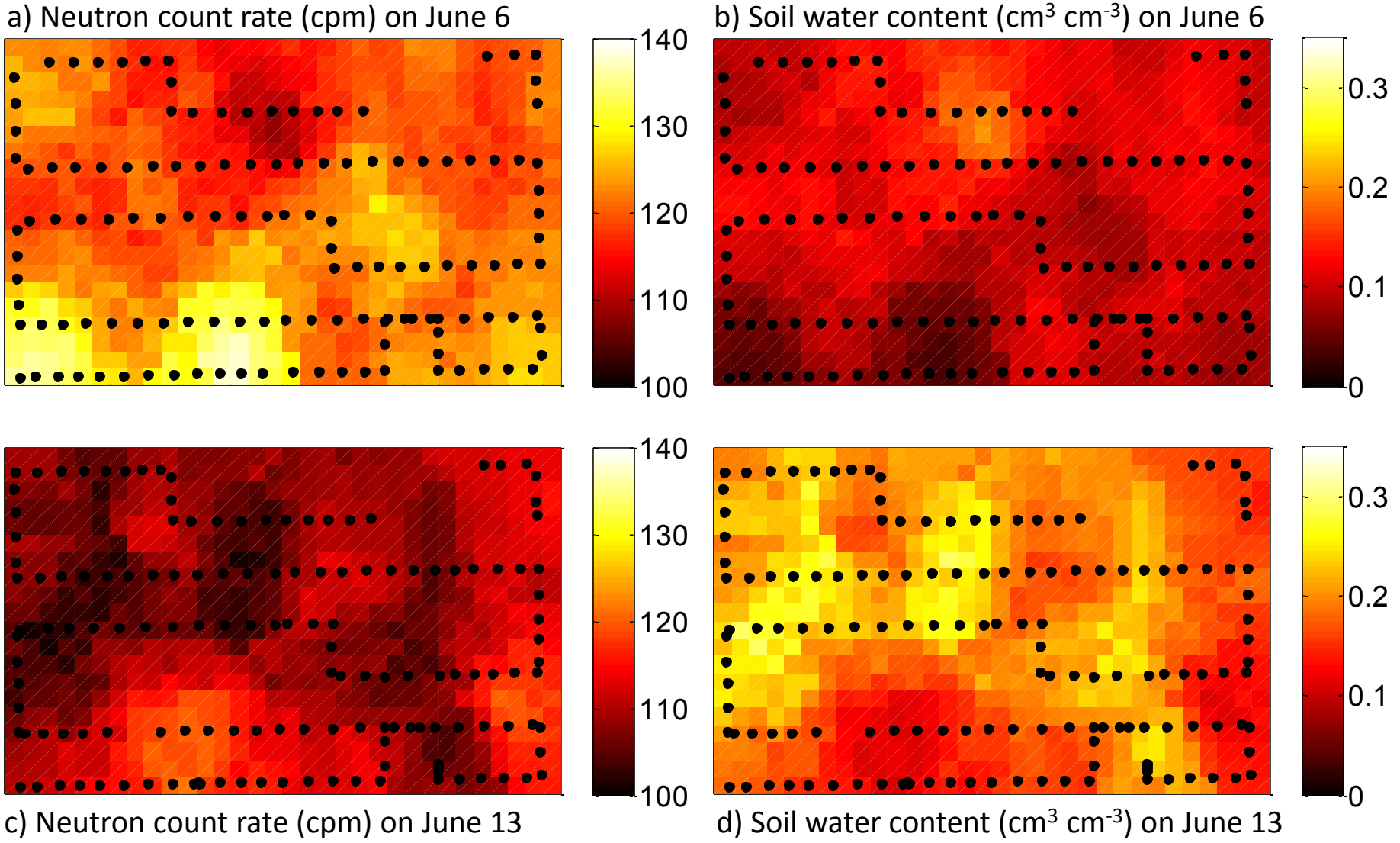
COSMOS rover validation (roving)

- Excellent agreement between Theta Probe soil water content in the target fields and the roving surveys for the surrounding domain on June 3 and 6.

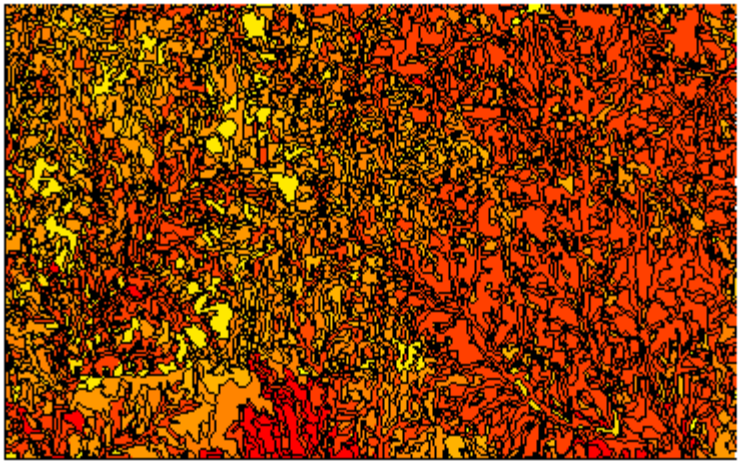
- Difference of 0.047 cm^3 cm^{-3} on June 13 after 37 mm of rainfall on June 12.



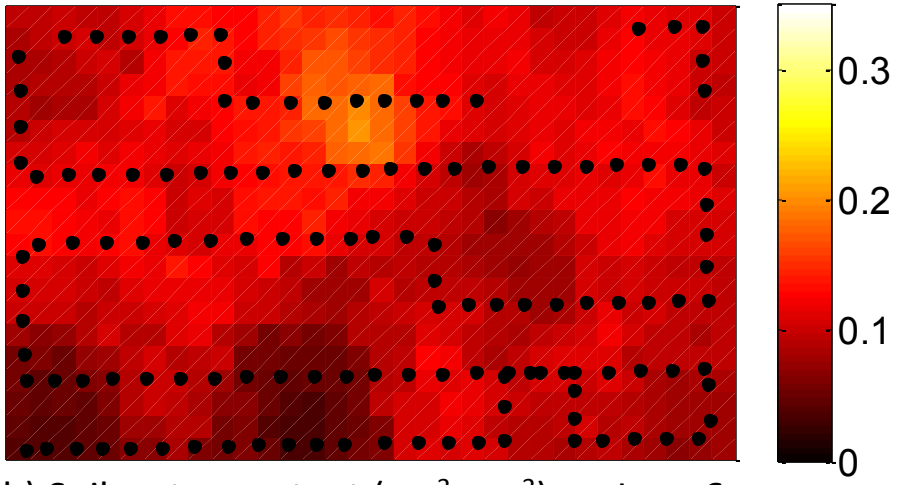
Mean soil water content and standard error of the mean from calibrated Theta Probe surveys (Target Fields), calibrated COSMOS Rover data collected while driving a circuit which encompassed the target fields (Small Rover Survey), and calibrated COSMOS Rover data collected while driving a grid pattern in a larger 16 by 10 km domain (Large Rover Survey).



COSMOS rover neutron count rates (a and c) and 0-5 cm soil water content estimates (b and d) for 16x10 km surveys around MOISST on June 6 (upper) and June 13 (lower) following 37 mm of rainfall on June 12.

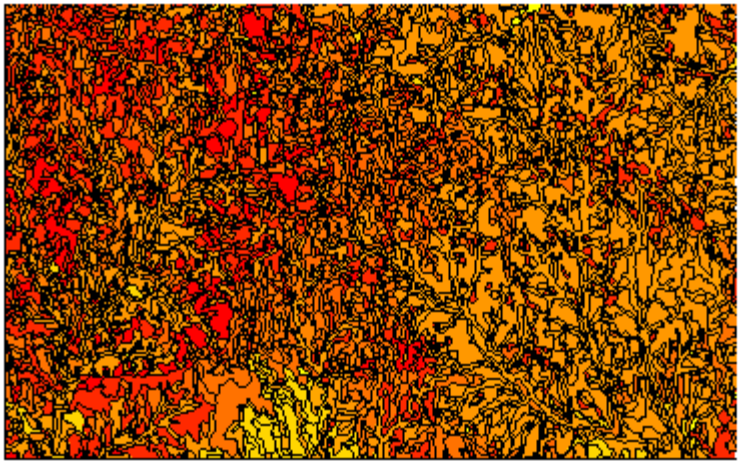


a) Surface sand content (%)

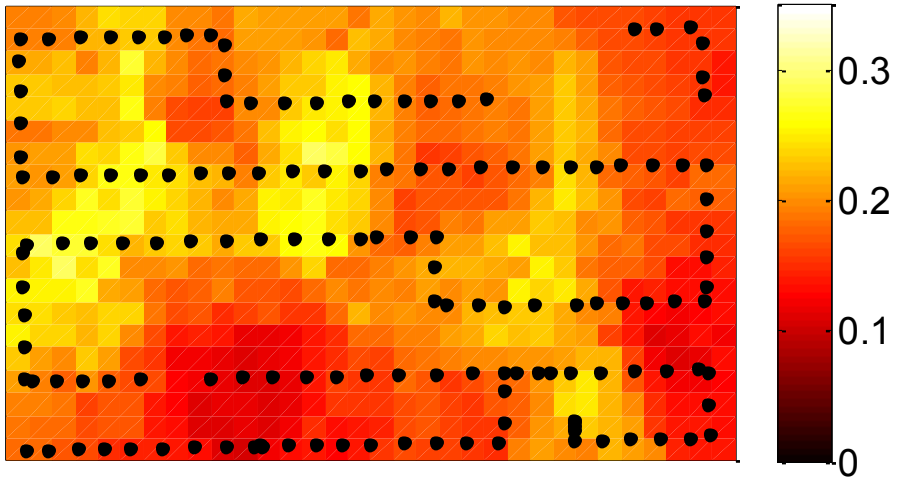


b) Soil water content (cm^3 cm^{-3}) on June 6

c) Surface clay content (%)



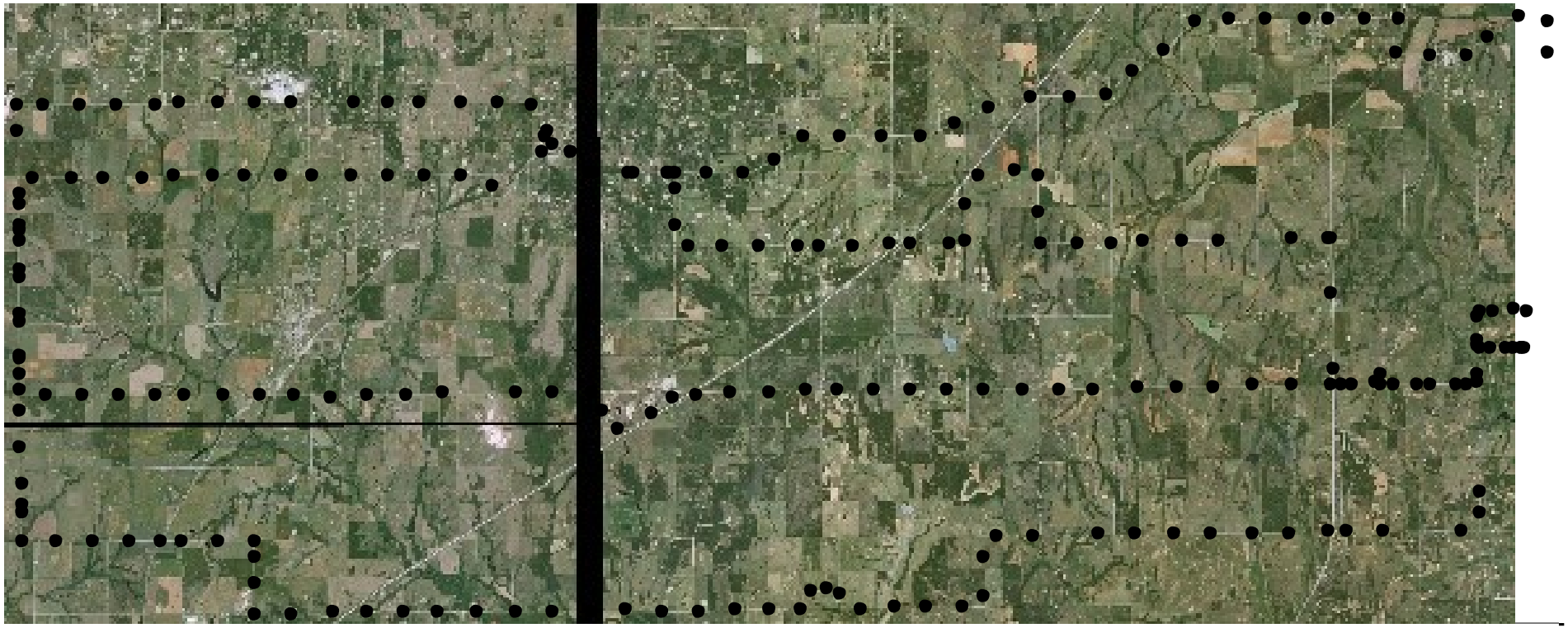
d) Soil water content (cm^3 cm^{-3}) on June 13



SSURGO estimated sand and clay content for the surface horizon for the dominant soil series in each map unit (a and c) and 0-5 cm soil water content estimates (b and d) for 16x10 km surveys around MOISST on June 6 (upper) and June 13 (lower) following 37 mm of rainfall on June 12.

Little Washita Survey

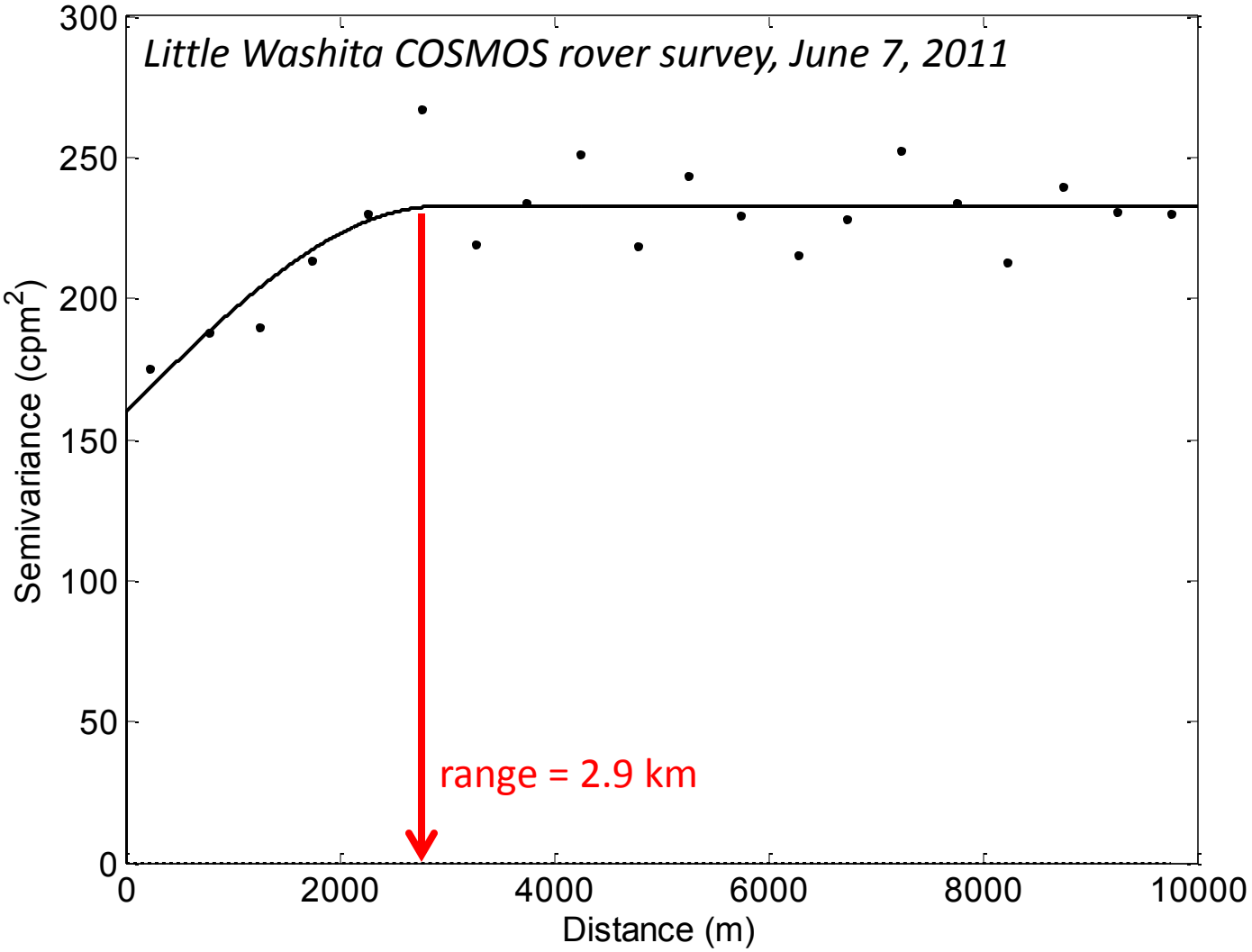
June 7, 2011

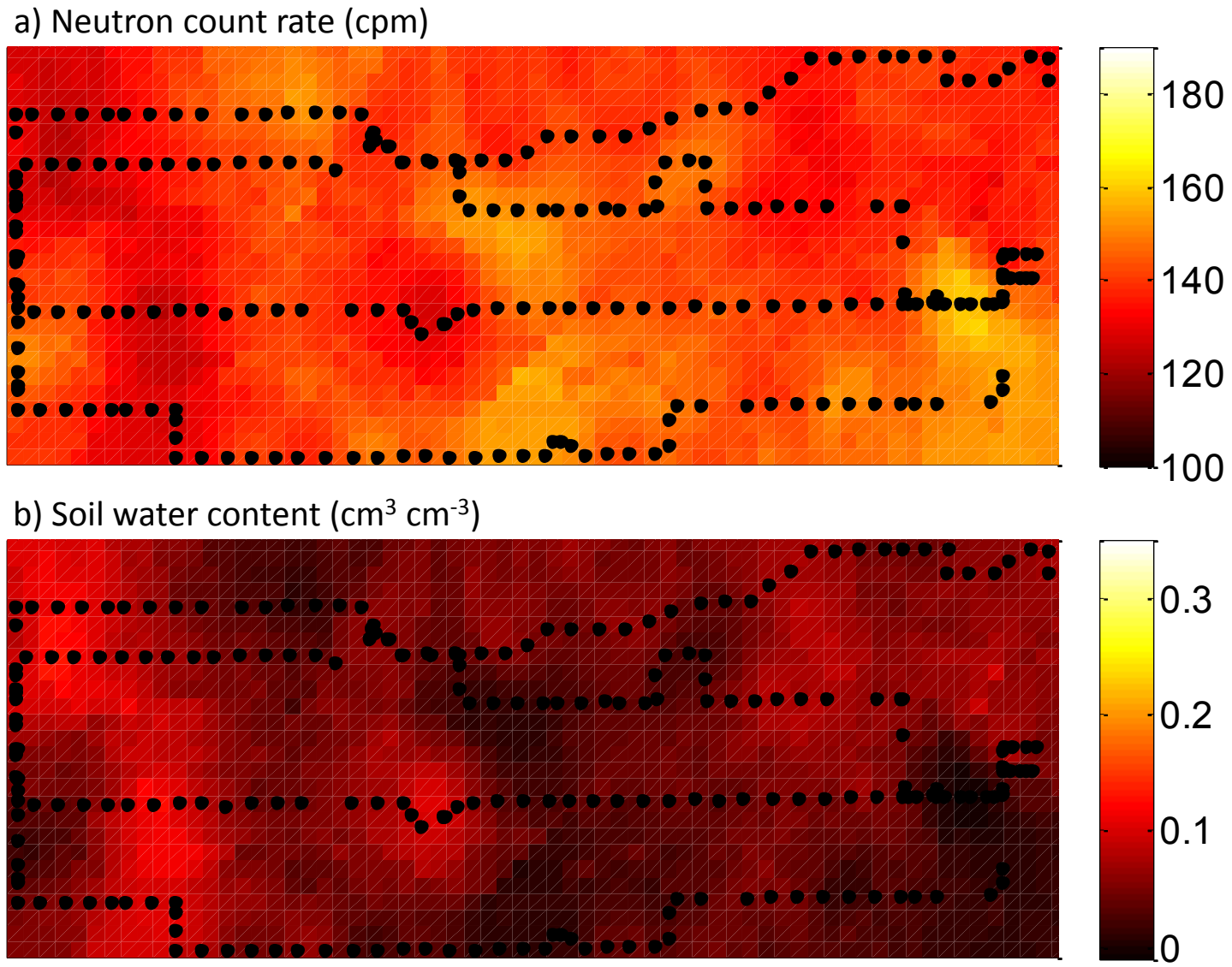


35x14 km domain in southwest Oklahoma containing 20 soil moisture stations (Micronet)

Micronet average soil water content at 5 cm = **0.08 cm^3 cm^{-3}** (SEM = 0.02)
COSMOS rover average soil water content, 0-5 cm = **0.063 cm^3 cm^{-3}** (SEM = 0.004)

Spatial structure of neutron counts





COSMOS rover neutron count rates (a) and 0-5 cm soil water content estimates (b) for a 34x14 km survey across the Little Washita watershed on June 7, 2011.

Conclusions

- Rover calibration for 0-5 cm soil moisture can be successfully completed using one day of ground truth data and measured lattice water content.

- Calibrated COSMOS rover estimated surface water content within 0.02 cm^3 cm^{-3} of the in situ data for 3 out of 4 surveys.

- Neutron count rates exhibited:
  - reasonable responses to rainfall and soil textural patterns
  - spatial structure with a 3 km length scale

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