Soil Moisture Estimation Using Active DTS at MOISST Site

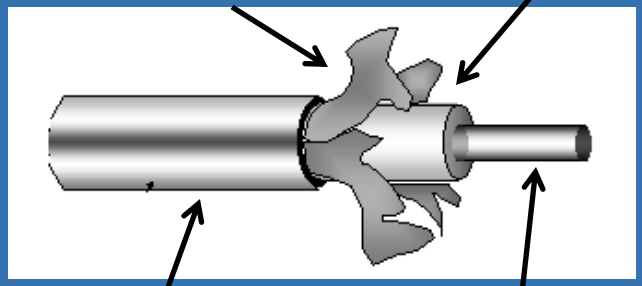
June 4, 2014

Chadi Sayde, Daniel Moreno, John Selker

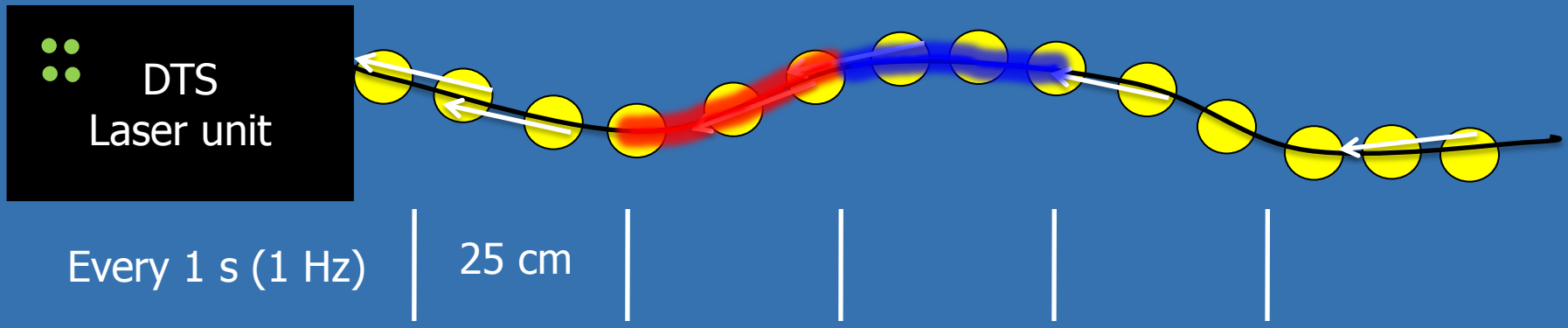
Department of Biological and Ecological Engineering
Oregon State University, USA

Measuring Temperature with DTS

Optical fiber



Fiber diameter 0.9 mm
Black and white jackets



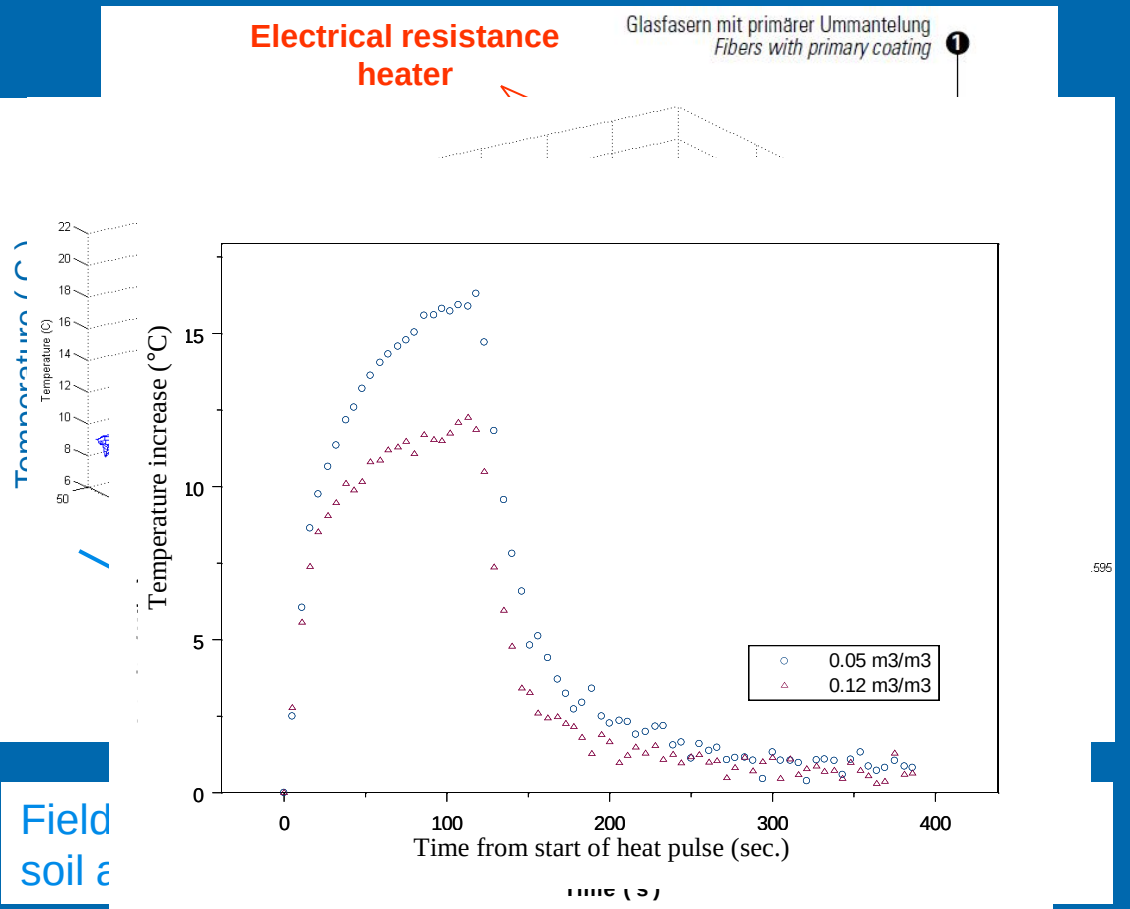
Measuring soil moisture content

Actively heated

Heat injected in soil along fiber optic cable

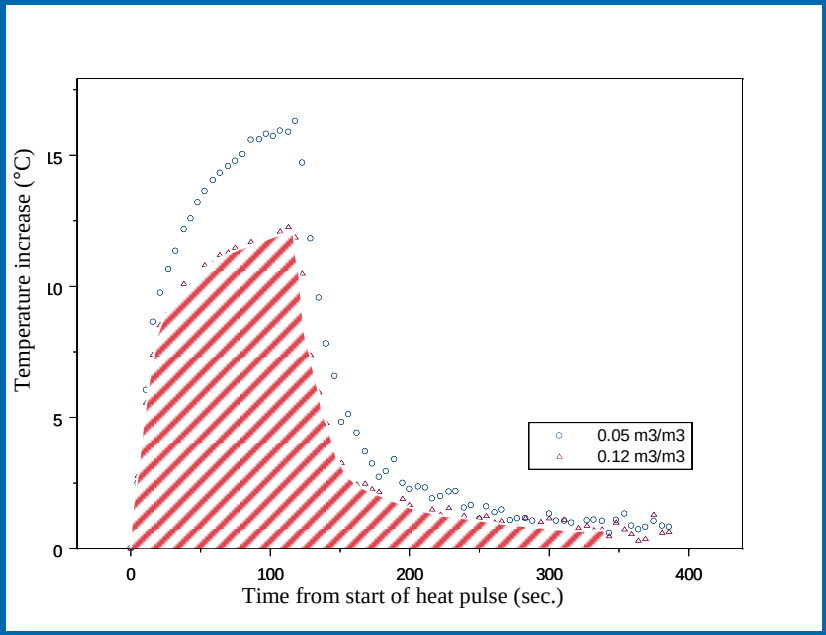
DTS reads temperature changes during heat pulse along fiber optic cable

Soil water content inferred from thermal response of soil to the heat pulse



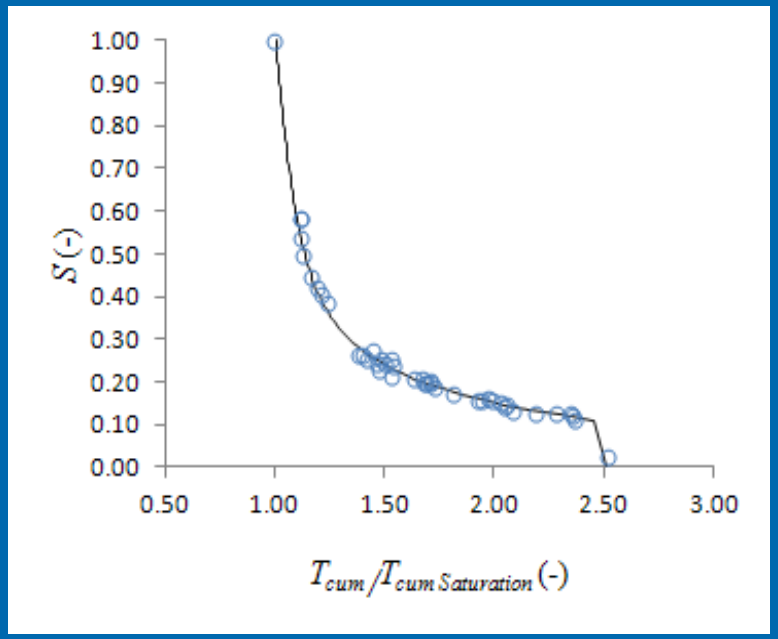
Heat Pulse Interpretation: **The Integral Method**

$$T_{cum} = \int_{t_0}^{t_j} \Delta T \, dt$$

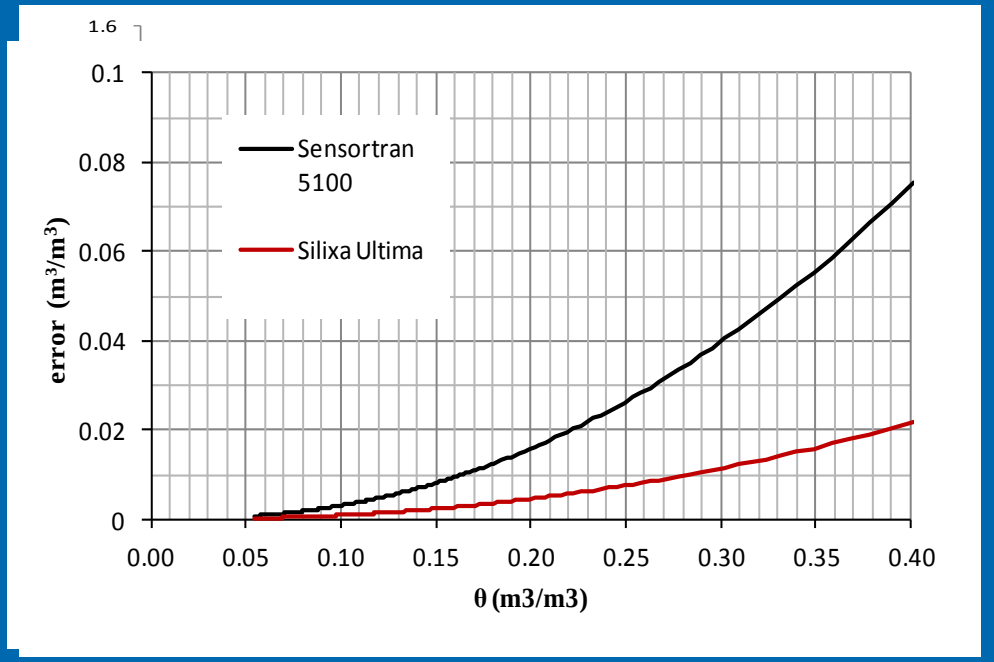


T_{cum}	is the cumulative temperature increase
t_0	is the time to start of a heat pulse
t_j	is the total time of integration
ΔT	is the temperature increase over ambient temperature.

Calibration Curve



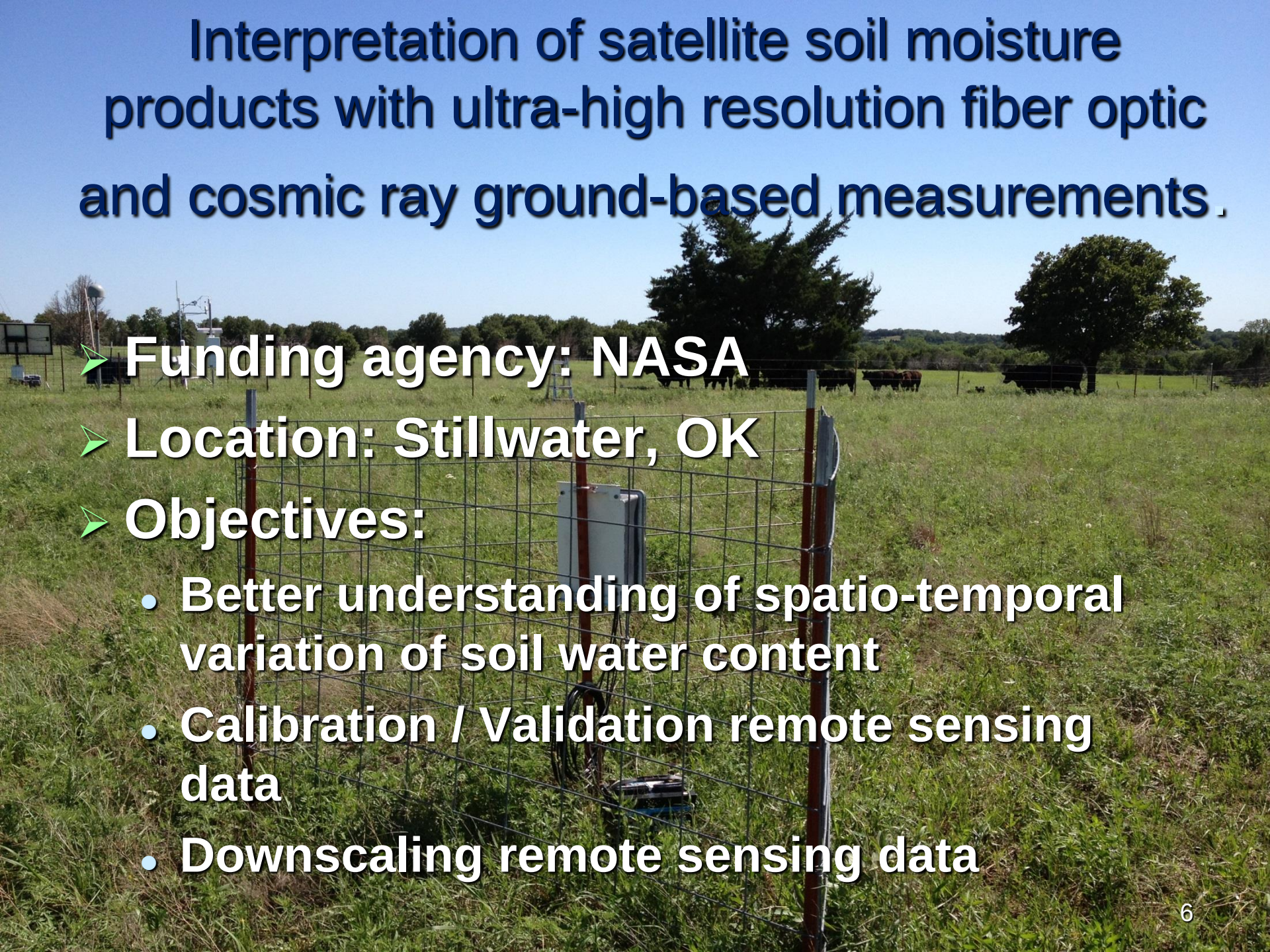
Calibration curve relating the degree of saturation (*S*) to T_{cum} normalized by its value at saturation



S vs. Θ measured from non-disturbed samples collected from the calibration soil column using KD2 probe

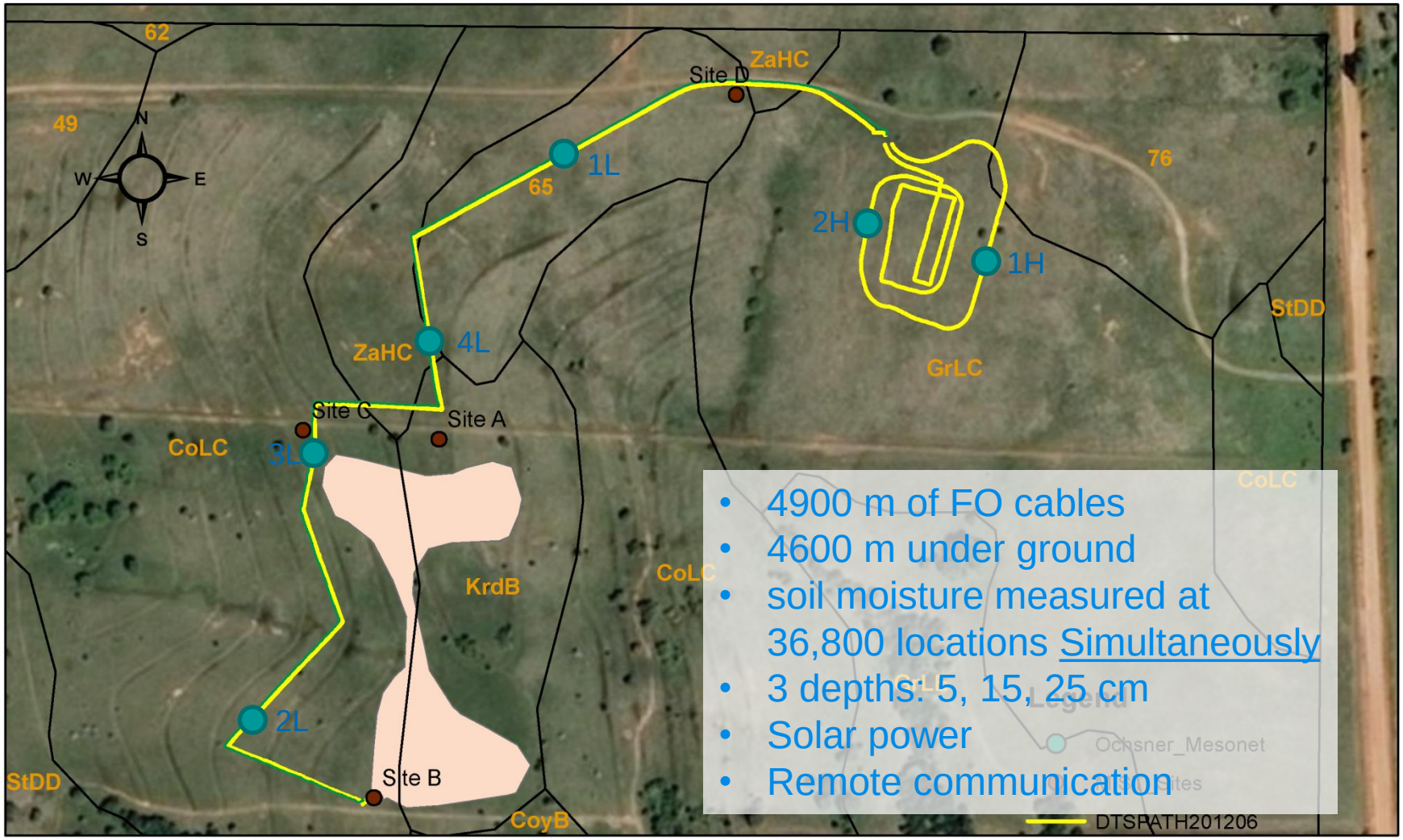
Error in soil water content estimation due to the DTS system performance

Interpretation of satellite soil moisture products with ultra-high resolution fiber optic and cosmic ray ground-based measurements.



- **Funding agency: NASA**
- **Location: Stillwater, OK**
- **Objectives:**
  - **Better understanding of spatio-temporal variation of soil water content**
  - **Calibration / Validation remote sensing data**
  - **Downscaling remote sensing data**

Fiber Optics Cable Path



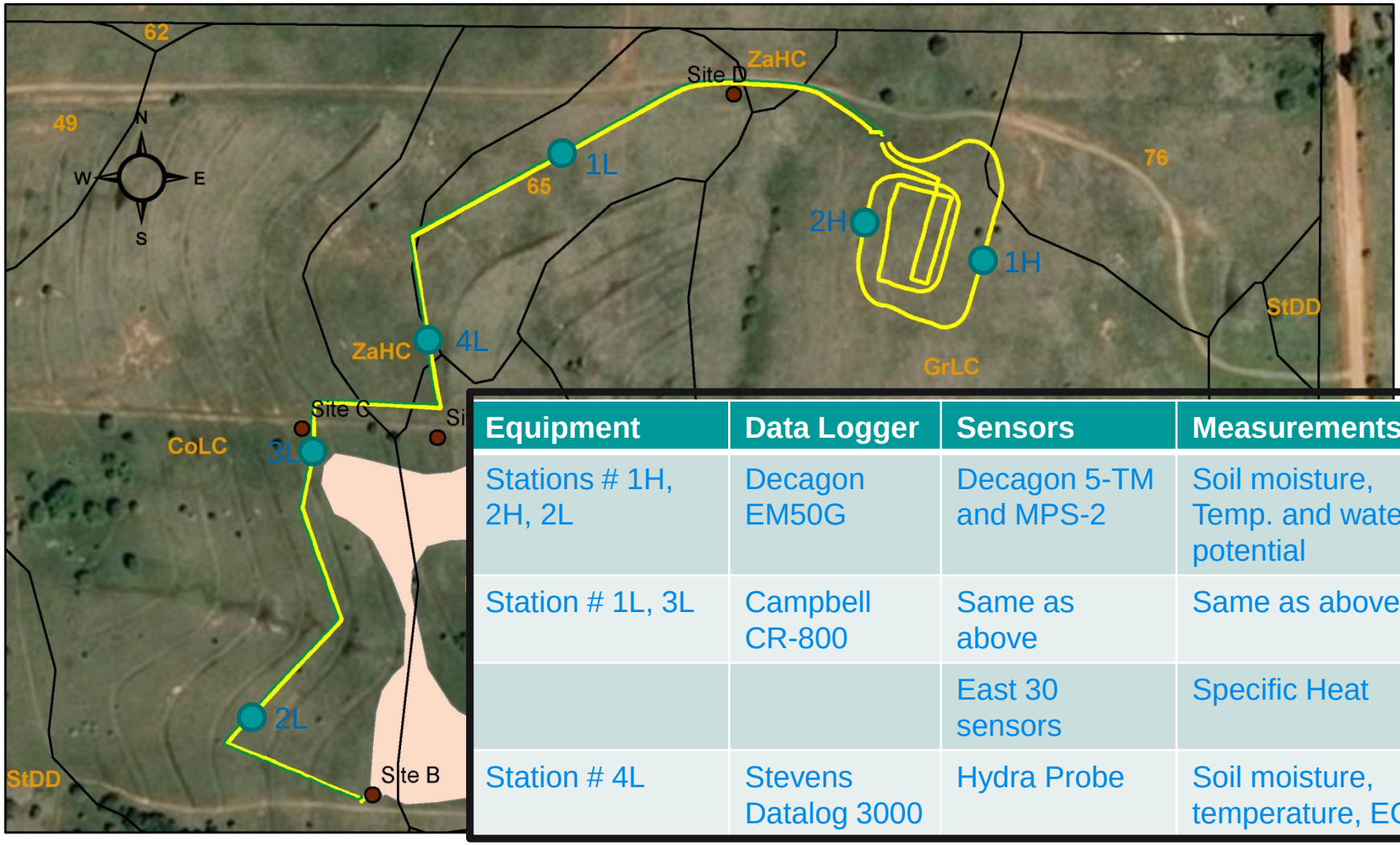
- 4900 m of FO cables
- 4600 m under ground
- soil moisture measured at 36,800 locations Simultaneously
- 3 depths: 5, 15, 25 cm
- Solar power
- Remote communication

NASA DTS MOISST Project

IMG_0525.MOV

Google

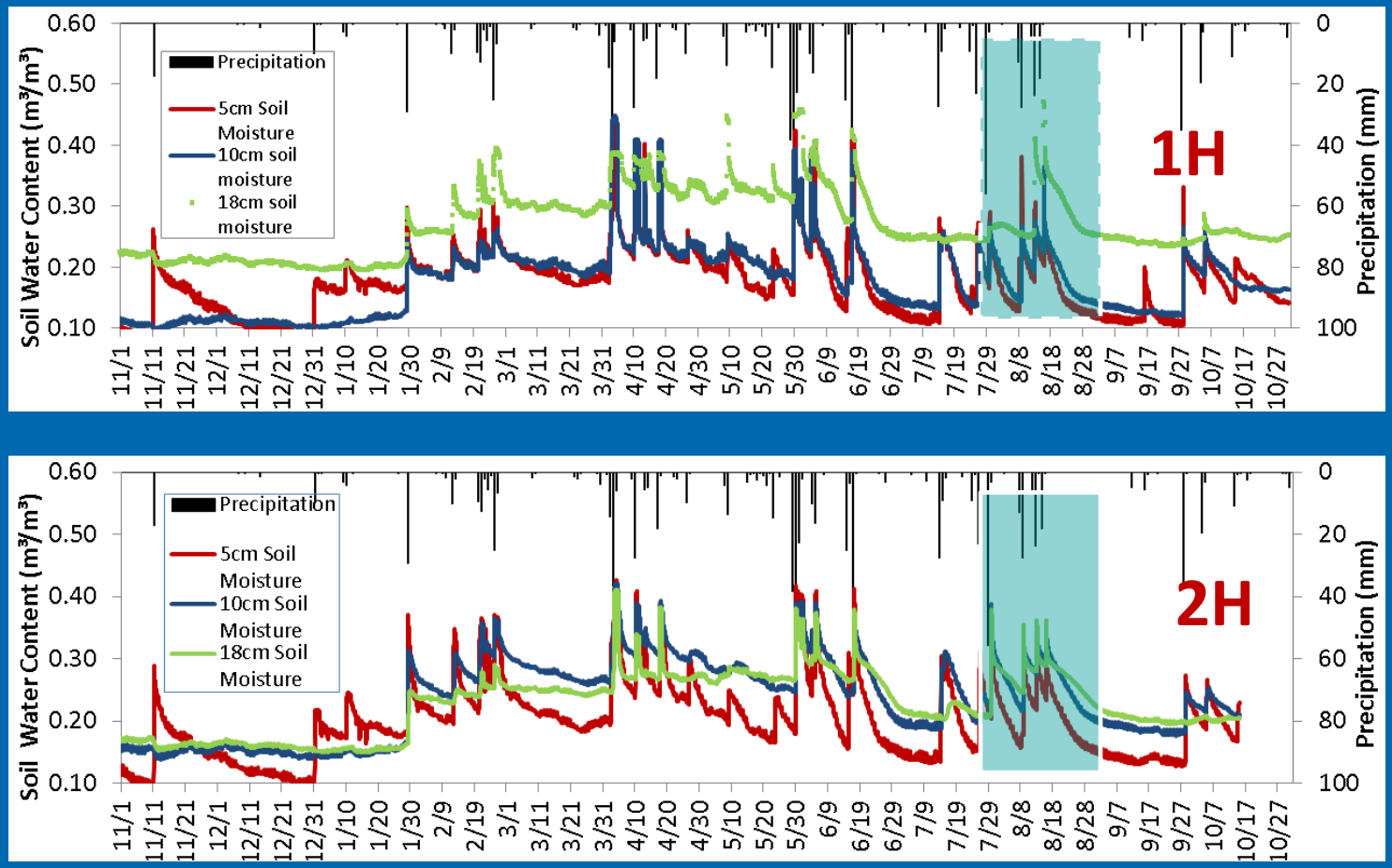
Fiber Optics Cable Path



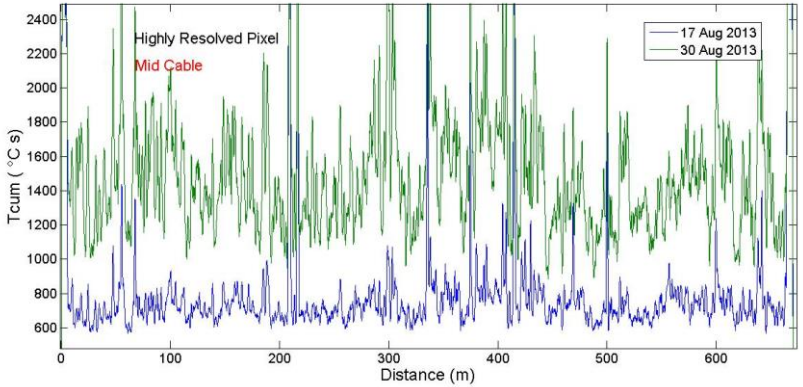
Equipment	Data Logger	Sensors	Measurements
Stations # 1H, 2H, 2L	Decagon EM50G	Decagon 5-TM and MPS-2	Soil moisture, Temp. and water potential
Station # 1L, 3L	Campbell CR-800	Same as above	Same as above
		East 30 sensors	Specific Heat
Station # 4L	Stevens Datalog 3000	Hydra Probe	Soil moisture, temperature, EC

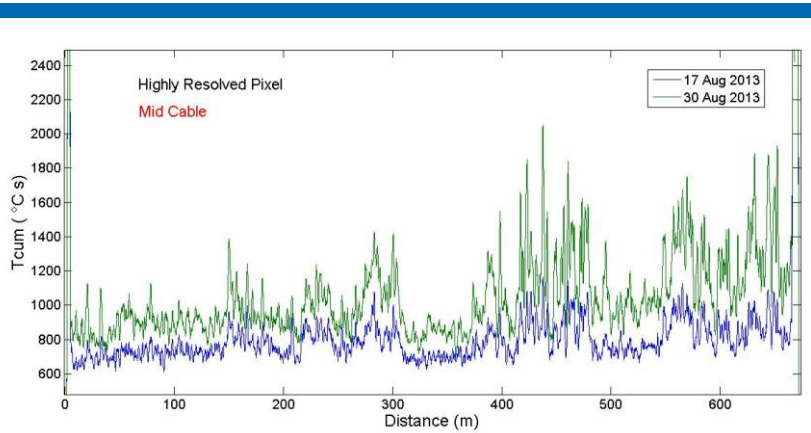
NASA DTS MOISST Project

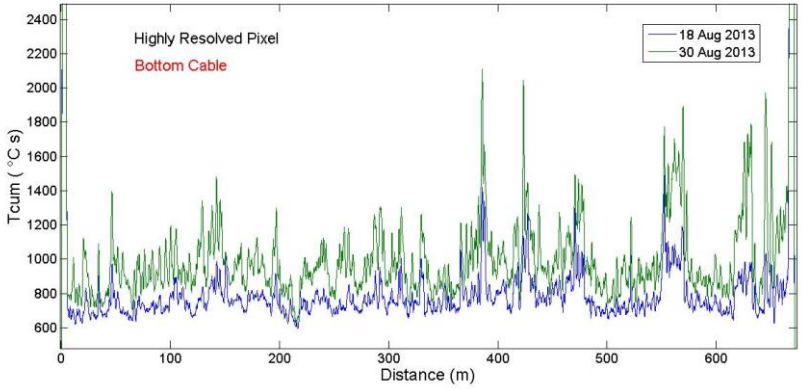
Precipitation recorded at the site and Soil Water Contents measured at Stations 1H and 2H

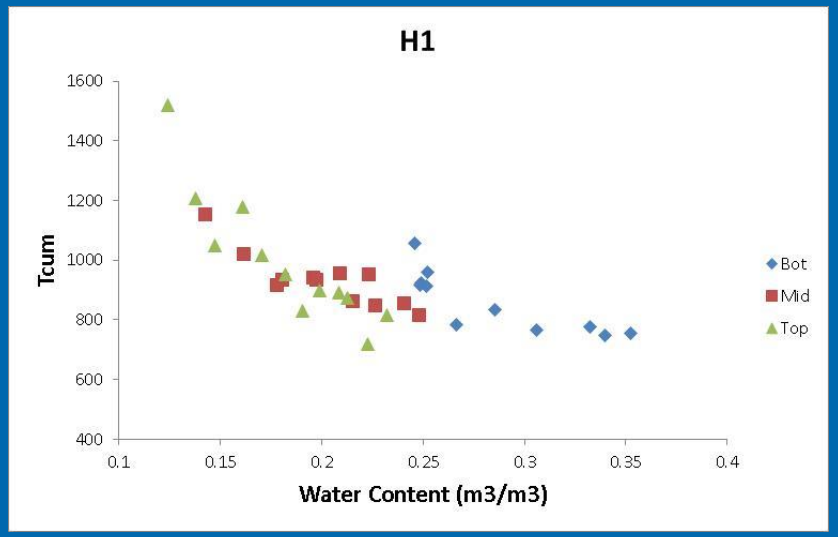


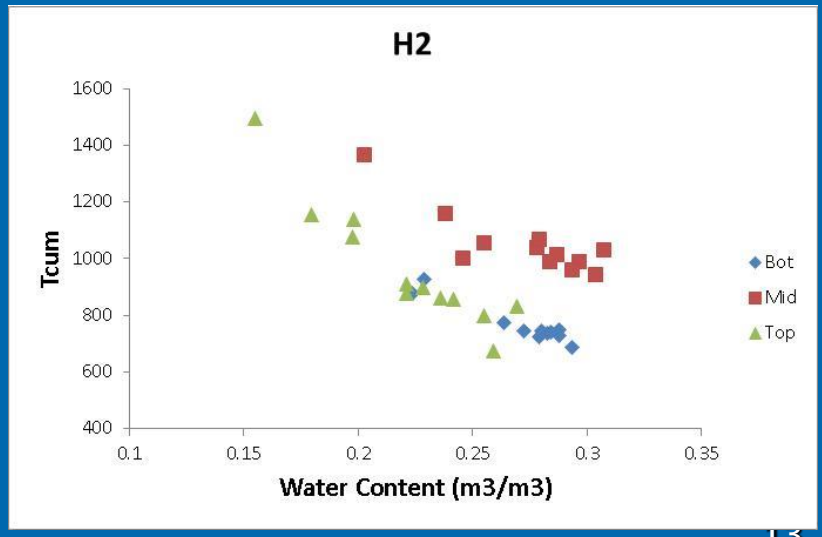
Tcum vs. soil water content measured at stations 1H and 2H in August, 2013



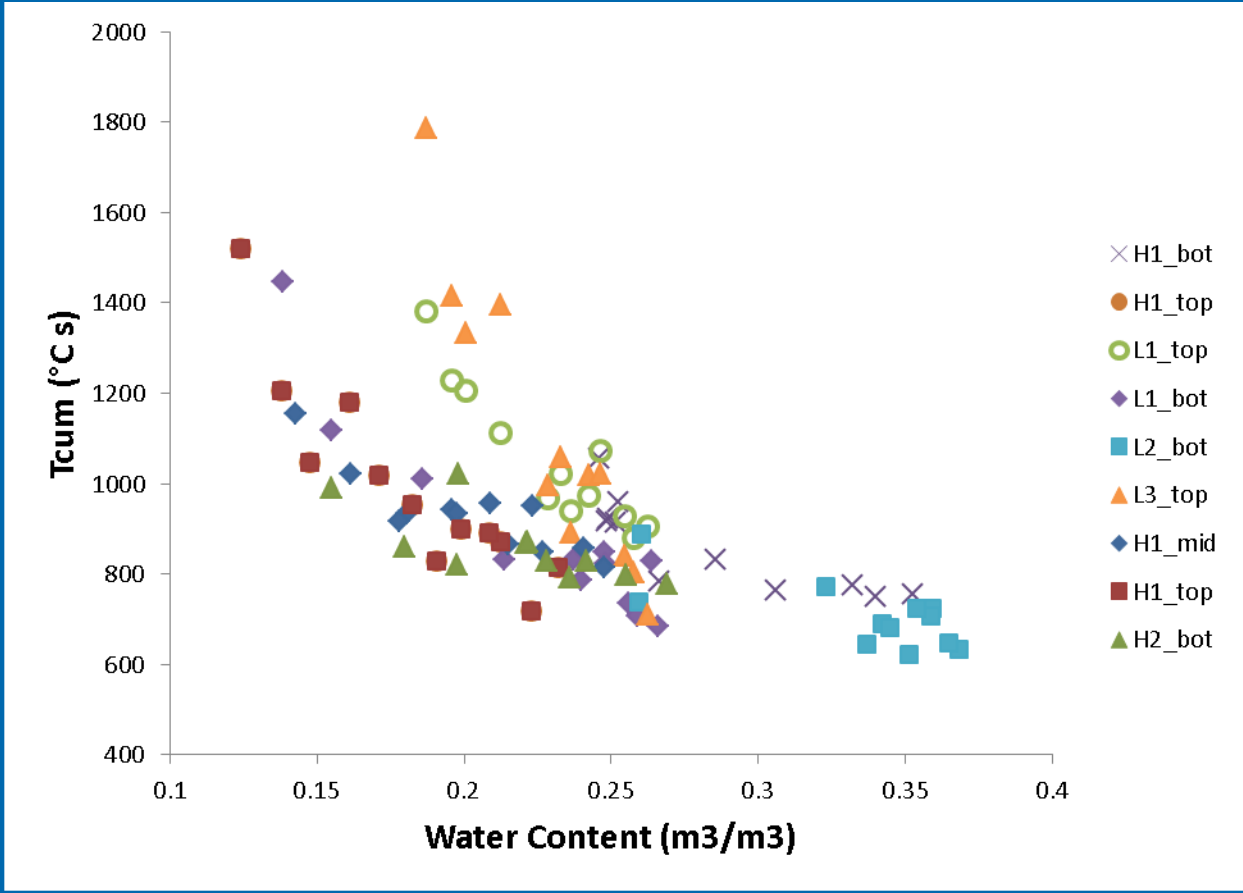




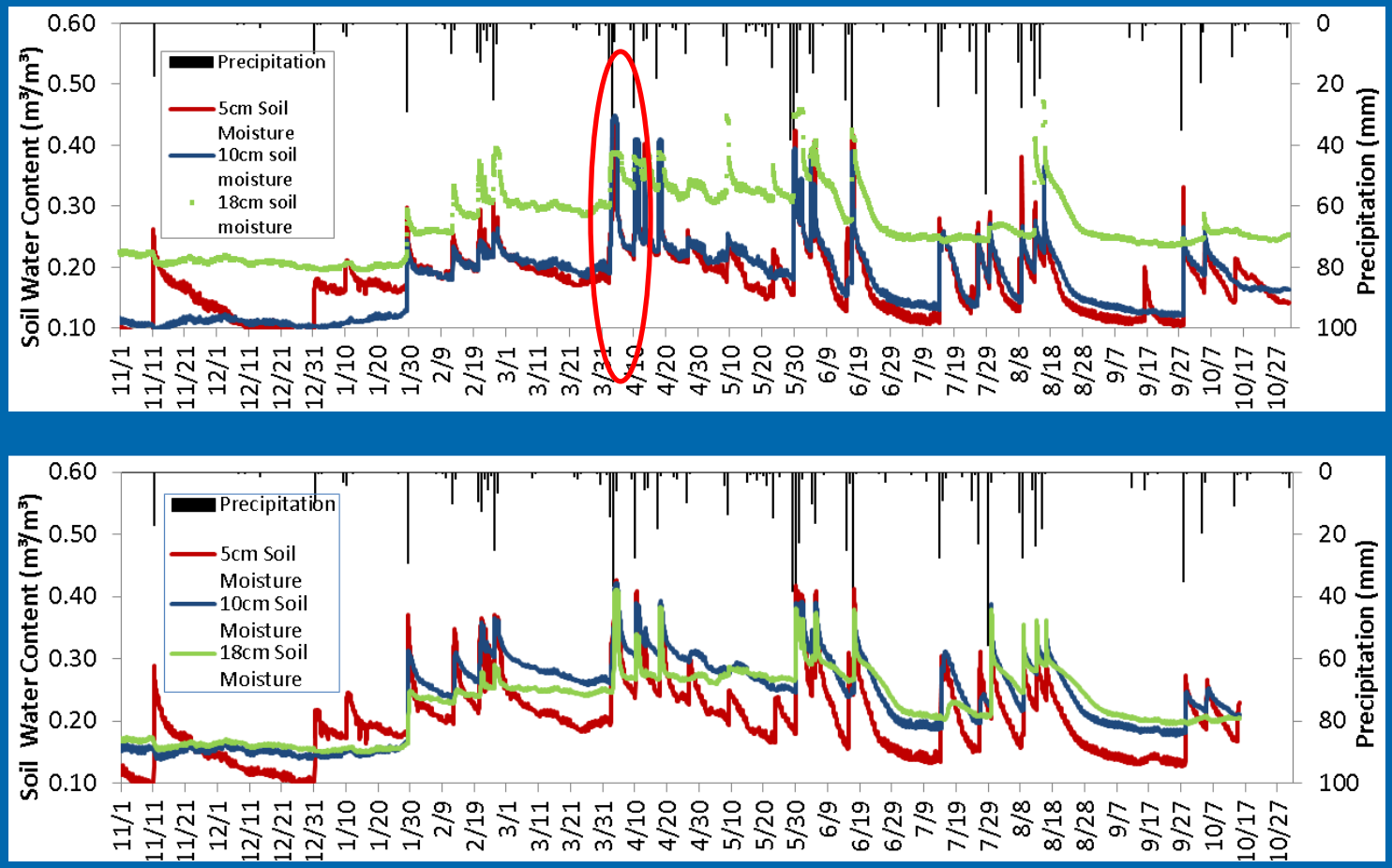




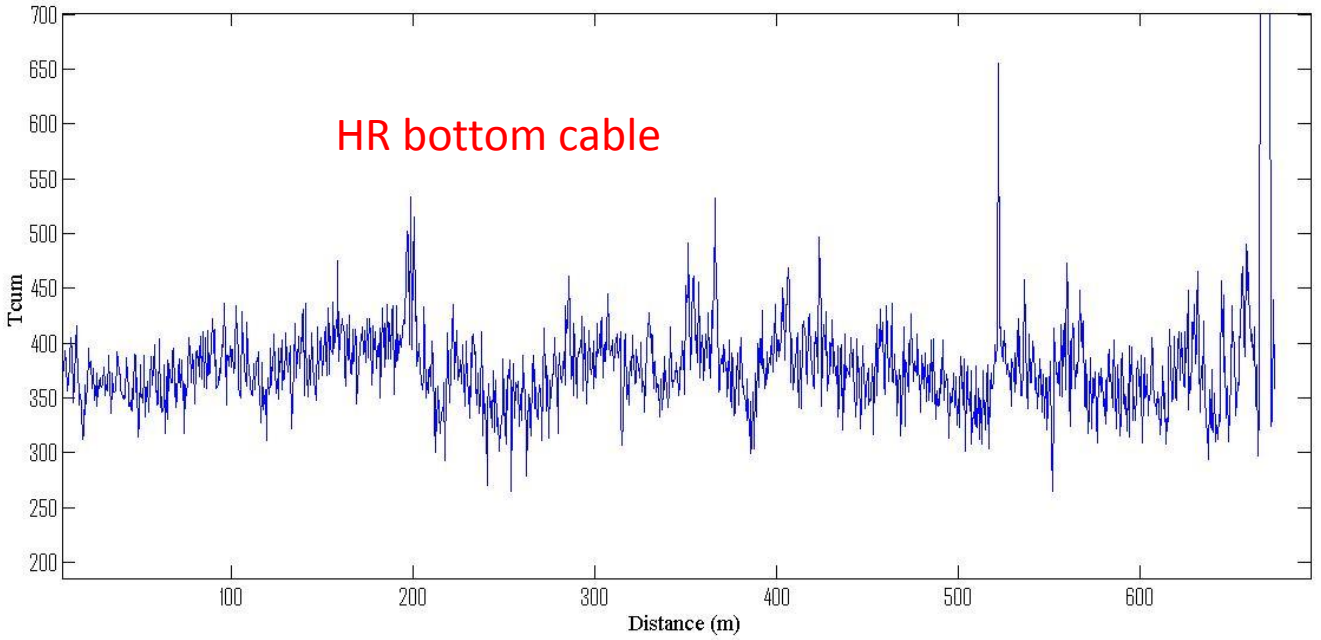
Spatial Variability of Soil Thermal properties

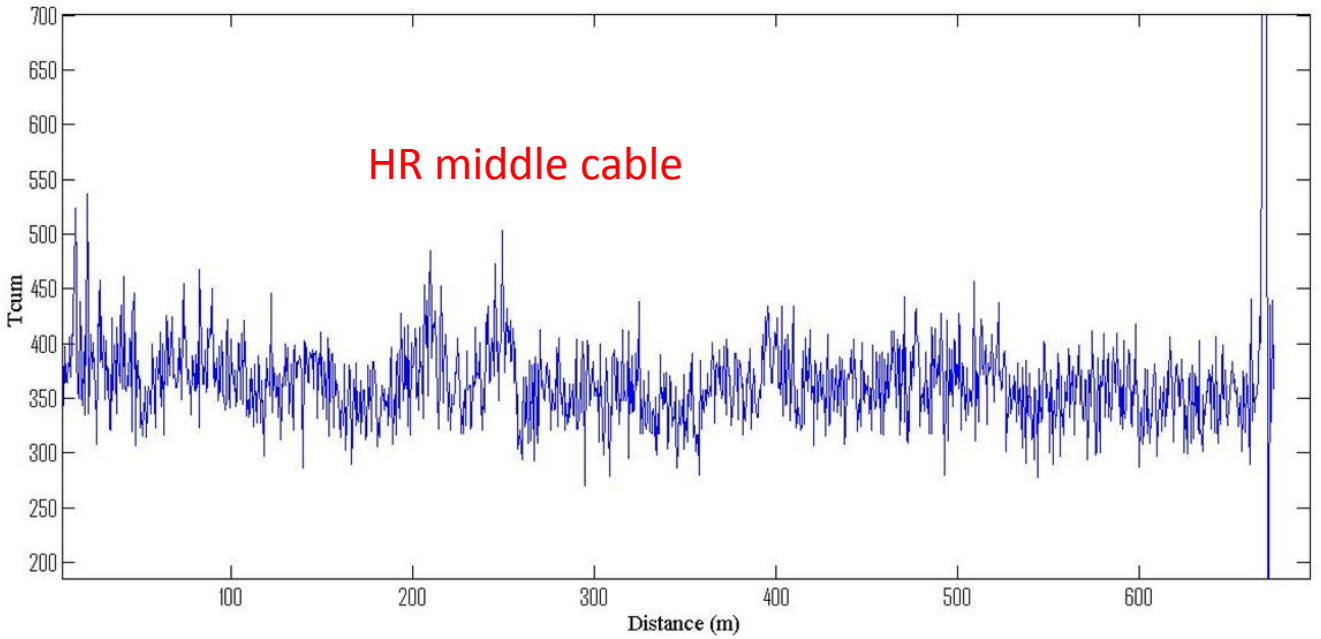


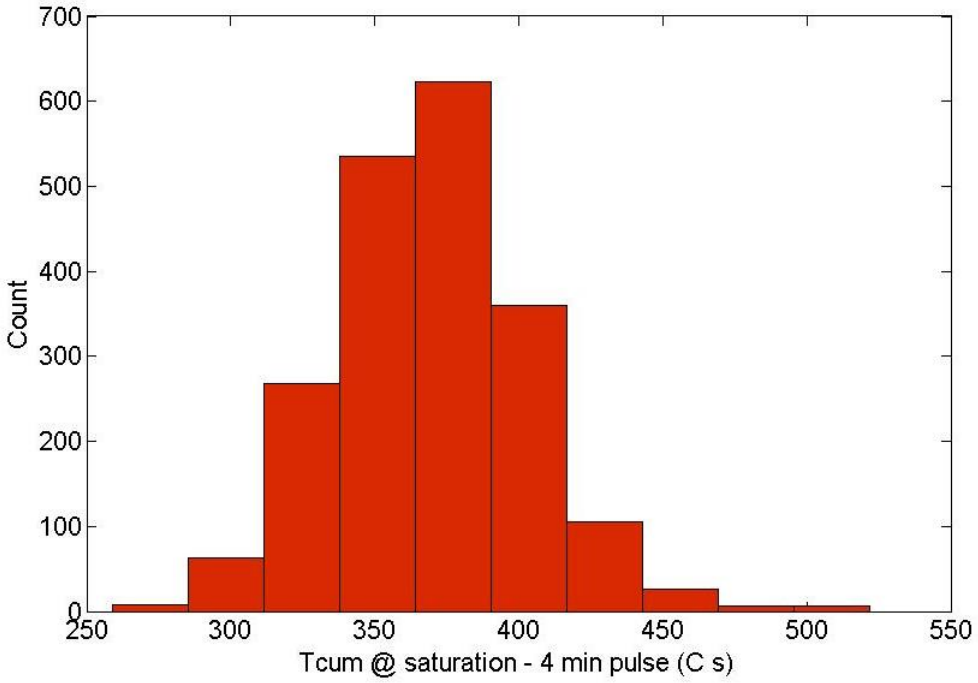
Precipitation recorded at the site and Soil Water Contents measured at Stations 1H and 2H

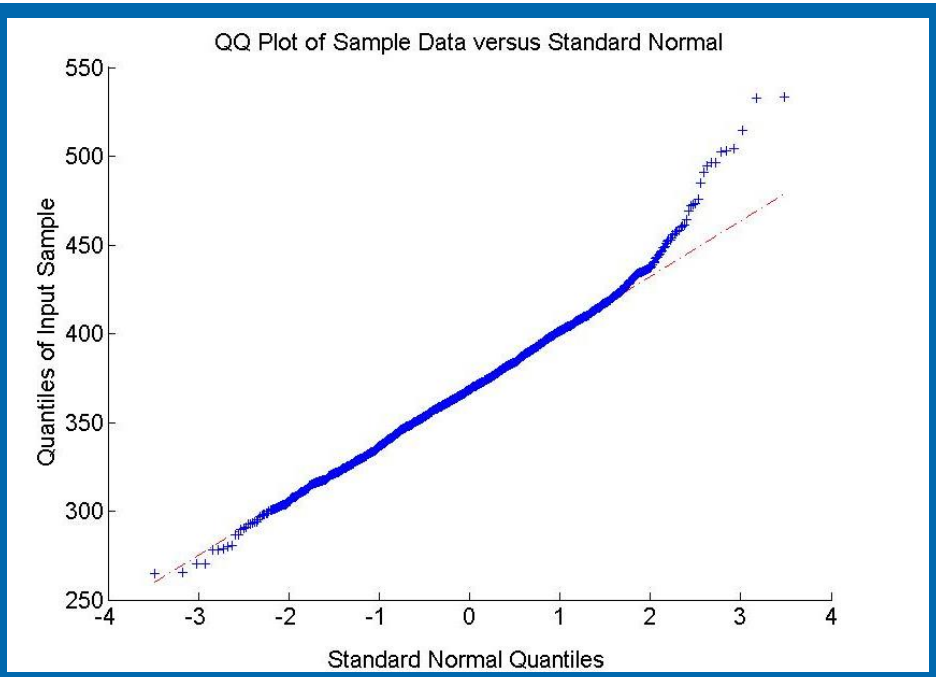


June 1, 2013 – Tcum from 4 min heat pulse



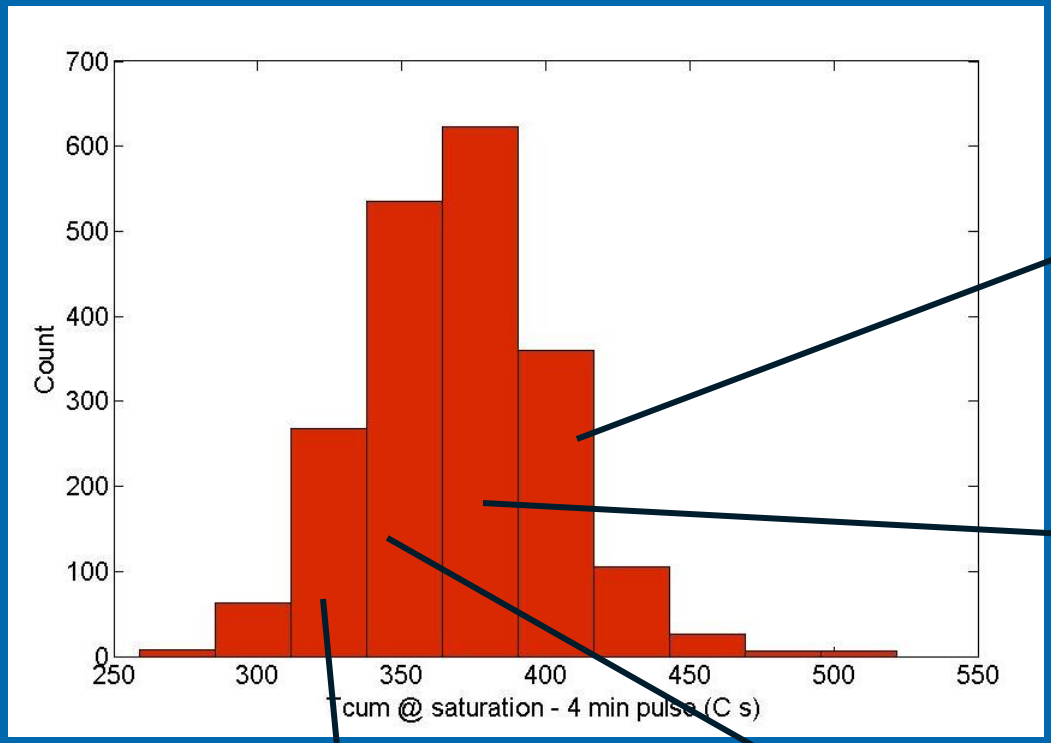


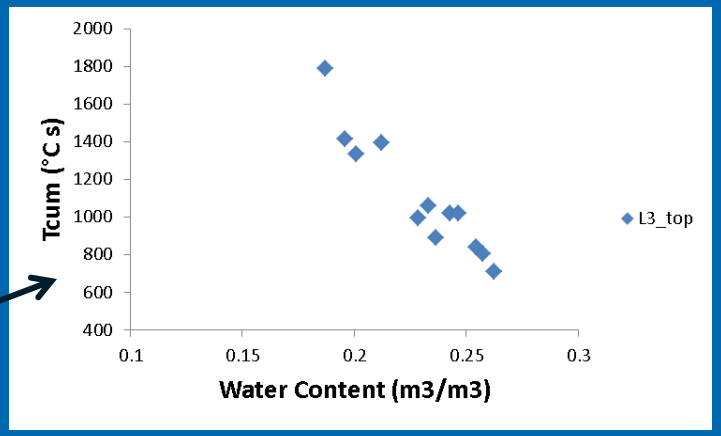


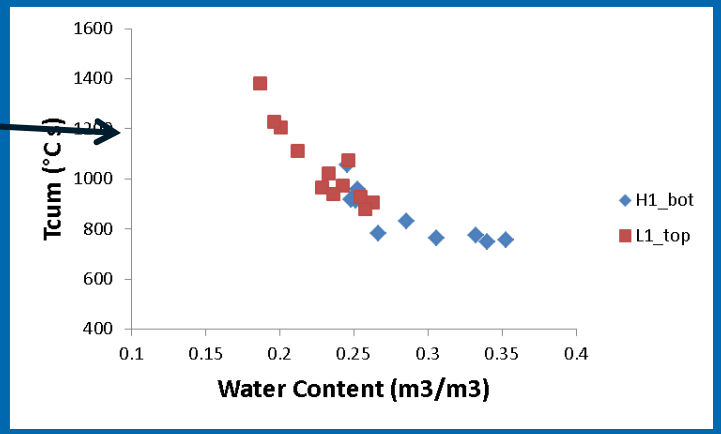


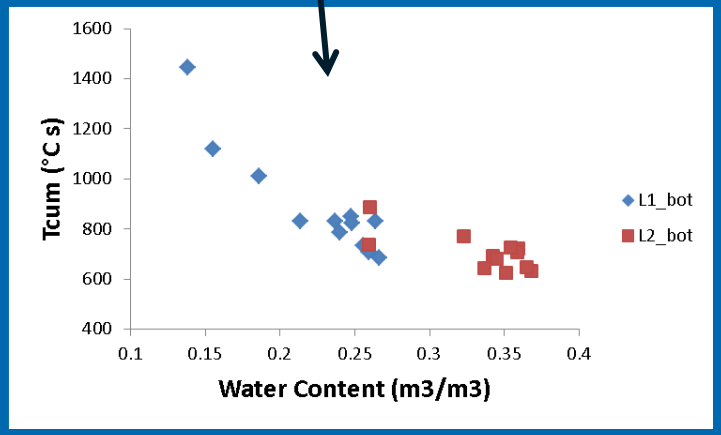
Histogram of Tcum on June 1, 2013

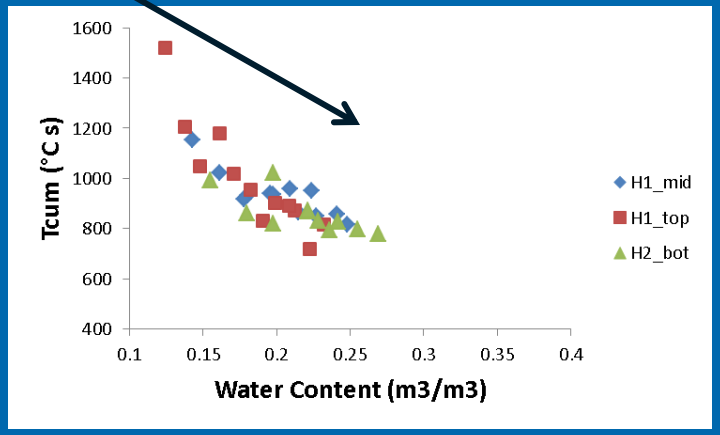
Saturated soil after heavy rainfall


Count
Tcum @ saturation - 4 min pulse (C s)


Tcum (°C s)
Water Content (m3/m3)
L3_top


Tcum (°C s)
Water Content (m3/m3)
H1_bot
L1_top

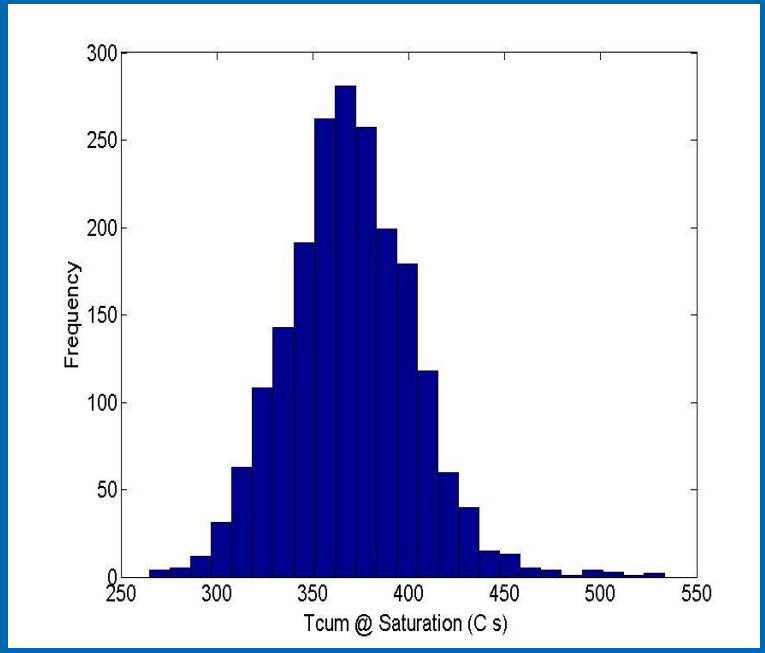

Tcum (°C s)
Water Content (m3/m3)
L1_bot
L2_bot


Tcum (°C s)
Water Content (m3/m3)
H1_mid
H1_top
H2_bot

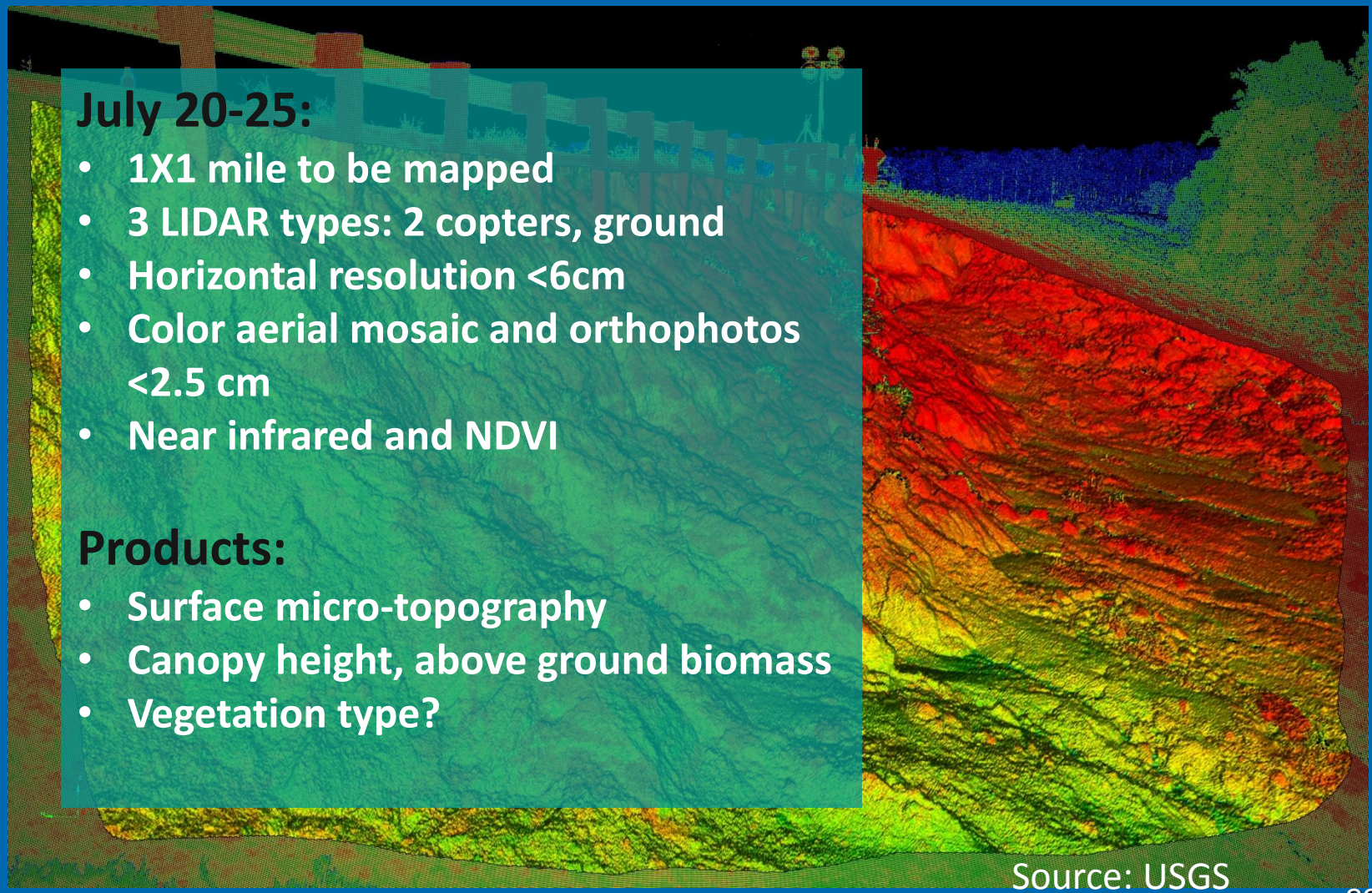
Future work: Increasing Calibration Accuracy

Generate distributed calibration curves:

- Thermal response curve generated from non disturbed samples
- Strategic detailed surveying of soil water content and soil thermal properties
- Calibration curve could be produced by few measured T_{cum}-θ couples per location
- Vegetation and topography indices



Ultra High Resolution LIDAR mapping of the site



July 20-25:

- 1X1 mile to be mapped
- 3 LIDAR types: 2 copters, ground
- Horizontal resolution <6cm
- Color aerial mosaic and orthophotos <2.5 cm
- Near infrared and NDVI

Products:

- Surface micro-topography
- Canopy height, above ground biomass
- Vegetation type?

Source: USGS

Summary

- Active DTS Soil Moisture product available in the summer
- Distributed calibration
- Dynamic calibration: Increased accuracy with more data integrated
- High resolution LIDAR micro-topography and vegetation height maps:
  - Improving the accuracy of DTS products
  - Effects of micro-topography on Hydrologic processes in the field
  - Upscaling DTS soil moisture

Thank You!

NEVER BLENDING IN
OKLAHOMA STATE
COWBOYS
CHLAMYDIA
is nothing to
about...