

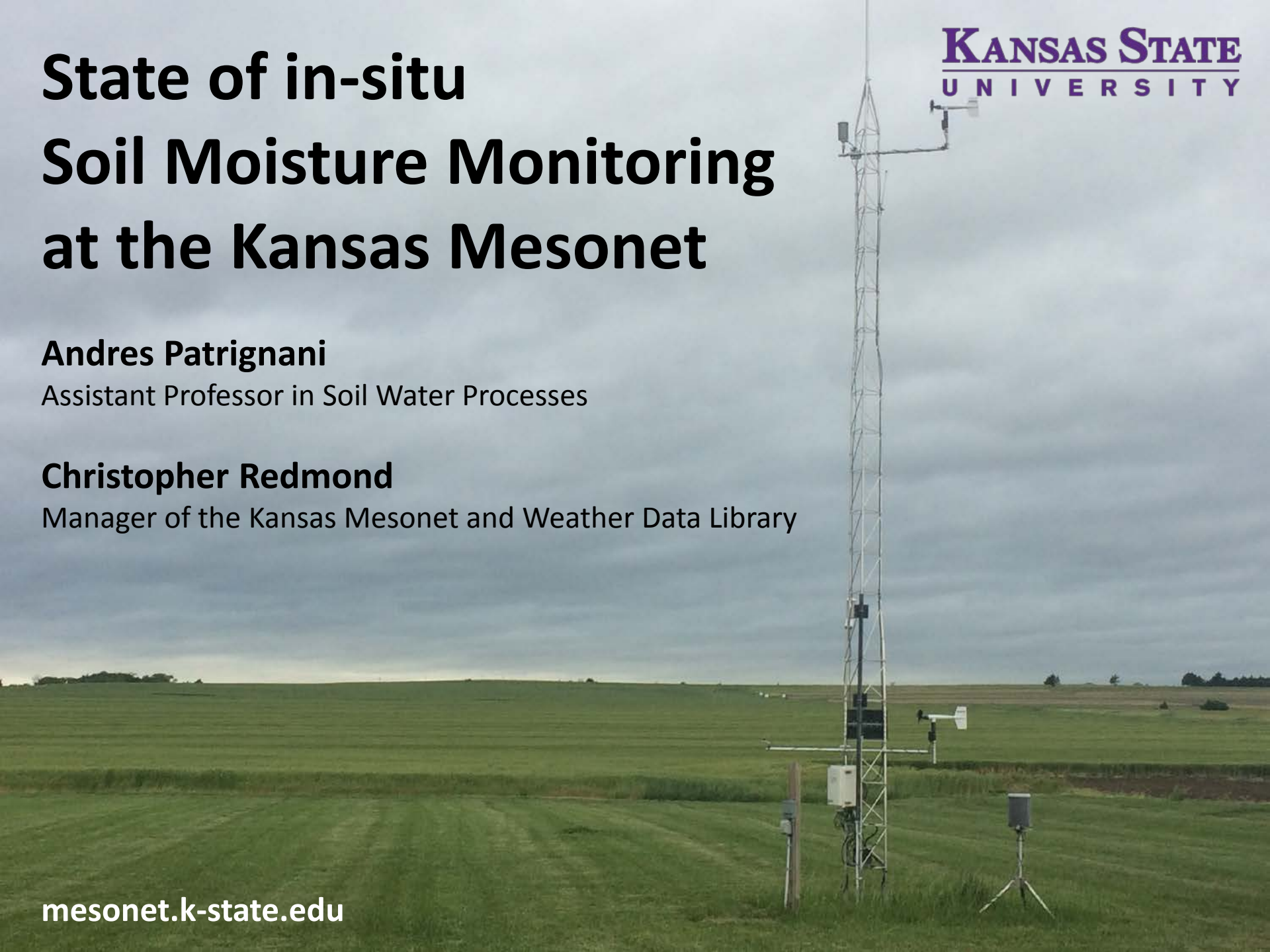
# State of in-situ Soil Moisture Monitoring at the Kansas Mesonet

**Andres Patrignani**

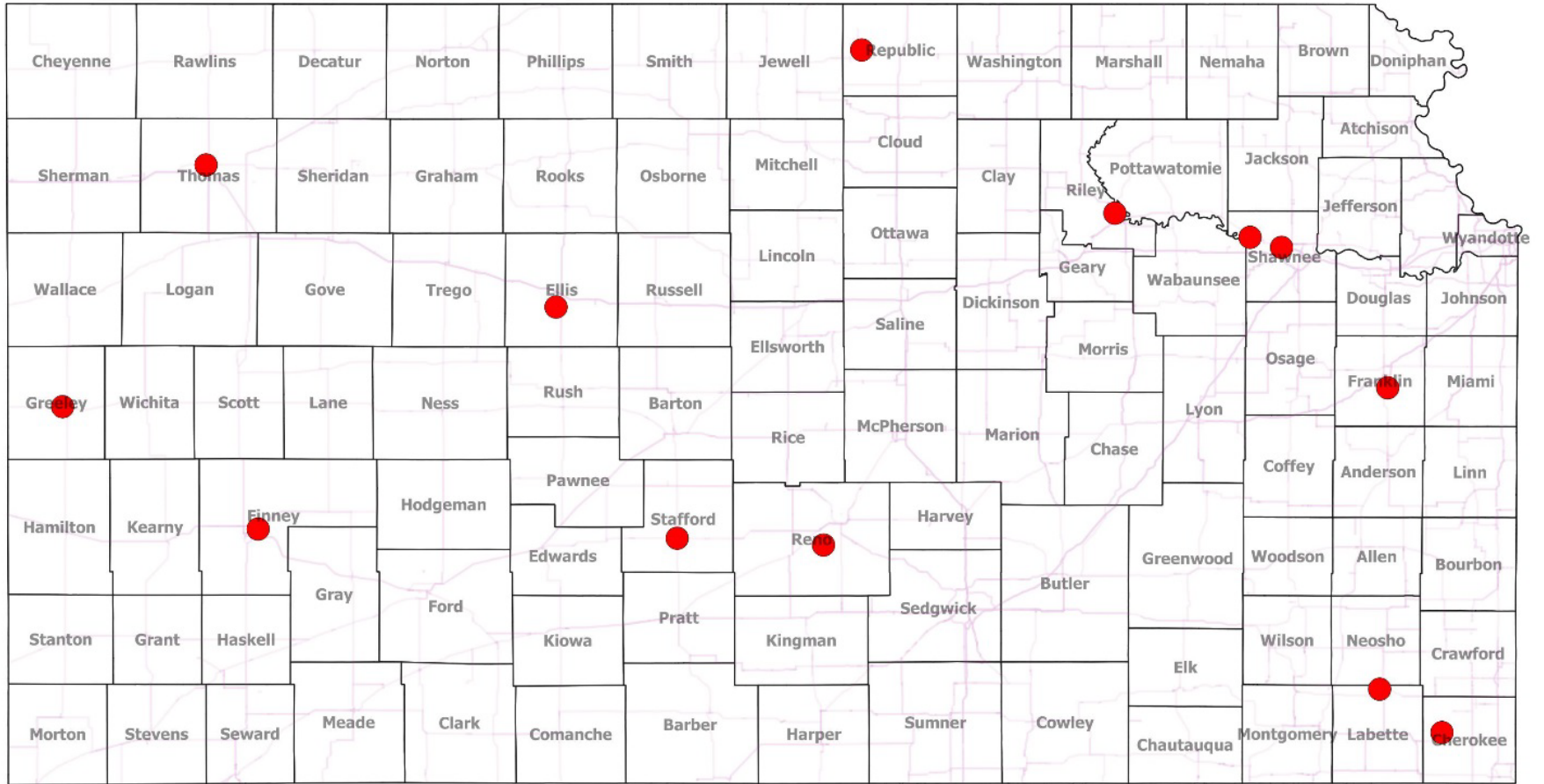
Assistant Professor in Soil Water Processes

**Christopher Redmond**

Manager of the Kansas Mesonet and Weather Data Library

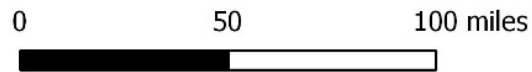


# 1990 K-State Kansas Mesonet



## Station Type

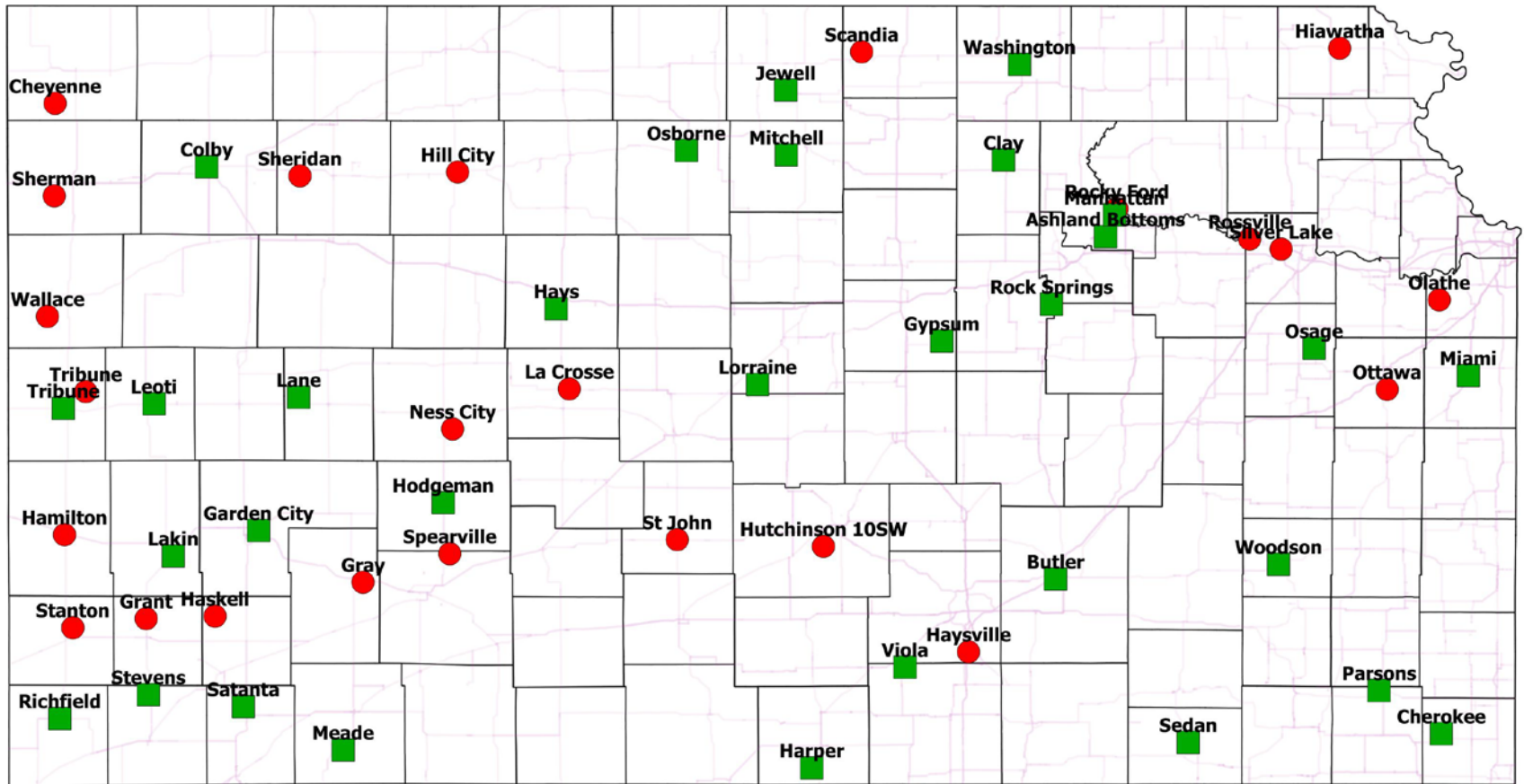
- Tripod
- Tower



Kansas State University Weather Data Library (WDL) Weather Station Mesonet  
As of: 1/11/15

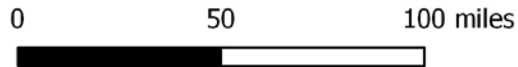
Created by: Christopher Redmond - WDL Manager  
christopherredmond@k-state.edu  
785-532-3029/785-477-6204  
mesonet.k-state.edu

# 2016 K-State Kansas Mesonet (4/18/16)



### Station Type

- 10ft Tripod
- 30' Tower



Kansas State University Weather Data Library (WDL) Weather Station Mesonet  
 As of: 4/18/16  
 Created by: Christopher Redmond - WDL Manager  
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 785-532-3029/785-477-6204  
[mesonet.k-state.edu](http://mesonet.k-state.edu)

# Network variables

<b>Current variable</b>	<b>Height</b>	<b>Observation frequency</b>
<b>Precipitation</b>	0.5 m	1-min, 5-min, hourly, daily
<b>Air temperature</b>	2.0 m	5-min, hourly, daily
<b>Barometric pressure</b>	1.5 m	1-min, 5-min, hourly, daily
<b>Relative humidity</b>	2.0 m	5-min, hourly, daily
<b>Wind speed</b>	2.0 m and 10.0 m	1-min, 5-min, hourly, daily
<b>Wind direction</b>	2.0 m and 10.0 m	5-min, hourly, daily
<b>Incoming solar radiation</b>	2.0 m	5-min, hourly, daily
<b>Soil temperature</b>	5, 10, 20, 50 cm depth	5-min, hourly, daily
<b>Soil moisture (CS655 probes)</b>	5, 10, 20, 50 cm depth	5-min, hourly, daily

# What's wrong with soil moisture?

- No strict siting protocol
- Soil moisture considered a second tier variable
- Different sensors and inconsistent profile layouts
  - Stevens: 5, 10, 20, 50, 90 cm
  - CS655: 20, 40, 60 cm
- No installation protocol

Kansas Mesonet station at **Scandia, KS**



Kansas Mesonet station at Sherman, KS

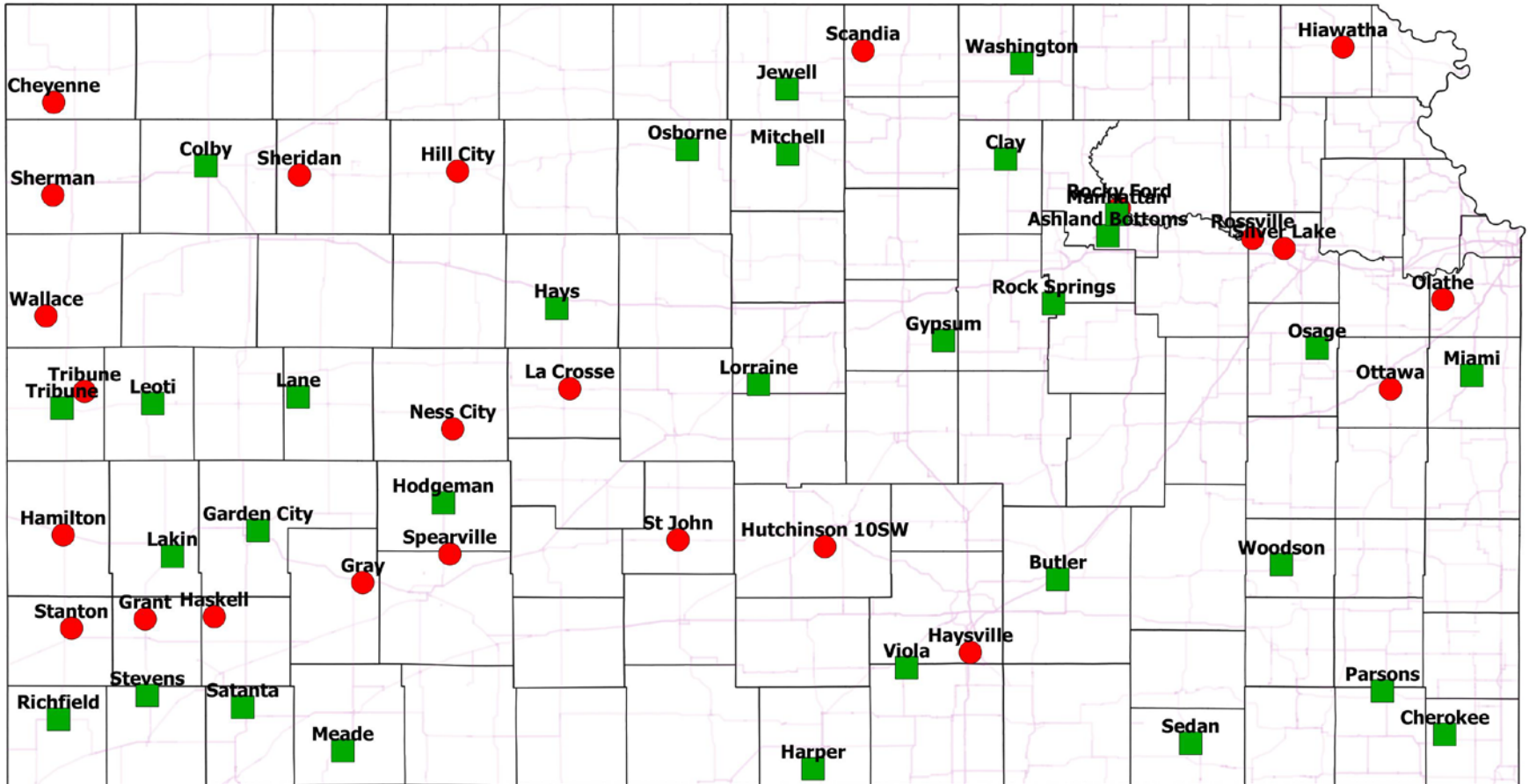


Kansas Mesonet station at **Ashland Bottoms, KS**



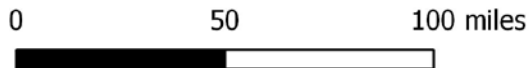


# 2016 K-State Kansas Mesonet (4/18/16)



## Station Type

- 10ft Tripod
- 30' Tower

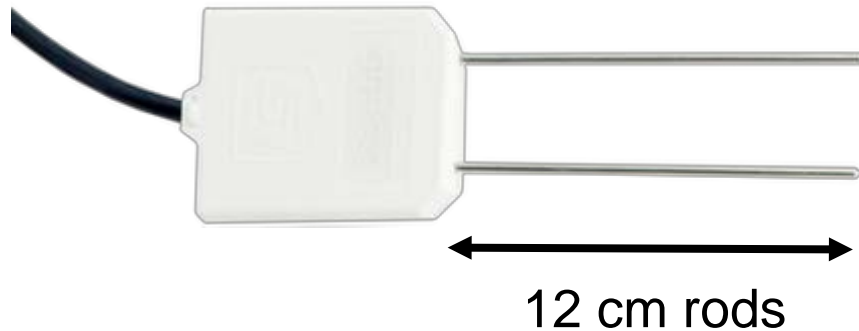


Kansas State University Weather Data Library (WDL) Weather Station Mesonet  
As of: 4/18/16

Created by: Christopher Redmond - WDL Manager  
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# Sensor Selection

CS655 Soil water reflectometer



## Output variables

1. Period average
2. Voltage ratio (signal attenuation)
3. Temperature
4. Dielectric constant
5. Electrical conductivity
6. Volumetric water content

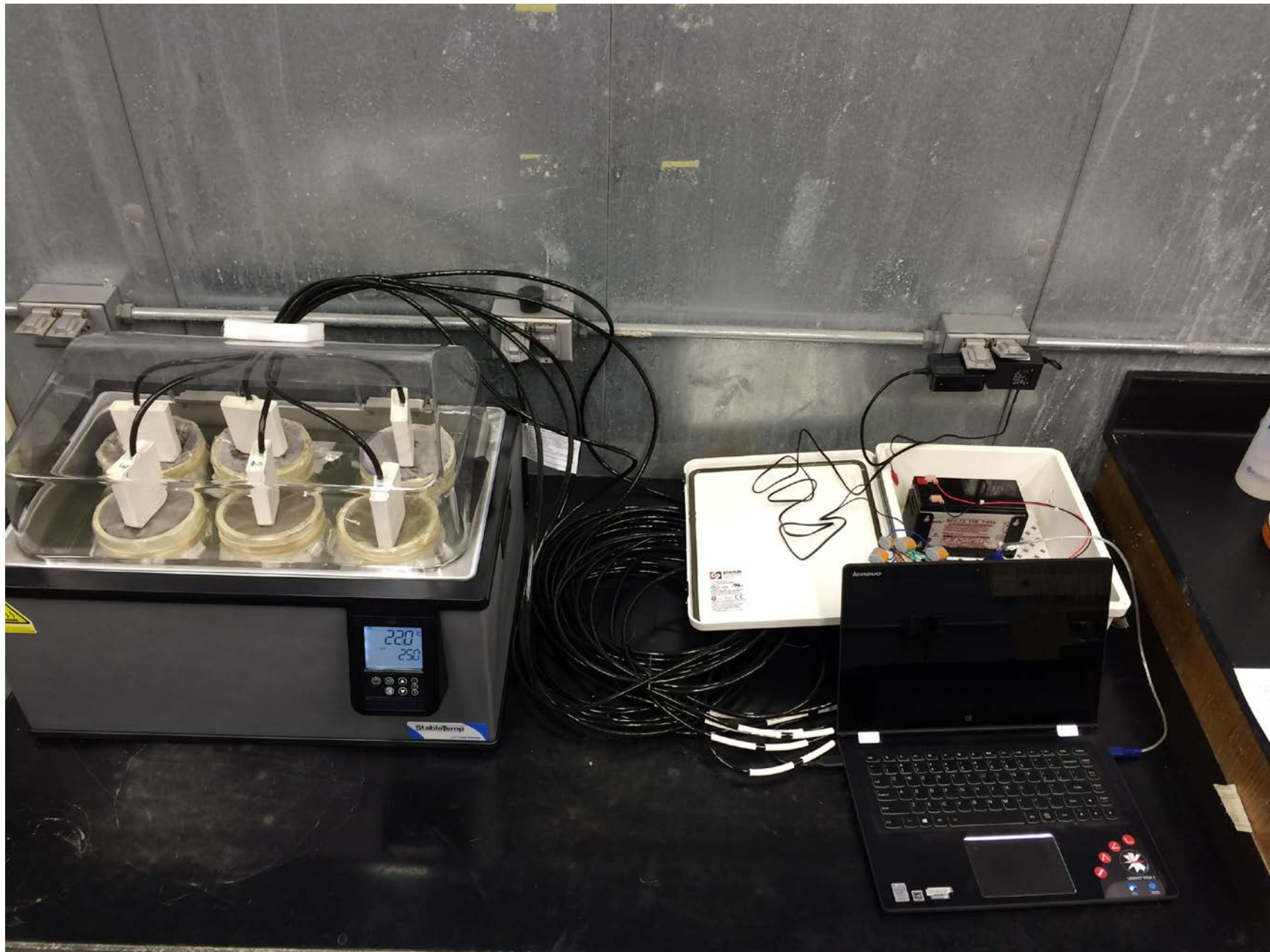
Period average  
EC



Dielectric  
constant



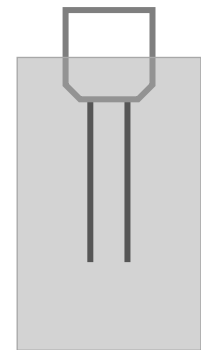
Volumetric  
water content



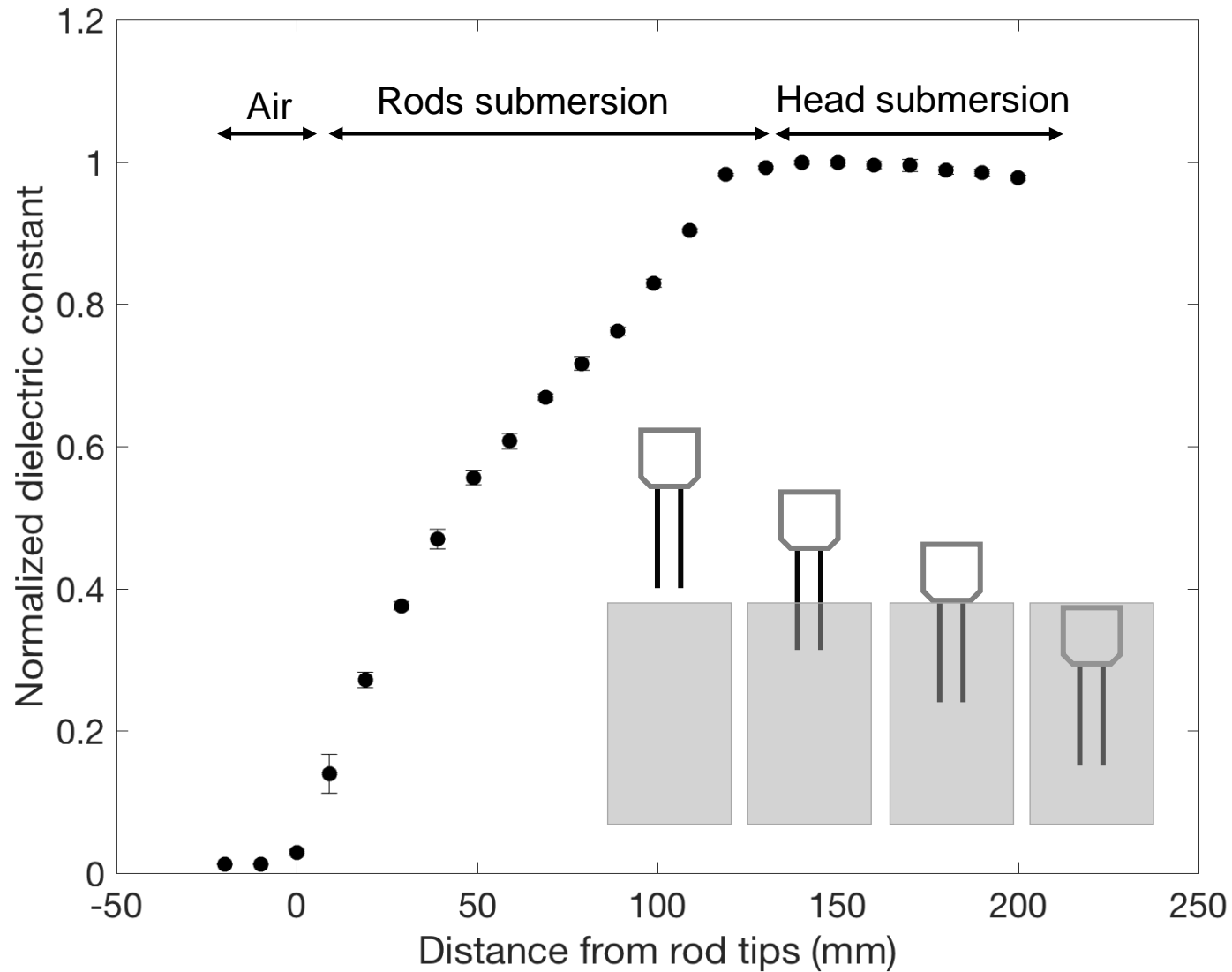
# Sensor-to-sensor Variability

- 4L container with de-ionized water-CaCl<sub>2</sub> solution at 22.1 degrees Celsius and 0.72 dS/m.
- We tested 4 sensors and sensor average was calculated based on three consecutive sensor readings.
- Sensors head was submersed 4 cm.

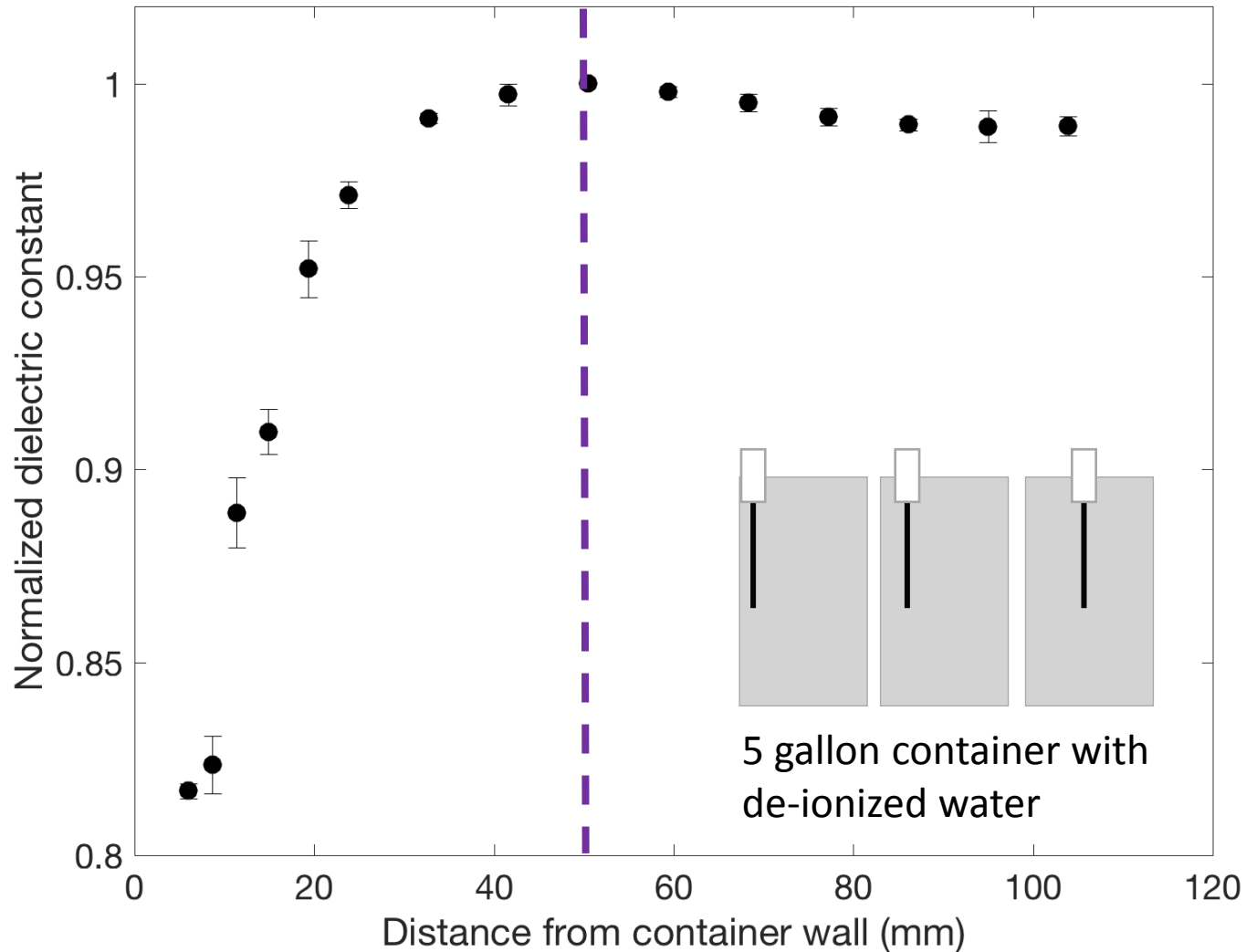
	PA	VR	T	Ka	EC
	Unitless	Unitless	Celsius	Unitless	dS/m
CV	0.18	0.26	0.31	0.50	1.57
Max	2.59	1.91	22.18	80.64	0.74
Min	2.58	1.9	22.02	79.68	0.71
Range	0.01	0.01	0.17	0.96	0.027



# Partial Rod Submersion

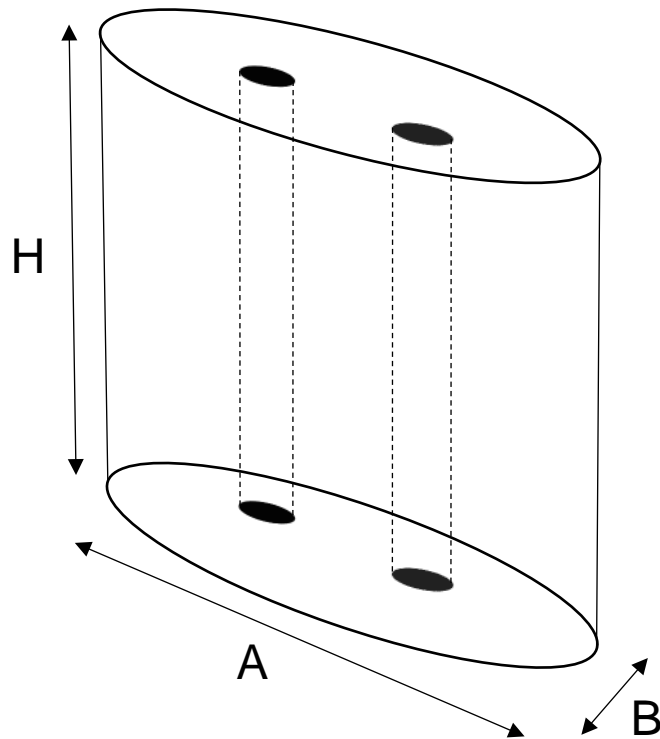


# Sensing Volume in Water



# Sensing Volume in Water

Elliptical cylinder



$$V = \pi \frac{A B H}{4} = 1600 \text{ cm}^3$$

$$A = 5 \text{ cm} + 3.5 \text{ cm rod spacing} + 5 \text{ cm} = 13.5 \text{ cm}$$

$$B = 5 \text{ cm} + 5 \text{ cm} = 10 \text{ cm}$$

$$H = 12 \text{ cm rods} + 3 \text{ cm beyond rods} = 15 \text{ cm}$$

Manufacturer reports 3600 cm<sup>3</sup>

# Electrical Conductivity

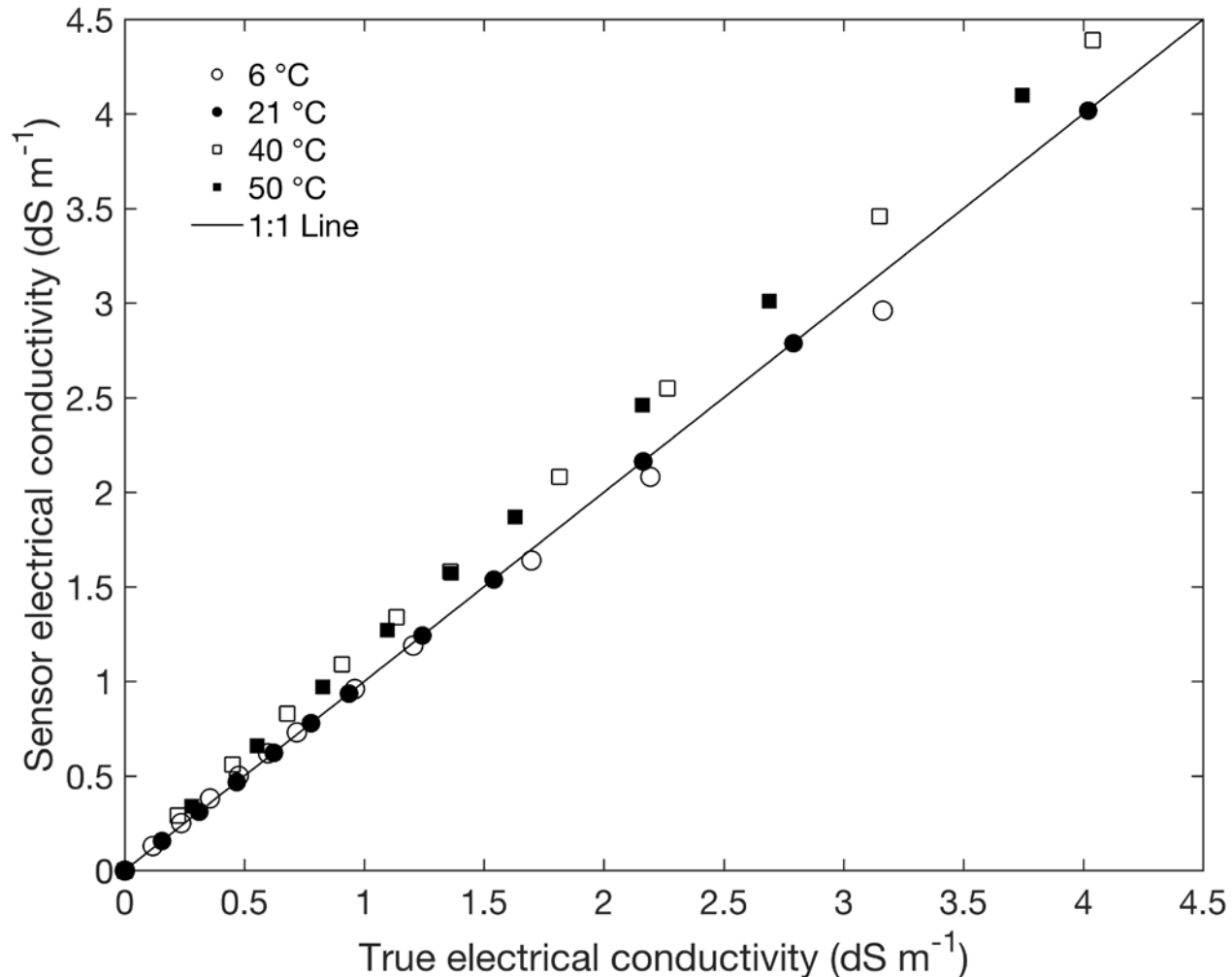
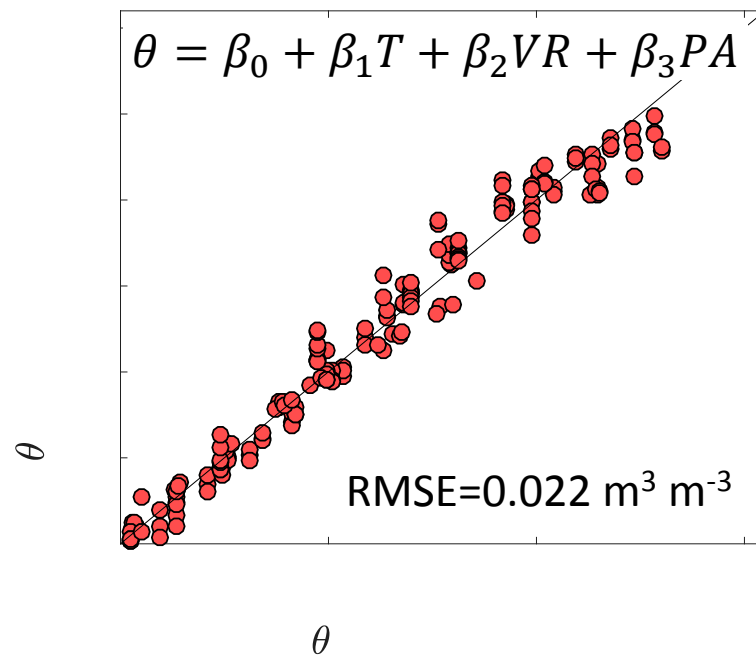
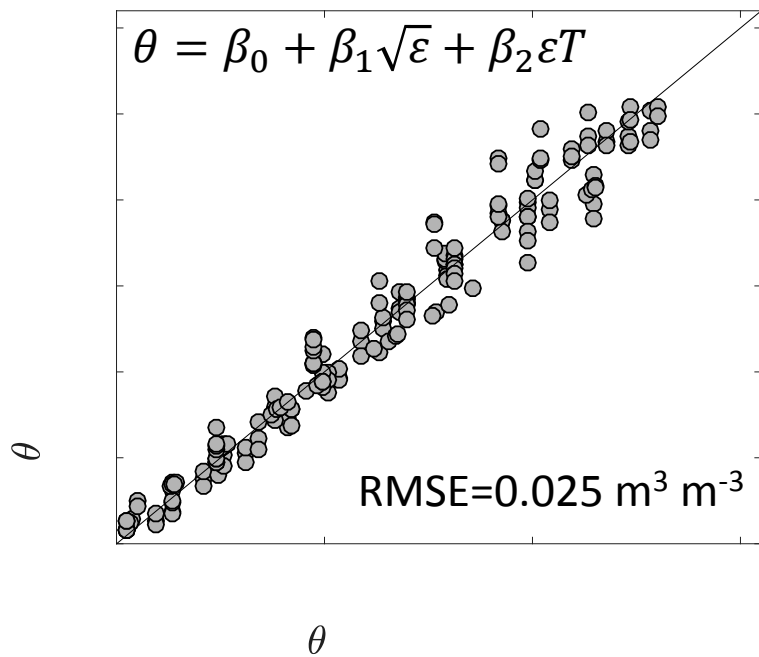
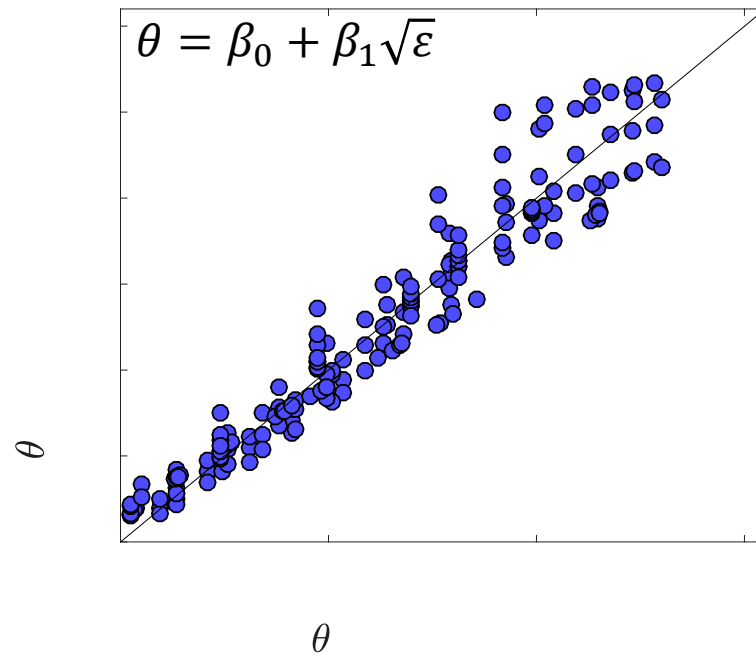
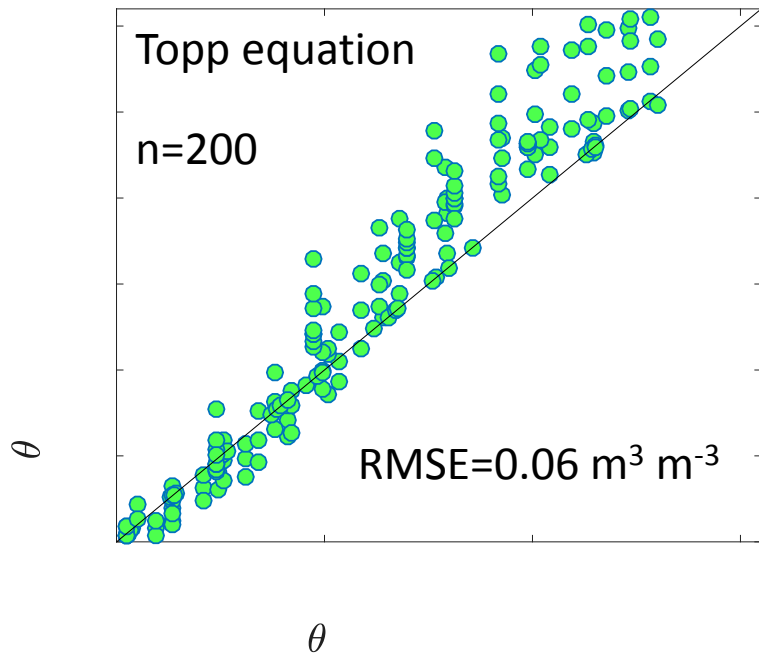


Figure showing the agreement of electrical conductivity values obtained with the CS655 sensor and theoretical electrical conductivity values of DI water-calcium chloride solutions at different temperatures.







**Bottom soil**

**Medium layers soil**

**Intact top soil**

Soil temperature sensors

Soil moisture sensors

CS655  
5 cm  
10 cm  
20 cm  
50 cm



# RESTful Service

<http://mesonet.k-state.edu/rest/>

Parameter	Example	Description
stn	Butler,Clay	Station name or comma-separated list of names (no space after the comma). <b>For a list of station names see below.</b> 'all' is an accepted station name and will return data for all stations.
net	KSRE	Network name, <b>alternative to "stn"</b> . One of 'KSRE', 'BBW' or 'EBW'. Selects all stations within the network.
int	day	Observation interval, one of 'day', 'hour' or '5min'
t_start	20160101000000	Timestamp of first observation: YYYYmmddHHMMSS
t_end	20160201000000	Timestamp of last observation: YYYYmmddHHMMSS

The examples in the table would be combined to create the following URL: [http://mesonet.k-state.edu/rest/stationdata/?stn=AshlandBottoms&int=day&t\\_start=20160101000000&t\\_end=20160201000000](http://mesonet.k-state.edu/rest/stationdata/?stn=AshlandBottoms&int=day&t_start=20160101000000&t_end=20160201000000)

# Future

- Deploy soil moisture sensors in 21 stations with towers during the summer 2017.
- Quality Control/Quality Assurance.
- Add soil moisture to the web API.
- Upgrade tripods to towers.
- Where do we install the next stations?