# The Oklahoma Mesonet: Why We Did It & Lessons Learned
## (Its Value to the Citizens of Oklahoma)

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**The Oklahoma Mesonet**

**Oklahoma Climatological Survey**
**University of Oklahoma**

**June 15, 2007**

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# *The Purpose of This Presentation*

- The purpose of this presentation is to reflect on “lessons learned” during the past 15-20 years in designing, implementing, maintaining, and operating the Oklahoma Mesonet.

- The focus will be on:
  - Overview of our network
  - Our good and not-so-good lessons learned
  - Our experience with soil moisture measurements

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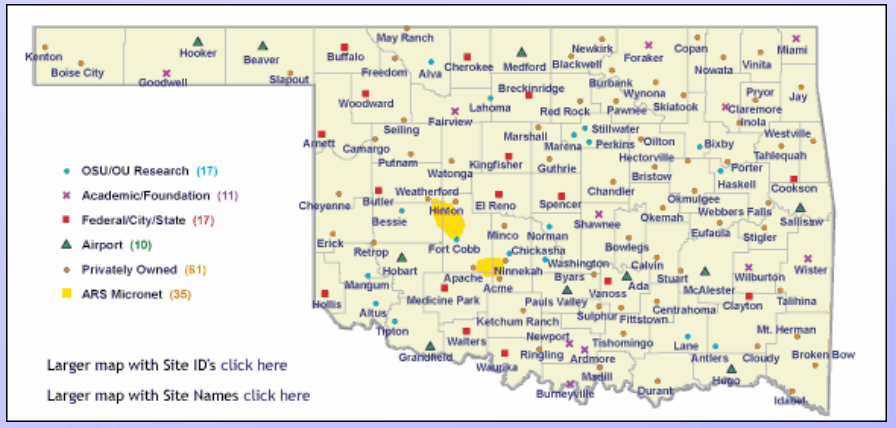
# *The Oklahoma Mesonet*

- Statewide weather & climate network — Planned 1986-1991
- Commissioned in 1994
- Atmospheric measurements with 5-minute resolution

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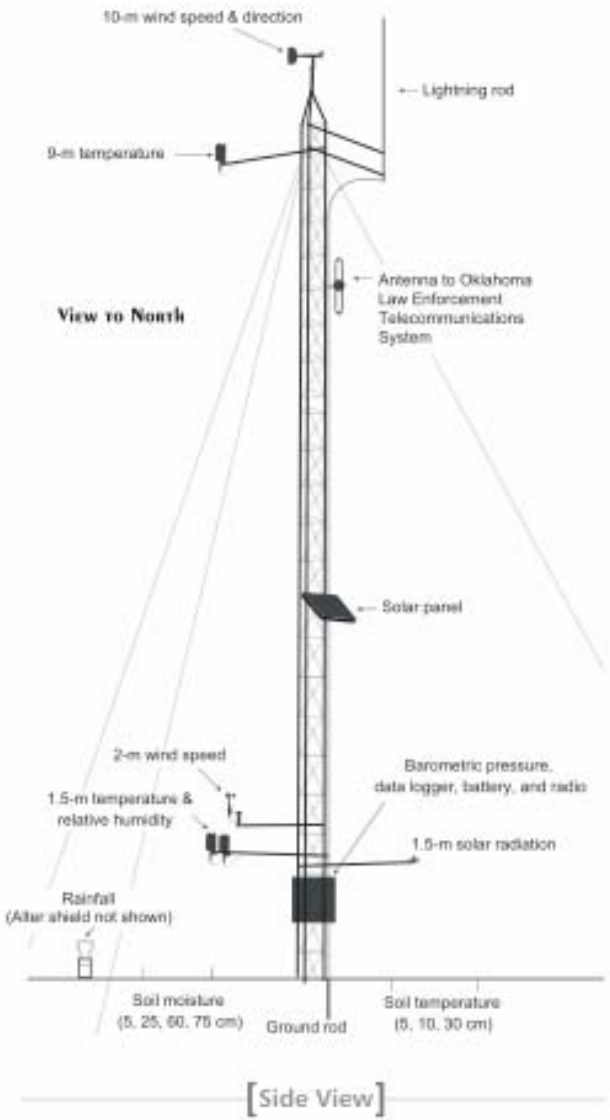
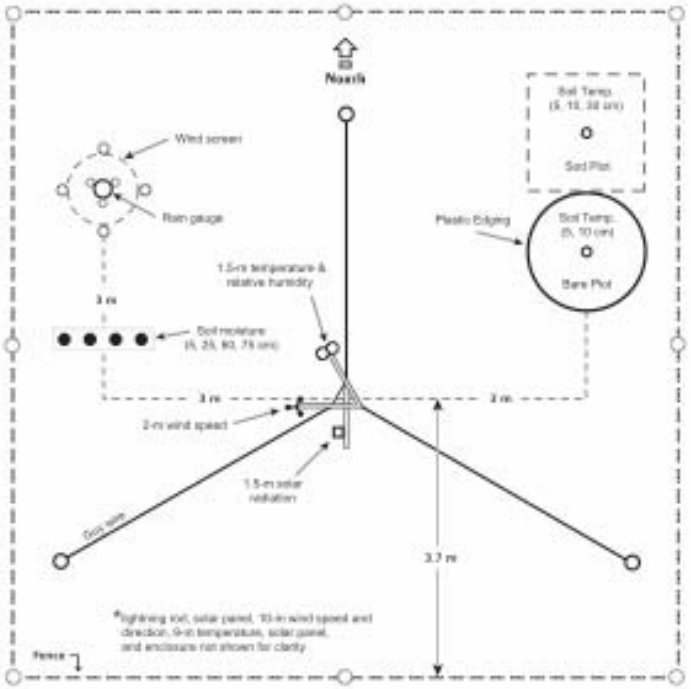
# The Oklahoma Mesonet
## Key Ingredients for Success

- Standardized hardware, siting and maintenance procedures at each site (Fig. 1)
- Reliable two-way communications with each remote site (Fig. 2). The near-zero recurring costs (due to a partnership with the Oklahoma Department of Public Safety) were the initial ingredients to foster development of the Mesonet.
- Aggressive data quality control and quality assurance procedures (QC/QA; Fig. 3; Shafer et al. 2000; Fiebrich and Crawford 2001; Fiebrich et al. 2005).
- Quality products, relevant to each sector of users, that are intuitive and operate on the user computers (Fig. 4).
- Strong educational outreach programs that support individual user groups with a variety of products (Fig. 5).
- Data that has a research quality, yet is provided in real time (< 5 minutes; Fig. 6).

# The Oklahoma Mesonet:
## Standardized Installations (Fig. 1)




[Side View]




[Top View]

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# Cost of a Typical Site ~$21K

- 10 m tower, lightning protection, guy wires, fencing, and datalogger enclosure
- 2 solar panels and 3 batteries to power datalogger, communications, and heating of anemometer
- Datalogger, multiplexer, and logger serial interface
- VHF radio, modem, antenna and cables
- Air temperature (with radiation shield), relative humidity, pressure, soil temperatures (5 depths), solar radiation, rainfall (with alter shield), ultrasonic wind speed (10 m), wind sentry (2 m), and soil moisture (3 depths)
  - http://www.mesonet.org/instruments

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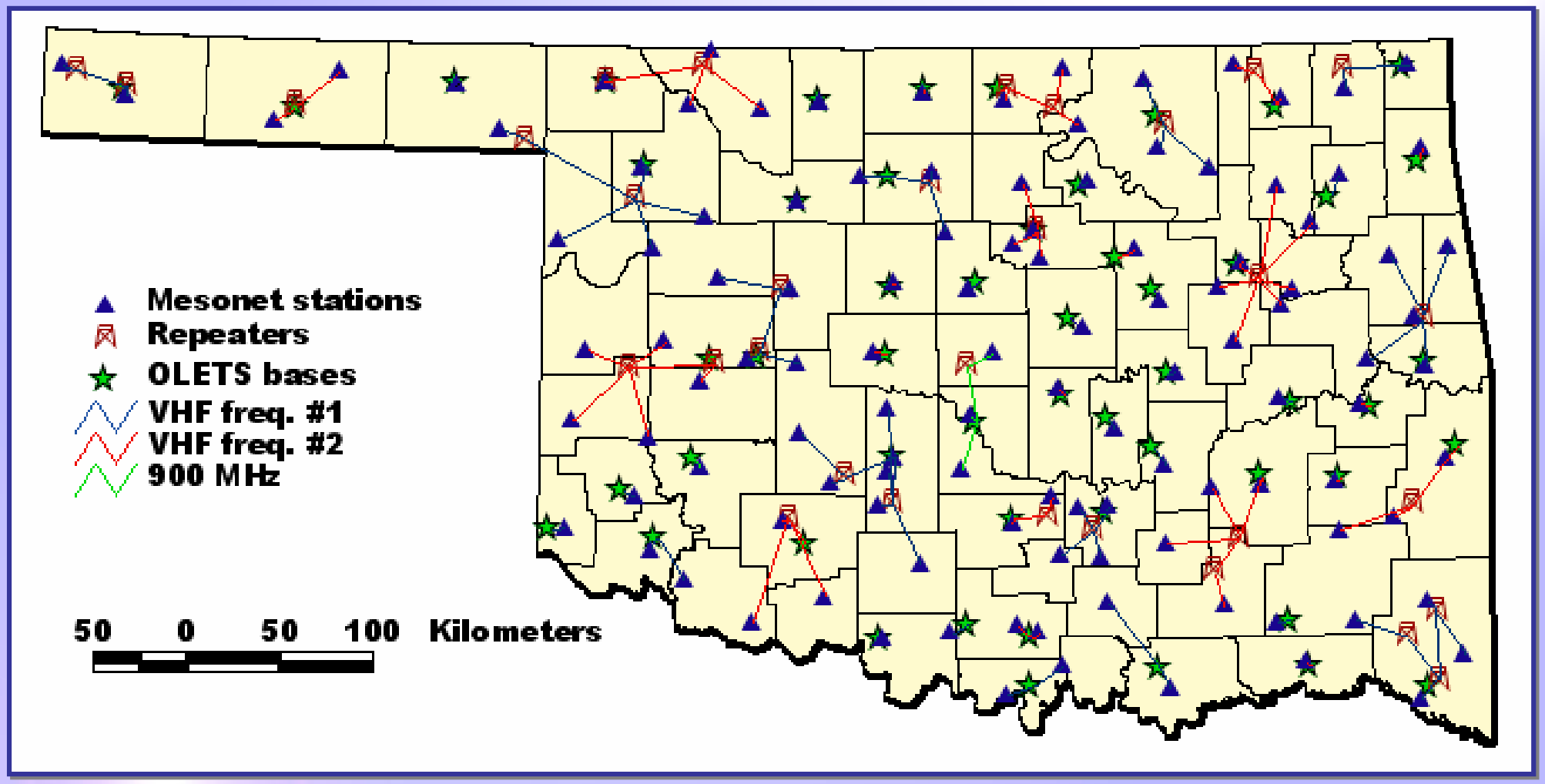
# Additional Equipment

- 74 sites have net radiometers and skin temperature sensors
  - Add ~$1800 per site

- 2 sites have 4-component net radiometers, 3-D sonic anemometers, and soil heat flux sensors
  - Add ~$16K per site


# The Initial, Key Ingredient:
## Reliable, No-Cost Communications (Fig. 2)

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# Communications Infrastructure Costs

- Remote Station



  - Modem, Radio, Antenna Cable, Antenna [~$1100]

- Base Station





  - UDS-10, Telnet Power Switch, Radio, Modem, Antenna Cable, Antenna, Router [~$1500]

- Repeater Station



  - Radio, Modem, Antenna Cable, Antenna [~$1100]

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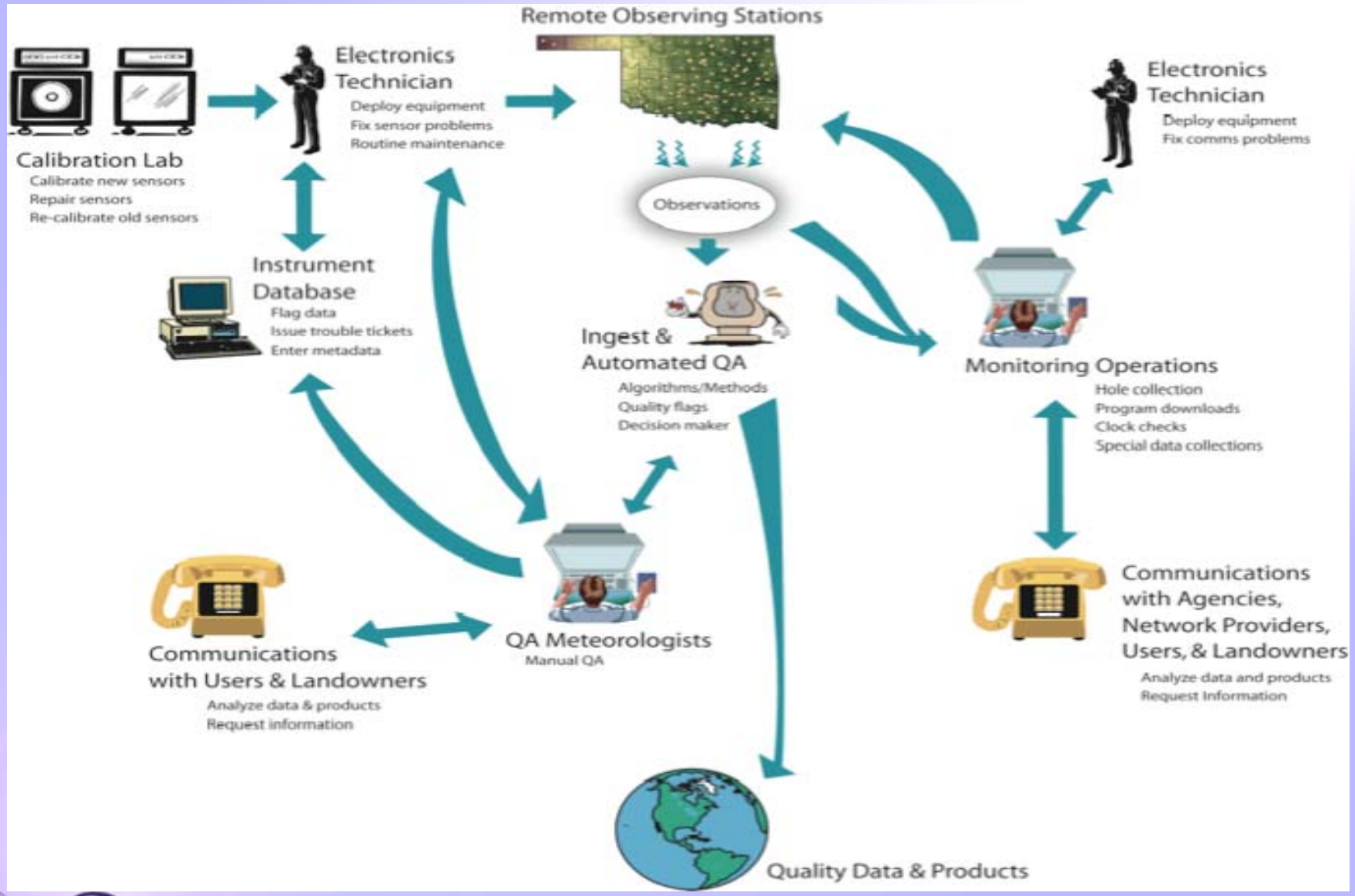
# The Oklahoma Mesonet:
## Aggressive Data QC/QA Procedures (Fig. 3)

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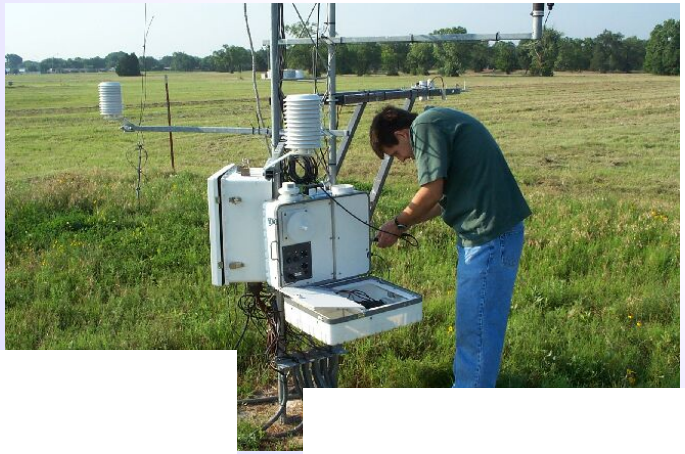
# QA System: Calibration




QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

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TIFF (Uncompressed) decompressor
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# QA System: Routine Maintenance

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# QA System: Automated QA

**Filters**

- Missing
- Range
- Qualparm
- Tech Visit

- Spatial
- Step
- Persistence
- Like Instrument
- Climate Range

**Independent Algorithms**

- Small Like
- Step to Normal
- Like Adjust Spatial
- Spatial Adjust Like
- Spatial Adjust Climate
- Like Adjust Climate
- Hot Soil Like Adjustment
- Hot Soil Spatial Adjustment

**Adjustment Tests**

- Soil Moisture Delta T
- Soil Moisture Step
- Soil Moisture TREF
- Soil Moisture Freeze
- Barometer Error
- Battery Check
- Theoretical Solar Radiation
- Heat Transfer
- Wind Speed Profile
- Net Radiation Rainfall
- IRT Obstruction

**Sensor-specific Tests**

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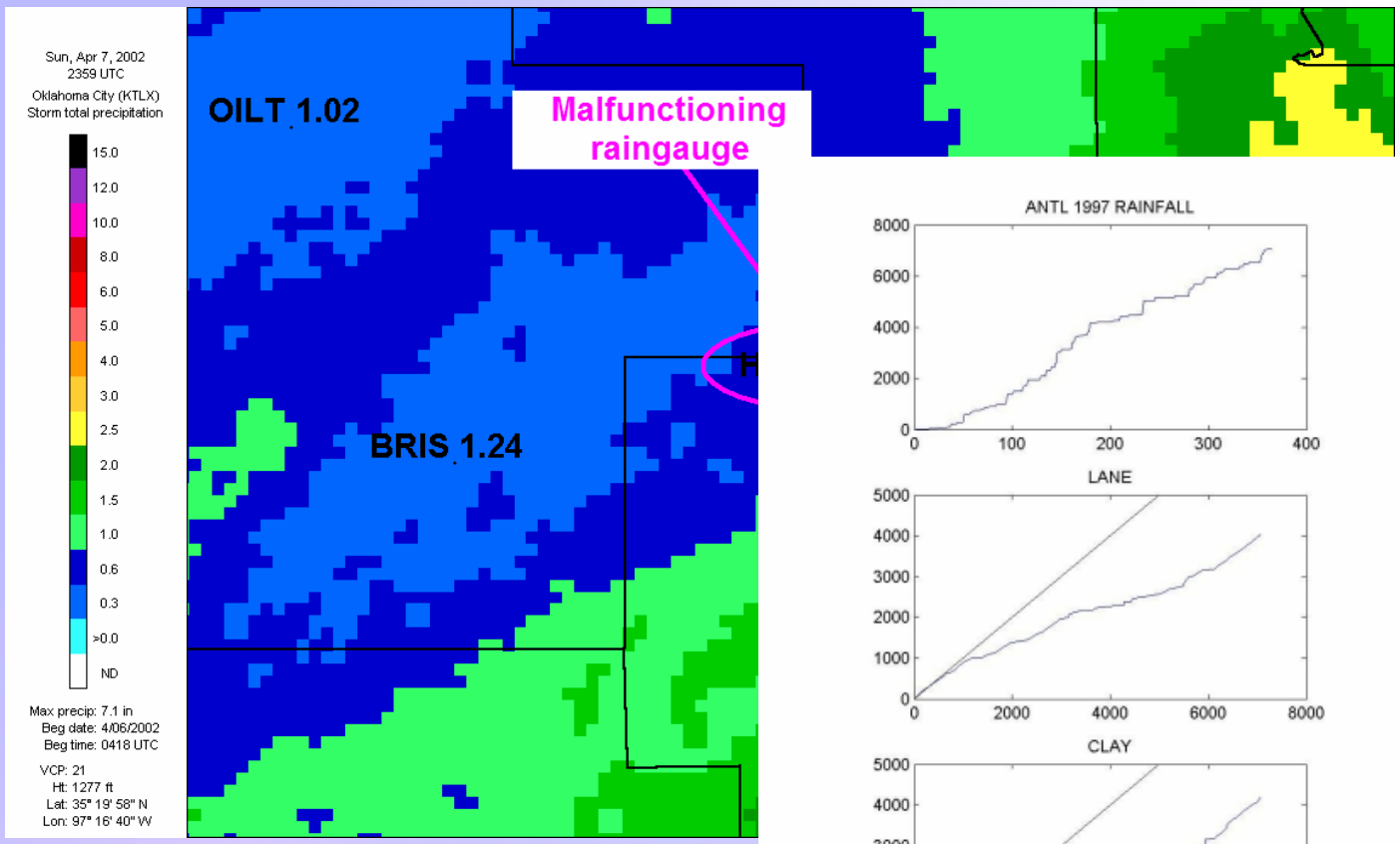
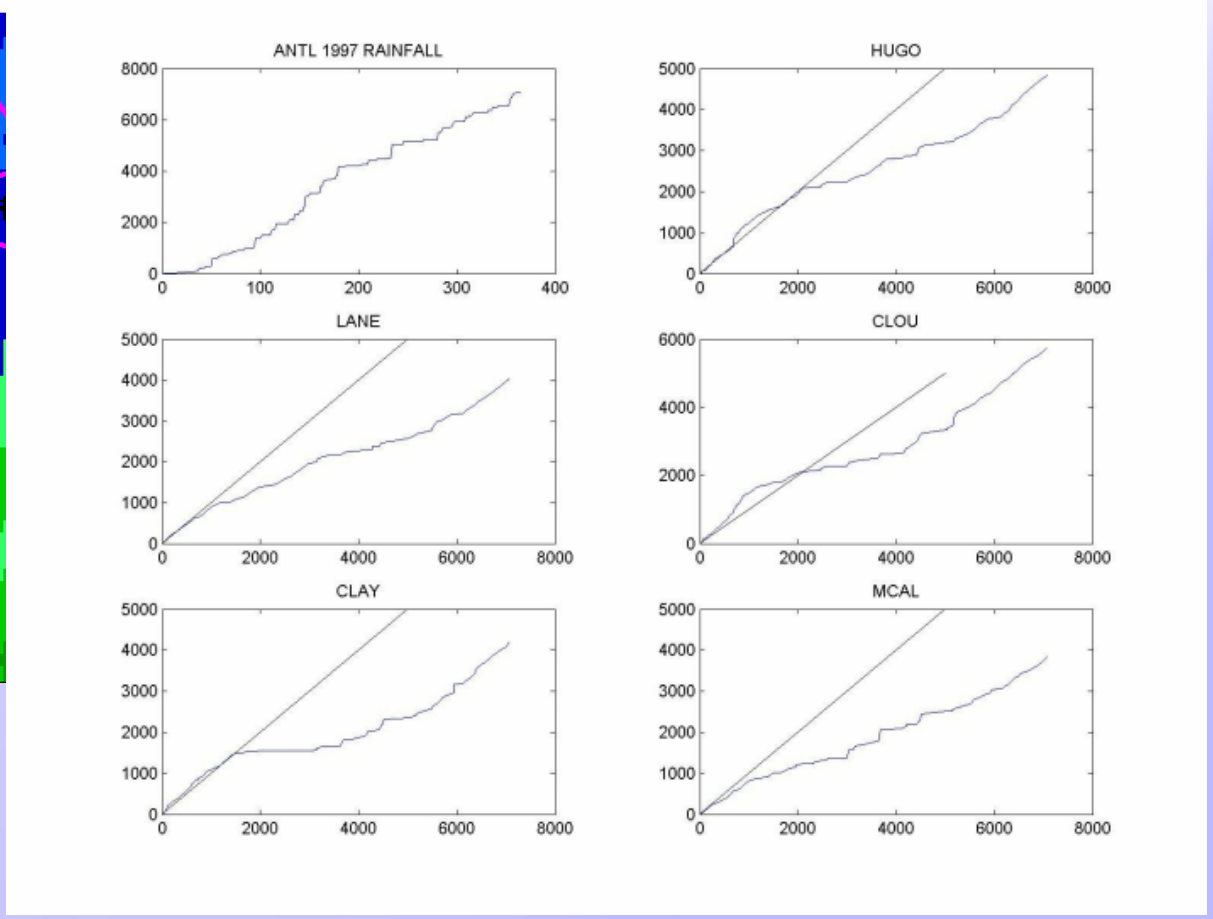
# QA System: Automated QA

- Air Temperatures at 1.5 and 9.0 m
- Relative Humidity
- Pressure
- Soil Heat Flux
- Solar Radiation
- Rainfall
- Wind Speeds at 2, 4, 9 and 10 m
- Wind Gusts at 10 m
- Wind Direction at 10 m
- Soil Moisture at 5, 25, 60 and 75 cm
- Net Radiation
- 4-Component Radiation
- Sensible Heat Flux
- Skin Temperature
- Soil Temperatures at 5, 10, 15 and 30 cm

38 unique variables tested in real-time
43 unique variables tested daily
9 additional variables tested for flux datasets

# QA System: Manual QA

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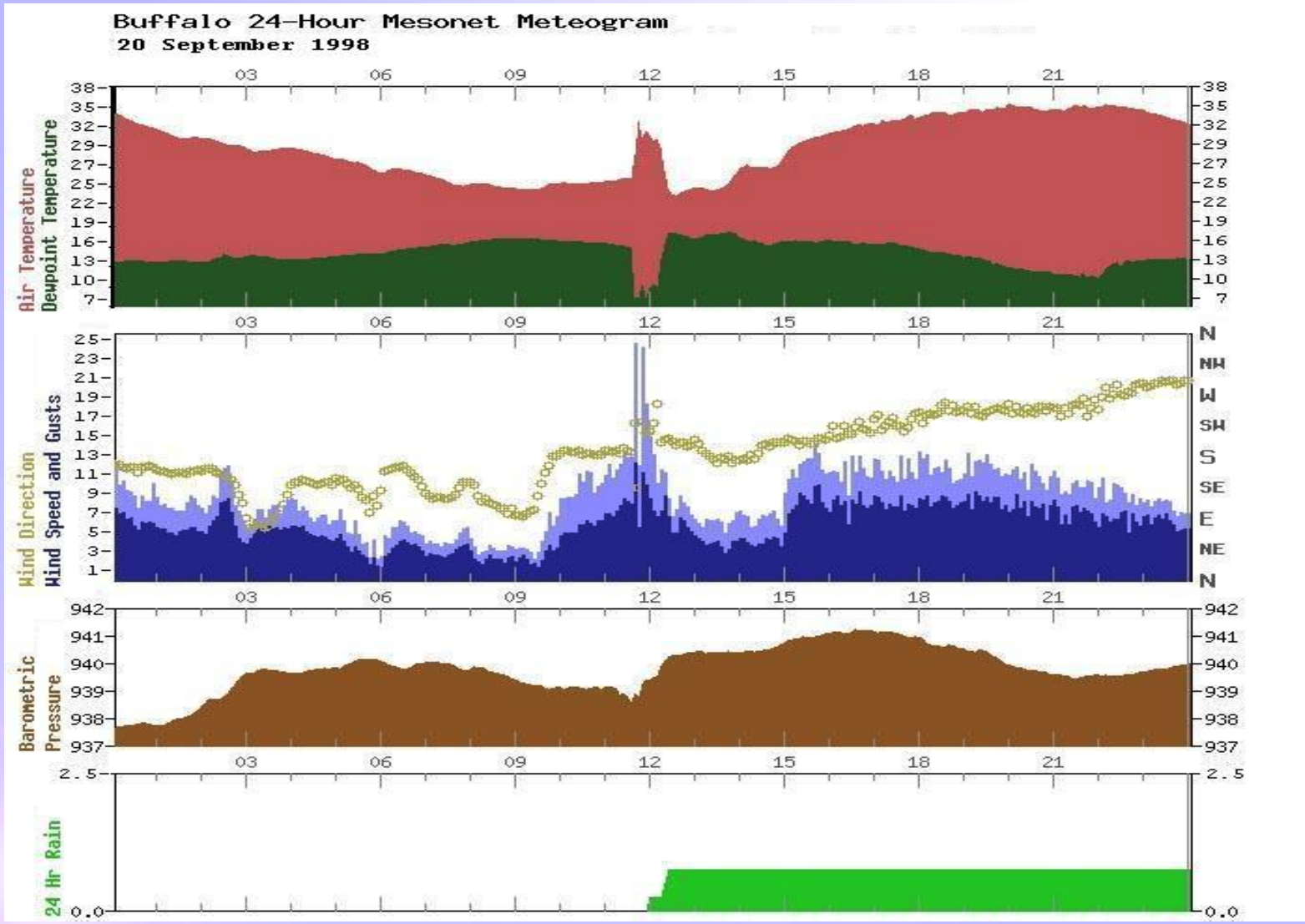
# Manual QA (cont.)



# QA System: Monitoring

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Ingest Timelog Report - Microsoft Internet Explorer

| | |
|---|---|
| Report Last Updated: | 2002-06-25 06:20:53 |
| Server: | LoggerNetB |
| Client: | devnull |
| Port: | raw |

| Station | Last Reported | Table | Latest Timestemp |
|---|---|---|---|
| ADAX | 2002-06-25 06:19:33 | | |
| | | ESM30C | 2002-06-25 06:00:00 |
| | | MES05H | 2002-06-25 06:15:00 |
| | | MES15B | 2002-06-25 06:15:00 |
| ALV2 | 2002-06-25 06:19:51 | | |
| | | ESM30C | 2002-06-25 06:00:00 |
| | | MES05H | 2002-06-25 06:15:00 |
| | | MES15B | 2002-06-25 06:15:00 |
| | | SUP05F1 | 2002-06-25 06:15:15 |
| | | SUP05F2 | 2002-06-25 06:15:15 |
| | | SUP05F3 | 2002-06-25 06:15:15 |
| BEEX | 2002-06-25 06:16:44 | | |
| | | MES05J | 2002-06-25 06:15:00 |

Data Holes - Microsoft Internet Explorer

## Latest Missing Records/Holes Count by Site

Mon, Jun 24, 2002
1146 UTC

MREC
## MREC
HOLE
ID Site ID
Mesonet sites
State border (OK)
County borders (OK)

Traffic Analysis for fxp1 -- bridge - Microsoft Internet Explorer

`Daily' Graph (5 Minute Average)

Bytes per Second: 680.0, 510.0, 340.0, 170.0, 0.0

6 4 2 0 22 20 18 16 14 12 10 8 6 4 2 0 22

Max In:454.0 B/s (6.5%) Average In:250.0 B/s (3.6%) Current In:171.0 B/s (2.4%)
Max Out:642.0 B/s (9.2%) Average Out:292.0 B/s (4.2%) Current Out:176.0 B/s (2.5%)

`Weekly' Graph (30 Minute Average)

Bytes per Second: 720.0, 540.0, 360.0, 180.0, 0.0

Mon Sun Sat Fri Thu Wed Tue Mon

PINE 4.21 MESSAGE TEXT Folder: systemreports Message 773 of 774 75%

Subject: Morning System Report 6/24/2002

Good Morning,

Critical: - NONE.

General System Report

LOG A: - OK.

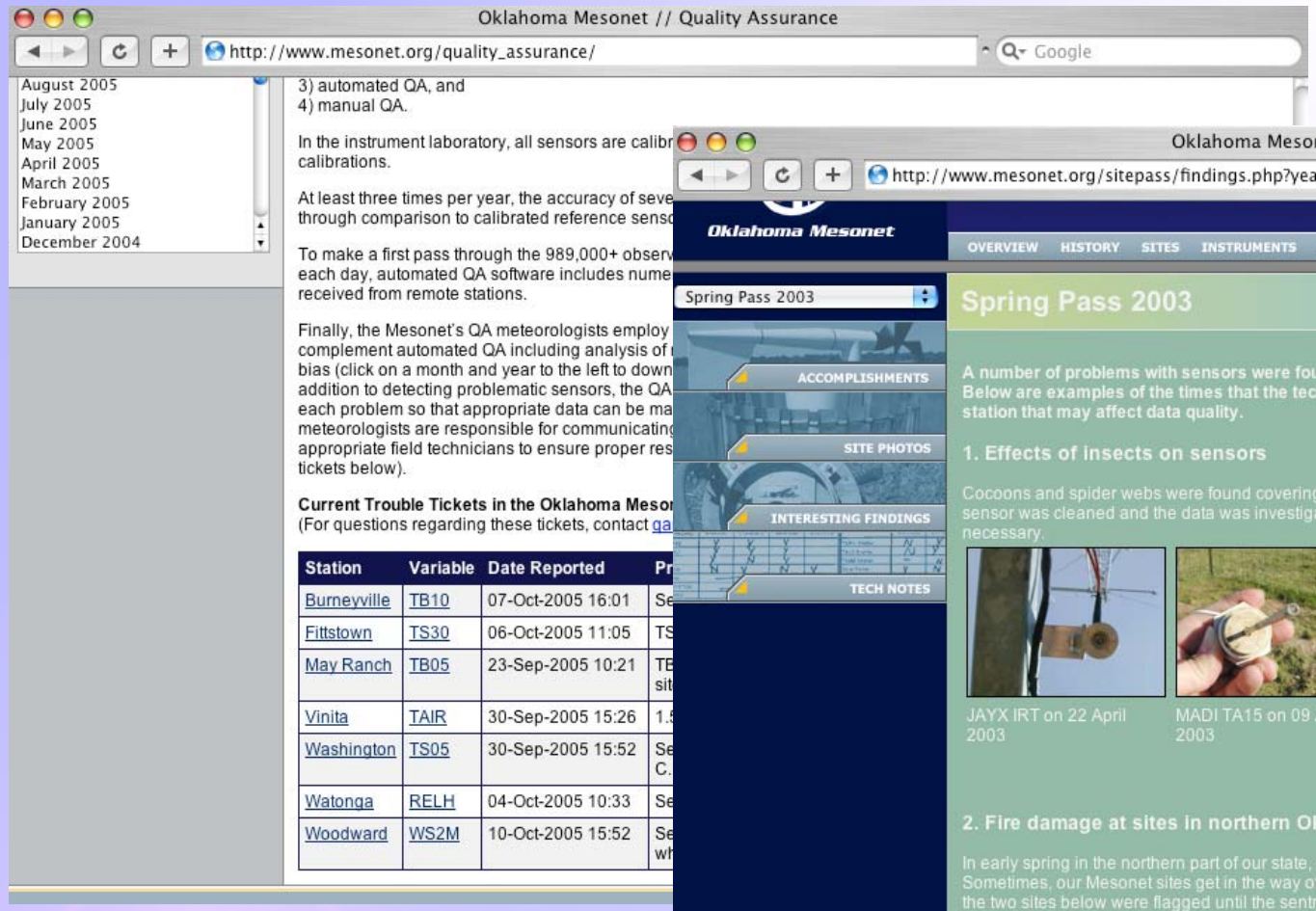
LOG B: - JAYX brief period of hvy PF about 3z.
- BREC mod PF past 4 hrs.
- FORA period of sct mod PF from about 2-8z.
- BOWL hvy PF past 5 hrs (just got some current data).
- CHER period of sct mod PF from about 1-5z.
- WOOD sct hvy PF from about 1-5z.

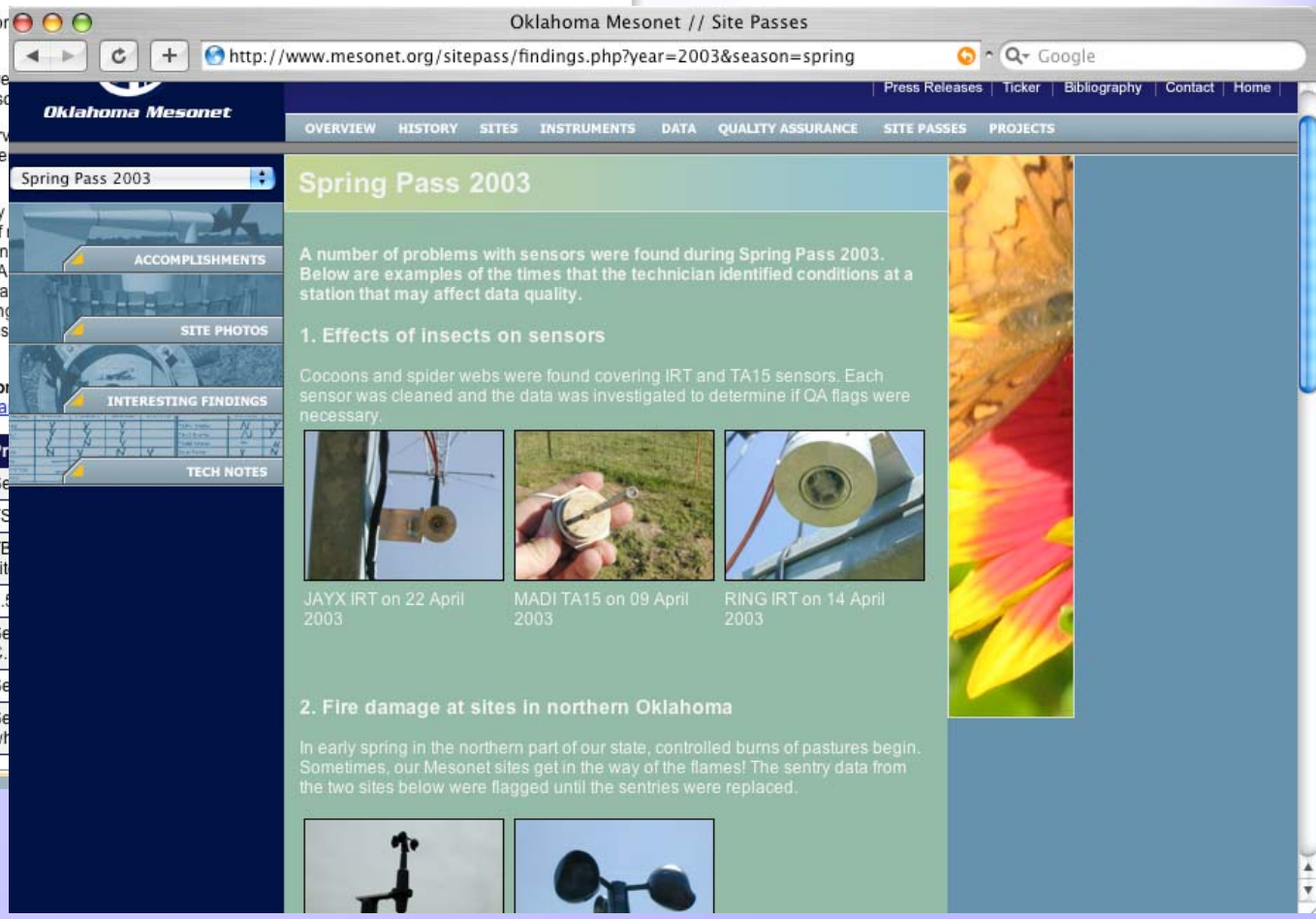
LOG C: - OK.

? Help, O OTHER CMDS, < MsgIndex, > ViewAttch, P PrevMsg, N NextMsg, - PrevPage, Spc NextPage, D Delete, U Undelete, R Reply, F Forwar

Start | Data Holes - Microsoft Int... | Ingest Timelog Report - M... | Traffic Analysis for fxp... | operations.ocs.ou.edu - ... | 6:25 AM

# QA System: Metadata

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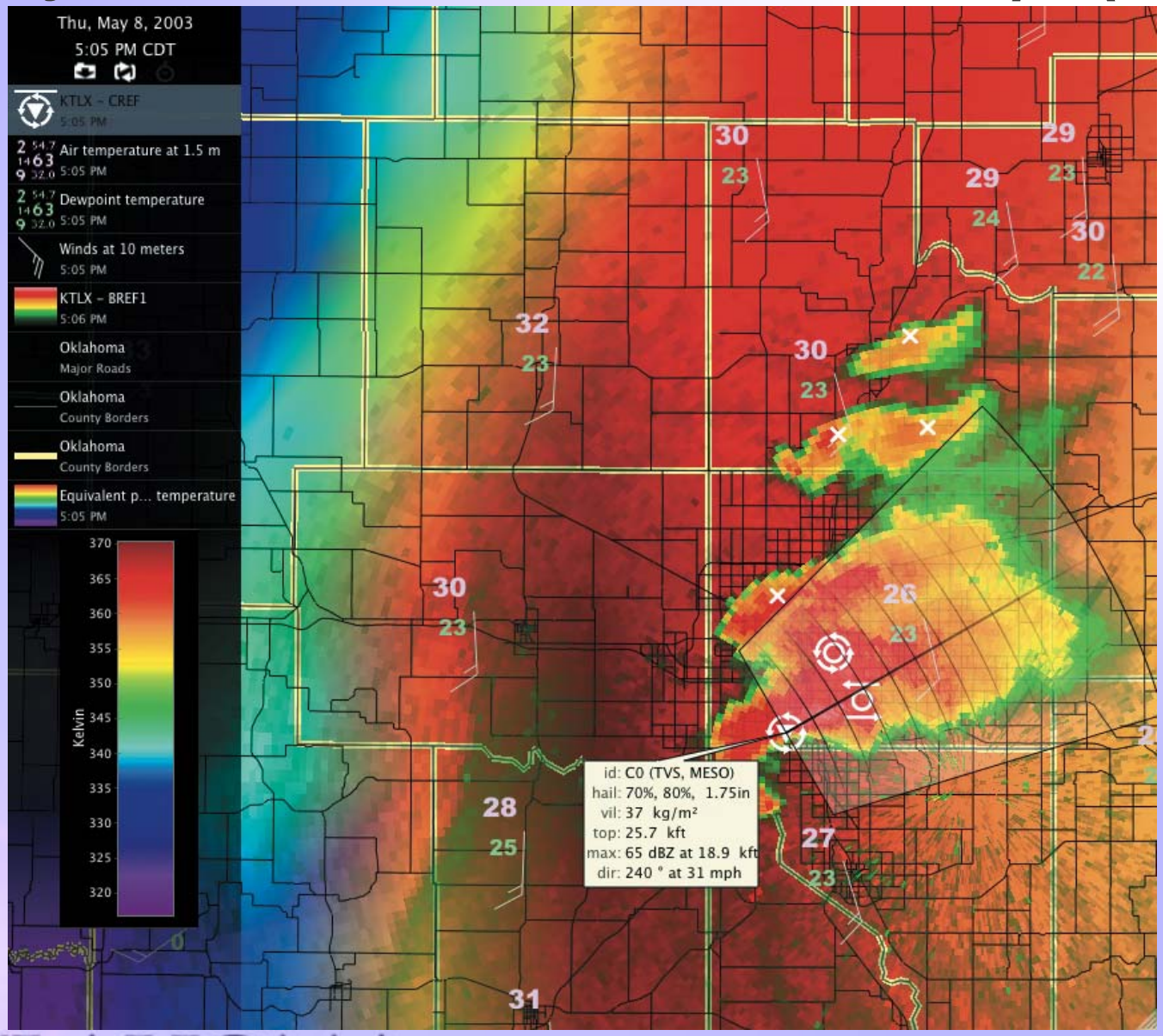
# The Oklahoma Mesonet:
## Quality Products Relevant to User Groups (Fig. 4)

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# The Oklahoma Mesonet
## Strong Educational Outreach Programs (Fig. 5)



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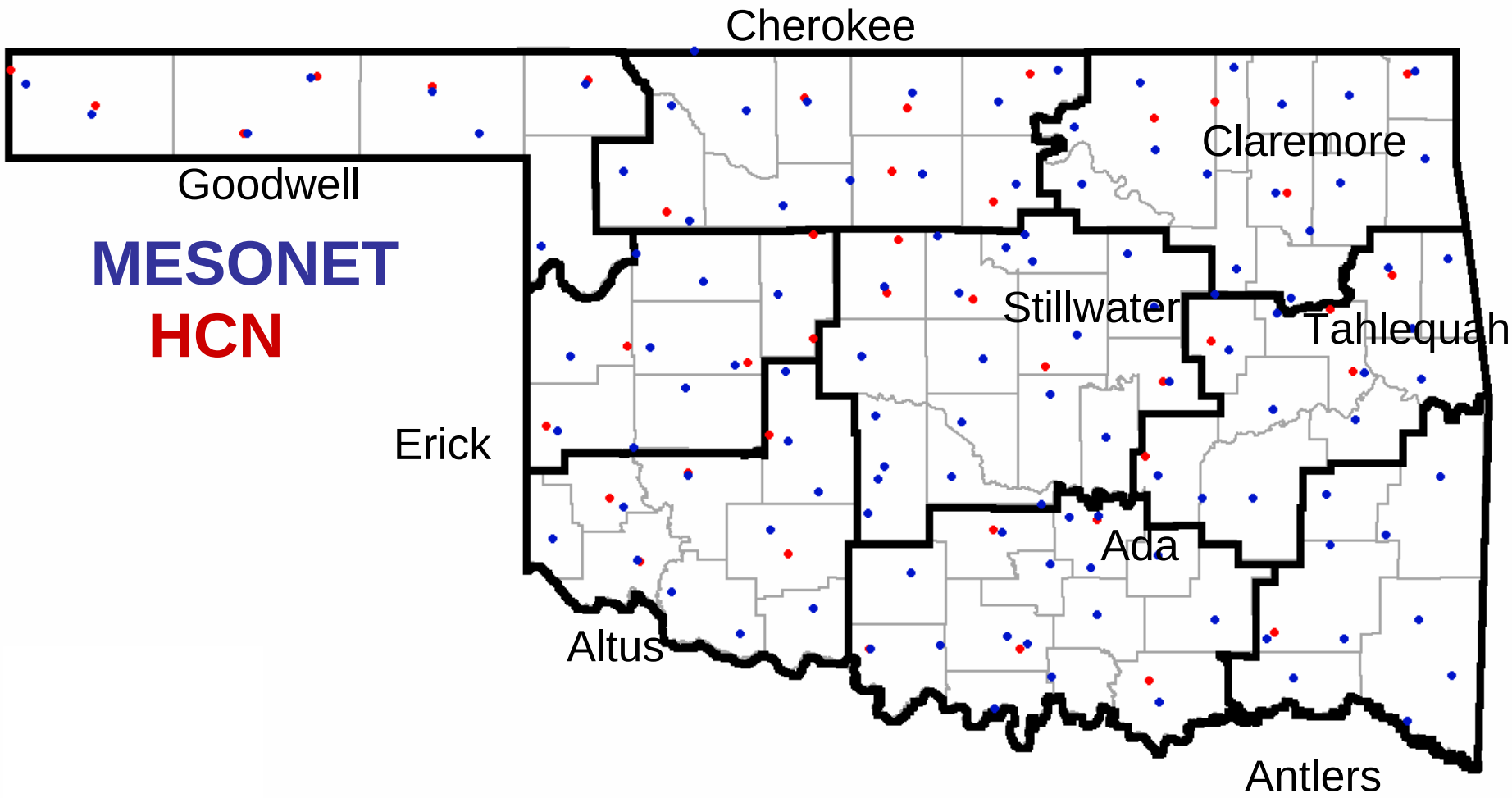
# Mesonet-HCN Comparisons

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# Summary of HCN-Mesonet Comparisons

| | >1°C | > 2°C | >3°C | >4°C | >5°C | >6°C |
|---|---|---|---|---|---|---|
| **Goodwell** | 1167 | 367 | 107 | 60 | 38 | 15 |
| **Cherokee** | 821 | 215 | 76 | 34 | 15 | 5 |
| **Claremore** | 904 | 379 | 53 | 17 | 6 | 0 |
| **Erick** | 1034 | 203 | 14 | 7 | 4 | 2 |
| **Stillwater** | 1125 | 398 | 78 | 38 | 18 | 11 |
| **Tahlequah** | 1130 | 388 | 83 | 32 | 14 | 6 |
| **Altus** | 1128 | 443 | 122 | 48 | 14 | 6 |
| **Ada** | 697 | 354 | 196 | 101 | 48 | 25 |
| **Antlers** | 1366 | 488 | 39 | 16 | 8 | 4 |
| **All Sites:** | **9372** | **3235** | **768** | **353** | **165** | **74** |
| **% of Data:** | **55.8%** | **19.3%** | **4.6%** | **2.1%** | **1.0%** | **0.4%** |

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# Daily Mean Temperatures at Goodwell, OK for 2005
## (Data from 'Co-located' CRN, HCN & Mesonet Sites)

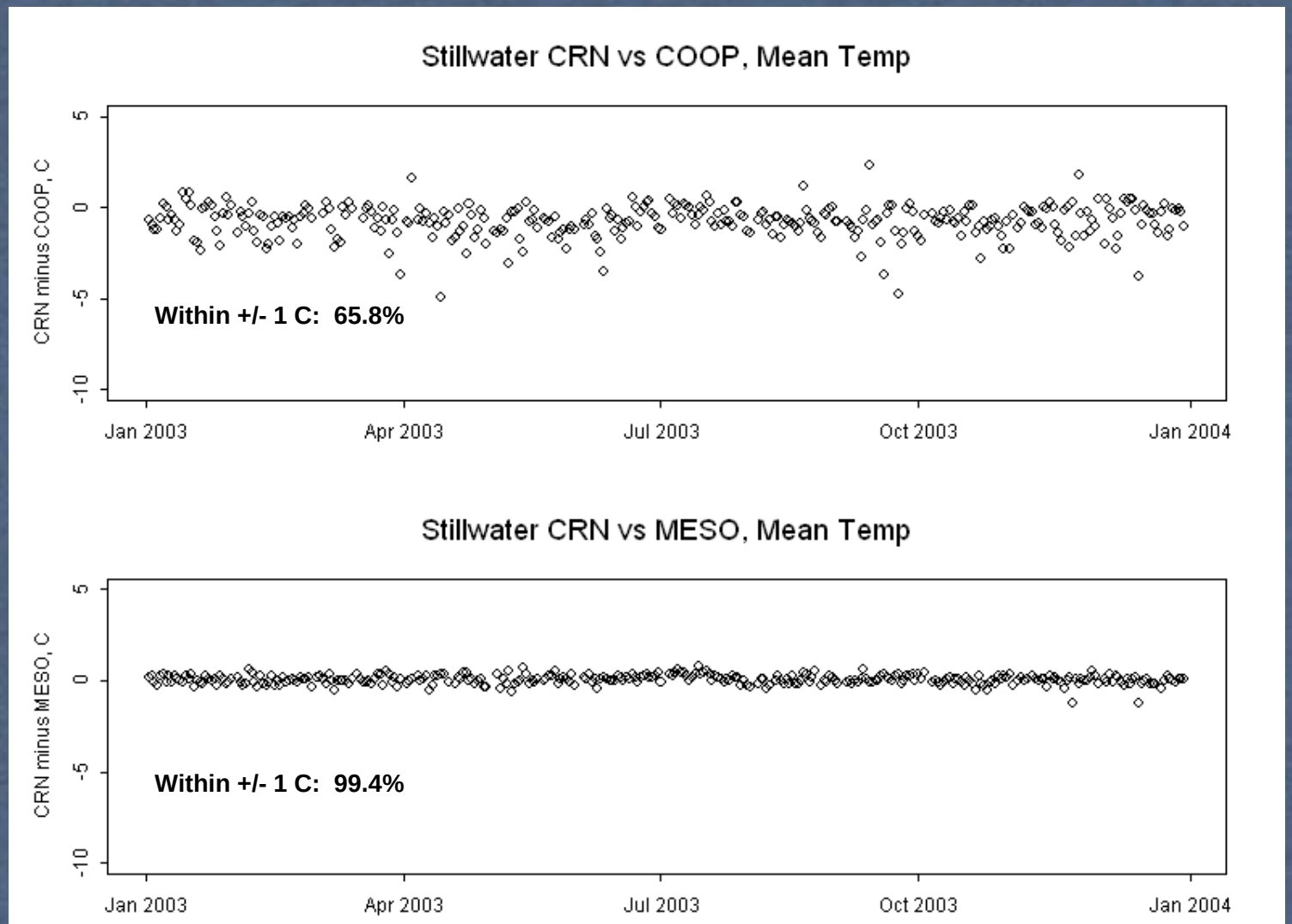


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**Figure 6**

Climatology-Hydrology Networks in WA
University of Washington
June 15, 2007

# The Oklahoma Mesonet
## Lessons Learned: Negatives

1. Instruments don't always work "as advertised"
2. Cheapest is not always the same as least expensive
3. Funding becomes secure when the check is cashed
4. Red tape unravels very slowly
5. People who are used to "free" don't expect ever to pay
6. It's orders of magnitude EASIER to collect metadata upon installation of the network rather than try to reconstruct it after the fact

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# The Oklahoma Mesonet
## Lessons Learned: Positives

1. Dedicated professionals can overcome institutional obstacles.
2. An informed and participatory clientele will ease the way.
3. Careful planning and adherence to standards pays off.
4. Committees can be made to work (reference item 1).
5. The most effective allies are those with a stake in your project.



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# The Oklahoma Mesonet
## Other 'Lessons Learned'

- Hardware has a limited shelf life - do not purchase until staff is *ready* to implement.
- Hire the best possible staff. We achieved this in Oklahoma by *'growing our own'*. This approach is far better than hiring off the street, and then, teaching them to care.
- People are a much more important investment than is technology. In 10 years, the initial technology will be worthless but the people will be invaluable if you have mentored them and expected them to be creative.

# Their Words: Public Safety

"We had a wildfire … along the Red River south of Grandfield. Using the Mesonet and your fire weather products, I was able to relay to the first fire truck that was en route to the scene how fast the fire should burn and what the winds, soil and air temperatures would be at the scene. Because the spread component was high, we dispatched 2 more trucks to the scene even before the first truck arrived. The 3 trucks had the fire out within 30 minutes, quite possibly saving property and lives."

– Tommy Thornton, Emergency Management Director

# Their Words: Agriculture

"The Mesonet has proven to be one of the most valuable production and marketing tools available to Oklahoma producers.... Mesonet data will play an increasing role in pesticide and fertilizer applications, prescribed burning, confined animal operations, and irrigation scheduling, to name a few."

– Mark Hodges, Exec. Director, Oklahoma Wheat Commission

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# Their Words: Drought Monitoring

"The OWRB depends upon the reliable and accurate real-time drought and water-resources information supplied through the Oklahoma Mesonet's vast suite of products. In addition, OCS staff have voluntarily provided many custom weather monitoring products … greatly enhancing the state's ability to monitor and respond to drought episodes. As a result, critical drought-related decisions can be made more quickly and more confidently."

– Brian Vance, Oklahoma Water Resources Board

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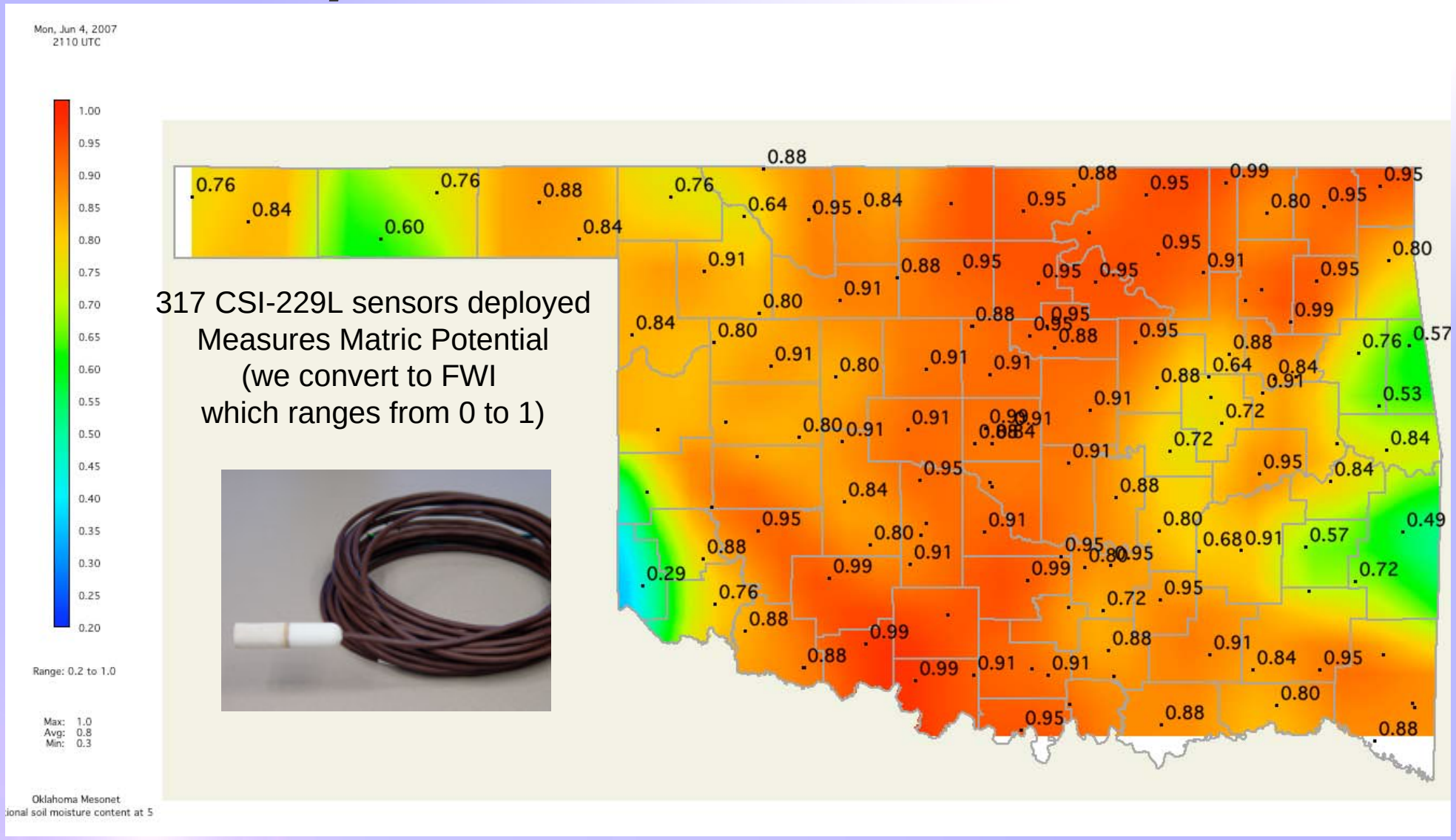
# Experience with Soil Moisture




317 CSI-229L sensors deployed
Measures Matric Potential
(we convert to FWI
which ranges from 0 to 1)

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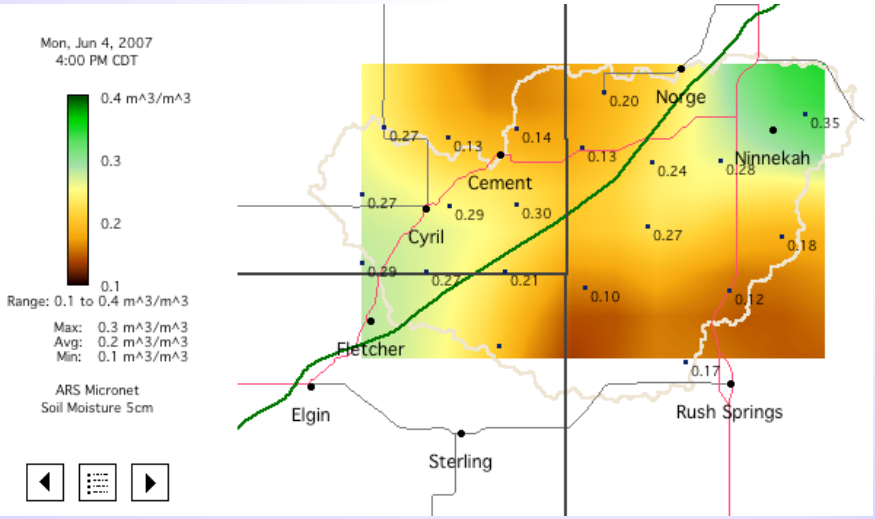
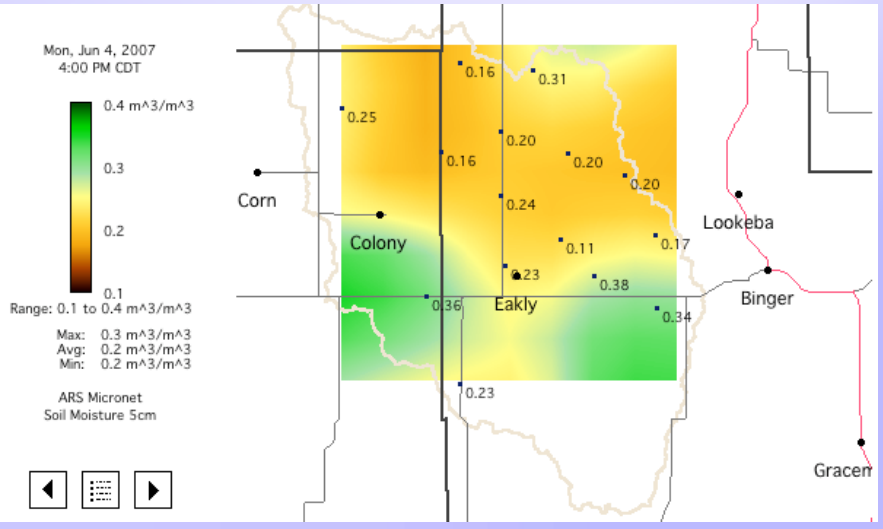
# Experience with Soil Moisture




105 Stevens Hydraprobe sensors deployed
Measures Water Fraction by Volume
(which ranges from 0 to ~.4)
Sensor also measure soil temperature
and soil salinity

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# Soil Moisture

Both are painful to install and maintain!

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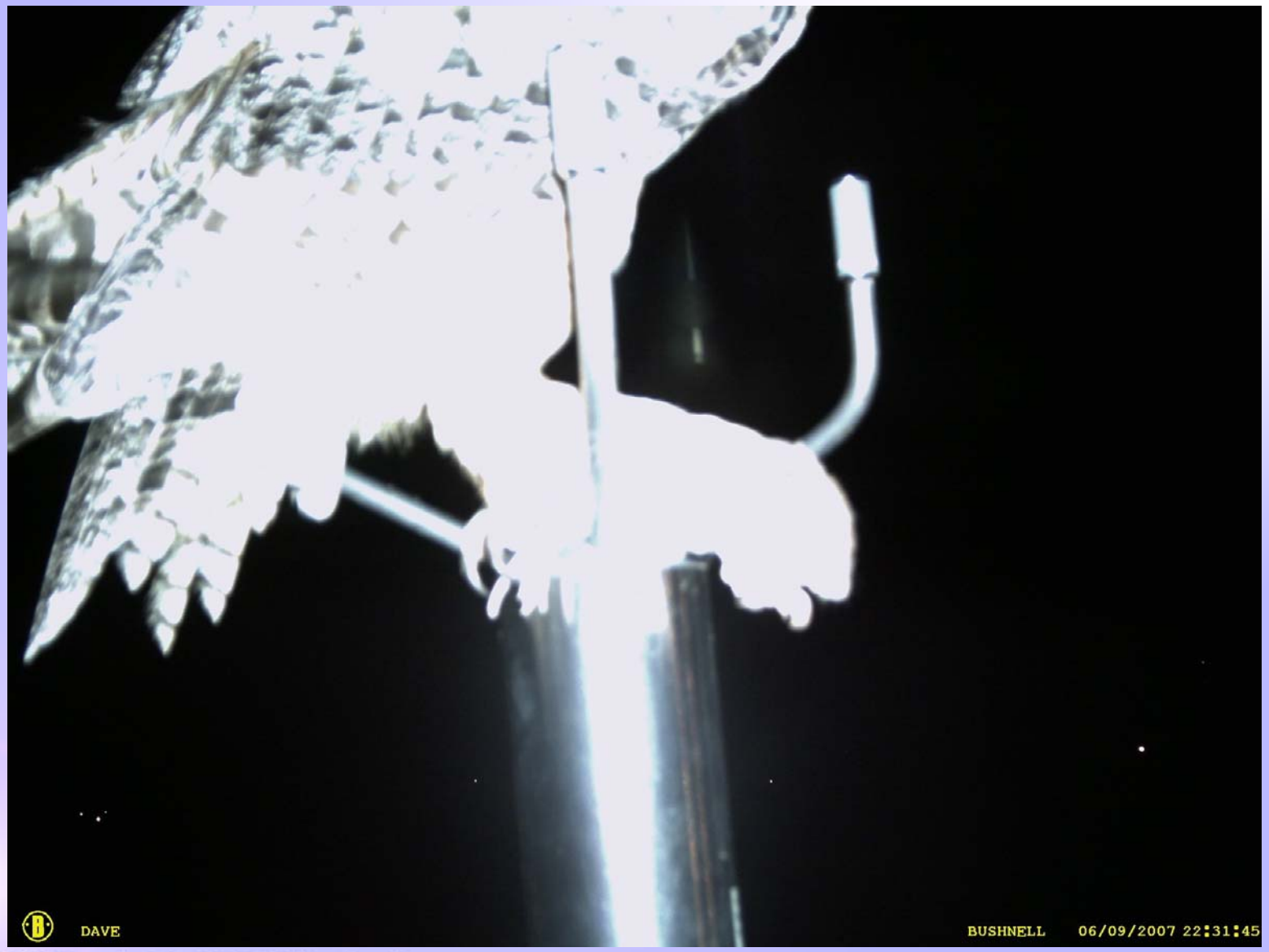
# The Keys to Our Success
## (National Research Council 2001)

- The blue ribbon panel believed the success of the Oklahoma Mesonet's was built upon five pillars:

- Users were involved from day one.
- Products were developed in direct partnership with users.
- Strong partnerships existed with mission agencies and with research elements.
- Information was accessible from the beginning.
- Education of users and potential users was an important element of the program.

# Sonic Anemometer Visitors

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# *Thank You…Any Questions?*

***Come visit Norman and let us show you our operation.***

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**Climatology-Hydrology Networks in WA**
**University of Washington**
**June 15, 2007**