Long Term Ecological Research
Network Office

Wireless Sensor Networks and Data Transmission – Webcams to Sensorwebs

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Data Transmission Example 1:

Weather data from Niwot Ridge LTER

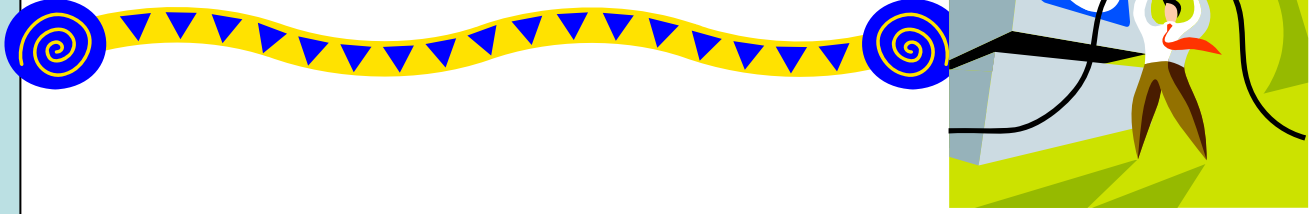
How to get data from the field to the research headquarters in Boulder, CO?

How is it done?

-Hardwired

Weather Station

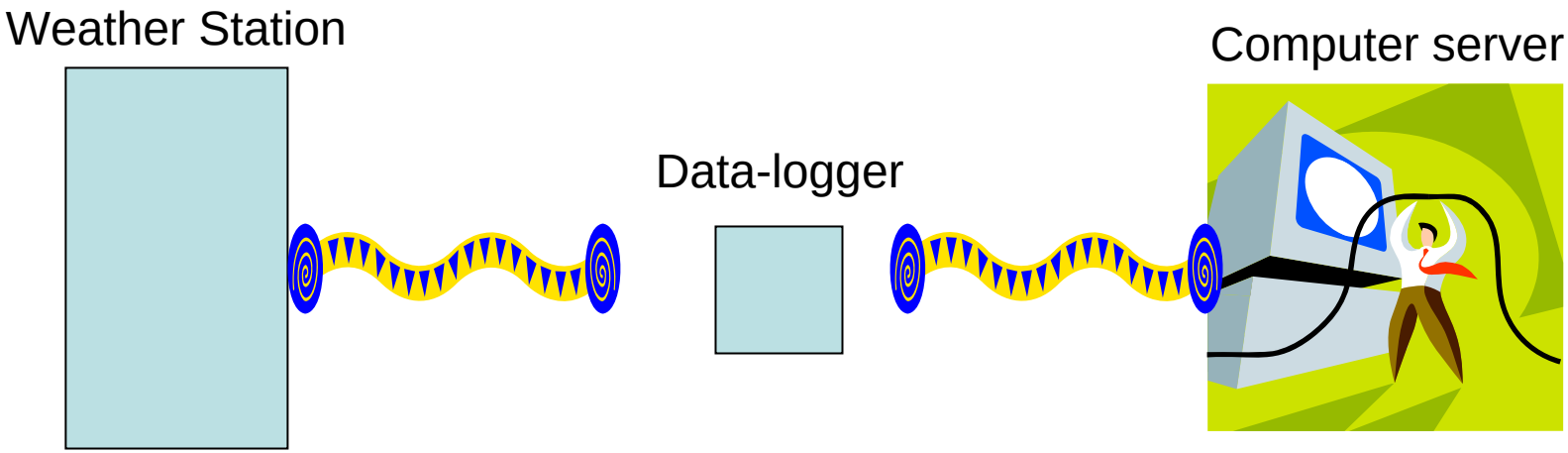
Computer server



1. Digital data from the weather station hard-wired to computer server

How is it done?

-Datalogger



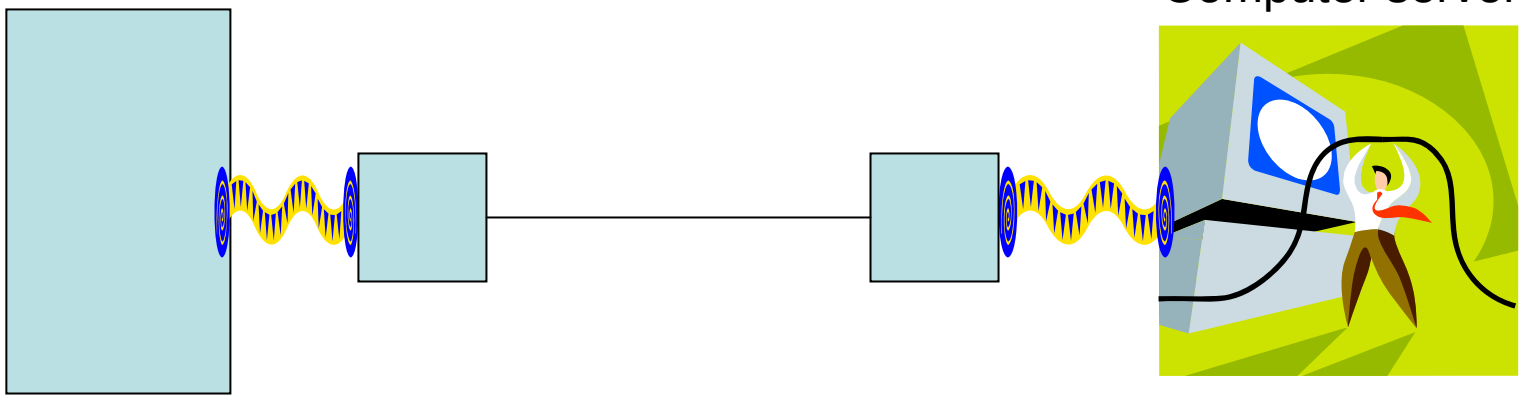
2. Digital data from the weather station collected by datalogger, later data logger connected to hard-wired to computer server.

How is it done?

-Wired MODEM

Weather Station

Computer server



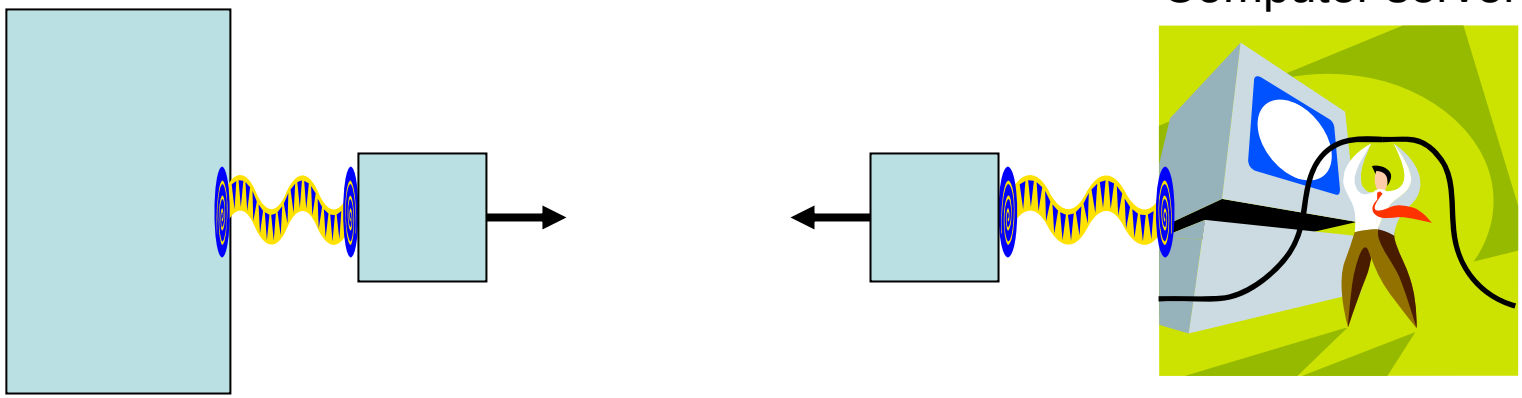
3. Digital data from the weather station sent by MODEM over conventional phone network, then transferred by similar modem to computer server. This could be a conventional dial-up, or DSL (Digital Subscriber Line) connection.

How is it done?

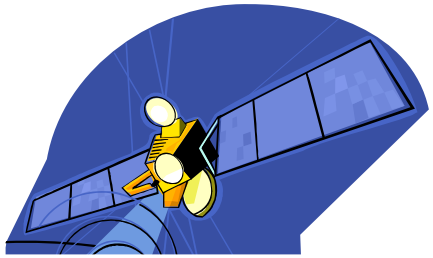
-Radio Modem

Weather Station

Computer server



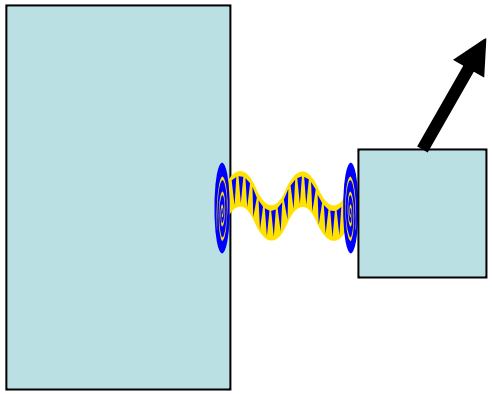
4. Digital data from the weather station sent by Radio MODEM, then transferred by similar modem to computer server. This could be something like a Cell Phone Connection, or by standard wireless radio such as FreeWave 900mhz. Note the data must be modulated from digital to analog for transmission, then demodulated back to its original form.



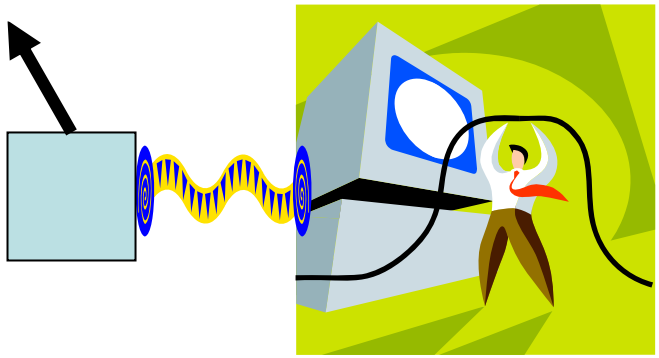
How is it done?

-Satellite Transmission

Weather Station



Computer server



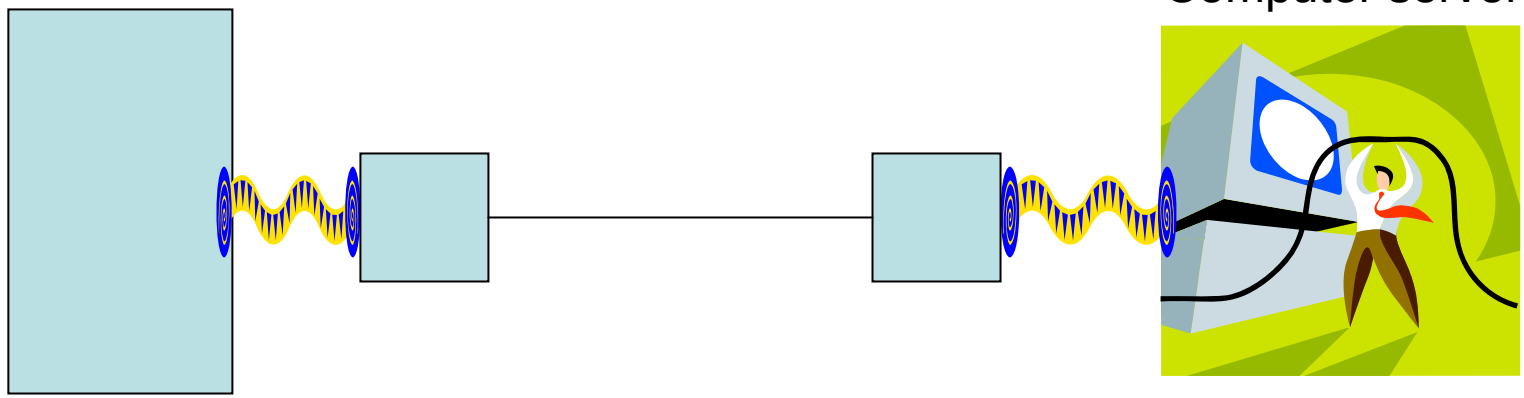
4. Another form of data sent by Radio MODEM, is to use a satellite relay. This could include environmental data sent to GOES, GMS or other satellites (DIRECWAY), then transferred to a ground receiving station to a computer server.

How is it done?

-Hardwired Internet

Weather Station

Computer server



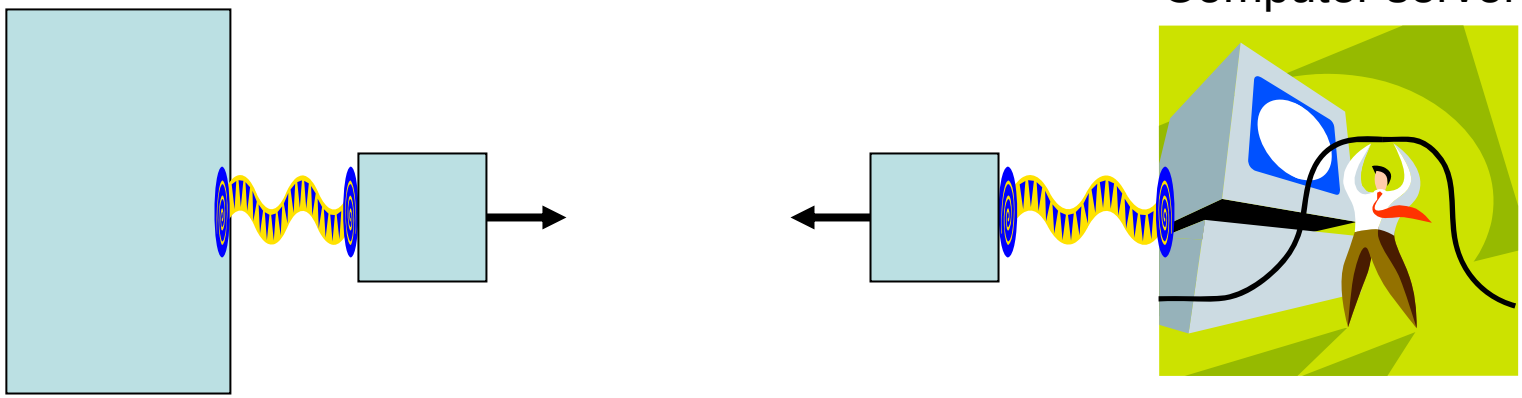
5. Digital data from the weather station connected sent by TCP/IP over digital network to computer server.

How is it done?

-Wireless Internet

Weather Station

Computer server



6. Digital data from the weather station connected sent by TCP/IP over wireless digital network to computer server.

The Niwot Ridge LTER site collects all data by serial connections to FreeWave 900 mhz radios, and collects the data from one “master” radio. Data are then transferred by direct T1 connection. They also have a pan/tilt/zoom Webcam on the main weather tower for monitoring purposes.

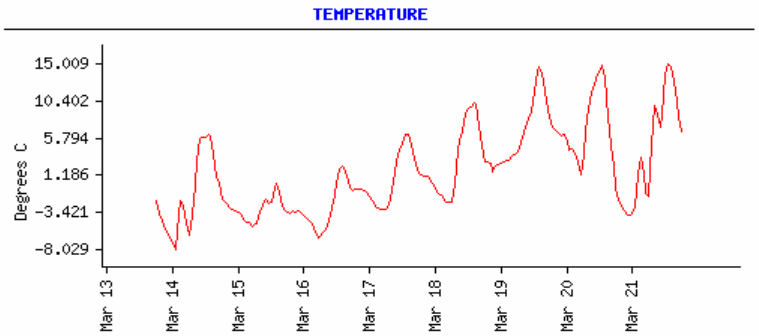
File Edit View Favorites Tools Help

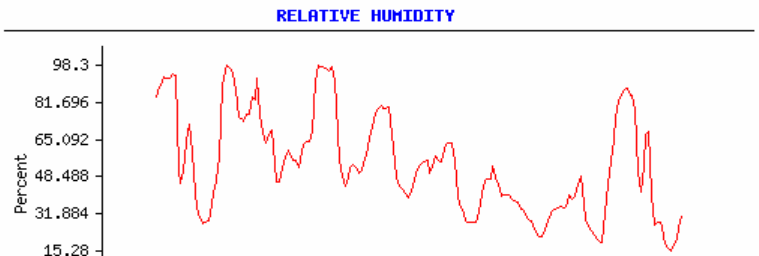
Current Niwot Ridge LTER Meteorological Data - C1

The following meteorological data are from the C1 station, at 3022m (9,912 ft) on Niwot Ridge. The peak wind gust information is recorded instantaneously, with a sampling interval of 5 seconds. The other measurements are one hour averages comprised of 720 samples collected at 5 second intervals. All the parameters are updated at the top of every hour. The following are for 1800 - 1900 Mountain Standard Time on 3/21/04. This page is also available displayed in U.S. customary units.

Temperature:	6.63 degrees C
Soil Temperature:	-.309 degrees C
Relative Humidity:	30.73 percent
Barometric Pressure:	716 millibars
Wind Speed:	2.493 meters/second
Wind Direction:	313 degrees
Peak Wind Gust:	7.25 meters/second
Time of Peak Gust:	1803 MST
Precipitation:	0 millimeters
Snow Depth:	91 centimeters

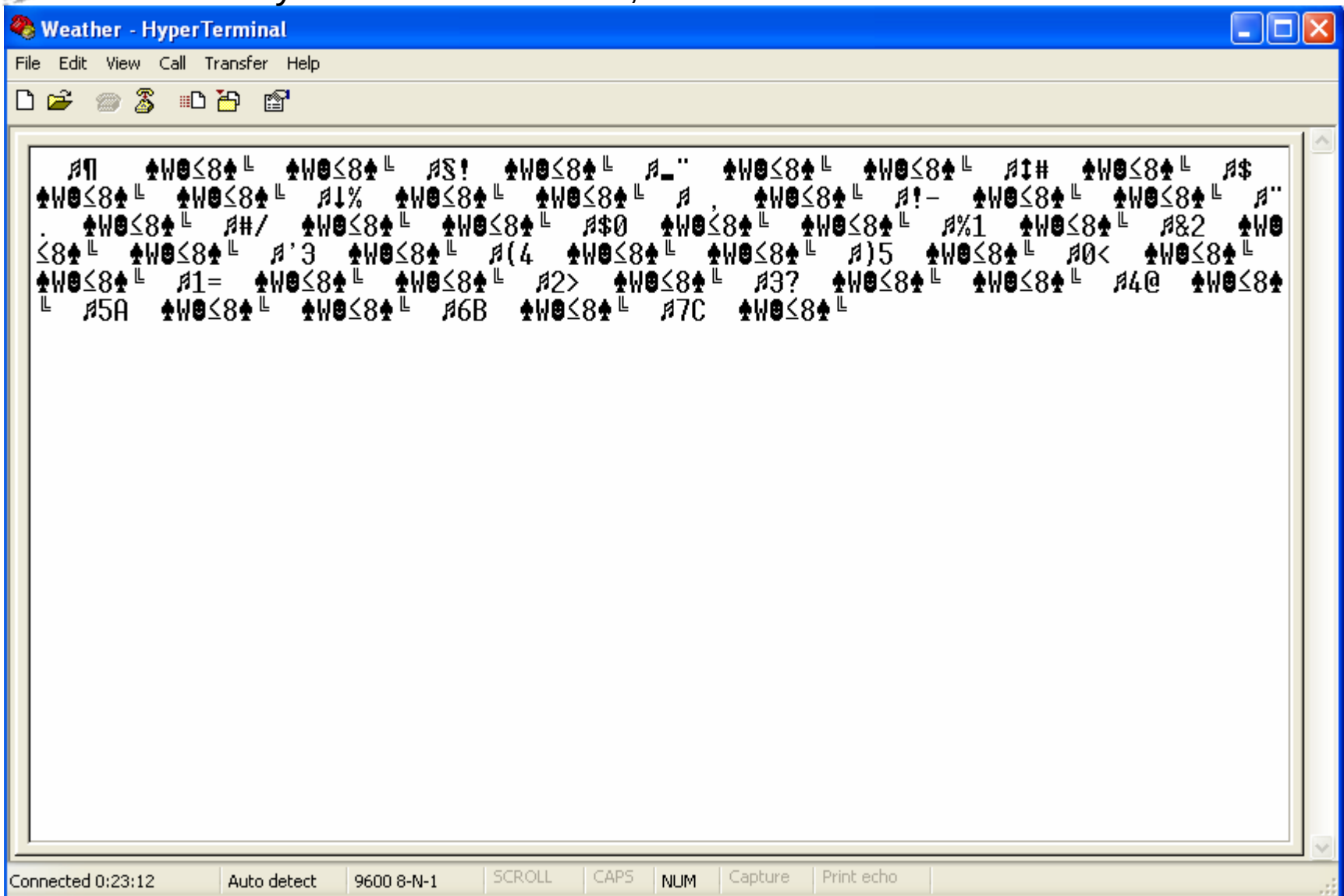
WARNING: These data are raw and have not been quality checked.





The Niwott Ridge LTER site collects all data by serial connections to FreeWave 900 mhz radios, and collects the data from one “master” radio

Serial Data – displayed as ASCII… Connecting a standard data link to raw digital data might not be what is needed. The data must be ingested by reading as raw (hexadecimal data), but the format (data protocol) of the data must be known as well. This should be available in the "user manual" (metadata) for the instrument. Hopefully translation will be done by the instrument itself, or the software that collects the data.



Example Data Translation Protocol…

Protocol of the WMR918 weather Station(4)----------

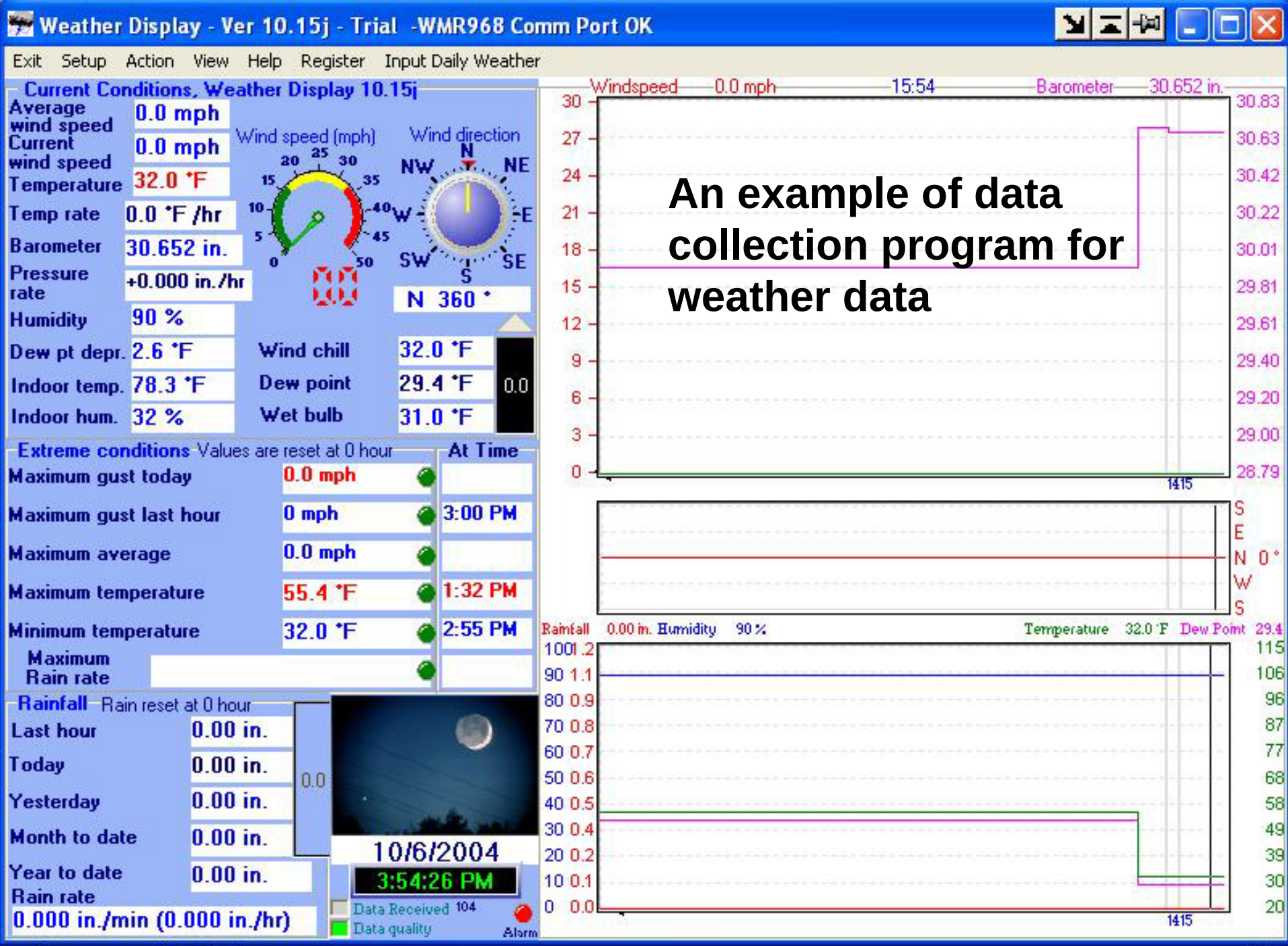
Data communication w/ the WMR918 weather station is unidirectional. i.e. the data frames are put on the serial line by the station.Each packet starts with two binary bytes of 0xFF. Each packet ends with a checksum. The type of packet is given by the third byte, and ranges from 0x00 through 0x0f. Each type of packet has a predetermined length.For example, a typical type 5 packet looks like: ff ff 05 00 09 02 47 09 dc 0c 50 79 0f The checksum is the simple addition of each byte in the packet, excluding the checksum byte, keeping only the lowest 8 bits. In all further examples, the leading "ff ff" will be omitted. The .taboutput from wmr918d omits the leading "ff ff".The known packet types are: 00 - anemometer and wind related data 01 - rain guage 02 - extra sensors 03 - outside temp, humidity and dewpoint 04 - unknown 05 - inside temp, humidity, dewpoint, and baro. 06 - inside temp, humidity, dewpoint, baro for wmr968 and some wmr918's. 07 - unknown 08 - unknown 09 - unknown 0a - unknown 0b - unknown 0c - unknown 0d - unknown 0e - sequence number 0f - hourly status report. H is a hex digit from 0 to f. D is a decimal digit from 0 through 9. B is bit encoded, bit 3 is the high bit (0x8).

Type 00 - anemometer and wind related data

Byte	Nibble	Bit	Meaning
1'	W	all	00
2'	W	all	FF
0	W	all	FF
1	Bx		Battery status. Higher value == lower battery volt
1	xB		Unknown
2	DD		Gust direction, bc of 0<abc<359 degrees
3	xD		Gust direction, a of 0<abc<359 degrees
3	Dx		Gust speed, c of 0<ab.c<56 m/s
4	DD		Gust speed, ab of 0<ab.c<56 m/s
5	DD		Average speed, bc of 0<ab.c<56 m/s
6	xD		Average speed, a of 0<ab.c<56 m/s
6	Bx		3 Sign of wind chill, 1 = negative
7	DD		Wind chill

Example: 00 00 90 01 00 00 00 07 96

Example: gust at 190 degrees, 0 m/s, average 0, wind chill 7 Celsius


Weather Display - Ver 10.15j - Trial -WMR968 Comm Port OK
Exit Setup Action View Help Register Input Daily Weather
Current Conditions, Weather Display 10.15j
Average wind speed 0.0 mph
Current wind speed 0.0 mph
Temperature 32.0 °F
Temp rate 0.0 °F /hr
Barometer 30.652 in.
Pressure rate +0.000 in./hr
Humidity 90 %
Dew pt depr. 2.6 °F
Indoor temp. 78.3 °F
Indoor hum. 32 %
Wind speed (mph)
Wind direction
N 360 °
Wind chill 32.0 °F
Dew point 29.4 °F
Wet bulb 31.0 °F
Extreme conditions Values are reset at 0 hour
At Time
Maximum gust today 0.0 mph
Maximum gust last hour 0 mph 3:00 PM
Maximum average 0.0 mph
Maximum temperature 55.4 °F 1:32 PM
Minimum temperature 32.0 °F 2:55 PM
Maximum Rain rate
Rainfall Rain reset at 0 hour
Last hour 0.00 in.
Today 0.00 in.
Yesterday 0.00 in.
Month to date 0.00 in.
Year to date 0.00 in.
Rain rate
0.000 in./min (0.000 in./hr)
10/6/2004
3:54:26 PM
Data Received 104
Data quality
Alarm
Windspeed 0.0 mph 15:54 Barometer 30.652 in.
An example of data collection program for weather data
Rainfall 0.00 in. Humidity 90 % Temperature 32.0 °F Dew Point 29.4
1415

LTER Web Cams - Live images from LTER sites

Niwot Ridge LTER (Tundra-Cam)

Tundra-Cam is a LIVE and INTERACTIVE webcam located at an elevation of 11,600 feet in the Colorado Front Range. The camera is above timberline on Niwot Ridge, about 25 miles west of Boulder. The peaks at the head of the ridge form the Continental Divide. Niwot Ridge is the sole alpine tundra site in the LTER Network.

Sevilleta LTER (SEVcam)

Live video feed from a birdfeeder located at the Sevilleta LTER field station on Sevilleta national Wildlife Refuge, in central NM about 1 hour south of Albuquerque.

Virginia Coast Reserve LTER

Live interactive views from the Hog Island Webcam located atop a water tower in Broadwater VA

Coweeta LTER (Coweeta-Cam) and **Coweeta LTER Fire Tower Webcam**

Live interactive views from the Coweeta Hydrological LaboratoryWebcam located in Otto, North Carolina

WebCams - The Basics:

WebCams are available from many manufacturers and in many styles. In general a WebCam consists of a video camera connected to a camera server. The camera may be fixed, or contain a pan/tilt (PT) or pan/tilt/zoom (PTZ) "robot" to control the camera. The robot itself may be a separate device. The camera server usually contains Web-based access/configuration integrated within the server. The server will usually be running a basic operating system to handle the network and web services – Linux is most common. Most camera servers also support standard SMPT email as well as ftp data transfers. The servers will support some type of data connection, which can be serial data, Ethernet or some form of wireless data link such as 802.11b.

For network connections to WebCams, it is important to use fixed IP addresses for data access even though most servers support dynamic DHCP IP assignment. This can be used if it is known what the IP address will be, but if it is more random, it isn't very useful to have to "guess" the IP address of the camera. For PT and PTZ cameras, the server also needs to control the camera robot, usually through a serial data connection controlled by device-specific drivers contained within the server. In most instances the camera, robot and camera server are integrated into a single device although separating the functions can allow for more flexibility.

Webcam Example 1: A basic fixed mount, wired AXIS 200 WebCam:

Check out The Sevilleta's WebCam at: http://schoolyard.lternet.edu/webcams/sev/ " or its direct connection at: "desierto.unm.edu". This is a fixed-focus, AXIS 200+ basic WebCam with an imbedded generic operating system and camera server which supports standard web access. The camera server also supports standard Email and ftp image data transfers. The server also has a serial data connection which can support dial in or out PPP network connections. The cameras are powered by standard 12VDC which simplifies field installation. A demonstration will be given of this and/or a similar Webcam, for instance the Coweeta WebCam at (http://65.160.56.201/view/view.shtml) which is an updated AXIS 2001 running an imbedded Linux server.

Basic fixed mount Ethernet linked AXIS 200 WebCam

•Camera, Web server in single configuration

•Support for standard html web access, smpt email, and ftp data transfers

•Serial data capability

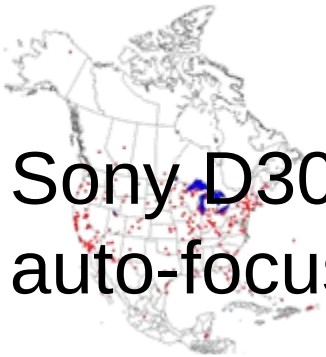
•12VCD power

•Relatively low image quality

•Fixed aperture (auto gain but no iris) - sensitive to sun, not-low-light capable

Webcam Example 2: A Pan/Tilt/Zoom Sony D30 video camera and AXIS 2401 video server.

The D30 is an old but popular cameras because of its high image quality and PTZ capability. It is a stand-alone camera, so requires some sort of data server, in this case an AXIS 2401 video server is used. The AXIS video controller configuration is similar to the AXIS 2001 camera setup, except that the PTZ functions must also be configured through a serial data port, with particular attention that the PTZ functions are configured in both the serial data and video data connections. Similar to the basic AXIS webcams, the AXIS 2401 video server also contains a second serial data port which can be configured to act as a standard modem. The internal modem can be configured to either call out to establish an internet connection, or can accept an incoming "call" from another computer to establish a data connection. This capability is particularly important since a data link using a long-range wireless serial data connection can be configured to transfer image data 50km or more with a clear line of sight. For example, a FreeWave 900mhz serial data radio, connected to the AXIS 2401 camera server permits the camera and camera server to be placed in the field. Newer versions of the FreeWave radio permit true TCP/IP connections (i.e. Ethernet) which simplifies the setup. All of the hardware, again is powered by 12VCD, so batteries and solar panels can be used. A demonstration will be given of the basic configuration of the server, from assigning an IP address to configuration of the PTZ functions.



Sony D30 pan/tilt/zoom auto-focus camera

- Popular for generic applications
- High quality images
- Low-light capable
- 12VCD power
- Requires protection from weather

AXIS 2401 camera server

- Single video input -although multiple and rack-mount servers available
- Two serial data ports -one for PTZ, one for digital serial data connection
- Ethernet-based setup
- Linux controller

AXIS Video Server - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

Address http://129.24.124.68/view/indexFrame.shtml Go Links

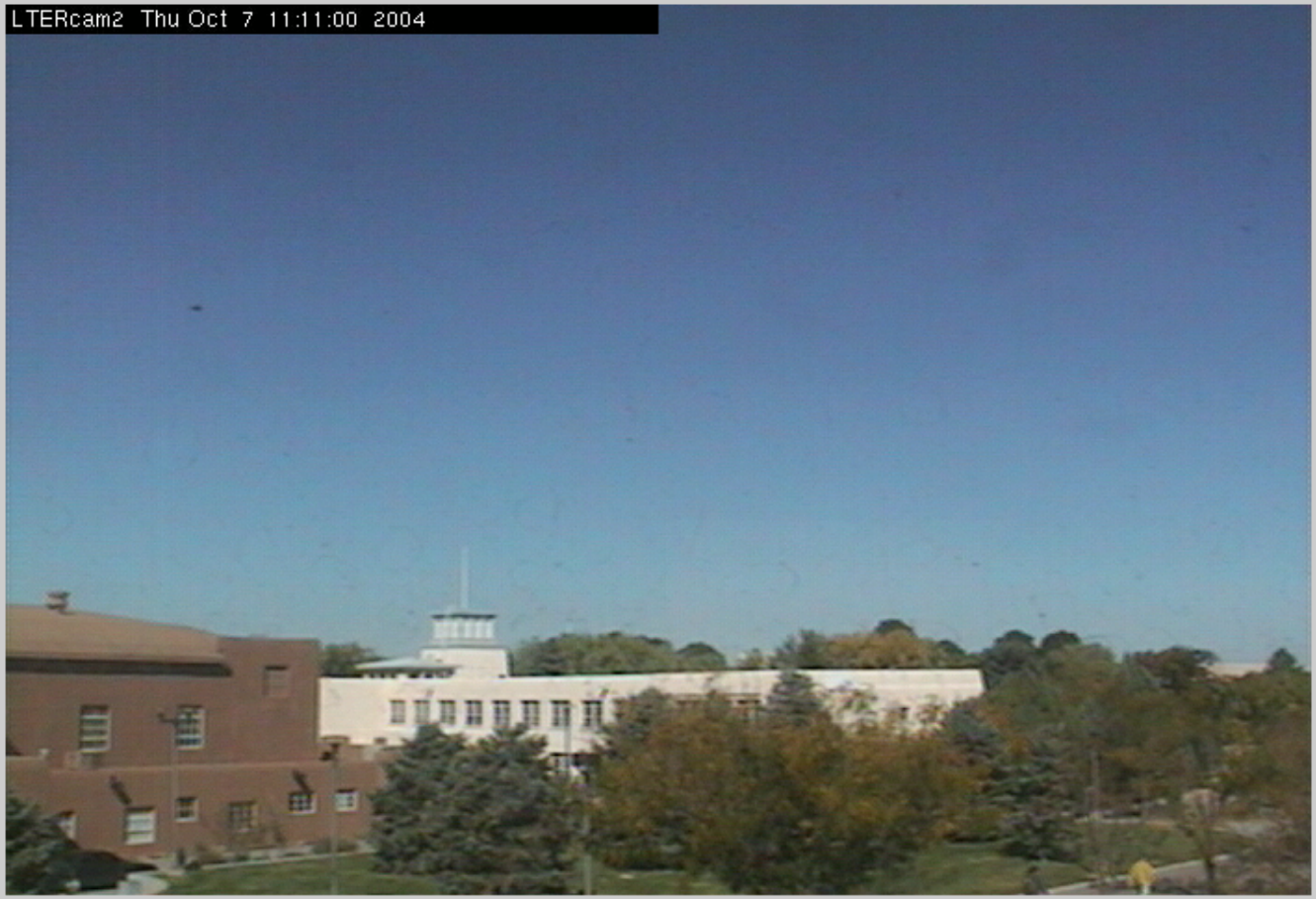
AXIS 2401 Video Server

AXIS COMMUNICATIONS

Admin

ZOOM Wide Tele

LTERcam2 Thu Oct 7 11:11:00 2004



Up

TILT

Down

Select preset position:

None

PAN Left Right

H

Done Internet

AXIS Video Server - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

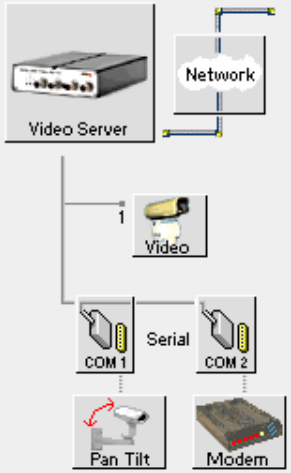
Address http://129.24.124.68/view/indexFrame.shtml Go Links

AXIS 2401 Video Server

AXIS COMMUNICATIONS

Admin Overview

View Application



Administration overview

The system Administration Tools are available via the adjacent graphical user interface, allowing simple point-and-click configuration and management of your AXIS 2401 Video Server.
Simply click on the appropriate icon to configure the corresponding part of your system.

Installation Wizard
Guides you through the installation; from setting up the unit for specified users, to configuring the supported networking protocols.

Application Wizard
Design your video server's application using the wizard to choose when and how to upload captured pictures.

Welcome Page Acknowledgements

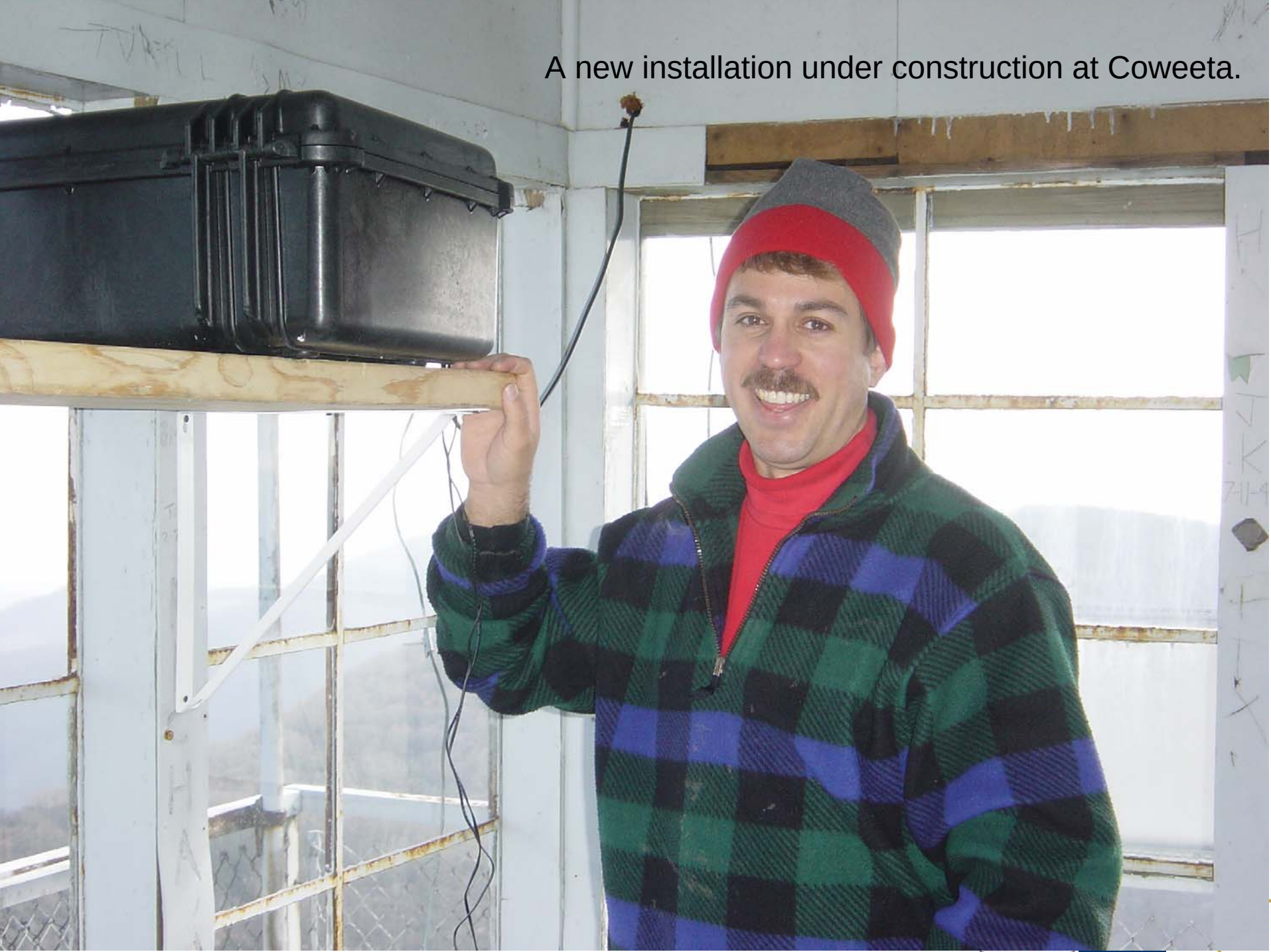
Done Internet

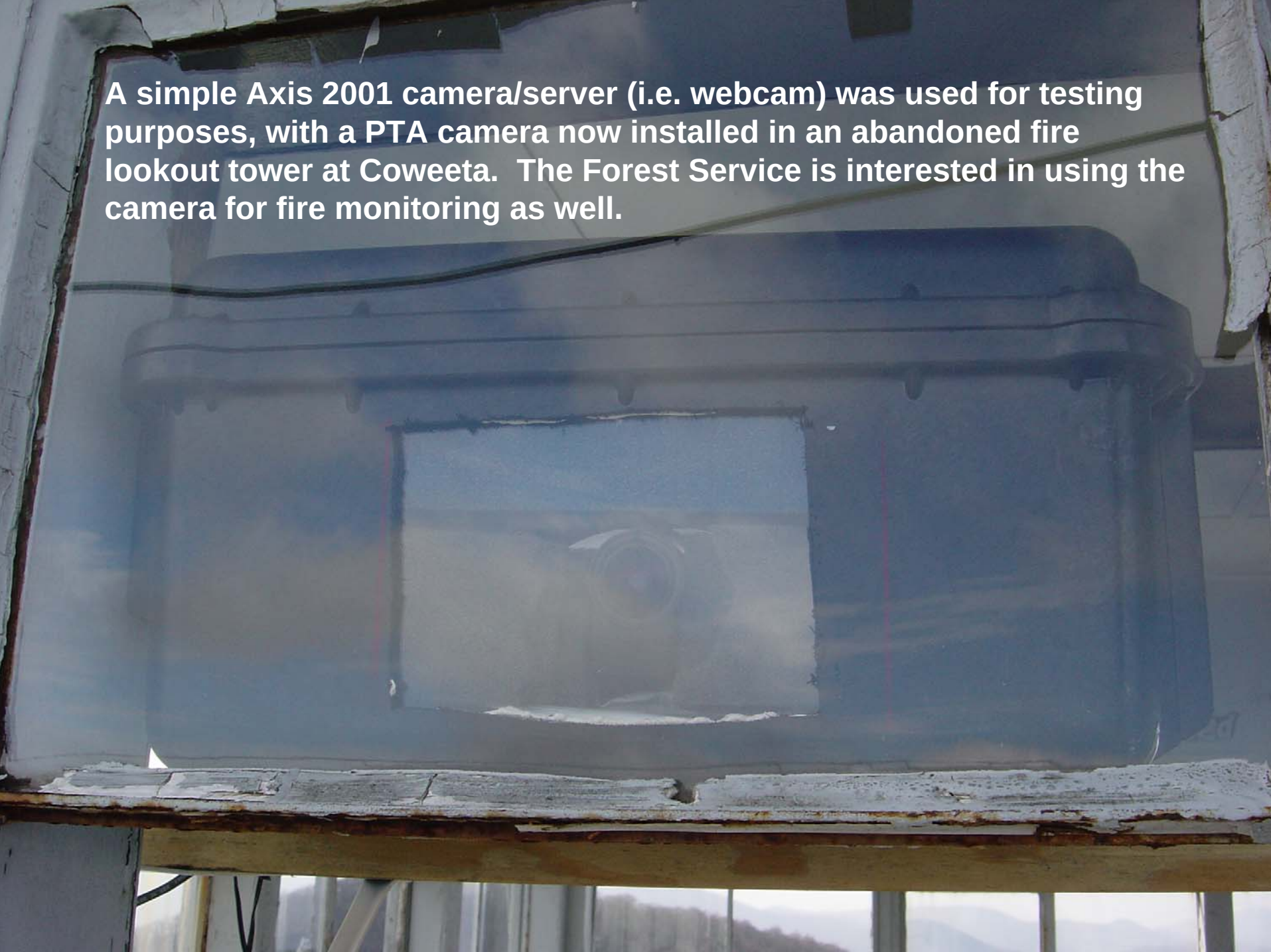
WebCam Example 3: A D-Link DCS 1000W fixed-focus 802.11b wireless WebCam.

The D-Link WebCam contains features similar to the AXIS cameras with the addition of standard 802.11b wireless data transmission which replaces the Ethernet data connection. Data transmission are limited to the standard 802.11b range of about 1000 feet (or less). The D-Link camera server configuration is somewhat more complicated than the AXIS server configuration since it requires that a temporary isolated local area network to be established to the computer and used to configure the camera. Although this seems somewhat more complicated, other network devices such as 802.11 routers have a similar configuration. It is important that once the camera is configured, that it use its supporting access point as the network gateway, rather than the local network gateway since the access point acts as the camera's central router. This is not an intuitive configuration since one generally uses the local gateway for all computer network configurations. An example will be given showing the configuration from start to finish of the D-Link DCS 1000W configuration.

802.11b wireless WebCam

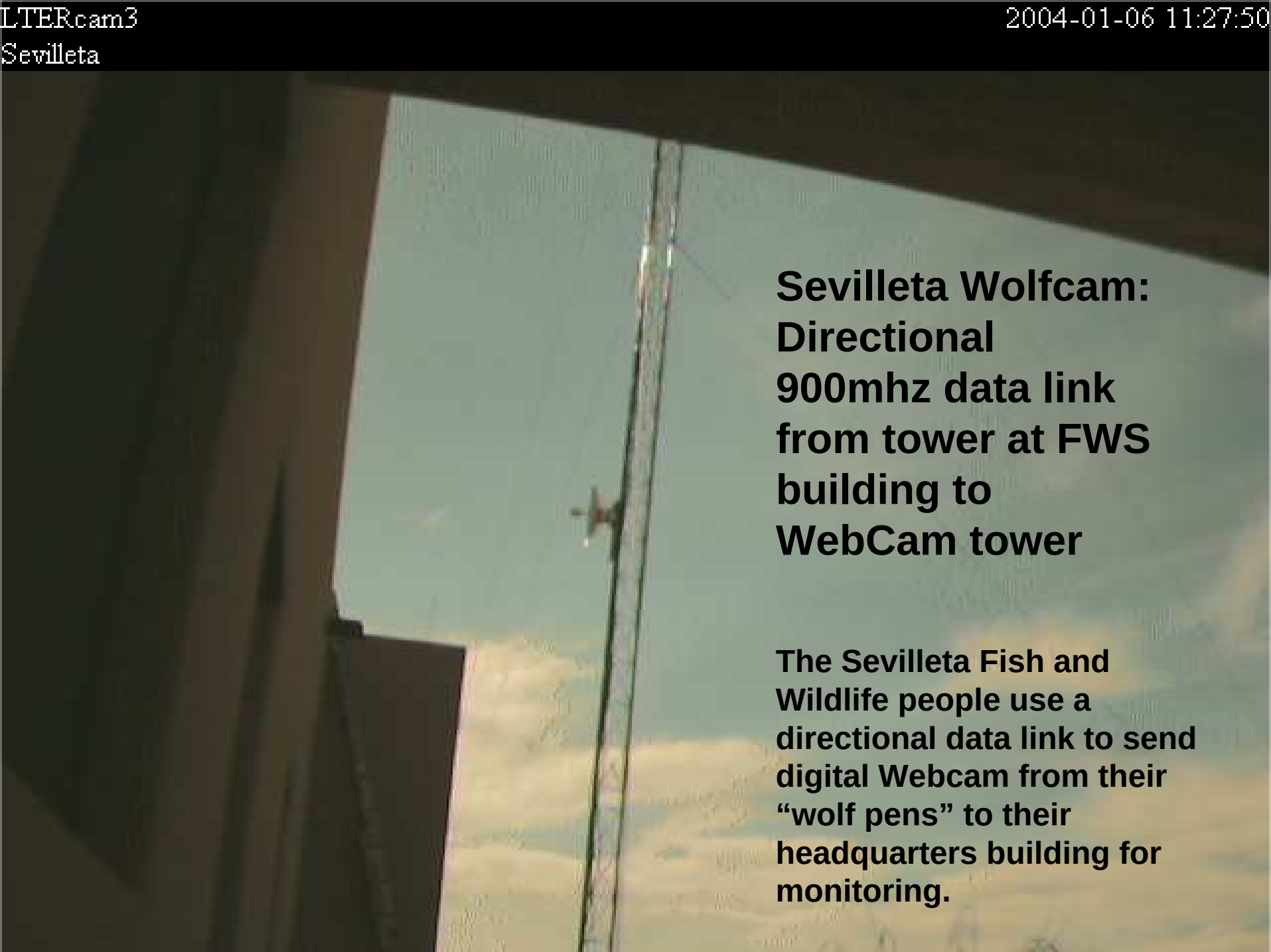
- Standard 802.11b wireless data access
- Stand-alone data transmission with trigger or timed picture transmission
- Simple multiple camera capability within an established 802.11b “cloud”
- 5VDC Power supply
- Fairly low image quality


A new installation under construction at Coweeta.



A simple Axis 2001 camera/server (i.e. webcam) was used for testing purposes, with a PTA camera now installed in an abandoned fire lookout tower at Coweeta. The Forest Service is interested in using the camera for fire monitoring as well.

Data from the WebCam and other sensors is powered by large 12VDC solar panels and relayed by a single high-gain antennae.



Sevilleta Wolfcam: Directional 900mhz data link from tower at FWS building to WebCam tower

The Sevilleta Fish and Wildlife people use a directional data link to send digital Webcam from their “wolf pens” to their headquarters building for monitoring.

AXIS Video Server - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://198.59.133.117/view/view.shtml Go Links

Sevilleta WolfCam: Complex Overview

IRIS Close Open

FOCUS Near Far Auto

ZOOM Wide Tele

Select preset position:

None

PAN-TILT

Live Access

The Panasonic pan/tilt/zoom camera setup is pre-programmed to view any of the remote wolf pens, or it can be controlled manually

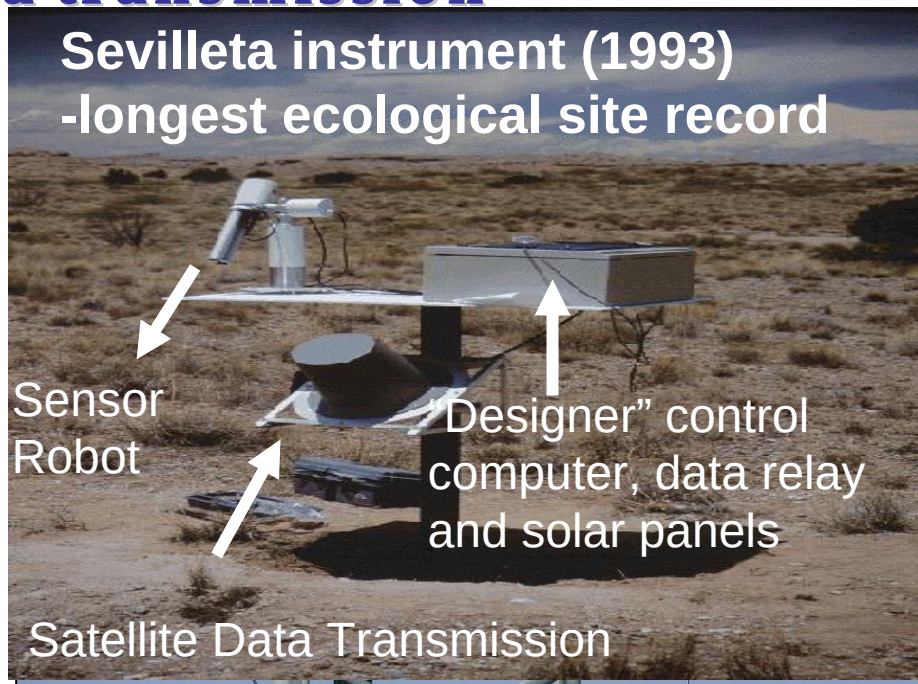
Done Internet

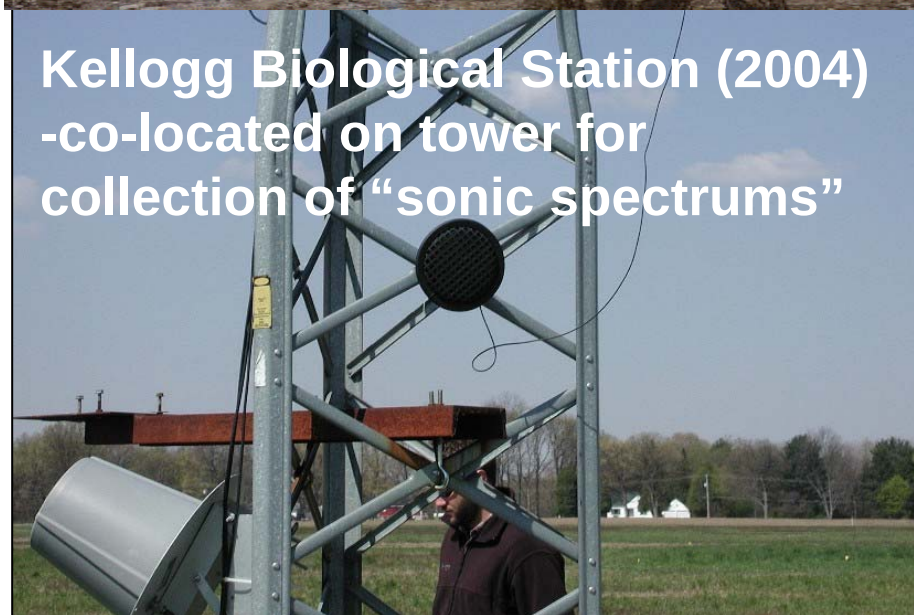
Radio links at the Sevilleta Field Station:

The Sevilleta LTER uses a variety of “wireless” data communication links ranging from licensed radio to 802.11x local and relay (8.2.11x local access as well as relay to the “Mackenzie Flats” research area). This relay collects data from the Sevilleta/JPL “Datura” Sensorweb

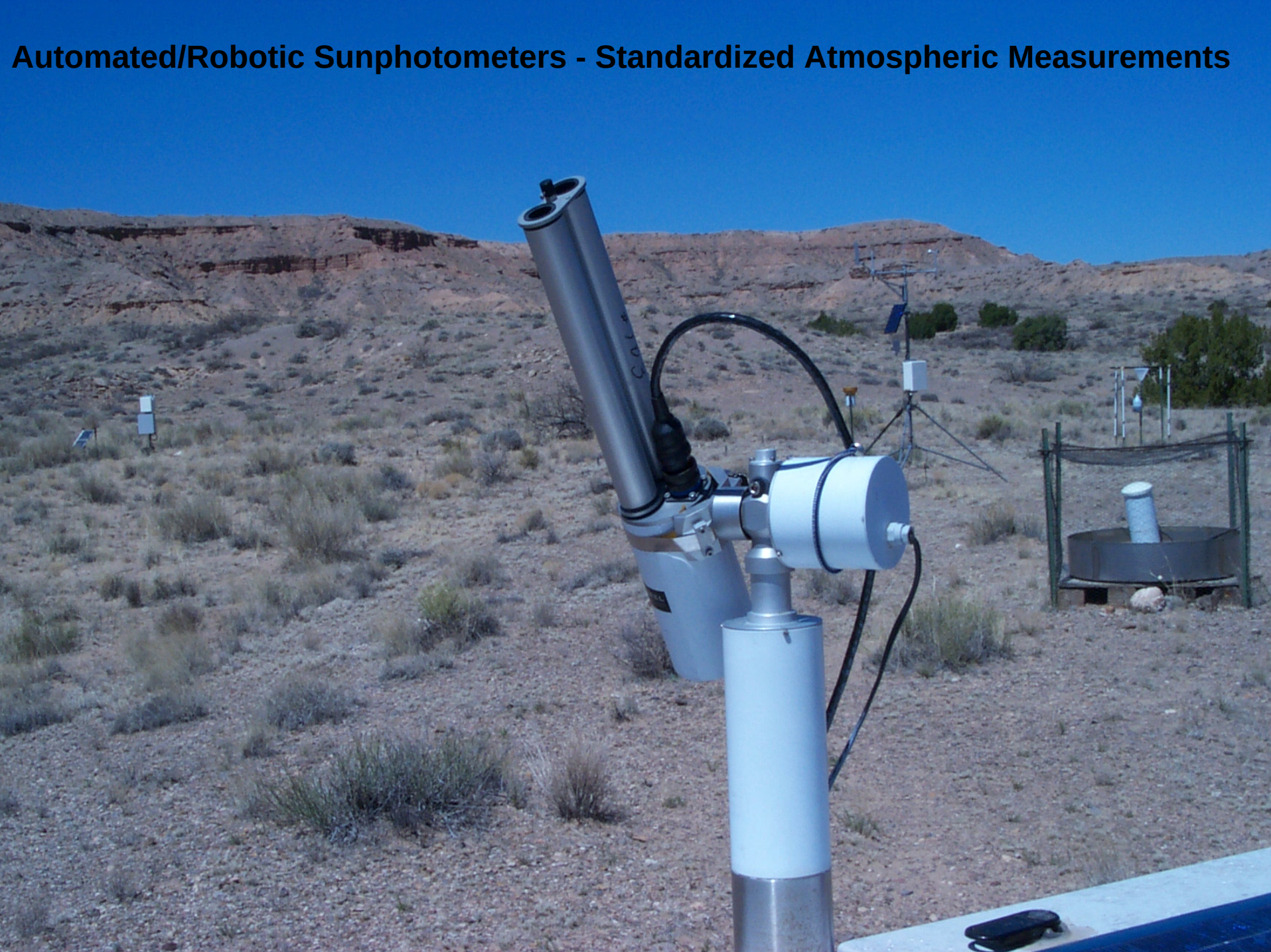
LTER NASA AERONET Collaboration – Robotic data collection with automated data transmission

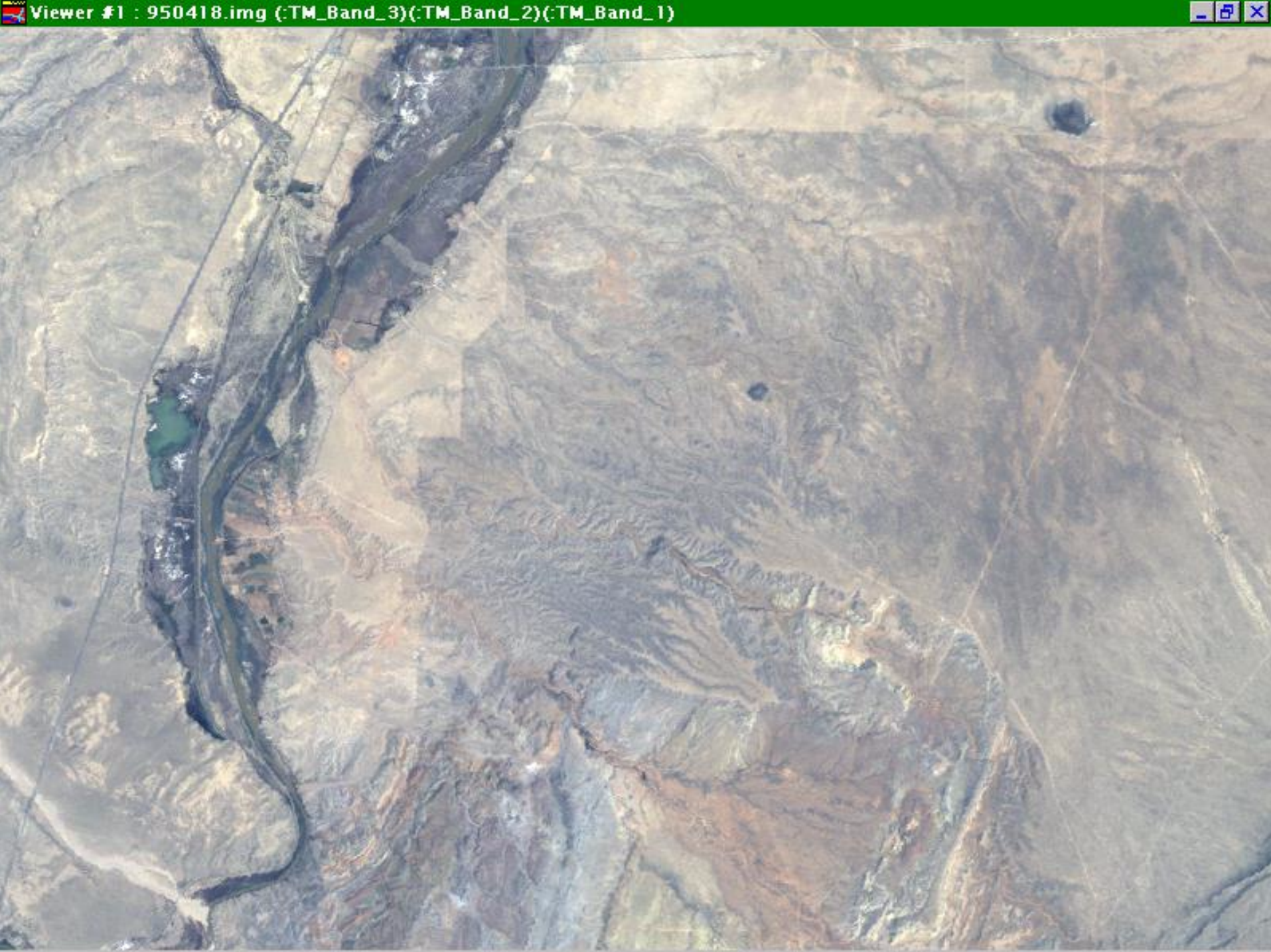
- Operational atmospheric aerosol data – (particles and water vapor in the atmosphere)
- SEV, AND, BNZ, KBS (KNZ, VCR, MCM, NTL, JRN, CAP)
- All data collection, analysis, archiving instrument calibration by NASA/Goddard with routine maintenance by LTER site
- Data collection by standard Vitel data logger
- Automatic data transmission to GOES meteorological satellite – 60 seconds of low bit-rate data in a 90 second window 2x/day.

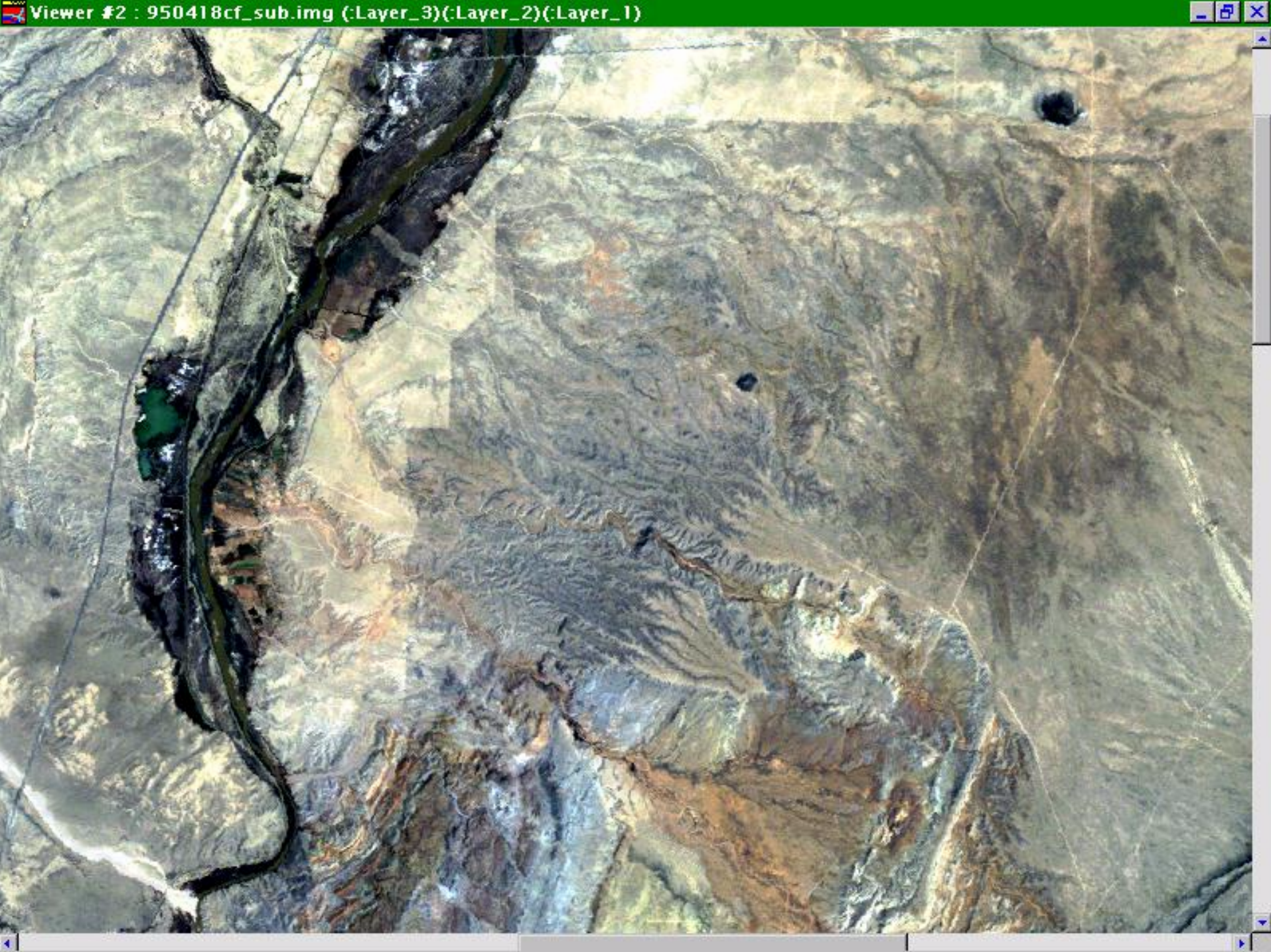




Automated/Robotic Sunphotometers - Standardized Atmospheric Measurements




Viewer #1 : 950418.img (:TM_Band_3)(:TM_Band_2)(:TM_Band_1)


Viewer #2 : 950418cf_sub.img (:Layer_3)(:Layer_2)(:Layer_1)

Home Page
Overview
Sensor Webs in the News
Deployments
Briefings & Papers
Related Sites
Contact Information

Sevilleta, New Mexico - Sensor Web 3.2

We have partnered with the University of New Mexico's Sevilleta Long-Term Ecological Research (LTER) Program both to test the upgraded Sensor Web technology (version 3.2) in the harsh, extremely hot New Mexico desert and to aid the scientists performing the ecological field work.

The primary scientific focus of this field work is to investigate the microclimate canopy effects of three desert shrub species: Juniper, Creosote, and Mesquite. Of central interest is how these different desert shrub species alter the microclimate beneath their canopies, and how this affects composition variation in plant communities. The output from the Sensor Web will also be compared to more traditional monitoring techniques to further test the technology.

The study site is located at the Sevilleta LTER site in central New Mexico (34° 21' 10.8" N latitude; 106° 52' 55.2" W longitude). The canopy of 3 species of desert shrubs is instrumented with Sensor Web pods, in triplicate. Three control pods were mounted in the open (between shrub species), for comparison with the meteorological station data. Every 5 minutes, each Sensor Web pod measures light levels, air temperature and humidity, as well as soil temperature and moisture. The system was initially deployed in late 2003 and is presently part of an ongoing experiment. This deployment represents another example of actually using the Sensor Web technology for meaningful environmental research. More details can be found here.

See an aerial map of the pod locations.

LIVE!

View Streaming, Real-Time Data Graphs from the fielded Sensor Web at the Sevilleta LTER site.


Soil sensors


Juniper tree


Mesquite shrub


Creosote bush


Deploying Pod 9


Server setup

Photographs courtesy of Sevilleta LTER Project

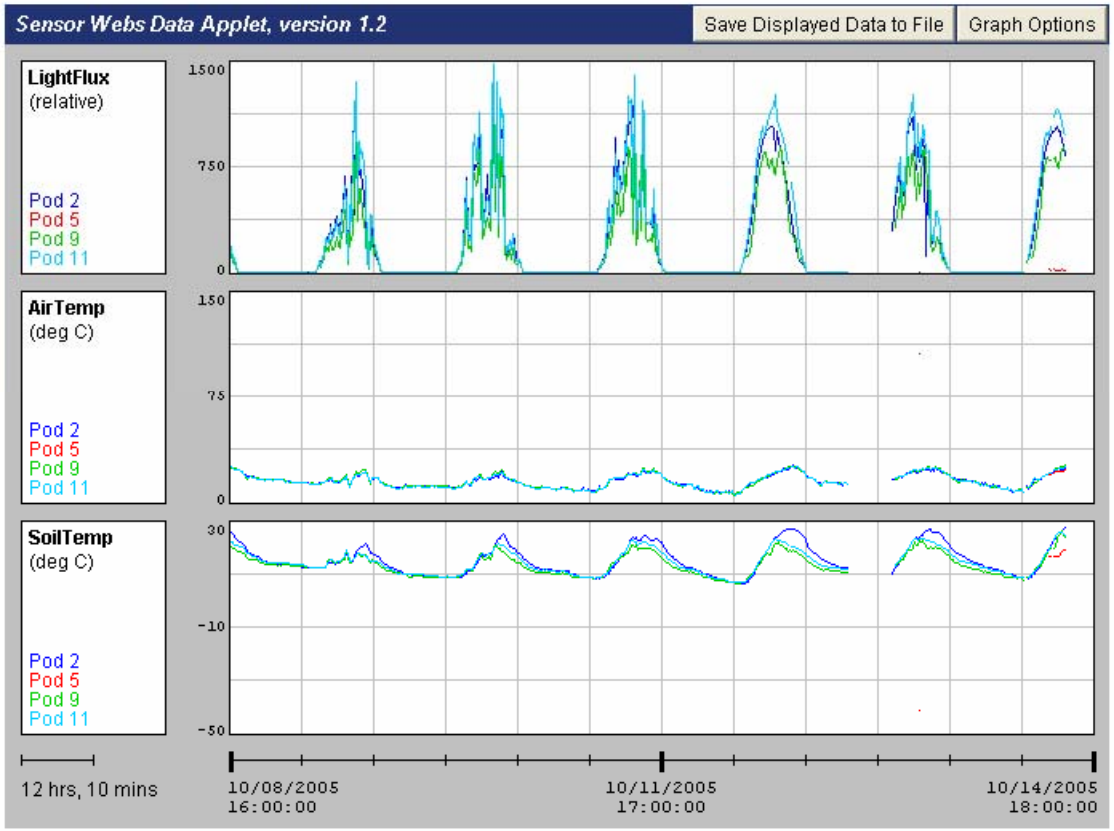
Sensor Webs Data Applet - Mozilla Firefox Beta 1

File Edit View Go Bookmarks Tools Help

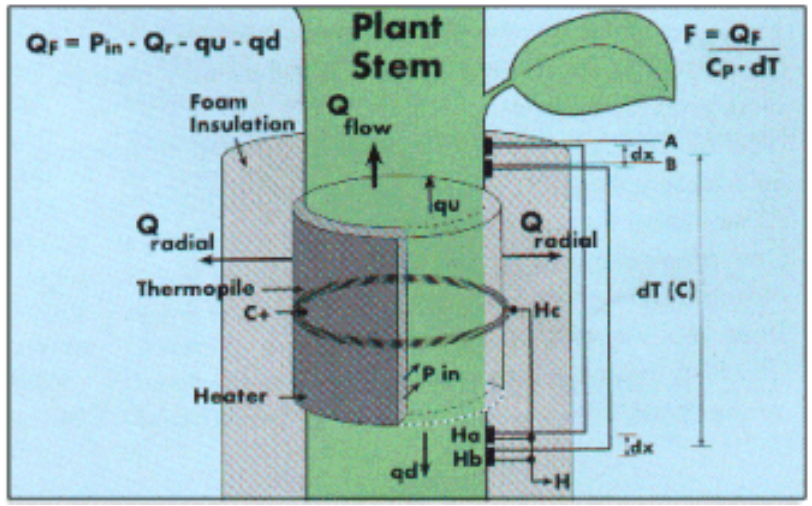
http://datura.unm.edu/webgui/

Getting Started Latest Headlines

sensorwebs Sevilleta Field Station Sensor Web (see map).



Sap Flow Sensors



FUNCTION: Measures Sap Velocity g/hr (transpiration)

- **APPLICATION:** herbs, grasses, shrubs, trees
- **PRINCIPLE:** thermocouples (heat), plant energy balance
- **PROS:** Real-Time, No calibration, non-intrusive
- **CONS:** need many, not wireless
- **CONTACTS:** Dynamax, Advanced Measurements and Controls Inc, Delta-T
- **COST:** $200 - $3500+

http://www.dynamax.com/

Radio & Acoustic Telemetry

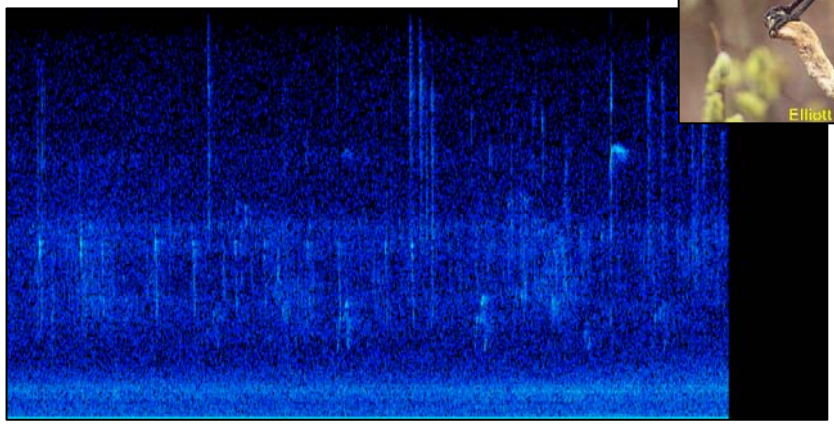
http://www.holohil.com/lb2pic.htm

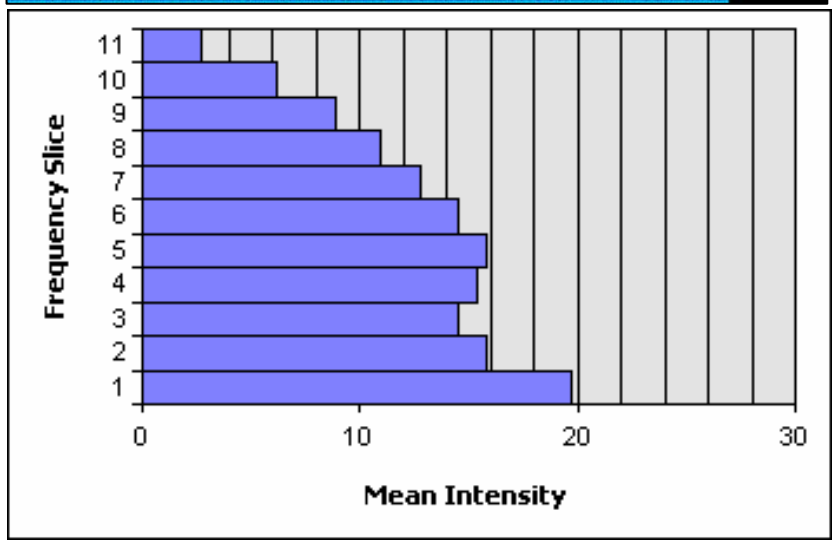
- http://www.lotek.com/

FUNCTION: Organism tracking & Sensing

- **APPLICATION:** Birds, Bats, Fish, Reptiles, Mammals
- **PRINCIPLE:** Micro-sensors (position, pressure, temp), Radio & Acoustic waves
- **PROS:** Wireless, Small, Long use history, No calibration, Real-time option
- **CONS:** Intrusive, Power limitations
- **CONTACTS:** Lotek, Telonics Inc, Holohil Systems Ltd
- **COST:** $135 - $350+

Pilot Study Experiment "Acoustic Pattern Matching"





- Ornithologic (bird) pattern matching
  - DSP/Matlab workbench
  - Match unknown dataset to an known signature
  - Stuart Gage - KBS

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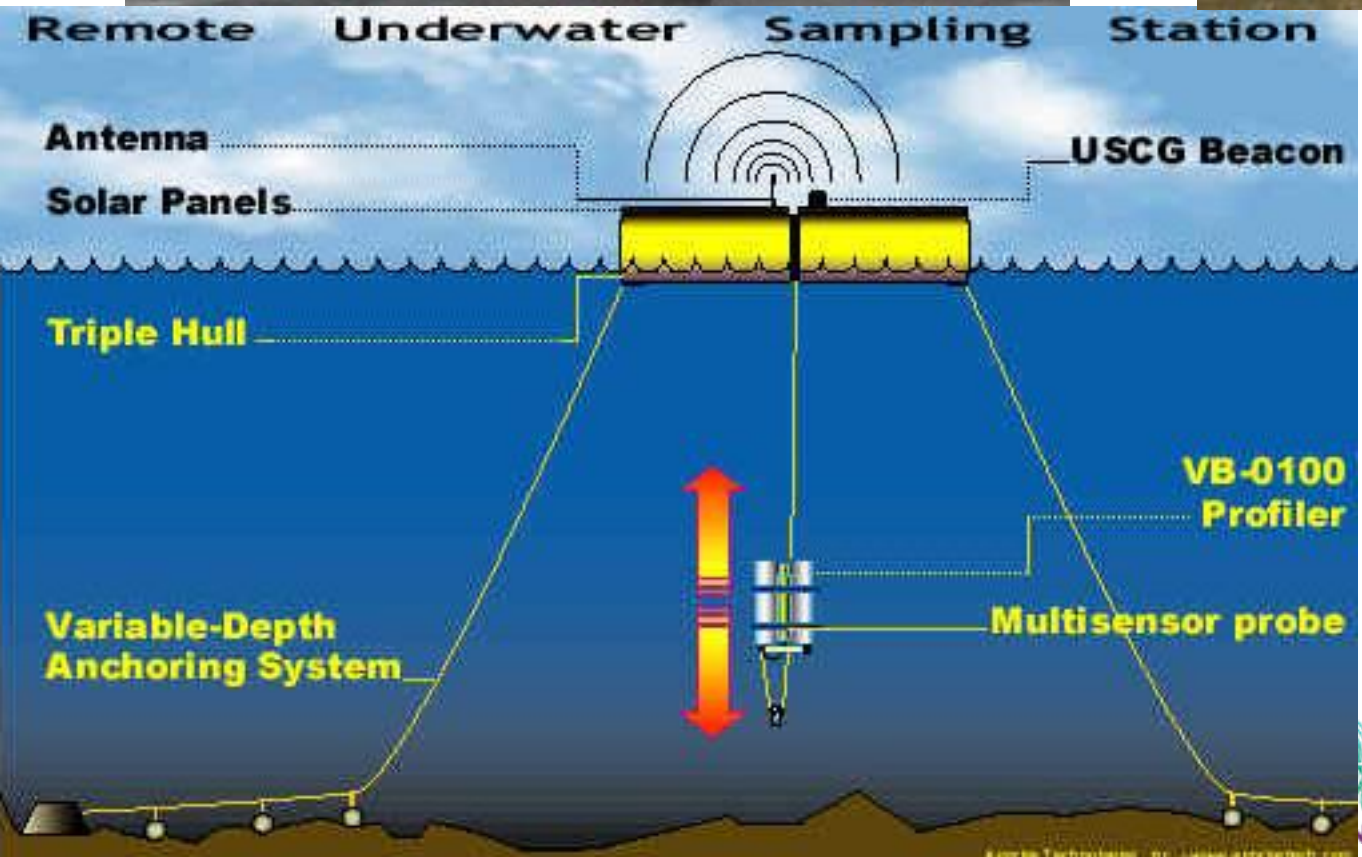
Multi-Parameter Sondes

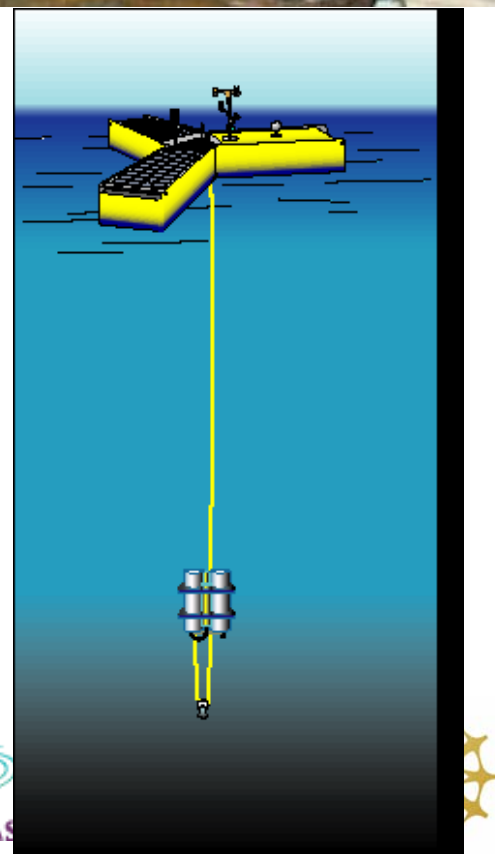
http://www.hydrolab.com/

FUNCTION: Measures 15 or more parameters including: Temperature, pH, Nutrients, Gas, Chlorophyll

- **APPLICATION:** Fresh & Marine water (physical, chemical)
- **PRINCIPLE:** Sensor cluster & Datalogger
- **PROS:** Multiple parameters simultaneously, Automated
- **CONS:**
- **CONTACTS:** Hydrolab, In-Situ Inc, Advanced Measurements and Controls Inc.
- **COST:** $3000 - $4000+

Wireless Profiler:





Long Term Ecological Research
Network Office

Web-based connections to field "sensors"

SEEK KNB NCEAS OBFS LTER NSF

LTER Web Cams - Live images from LTER sites

Niwot Ridge LTER (Tundra-Cam)

Tundra-Cam is a LIVE and INTERACTIVE webcam located at an elevation of 11,600 feet in the Colorado Front Range. The camera is above timberline on Niwot Ridge, about 25 miles west of Boulder. The peaks at the head of the ridge form the Continental Divide. Niwot Ridge is the sole alpine tundra site in the LTER Network.

Web Access

Sevilleta LTER (SEVcam)

Live video feed from a birdfeeder located at the Sevilleta LTER field station on Sevilleta national Wildlife Refuge, in central NM about 1hour south of Albuquerque.

Web Access

Virginia Coast Reserve LTER

Live interactive views from the Hog Island Webcam located atop a water tower in Broadwater VA

Web Access

Coweeta LTER (Coweeta-Cam) and **Coweeta LTER Fire Tower Webcam**

Live interactive views from the Coweeta Hydrological LaboratoryWebcam located in Otto, North Carolina

Web Access

Web Access

Sony D30 pan/tilt/zoom auto-focus camera

- Popular for generic applications
- High quality images
- Low-light capable
- 12VCD power
- Requires protection from weather

AXIS 2401 camera server

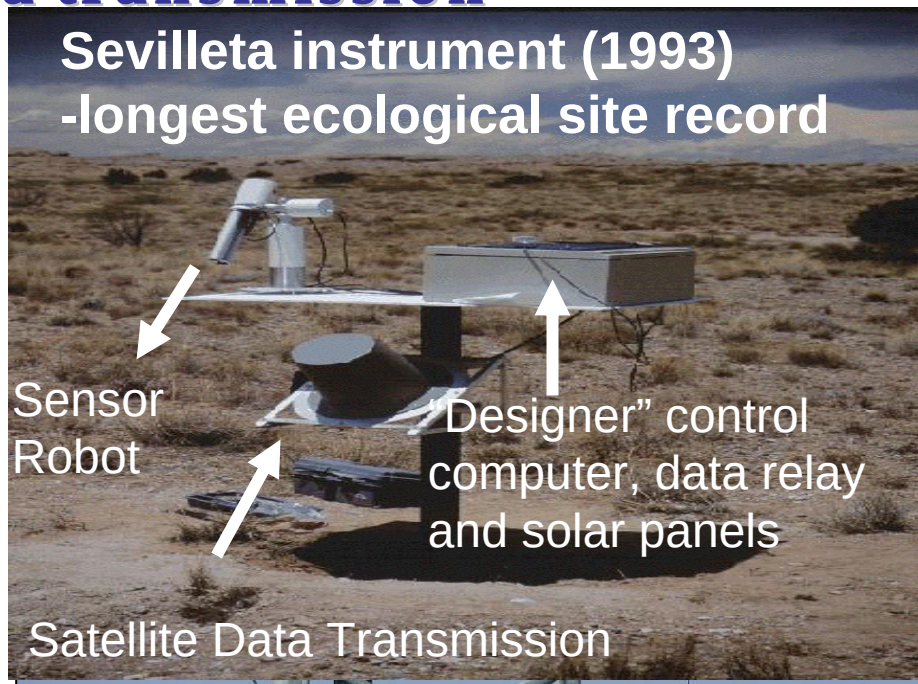
- Single video input -although multiple and rack-mount servers available
- Two serial data ports -one for PTZ, one for digital serial data connection
- Ethernet-based setup
- Linux controller

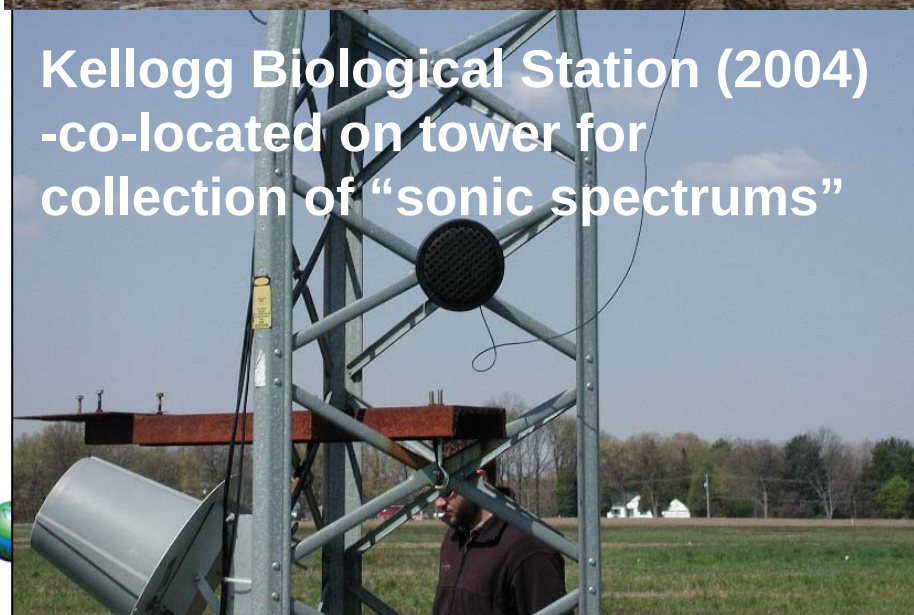
[Data Access]

LTER NASA AERONET Collaboration – Robotic data collection with automated data transmission

- Operational atmospheric aerosol data – (particles and water vapor in the atmosphere)
- SEV, AND, BNZ, KBS (KNZ, VCR, MCM, NTL, JRN, CAP)
- All data collection, analysis, archiving instrument calibration by NASA/Goddard with routine maintenance by LTER site
- Data collection to standard Vitel data logger
- Automatic data transmission to GOES meteorological satellite – 60 seconds of low bit-rate data in a 90 second window 2x/day.

Data Access





Sensor Webs Deployments - Sevilleta - Mozilla Firefox Beta 1

File Edit View Go Bookmarks Tools Help

http://sensorwebs.jpl.nasa.gov/resources/sevilleta.shtml

Getting Started Latest Headlines

sensorwebs

NASA JPL

Sevilleta, New Mexico - Sensor Web 3.2

We have partnered with the University of New Mexico's Sevilleta Long-Term Ecological Research (LTER) Program both to test the upgraded Sensor Web technology (version 3.2) in the harsh, extremely hot New Mexico desert and to aid the scientists performing the ecological field work.

The primary scientific focus of this field work is to investigate the microclimate canopy effects of three desert shrub species: Juniper, Creosote, and Mesquite. Of central interest is how these different desert shrub species alter the microclimate beneath their canopies, and how this affects composition variation in plant communities. The output from the Sensor Web will also be compared to more traditional monitoring techniques to further test the technology.

The study site is located at the Sevilleta LTER site in central New Mexico (34° 21' 10.8" N latitude; 106° 52' 55.2" W longitude). The canopy of 3 species of desert shrubs is instrumented with Sensor Web pods, in triplicate. Three control pods were mounted in the open (between shrub species), for comparison with the meteorological station data. Every 5 minutes, each Sensor Web pod measures light levels, air temperature and humidity, as well as soil temperature and moisture. The system was initially deployed in late 2003 and is presently part of an ongoing experiment. This deployment represents another example of actually using the Sensor Web technology for meaningful environmental research. More details can be found here.

See an aerial map of the pod locations.

LIVE!

View Streaming, Real-Time Data Graphs from the fielded Sensor Web at the Sevilleta LTER site.


Soil sensors


Juniper tree


Mesquite shrub


Creosote bush

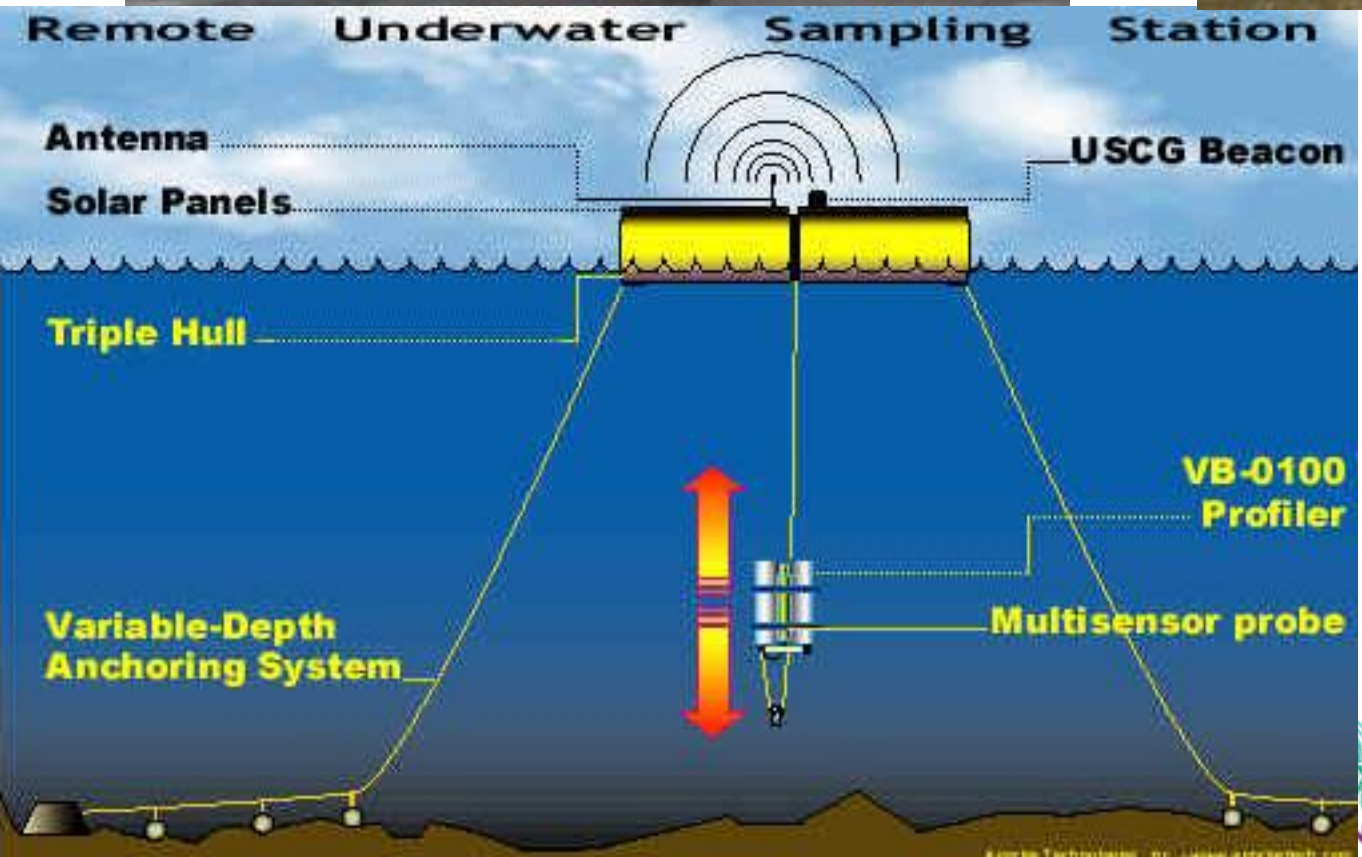

Deploying Pod 9

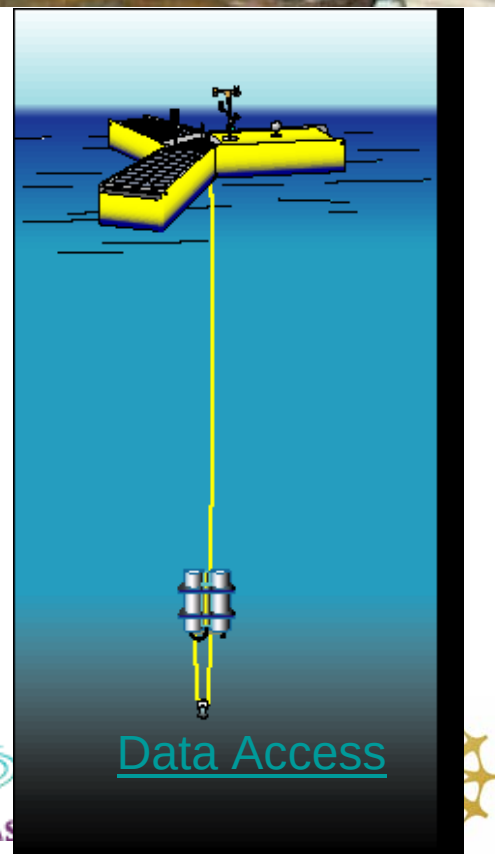

Server setup

Photographs courtesy of Sevilleta LTER Project

Data Access

Wireless Profiler:





Data Access