USING ELECTRONIC TECHNOLOGY TO REMOTELY MONITOR CONDITIONS, AND DISPLAY DATA ON INTERNET IN REAL-TIME

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ABSTRACT

This session describes the use of electronic equipment to monitor soil temperature and moisture, air temperature, relative humidity, wind speed, solar radiation, leaf wetness, and rainfall. Presenter will explain how to use the equipment to monitor conditions, transfer the data, and display the information in real-time on the Internet. Potential applications include: 1) provide real-time information to crop producers for use in crop management decisions; 2) remotely monitor equipment operation; and 3) record remote conditions to calculate evapotranspiration. The presenter uses the technology to remotely monitor soil and ambient conditions using electronic sensors and data loggers, and solar charged cellular modems. The data is transferred to computers using cellular and ftp technology, allowing for near real-time display on the Internet. The sensors and data loggers are Onset products: http://www.onsetcomp.com/index.php. The modems and solar chargers are SolarStream from Upward Innovations: http://www.upwardinnovations.com/upward/home.html. The data is displayed on the Internet by computers and servers operated by Data Garrison: https://datagarrison.com. The data is also display the real-time data from the remote sites on the North Dakota State University Extension Agricultural and Biosystems Engineering Web site at: http://www.ag.ndsu.edu/agmachinery/wirelesstechnology.

Keywords: remote monitoring, technology, electronic, cellular

INTRODUCTION

This project is designed to demonstrate available technology capable of sensing soil and ambient field conditions remotely, and displaying the data on the Internet in near real-time. The authors collaborated with other North Dakota State University research and extension faculty to monitor conditions in various projects in order to demonstrate these technologies with real data. A residue management project involved monitoring rainfall, soil temperature, soil moisture, rainfall, and wind speed in three wheat stubble heights in three locations across North Dakota. A tile drain demonstration site, involved monitoring rainfall, soil temperature, and soil moisture, comparing drained and non-drained conditions in the same field. A third project involved monitoring soil and ambient conditions in soybean tillage demonstration sites.

MONITORING EQUIPMENT

Data Loggers and Sensors

Each monitoring site is equipped with a battery-powered HOBO Weather Station Data Logger and Hobo Smart Sensors that provide a digital readout. The sensors are connected to the data logger with a cable, thus limiting the sensing distance away from the data logger. (Figure 1) Cable extensions are available to extend the distance. The data accuracies are different for each sensor type, and are available on the Onset Corporation Web site.

The Weather Station Data Loggers can accept up to 12 plug-and-play smart sensors, with adapters to accept ten additional sensors. The data can be offloaded directly to a modem, or to a computer using a USB cable. The data logger is powered by four AAA batteries. The use of lithium batteries facilitates operation in cold temperatures.

Fig. 1. Cellular Modem with Solar Charger, Data Logger, and Rain Gauge.

Sensor Issues

The sensors generally function properly, and are warranted by the manufacturer for one year. The smart sensor housing need to be protected from rain and standing water, either by adding silicone sealer where the cables enter and leave the sensor housing, or wrapping the entire smart sensor in waterproof material. The sensor cables may need to be protected from damage from animals or other physical harm.

All sensors withstand weather conditions typical of the Northern Great Plains, although soil the moisture sensors do not function when the soil is frozen.

COMMUNICATION TECHNOLOGY

Cellular Modems

Each remote site is equipped with a six volt, battery powered, cellular modem, and a solar charger to maintain power for the modem. (Figure 2) The data is transferred from the logger to the modem by a cable connection. The cellular modems were purchased from Upward Innovations Company.

The data is sensed at various time intervals at each site and transferred to a remote computer via cellular communication technology every six hours. Electronic commands can be sent to the data loggers using the cellular communications.

Fig. 2. Cellular Modem with Solar Charger

Cellular Service

Upward Innovations modems use various cellular services based on local available coverage. The services in projects described in this article used Sprint Cellular service in five sites. One site uses Iridium Satellite cellphone service because of a lack of Sprint coverage. A minimum cellular subscription service is required at each site.

Upward Innovations provides the cellular service subscriptions. They also provide a no-cost, secure Web site to store and display the data from each remote monitoring site. (Figure 3
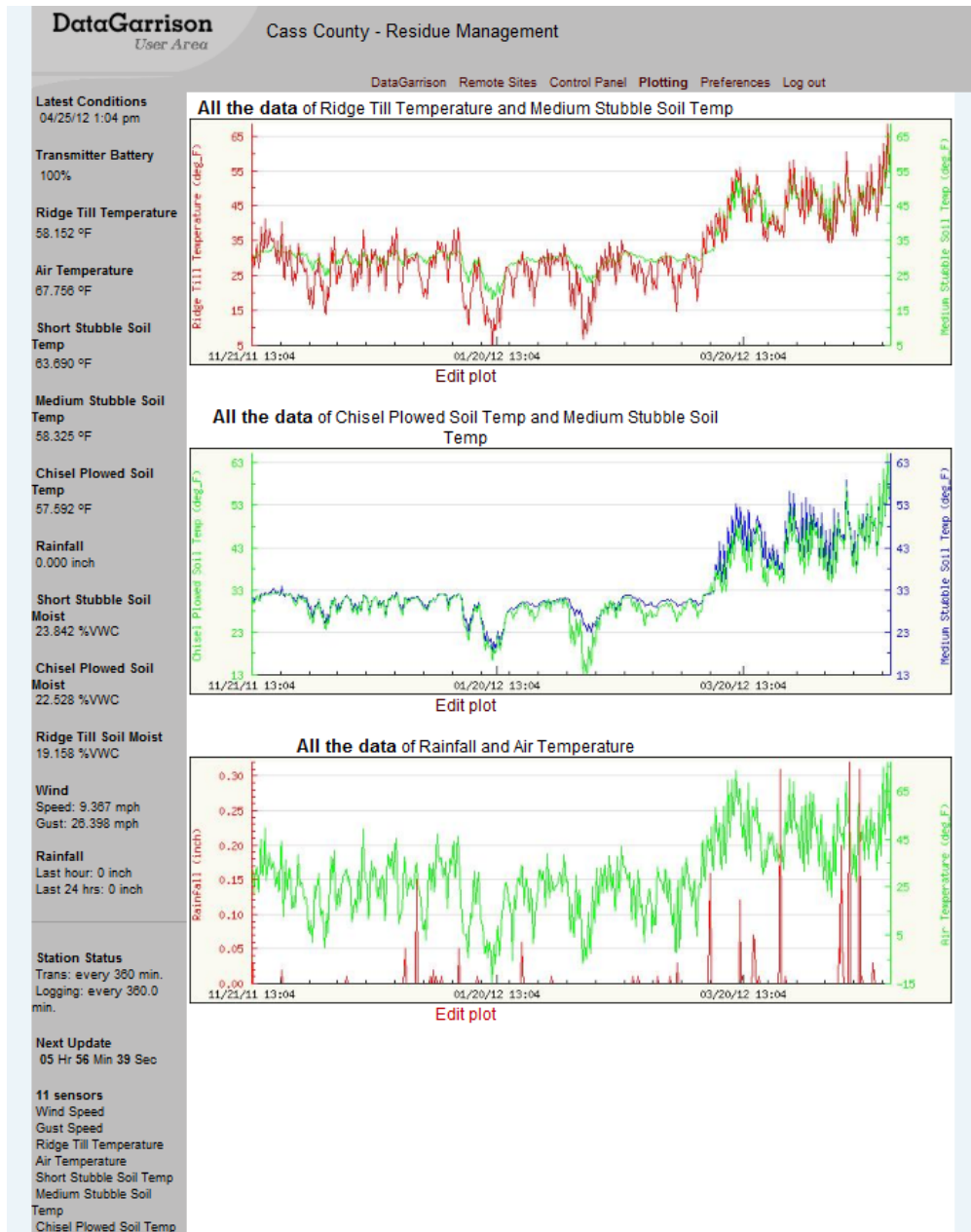

Fig. 3. Secure Web site provided by Upward Innovations.

Communication Issues

This project has experienced few communication problems, and those are serviced and resolved by Upward Innovations technical service personnel. During winter months when there are fewer hours of sunlight available to keep the modem batteries charged we decreased the data transmission rate to conserve battery power.

DISPLAYING DATA ON INTERNET

Transferring Data to Server Computer

The Upward Innovations Web site service includes FTP service to transfer the data in digital text format to server computers connected to the Internet. The FTP service is programmed to transfer the digital text data from the Upward Innovations computer to the North Dakota State University computer server each time it is received from the remote data logging sites.

Serving Data on the Internet

The text files are displayed on the Internet using flash and JavaScript (HTML5) freely available on the Internet from amCharts Company. (Figure 4)
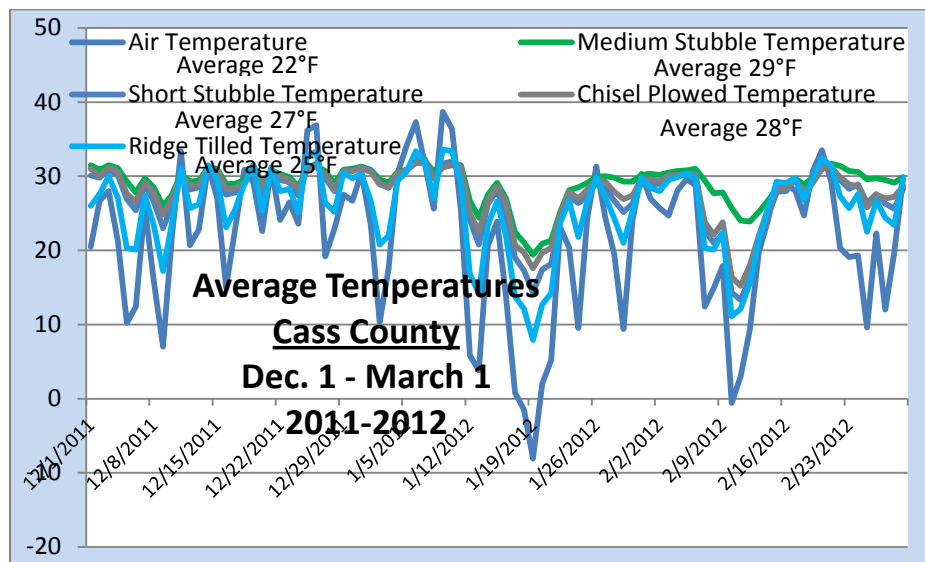

Fig. 4. Data displayed on Internet using amCharts Company charts.

Internet Display Issues

Each sensor at the remote data logging sites is identified by a serial number. The text file generated by the data logger records the data from each sensor from smaller serial number to larger numbers. When sensors are replaced the new sensor has a different serial number and is therefore displayed in a different location in the text file. When the digital text file arrives at the server computer, the amChart server software is programmed to read the text file data by increasing serial numbers. Therefore, each time sensors are changed at the remote monitoring site, the server software requires some minor reprogramming as well.

COSTS

Total equipment costs at each remote monitoring site in this project varies from approximately $1,500 to $2,500, based on the type and number of sensors at each location. The annual cellular subscription costs are $180 for each site using Sprint services and $360 for the site using Iridium services.

SUMMARY

Real-time monitoring of soil and ambient conditions at the remote sites described in this article are displayed on the Internet at http://www.ageng.ndsu.nodak.edu/farmmonitor/index.php. The technology described can be used to: 1) gather research data to support teaching and Extension publications; 2) provide real-time information to crop producers for use in crop management decisions; 3) demonstrate remote monitoring technologies for Extension audiences. The soil and ambient conditions are monitored using electronic sensors and data loggers. The data is transferred to computers using cellular and ftp technology, allowing for near real-time display on the Internet. Conditions monitored include soil temperature and moisture, air temperature, relative humidity, wind speed, solar radiation, leaf wetness, and rainfall in six locations.

This technology could be used in various applications including crop production conditions where fields are in remote locations or distant from management personnel.

REFERENCES

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