SOIL MOISTURE / SOIL TEMPERATURE MONITORING NETWORK PILOT PROJECT

by

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ABSTRACT:

The problem exists that no national coordinated system is available to collect, interpret, and archive the atmospheric and soil climatic data required for global change and natural resource assessment, analysis and research. Baseline information is critically needed for research into these areas and to begin the process of obtaining historical information which is required to make better resource management decisions.

As a result of this problem, the Natural Resources Conservation Service (NRCS), Resources Inventory and Geographical Information System Division (RIGIS), formerly the Resources Inventory Division (RID), which has the responsibility for monitoring and conducting a Natural Resources Inventory (NRI) for accessing short term natural phenomenon, and development of national trends collaborated with the Soils Division in 1990 and established a Soil Moisture/Soil Temperature (SM/ST) Pilot Project (formerly called Global Climate Change Pilot Project). Twenty-one sites have been established in nineteen states across the United States. These sites have been operating since 1992.

INTRODUCTION:

The SM/ST Pilot Project has four major objectives. The first objective of this pilot project is to demonstrate the feasibility of a national, NRCS (and other partners) remote data collection system for gathering remote resource information.

The second objective is to resolve existing technical challenges associated with sensor design, sensor interfaces for remote data transmission, and data management concerns. NRCS has successfully operated a near real-time data collection system called SNOTEL since 1977 which covers an area of approximately 1 million square miles in the western United States. The SNOTEL system uses meteor-burst radio communication techniques to collect remote site information and the system has proven to be cost efficient and extremely reliable. The current SM/ST project utilizes meteor burst communications to acquire information from the 21 remote sites.

Third, atmospheric and to a lesser extent, soil moisture and soil temperature data are collected in small and uncoordinated systems throughout the United States for varying purposes. Some of these systems rely on manual techniques to obtain the site information, while others use different automated techniques. The data are then either entered onto paper or placed into a computerized database. To varying degrees, this information is made available to the user; however the user must know that the data exists. The goal for this pilot project was to identify those data networks across the nation, find out what type of data they were obtaining, and finally, integrate some or all of the other network data into our easily accessible system for use by our customers. NRCS successfully partnered with the six Regional Climate Centers across the U.S. to identify existing networks. This project has now identified the various networks and generally what type of information is available. It is now possible for us to obtain the data from these other networks and make it available for use.

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Presented at the Western Snow Conference, 1996, Bend, Oregon

The fourth and final objective is to make the information from the SM/ST pilot project available to the users. The information is available through a dial up, menu driven computer system, located at the NRCS, Water & Climate Center in Portland, Oregon. This computer system is available 24 hours a day. User access requires only a signed agreement between the individual/agency and NRCS.

METEOR BURST TECHNOLOGY & GEOGRAPHIC COVERAGE:

The SM/ST Pilot Project uses meteor burst communication techniques for obtaining remote site information. This type of communication system does not rely on satellites to transmit the data, rather it bounces radio signals off cosmic dust. The earth is constantly being bombarded by particles and those that are at least one gram or larger in weight and leave a sufficient ionized gas trail behind them, enable meteor burst communication to reflect or re-radiate a signal back to the earth. If a remote site detects this signal, it will transmit the data back to the master station. A master station is a ground based facility designed to transmit and receive a radio signal. Once the master station has the remote site data, it uses standard telephone connections to transfer the data to the Central Computer Facility in Portland. Figure 1 identifies the location of the 21 SM/ST Pilot Project sites, the three master stations, and the Central Computer Facility.

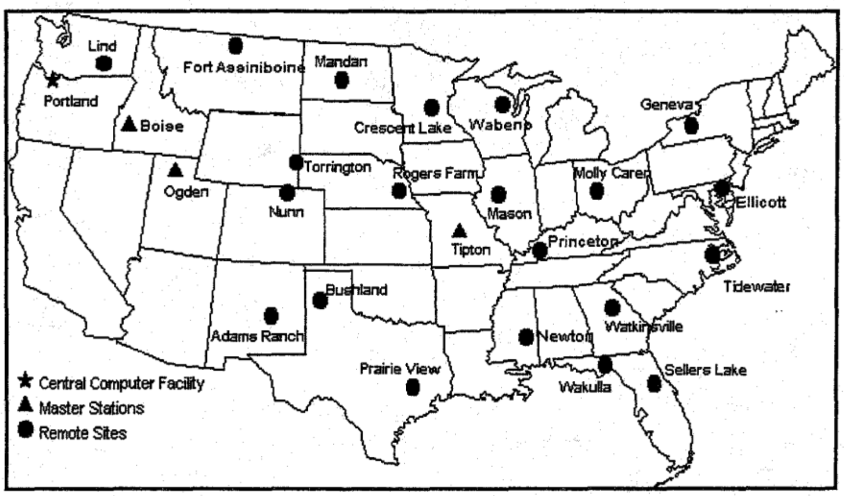

Figure 1

The SM/ST project leases one master station from Meteor Communication Corporation (MCC) which is headquartered in Kent, Washington. This master station serves the midwest and east coast and is located at Tipton, Missouri. Fourteen SM/ST remote sites report through this facility. The remaining seven sites report through the existing NRCS owned and operated SNOTEL master stations. The SNOTEL system currently operates a network of about 600 active remote sites. The SNOTEL master stations are located near Boise, Idaho and Ogden, Utah.

Data from the master stations are sent via normal telephone communications to the Central Computer Facility (CCF) in Portland, Oregon. It is at this center, that the data are quality controlled, stored, analyzed, and made available to the users.

Table 1 lists the uncorrected GPS latitude and longitude for each of the remote sites and the three master stations.

SOIL MOISTURE / SOIL TEMPERATURE PILOT PROJECT
Site Location Information
Current as of
February 27, 1995

	Site Name	State	Latitude	Longitude
1.	Adams Ranch	NM	N34-15.13	W105-25.17
2.	Bushland	TX	N35-10.48	W102-05.67
3.	Crescent Lake	MN	N45-24.90	W093-56.86
4.	Ellicott	MD	N39-15.10	W076-55.41
5.	Fort Assiniboine	MT	N48-29.45	W109-48.02
6.	Geneva	NY	N42-52.59	W077-01.84
7.	Lind	WA	N46-26.34	W119-01.22
8.	Mason	IL	N40-18.79	W089-54.10
9.	Mandan	ND	N46-46.62	W100-54.45
10.	Molly Caren	OH	N39-57.40	W083-26.58
11.	Newton	MS	N32-19.93	W089-04.98
12.	Nunn	CO	N40-51.61	W104-44.38
13.	Princeton	KY	N37-06.15	W087-50.45
14.	Prairie View	TX	N30-05.68	W095-58.30
15.	Rogers Farm	NE	N40-50.78	W096-27.98
16.	Sellers Lake	FL	N29-06.24	W081-37.92
17.	Tidewater	NC	N35-52.33	W076-39.49
18.	Torrington	WY	N42-03.80	W104-09.10
19.	Wabeno	WI	N45-28.11	W088-35.20
20.	Wakulla	FL	N30-18.35	W084-25.48
21.	Watkinsville	GA	N33-53.05	W083-25.67
22.	Tipton Master Station	MO	N38-36.33	W092-48.79
23.	Boise Master Station	ID	N43-28.87	W116-14.93
24.	Ogden Master Station	UT	N41-15.55	W112-14.50

Table 1

Each SM/ST remote site is equipped with a complete atmospheric, soil temperature, and soil moisture sensor package. Table 2 identifies the type of sensors used at each site.

SENSOR TYPE	**SENSOR TYPE**
Precipitation	Air Temperature Current, Max, Min, Avg.
Solar Radiation	Wind Run
Relative Humidity	Soil Temperature at 5, 10, 20, 50, 102, 203 mm
Coleman Soil Moisture Sensors at 5, 10, 20, 50, 102, 203 mm	Watermark Soil Moisture Sensors at 5, 10, 20, 50, 102, 203 mm

Table 2

RESULTS:

Overall system performance has improved since 1991. Matching sensor power requirements with proper solar panel and battery capacity has improved performance significantly. In 1991, 92, and 93, the 21 sites reported the required four times per day about 80% of the time.. In 1994, additional solar panels were added to better match the site power requirements and site performance has exceeded 95 % for the last two years.

SM / ST sites are designed to operate in an unattended mode and provide near real-time information. Gathering sufficient ground truth data required to calibrate the soil moisture sensor has been a challenging undertaking for NRCS soil scientists. At the present time, generic soil moisture equations are being tried to provide some measure of the soil moisture conditions. NRCS Soil Scientists at Lincoln are currently testing a variety of different soil moisture sensors and evaluating their effectiveness and some will be installed at SM/ST sites this summer.

The initial installation of the below ground soil sensors, using a "spider web" configuration that had individual holes for the sensors at each depth, was designed for ease of replacing a defective sensor. Each sensor was encased in PVC pipe and attached with flex conduit to run wires into the outside NEMA enclosure. This design was to protect the sensor and wires from rodent damage and facilitate replacement. While this design did prove to be an effective and efficient way to replace sensors with minimal disturbance to the others, it was postulated that this design was transferring water and heat to the sensors faster than through the normal action of the soil. Therefore; the 1992 below ground sensor installations utilized a wire mesh screen "rat cage," to protect the sensors and wires in a single stack.

The "rat cage" design eliminated the transfer of water and heat to the below ground sensors. However; it is not possible to replace a failed sensor inside the "rat cage" without disturbing the entire sensor stack. When a sensor needs replacing, a hole is dug close to the existing sensor package and the sensor is placed at the appropriate depth. So far, this has proved to be successful.

In October 1994, real-time validation of sensor data began. Precipitation and air temperature are checked each day. Initially, two checks are performed for precipitation; they are sensor limits and rate of change. Air temperature is only checked for sensor limits. If a sensor value exceeds the allowed validation profile for that site, the data are flagged as suspect and a data flag are placed alongside the data value in the database. Additional real-time validation profiles are being developed for other sensors and implementation of these additional checks will be put into production as they are developed.

CONCLUSION:

The Soil Moisture / Soil Temperature Pilot Project is proving to be very successful in providing near real-time information that is being used to make better resource management decisions as well as providing valuable information for carbon sequestration, climatic change trends, and a possible basis for an Agricultural Weather Network. The accumulation of this valuable data set will enhance the process of making quantified predictions about the soil-climate interface. This data set will become the backbone for a much larger NRCS proposed system called SCAN (Soil Climate and Analysis Network). SCAN calls for adding up to 1000 data sites nationwide, as well as integrating data from other smaller networks that collect this type of important information into a common access point. From this access point, basic data and analysis products can be generated and made available for resources managers and researchers. Budget initiatives to fund SCAN have been proposed to NRCS over the last several years, but the operation of the SM / ST Pilot Project is currently the only system that is funded.

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