SNOTEL

Automated Snow Surveys

By

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During the early 1960's the Soil Conservation Service (SCS) commenced a series of operational studies to determine whether a practical remote-type snow water equivalent sensor could be developed. The studies resulted from the need for more frequent data to use in increasingly sophisticated water supply forecasts and from the continued reduction in personnel available to manually measure snow and other related hydrometeorological variables.

The initial studies proved to be quite successful. They resulted in the development of snow pillows and proceeded to prototype telemetry systems for the transmission of pillow snow water equivalent and other related data from the snow-covered mountains to SCS headquarter offices.

By the late 1960's the SCS prototype data acquisition systems using conventional "line of sight" communication techniques were operating in eight western states. Based on the success of these systems, it became apparent that automation concepts held great promise both from the technical and use standpoints.

Consequently SCS, supported by numerous cooperators and user groups, initiated requests for additional funds to be used to design, install, operate, and maintain a network of 511 data sites in the western United States. This system, which has come to be known by its acronym SNOTEL (SNow TELemetry), was given initial funding for implementation in fiscal year 1974.

In order to understand the SNOTEL plan, it is necessary to understand how SCS operates its snow survey and water supply forecast program. This program, along with the other programs of SCS, is organizationally operated on a state basis. In addition, this program is only operated by SCS in the western United States. Thus in each western state with the exception of California, which has a state program operated by its Department of Water Resources, SCS has a snow survey unit. This unit is headed by a snow survey supervisor who functions under the technical and administrative direction of a state conservationist. Although state boundaries do not necessarily follow watershed or river basin boundaries, the program operation--measurement, interpretation, and reporting--is the function and responsibility of each state.

Thus a primary consideration of SNOTEL was to design a system which would fit into this organizational arrangement. In addition, since data collected in one state is of importance to adjacent states and cooperators, the design also required a capability for data exchange. A further consideration was the need for equipment and procedural standardization.

In fiscal year 1974 SCS entered into a contract with Systems Consultants Incorporated (SCI) San Diego, Calif. for a systems study to determine what type of an automated system would best meet the needs of SCS and its cooperators. Of particular importance to SCS was:

A. What were the user's needs both as to type of data and frequency.

B. What communication technique would best fit the system.

C. What type of system control would be required for the acquisition, exchange and storage/retrieval/analysis of data.

This system study, coupled with other studies conducted by SCS personnel, resulted in the SNOTEL plan.

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Basically, the plan calls for incremental implementation of a 511 data-site network in the western states. A key element in the data acquisition system will be a system control minicomputer located in Portland, Oregon. This computer will monitor and control two or more "master" telemetry stations which in turn will control and acquire data from the aforementioned data sites. In addition each SCS state office will be equipped with CRT terminals through which they will request and acquire data. Supplementally, the Department of Agriculture computer facility at Ft. Collins, Colorado will be used for SNOTEL data base management.

Communication between the Portland "central" computer, the state office terminals, the "master" stations, and Ft. Collins will be handled by land lines (dial-up and private). Access to data by other cooperators and users will be through the Portland "central".

Communication between the "master" stations and data sites will use the meteor burst telemetry technique. The following is a summary extract from our consultants report on meteor burst communications.

> "Each day billions of meteors enter the earth's atmosphere and in burning in the E-region (80-120km altitude), form long columns of ionized particles. These columns diffuse rapidly and usually disappear within a few seconds. During their brief existence the ionized columns will reflect radio signals, thus giving rise to what is called meteor burst, meteor scatter, or meteor propagation.
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> The usefulness of such trails for communication purposes is dependent upon several known factors such as time of day, season, and latitude. The earth's forward orbital velocity combines with its rotational velocity in the predawn hours and opposes it in early evening hours, resulting in a daily cyclical variation in meteor burst rate that has been observed to exhibit a range of activity ratios from 3 to 1 to as great as 8 to 1. In addition to diurnal variation, seasonal variations occur. In the springtime, the northern hemisphere is tilted away from the apex of the earth's way (orbital velocity vector), and in the fall it tilts toward the apex position. For this reason, greatest meteoric activity in the northern hemisphere occurs at the autumnal equinox, while the least activity occurs at the vernal equinox.
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> Meteor-ionization trails are capable of reflecting incident VHF signals for distances up to 1,500 miles between transmitter and receiver. The paths are unaffected by ionospheric variations and other disturbances that occur in the HF band.
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> In almost every case, meteor burst systems, both experimental and operational, have been directed toward continuous communications such as teletype traffic. The nature of the "burst" type communication paths has made these systems somewhat slow and complex, when compared to line of sight or wire communications. Nevertheless, the meteor burst systems have proven effective and are still in use. The main reason that more meteor burst systems have not been installed is the introduction of communications satellites.
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> However, the nature of most remote data acquisition systems is periodic transmission of short messages from many remote locations, an application tailormade for the duty cycle of meteor burst communications systems. In addition, the historic problems of reliability and power requirements of remote transmitters/receivers have been eliminated by today's technology.
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> Due to the varying angle of meteor trails as they enter the earth's atmosphere and the relative wide beam width of the transmitting and receiving antennas, a meteor burst communication system is able to establish reliable communication with remote sites located in valleys and behind mountains. For example, a meteor entering the atmosphere at a steep angle relative to the earth's surface could create a radio path that would allow data to be extracted from the bottom of the Grand Canyon from a distance of 300 miles. Since the optimum path for meteor burst communication is not on the great circle connecting the two points as might be expected but several degrees on either side (dependent on time of day), data from a remote site directly east of Mt. Hood could be received in Portland, for example, simply by using a path around the mountain."

The SNOTEL plan calls for the incremental implementation of the automated system over a period of 5 years. Currently, the first procurement phase is underway with invitations for bids or requests for proposals "on the street or pending." This phase will consist of three principal parts:

A. Procurement of the Portland "central" computer.

B. Procurement of 2 or more "master" meteor burst stations and from 100 to 150 data site (transceiver, control and logic units, antennas, etc.).

C. Procurement of sensors, transducers, shelters and other related equipment.

Our plans call for the SCS offices in each state to install by October 1, 1975 the sensors (stainless steel pillows, precipitation gages, and temperature unit) and the transducer shelters and antenna towers. Projected state sites by states are as follows:

	If 100 Installed	If 150 Installed
Arizona	4	4
Colorado	8	8
Idaho	13	16
Montana	14	30
New Mexico	3	3
Nevada	12	12
Oregon	14	25
Utah	14	30
Washington	5	5
Wyoming	13	17

The successful offeror on the so called "meteor burst" system will be required to install all equipment necessary to encode and transmit sensor data to the "master stations". The system will be digital and of the "on call" type. In addition this system will be designed to accept up to 16 sensor inputs. Further, it will provide a battery voltage sensor and a power supply capable of 9 months unattended operation with sufficient power to supply excitation voltage to the government furnished sensors.

The "central" computer will have the following characteristics:

32 K - 16 bit memory
Disk Storage Subsystem
16 I/O Channels
Paper-Tape Reader
Real-Time Clock
Automatic Bootstrap
Card Reader 300 cds/min
Printer 200 lines/min
Asychronous Multiplexer
CRT
Thermal Printer 80 ch/line - 240 lines/min
Software: Fortran, Algol, etc.

Application software will be developed in-house by the government as well as by contract.

Subject to meeting all technical requirements, the central computer and the meteor burst systems will be either leased or purchased. The lease or purchase decision will be based on cost comparisons following required government procedures. Likewise, contractor maintenance of either purchased or leased equipment will be acquired.

In succeeding years, the initial network and system will be expanded to its projected maximum of 511 stations.

We in SCS feel that the initial system as well as the ultimate system will provide the type of data urgently needed by a wide variety of water users in their daily water management activities. We are confident that the SNOTEL system will enable us to provide improved service to agricultural water users, to respond quickly when more frequent data is required and to obtain important hydrologic data from locations that previously were practically inaccessible to ground crews.