TELEMETRY and the INTERNET

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ABSTRACT

This paper provides an overview of recent advances in wireless telemetry and Internet browser technology for the collection and distribution of water, weather and climate data. Comparisons between performance, data reliability and life cycle costs are presented for the various options that are available to the user for routing data from a remote site to a desktop browser.

The choice between using satellite, cellular, meteor burst and various VHF/UHF technologies is not always clear cut and involves a trade-off between geographic coverage, latency of data and network service fees. This paper provides guidelines and figures of merit to assist the user in choosing an appropriate wireless technology.

Web based access to remote sites is becoming a very cost effective means of collecting, archiving and displaying hydrometeorological data using a desktop PC. Remote station configuration, security, data basing and text messaging are topics that are discussed.

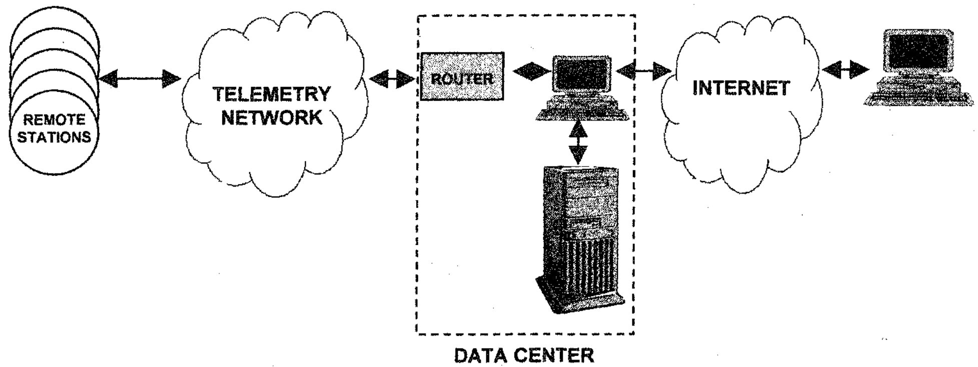
Finally, cooperative arrangements between government and industry are becoming more common place to take advantage of the various telemetry and browser technologies that are being used by these various agencies. A cooperative venture between Natural Resources Conservation Service (NRCS) and Meteor Communications Corporation (MCC) in Stoneville, Mississippi is described as an example of this trend.

INTRODUCTION

Water, one of nature's simplest and most abundant elements is crucial to our everyday existence. All too often, this vital resource is in short supply—or in too great a supply. In 1999, the snowpack in the western United States was 130% above normal. In 2000 the snowpack was normal and it is forecasted to be at less than 70% of normal for 2001.

With such wide variations in snowpack, it is extremely important for the streamflow forecaster to have the necessary tools to collect, archive and distribute snowpack and streamflow data to provide timely and accurate predictions of the available water supply for each season.

In this paper, we focus on the streamflow forecaster and what is needed for them to produce timely and accurate streamflow forecasts, but any user of data would require more or less the same kind of tools. The tools that are generally available to the forecaster are shown in the network diagram below.



TYPICAL DATA COLLECTION NETWORK
FIGURE 1

It consists of four basic elements: (1) remote stations for measuring water, weather and climate data, (2) a telemetry network for controlling and retrieving the data, (3) a repository for the data, and (4) a means for efficiently distributing the data to the end users. Since one size does not fit all, there are a number of variations to this network. In its simplest form it may be a single wireless link from a remote station directly into an end user's office. At the other extreme it may be thousands of stations dispersed throughout a large geographic area and interconnected with either a satellite or terrestrial based network. The key factors in selecting an appropriate telemetry network include the following:

* data reliabilty
* latency of data
* geographic coverage
* cost; both initial and recurring
* network ownership and control of data flow
* ease of installation and maintenance

Once collected and stored in a secure data repository the data must then be made available to the general public through an ubiquitous network that can be easily accessed by all end users. The Internet is rapidly beginning to fill that important role and is being effectively used by many agencies. Data is generally made available through the Internet by browser access to web sites. Data center server software and hardware is now being developed that allow the end user to make on-line changes to the configuration and reporting rates of their remote stations through the use of common web browsers without the need for special software installed on his desktop.

With the availability of these new and developing tools, more is expected of the forecaster. Not only are they expected to be well versed in these technologies but they are also expected to use them to their maximum advantage in providing timely and reliable data to the water resource manager.

It is the intent of this paper to assist the streamflow forecasters in selecting, or augmenting, their data collection and distribution capabilities.

TELEMETRY CHOICES

The choice between using satellite, cellular, meteor burst and various forms of UHF/VHF technologies is not always clear cut. There are important trade-offs to take into account.

Most notably the maturity of the technology, the assurance of it being around for the next 5-10 years and finally the cost of operating and maintaining the network. Independent ownership and control of the network may also be an important consideration for some users. However, the best option for most forecasters is to become a subscriber on one the many service networks that are available today. In this way, forecasters can focus their talents and energy on what they do best and leave all the network communication problems to someone else.

Lots of options exist. When choosing among them, the most important consideration is service. No matter how slick-looking the device, it will be worthless if you can't collect your data because of poor coverage. Lots of coverage area maps are only marginally useful as they only let you know what is theoretically possible in a given region. The cellular providers are notorious for this. Whether a service can truly be accessed in a particular area is best determined firsthand.

The first task is, therefore, to determine the area of coverage that is required. Two broad choices exist: regional coverage or nationwide coverage. Generally speaking, regional coverage will be less expensive but there will be more uncertainty in coverage for all sites. A national service network will take the guesswork out of coverage, however, the service fees may be higher.

Once the area of coverage has been decided the next big challenge in selecting a particular service network is to sift through all the advertising material to figure out exactly what the coverage area will be, how much it will really cost and what the true latency of the data will be. This data is often difficult to obtain with any level of specificity. Quite often, you won't really know until you're on-line and you receive your first monthly invoice.

One of the purposes of this paper is to assist the forecaster in evaluating the various options that are available to him and narrow the choice down to several. At that point, further due diligence is required. Another good option is to ask for a 30-day trial. There is no substitute for firsthand knowledge and experience.

Nationwide Coverage

In the context of this paper, nationwide coverage refers to the ability to place a remote station at any location within the US and not be restricted by terrain or general location.
There are at least five basic choices for true 100% national coverage. There may be others but these are certainly representative. Four are satellite based and one is terrestrial. They are shown in Table 1. As stated earlier, exact data is difficult to obtain and therefore some entries in Table 1 are given as a range. Also, some entries were left blank when information was either not available or couldn't be determined.

NETWORK FEATURES	MeteorComm	GOES	ARGOS	ORBCOMM	INMARSAT C
▪ Communications Technology	Meteor Burst	2 Geostationary Satellites	2 Polar Orbiting Satellites. -28/day at the poles -6-7/day at the equator	28 Polar Orbiting Satellites.	Geostationary Satellite
▪ Independent Ownership (Control of Network)	Yes	No	No	No	No
▪ Geographic Coverage	North America	Western Hemisphere	Global	Global	Global
▪ Two-way Communications	Yes	No	No	Yes	Yes
▪ Transceiver Cost	$1,975	$2,000-$3,000 (transmit only)	$2,000 (transmit only)	$750-$1,000	$3,000-$4,000
▪ Optional Receiver Cost	Included	$2,000	Not available	Included	Included
▪ Latency of Data (average)	5 minutes	4 hours	1-4 hours	15-30 minutes	1-4 hours
▪ Event Reporting	Yes	Yes	No	Yes	Yes
▪ SCADA Capability	Yes	No	No	Limited	Yes
▪ Service Fees	$ 9.95/mo. 0-1 Kbytes $19.95/mo. 1-6 Kbytes $29.95/mo. 6-24 Kbytes	$50/year/DCP (USGS)	$7.50/day, minimum 32 bytes/transmission	$30/month base cost plus: $25/mo. for 0-2 Kbytes $40/mo. for 2-5 Kbytes $80/mo. for 5-10 Kbytes	$0.02 per byte 32 byte data packets
▪ Data Reliability	100%	Data can be lost if transmit slot is missed	*	*	*
▪ Text Messaging	Yes	No	No	Yes	Yes
▪ Built-in Data Logging	Yes	Yes	Yes	No	No
▪ I/O for External Data Logger	Yes	Yes	Yes	Yes	Yes
▪ DCP Maintenance Monitoring	Yes	Yes	*	*	*
▪ Remote DCP Programming Capability	Yes	No	No	*	*

*Data not available or could not be determined

TABLE 1: TELEMETRY OPTIONS FOR DATA COLLECTION (Nationwide Coverage)

The first decision to make is a requirement for two-way communications. Two-way communications are important for messaging to personnel at the remote site, changing update rates and making on-line programming changes to the data collection platform from your office

If two-way communication is required, the choice is narrowed to MeteorComm, OrbComm and Inmarsat. GOES has plans for making a receiver available, however, the roll-out date is uncertain at this time and the additional cost for the receiver is projected to be $2,000.

The other important decision is cost. Table 2 provides the approximate monthly service fees for each of the networks. The fees are based on collecting 25, 100 and 200 sensor values per day, each sensor value consisting of two bytes. For example, 100 sensor values equates to collecting data from 4 sensors every hour.

NETWORK	SENSOR VALUES/DAY (2 bytes/sensor value)		
	25	100	200
GOES	$0-4	$0-4	$0-4
MeteorComm	$10	$20	$25
INMARSAT	$30	$120	$240
ORBCOMM	$55	$110	Negotiated
ARGOS	$225	$225	Negotiated

TABLE 2: MONTHLY SERVICE FEES

If data is only to be transmitted once every four hours, GOES is certainly the least expensive. As data collection requirements increase the other satellite service fees may become prohibitive.

The 5-year life cost for each network service is shown in Table 3. The cost calculations are based on reading 100 sensor values per day. It is important to note that as data collection requirements increase the initial cost of the transceiver becomes less of a factor.

NETWORK	TRANSCEIVER COST	SERVICE FEES	TOTAL
GOES	$3,000	$0-250	$3,000
MeteorComm	$2,000	$1,200	$3,200
ORBCOMM	$750	$6,600	$7,350
INMARSAT	$3,500	$7,200	$10,700
ARGOS	$2,000	$13,500	$15,500

TABLE 3: 5 YEAR LIFE CYCLE COST (100 sensor values per day)

Regional Coverage

Regional coverage, as distinct from national coverage, is defined in the context of this paper as a wide area network (WAN). Communications coverage is not ubiquitous but is normally available in certain geographic areas or cells. This can range from a single cell using spread spectrum to thousands of cells provided by a cellular network. End-users have the option of either designing and installing their own network or to be a subscriber on a network service , such as cellular. It should be pointed out that regional coverage can also be obtained with one of the telemetry networks described previously for national coverage.

The technologies used for regional coverage are all line-of-sight (LOS). There are many options and variations available, however, they fall into the general categories of cellular, spread spectrum, UHF and VHF. The technologies listed in Table 4 are representative.

The entries in Table 4 are listed in descending order of the frequency band they occupy. Cellular is highest at frequencies above 900 MHz and VHF is lowest at frequencies below 300 MHz. The advantage of the higher frequencies is the use of smaller antennas, however, site selection is more dependent on terrain factors. Lower frequencies will provide greater areas of coverage.

Perhaps the most difficult assessment to make among the various technologies is the range of communications that can be expected between a remote station and a base station because this is greatly influenced by terrain, transmit power and electrical noise. The terrain is a greater factor at the higher frequencies and noise is more of a contributing factor at the lower frequencies.

To obtain a first order assessment of range, each technology was modeled using a standard RF Propagation Analyses program. The assumptions were (1) flat terrain, no obstructions (2) a tower height of 20 feet and (3) the use of an omni-directional antenna (2 dbi gain). The coverage results in Table 4 are stated as an approximate range that can be expected under normal circumstances, and for the assumptions stated. As previously mentioned, significant variations can occur due to terrain, noise and transmit power.

The height of the antenna is everything. The higher the antenna, the more extended the range will be.

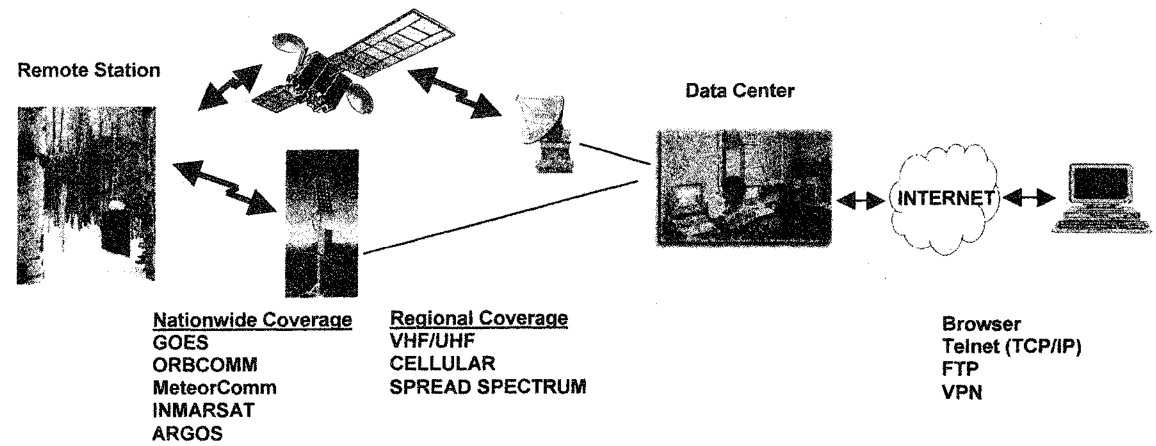
THE INTERNET

The availability and widespread use of the Internet has had a significant impact on the way we collect and distribute data today. At the click of a mouse we can immediately access the data from our remote stations from virtually any place in the world. Web based data access is now commonplace.

NETWORK FEATURES	AMPS[1]	MicroBurst[2]	FreeWave[2]	Various	Packet Radio
▪ Communications Technology	Cellular/CDPD	IS-41/SS7	Spread Spectrum	VHF/UHF	ELOS (VHF)
▪ Range, where coverage is available (flat terrain, 20' tower, 2dbi antenna)	5-10 miles TX = 100mw	10-15 miles TX = 3 watts	10-15 miles TX = 1 watt	20-30 miles TX = 25 watts	30-50 miles TX = 100 watts
▪ Independent Ownership Control of Network)	No	No	Yes	Yes	Yes
▪ Two-way Communications	Yes	Yes	Yes	Yes	Yes
▪ Transceiver (Modem) Cost	$500-$1,000	$525	$1,300	$500-$1,000	$1,975
▪ Latency of Data (average)	1-60 minutes	Near real-time (dependent on network loading)	Real-time	Real-time	Real-time
▪ Event Reporting	Yes	Yes	Yes	Yes	Yes
▪ SCADA Capability	Yes (requires datalogger)	Yes (requires datalogger)	Yes	Yes	Yes
▪ Service Fees	$20-$40/month plus long distance charges)	$30/month minimum for 2200 bytes	No	No	No, if customer owned Minimum $9.95/month for 15 Kbytes[3]
▪ Data Reliability	High	High	High	High	High
▪ Text Messaging	Yes	Yes	Yes	Yes	Yes
▪ Built-in Data Logging	No	Yes	No	No	Yes
▪ I/O for External Data Logger	Yes ○	Yes	Yes	Yes	Yes
▪ DCP Maintenance Monitoring (built-in)	No	No	No	Limited	Yes
▪ Remote DCP Programming	Yes	Yes	Yes	Yes	Yes

(1) Advanced mobile phone service (2) Representative of similar products (3) FleetTrak

TABLE 4: TELEMETRY OPTIONS FOR DATA COLLECTION (Regional Coverage)



DATA ROUTING FROM FIELD TO DESKTOP
FIGURE 2

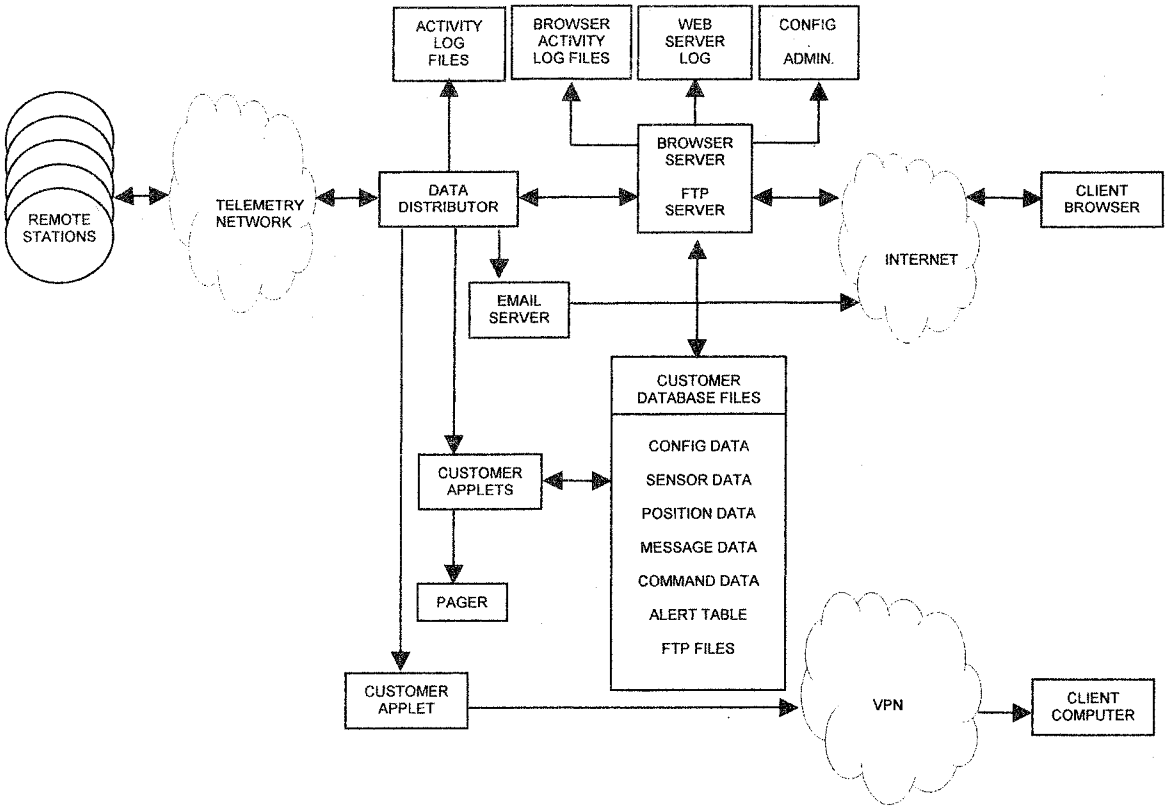
The Internet can be used in two primary areas within a data collection network as illustrated in Figure 2. In can be used for routing data from a base station, or satellite earth station, directly to the forecaster's desktop PC. This is typically done through a Telnet (TCP/IP) session. It is then used again for distributing this processed data to the various clients on the network. This is normally done with a browser accessing a web site.

The browser is now being used not only for viewing the data but also for on-line control of the data collection platform. The ability to make programming changes in response to varying conditions that may be occurring at the data collection site can be a powerful tool for the forecaster to use during times of dynamic change.

The significant advantage of a browser is that there is no new software to install on your desktop PC. Special software maintenance and periodic updates are not required. This is all done in the data center.

Web Based Access of Sensor Data

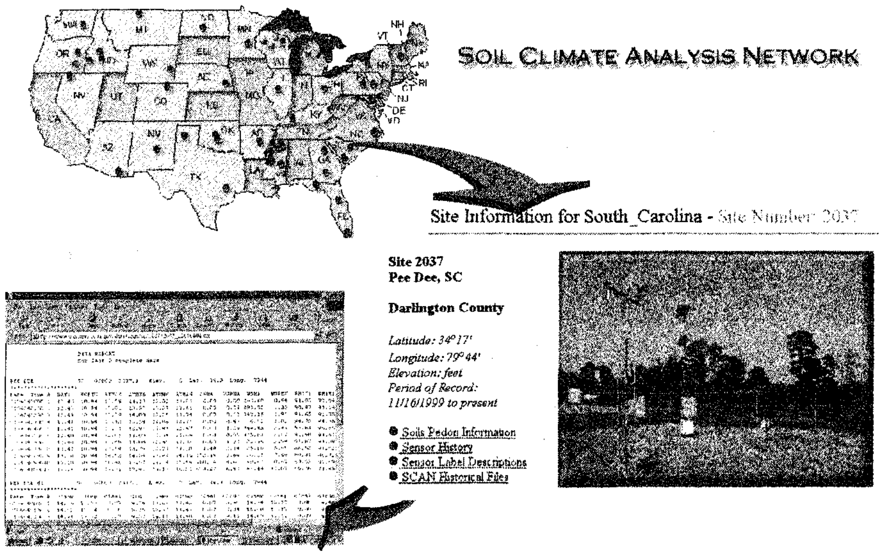
The functional block diagram in Figure 3 illustrates the basic requirements for a data center to provide wed based access of data.



WEB BASED ACCESS OF SENSOR DATA
FIGURE 3

As data is collected, processed and updated it is stored in a database that can be accessed through a browser server. The data can either be made available to the general public or password protected to a select clientele.

A typical web site will use a map for showing the geographic location of all the customer's sites. Clicking on the site of interest will display a picture of the site, pertinent geographic parameters and the complement of sensors used at the site. A menu is normally provided for the user to select both current and historical data. The NRCS web site shown in Figure 4 is typical.

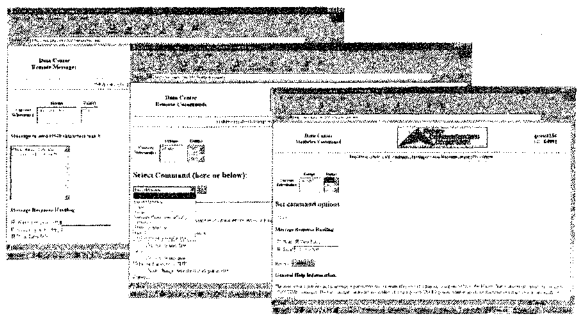


WEB BASED DATA ACCESS
FIGURE 4

Web Based Control of the Data Collection Site

With some enhancements in the data center hardware and software the browser can become an interactive tool for dynamically controlling the configuration of the data collection platform. . A prerequisite for using an interactive browser will be the use of a telemetry network that has two-way communications and supporting protocols.

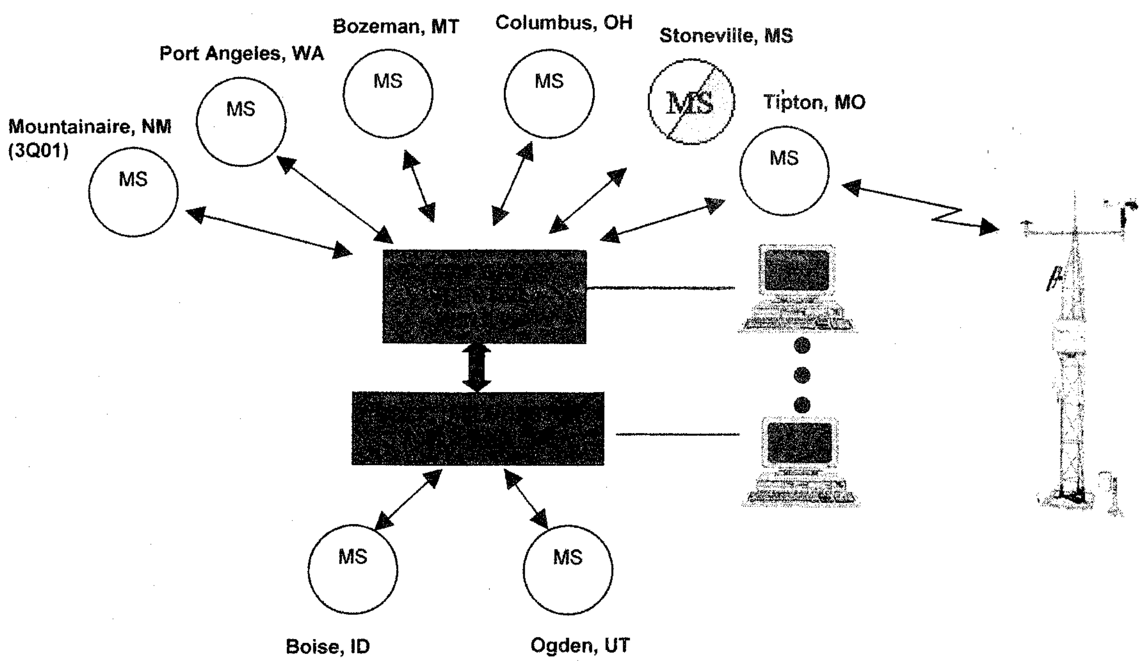
Through the use of customer applets, interactive control is available through both browser access and virtual private networks (VPN). The data base files must also be expanded to include messaging, commands, alerts and FTP files. Confirmation of changes made to the data collection platform (update rates, program downloads, etc.) can be sent to the originator immediately while on-line, or at a later time via email or pager. Two-way messaging and notification of alerts are handled in the same manner. Typical web pages for messaging and configuration control are shown in Figure 5.



BROWSER CONTROL OF DCP
FIGURE 5

COOPERATIVE ARRANGEMENTS BETWEEN GOVERNMENT AND INDUSTRY

Advances in wireless technologies and use of the Internet have ushered in the era of being connected and on-line at all times. In addition, open architectures have allowed using a combination of telemetry options to fit varying communication needs within the same network. Strategic partnerships are being formed that allow the shared use of independently owned networks to the mutual advantage of each partner. One example of such a partnership is the cooperative arrangement between NRCS and MCC, as shown in Figure 6.



NRCS/MCC NETWORK CONFIGURATION
FIGURE 6

NRCS owns and operates two meteor burst master stations in Ogden and Boise for collecting snowpack data in the 11 western states. MCC also owns and operates six master stations and provides nationwide coverage for a variety of data collection applications.

NRCS desired to install a master station in Stoneville, MS in support of its Soil Climate Analyses Network (SCAN), however, budget constraints delayed that from occurring. A cooperative partnership was formed whereby MCC installed one of its master stations in Stoneville on land made available by NRCS, including utilities. In return, MCC provided the master station equipment and a 50% discount to NRCS off its standard service fees. Data between the two networks is routed directly between each partner's data centers in Portland and Seattle. This is a win-win arrangement. NRCS is able to collect the SCAN data it needs at a considerable cost saving and MCC did not have to make the capital expenditures for land, infrastructure and utilities.

SUMMARY

The availability and widespread use of the Internet, coupled with advances in wireless telemetry, provides the forecaster, and other users, with a powerful set of tools to obtain real time information on which to make decisions. At the same time, choosing the correct tools can be a daunting task because each telemetry option provides distinct advantages and disadvantages.

Data reliability, communication coverage, maintenance, network control and life cycle costs are among the predominant factors to take into account when selecting a telemetry network. This paper has provided an overview of these various factors to assist the forecaster in evaluating the various options and making an informed decision. There are many factors and choices to sort through to find the perfect match for the type of network that will satisfy the forecaster's needs. At the end of the day, due diligence and first hand knowledge are keys to success.

With advances in data center hardware and software, the common browser is now used to not only view the data on your desktop PC but also to control the remote station that is measuring and scaling the data. Some of the telemetry networks described in this paper provide this service for their subscribers and end-users. This has the advantage that no new software has to be installed and maintained on your laptop or PC. At the click of a mouse you can now access and control your data from virtually any place in the world.

Finally, open system architectures are allowing a combination of Internet and telemetry options to be interconnected between networks. Strategic partnerships then allow the shared use of assets and new technologies to the mutual benefit of each partner. The NRCS and MCC partnership was described as an example of such a cooperative arrangement.