

SNOTEL - TECHNOLOGY TO MITIGATE NATURAL
DISASTER IMPACTS ON A WATERSHED BASIS

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ABSTRACT

SNOTEL (remote data acquisition technology via meteor burst) has been successfully applied mitigating losses from water and climate related natural disasters by the USDA, Natural Resources Conservation Service (NRCS).

Remote SNOTEL sites monitor snow water equivalent of mountain and plains snowpacks, precipitation, air temperature, and soil moisture and temperature. This near real-time information drives predictive analyses (amounts and timing) of seasonal surface water runoff that supplies irrigation and municipalities. Stream flow amounts for fisheries, power generation, river transportation, or flood management are also determined from this data. Recreation and wildlife managers, and building safety engineers rely on this information in making critical design, and management decisions. Decisions are seasonal, event, or emergency based.

Non-NRCS resource information is integrated into the analyses for comprehensive understanding of basin, watershed, and effected areas. Results are immediately available by world wide web services, word of mouth in local communities, official reports, news, and by computer access of our data center.

Mitigation is achieved: as production is balanced with investments according to the outlooks of the seasonal probability of adequate water supply; advance information about soil moisture shortages or excesses prevent costly mistakes; hourly SNOTEL data monitors critical flood source areas of watersheds during rain or snow, runoff over saturated soils profiles, and extraordinary snowmelt events. Protection of life, property, and sustainable agriculture is the outcome.

INTRODUCTION

The NRCS remote data acquisition system, SNOTEL (Snow Telemetry) provides near real-time snow and climate data for effective scientific based resource decisions for watersheds.

Our mortal human experience includes four pertinent factors; (1) The need for adequate quality water for agriculture, industry, and life; (2) The health and resilience of the land, and its watersheds; (3) The forces of economic/societal pressures; (4) and the variability of weather. This never ending scene of interaction is played across the face of our earth.

Mostly, we are successful in sustaining our environment. However, the graveyards of fallen empires around our globe solemnly remind us of our need to be in harmony with nature. Natural disasters still occur in this relationship, however. Effects are often costly, impacting the stability of economies, societies, and watershed health. The United States strives, like all countries, to mitigate losses from these events of excesses, untimeliness, and shortages of surface waters, and soil moisture levels that originate from precipitation events. The application of modern SNOTEL technology has brought dramatic improvement to mitigation of these threats.

SNOTEL - MONITORING OF CRITICAL NATURAL RESOURCES

The NRCS SNOTEL network was established in 1975. This automated system has replaced and supplemented traditional manual snow surveys and limited hydrometeorological data that was gathered from watersheds in the arid western half of our country. Needing a better understanding of poorly monitored headwaters areas and more precision in forecasting the

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resultant seasonal water supplies have caused this deployment of the worlds first meteor burst communications based data collection network.

SNOTEL has proved to be very cost effective, using only three base stations for U.S. coverage. Meteor burst communications provides year-around data from the remote sites and from as far away as 1600 km from their master station. This natural phenomena of tiny meteorites burning as they enter the earth's atmosphere fifty to seventy miles above the earth's surface, provides the reflectors needed for radio transmissions of the data. This wireless and radio repeaterless system provides 98 to 99% response from the network of remote sites daily. The power requirement is minimal, requiring only a twelve volt solar charged battery. These remote sites operate unattended, with only several maintenance visits per year.

Daily data is provided to the SNOTEL central computer facility. Provisional data quality screening is performed and the data become available via internet/web service from about 700 locations in western US and Alaska. The data menu includes snow water equivalent of mountain snowpacks, precipitation, air temperature, as well as other parameters (snow depth, solar radiation, wind run, and relative humidity) as needed, and in another 21 stations (nation-wide) soil moisture and soil temperature readings. In emergencies, selected locations or the entire system are activated for hourly reports from the central system office in Portland, OR.

Climate and soil moisture information from other sources is also obtained and integrated through our Unified Climate Access Network (UCAN). UCAN provides ready access to the various climate data resources and analysis tools from all official US climate data sources by internet links. With the most complete information set available, conditions are analyzed and predictions determined for the seasonally variable surface water runoff at over 1000 stream gage points. Information products are provided to many users including; irrigation and municipal water supply groups, stream flow managers for fisheries habit, power generation, river transportation, reservoir operators, and flood control officials. Recreation interests, wildfire and wildlife managers, and building structural safety engineers also rely on this information source. Critical design, and management decisions are seasonal, climatic event, or emergency based. Snow packs are analyzed for forage management, winter crop cover protection, traffic concerns, and potential for snow avalanches.

Additionally, soil moisture monitoring provides information critical to crop productivity forecasting, drought potential, and wind erosion risks. Climatic events which could trigger landslides on unstable saturated slopes or intensify existing high flood hazard potentials are also noted for appropriate mitigating actions.

Data is made available through the web, on-line telecomputer interface to the SNOTEL central computer facility, as well as printed copy.

MITIGATION - CLIMATIC EVENT AND SEASONAL NATURAL DISASTERS

SNOTEL information has been effective in the mitigation of damages and losses during climatic events and on a seasonal basis:

- Farmers and herdsman make decisions about annual investments of fertilizers, seeds, capital investments of equipment and livestock, and range management based upon their expected seasonally variable water supply. Information is provided in a probabilistic way for analysis of their particular risk. This prevents costly economic mistakes, unnecessary nutrient pollution of runoff, and erosion of the soil resource base.
- Farmers in fallow/dry farming regions evaluate the soil moisture condition and estimate the possibility of success for the next crop or the likelihood of losses from unrealized precipitation and resultant drought. They are making the best informed decision possible.
- Hourly data from mountain watersheds has proven invaluable during extraordinarily rapid spring snowmelt, or unseasonable rain on snow events. Here are several recent examples:

1. February of 1996 brought heavy rains onto Pacific Northwest snowpacks quickly releasing runoffs of serious flooding stage with no lessening of the storms in sight. The Willamette River management, and emergency flood operations officials made first hand use of SNOTEL information from the key watershed headwaters. It provided them hourly analyses of the rain on the melting snowpack. Thus they were able to predict the development of the streamflows and delineate the threatened areas before the floodwaters arrived. As the heavy warm rains continued to melt snowpacks rapidly, evacuations were planned with adequate advance warning, and flood protection barriers for the downtown business district and southwestern neighborhood sandbagging were implemented in time to minimize losses. In previous similar runoffs on the Willamette River major losses would have been encountered. SNOTEL information and runoff forecasting support hour by hour, greatly reduced what could have caused multi-millions of dollars worth of losses.

2. During December, 1996 -January, 1997, the Pacific Northwest, and in particular Southern Oregon, Northern and Central California, the Truckee drainage from Lake Tahoe in CA/NV and the nearby Carson and Walker Rivers suffered extremely high precipitation, melting snow and heavy flooding as a result. Although the disastrous event materialized very rapidly the SNOTEL information was again very effective in minimizing damages by the millions of dollars to communities, transportation, industry, and agriculture in these regions.

- Municipalities or water short irrigation systems monitor the SNOTEL information products closely to mitigate possible losses by implementing timely water conservation measures and delivering available water according to various decreed water rights.
- Winter recreation area and transportation managers access the SNOTEL information frequently to monitor rapidly changing avalanche conditions and issue warnings or take actions to mitigate loss of life and property by winter motorists or skiers.
- Local city and recreation officials utilize current information to evaluate safety of snow loaded roofs in exceptional snow packs and take evasive action as necessary. Building codes include the snow load data in construction standards.

MITIGATION - LONG TERM NATURAL DISASTERS

Watersheds of our nation which are in good condition absorb unusual high precipitation and runoff events, and are a natural buffer mitigating many damages that the fickleness of climate inflicts. This precious resilience however can be eroded away for the sake of short term economic gains. SNOTEL type resource data benefits this long term cause in the following ways:

- Long term records of data from the SNOTEL system provide historical reference points to inventory baseline resource conditions, and to assess watershed health.
- Global climate change concerns are addressed by the Soil Moisture-Soil Temperature system data as it benchmarks and supports studies of GEWEX Continental-scale International Project (GCIP) under the Global Energy and Water Cycle Experiment (GEWEX).
- Long term productivity of the soil and watershed is kept in balance with desired economic objectives by continuous evaluation of moisture accumulations in the soil profiles, soils characteristics, projected seasonal precipitation, and proposed farming or livestock management practices.
- Multi-year droughts wreak severe economic, social and soils degradation upon the landscape. These losses are minimized by continuous assessment of the soil moisture and the resultant moisture balance over large regions. Soils that are not abused during precipitation stressed periods will retain their productivity for future generations. Millions of dollars of loss are averted annually in the Great Plains and irrigated areas of the US by planning seasonal and long term farming and grazing according to current climate trends, current soil moisture, and expected surface water flows from snowmelt. The seventeen governors of the Western States formed a Drought Coordination Council in 1996, integrating data and analysis sources to make regular assessments of soil moisture

and drought conditions, and plan mitigations. SNOTEL and Soil Moisture data are major inputs to this evaluation.

- Loss of aquifers' water producing capacity can be mitigated by utilizing current and historic climate information provided by SNOTEL. Direct correlations between seasonal precipitation and aquifer recharge can warn of excessive drawdowns.
- Water quality is enhanced by the natural buffering actions of healthy watersheds. Some water quality parameters are being reported from the SNOTEL system now. As the technology of remote sensing of these complicated and labor intensive parameters improves, large scale applications of SNOTEL will enhance decision making to strengthen buffering capability of US watersheds.

Fish and wildlife habitat management is enhanced by utilizing current and historic climate information gathered from the SNOTEL and other climatic and streamflow stations. This information resource will play a significant part in determining and implementing Pacific Northwest habitat improvement for the salmon.

PROGRESS AND IMPLEMENTATION

SNOTEL information plays a major role in the development the arid U.S. West where over 75% of the available surface waters come from annual melting of mountain snowpacks. Much of our significant irrigated agriculture product also comes from this region. Competing pressures are mounting as expanding populations, industry, and agriculture vie vigorously for the limited water in regions of our country where water use is several times the naturally occurring supply. SNOTEL data collection is receiving increased financial and monetary support from non-government sources. Expanding urbanization and agricultural productivity in previously water abundant areas of the country are now beginning to seek out the SNOTEL water resource monitoring technology for their areas.

The NRCS Cooperative Snow Surveying and Water Supply Forecasting Program is the steward of the SNOTEL system. An economic evaluation of this program reported benefits of over 20 times the program cost. This has prompted several reviews by policy makers desiring to transfer this successful service to private enterprise. These efforts have met with customer disapproval. The continuing consistency, reliability, quality, easy access to current and historic data, and unbiased interpretive products of the SNOTEL system are apparently the basis for this response.

NRCS is currently leading in the sponsorship for several new budget initiative proposals for expansion of this technology nationwide:

- SCAN (Soil Climate Analysis Network) - This is a national network of new SNOTEL type sites with integration of various existing soil moisture and soil temperature sites and systems. A single source for this information on a nationwide basis is not currently available. SCAN and the previously mentioned UCAN information system could provide monitoring of the soil moisture and temperature conditions, and an ongoing assessment of crop productivity potential and risks involved.
- NSDMS (National Snow Data Management System) - This is an expansion of the very successful snow surveys and water supply forecasting activities into the remaining snow zones of the U.S. These areas now offer only disparate and incomplete data collection and water supply forecasting services for watershed management, and flood warnings.

USDA and NRCS provide the federal leadership for this activity with strong cooperation by private, state, utility and local entities. Twenty percent of the capital investment for existing remote stations have been provided by cooperating water users. About fifteen percent of the monetary and various in-kind service resources currently supporting SNOTEL operation and maintenance are from non-NRCS sources.

SUMMARY

Mitigation of natural climate based disasters from event, seasonal, or over long term has been greatly improved by the use of the SNOTEL automated remote sensing of snowpack,

precipitation, air temperatures, soil moisture, soil temperatures, and other hydrometeorological data. SNOTEL arms water managers with a growing technology to meet the continuing excesses, untimeliness, and shortage of waters, and soil moisture levels that originate from the interactions of climate events, soil, and mankind.

Agricultural opportunity for the future is preserved as decisions are made event by event, season by season, and years in advance in a watershed context that prevent mankind's ambitions and climatic conditions to be combined in ways that over tax the natural resilience of watersheds. It is our intent to share our expertise and understanding of the SNOTEL technology wherever it may be applied for the sake of sustaining global agricultural opportunity and societal stability.

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