New & Improved NRCS Snow and Water Supply Forecast Products

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This year, the Natural Resources Conservation Service (NRCS) is celebrating 100 years of providing snow information to natural resource managers and the general public. This month's feature article honors this occasion and introduces some new products from the NRCS National Water and Climate Center.

History of NRCS snow monitoring

Nearly 100 Years ago Dr. James E. Church of the University of Nevada, Reno began the first routine snow surveys in the mountains around Lake Tahoe. Church was a renaissance man and one of the great American naturalists, a cultured classics professor, rugged outdoorsman, exacting scientist, and early member of the Sierra Club. Spurred on by the same turn-of-the-century sense of exploration and adventure that drove Cook, Scott and Amundsen to the North and South Poles, Church ventured into hostile terrain, decades before the popularity of winter sports. He designed and developed the manual measurement technology still in use today, collected the early snow samples and helped produce the first water supply forecasts.

In the 1930s, snow survey and water supply forecast responsibilities were gathered together under the Natural Resources Conservation Service (NRCS, then called the Soil Conservation Service). Today, the NRCS National Water and Climate Center (NWCC) in Portland, Oregon continues this legacy, analyzing and archiving snow data, as well as producing water supply forecasts. The NWCC benefits from the dense network of NRCS field personnel, including the Data Collection Officers and Water Supply Specialists who collect and quality control data and work closely with local irrigators and water managers in interpretation, planning and decision-making.

To this day, routine manual measurements of snowpack at high elevations continue every month through the snow accumulation and melt season. Originally designed to support water supply forecasting, this data has found many research applications, becoming the most comprehensive record in existence of winter mountain climate, at many remote and climatologically harsh locations far from any traditional valley weather stations. About 25 years ago, the NRCS invested heavily in automating this manually intensive monthly observation system, creating the SNOTEL (SNOw TELemetry) network. By increasing the numbers of and spatial distribution of snow measurement sites through the years, the NRCS is able to provide more precise estimates of basin-wide snowpack and better streamflow forecasts.

New GIS-based map products

Today, the NRCS combines manual measurements, an ever-expanding network of SNOTEL sites, and the powerful advances in information technology and data communication, to monitor the pulse of western snowpacks and water supplies and communicates that information to users through innovative new products. In just the past few years, the NRCS has made great advances in visualization of hydrologic data. In 2006, the NWCC added an extensive section of real-time map-based GIS products (http://www.wcc.nrcs.usda.gov/gis/). Every day an array of maps containing snowpack, snow density, precipitation, and temperature are generated in a variety of contexts.

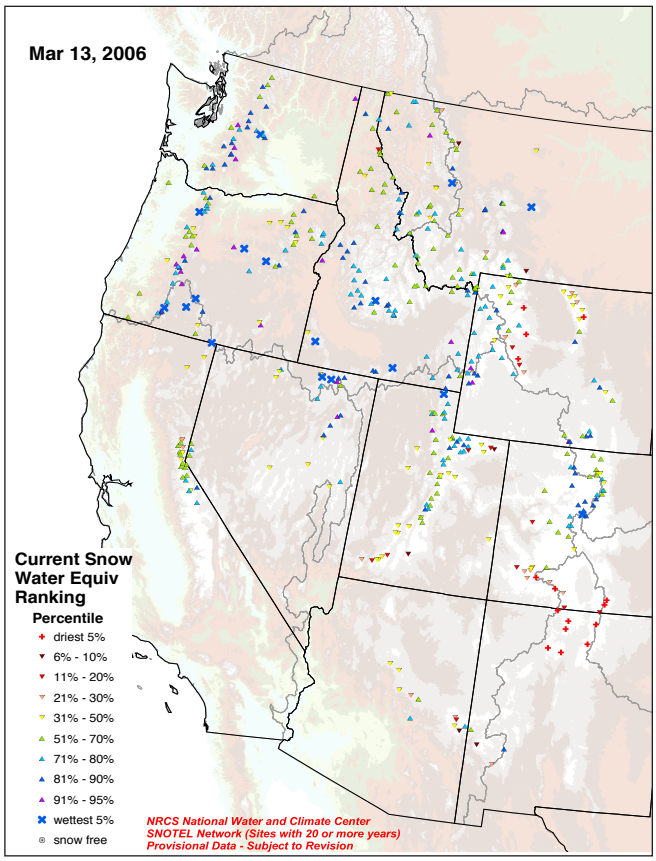

Figure 1a: March 13, 2006 SNOTEL Snow water equivalent (SWE) percentile map for the western U.S. The SWE for this date highlights the short spatial distance between record highs and record lows in the Intermountain West region. The water availability pages for each state in this Summary (pages 10-12) contain maps similar to this one, but show the percent of normal SWE rather than the percentile ranking.

While many users are familiar with snow data displayed as percent of normal, new maps of percentile rankings and of record highs or lows help users determine the historical significance of current conditions (Figure 1a). In order to monitor the current water year, some maps show the change in conditions over the last week, others show current status with respect to the entire season. The NWCC webpage also provides fine resolution snow

Figure 1b: NRCS Google Earth product with links to site photos (showing Utah, near Salt Lake on March 13, 2006).

depth maps of every state, useful for winter recreation and other purposes such as wildlife management.

Precipitation and temperature maps using data collected at SNOTEL sites are also available on the NWCC GIS website. Precipitation and temperature data are also extracted from the Applied Climate Information System (ACIS) to create merged National Weather Service (NWS) and NRCS maps. High density maps show monthly and seasonal precipitation and the multi-agency temperature maps are sufficiently detailed to see when inversions occur between NWS valley stations and NRCS stations in the mountains. All of the data behind the GIS-based maps are available for any user interested in doing finer scale analysis.

New Google Earth-based map products

The NWCC recently released a 3-D visualization layer to view SNOTEL data using Google Earth. (http://www.wcc.nrcs.usda.gov/snotel/earth/index.html) SNOTEL sites are color-coded by snowpack as percent of normal, and if one highlights an individual station, a new window to additional information opens including site photos and tables and charts of real-time and historical data (Figure 1b). Later this spring, a Google Earth Layer of water supply forecasts will be released. These layers make an excellent companion to the spatial data compiled by the National Operational Hydrologic Remote Sensing Center (NOHRSC), available at http://www.nohrsc.noaa.gov/earth/

Other snowpack and water supply products available by request from NWCC

Often forecasters and users ask about snow conditions: "Where we are now? How does this compare to history? What is the range of possibilities for the future?" The NWCC developed a product that answers all of these questions for daily SNOTEL data. The chart in Figure 1c shows the historical range of snowpack variability for a station in southern Colorado over the period of record in gray. The 1971-2000 normal is shown as a heavy black line. The current year to date is displayed in red and, in this example, the snowpack has reached new record highs for this date. Derived using a statistical technique, the colored lines on the right side of the graph depict the range of possibilities, showing that not even the best case scenario could bring the snowpack back to 100% of average by April 1st. The various colored lines indicate the probability that future snow will be less than a certain amount on any given day. While the NWCC moves towards an interactive web interface to this product, NWCC personnel will gladly provide this information on request.

While having up-to-date snowpack information is useful, ultimately, users would like to know the implications for water supplies. The most common request from users to the NWCC is for more frequent updates to the official forecasts issued once per month, i.e. "A large storm just hit our basin. What does this mean for this summer's flow? Do these storms mean that we will have enough water to irrigate?" To address these concerns, the NWCC is further taking advantage of daily SNOTEL data by developing an automated daily statistical forecast system. The current prototype system is running twice daily for 45 locations in the Intermountain West region (15 in the state of Colorado, 6 in Utah, and 1 in Wyoming).

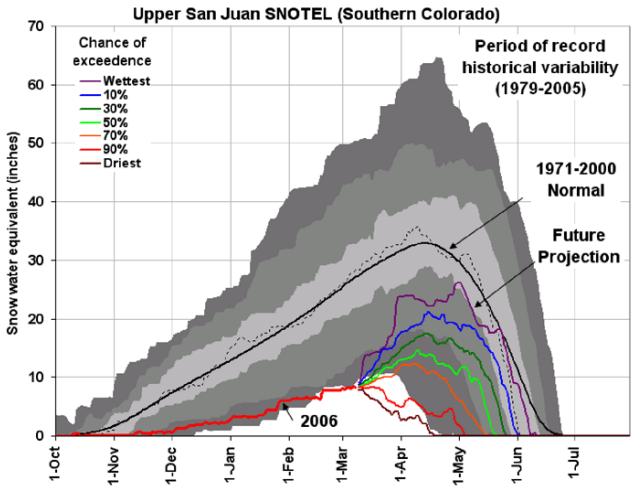

Figure 1c: Progress of snowpack to date (red) in the context of historical variability (gray) with the range of future possibilities (colored lines). The future lines indicate the percent chance that snowpack will be more than a particular amount on a given day. For example, the top purple line is the most possible snow, the blue line shows the amount for which there is a 10% chance exceeding and the dark green line shows the amount for which there is a 30% chance exceeding. The gray areas show the period of record frequency of occurrence so that the top of the gray area is the maximum of record, and below that is the 10%, 30%, 50% (dotted line), 70%, 90% exceedance and minimum of record. Since mid-February this site has set new record lows for this date. The 1971-2000 normal (heavy black line) is provided for reference.

Figure 1d tracks the progress of the forecasts for inflows to the Vallecito Resevoir in the San Juan basin in southern Colorado. Again, the gray background indicates the range of historical variability and the colored lines show how a forecast of April-July water volume changes throughout the season. As early as December, a month before the first official forecast for the season, dry conditions already indicated a diminished water supply.

The graphs provide a quick look whereas a data sheet provides a wealth of additional information and diagnostics. Several users are helping the NWCC refine and improve this product. If you are interested in more information, contact Tom Pagano at the address provided below.

New directions for NRCS forecasting products

The NRCS is forging ahead with other new forecasting technologies, such as simulation modeling. This technique involves the running of sophisticated models that track the growth and melt of snow across a basin, and can simulate the conversion of melt into runoff, quantifying the effects of long-term soil moisture deficits.

Picking the right model and running it properly is not a trivial task and the NRCS has found Regional Integrated Science Experiments (RISAs) such as the Western Water Assessment invaluable in helping the agency take advantage of the latest modeling technology. The southwest RISA, CLIMAS, has also aided the NRCS's forecast evaluation activities, working with water managers to develop a better understanding of how they interpret the quality and utility of NRCS water supply outlooks.

While the NRCS has been forecasting water supplies for close to 70 years, it is evident that the physical and demographic landscapes of the Intermountain West are changing.

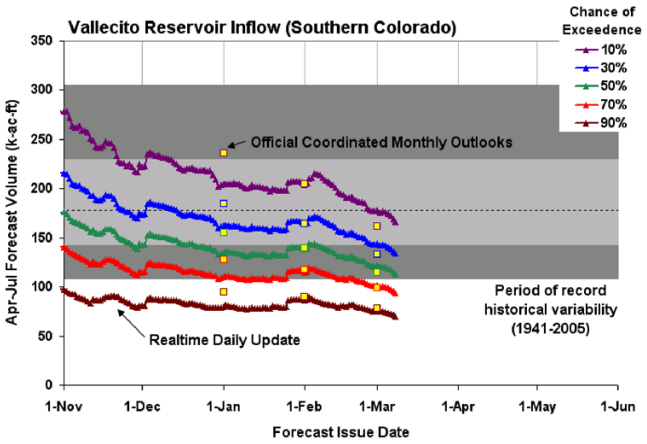

Figure 1d: Official outlooks (yellow squares) are available once a month while an experimental system (colored lines) fills in the gaps daily, tracking with snow events or dry conditions as they happen. The color scheme is similar to Figure 1c, where the gray background shows the historical range of variability, including the period of record 10%, 30%, 50% (dotted line), 70% and 90% chance of exceedance.

Over allocated supplies and increasing demands require precision management of water. The NRCS plays a significant role in that process, from the deserts of southern Arizona to the rivers of the Arctic Circle. It is now more important than ever that natural resource managers understand risks and operate using the best guidance. NRCS strives to provide this guidance in the most understandable form and in a rich context of hydrological and societal information. To this end, the importance of the climate and social science research and user outreach and education by the RISA groups cannot be understated.

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On the Web

- To find out more about the snow science centennial celebration, visit http://www.wcc.nrcs.usda.gov/centennial.html
- To find new GIS-based products, visit http://www.wcc.nrcs.usda.gov/gis/
- To find Google Earth-based products, visit http://www.wcc.nrcs.usda.gov/snotel/earth/index.html