



The Documentation of Extreme Hydrometeorological Events: Two Case Studies in Utah, Water Year 2005

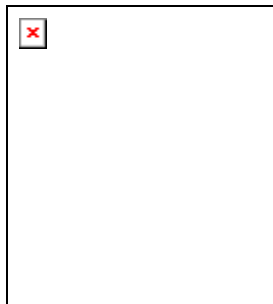
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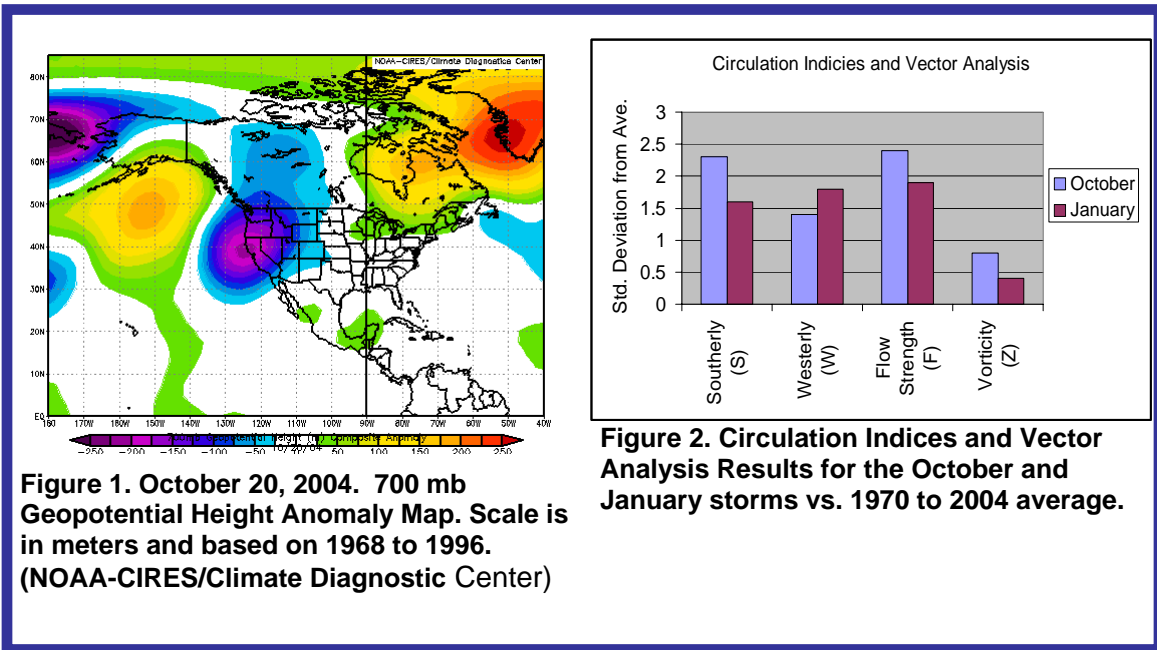
United States Department of Agriculture



INTRODUCTION

The Natural Resources Conservation Service (NRCS) maintains a network of over 700 automated hydrometeorological stations called SNOTEL SNOW TELemetry for the purpose of making water supply predictions. These stations consist of a snow pillow to measure the snow water equivalent of the snowpack, a precipitation gage, air temperature, and in many cases snow depth and soil moisture. Many SNOTEL sites and all sites out of the Utah Data Collection Office (DCO) are now measured hourly. The SNOTEL network represents the largest network of near real-time hydrometeorological stations in the mountainous regions of the Western U.S. As such, data from the SNOTEL system are used for a large variety of applications. Extreme events are encountered during the course of data collection.

These events are of particular interest to a wide variety of data users, due to large economic impacts of associated floods and droughts. The Utah DCO is working towards implementing a program-wide protocol for the documentation of such events. A current working definition of an extreme event requiring greater investigation is when a site with 15 or more years of record is outside the historic upper or lower 5%, and these data could have extreme consequences. These events will be validated and documented using whatever means are practical and reasonable, including, but not limited to, ground verification, comparison with neighboring sites, and remote sensing products. Two such events were apparent during the first third of the 2005 water year in Utah, and are the motivation for this poster. They are the events of October 17 to October 23, 2004, and January 8 to January 11, 2005, and will be presented here.



October 2004

Storm Analysis:

A strong low pressure system centered off the coast of Northern California creating a strong SW flow over Utah (Figure1). Circulation and Vector analysis indicates this event was dominated by greater southerly vectors (S) and stronger air flow (F). Interestingly, increased vorticity (Z), or atmospheric instability, was not a factor (Figure 2). For more information on this technique, see Losleben (2000). Storm totals for October 17th through 23rd ranged between 31.5cm and 2cm with an average of 12.7 cm for 88 sites. This storm was followed by another significant, but lower intensity storm with little or no gap at many sites before the beginning of November. Of the 77 SNOTEL sites with a period of record of 15 years or greater, 51 had the cumulative October precipitation of record, and two tied the record. Twenty-four hour precipitation intensity frequency analysis revealed 12 of 86 sites (two missing) in excess of 25 year return intervals with 6 of those sites exceeding 100 year return intervals, with Gutz Peak site exceeding 1000 years (Figure 3) (NOAA 2005). Five of the six highest intensity sites were in the Southwest region of Utah. Additionally, the maximum 24 hour precipitation was compared with the historic 24 hour maximum, when sites had 15 or more years of record. This revealed 12 of 77 sites with a record 24 hour precipitation intensity, six of which were in SW Utah.

Stream Response:

In general stream response to this event was relatively benign. This was in part a result of very low antecedent soil moisture and snowpack conditions. Most rivers showed moderate increases, while rivers in the Southwest and South-Central regions of the State showed increases on the order of 100 fold, these were still well below flood stage, and reservoir levels allowed much of this water to be captured.

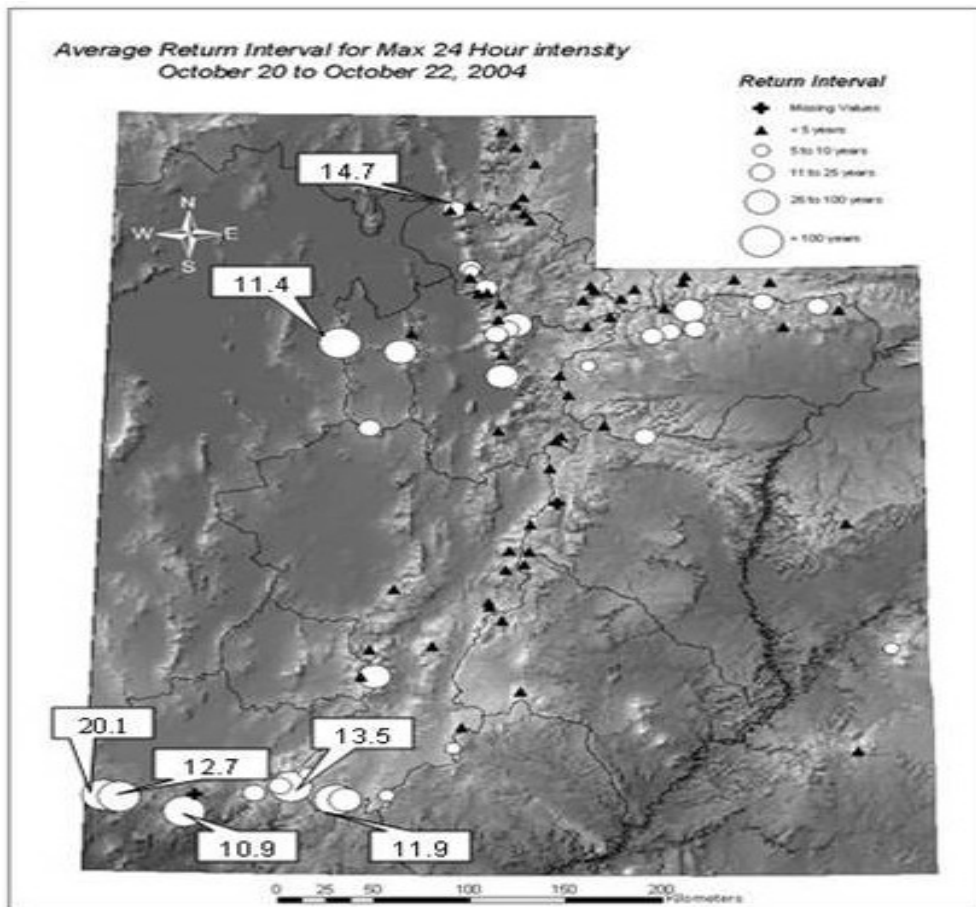


Figure 3. Average return interval for maximum 24 hour precipitation intensity. Select sites indicate maximum rate.

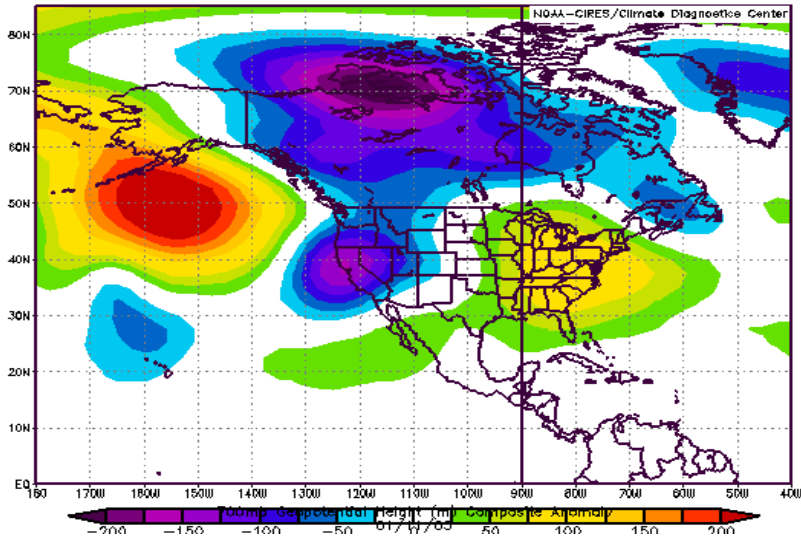


Figure 4. January 11, 2005 Geopotential Height Anomaly Map
Scale is in meters and based on 1968 to 1996 (NOAA-CIRES)

*Basin Average Accumulated Precipitation
and SWE in Centimeters
Jan 8, 2005 thru Jan 11, 2005*

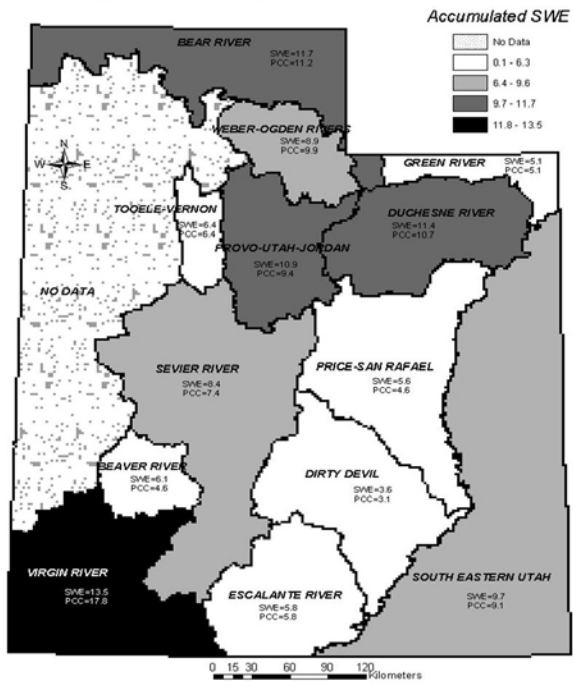


Figure 5. Basin Average precipitation and SWE
increase for January event.

January 2005

Storm Analysis:

Another very deep and slow moving low pressure system centered over the Southwest U.S. brought warm moist air over Utah for the days of this event. The timing of this storm was from January 8th to 11th 2005. The atmospheric circulation creating the January event was very similar to that of the October event, but with slightly weaker low pressure and Southwest flow (figure 4). This slightly weaker system corresponded to a somewhat weaker southerly flow (S) and flow vector (F), but a stronger westerly flow vector (W) (Figure 2). Similar to the October event, this storm impacted most of the state of Utah, but run-off in all but the Southwestern portion of the State was moderated as nearly all of these areas experience almost exclusively snow. Portions of Southwestern Utah collected a mixture of rain and snow, and had greater accumulation than other parts of the State. Basin average accumulated precipitation and snow water equivalent (SWE) for the entire state is displayed in (Figure 5).

A closer look at accumulation in the Southwestern region of the State can be found in (Figure 6). The Little Grassy SNOTEL is the lowest elevation SNOTEL site in the Virgin Basin at 1830 meters. This site showed little net change in SWE during the event, starting and ending the event at near 15cm of SWE, indicating mostly rain fell at this elevation, but passed through the snowpack without causing significant melt. SNOTEL sites above approximately 2130 meters in this region collected nearly all precipitation as SWE and therefore did not represent a winter flooding risk. There is however a very large area that is not adequately represented by any measurement network in the 1500-to-1830 meter range that had a significant snowpack before this event, and lost most if not all of it in addition to very high rain accumulation (Figure 7).

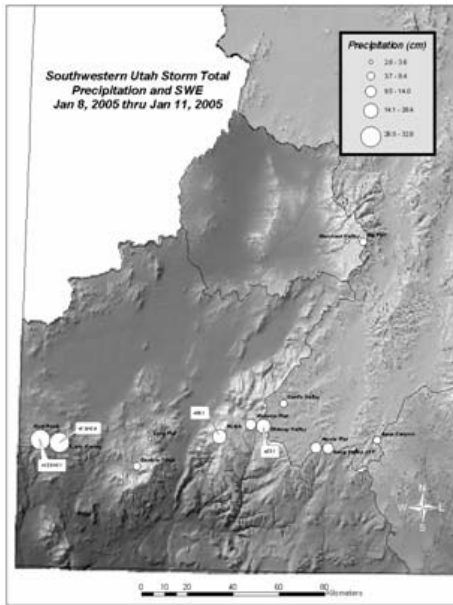
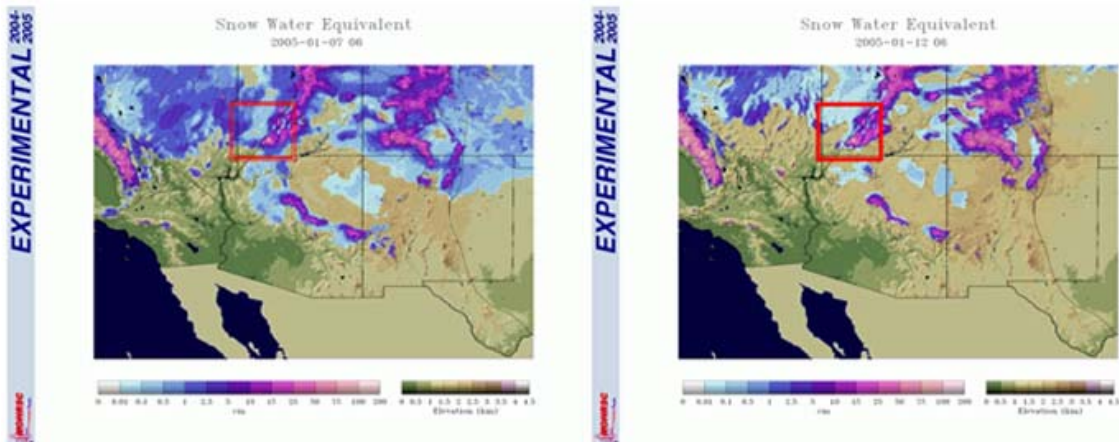


Figure 6. Southwestern Utah SNOTEL January Storm total precipitation. Change of SWE is indicated for selected sites



Stream Response:

The stream response to the rain, rain on snow, and snowmelt event of January 8th to 11th 2005 was enormous, but very difficult to quantify. Runoff conditions were greatly enhanced by wet soil moisture conditions left behind by the October event, leading to unusually high runoff efficiency (Figure 8). Additionally, the loss of significant low elevation snowpack was a major contributor. Most of the USGS stream gages in the heaviest hit drainages of the Virgin, Santa Clara, and their tributaries were significantly compromised. The USGS has estimated flows and return intervals for the stations in the area, but only stations in less severely impacted areas have continuous real time records that include the peak flow. Many stations had estimated recurrence intervals near and in excess of 100 years (USGS 2005a, USGS 2005b). Stream channels were very significantly altered and had an enormous impact on adjacent property and infrastructure (Figures 9).

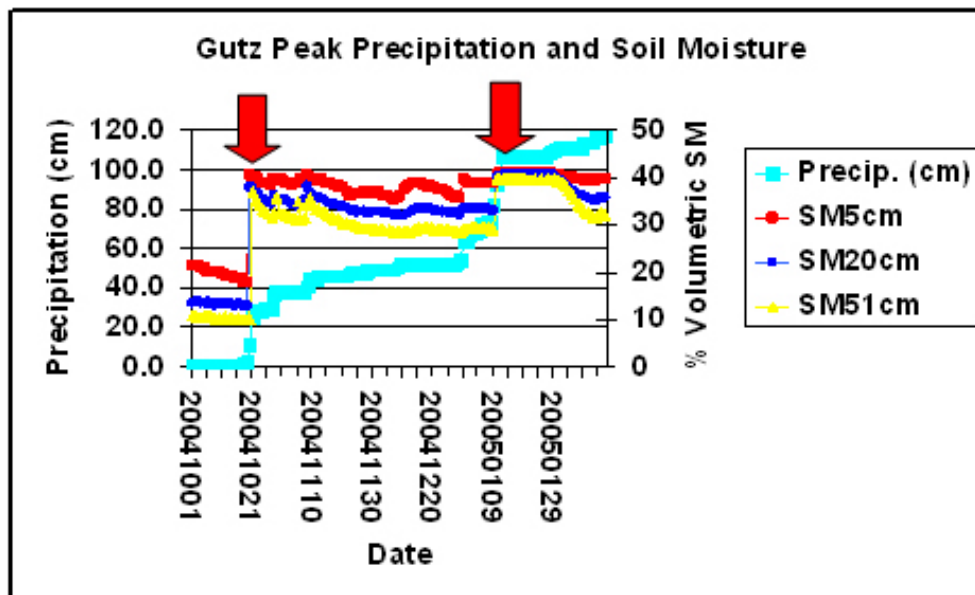


Figure 8. Gutz Peak SNOTEL Soil Moisture and Precipitation. Extreme events indicated with arrows



Figure 9. Bridge over Santa Clara River Before and after. Right most photos is river left of bridge (USGS)



A 3.7 meter gage about to be extended in Southwestern Utah 1/19/05. (NRCS)



Enterprise Reservoir before and after.

Data Quality Assurance

Standard methods for data quality insurance include but are not limited to, ground verification, and comparison with neighboring sites, redundant instrumentation, and additional land and satellite data networks. The nature of an extreme event causes difficulty with remote stations, and requires greater data scrutiny. The relatively warm temperatures of the October event allowed precipitation measurements work accurately with very few exceptions. Ground verification of eight high accumulation sites shortly after this event revealed very close agreement with telemetered values. The much colder temps and greater snow component of the January event caused significant problems with precipitation measurements. Snow plugs formed in many gages preventing the real time measurements. In these cases, real-time estimates were made based on changes in SWE, snow depth, and neighboring sites. A more accurate post event estimate was made after the plug is naturally or manually removed. Six high accumulation sites were visited shortly after the January event. Precipitation plugs, if present were removed and ground verification taken. Post plug ground verification was consistent with telemetered values. These problems made frequency analysis impossible for the January event, but accurate estimates of storm totals were obtained.

SUMMARY

The Storms of October 17th - 23rd, 2004 and January 8th - 11th, 2005 had a very significant impact on immediate hydrologic conditions in the state of Utah as well as on the water year as a whole. While the January event was of similar magnitude to the October event, impacts of high flows far exceeded the October event. The October event set the stage for the extreme run-off generated in January. Estimates for damages caused by the January event exceed 150 million dollars (Utah Flood Relief, 2005). Combined precipitation totals from these two events were near the average water year total for several sites in the Southwestern region of the state. The extreme nature of these events will draw additional interest in hydrometeorological data from these time periods. In the near future data users will have access to an event summary report for these and future extreme events through the Utah Data Collection Office or its web page (NRCS 2005).

Acknowledgements:

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Photos: USGS and NRCS, top right photo source unknown

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