ESTIMATION OF 30 YEAR AVERAGE ANNUAL PRECIPITATION FOR SNOTEL SITES IN IDAHO

by

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INTRODUCTION

The Soil Conservation Service (SCS) operates and maintains a network of 69 automated SNOTEL (SNOw TELemetry) sites in Idaho. These sites use meteor burst technology to transmit daily values of accumulated precipitation (rain or snow), snow water equivalent from snow pillows, and maximum, minimum and average air temperatures. Of these sites, 54 have a continuous data record from water year 1982, six began in 1983, and five sites were installed between 1984 and 1986. The remaining four sites began in 1989 or later and are not discussed in this report.

The reliability of the SNOTEL system is widely accepted, and the data are utilized by many other agencies, public and private utilities, irrigation districts, recreation interests, consultants and others for a variety of purposes. One of the most common forms of reporting and displaying SNOTEL and other data is the percent of average conditions. Thus it is important and necessary to define a consistent time frame to represent the average or normal conditions since all stations do not have the same period of record. Beginning with the 1992 water year, the SCS and the National Weather Service (NWS) have agreed to implement a standard 30 year base period, 1961 - 1990, and develop 30 year averages for currently active stations. Every five years thereafter, the base period will change to the most recent 30 years and the averages will be recalculated.

The previously used base period was the 25 year period 1961 - 1985, and average precipitation values for Idaho SNOTEL sites were calculated in 1986 using their relationship to NWS precipitation sites. Although the procedures used were sound, they were based on only four years of actual data in most cases. One method for calculating new 1961 - 1990 SNOTEL precipitation averages would be to simply add the data for 1986 - 1990 to the existing 25 year averages and compute new 30 year values. This method, however, would validate the assumption that the 25 year averages based on only four years of data were representative of the 1961 - 1985 period. In reality, the 1982 - 1985 years were some of the highest precipitation years since 1961 and none of those years would be considered "low" years (Figure 1). The 1982 - 1990 period, however, contains some of the lowest and highest annual precipitation values within the 30 year record (Figure 1). Because of this, it was decided that a new analysis of the complete SNOTEL period of record be performed which could take advantage of current software capabilities to provide a more thorough examination of the relationship of SNOTEL annual precipitation to NWS annual precipitation.

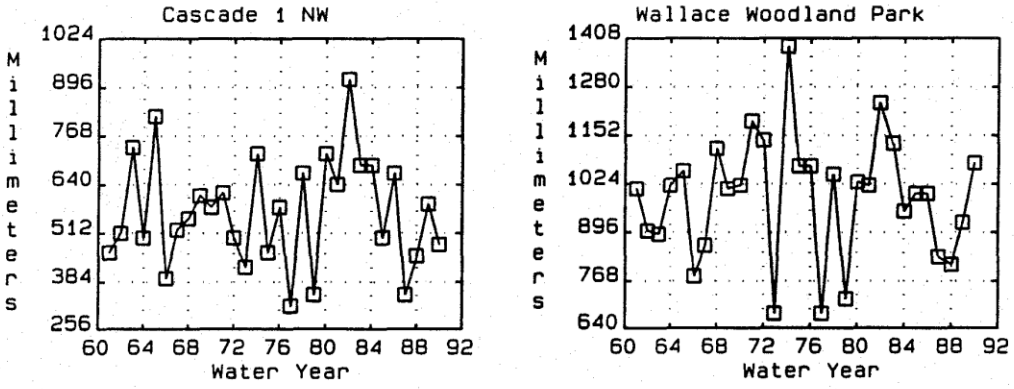

Figure 1. 1961 - 1990 water year annual precipitation for a typical site in north Idaho (Wallace) and central Idaho (Cascade).

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reduce possible anomalous conditions at an individual NWS station. This new variable was the mean value (one for each year) of the three NWS stations' annual precipitation and was regressed and plotted against the SNOTEL site as stated previously. In nearly all cases the R value for this transformed variable regression was greater than each of the individual site R values. A 30 year average was then calculated for the SNOTEL site using the transformed regression equation and the mean 1961 - 1990 average from the three NWS sites. This new 30 year SNOTEL estimate was compared to the estimate calculated from the individual NWS sites and in all cases was very close. Because of this result, the final SNOTEL 30 year average selected was the mean of the three individual averages.

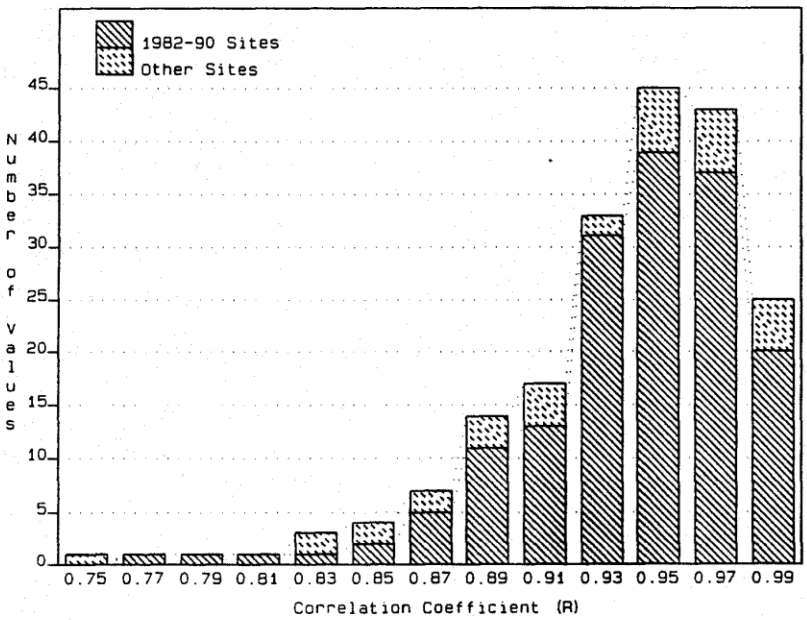

Figure 3. Frequency distribution of 195 SNOTEL - NWS correlation coefficients for 54 SNOTEL sites with complete 1982 - 1990 record (1982 - 90 Sites) and 11 sites with less than nine years of data (Other Sites).

RESULTS AND DISCUSSION

The regression analyses indicated a strong overall correlation for annual precipitation between SNOTEL and NWS stations. Figure 3 shows the frequency distribution of R values from the three highest correlating NWS sites for each SNOTEL site. The 54 SNOTEL sites having a complete 1982 - 1990 record are shown as one group while the 11 other sites are shown as a second group. For the 54 sites, 86.4 percent of the R values exceed 0.90 and nearly half (49.4 percent) equal or exceed 0.95. For the sites with less than nine years data 70 percent of the R values exceed 0.90 and 39 percent exceed 0.95. For all sites, 84 percent of the R values are greater than 0.90 and 47 percent exceed 0.95. Nearly three quarters (72 percent) of the SNOTEL sites had at least one NWS site with an R value of greater than 0.95 while 92 percent had at least one NWS site with an R value of greater than 0.90. These results are highly satisfactory for the intended purpose of estimating 30 year average annual SNOTEL precipitation. The AAP values were then distributed into monthly average SNOTEL precipitation using regional monthly percentage distribution values derived from the NWS sites' 30 year average monthly precipitation. Discussion of that procedure is beyond the scope of this paper.

Development of reliable high elevation averages fills a large void in our knowledge of precipitation patterns. The 1961 - 1990 Idaho SNOTEL averages are currently being used by the Idaho State Climatologist's office to prepare an updated mean annual precipitation (MAP) map for the state of Idaho. The previous MAP map utilized 1930 - 1957 data and high elevation information was limited to available snow course measurements between January and May and some assumption of what percent of annual precipitation occurred as snow. Analyses involving the monthly SNOTEL averages are also becoming more and more important to water supply forecasting activities, reservoir operations, forest management and other purposes.

Table 1. Example linear regression results with SNOTEL 1982 - 1990 annual precipitation as dependent variable for overall high correlating site (Jackson Peak) and low correlating site (Humboldt Gulch).

SNOTEL Site	NWS Site	Correlation Coefficient	Std. Err(mm)	Y Intercept	Regression Slope
Jackson Peak	Centerville Arbaugh Ranch	0.991	47.4	-21	1.705
Jackson Peak	Idaho City	0.988	54.3	221	1.526
Jackson Peak	Arrowrock Dam	0.982	64.9	216	1.885
Jackson Peak	Cascade 1 NW	0.946	112.2	119	1.817
Jackson Peak	Boise WSFO AP	0.935	123.1	08	3.583
Jackson Peak	Garden Valley R S	0.930	127.3	353	1.407
Jackson Peak	Mc Call	0.907	145.8	25	1.676
Humboldt Gulch	Kellogg	0.907	74.8	325	1.205
Humboldt Gulch	Headquarters	0.906	75.1	602	0.847
Humboldt Gulch	Saint Maries	0.858	91.2	786	0.750
Humboldt Gulch	Cabinet Gorge	0.848	94.2	547	1.005
Humboldt Gulch	Elk River 1 S	0.848	94.1	-158	1.690
Humboldt Gulch	Wallace Woodland Park	0.843	95.5	280	1.055
Humboldt Gulch	Bonners Ferry 1 SW	0.841	96.1	341	1.622
Humboldt Gulch	Priest River EXP Station	0.811	104.1	479	1.081
Humboldt Gulch	Bayview Model Basin	0.763	115.0	356	1.495
Humboldt Gulch	Porthill	0.728	121.6	645	1.351
Humboldt Gulch	Potlatch	0.712	124.6	548	1.197
Humboldt Gulch	Coeur D'Alene	0.660	133.6	660	0.991
Humboldt Gulch	Sandpoint KSPT	0.641	136.5	701	0.732

Table 2. Sample results showing individual estimates of SNOTEL AAP for the three highest correlating NWS sites.

SNOTEL Site (Y)	SNOTEL AAP (mm)	NWS Site (X)	NWS AAP (mm)	Regres. Constant	Regres. Slope	Corr. Coef.
Bear Basin	945	Mc Call	705	-11	1.355	0.960
Bear Basin	947	New Meadows	633	128	1.293	0.960
Bear Basin	947	Council	655	156	1.207	0.947
Deadwood Summit	1460	Idaho City	629	268	1.895	0.985
Deadwood Summit	1419	Cascade	567	101	2.323	0.972
Deadwood Summit	1497	New Meadows	633	160	2.113	0.962
Lookout	1353	Wallace	989	-30	1.399	0.890
Lookout	1478	Headquarters	974	487	1.018	0.867
Lookout	1452	Powell	1009	281	1.160	0.829
Magic Mountain	846	Twin Falls WSO	266	-43	3.343	0.922
Magic Mountain	842	Burley FAA	251	104	2.939	0.907
Magic Mountain	858	Fairfield RS	406	232	1.542	0.866
Somsen Ranch	753	Oakley	295	-120	2.959	0.954
Somsen Ranch	655	Burley FAA	251	8	2.580	0.949
Somsen Ranch	620	Grace	401	122	1.244	0.930

Examination of the individual SNOTEL AAP estimates showed that for some sites the three values were very close together and for others they were quite different. For this reason, the mean of the three estimated SNOTEL averages was calculated and selected as the initial estimate of the SNOTEL 1961 - 1990 AAP.

The final analysis compared the three individual 30 year averages calculated for each SNOTEL site with the mean of the three averages. If the three individual values were within five percent of the mean value, the mean value was considered final. Sixteen SNOTEL sites fell outside this subjective five percent window with the largest departure occurring for Somsen Ranch (range 11.3 to -8.2 percent of the mean). These sites were further examined. A new independent variable was constructed for the 1982 - 1990 period in an attempt to

METHODS

Water year annual SNOTEL precipitation was compared to water year annual precipitation at nearby NWS stations for the 1982 - 1990 period using simple linear regression. Approximately 70 NWS stations in Idaho and adjacent states had fairly complete 1961 - 1990 monthly precipitation records and were used in the analysis. Data for all stations were obtained from the SCS West National Technical Center's Centralized Forecast System Computer in Portland, Oregon. Missing monthly values for SNOTEL sites were estimated from snow pillow data (winter) at the same site, or from precipitation and/or snow pillow data from nearby SNOTEL sites to obtain an annual value. Missing monthly values for NWS sites were checked against National Oceanic and Atmospheric Administration (NOAA) published records. Published values were added and missing values were estimated using relationships to nearby stations to obtain the 1982 - 1990 annual values.

The data were analyzed using a linear regression program with SNOTEL annual precipitation as the dependent variable and NWS annual precipitation as the independent variable. This procedure was automated and allowed quick analyses of seven NWS stations at a time for each SNOTEL site. The automated procedure produced scatter plots for each SNOTEL-NWS pair on the computer screen which allowed visual checking of the data set during the analysis. Figure 2 shows an example of these plots.

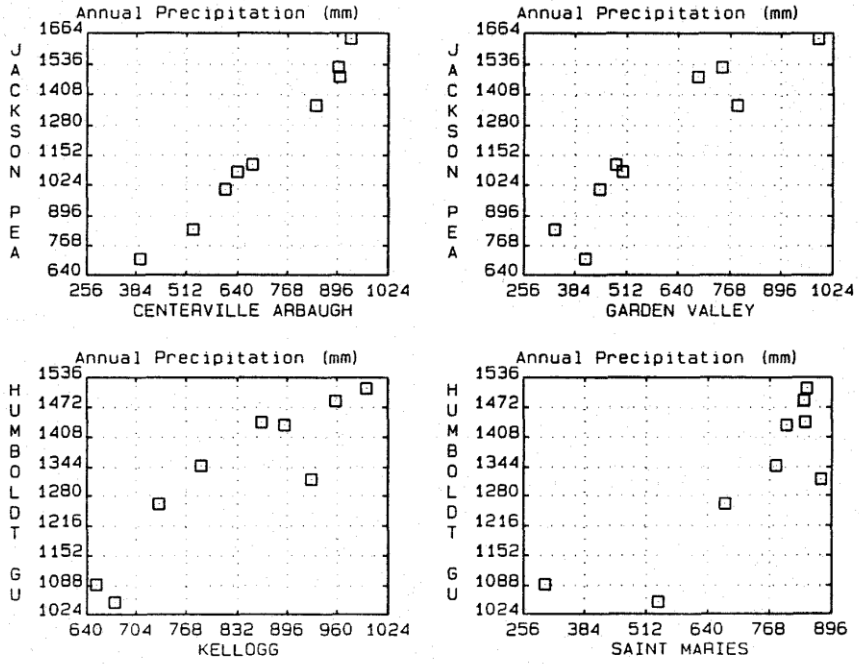

Figure 2. Sample plots of SNOTEL annual precipitation (Y) versus NWS annual precipitation (X) for the 1982 - 1990 period.

If high correlation coefficients (R) with the SNOTEL site ($R > 0.95$) were obtained for three of the first seven NWS sites tested, no further regressions were done for that SNOTEL site. Otherwise, the nearest 14 NWS stations were examined. Table 1 shows example results of the output for Jackson Peak (southern Idaho) and Humboldt Gulch (northern Idaho) SNOTEL sites.

When all SNOTEL sites were analyzed, the three NWS stations which produced the highest R values for each SNOTEL site were selected and entered into a database along with the corresponding regression equations and R values. Of the 70 NWS stations originally analyzed, 47 appeared in the list of best three correlators to SNOTEL sites, and the 1961 - 1990 average annual precipitation (AAP) was calculated for these 47 NWS stations. Missing values in the 30 year record for the 47 NWS sites were verified with NOAA publications and estimated where necessary (as stated previously) in order to calculate the 30 year average. Three estimated 30 year AAP values were then calculated for each SNOTEL site using the three selected NWS stations' 30 year AAP values and corresponding regression equations (Table 2).