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A Computerized Method of Precipitation Data Quality Control

Ronald H. Campbell

A COMPUTERIZED METHOD OF PRECIPITATION DATA QUALITY CONTROL

By

Ronald H. Campbell

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ABSTRACT

A computerized data quality check and data edit program has been developed to aid in the processing of telemetered precipitation data. The logic considerations and program development are discussed and results are displayed. This effort has resulted in successful editing of large amounts of precipitation data gathered by automated remote data acquisition techniques. The application of this processing routine has resulted in reducing data editing costs to about three percent of that required to do the work manually.

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Introduction

The experimental design of the Wasatch Weather Modification Project provides for the evaluation of cloud seeding activities through the comparison of precipitation amounts for seeded and unseeded periods. The present experimental design requires simultaneous half-hourly precipitation data from gages in and near the primary target area for each 8-hour experimental period. These data requirements for meteorological evaluation of the experiment have led to the development of new acquisition and processing techniques of precipitation data.

The requirements for evaluating cloud seeding experiments utilizing precipitation data brought about the construction of the Utah State University telemetering precipitation gage network (Israelsen and Griffin, 1969; Chadwick, 1968, 1969). The readout system for the network can provide as many as three readings per hour for each of 46 stations. Readouts are sequential, and errors are found in the data. Thus, a need arose to develop an objective method for interpolation of simultaneous data points from quality checked data.

The data quality problem results from a combination of several factors concerning the type of gage used, the nature of the transducer, and problems peculiar to radio telemetry, i.e. wind forces on the gage transmitted to the transducer, vibratory motions of the gage caused by the wind, snow and ice sticking or riming developing temporarily on the sides of the collection cans, radio interference, friction between the cans and guides.

With as many as 75,000 data points per year being read out from the network, the computerization of the entire precipitation data processing procedure was highly desirable. Half-hourly precipitation data were obtained in two steps. The first step was the relatively simple conversion of the electronic readout period to cumulative precipitation in the storage gage. The inches water equivalent is obtained through individual calibration curves which are determined each season for each station's transducer.

The second, and more complicated step, was the data quality check, editing, and data interpolation. Before a satisfactory data quality control program was developed, much editing was done by hand. Manual editing served to categorize anomalous data points and provided the basis for development of subsequent objective criteria by which data could be evaluated. These criteria and the computer program logic are discussed as follows.

Categorization of Questionable Data Points

Data points are examined for one station at a time and in sets of at least eight precipitation values. Typical data sets consist of from 40 to 200 points.

Data points considered questionable are categorized into three groups using the criteria outlined as follows. Figure 1 is a graphical display of these types.

(1) Precipitation values may be so unreasonable that they are obviously unacceptable. These points are called "outliers" and seem to occur randomly. They occur above and below the cumulative precipitation curve. Radio interference or other electronic problems appear to be the most likely causes for these outliers.

(2) Precipitation values may exhibit relatively small departures from the apparent cumulative precipitation curve. These departures also seem to occur randomly and are referred to as "noise" points. The most suspected sources of this type error are wind and friction. The wind may cause a bouncing or vibration of the can and friction may cause a sticking of the can guide. These noise points are usually within .03 inch of a five-point moving average of the cumulative precipitation curve.

(3) Several precipitation values in succession may indicate a negative trend in precipitation. These trends cannot be rationalized to be the result of evaporative losses or leaking cans. One explanation is that ice or snow stick temporarily on the outside of the gage. Since this is a weighing gage system, both this accumulation and subsequent melting or sublimation are reflected in the measurements. Temperatures observed during periods in which these negative trends occur support this concept. The data points describing such a trend are termed "overshoot" and seem to occur under a limited set of meteorological conditions.

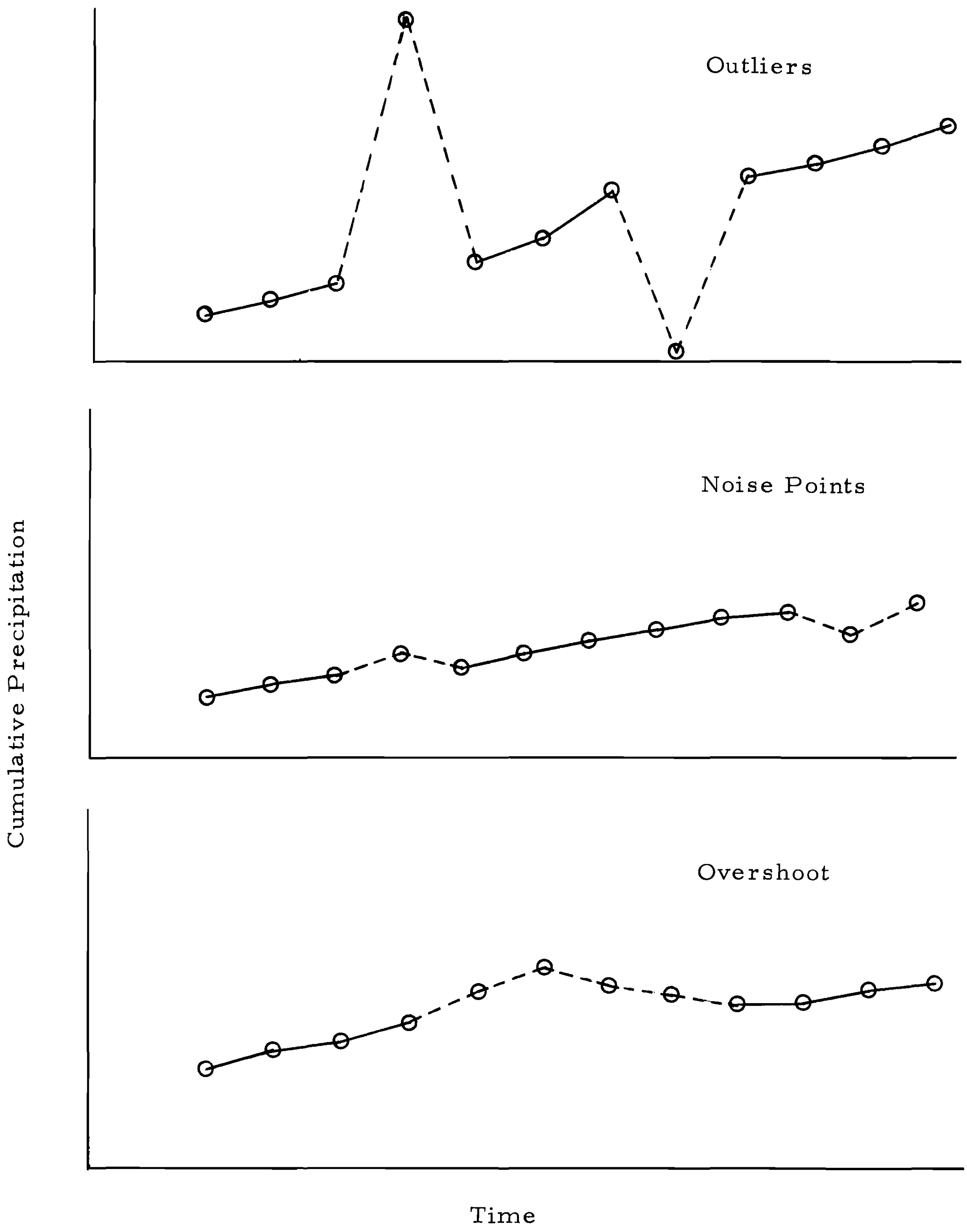

Figure 1. Types of questionable data points. (Dashed line indicates questionable points.)

A Reasonable Cumulative Precipitation Curve

Objective criteria by which data points can be judged were developed from the standpoint of a reasonable cumulative precipitation curve. All data points making up the curve must indicate zero or a positive amount of precipitation. The value of $\Delta P/\Delta t$, change of precipitation with respect to time, must also have an upper bound. This bound is a function of the geographical location, elevation, and nature of the precipitation process. A value of $\Delta P/\Delta t > 0.5$ inch per hour is fairly uncommon for this region in the wintertime as indicated by the relative frequency of cold season hourly precipitation amounts (Table 1) at the Silver Lake-Brighton station. This is a fairly high-yield high-altitude station near the experimental area.

These results indicate that .5 inch per hour can be set as a general upper bound on $\Delta P/\Delta t$ for the data editing scheme. However, precipitation data points indicating rates greater than .5 inch per hour are accepted as valid if the curve continues a monotonic, non-decreasing trend. The main purpose in defining a maximum $\Delta P/\Delta t$ value is to insure that the first point of a data set is valid. Δt values generally range from 20 to 40 minutes for the data being considered.

Table 1. Relative frequency distribution of hourly precipitation values for Silver Lake-Brighton 1957-66 November through April.

Class (Inches)	Number of Occurrences
.01-.05	4271
.06-.10	578
.11-.15	153
.16-.20	44
.21-.25	8
.26-.30	6
above .30	0

The Data Quality Criteria

The preceding considerations are the basis for the complete set of data quality control criteria. These in combination with factors peculiar to equipment and data processing methods, provide enough information to successfully edit telemetered precipitation data.

An attempt was made to keep input data requirements of the computer program to a minimum and still obtain good results. A review of the manually edited data showed that satisfactory results could be obtained without using the supplementary data originally employed. This supplementary data included concurrent facsimile charts, temperature observations, upper air sounding data, and precipitation data from adjacent gages.

The first consideration in data quality control for the system is to check the time parameters for obvious keypunch errors or Automatic Readout Console errors. The number of data point errors in this category is very small, on the order of 0.1 percent. This check is accomplished by requiring that all data points lie within specified time bounds and that only one data point per station be accepted for a given time.

The next criterion is set up to discard outlying data points, those mentioned in category (1) above. The most useful test for outliers is the requirement that a data point be not more than .03 inch below the average of the preceding four data points and not more than .03 inch above the average of the following four data points. This is the requirement that, neglecting noise, a cumulative precipitation value has to lie on a monotonic, non-decreasing curve. Good results were obtained when only points yielding an absolute precipitation rate greater than .2 inch per hour were subjected to the test. Data points failing the test are deleted from the data set.

The effect of testing only points associated with $\Delta P/\Delta t > 0.2$ inch per hour was to leave in the negative trends mentioned previously in category (3).

Overshoot seems to occur under a rather limited set of meteorological conditions. Most of the time the amount of overshoot is less than .1 inch and was identified on about 10 percent of the total data read out from the network during the 1970-71 season. The criteria used to define overshoot is that each of three successive data points be at least .03 inch less than each of the two data points at the beginning of the negative trend.

After identifying the overshoot, the problem is to ascertain its beginning and ending times. It seemed reasonable to place the end of the overshoot at the point where the curve begins once again a monotonic, non-decreasing trend. The identification of the beginning of overshoot is more difficult. The only certain thing is that it occurred when the gage indicated a precipitation event. For the present, the beginning of overshoot is arbitrarily placed two data points prior to the point where the cumulative curve exceeds the precipitation value at the end of the overshoot. The peak value of the overshoot is adjusted downward to the precipitation value corresponding to the end of the overshoot and no precipitation is assumed during the time interval between the peak overshoot value and the end of the overshoot. The precipitation curve from the time of the start of the overshoot to the time of the peak overshoot value is adjusted to keep within the monotonic, non-decreasing curve criteria, and yet maintain as much of its original shape as possible. An example is shown in Figure 2.

Whereas these corrective procedures for overshoot are quite intuitive, the results match favorably those done by hand with supporting meteorological data. It is questionable whether more effort is justified in deriving a better editing procedure. A new type gage is presently

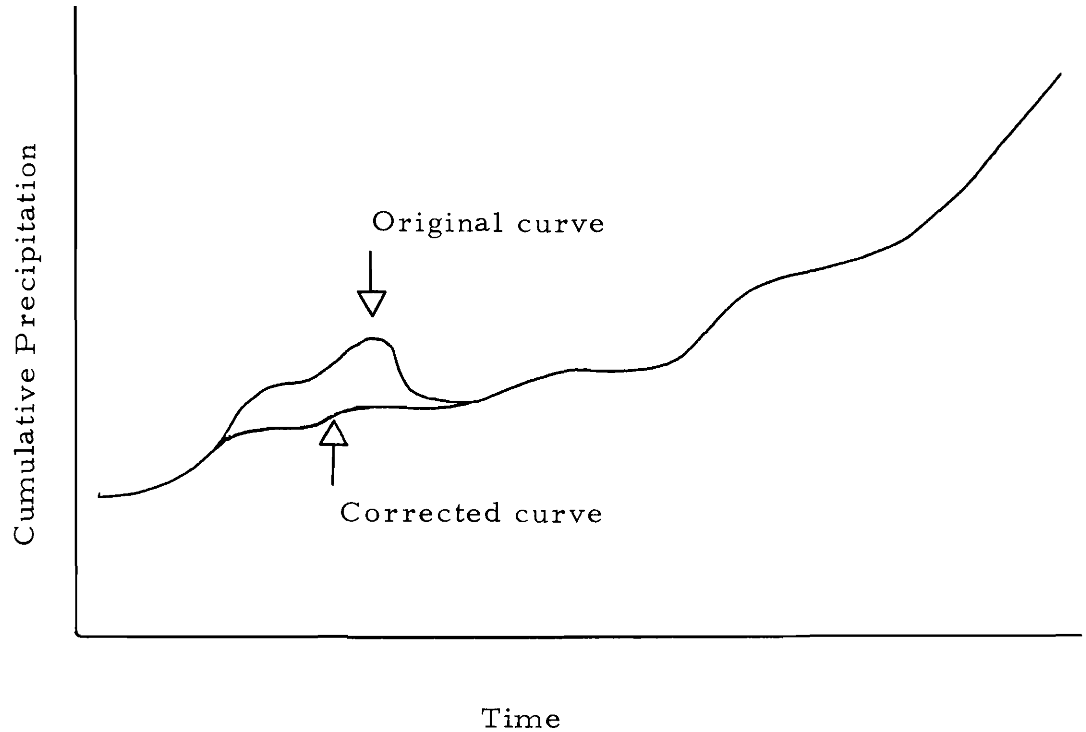

Figure 2. Overshoot correction procedure.

being tested which could eliminate the overshoot problem.

The cumulative precipitation curve, having been subjected to the above treatments, is now ready to be checked for noise points. The requirement for the first data point of the set is that it be less than the average of the next four data points. The remainder of the data points are required to be greater than or equal to the preceding data point, but less than the average of the following four data points. This average is taken so that the effect of a noise point in the four will be negligible. If a point is outside this given range, but within .03 inch of the limits, it is corrected the least amount possible to bring it within the limits and retained. Otherwise, it is discarded.

On a few occasions the average of the four testing points is less than both the point being tested and the preceding test point. In this case data are processed as follows.

Let P_i be the i^{th} precipitation value. This is the point being tested. Let P_{i-1} be the point which has just been tested and now is used to test P_i. Let P_j, $j = i+1, i+4$ be the remainder of the test points and let $A = 1/4 \sum_{j=i+1}^{i+4} P_j$.

The test for a noise point described above was the requirement that $P_{i-1} \leq P_i \leq A$. The problem arises when $P_{i-1} > A$. If this happens, the most often occurring value of P_j, $j=i, i+4$ is assigned to A and the test is completed. If no value occurs more than once, the mid-point of the smallest region in which two or more of the P_j, $j=i, i+4$ lie is assigned to A.

These procedures have been programmed on a computer with various small additions and special provisions for handling the first few and last few data points of each set. Following the data editing procedures of the program, a tabulation for data quality control is accomplished by machine which includes the following: number of data points input, the number of outliers rejected, the number of noise points rejected, the number of noise points adjusted, the number of overshoot points adjusted, the number of data points left untouched, the total number of data points accepted, the total number of data points rejected and the percent of total input accepted. Figure 3 is an example of the original and final data sets. The computer program then interpolates half-hourly precipitation values for the entire time period covered by the data set—usually one or two days of data.

Results

All of the telemetered precipitation data for the 1969-70 and 1970-71 experimental seasons have been quality checked and edited by this program. The results agree well with manual editing.

STATION 16406

	UNEDITED DATA			EDITED DATA		
POINT	DAY	PCPTN	CHANGE	DAY	PCPTN	CHANGE
1	46.303	28.64	0.0	46.303	28.64	0.0
2	46.318	28.64	0.0	46.318	28.64	0.0
3	46.336	28.64	0.0	46.336	28.64	0.0
4	46.359	28.64	0.0	46.359	28.64	0.0
5	46.380	28.64	0.0	46.380	28.64	0.0
6	46.400	28.64	0.0	46.400	28.64	0.0
7	46.420	28.64	0.0	46.420	28.64	0.0
8	46.440	28.64	0.0	46.440	28.64	0.0
9	46.461	28.64	0.0	46.461	28.64	0.0
10	46.483	28.64	0.0	46.483	28.64	0.0
11	46.504	28.64	0.0	46.504	28.64	0.0
12	46.524	28.66	0.02	46.524	28.66	0.02
13	46.545	28.71	0.05	46.545	28.71	0.05
14	46.565	28.71	0.0	46.565	28.71	0.0
15	46.587	28.71	0.0	46.587	28.71	0.0
16	46.606	28.71	0.0	46.606	28.71	0.0
17	46.672	28.74	0.03	46.672	28.74	0.03
18	46.687	28.75	0.01	46.687	28.75	0.01
19	46.709	28.75	0.0	46.709	28.75	0.0
20	46.729	28.75	0.0	46.729	28.75	0.0
21	46.748	28.75	0.0	46.748	28.75	0.0
22	46.769	28.75	0.0	46.769	28.75	0.0
23	46.790	28.75	0.0	46.790	28.75	0.0
24	46.822	28.81	0.06	46.822	28.81	0.06
25	46.861	28.84	0.03	46.861	28.84	0.03

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HALF HOURLY PRECIPITATION DATA FOR STATION 16406
ACCOUNTING DATA FOR STATION 16406
25 POINTS ENTERED
0 POINTS ADJUSTED FOR OVERSHOOT
0 POINTS ADJUSTED FOR NOISE
0 OUTLIERS REJECTED
0 NOISE POINTS REJECTED
25 ORIGINAL DATA POINTS LEFT UNTOUCHED
25 POINTS ACCEPTED
0 POINTS REJECTED
100 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED

Figure 3. Sample output of a data set with data quality parameters.

The cost of manually editing data for a single experimental period was about $200. This compares to a computer cost of about $6. Thus, the initiation of computer editing of precipitation data has resulted in over a thirtyfold savings in the cost of this particular data processing.

The computer program is set up to edit a period of data which includes one or more experimental periods. It then outputs half-hourly data in individual sets for each experimental period. This process is completed one station at a time. A few data sets from the telemetry network are discussed and graphed for the experimental period of February 15, 1971, 0930 to 1730 MST.

Figure 4 shows data and graphs from Tony Grove Ranger Station gages 602 and 603. Both cases show noise points which were adjusted by the computer program.

STATION 602

	UNEDITED DATA			EDITED DATA		
POINT	DAY	PCPTN	CHANGE	DAY	PCPTN	CHANGE
1	46.320	21.37	0.0	46.320	21.37	0.0
2	46.340	21.37	0.0	46.340	21.37	0.0
3	46.364	21.39	0.02	46.364	21.39	0.02
4	46.384	21.40	0.01	46.384	21.40	0.01
5	46.403	21.41	0.01	46.403	21.41	0.01
6	46.424	21.41	0.0	46.424	21.41	0.0
7	46.443	21.48	0.07	46.443	21.48	0.07
8	46.463	21.49	0.01	46.463	21.49	0.01
9	46.486	21.51	0.02	46.486	21.51	0.02
10	46.507	21.57	0.06	46.507	21.57	0.06
11	46.547	21.70	0.13	46.547	21.70	0.13
12	46.569	21.71	0.01	46.569	21.71	0.01
13	46.590	21.74	0.03	46.590	21.74	0.03
14	46.609	21.77	0.03	46.609	21.76	0.02
15	46.674	21.76	-0.01	46.674	21.76	0.0
16	46.689	21.76	0.0	46.689	21.76	0.00
17	46.712	21.75	-0.01	46.712	21.76	0.0
18	46.731	21.76	0.01	46.731	21.76	0.0
19	46.750	21.76	0.0	46.750	21.76	0.0
20	46.772	21.79	0.03	46.772	21.79	0.03
21	46.793	21.79	0.0	46.793	21.79	0.0
22	46.826	21.79	0.0	46.826	21.79	0.0
23	46.866	21.82	0.03	46.866	21.82	0.03

****

HALF HOURLY PRECIPITATION DATA FOR STATION 602
ACCOUNTING DATA FOR STATION 602
23 POINTS ENTERED
0 POINTS ADJUSTED FOR OVERSHOOT
2 POINTS ADJUSTED FOR NOISE
0 OUTLIERS REJECTED
0 NOISE POINTS REJECTED
21 ORIGINAL DATA POINTS LEFT UNTOUCHED
23 POINTS ACCEPTED
0 POINTS REJECTED
100 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED

STATION 603

	UNEDITED DATA			EDITED DATA		
POINT	DAY	PCPTN	CHANGE	DAY	PCPTN	CHANGE
1	46.305	22.25	0.0	46.305	22.25	0.0
2	46.319	22.27	0.02	46.319	22.27	0.02
3	46.340	22.26	-0.01	46.340	22.27	0.0
4	46.363	22.29	0.03	46.363	22.29	0.02
5	46.384	22.30	0.01	46.384	22.30	0.01
6	46.402	22.32	0.02	46.402	22.32	0.02
7	46.424	22.32	0.0	46.424	22.32	0.0
8	46.443	22.38	0.06	46.443	22.38	0.06
9	46.463	22.41	0.03	46.463	22.41	0.03
10	46.486	22.43	0.02	46.486	22.43	0.02
11	46.507	22.50	0.07	46.507	22.50	0.07
12	46.526	22.56	0.06	46.526	22.56	0.06
13	46.547	22.62	0.06	46.547	22.62	0.06
14	46.569	22.63	0.01	46.569	22.62	0.0
15	46.590	22.62	-0.01	46.590	22.62	0.0
16	46.609	22.63	0.01	46.609	22.62	0.0
17	46.674	22.63	0.0	46.674	22.62	0.0
18	46.689	22.63	0.0	46.689	22.62	0.0
19	46.712	22.62	-0.01	46.712	22.62	0.0
20	46.731	22.61	-0.01	46.731	22.62	0.0
21	46.750	22.60	-0.01	46.750	22.62	0.0
22	46.772	22.68	0.08	46.772	22.68	0.06
23	46.793	22.72	0.04	46.793	22.72	0.04
24	46.826	22.73	0.01	46.826	22.73	0.01
25	46.866	22.77	0.04	46.866	22.77	0.04

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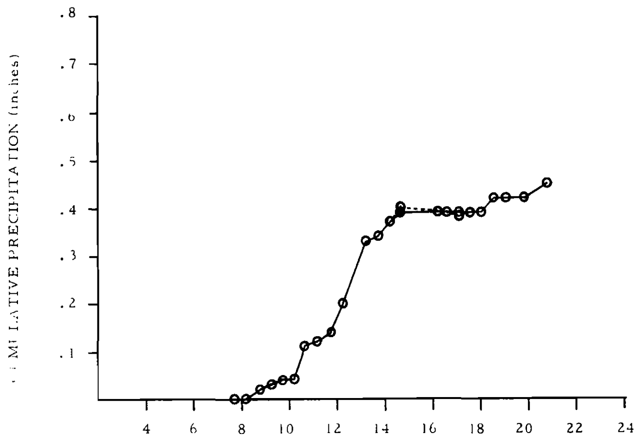
HALF HOURLY PRECIPITATION DATA FOR STATION 603
ACCOUNTING DATA FOR STATION 603
25 POINTS ENTERED
0 POINTS ADJUSTED FOR OVERSHOOT
7 POINTS ADJUSTED FOR NOISE
0 OUTLIERS REJECTED
0 NOISE POINTS REJECTED
18 ORIGINAL DATA POINTS LEFT UNTOUCHED
25 POINTS ACCEPTED
0 POINTS REJECTED
100 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED



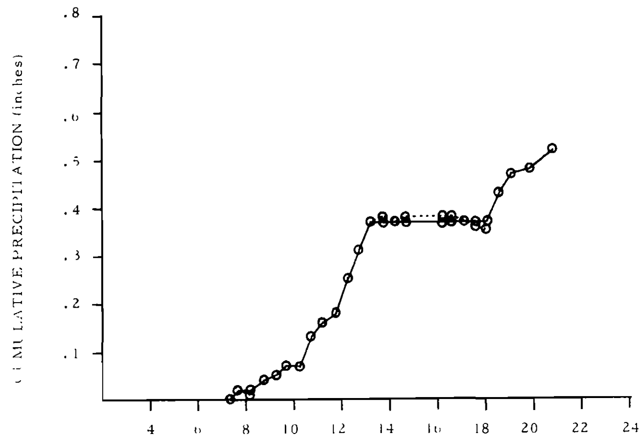


Figure 4. Final (solid curve) and original (dashed curve) data from Tony Grove Ranger Station gages 602 and 603. The curve adjustment here is typical of that required for noise points. (The day listed is the day of the year and precipitation is listed in inches.)

Questionable points are indicated by a dashed line on the graphs.

Data for Gold Hill gage 1001 and Cinnamon Creek gage 1203 are graphed and displayed in Figure 5. These curves appear to contain overshoot as determined from a qualitative definition of the term. However, the quantitative criteria for overshoot is not met. That is, each of three successive data points must be at least .03 inch less than each of two data points at the beginning of the negative trend. The data for Cinnamon Creek gage 1203 would have met the overshoot criteria except that the highest point of the set was rejected as an outlier.

Figure 6 shows data for Franklin Basin gage 1603 and Hell Canyon gage 1701. These data sets were quality checked by the machine and required no adjustment. Note that one outlier was rejected for the Franklin Basin gage. This was a duplicate time point which occurred at day 46.402.

The overshoot correction is shown in Figure 7 for Dry Bread Pond gage 5004 and Porcupine gage 12501. The first appearance of overshoot on the graph for Dry Bread Pond was not overshoot as defined quantitatively. The second appearance of overshoot on this graph and on the one following was identified as overshoot and treated as such.

The overshoot occurring on Porcupine gage 12501 is typical of snow and ice accumulation and subsequent melting off. The overshoot occurrence on Dry Bread Pond gage is more difficult to explain.

STATION 1001

UNEDITED DATA

POINT	DAY	PCPTN	CHANGE
1	46.303	21.15	0.0
2	46.326	21.15	0.0
3	46.347	21.14	-0.01
4	46.370	21.14	0.0
5	46.388	21.14	0.0
6	46.410	21.14	0.0
7	46.429	21.13	-0.01
8	46.450	21.15	0.02
9	46.471	21.16	0.01
10	46.493	21.16	0.0
11	46.513	21.19	0.03
12	46.533	21.22	0.03
13	46.554	21.23	0.01
14	46.576	21.32	0.09
15	46.596	21.36	0.04
16	46.615	21.38	0.02
17	46.678	21.35	-0.03
18	46.696	21.38	0.03
19	46.718	21.38	0.0
20	46.737	21.40	0.02
21	46.759	21.41	0.01
22	46.777	21.39	-0.02
23	46.800	21.37	-0.02
24	46.839	21.36	-0.01
25	46.879	21.42	0.06

EDITED DATA

DAY	PCPTN	CHANGE
46.303	21.14	0.0
46.326	21.14	0.0
46.347	21.14	0.0
46.370	21.14	0.0
46.388	21.14	0.0
46.410	21.14	0.0
46.429	21.14	0.0
46.450	21.15	0.01
46.471	21.16	0.01
46.493	21.16	0.0
46.513	21.19	0.03
46.533	21.22	0.03
46.554	21.23	0.01
46.576	21.32	0.09
46.596	21.36	0.04
46.615	21.37	0.01
46.678	21.37	0.0
46.696	21.37	0.0
46.718	21.37	0.0
46.737	21.37	0.0
46.759	21.37	0.0
46.777	21.37	0.0
46.800	21.37	0.0
46.839	21.37	0.0
46.879	21.42	0.05

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HALF HOURLY PRECIPITATION DATA FOR STATION 1001
ACCOUNTING DATA FOR STATION 1001
25 POINTS ENTERED
0 POINTS ADJUSTED FOR OVERSHOOT
11 POINTS ADJUSTED FOR NOISE
0 OUTLIERS REJECTED
0 NOISE POINTS REJECTED
14 ORIGINAL DATA POINTS LEFT UNTOUCHED
25 POINTS ACCEPTED
0 POINTS REJECTED
100 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED

STATION 1203

UNEDITED DATA

POINT	DAY	PCPTN	CHANGE
1	46.311	20.60	0.0
2	46.326	20.59	-0.01
3	46.346	20.60	0.01
4	46.369	20.61	0.01
5	46.389	20.58	-0.03
6	46.409	20.61	0.03
7	46.428	20.65	0.04
8	46.449	20.69	0.04
9	46.470	20.70	0.01
10	46.492	20.71	0.01
11	46.512	20.79	0.08
12	46.532	21.02	0.23
13	46.554	20.98	-0.04
14	46.575	20.88	-0.10
15	46.596	20.86	-0.02
16	46.615	20.82	-0.04
17	46.678	20.88	0.06
18	46.695	20.87	-0.01
19	46.718	20.89	0.02
20	46.737	20.89	0.0
21	46.758	20.87	-0.02
22	46.777	20.86	-0.01
23	46.799	20.85	-0.01
24	46.838	20.87	0.02
25	46.878	20.88	0.01

EDITED DATA

DAY	PCPTN	CHANGE
46.311	20.60	0.0
46.326	20.60	0.0
46.346	20.60	0.0
46.369	20.61	0.01
46.389	20.61	0.0
46.409	20.61	0.0
46.428	20.65	0.04
46.449	20.69	0.04
46.470	20.70	0.01
46.492	20.71	0.01
46.512	20.79	0.08
46.575	20.86	0.07
46.596	20.86	0.00
46.678	20.86	0.0
46.695	20.86	0.0
46.718	20.86	0.0
46.737	20.96	0.0
46.758	20.86	0.0
46.777	20.86	0.0
46.799	20.86	0.0
46.838	20.87	0.01
46.878	20.88	0.01

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HALF HOURLY PRECIPITATION DATA FOR STATION 1203
ACCOUNTING DATA FOR STATION 1203
25 POINTS ENTERED
0 POINTS ADJUSTED FOR OVERSHOOT
[illegible] POINTS ADJUSTED FOR NOISE
1 OUTLIERS REJECTED
2 NOISE POINTS REJECTED
13 ORIGINAL DATA POINTS LEFT UNTOUCHED
22 POINTS ACCEPTED
3 POINTS REJECTED
88 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED

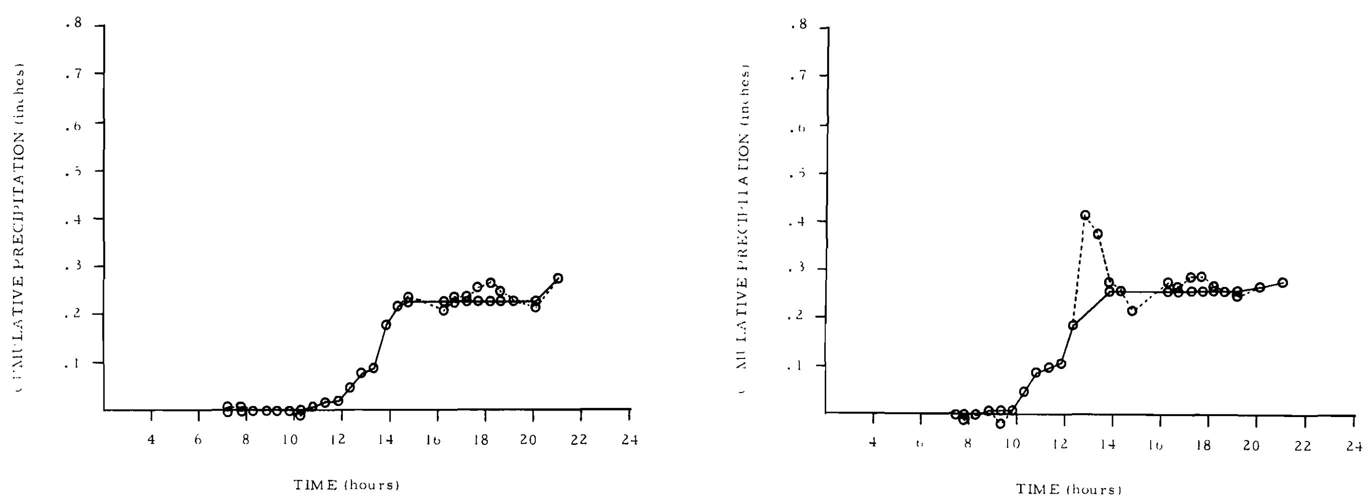


Figure 5. Final (solid curve) and original (dashed curve) data for Gold Hill gage 1001 and Cinnamon Creek gage 1203. These curves appear to contain overshoot regions as explained qualitatively, however, they do not meet the exact criteria. Even though these curves were not subjected to the noise point routine, reasonable adjustments were still made.

The data processing steps shown and discussed are typical of those taken on most of the data from the telemetry network. The actual handling of questionable data points for the cases of outliers and noise points is in accord with theory. However, the problem of where to place the beginning time of overshoot in a data set is still open to question.

Conclusion

The development of this data quality control program is a considerable achievement in automated precipitation data processing. Its development has reduced the cost of acquisition of reliable precipitation data to 3 percent of the original cost, and makes it possible to have the final edited precipitation data within a few days of the operational event, instead of the few weeks required by the manual editing. With the completion of a planned paper tape punch output, this time will be further reduced to a few hours. The research capability of the Wasatch Weather Modification Project has also been enhanced through the development and use of this program.

STATION 1603

POINT	UNEDITED DATA DAY	PCPTN	CHANGE	EDITED DATA DAY	PCPTN	CHANGE
1	46.304	25.29	0.0	46.304	25.29	0.0
2	46.318	25.29	0.0	46.318	25.29	0.0
3	46.339	25.29	0.0	46.339	25.29	0.0
4	46.361	25.29	0.0	46.361	25.29	0.0
5	46.392	25.29	0.0	46.382	25.29	0.0
6	46.402	25.29	0.0	46.402	25.29	0.0
7	46.492	25.29	0.0	46.422	25.29	0.0
8	46.422	25.29	0.0	46.441	25.30	0.01
9	46.441	25.30	0.01	46.463	25.30	0.0
10	46.463	25.30	0.0	46.485	25.30	0.0
11	46.485	25.30	0.0	46.506	25.30	0.0
12	46.506	25.30	0.0	46.525	25.30	0.0
13	46.525	25.30	0.0	46.547	25.30	0.0
14	46.547	25.30	0.0	46.567	25.30	0.0
15	46.567	25.30	0.0	46.589	25.33	0.03
16	46.589	25.33	0.03	46.608	25.33	0.0
17	46.608	25.33	0.0	46.673	25.33	0.0
18	46.673	25.33	0.0	46.688	25.33	0.0
19	46.688	25.33	0.0	46.711	25.33	0.0
20	46.711	25.33	0.0	46.730	25.33	0.0
21	46.730	25.33	0.0	46.750	25.33	0.0
22	46.750	25.33	0.0	46.771	25.33	0.0
23	46.771	25.33	0.0	46.791	25.33	0.0
24	46.791	25.33	0.0	46.824	25.33	0.0
25	46.824	25.33	0.0	46.864	25.33	0.0
26	46.864	25.33	0.0			

****

HALF HOURLY PRECIPITATION DATA FOR STATION 1603

ACCOUNTING DATA FOR STATION 1603

26 POINTS ENTERED
0 POINTS ADJUSTED FOR OVERSHOOT
0 POINTS ADJUSTED FOR NOISE
1 OUTLIERS REJECTED
0 NOISE POINTS REJECTED
25 ORIGINAL DATA POINTS LEFT UNTOUCHED
25 POINTS ACCEPTED
1 POINTS REJECTED
96 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED

STATION 1701

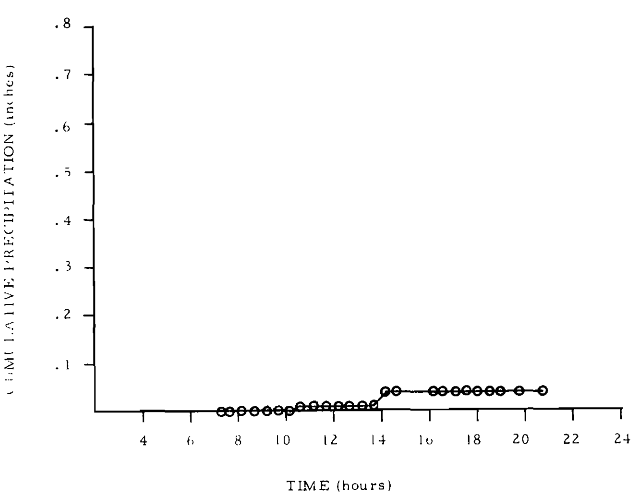
POINT	UNEDITED DATA DAY	PCPTN	CHANGE	EDITED DATA DAY	PCPTN	CHANGE
1	46.320	30.91	0.0	46.320	30.91	0.0
2	46.340	30.93	0.02	46.340	30.93	0.02
3	46.364	30.93	0.0	46.364	30.93	0.0
4	46.384	30.93	0.0	46.384	30.93	0.0
5	46.403	30.96	0.03	46.403	30.96	0.03
6	46.404	30.97	0.01	46.404	30.97	0.01
7	46.424	30.98	0.01	46.424	30.98	0.01
8	46.443	30.98	0.0	46.443	30.98	0.0
9	46.464	30.99	0.01	46.464	30.99	0.01
10	46.486	30.99	0.0	46.486	30.99	0.0
11	46.508	31.00	0.01	46.508	31.00	0.01
12	46.526	31.07	0.07	46.526	31.07	0.07
13	46.547	31.07	0.0	46.547	31.07	0.0
14	46.569	31.09	0.02	46.569	31.09	0.02
15	46.590	31.09	0.0	46.590	31.09	0.0
16	46.609	31.10	0.01	46.609	31.10	0.01
17	46.674	31.10	0.0	46.674	31.10	0.0
18	46.689	31.10	0.0	46.689	31.10	0.0
19	46.712	31.10	0.0	46.712	31.10	0.0
20	46.732	31.10	0.0	46.732	31.10	0.0
21	46.751	31.10	0.0	46.751	31.10	0.0
22	46.772	31.11	0.01	46.772	31.11	0.01
23	46.793	31.11	0.0	46.793	31.11	0.0
24	46.827	31.11	0.0	46.827	31.11	0.0
25	46.967	31.11	0.0	46.967	31.11	0.0

****

HALF HOURLY PRECIPITATION DATA FOR STATION 1701

ACCOUNTING DATA FOR STATION 1701

25 POINTS ENTERED
0 POINTS ADJUSTED FOR OVERSHOOT
0 POINTS ADJUSTED FOR NOISE
0 OUTLIERS REJECTED
0 NOISE POINTS REJECTED
25 ORIGINAL DATA POINTS LEFT UNTOUCHED
25 POINTS ACCEPTED
0 POINTS REJECTED
100 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED



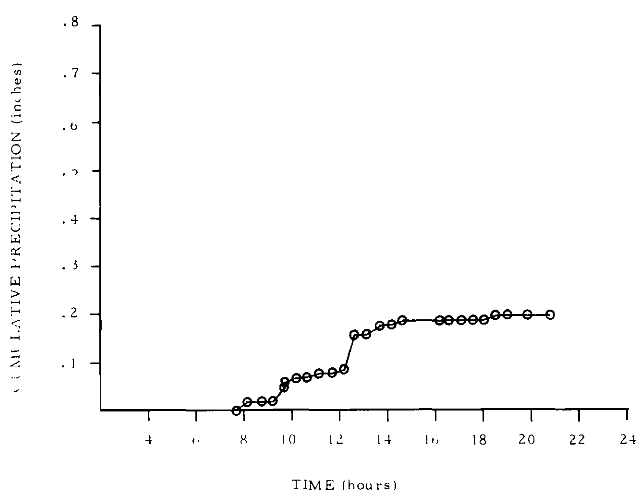


Figure 6. Data sets for Franklin Basin gage 1603 and Hell Canyon gage 1701. No corrections were made on data points in these sets. However, one time outlier at day 46.402 was found and discarded from the data set of station 1603.

STATION 5004
START, MID, AND END POINT 16 20 23
OVERSHOOT ADJUSTED DATA FOLLOW

POINT	TIME	NEW VALUE	OLD VALUE
16	46.670	27.84	27.84
17	46.685	27.86	27.86
18	46.706	27.87	27.90
19	46.726	27.87	27.92
20	46.746	27.87	27.92
21	46.767	27.87	27.87
22	46.787	27.87	27.86
23	46.816	27.87	27.87

	UNEDITED DATA			EDITED DATA		
POINT	DAY	PCPTN	CHANGE	DAY	PCPTN	CHANGE
1	46.315	27.46	0.0	46.315	27.46	0.0
2	46.334	27.46	0.0	46.334	27.46	0.0
3	46.357	27.46	0.0	46.357	27.46	0.0
4	46.379	27.47	0.01	46.379	27.47	0.01
5	46.397	27.49	0.02	46.397	27.49	0.02
6	46.418	27.49	0.0	46.418	27.49	0.0
7	46.438	27.53	0.04	46.438	27.53	0.04
8	46.458	27.62	0.09	46.458	27.62	0.09
9	46.480	27.72	0.10	46.480	27.72	0.10
10	46.501	27.80	0.08	46.501	27.80	0.08
11	46.522	27.82	0.02	46.522	27.82	0.02
12	46.542	27.89	0.07	46.542	27.86	0.04
13	46.563	27.91	0.02	46.585	27.86	0.0
14	46.585	27.86	-0.05	46.604	27.86	0.00
15	46.604	27.88	0.02	46.670	27.86	0.0
16	46.670	27.84	-0.04	46.685	27.86	0.0
17	46.685	27.86	0.02	46.706	27.87	0.01
18	46.706	27.90	0.04	46.726	27.87	0.0
19	46.726	27.92	0.02	46.746	27.87	0.0
20	46.746	27.92	0.0	46.767	27.87	0.0
21	46.767	27.87	-0.05	46.787	27.87	0.0
22	46.787	27.86	-0.01	46.816	27.87	0.0
23	46.816	27.87	0.01	46.856	27.88	0.01
24	46.856	27.88	0.01			

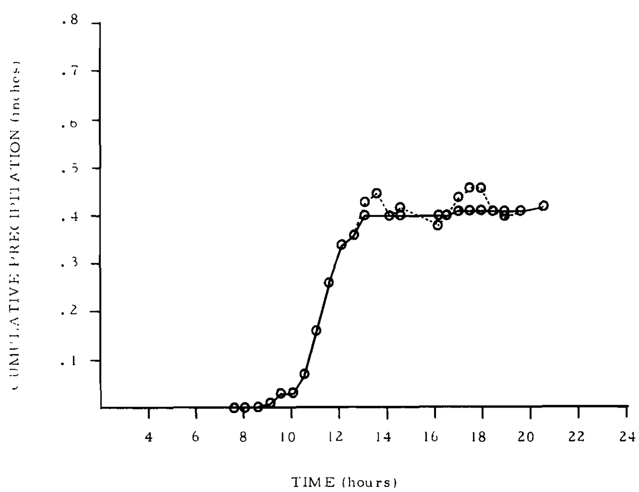
****
HALF HOURLY PRECIPITATION DATA FOR STATION 5004
ACCOUNTING DATA FOR STATION 5004
24 POINTS ENTERED
4 POINTS ADJUSTED FOR OVERSHOOT
3 POINTS ADJUSTED FOR NOISE
0 OUTLIERS REJECTED
1 NOISE POINTS REJECTED
16 ORIGINAL DATA POINTS LEFT UNTOUCHED
23 POINTS ACCEPTED
1 POINTS REJECTED
96 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED

STATION 12501
START, MID, AND END POINT 11 17 20
OVERSHOOT ADJUSTED DATA FOLLOW

POINT	TIME	NEW VALUE	OLD VALUE
11	46.536	16.95	16.95
12	46.556	17.19	17.19
13	46.578	17.23	17.33
14	46.599	17.23	17.35
15	46.618	17.23	17.35
16	46.666	17.23	17.34
17	46.680	17.23	17.34
18	46.700	17.23	17.30
19	46.721	17.23	17.30
20	46.739	17.23	17.23

	UNEDITED DATA			EDITED DATA		
POINT	DAY	PCPTN	CHANGE	DAY	PCPTN	CHANGE
1	46.306	16.91	0.0	46.306	16.90	0.0
2	46.328	16.90	-0.01	46.328	16.90	0.0
3	46.352	16.90	0.0	46.352	16.90	0.0
4	46.373	16.90	0.0	46.373	16.90	0.0
5	46.392	16.90	0.0	46.392	16.90	0.0
6	46.431	16.91	0.01	46.431	16.91	0.01
7	46.452	16.91	0.0	46.452	16.91	0.0
8	46.472	16.91	0.0	46.472	16.91	0.0
9	46.496	16.91	0.0	46.496	16.91	0.0
10	46.516	16.92	0.01	46.516	16.92	0.01
11	46.536	16.95	0.03	46.536	16.95	0.03
12	46.556	17.19	0.24	46.556	17.19	0.24
13	46.578	17.33	0.14	46.578	17.23	0.04
14	46.599	17.35	0.02	46.599	17.23	0.0
15	46.618	17.35	0.0	46.618	17.23	0.0
16	46.666	17.34	-0.01	46.666	17.23	0.0
17	46.666	17.34	0.0	46.680	17.23	0.0
18	46.680	17.34	0.0	46.700	17.23	0.0
19	46.700	17.30	-0.04	46.721	17.23	0.0
20	46.721	17.30	0.0	46.739	17.23	0.0
21	46.739	17.23	-0.07	46.761	17.23	0.0
22	46.761	17.23	0.0	46.780	17.23	0.0
23	46.780	17.23	0.0	46.805	17.23	0.0
24	46.805	17.23	0.0	46.845	17.27	0.04
25	46.845	17.27	0.04	46.886	17.34	0.07
26	46.886	17.34	0.07			

****
HALF HOURLY PRECIPITATION DATA FOR STATION 12501
ACCOUNTING DATA FOR STATION 12501
26 POINTS ENTERED
7 POINTS ADJUSTED FOR OVERSHOOT
1 POINTS ADJUSTED FOR NOISE
1 OUTLIERS REJECTED
0 NOISE POINTS REJECTED
17 ORIGINAL DATA POINTS LEFT UNTOUCHED
25 POINTS ACCEPTED
1 POINTS REJECTED
96 PERCENT OF TOTAL POINTS INPUT WERE ACCEPTED



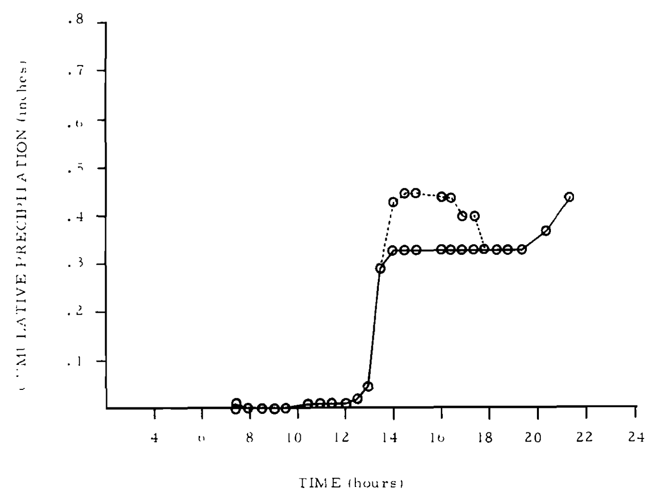


Figure 7. Final (solid curve) and original (dashed curve) data sets for Dry Bread Pond gage 5004 and Porcupine gage 12501. Overshoot was detected and treated in these data sets.

References

Chadwick, Duane G., July 1968: USU Remote Total Precipitation Telemetry Station. PRWG30-6, Utah Water Research Laboratory, Utah State University, Logan, Utah.

Chadwick, Duane G., 1969: Telemetry System Modifications and 1968-69 Operation. PRWG30-8, Utah Water Research Laboratory, Utah State University, Logan, Utah.

Israelsen, C. Earl and Don L. Griffin, 1969: USU Telemetering Precipitation Gage Network. Technical Report PRWG30-7, Utah Water Research Laboratory, Utah State University, Logan, Utah.

APPENDIX A

The Computer Program

In this appendix, the computer program is described in separate parts related to the specific types of data quality checks and data editing procedures. Reference is made to the variable list in Appendix B and the computer program listing in the latter part of this appendix. The computer program is referred to by line number of the listing.

Lines 5-6

The starting day and ending day of the data set are read in. The variable KEROR is normally read in as a zero. If any other number is read in for KEROR, the program prints out intermediate data sets during the edit process. This is mainly for program debugging. The number of sets of operational event precipitation data to be output is the fourth input variable.

Lines 7-8

Starting and ending times for individual operational seeding events and their identification are read in.

Line 9

This is a data statement to define the last day of each month of the year in terms of day of year. It must be changed when data for a leap year is being edited.

Lines 10-12

The read, write, and punch channels for the computer are defined.

Lines 13-30

A data set for one station is read in from cards. There are seven cumulative precipitation values per card in the format explained in Appendix C. After each card is read, a test is made for change in station number. This change indicates the end of the data set for one station and a transfer is made to the processing portion of the program. A short routine is included here to make a reverse search on the last seven values read in for a station. Its purpose is to find the last data point of the set since the number of data points in a set is usually not an even multiple of seven.

Lines 31-42

The station identification is printed out and a check is made here to insure that more than seven data points are available for the editing procedure. The original set of data points is then transferred to another array to be kept for later printing and manual comparison with the edited data set.

Lines 43-77

A time check is made on the data points by first making sure that all values are stored in chronological order. If more than one point exists for a given time, the first of the two values is deleted. This is based on the assumption that a keypunch error was made and corrected on the second of the two cards. The deletion of the bad data point is accomplished by decreasing the total number of points in the set by one and setting the i^{th} storage location to the value of the $(i+1)^{th}$ point of the set. This is done from the bad point on to the end of the data set. A check is then made for negative cumulate precipitation values and data points lying outside of the data set region timewise.

Lines 78-99

This routine finds a reasonable starting data point for the set, i.e., reduces the possibility that an outlier be selected as the initial point. This is done in the following manner. Let b_1 and b_2 denote precipitation rates in inches/hour between points one and two and points two and three respectively. The first data point is regarded as valid if $b_1 < -.5$ and $b_2 > +.5$, or $-.5 < b_1 < .5$ with no restrictions on b_2, or $b_1 > .5$ and $b_2 < -.5$. The additional requirement that the absolute value of the difference in cumulative precipitation between points one and two be less than one inch must also be met. Justification of this criteria is somewhat lengthy and is not included in this report. If the first data point is rejected, the procedure is repeated until a suitable starting point is found.

Lines 100-137

Outlying data points are discarded here by the procedure outlined in the data quality criteria section of this report.

Lines 138-236

This section of the program checks the data set for overshoot, and if detected, corrects it as outlined previously in the Data Quality Criteria section.

Precipitation rates are calculated point by point for each pair of points in the data set and counting variables are initialized. If the debugging variable, KEROR, is other than zero, the data set and rates are printed out before the overshoot check starts. Lines 152 and 167 check for overshoot as described previously. Lines 168-176 find the end of the overshoot, and lines 177-191 correct the overshoot as explained in the previous section of this report. The adjusted and the original precipitation values are printed out for future reference.

Lines 237-326

Noise points are checked for in this section of the program. The checking and editing procedures are programmed as described in the Data Quality Criteria section of this report.

Lines 327-346

The edited and unedited data sets are printed. This allows for subsequent examination of both data sets simultaneously. An example of this printout is shown in Figure 3.

Lines 347-374

When the variable, KEROR, is set to a value other than zero, this section punches the edited curve in the same format as the input data. This allows the graphing of the two curves on a hybrid computer enabling evaluation of the editing procedure.

Lines 375-404

A printout of the data quality parameters is done at this stage. Figure 3 shows an example.

Lines 405-515

Interpolation, printing, and punching of half-hourly precipitation values is handled by this portion of the program. The day and month are defined in terms of the day of the year associated with the first data point of the set. An incremental parameter A is defined as 1/48. A time of day parameter ST is defined in decimal equivalence of integral numbers of half hours for the times at which the individual interpolated precipitation values are calculated. The proper interval for interpolation is determined from the parameter ST and the half-hourly precipitation value is computed. The time parameter is incremented by 1/48 of a day and the process is repeated for the time interval of the entire data set. The data are output on cards with one card for each 12 hours of data making two cards output per day. A card image is shown in Appendix C. Each card lists the station number, the year, month, and day of the data, 24 half-hourly values, maximum interpolation interval, a start time and end time for the data of each individual card, the operational event identification, and a number indicating whether a card is for a.m. or p.m.

Lines 516-522

If at one of the check points in the program, an indication is given that too much data has been discarded, the program branches to this point and prints out the input data set with a message to the user.

Lines 523-529

This routine transfers the first data points of the next set into the first seven locations of the data set array. Control is then transferred back to line 15 where the process is carried out on the next data set. A blank card is placed at the end of the data which causes zero to be read in as the station number. When this condition is sensed, the stop command in line 529 is executed.

```
C*****************************************************************************
C
C  WASATCH WEATHER MODIFICATION PROJECT PRECIPITATION DATA QUALITY CONTROL
C
C  PROGRAM DEVELOPED AND WRITTEN BY
C  RONALD H. CAMPBELL
C  RESEARCH ASSISTANT
C  DEVELOPED THROUGH FUNDING BY THE BUREAU OF RECLAMATION
C  OFFICE OF ATMOSPHERIC WATER RESOURCES
C
C*****************************************************************************
C
C
C  DIMENSION DATA ARRAYS
      DIMENSION STS(25),ETS(25),OE(25)
      DIMENSION T(500),P(500),TC(500),PC(500)
      DIMENSION FMT(15),NUM(13),S(500),KT(7),KP(7),KS(7)
      INTEGER PR(800),PT(800)
C  READ IN DAY TIME LIMITS AND DAYS OF MONTH FOR OUTPUT
      READ (5,841) SDAY,EDAY,KEROR,NOSET
  841 FORMAT (2F6.3,I1,I3)
      READ (5,2842) (OE(I),STS(I),ETS(I),I=1,NOSET)
 2842 FORMAT (4(A4,2X,2F6.3,2X))
C  THE FOLLOWING DATA CARD MUST BE CHANGED FOR LEAP YEAR
C  THE NUMBERS ARE THE DAY OF THE END OF EACH MONTH OF THE YEAR WITH A ZERO
C  AS THE FIRST VALUE
      DATA NUM/0,31,59,90,120,151,181,212,243,273,304,334,365/
      NR=5
      NW=6
      NPUN=7
C  READ IN DATA TO BE EDITED
      READ (NR,1)   KSTN,KYR,(T(I),P(I),I=1,7)
    1 FORMAT (I5,I2,3X,7(F6.3,F4.2))
   19 DO 20 I=1,71
      J=I*7+1
      K=J+6
      READ (NR,1)   LSTN,KYR,(T(L),P(L),L=J,K)
      IF (LSTN.NE.KSTN) GO TO 21
      LYR=KYR
   20 CONTINUE
   21 NP=J-1
      NPP=NP
      DO 5 I=1,7
      J=NP-I+1
      IF (T(J).LT..001) GO TO 5
      NP=NP-I+1
      GO TO 6
    5 CONTINUE
    6 CONTINUE
C  WRITE OUT STATION NUMBER
      WRITE (NW,666) KSTN
  666 FORMAT (1H1,7HSTATION,I6)
      NPI=NP
      IF (NP.GT.7) GO TO 261
C  CHECK FOR SUFFICIENT NUMBER OF DATA POINTS FOR EDITING
      WRITE (NW,262) (T(I),P(I),I=1,NP)
  262 FORMAT(19H INSUFFICIENT DATA ,4(F9.3,F6.2))
      GO TO 127
  261 CONTINUE
C  TRANSFER ORIGINAL DATA FOR PRINOUT LATER
      DO 25 I=1,NP
      TC(I)=T(I)
   25 PC(I)=P(I)
      NLCR=0
C  *********************************************************************
C  TIME CHECK
  400 I=1
      J=0
  401 I=I+1
  431 CONTINUE
      IF (T(I)-T(I-1)) 402,403,404
  402 K=I-1
```

```
  406 J=1
      A=T(I)
      T(I)=T(I-1)
      T(I-1)=A
      A=P(I)
      P(I)=P(I-1)
      P(I-1)=A
      GO TO 404
  403 NP=NP-1
      DO 407 K=I,NP
      T(K)=T(K+1)
  407 P(K)=P(K+1)
      NLOR=NLOR+1
      IF (I.LE.NP) GO TO 431
  404 IF (I.LT.NP) GO TO 401
      IF (J.GT.0) GO TO 400
C*****************************************************************************
C  CHECK FOR NEGATIVE CUMULATIVE PRECIPITATION VALUES AND OUTLYING TIME POINTS
  461 I=0
  462 I=I+1
  463 IF (P(I).LT.0.) GO TO 465
      IF (T(I).LT.SDAY) GO TO 465
      IF (T(I).GT.EDAY) GO TO 465
      GO TO 466
  465 NP=NP-1
      DO 471 J=I,NP
      P(J)=P(J+1)
  471 T(J)=T(J+1)
      NLOR=NLOR+1
      IF (I.LE.NP) GO TO 463
  466 IF (I.LT.NP) GO TO 462
C*****************************************************************************
C  FIND STARTING POINT FOR GOOD DATA
      IF (NP.LT.7) GO TO 126
      I=1
   83 I=I+1
      B1=(P(I)-P(I-1))/((T(I)-T(I-1))*24.)
      B2=(P(I+1)-P(I))/((T(I+1)-T(I))*24.)
      IF (B1+.5) 80,80,82
   80 IF (B2-.5) 83,89,89
   82 IF (B1-.5) 89,84,84
   84 IF (B2+.5) 89,83,83
   89 CONTINUE
      A=P(I)-P(I-1)
      A=ABS(A)
      IF (A.GT.1.) GO TO 83
  810 IF (I.EQ.2) GO TO 30
      J=I-1
      DO 27 I=J,NP
      K=I-J+1
      T(K)=T(I)
   27 P(K)=P(I)
      NP=NP-J+1
      NLOR=NLOR+J-1
   30 CONTINUE
C*****************************************************************************
C  CHECK FOR OUTLYING DATA POINTS
  410 I=1
  411 I=I+1
  428 B=P(I)-P(I-1)
      C=ABS(B)/((T(I)-T(I-1))*24.)
      IF (C.LT..2) GO TO 443
      IF (I.EQ.NP) GO TO 420
      C=P(I+1)-P(I)
      D=B+C
      D=ABS(D)
      IF (D.LT..02) GO TO 420
C  CHECK FOR ABOVE AVERAGE OF FOLLOWING POINTS
      ST=0.
      NB=I+5
      JJ=I+1
      IF (NB.GT.NP) NB=NP
```

```
      IF (JJ.GT.NB) JJ=NB
      DO 150 J=JJ,NB
  150 ST=ST+P(J)
      A=NB-JJ+1
      ST=ST/A+.03
      IF (P(I).GT.ST) GO TO 420
C  CHECK TO SEE THAT P(I) IS GREATER THAN AVERAGE OF PRECEEDING POINTS
      ST=0.
      JJ=I-5
      NB=I-1
      IF (JJ.LT.1) JJ=1
      DO 413 J=JJ,NB
  413 ST=ST+P(J)
      A=NB-JJ+1
      ST=ST/A-.03
      IF (P(I).LT.ST) GO TO 420
      GO TO 443
  420 NP=NP-1
      IF (NP.LT.8) GO TO 126
      DO 425 J=I,NP
      T(J)=T(J+1)
  425 P(J)=P(J+1)
      NLOR=NLOR+1
      IF(I.LE.NP) GO TO 428
  443 IF (I.LT.NP) GO TO 411
C  *******************************************************************
C  OVERSHOOT ROUTINE
      NV=NP-4
      PR(1)=P(1)*100.+.1
      DO 201 I=2,NP
      PR(I)=P(I)*100.+.1
  201 S(I-1)=(P(I)-P(I-1))/((T(I)-T(I-1))*24.)
      NCNT=0
      NQ=0
      J=1
      NO=0
      NPS=NP-1
      NAOS=0
      IF (KEROR.EQ.0) GO TO 814
      WRITE (6,230) (I,T(I),P(I),S(I),I=1,NP)
  230 FORMAT (1X,I8,F10.3,2F6.2)
  814 I=1
  202 I=I+1
      IF (NO.EQ.1) GO TO 225
      IF (NQ.GE.1) GO TO 223
      IF (S(I)) 204,205,205
  223 NS=I-NQ
      IF (P(I+1)-P(NS)) 204,205,205
  204 NCNT=NCNT+1
      NQ=NQ+1
      IF (NCNT-3) 203,206,206
C  OVERSHOOT IS INDICATED
C  RECHECK OVERSHOOT IDENTIFICATION
  206 L=I-2
      LL=L-1
      A=P(LL)-.02
      DO 224 LA=L,I
      IF(A.LE.P(LA+1)) GO TO 265
  224 CONTINUE
      IK=0
      NO=1
      I=I-1
  225 IF (S(I)+.01) 207,208,208
  265 I=I-2
      GO TO 205
  208 CONTINUE
      IK=IK+1
      IF (IK-3) 211,209,209
C  END OF OVERSHOOT IS IDENTIFIED
C  L IS POINT OF MAX PCPTN
C  K IS LAST POINT OF OVERSHOOT
```

```
  209 K=I-2
C  IDENTIFY START TO ADJUST TIME
  210 CONTINUE
      NN=L-J+1
      JA=J+1
      DO 213 MM=JA,NN
      M=NN-MM+1
      IF (P(M).GT.P(K)) GC TO 213
      GO TO 214
  213 CONTINUE
  214 CONTINUE
      KM=M-1
      IF (KM.LT.1) KM=1
      IF (KM.EQ.1) GC TO 215
      A=T(KM+1)-T(KM)
      IF (A.GT..08) KM=KM+1
  215 CONTINUE
      WRITE (NW,980) KM,L,K
  980 FORMAT (26H START, MID, AND END PCINT,3I5)
  981 CONTINUE
C  KM IS THE POINT PRECEEDING THE START OF THE OVERSHOCT
      C=P(L)
      WRITE (6,593)
  593 FORMAT (32H OVERSHOCT ADJUSTED  DATA FOLLCW )
      WRITE (6,595)
  595 FORMAT (1X,36HPOINT   TIME   NEW VALUE   ULD VALUE)
      KKB=L-1
  816 DO 222 M=KM,KKB
      B=P(KM)+(C-P(KM))*(T(M)-T(KM))/(T(L)-T(KM))
      B=P(M)-B
      A=P(M)
      P(M)=P(KM)+(P(L)-P(KM))*(T(M)-T(KM))/(T(L)-T(KM))
      P(M)=P(M)+B
      IF (P(M).GT.P(K)) P(M)=P(K)
      WRITE (6,594) M,T(M),P(M),A
  594 FORMAT (1X,I4,F8.3,3X,F9.2,3X,F9.2)
  222 CONTINUE
      DO 221 M=L,K
      A=P(M)
      P(M)=P(K)
      WRITE (6,594) M,T(M),P(M),A
  221 CONTINUE
      NAOS=NAOS+1
  205 NCNT=0
      NQ=0
      NO=0
      GC TO 203
  207 IK=0
  211 IF (I.LT.NPS) GO TO 203
      K=I
      GO TO 210
  203 IF (I.LT.NPS) GC TO 202
      IF (NAOS.EQ.0) GO TC 227
      NAOS=0
      DO 226 I=1,NP
      A=PR(I)
      A=P(I)-A*.01
      A=ABS(A)
      IF (A.GT..005) NAOS=NAOS+1
  226 CONTINUE
  227 CONTINUE
      NNPR=NP
C*****************************************************************************
C  NOISE POINT CHECKING RCUTINE
   28 I=1
      DO 29 J=1,NP
      PR(J)=P(J)*100.+.1
   29 CONTINUE
      M=0
      NNP=NP-1
   38 I=I+1
   31 CONTINUE
```

```
      A=0
      K=I+1
      L=I+4-M
      DO 480 J=K,L
  480 A=A+P(J)
      B=L-K+1
      A=A/B+.0001
      IF (P(I-1).GT.A) GO TC 719
   23 IF (P(I).LT.P(I-1)) GC TC 18
      IF (P(I).GT.A) GO TC 22
      GO TO 40
   18 IF ((P(I)+.03).LT.P(I-1)) GC TO 35
      P(I)=P(I-1)
      GO TO 40
   22 IF ((P(I)-.03).GT.A) GO TO 35
      P(I)=A
      GO TO 40
  719 J=I+4
      IF (J.GT.NP) J=NP
      IF ((J-I).LE.2) GO TO 726
      A=.005
  722 K=C
      DO 720 MM=I,J
      L=0
      DO 721 N=I,J
      B=P(MM)-P(N)
      B=ABS(B)
      IF (B.GT.A) GO TO 721
      L=L+1
  721 CONTINUE
      IF (L.LE.K) GO TO 720
      K=L
      NAS=MM
  720 CONTINUE
      IF (K.GT.1) GC TO 723
      A=A+.01
      GO TO 722
  723 IF (P(I-1).LE.P(NAS)) GO TO 724
      K=I-1
  725 P(K)=P(NAS)
      K=K-1
      IF (K.LT.1) GC TO 724
      IF (P(K).GT.P(NAS)) GC TC 725
  724 A=P(NAS)
      GO TO 23
  726 IF ((P(I-1)-P(I+1)).GT..03) GO TO 35
      P(I+1)=P(I-1)
      A=P(I+1)
      GO TO 23
   35 NP=NP-1
      NV=NV-1
      IF (NP.LT.7) GC TO 126
      DO 36 K=I,NP
      T(K)=T(K+1)
      PR(K)=PR(K+1)
   36 P(K)=P(K+1)
      NNP=NP-1
      IF (I.LE.NV) GO TO 31
      M=M+1
      IF (I.LE.NNP) GO TO 31
      I=I-1
      GO TO 71
   40 CONTINUE
      IF (I.LT.NV) GO TO 38
      M=M+1
      IF (I.LT.NNP) GO TO 38
   71 B=(P(I+1)-P(I))/((T(I+1)-T(I))*24.)
      IF (B.LT..5) GO TO 74
      GO TO 73
   74 IF (B.GE.0.) GO TO 75
      IF ((P(I)-P(I+1)).GT.03) GO TO 73
      P(I+1)=P(I)
```

APPENDIX B

Description of Program Symbols

Arrays

Symbol	Description
ETS	End time of operational event
KP,KS,KT	Output parameters to be punched for plotting
NUM	Day of year which ends each month
OE	Operational event identification
P	Cumulative precipitation
PC	Cumulative precipitation
PR	Cumulative half-hourly precipitation
PT	Non-cumulative half-hourly precipitation
S	Change of precipitation with time
STS	Beginning time of operational event
T	Time of data point
TC	Time of data point

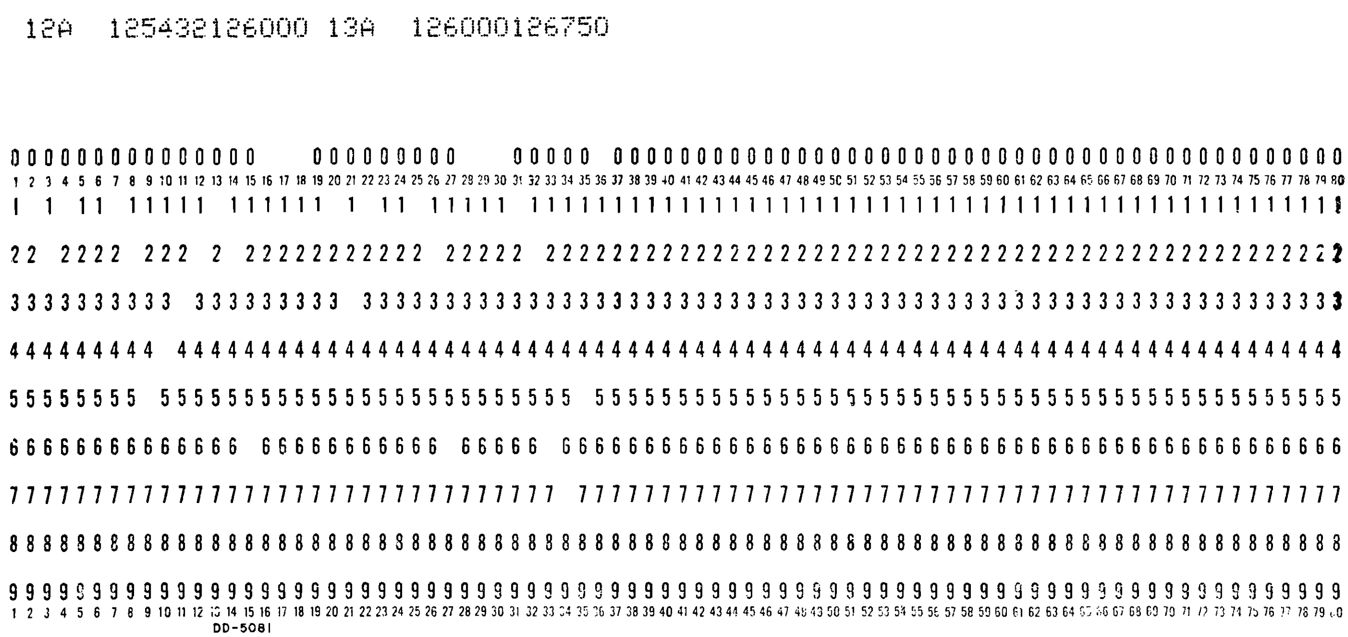
Single Variables

A,B,C,D,ST	Storage parameters for sorting and miscellaneous computation
AA,MB	Largest time interval of interpolation
B1,B2	$\Delta P/\Delta t$ for points one through three
BBB	Beginning time for interpolated data set
DA,DB	Difference between successive cumulative precipitation values
EDAY	Ending day and time of data set
I,J,K,L,M	Control parameters
JJ,NB	Indexes for the outlier routine
JJJ,KKK,MN	Parameters used in the half-hourly interpolations
KEROR	Data set debug parameter
KK,KDAY	Month and day of output data
KSTAR,KSTART	Beginning time of interpolated data
KSTN	Station identification
KSTO,KSTOP	End times of interpolated data
KYR	Year
LSTN	Station identification
LYR	Year
MM	Control parameter in noise point routine
NAOS	Number of points adjusted for overshoot
NAN	Number of points adjusted for noise
NCNT,NQ,NO,N	Control parameters for overshoot routine
PS,IK,NN,JA,M	Control parameters for overshoot routine
KM,KKB,LL,LA	Control parameters for overshoot routine
NLOR	Number of outliers
NNPR	Number of noise points rejected
NODP	Number of data points left untouched
NOSET	Number of operational events in data set

Operational Event Information

Column	Description
1-4	Operational event number
5-6	Blank
7-12	Beginning time of operational event in thousandths of days of the year
13-18	Ending time of operational event in thousandths of days of the year
19-20	Blank

This pattern continues for each operational event data subset contained in the main data set. The program provides for up to 25 such data subsets making a possibility of 9 cards for this information. The example has two data subsets.

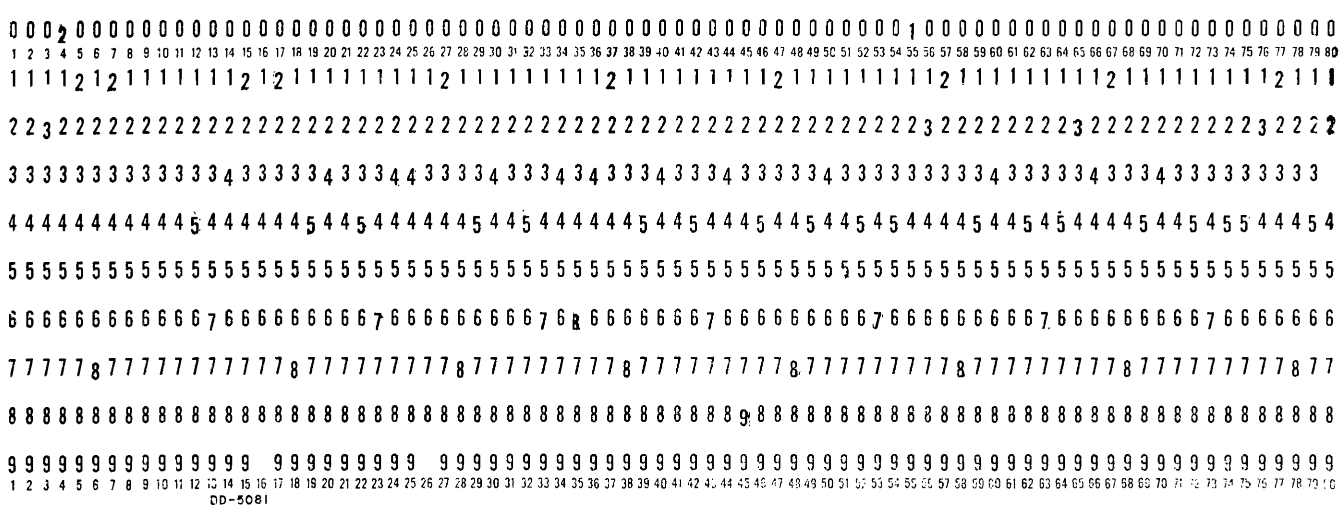


Precipitation Data Card

Column	Description
1-5	Station number
6-7	Year
8-10	Blank
11-16	Time of precipitation point in thousandths of days of the year
17-20	Cumulative precipitation in hundredths of inches
21-26	Same as 11-16 for the next data point
27-30	Same as 17-20 for the next data point

This pattern continues for the remainder of the data set. If the number of points in the data set is not an even multiple of 7, the remaining fields on the last card are left blank.

```
20171     467921743 468251743 468651743  0   0    0   0   0    0   0   0    0   0   0    0
20171     466081743 466741743 466891743 467101743 467311743 467501743 467711743
20171     464631743 464861743 465071743 465261743 465471743 465681743 465891743
20171     463191743 463391743 463631743 463841743 464021743 464231743 464421743
```



Card Output

Column	Description
1-5	Station number
6-7	Year
8-9	Month
10-11	Day
12-59	Half-hourly precipitation (2 columns per half hour)
60-62	Blank
63	Maximum length of interpolation period
64-65	Blank
66-69	Beginning time of data
70-73	Ending time of data
74	Blank
75-78	Operational event ID
79	Blank
80	First or second half of day

```
120371 215 6 2 2 2 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0   2  12302130  17A 2
120371 215 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 2 4 2 1 4   2   7301200  17A 1
100171 215 3 2 4 7 3 1 0 0 0 0 0 0 0 0 0 0 2 2 1 0 0 0 0 0   2  12302130  17A 2
100171 215 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1   2   7301200  17A 1
```