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Long-term precipitation database, Reynolds Creek Experimental Watershed, Idaho, United States

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Abstract. An extensive precipitation database has been developed over the past 35 years with the first records starting in January 1962 and going through September 1996 from the Reynolds Creek Experimental Watershed located near the north end of the Owyhee Mountains in southwest Idaho. Precipitation ranges from 236 mm on the lowest elevations at the north end of the watershed to 1123 mm at the southwest corner of the watershed. There are continuous 35 year records available for 12 sites, 20–32 year records available for 8 sites, 10–19 year records available for 25 sites, and 4–9 year records for 8 sites for a total of 53 sites. All of these data have been stored as breakpoint and hourly records in the U.S. Department of Agriculture, Agricultural Research Service, Northwest Watershed Research Center database. These breakpoint and hourly data are available from the anonymous ftp site: ftp.nwrc.ars.usda.gov.

1. Introduction

Precipitation amounts and their spatial and seasonal variations are basic to all hydrologic and natural resource studies. The U.S. Department of Agriculture, Agricultural Research Service, Northwest Watershed Research Center (NWRC) operates a precipitation gauge network as an integral part of the hydrologic studies on the Reynolds Creek Experimental Watershed (RCEW) [*Slaughter et al*., this issue]. The experimental area is a 239 km^2 watershed located in the Owyhee Mountains of southwest Idaho. The lowest elevation on the watershed is 1101 m; the eastern boundary rises to ~1525 m; the western boundary rises to a peak of 2241 m. Reynolds Creek is a north flowing tributary of the Snake River.

2. Precipitation Gauge Network

The original gauge network, established in 1960–1961, consisted of 83 unshielded 12 inch (30.48 cm) weighing-recording gauges. Because most of the precipitation that falls on the higher elevations of RCEW is snow, there was a significant undercatch by the network of single, unshielded gauges. Undercatch of snow is especially acute in windy environments such as those encountered in areas within the RCEW [*Hanson et al*., 1996]. Therefore, during 1967–1968 the network was converted to 46 dual-gauge installations which were designed to more accurately measure snowfall [*Hamon*, 1971; *Hanson et al*., 1999]. The dual-gauge system consists of an unshielded and a shielded universal recording gauge with orifices 3.05 m above ground. The shield is an Alter-type with the shield's baffles individually constrained at an angle of 30° from vertical [*Hamon, 1973; Hanson et al*., 1999]. *Hamon* [1971] gives a complete listing of both the original gauge network and the dual-gauge network and maps of RCEW which show both gauge networks. Table 1 gives the location, elevation, and length of record of each of the dual-gauges, and their locations on the watershed are shown in Plate 3a of *Slaughter et al*. [this issue]. Each dual-gauge location identification is referenced to a grid described by *Seyfried et al*. [2000].

3. Precipitation Record

3.1. Dual-Gauge Catch

The continuous precipitation records were computed for the dual-gauge sites using the following equation:

$$A = S^B U^{(1-B)}, \tag{1}$$

where A is the computed wind-adjusted precipitation, U is the unshielded precipitation catch, and S is the shielded precipitation catch. The coefficient B was found to be 1.7 by *Hamon* [1971], but on the basis of further studies, *Hamon* [1972] set B at 1.8 which is used by the NWRC to obtain A in (1). *Hamon* [1971, 1973] gives a detailed account of the procedures that were used to obtain values for B.

3.2. Computed Precipitation 1962–1967

Computed precipitation prior to 1968 was derived from unshielded-gauge data from sites that were located at or near the dual-gauge sites. For 10 years after the dual-gauges were installed, the prior unshielded gauges that were located at the three RCEW weather stations, the locations of which are shown in Plate 3a of *Slaughter et al*. [this issue], were kept operational along with the dual-gauges so that a relationship could be determined between A in (1) and an original unshielded precipitation value. Computed precipitation A was then determined for 1962–1968 from unshielded-gauge data by regression techniques that incorporated seasonal (summer and winter) and elevation parameters. A double-mass curve analysis [*Searcy and Hardison*, 1960] was done on the data from each dual-gauge site to determine if the 1962–1967 adjusted record was significantly different from the record since 1968. There were no significant differences ($p = 0.05$) between the earlier and later records.

3.3. Record Length and Quality

There are continuous records (January 1962 through September 1996) available for 12 sites, 20–32 year records available for 8

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Table 1. Precipitation Network, Reynolds Creek Experimental Watershed, Idaho

	Location		Elevation		Record		
Site Identification	Easting, m	Northing, m	GPS, m	DEM, m	Begins	Dual Gauge Installed	Ends
012x29	514,030	4,793,587	1575	1581	01/01/1962	12/21/1967	12/31/1976
015x95	517,995	4,792,516	1392	1379	01/01/1962	02/07/1968	12/31/1976
023x01	514,232	4,792,210	1506	1482	01/01/1962	12/08/1967	12/31/1984
024x76	516,644	4,791,220	1331	1324	01/01/1962	02/07/1968	12/31/1976
031x48	512,258	4,790,259	1794	1789	01/01/1968	01/01/1968	12/31/1975
033x76	514,998	4,789,592	1437	1436	01/01/1962	01/24/1968	12/31/1978
043x41	514,218	4,788,407	1473	1462	01/01/1965	12/21/1967	12/31/1975
045x04	517,930	4,789,220	1228	1222	01/01/1965	02/07/1968	12/31/1975
047x52	520,763	4,788,203	1144	1132	01/01/1965	03/08/1968	12/31/1975
049x61[a,b]	523,857	4,788,096	1285	1286	01/01/1965	03/08/1968	09/30/1996
053x93	514,284	4,785,992	1586	1516	01/01/1968	01/01/1968	12/31/1984
054x23	516,137	4,787,022	1356	1352	01/01/1965	01/25/1968	12/31/1975
055x88	518,535	4,786,229	1177	1168	01/01/1965	02/29/1968	12/31/1975
057x96[b]	521,391	4,786,033	1188	1186	01/01/1962	03/04/1968	09/30/1996
059x71	523,885	4,786,147	1341	1334	01/01/1965	03/06/1968	12/31/1975
061x25	511,681	4,785,632	1784	1794	01/01/1965	12/07/1967	12/31/1975
072x67	513,600	4,783,351	1593	1599	01/01/1965	11/22/1967	12/31/1975
074x12	515,878	4,784,083	1447	1436	01/01/1968	01/01/1968	12/31/1975
075x89	518,793	4,782,905	1216	1205	01/01/1965	03/08/1968	12/31/1975
076x59[b]	520,367	4,783,418	1207	1202	01/01/1962	01/22/1968	09/30/1996
078x14	522,623	4,784,183	1304	1303	01/01/1965	03/06/1968	12/31/1975
083x92	514,571	4,781,140	1674	1681	01/01/1965	11/22/1967	12/31/1975
088x65	522,923	4,781,716	1327	1325	01/01/1962	02/07/1968	12/31/1984
095x10[b]	517,240	4,780,800	1491	1486	01/01/1962	12/20/1967	09/30/1996
097x00	520,504	4,781,047	1259	1241	01/01/1965	01/22/1968	12/31/1975
098x97[b]	523,353	4,779,404	1413	1417	03/17/1972	03/13/1972	09/30/1996
106x36	519,807	4,778,984	1302	1313	01/01/1968	01/18/1968	12/31/1975
108x04	522,689	4,779,129	1458	1472	01/01/1965	01/02/1968	12/31/1975
114x19	517,165	4,777,608	1808	1794	01/01/1962	11/20/1967	12/31/1984
116x91[b]	519,008	4,776,343	1459	1465	01/01/1962	01/18/1968	09/30/1996
119x03	524,186	4,777,644	1617	1620	01/01/1965	03/07/1968	12/31/1975
124x84	516,399	4,774,981	1812	1803	01/01/1962	11/20/1967	12/31/1984
126x97	520,090	4,774,640	1674	1669	01/01/1962	03/22/1968	12/31/1984
127x07[b]	521,742	4,776,189	1652	1653	01/01/1962	02/13/1968	09/30/1996
128x87	523,498	4,774,772	1993	1990	01/01/1965	03/07/1968	12/31/1975
138x22[b]	522,594	4,774,226	1870	1866	10/13/1983	10/13/1983	09/30/1996
138x31	522,630	4,773,998	1900	1908	04/06/1972	04/06/1972	12/31/1975
138x33	522,328	4,773,974	1902	1902	10/08/1983	10/08/1983	09/30/1996
138x44	522,908	4,773,882	1956	1964	11/04/1983	11/04/1983	12/31/1994
144x62[b]	515,945	4,771,988	1815	1808	01/01/1962	11/17/1967	09/30/1996
145x37	518,473	4,772,498	1591	1581	01/01/1965	01/18/1968	12/31/1975
147x35[b]	521,336	4,772,334	1872	1868	01/01/1962	03/22/1968	09/30/1996
154x64	516,185	4,770,208	2089	2093	01/01/1968	01/01/1968	12/31/1975
155x07[b]	518,424	4,771,320	1654	1649	01/01/1962	01/18/1968	09/30/1996
156x68	520,285	4,770,365	1936	1928	01/01/1965	11/17/1967	12/31/1975
163x20[b]	514,134	4,769,430	2170	2166	01/01/1962	10/26/1967	09/30/1996
163x35	515,042	4,769,342	2147	2152	01/01/1972	11/11/1970	12/31/1975
165x02	517,663	4,769,620	1824	1825	01/01/1969	01/01/1969	12/31/1975
166x94	519,690	4,768,437	2034	2035	01/01/1968	01/01/1968	12/31/1975
167x07[b]	521,596	4,769,779	2003	2009	01/01/1962	03/22/1968	09/30/1996
174x17[b]	516,815	4,768,026	2074	2076	01/01/1962	11/08/1968	09/30/1996
176x07[b]	520,055	4,768,117	2061	2067	01/01/1962	01/01/1968	09/30/1996
176x14[b]	519,693	4,767,923	2097	2097	01/01/1968	01/01/1968	09/30/1996

[a]Site was not in operation from 01/01/1976 through 08/12/1979.
[b]Site is currently in operation.

sites, 10–19 year records available for 25 sites, and 4–9 year records available for 8 sites for a total of 53 sites. Prior to 1995, the record for each site was read by a chart reader and was verified as to correctness, and then a breakpoint record was stored in the NWRC data bank. Since 1995 the precipitation records have been stored electronically and verified as to correctness by a data processing program, and then a breakpoint record for each site was stored in the NWRC data bank.

Missing site information, because of clock stoppage, etc., was estimated based on timing information from nearby sites and the total precipitation in the receiver which was measured during regular gauge servicing. Delayed precipitation input because of infrequent snow capping of some of the high-elevation gauges was distributed across each of those events.

4. Spatial and Temporal Precipitation Characteristics

Precipitation data from six sites with 35 water years (1962–1996) of record were used to develop the following RCEW

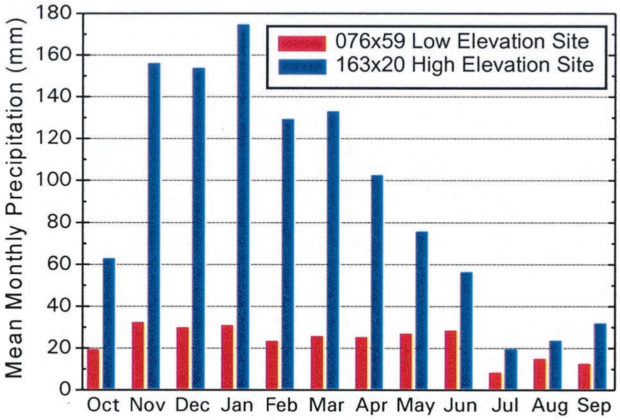

Plate 1. Mean monthly precipitation at sites 076x59 and 163x20 on Reynolds Creek Experimental Watershed.

Table 2. Average Annual Precipitation and Elevation of Six Sites on the Reynolds Creek Experimental Watershed, Idaho

Site	Elevation, m	Precipitation: Annual, mm	Precipitation: Percent of Annual From Snow	Snow Months[a]
057x96	1188	236	20	D, J
076x59	1207	275	22	D, J
116x91	1459	471	34	D, J, F
155x07	1654	712	63	N, D, J, F
176x07	2061	994	76	N, D, J, F, M, A
163x20	2170	1123	76	N, D, J, F, M, A

[a]Months when the mean monthly temperature was ≤1°C were considered snow months [*Cooley et al*., 1988]. Abbreviations are as follows: N, November; D, December; J, January; F, February; M, March; and A, April.

precipitation spatial and temporal characteristics. Annual precipitation increased 887 mm, or 4.8 times, over a distance of only 17.6 km between sites 057x96 and 163x20 (Table 2). This precipitation distribution is associated with elevation and storm patterns [*Hanson et al*., 1980]. Most of the major winter storms move onto the RCEW from the west and southwest, and thus there is more precipitation on the leeward slopes along the south and southwest sides of the watershed and less precipitation on the north and east sides. Monthly precipitation data at sites 076x59 and 163x20 (Plate 1) show how precipitation varies by month with elevation. July is the driest month at both sites and ranged from 8 mm at site 076x59 to 20 mm at site 163x20. The highest monthly precipitation was ~30 mm during June, November, December, and January at site 076x59 and was 177 mm during January at site 163x20. Generally, July, August, and September are the driest months on the RCEW, and November, December, and January are the wettest.

There was a very good relationship between average annual precipitation and elevation (Plate 2) for the six-site data set that was analyzed for this data release. Plate 2 shows that the precipitation-elevation relationships depended on season. Winter storms produced ~5 times more precipitation at the higher elevations than at the low elevations. Precipitation increase with elevation was much less during the summer months (May–October) than during the winter months (November–April). On average, summer precipitation is more uniform across RCEW than winter precipitation.

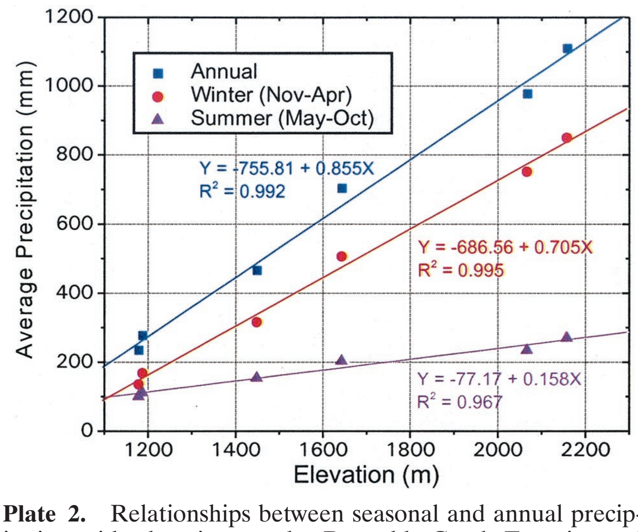

Plate 2. Relationships between seasonal and annual precipitation with elevation on the Reynolds Creek Experimental Watershed.

As shown in Table 2, 20% of the of the annual precipitation that fell at the lower elevations was snow, whereas at the high elevations 76% was snow. Monthly precipitation was considered snow when the mean monthly temperature was ≤1°C [*Cooley et al*., 1988].

5. Data Availability

Precipitation data from the 53 measurement stations, including 16 currently in operation (049x61, 057x96, 076x59, 095x10, 098x97, 116x91, 127x07, 138x22, 144x62, 147x35, 155x07, 163x20, 167x07, 174x17, 176x07, and 176x14), 1 that was discontinued on October 1, 1996 (138x33), and 36 that were discontinued prior to October 1, 1996, are available from the anonymous ftp site ftp.nwrc.ars.usda.gov maintained by the U.S. Department of Agriculture Agricultural Research Service Northwest Watershed Research Center in Boise, Idaho, United States. A more complete description of the precipitation data is given by *Hanson* [2000] and is also available in electronic form on the same ftp site. A detailed description of data formats, access information, licensing, and disclaimers is presented by *Slaughter et al*. [this issue].

6. Examples of Data Use

Studies by *Hanson* [1989] and *Hanson et al*. [1999] showed that the wind-adjusted precipitation amounts measured by the dual-gauge system were about the same amounts of rain, rain and snow mixed, and snow as the precipitation catch measured by the same type of recording gauges located in large shields such as the Wyoming shield. *Johnson and Hanson* [1995] used rotated principal component analysis to examine the spatial variability of precipitation and the relative influences of both topography and meteorology on temporal precipitation variability over the Reynolds Creek Experimental Watershed. They found that the spatial patterns identified using monthly versus daily time increments more closely matched the topography, indicating the greater influence of elevation, location, and other factors at the longer time steps.

Results obtained by *Cooley et al*. [1988] using data from the Reynolds Creek Experimental Watershed showed that the relationship between the erosivity index, EI, and precipitation amounts varies considerably. In general, snowfall accounted for only a minor portion (4%) of the EI based on the annual precipitation at low-elevation valley sites; however, at high-elevation sites snowfall accounted for most (up to 71%) of the EI based on annual precipitation. Therefore it is important to use only the rainfall portion of annual precipitation when determining EI in areas where snowfall is significant, rather than using total annual precipitation.

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