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Environmental Research Laboratories

Variability of High Plains Precipitation

C. D. WHITEMAN

BOULDER, COLO.
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VARIABILITY OF HIGH PLAINS PRECIPITATION

C. D. Whiteman

Precipitation statistics are presented for the High Plains area of the United States. These include measures of the variability of annual, monthly, cold season, and crop-growing season precipitation. Maps show the spatial distribution of coefficients of variation. The natural variability of High Plains precipitation is compared with that of other parts of the country having similar annual amounts of precipitation.

1. INTRODUCTION

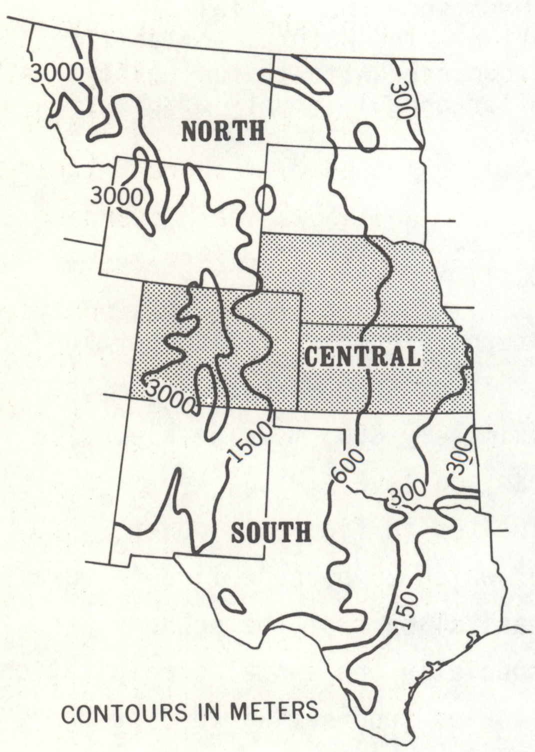
The High Plains area is the western, higher elevation portion of the Great Plains of the United States. It extends eastward from the foothills of the Rocky Mountains for approximately 800 km. The elevation varies between 3000 and 150 m above mean sea level (MSL).

The High Plains states, as delineated in figure 1, cover 2,890,000 sq km and contain 23,019,000 people, of which 28 percent live in rural areas. Because agriculture is a substanital part of the economy, the region is dependent on the climate, especially the annual precipitation.

The climate of the High Plains varies from semi-arid over the Western Plains in the "rain shadow" of the Rocky Mountains to sub-humid grassland climate farther east. The precipitation regime is characterized by relatively small mean annual precipitation with large year-to-year variability. Need for additional precipitation exists through most of the area but the degree varies with location and time of year.

A major national precipitation enhancement experiment may soon begin at a site in the High Plains. Many factors must be considered in selecting a site for the proposed program. A precipitation climatology is one that should have an important bearing on the final selection of the site, as well as aid in the design of the statistical and physical experiments.

The ultimate verification of the success of a seeding experiment is determined by a statistical analysis of the amount of precipitation that reaches the ground. To find statistically significant increases or decreases in precipitation at the ground, precipitation during the seeding experiment must be shown to differ significantly from that in an adjacent unseeded area, or, from precipitation expected on the basis of historical records. Alternatively, the seeded days in the target area must be shown to differ from the unseeded days in the same target. Several factors are important in choosing the location of a seeding experiment. The need for additional precipitation may be a strong factor for locating an experiment in a dry area. Experimental concerns, especially the ease of verifying the seeding effect, may be a strong factor for locating the experiment in a different area that has more favorable natural precipitation characteristics. In general, the most favorable area for statistically verifying the effects of seeding are those



HIGH PLAINS TOPOGRAPHY

Figure 1. High plains topography and regions.

having low variabilities in the distribution of natural precipitation in space and time.

This paper presents statistics that define the spatial and temporal distributions of High Plains precipitation. This information should be useful in the location and design of future precipitation modification experiments in the High Plains.

2. ANALYSIS OF DATA

Annual and monthly precipitation data were taken from the Local Climatological Data Summaries published by the Environmental Data Service (1971). All 60 stations in the High Plains were included. Figure 2 locates them and shows their standard three-letter identifiers.

Most of the stations used in this analysis had a 40 year (1932 and 1971) period of record; a few stations had less, the shortest being 32 years at Casper, Wyoming. Data were punched on cards and a computer program calculated average monthly and annual precipitation as well as standard deviations and coefficients of variation. The seasonal and annual amounts and variations of precipitation were also calculated.

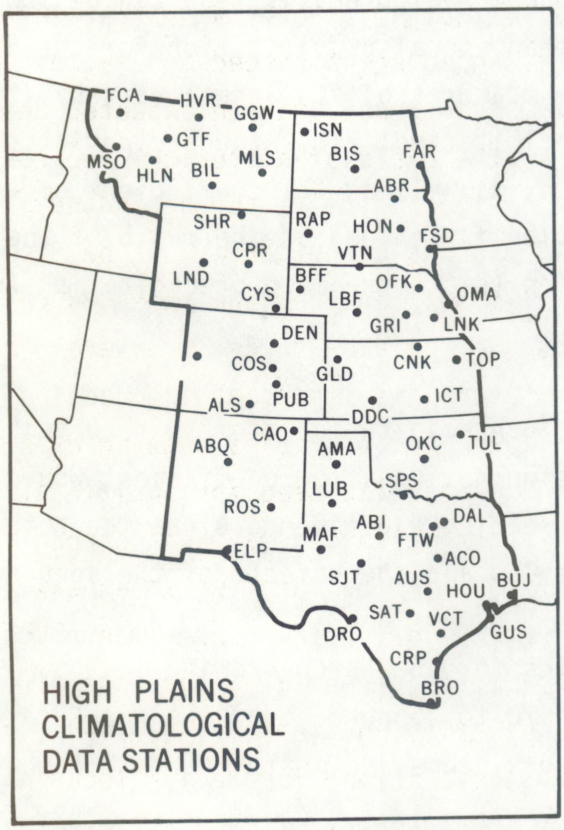


Figure 2. Locations of High Plains climatological data stations. The names of the National Weather Service offices correspond to the standard three-letter identifiers listed in table 1.

3. RESULTS

3.1 Annual Precipitation

Figure 3 shows distribution of mean annual precipitation,[1] which varies from about 23 inches in the western plains to about 56 inches in Oklahoma. Isohyets run north and south roughly paralleling the topography of the region; the highest annual precipitation is in the southeastern plains near the Gulf of Mexico. Relatively large amounts of annual precipitation are found in the Rocky Mountains just west of the High Plains and in the Black Hills of South Dakota, where orographic precipitation processes occur. The variation of mean annual precipitation can be shown in several ways. Table 1 shows the mean annual precipitation for the 60 High Plains stations as well as three measures of its annual variability. The first measure is the range of precipitation. The standard deviation of annual precipitation is also listed, as well as the coefficient of variation. The coefficient of variation is defined as the ratio of the standard deviation of the precipitation (s) to the mean precipitation ($\overline{x}$) of the period of record,

$$r = \text{coefficient of variation} = s/\overline{x} \ .$$

A station having no variation in precipitation from year to year would have a coefficient of 0. A region having a low coefficient would potentially be a good location for a seeding experiment, since the natural variability of precipitation would be low and the effects of the seeding would be easily detected.

Table 2 shows similar statistics for the "crop-growing season," April through September, during which 70 to 75 percent of the High Plains precipitation falls. Convective cloud systems are most frequent in the High Plains during this period.

Table 3 shows the same information for the "cold season," September through April, when shallow orographic cloud systems have their highest frequency of occurrence in the High Plains (Whiteman, 1973).

[1] Taken from the Climatic Atlas of the United States (1968).

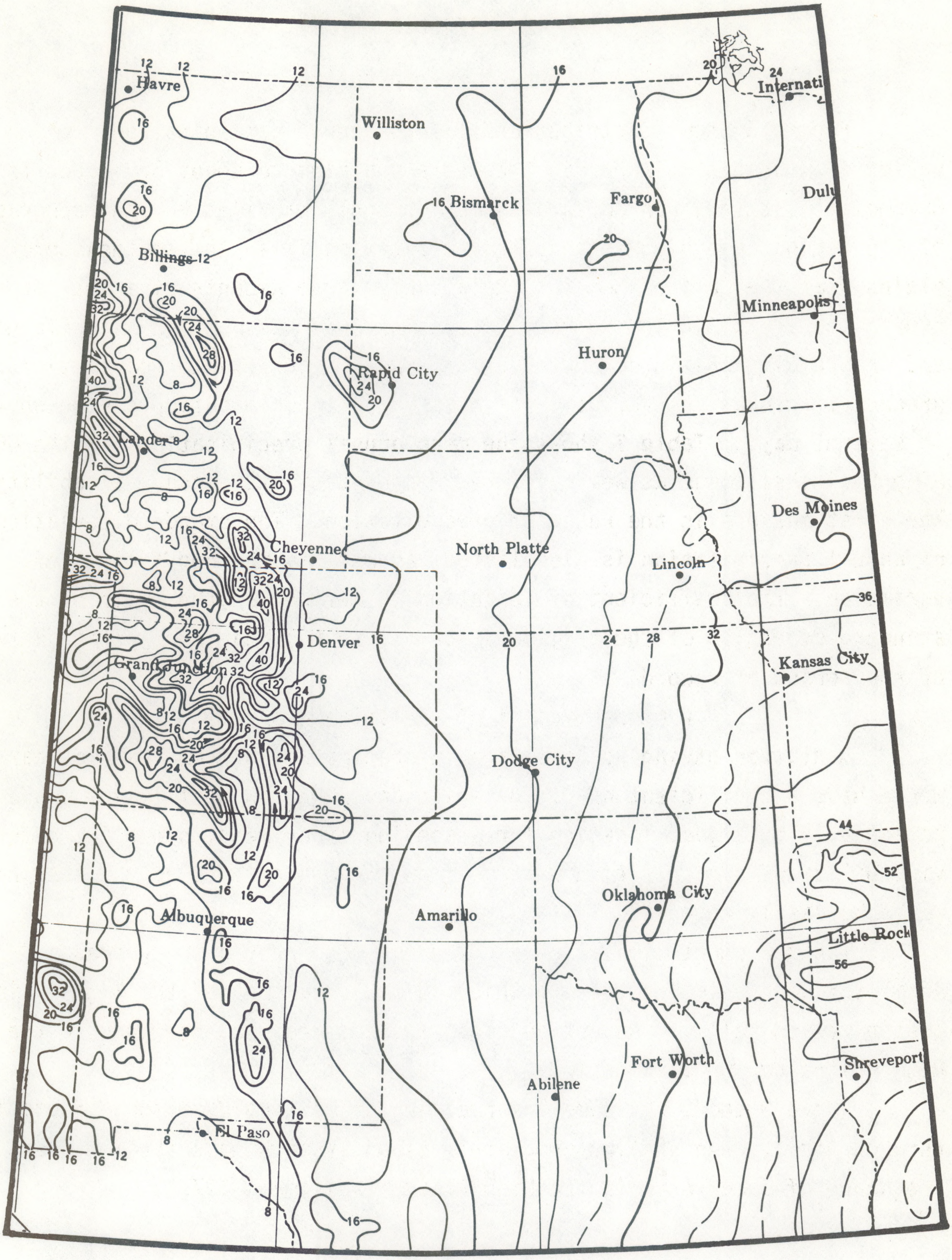


Figure 3. Distribution of normal annual precipitation amounts (inches) across the High Plains.

Table 1. High Plains Precipitation Statistics

Station	Identifier	Period of Record (Years)	Mean Annual Precip. (Inches)	Range (Inches)	Stand. Dev. of Annual Precip. (Inches)	Coefficient of Variation
Havre, Montana	HVR	40	11.61	7.34 - 18.11	2.87	.25
Kalispell, Montana	FCA	40	15.67	10.42 - 22.36	3.23	.21
Glasgow, Montana	GGW	40	12.06	6.83 - 20.85	3.44	.29
Williston, North Dakota	ISN	40	14.01	6.13 - 19.60	3.32	.24
Great Falls, Montana	GTF	40	14.35	7.45 - 21.59	3.45	.24
Missoula, Montana	MSO	40	13.12	8.62 - 16.98	2.20	.17
Helena, Montana	HLN	40	11.20	6.28 - 16.09	2.42	.22
Miles City, Montana	MLS	40	13.24	5.51 - 19.00	3.62	.27
Bismarck, North Dakota	BIS	40	15.39	5.97 - 21.53	3.36	.22
Fargo, North Dakota	FAR	40	18.70	8.87 - 30.38	4.10	.22
Billings, Montana	BIL	37	13.99	7.90 - 21.22	3.12	.22
Aberdeen, South Dakota	ABR	40	19.00	12.43 - 28.19	4.08	.21
Sheridan, Wyoming	SHR	40	15.74	8.23 - 24.58	3.69	.23
Rapid City, South Dakota	RAP	40	16.41	7.51 - 27.70	4.12	.25
Huron, South Dakota	HON	40	18.33	9.72 - 31.71	4.82	.26
Lander, Wyoming	LND	40	13.63	6.41 - 21.89	3.38	.25
Casper, Wyoming	CPR	32	11.26	7.34 - 16.24	2.45	.22
Valentine, Nebraska	VTN	40	17.24	10.73 - 24.78	3.81	.22
Sioux Falls, South Dakota	FSD	40	25.11	15.33 - 32.25	4.19	.17

Scotts Bluff, Nebraska	BFF	40	14.51	7.70 - 21.91	3.36	.23
Norfolk, Nebraska	OFK	40	23.90	15.81 - 37.05	4.41	.18
Cheyenne, Wyoming	CYS	40	14.54	5.94 - 23.69	3.45	.24
North Platte, Nebraska	LBF	40	18.96	10.46 - 33.44	5.46	.29
Omaha, Nebraska	OMA	40	28.50	14.90 - 44.85	6.57	.23
Grand Island, Nebraska	GRI	40	22.46	11.91 - 32.63	5.34	.24
Lincoln, Nebraska	LNK	40	27.58	14.09 - 41.33	6.23	.23
Denver, Colorado	DEN	40	14.88	7.51 - 23.31	4.26	.29
Grand Junction, Colorado	GJT	40	8.25	4.41 - 15.69	2.36	.29
Goodland, Kansas	GLD	40	16.50	9.19 - 28.74	4.42	.27
Colorado Springs, Colorado	COS	38	14.57	6.07 - 25.43	4.41	.30
Topeka, Kansas	TOP	40	32.64	19.07 - 50.64	8.37	.26
Pueblo, Colorado	PUB	40	11.40	5.78 - 23.09	3.73	.33
Dodge City, Kansas	DDC	40	19.76	9.97 - 34.29	6.22	.31
Witchita, Kansas	ICT	40	29.80	12.15 - 50.48	8.63	.29
Concordia, Kansas	CNK	40	26.47	12.83 - 40.76	7.16	.27
Alamosa, Colorado	ALS	39	7.08	3.40 - 11.55	2.22	.31
Clayton, New Mexico	CAO	39	14.79	5.54 - 25.70	5.90	.40
Tulsa, Oklahoma	TUL	40	37.24	23.24 - 58.21	8.28	.22
Oklahoma City, Oklahoma	OKC	40	31.46	17.84 - 46.46	6.66	.21
Albuquerque, New Mexico	ABQ	40	8.12	4.06 - 15.88	2.51	.31
Amarillo, Texas	AMA	40	19.60	9.56 - 37.21	6.12	.31
Witchita Falls, Texas	SPS	40	26.47	16.07 - 43.70	6.50	.25
Lubbock, Texas	LUB	40	18.13	9.72 - 40.55	6.37	.35

Table 1. High Plains Precipitation Statistics — Continued

Station	Identifier	Period of Record (Years)	Mean Annual Precip. (Inches)	Range (Inches)	Stand. Dev. of Annual Precip. (Inches)	Coefficient of Variation
Roswell, New Mexico	ROS	40	11.06	4.35 - 32.92	4.76	.43
Dallas, Texas	DAL	40	35.11	17.52 - 55.14	8.98	.26
Fort Worth, Texas	FTW	40	32.24	18.55 - 51.03	8.63	.27
Abilene, Texas	ABI	40	23.91	9.78 - 46.43	8.07	.34
Midland, Texas	MAF	40	13.96	4.24 - 30.33	5.49	.39
El Paso, Texas	ELP	40	7.56	2.73 - 17.19	2.90	.38
San Angelo, Texas	SJT	38	18.47	7.41 - 40.40	7.59	.41
Waco, Texas	ACO	40	31.70	14.92 - 48.91	7.85	.25
Austin, Texas	AUS	40	32.33	11.42 - 51.30	9.02	.28
Port Arthur, Texas	BUJ	40	53.86	33.07 - 84.19	13.15	.24
Houston, Texas	HOU	39	46.16	28.32 - 72.86	12.14	.26
San Antonio, Texas	SAT	40	27.86	13.70 - 48.83	8.63	.31
Del Rio, Texas	DRO	40	17.87	4.34 - 34.62	7.46	.42
Galveston, Texas	GUS	40	41.98	21.40 - 70.59	11.74	.28
Victoria, Texas	VCT	40	34.44	17.95 - 51.03	9.05	.26
Corpus Christie, Texas	CRP	40	28.15	14.66 - 44.35	8.15	.29
Brownsville, Texas	BRO	40	26.24	11.59 - 47.51	7.40	.28

Table 2. Crop-Growing Season (Apr.-Sept.) Precipitation Statistics

Station	Identifier	Period of Record (Yrs)	Mean Crop-Growing Season Precipitation (Inches)	Range (Inches)	Standard Deviation (Inches)	Coefficient of Variation
Havre, Montana	HVR	40	8.48	3.92 - 15.84	2.80	.33
Kalispell, Montana	FCA	40	8.31	4.33 - 14.62	2.36	.28
Glasgow, Montana	GGW	40	9.21	4.05 - 15.79	3.11	.34
Williston, North Dakota	ISN	40	10.56	4.11 - 15.35	3.15	.30
Great Falls, Montana	GTF	40	9.79	4.66 - 16.80	2.88	.29
Missoula, Montana	MSO	40	7.43	4.35 - 10.79	1.69	.23
Helena, Montana	HLN	40	7.70	2.98 - 12.92	2.22	.29
Miles City, Montana	MLS	40	9.73	3.53 - 16.44	3.29	.34
Bismarck, North Dakota	BIS	40	11.98	3.34 - 19.39	3.33	.28
Fargo, North Dakota	FAR	40	14.39	4.08 - 26.15	4.07	.28
Billings, Montana	BIL	37	9.32	5.48 - 15.39	2.63	.28
Aberdeen, South Dakota	ABR	40	14.41	7.63 - 22.30	3.64	.25
Sheridan, Wyoming	SHR	40	10.45	5.16 - 18.44	2.98	.29
Rapid City, South Dakota	RAP	40	12.75	4.04 - 23.08	3.79	.30
Huron, South Dakota	HON	40	13.63	6.01 - 24.39	4.01	.29
Lander, Wyoming	LND	40	8.89	3.01 - 17.45	3.13	.35
Casper, Wyoming	CPR	32	7.26	2.52 - 11.84	2.28	.31
Valentine, Nebraska	VTN	40	13.86	7.01 - 21.39	3.27	.24

Table 2. Crop-Growing Season (Apr.-Sept.) Precipitation Statistics — Continued

Station	Identifier	Period of Record (Yrs)	Mean Crop-Growing Season Precipitation (Inches)	Range (Inches)	Standard Deviation (Inches)	Coefficient of Variation
Sioux Falls, South Dakota	FSD	40	18.98	11.08 - 27.22	3.71	.20
Scotts Bluff, Nebraska	BFF	40	11.46	6.29 - 18.82	3.31	.29
Norfolk, Nebraska	OFK	40	18.24	11.65 - 29.34	4.08	.22
Cheyenne, Wyoming	CYS	40	10.74	4.76 - 16.08	2.78	.26
North Platte, Nebraska	LBF	40	15.33	6.63 - 29.64	5.34	.35
Omaha, Nebraska	OMA	40	21.34	7.80 - 35.25	5.84	.27
Grand Island, Nebraska	GRI	40	17.67	6.44 - 28.07	4.89	.28
Lincoln, Nebraska	LNK	40	20.39	10.46 - 33.83	5.64	.28
Denver, Colorado	DEN	40	10.33	4.00 - 18.09	3.63	.35
Grand Junction, Colorado	GJT	40	4.33	1.38 - 8.71	1.44	.33
Goodland, Kansas	GLD	40	12.95	5.57 - 23.64	3.95	.31
Colorado Springs, Colorado	COS	39	11.90	3.85 - 22.51	3.94	.33
Topeka, Kansas	TOP	40	23.51	11.45 - 39.42	6.64	.28
Pueblo, Colorado	PUB	40	8.48	3.80 - 15.16	2.97	.35
Dodge City, Kansas	DDC	40	14.86	6.48 - 28.45	5.30	.36
Wichita, Kansas	ICT	40	21.51	7.38 - 40.42	7.52	.35
Concordia, Kansas	CNK	40	20.11	9.58 - 34.84	6.58	.33
Alamosa, Colorado	ALS	40	5.01	2.30 - 8.23	1.77	.35
Clayton, New Mexico	CAO	39	11.82	4.91 - 30.88	4.92	.42

Tulsa, Oklahoma	TUL	40	24.40	12.00 - 38.35	6.60	.27
Okahoma City, Oklahoma	OKC	40	21.45	12.84 - 34.91	5.56	.26
Albuquerque, New Mexico	ABQ	40	5.40	2.22 - 10.24	1.84	.34
Amarillo, Texas	AMA	40	14.72	5.40 - 27.29	5.07	.34
Wichita Falls, Texas	SPS	40	17.19	9.49 - 37.00	5.55	.32
Lubbock, Texas	LUB	40	13.20	6.52 - 29.05	4.87	.37
Roswell, New Mexico	ROS	40	7.82	2.30 - 24.81	4.00	.51
Dallas, Texas	DAL	40	19.33	9.60 - 34.70	6.05	.31
Fort Worth, Texas	FTW	40	18.72	8.32 - 32.79	6.44	.34
Abilene, Texas	ABI	40	16.14	4.01 - 36.86	6.79	.42
Midland, Texas	MAF	40	9.81	1.96 - 21.33	4.34	.44
El Paso, Texas	ELP	40	4.87	1.39 - 10.90	2.20	.45
San Angelo, Texas	SJT	39	12.65	3.43 - 35.79	6.48	.51
Waco, Texas	ACO	40	17.69	5.75 - 31.82	5.85	.33
Austin, Texas	AUS	40	18.25	6.03 - 31.18	6.07	.33
Port Arthur, Texas	BUJ	40	30.56	14.04 - 57.57	10.13	.33
Houston, Texas	HOU	39	24.96	11.87 - 41.75	8.35	.33
San Antonio, Texas	SAT	40	16.92	8.92 - 34.20	6.43	.38
Del Rio, Texas	DRO	40	11.96	1.43 - 28.00	5.72	.48
Galveston, Texas	GUS	40	23.38	8.00 - 44.65	8.72	.37
Victoria, Texas	VCT	40	20.61	8.54 - 37.04	6.35	.31
Corpus Christie. Texas	CRP	40	17.61	6.74 - 30.95	6.19	.35
Brownsville, Texas	BRO	40	16.62	5.46 - 31.93	5.92	.36

Table 3. High Plains Cold Season (Sept.-Apr.) Precipitation Statistics

Station	Identifier	Period of Record (Years)	Mean Cold Season Precip. (Inches)	Cold Season Range (Inches)	Stand. Dev. of Cold Season Precip. (inches)	Coefficient of Variation
Havre, Montana	HVR	40	5.14	2.54 - 8.50	1.48	.29
Kalispell, Montana	FCA	40	9.43	4.47 - 15.59	2.31	.24
Glasgow, Montana	GGW	40	4.74	1.57 - 9.89	1.82	.38
Williston, North Dakota	ISN	40	5.81	2.74 - 9.62	1.74	.30
Great Falls, Montana	GTF	40	6.82	3.96 - 11.72	1.84	.27
Missoula, Montana	MSO	40	7.72	4.03 - 11.11	1.61	.21
Helena, Montana	HLN	40	5.35	3.18 - 8.92	1.35	.25
Miles City, Montana	MLS	40	5.77	2.07 - 13.34	2.25	.39
Bismarck, North Dakota	BIS	40	6.04	4.44 - 9.52	1.68	.28
Fargo, North Dakota	FAR	40	8.00	4.29 - 12.95	2.19	.27
Billings, Montana	BIL	37	7.48	3.56 - 12.44	2.30	.31
Aberdeen, South Dakota	ABR	40	8.30	4.38 - 12.99	2.25	.27
Sheridan, Wyoming	SHR	40	8.63	3.94 - 15.95	2.36	.27
Rapid City, South Dakota	RAP	40	6.89	2.24 - 11.60	2.34	.34
Huron, South Dakota	HON	40	8.32	3.94 - 15.69	2.81	.34
Lander, Wyoming	LND	40	8.23	3.80 - 14.71	2.43	.30
Casper, Wyoming	CPR	32	6.40	3.82 - 10.57	1.40	.22
Valentine, Nebraska	VTN	40	6.63	3.44 - 11.88	2.01	.30
Sioux Falls, South Dakota	FSD	40	11.30	5.56 - 16.96	2.73	.24

Scotts Bluff, Nebraska	BFF	40	5.95	3.47 - 11.99	1.73	.29
Norfolk, Nebraska	OFK	40	10.09	4.98 - 16.68	2.87	.28
Cheyenne, Wyoming	CYS	40	6.72	2.81 - 14.81	2.19	.33
North Platte, Nebraska	LBF	40	7.59	3.11 - 17.76	2.91	.38
Omaha, Nebraska	OMA	40	12.80	5.88 - 27.06	4.09	.32
Grand Island, Nebraska	GRI	40	9.31	4.19 - 15.74	3.06	.33
Lincoln, Nebraska	LNK	40	12.65	6.62 - 18.79	3.45	.27
Denver, Colorado	DEN	40	7.79	2.94 - 12.28	2.29	.29
Grand Junction, Colorado	GJT	40	5.55	3.20 - 11.09	1.89	.34
Goodland, Kansas	GLD	40	6.42	3.21 - 13.30	2.49	.39
Colorado Springs, Colorado	COS	38	5.34	3.12 - 12.89	2.23	.42
Topeka, Kansas	TOP	40	15.57	7.02 - 27.74	5.36	.34
Pueblo, Colorado	PUB	40	5.05	1.95 - 12.35	2.25	.45
Dodge City, Kansas	DDC	40	8.21	2.03 - 13.67	2.97	.36
Witchita, Kansas	ICT	40	14.52	5.85 - 29.63	5.44	.37
Concordia, Kansas	CNK	40	11.38	4.39 - 17.74	3.20	.28
Alamosa, Colorado	ALS	39	3.46	.70 - 7.38	1.54	.45
Clayton, New Mexico	CAO	40	5.70	.81 - 19.31	3.71	.65
Tulsa, Oklahoma	TUL	40	21.35	8.67 - 41.35	7.00	.33
Oklahoma City, Oklahoma	OKC	40	16.74	8.31 - 26.91	4.41	.26
Albuquerque, New Mexico	ABQ	40	4.11	1.34 - 8.69	1.72	.42
Amarillo, Texas	AMA	40	8.03	2.31 - 18.13	3.31	.41
Witchita Falls, Texas	SPS	40	14.94	8.22 - 26.86	4.66	.31
Lubbock, Texas	LUB	40	8.46	3.58 - 18.99	4.32	.51
Roswell, New Mexico	ROS	40	5.48	2.24 - 19.86	3.24	.59

Table 3. High Plains Cold Season (Sept.-Apr.) Precipitation Statistics — Continued

Station	Identifier	Period of Record (Years)	Mean Cold Season Precip. (Inches)	Cold Season Range (Inches)	Stand. Dev. of Cold Season Precip. (Inches)	Coefficient of Variation
Dallas, Texas	DAL	40	23.31	11.35 - 37.51	6.30	.27
Fort Worth, Texas	FTW	40	20.73	10.48 - 36.97	6.06	.29
Abilene, Texas	ABI	40	12.62	5.73 - 22.77	4.31	.34
Midland, Texas	MAF	40	6.84	2.02 - 18.83	3.32	.49
El Paso, Texas	ELP	40	4.11	1.44 - 12.63	2.31	.56
San Angelo, Texas	SJT	38	11.02	3.48 - 32.85	5.75	.52
Waco, Texas	ACO	40	20.95	9.72 - 39.17	6.14	.29
Austin, Texas	AUS	40	20.94	5.89 - 37.57	6.99	.33
Port Arthur, Texas	BUJ	40	32.83	15.93 - 57.56	9.27	.28
Houston, Texas	HOU	39	29.02	16.07 - 54.20	8.94	.31
San Antonio, Texas	SAT	40	17.12	6.50 - 36.18	7.09	.41
Del Rio, Texas	DRO	40	10.54	3.90 - 24.92	5.27	.50
Galveston, Texas	GUS	40	26.82	16.10 - 49.64	8.37	.31
Victoria, Texas	VCT	40	21.20	11.08 - 37.99	7.22	.34
Corpus Christie, Texas	CRP	40	17.60	7.98 - 38.60	6.47	.37
Brownsville, Texas	BRO	40	16.63	5.85 - 42.07	6.79	.41

Figures 4 through 6 show the spatial distribution of the coefficients of variation across the High Plains for annual, crop-growing season, and cold season, respectively.

The annual coefficient of variation is lowest in the northern half of the High Plains and along the eastern edge of the region. High coefficients are in western Texas and New Mexico.

The coefficients of variation for the crop-growing season follow the same patterns as those for annual coefficients, although crop-growing season coefficients average 0.055 higher than the corresponding annual coefficients. High Plains areas with large differences between annual

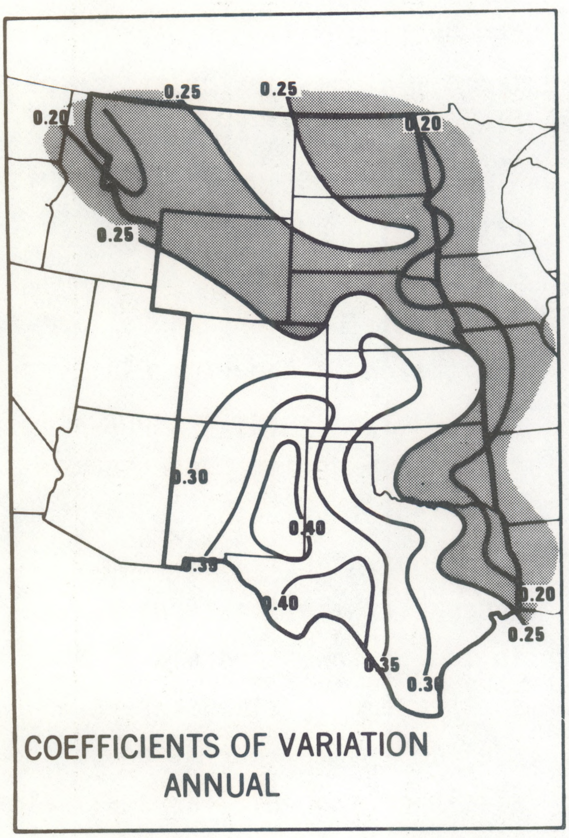


Figure 4. Distribution of coefficients of variation for annual precipitation amounts in the High Plains.

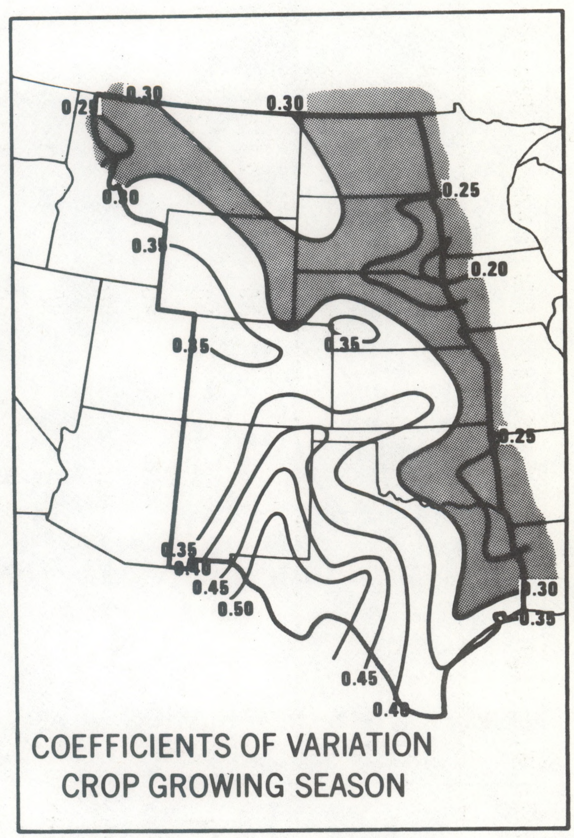


Figure 5. Distribution of coefficients of variation for crop growing season (April through September) precipitation amounts.

and crop-growing season coefficients include central and southern Texas, southern New Mexico, Montana, Wyoming, and North Dakota.

The cold season coefficients also follow the same pattern as the annual coefficients, although they average 0.074 higher than corresponding annual coefficients. A 10 percent increase in annual precipitation would thus be easier to detect statistically than a 10 percent increase during the cold season.

High Plains areas with large differences between annual and cold season coefficients coincide with those areas having the highest values of cold season coefficients; e.g., New Mexico, west Texas, southeastern Colorado, and east Montana. Another measure of the variability of precipitation is the ratio of the extreme maximum to the extreme minimum for the entire period of record (table 1).

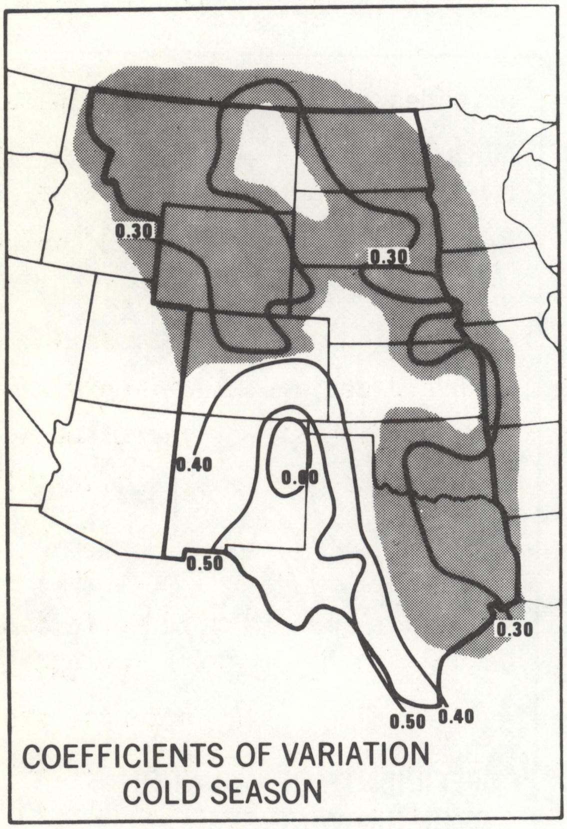


Figure 6. Distribution of coefficients of variation for cold season (September through April) precipitation amounts.

The average value of this ratio for annual precipitation at all 60 High Plains stations is 3.48. Thus, the annual precipitation in the High Plains varied by a factor of approximately 3.5 during these years. The highest value, 7.98, of this ratio was at Del Rio, Texas. In general, the highest values are in the Southwestern Plains and in the same locations where the coefficients of variations are also highest. Similar statistics are computed for seasonal precipitation in tables 2 and 3.

3.2 Monthly Precipitation

Figure 7 shows the mean monthly distribution of precipitation for the United States. The precipitation regime in the High Plains is characterized by large amounts of late spring and summer precipitation with relatively small amounts of natural precipitation during the winter. This contrasts directly to the distribution along the west coast and in the Northwestern United States where the summer is relatively dry.

Most of the precipitation in the High Plains falls as rain, although, as much as 36 inches (91 cm) of snow falls in a average year in much of the northern half of the High Plains (see fig. 8). Central Texas receives only 2 to 4 inches (5 to 10 cm) of snow in a normal year, while the Rocky Mountains and the Black Hills receive up to 170 inches, or 425 cm, more than adjoining High Plains areas.

The Northern Plains receive more episodes of measurable precipitation than the Southern Plains (fig. 9). The mean number of days with 0.01 inches or more of precipitation varies from 60 in the southern part of the High Plains to 100 in the north. Once again, the mountains adjoining the western plains receive more precipitation episodes than the plains.

Table 4 gives the monthly mean precipitation for 60 stations in the High Plains. Also included are the standard deviations of monthly precipitation amounts and the corresponding coefficients of variation. Figures 10 through 21 show the spatial distribution of these coefficients.

The monthly precipitation can vary considerably from year to year, as seen by the standard deviations. In many cases, stations have coefficients of variation close to 1, indicating that the standard deviation and the monthly mean precipitation are of the same magnitude. The coefficients of variation for the 60 High Plains stations show that most stations in the northern High Plains have their highest coefficients in the fall and early winter. Stations in the south have high coefficients in late fall and early winter and a secondary maximum in July.

Another important aspect of the distribution of monthly precipitation has been investigated by Staver (1972). His investigation ascertained how each month of 30 years precipitation compared with that month's

NORMAL MONTHLY TOTAL PRECIPITATION (Inches)

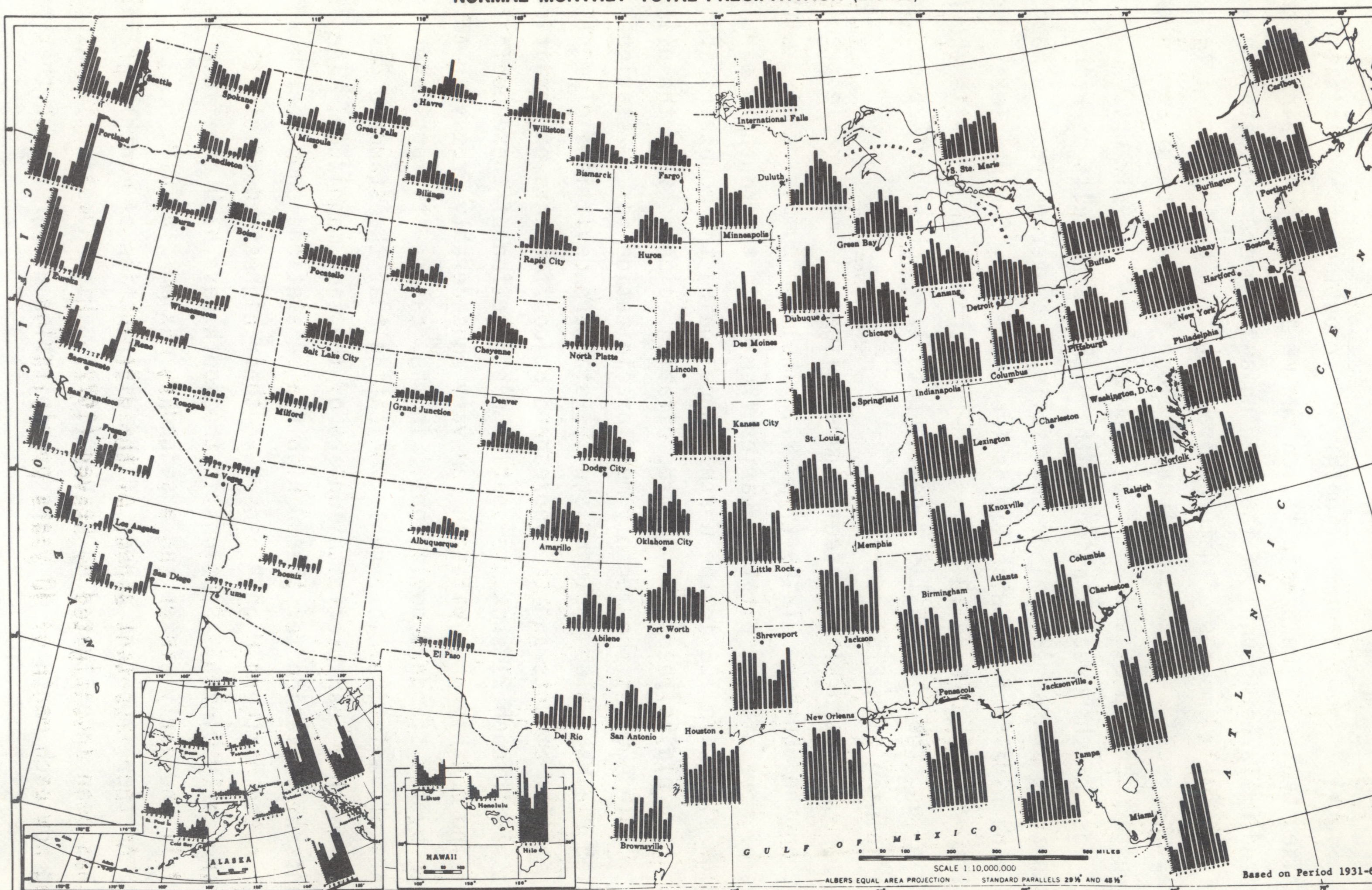


Figure 7. Normal monthly total precipitation (inches) for the United States.

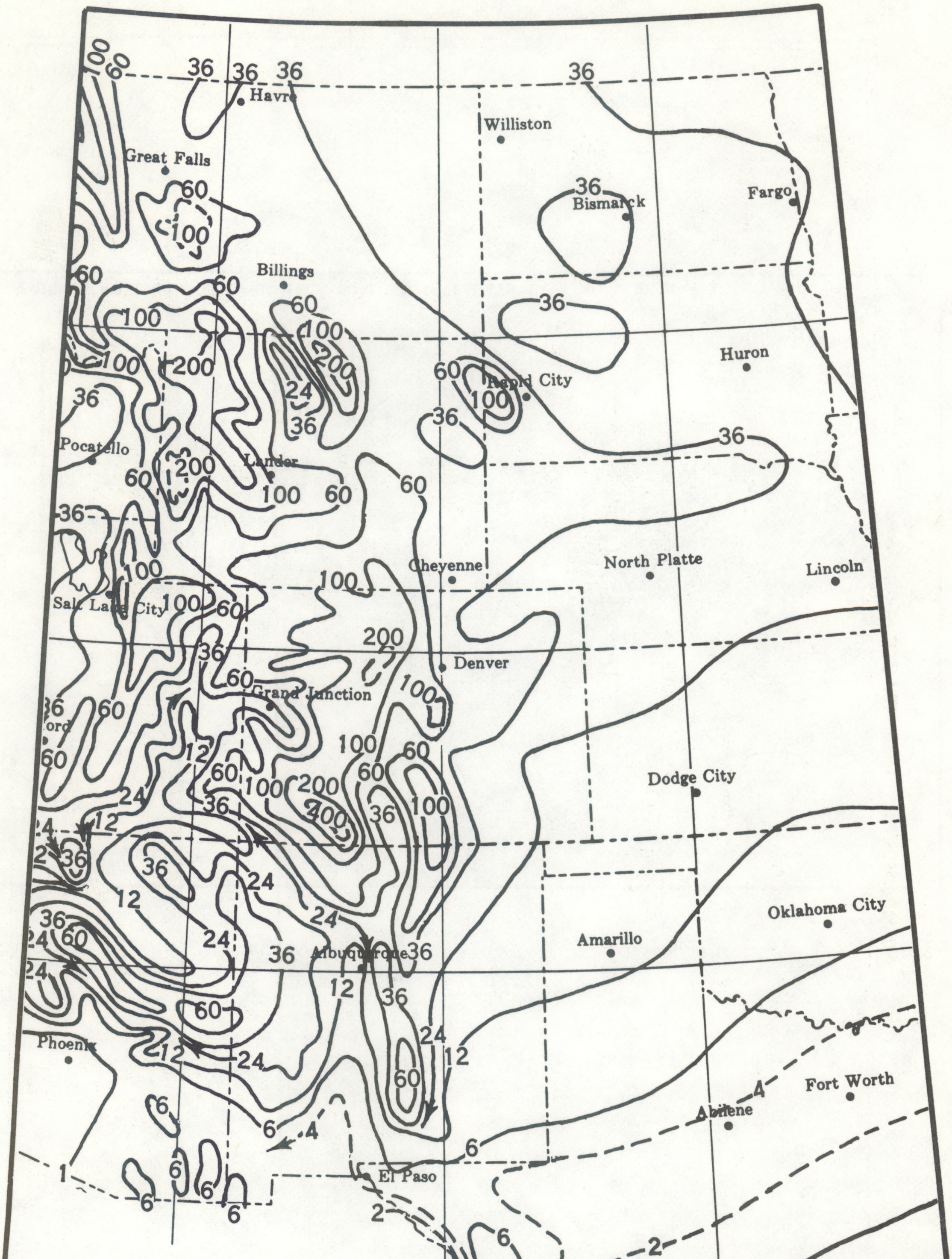


Figure 8. Mean annual total snowfall (inches) for the High Plains area of the United States.

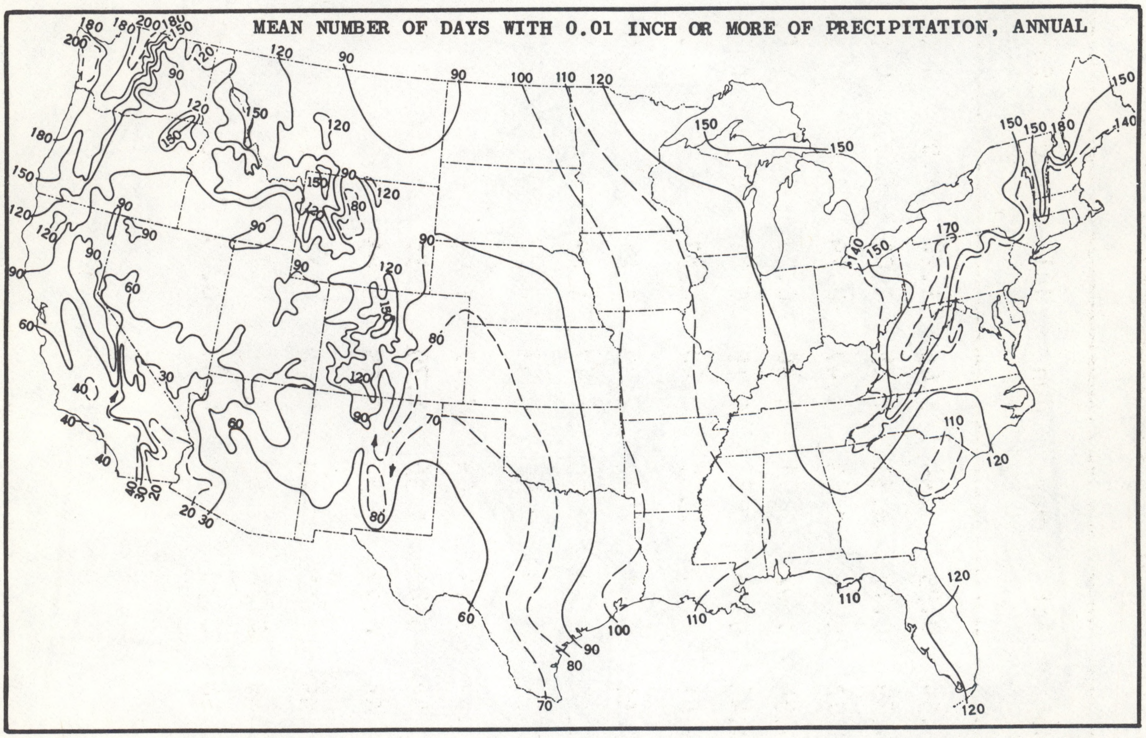


Figure 9. Mean number of days per year having 0.01 inches or more of precipitation.

Table 4. High Plains Monthly Precipitation Statistics

Station	Identifier	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		0.55[1]	0.41	0.54	0.99	1.44	2.65	1.28	1.09	1.03	0.72	0.44	0.47
Havre, Montana	HVR	0.45[2]	0.24	0.39	0.77	0.91	1.25	1.01	0.97	0.93	0.60	0.44	0.38
		0.82[3]	0.58	0.72	0.78	0.63	0.47	0.79	0.89	0.90	0.83	1.01	0.81
		1.48	0.98	0.94	1.02	1.71	2.40	0.97	1.16	1.05	1.20	1.33	1.43
Kalispell, Montana	FCA	0.70	0.45	0.48	0.48	0.88	1.15	0.81	0.98	0.83	0.79	0.78	0.83
		0.48	0.46	0.51	0.47	0.52	0.48	0.83	0.85	0.79	0.66	0.59	0.58
		0.50	0.37	0.51	0.98	1.52	2.89	1.41	1.51	0.91	0.65	0.42	0.41
Glasgow, Montana	GGW	0.36	0.27	0.36	0.92	0.99	1.47	1.09	1.44	0.95	0.51	0.35	0.34
		0.73	0.71	0.71	0.94	0.65	0.51	0.77	0.95	1.05	0.78	0.84	0.83
		0.58	0.50	0.64	1.14	1.64	3.17	2.05	1.42	1.14	0.77	0.53	0.52
Williston, North Dakota	ISN	0.36	0.36	0.44	0.82	1.36	1.79	1.30	1.06	0.99	0.74	0.42	0.36
		0.61	0.73	0.68	0.72	0.83	0.56	0.63	0.74	0.87	0.96	0.80	0.69
		0.78	0.71	0.96	1.11	2.20	2.94	1.18	1.20	1.15	0.71	0.72	0.69
Great Falls, Montana	GTF	0.55	0.49	0.56	0.78	1.50	1.41	0.93	1.20	0.88	0.52	0.56	0.48
		0.70	0.69	0.58	0.70	0.68	0.48	0.79	1.00	0.76	0.74	0.77	0.69

1 Average Precipitation
2 Standard Deviation
3 Coefficient of Variation

Table 4. High Plains Monthly Precipitation Statistics — Continued

Station	Identifier	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		1.11	0.83	0.77	1.03	1.74	2.03	0.82	0.82	1.00	0.96	0.87	1.15
Missoula, Montana	MSO	0.71	0.45	0.37	0.65	0.95	0.98	0.66	0.64	0.66	0.61	0.51	0.68
		0.64	0.54	0.48	0.63	0.55	0.49	0.81	0.79	0.66	0.63	0.58	0.59
		0.56	0.43	0.71	0.90	1.65	2.26	0.96	0.97	0.96	0.67	0.54	0.59
Helena Montana	HLN	0.48	0.32	0.37	0.45	0.89	1.04	0.63	0.66	0.85	0.49	0.39	0.38
		0.85	0.75	0.52	0.50	0.54	0.46	0.65	0.68	0.89	0.73	0.72	0.65
		0.52	0.44	0.68	1.22	1.86	2.97	1.44	1.20	1.04	0.91	0.46	0.49
Miles City, Montana	MLS	0.34	0.31	0.42	0.82	1.12	1.84	1.10	0.97	1.07	1.17	0.33	0.40
		0.65	0.69	0.62	0.67	0.61	0.62	0.76	0.81	1.03	1.28	0.71	0.82
		0.48	0.43	0.71	1.41	2.04	3.48	2.17	1.66	1.21	0.85	0.54	0.41
Bismarck, North Dakota	BIS	0.31	0.27	0.55	0.97	1.23	1.75	1.33	1.32	0.90	0.81	0.54	0.26
		0.65	0.64	0.77	0.69	0.60	0.50	0.61	0.80	0.75	0.95	1.01	0.64
		0.55	0.46	0.80	1.98	2.16	2.99	2.82	2.73	1.72	1.15	0.71	0.63
Fargo, North Dakota	FAR	0.41	0.38	0.52	1.24	1.21	1.37	2.14	1.84	1.37	0.87	0.53	0.44
		0.75	0.82	0.65	0.63	0.56	0.46	0.76	0.67	0.80	0.76	0.74	0.70
		0.66	0.62	1.01	1.49	2.04	2.69	0.88	0.90	1.32	1.05	0.70	0.63
Billings, Montana	BIL	0.53	0.40	0.55	1.06	1.15	1.75	0.67	0.72	1.00	0.87	0.47	0.46
		0.81	0.64	0.55	0.71	0.56	0.65	0.76	0.80	0.76	0.83	0.68	0.72

		0.59	0.62	1.03	2.13	2.42	3.61	2.65	2.01	1.59	1.14	0.67	0.53
Aberdeen,	ABR	0.50	0.49	0.83	1.45	1.39	1.97	1.27	1.34	1.11	0.92	0.55	0.41
South Dakota		0.84	0.79	0.81	0.68	0.57	0.55	0.48	0.67	0.70	0.81	0.82	0.76
		0.70	0.75	1.26	2.15	2.49	2.69	1.03	0.89	1.19	1.11	0.83	0.65
Sheridan,	SHR	0.43	0.48	0.73	1.17	1.48	1.84	0.96	0.73	0.80	0.78	0.49	0.36
Wyoming		0.61	0.64	0.58	0.55	0.60	0.68	0.93	0.82	0.67	0.71	0.59	0.55
		0.45	0.53	1.00	2.12	2.86	3.30	1.96	1.41	1.11	0.86	0.45	0.37
Rapid City	RAP	0.39	0.42	0.63	1.40	2.05	1.60	1.31	1.13	0.95	0.66	0.42	0.24
South Dakota		0.87	0.79	0.63	0.66	0.72	0.48	0.67	0.80	0.86	0.76	0.94	0.64
		0.44	0.69	1.08	2.00	2.52	3.43	2.04	2.01	1.62	1.32	0.65	0.51
Huron,	HON	0.39	0.66	0.76	1.52	1.73	1.78	1.30	1.34	0.99	1.37	0.63	0.42
South Dakota		0.87	0.95	0.71	0.76	0.69	0.52	0.63	0.67	0.61	1.04	0.97	0.81
		0.46	0.66	1.12	2.49	2.59	1.66	0.70	0.45	1.01	1.24	0.83	0.44
Lander,	LND	0.39	0.51	0.58	1.34	1.56	1.53	0.61	0.48	0.92	1.03	0.61	0.32
Wyoming		0.85	0.77	0.52	0.54	0.60	0.92	0.88	1.08	0.91	0.84	0.74	0.74
		0.49	0.51	0.90	1.52	2.02	1.36	0.91	0.57	0.88	0.92	0.68	0.48
Casper,	CPR	0.31	0.23	0.55	1.05	1.25	0.92	0.57	0.53	0.74	0.66	0.42	0.62
Wyoming		0.64	0.45	0.61	0.69	0.62	0.68	0.62	0.94	0.84	0.72	0.62	0.49
		0.35	0.51	0.87	1.93	2.79	3.27	2.29	2.26	1.32	0.90	0.42	0.32
Valentine,	VTN	0.36	0.47	0.59	1.13	1.74	1.51	1.29	1.42	0.93	0.82	0.52	0.28
Nebraska		1.03	0.92	0.67	0.59	0.62	0.46	0.56	0.63	0.70	0.92	1.26	0.85

Table 4. High Plains Monthly Precipitation Statistics — Continued

Station	Identifier	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		0.61	1.00	1.46	2.38	3.39	4.26	2.93	3.23	2.78	1.42	0.89	0.76
Sioux Falls	FSD	0.51	0.84	0.81	1.52	2.14	1.62	1.64	2.08	1.49	1.19	0.72	0.66
South Dakota		0.83	0.84	0.56	0.64	0.63	0.38	0.56	0.64	0.53	0.84	0.81	0.87
		0.32	0.37	0.82	1.71	2.84	3.11	1.60	1.01	1.18	0.75	0.40	0.39
Scotts Bluff,	BFF	0.26	0.26	.053	1.17	1.62	1.72	1.05	0.62	0.98	0.64	0.34	0.26
Nebraska		0.81	0.70	0.64	0.68	0.57	0.55	0.66	0.62	0.83	0.86	0.85	0.66
		0.68	0.87	1.44	2.07	3.52	4.63	3.09	2.57	2.36	1.26	0.69	0.71
Norfolk,	OFK	0.58	0.62	0.95	1.37	1.88	2.53	2.02	1.34	1.69	1.05	0.63	0.49
Nebraska		0.85	0.71	0.66	0.66	0.53	0.55	0.65	0.52	0.71	0.83	0.91	0.70
		0.47	0.49	1.09	1.72	2.49	2.17	1.77	1.39	1.19	0.84	0.52	0.40
Cheyenne,	CYS	0.48	0.38	0.66	1.09	1.30	1.14	0.93	0.79	0.90	0.79	0.43	0.36
Wyoming		1.02	0.78	0.61	0.63	0.52	0.53	0.53	0.57	0.76	0.95	0.83	0.90
		0.42	0.49	0.93	2.04	3.04	3.57	2.74	2.02	1.92	0.92	0.46	0.42
North Platte,	LBF	0.46	0.43	0.80	1.42	1.86	1.87	1.74	1.48	1.74	1.04	0.41	0.28
Nebraska		1.09	0.87	0.86	0.70	0.61	0.52	0.64	0.74	0.91	1.14	0.89	0.66
		0.82	0.99	1.49	2.61	3.80	4.59	3.51	3.81	3.03	1.91	1.15	0.80
Omaha,	OMA	0.89	0.73	0.93	1.75	2.21	2.11	2.13	2.52	2.37	1.42	1.04	0.66
Nebraska		0.85	0.74	0.62	0.67	0.58	0.46	0.61	0.66	0.78	0.74	0.90	0.82

		0.57	0.84	1.13	2.24	3.80	4.14	2.77	2.44	2.28	1.04	0.63	0.58
Grand Island,	GRI	0.53	0.65	0.79	1.41	2.09	2.30	2.11	1.34	1.85	0.99	0.68	0.51
Nebraska		0.93	0.78	0.70	0.63	0.55	0.56	0.76	0.55	0.81	0.95	1.07	0.89
		0.83	1.09	1.62	2.37	3.45	4.75	3.44	3.29	3.09	1.71	1.09	0.85
Lincoln,	LNK	0.66	0.79	1.05	1.64	1.74	2.87	1.96	1.76	1.83	1.24	1.01	0.70
Nebraska		0.80	0.72	0.65	0.69	0.51	0.60	0.57	0.54	0.59	0.73	0.93	0.82
		0.55	0.68	1.18	1.94	2.54	1.69	1.63	1.23	1.30	0.99	0.68	0.46
Denver,	DEN	0.40	0.47	0.69	1.15	1.57	1.30	1.21	0.90	1.20	1.05	0.51	0.33
Colorado		0.72	0.69	0.59	0.59	0.62	0.77	0.75	0.73	0.92	1.06	0.75	0.72
		0.61	0.62	0.72	0.74	0.64	0.48	0.54	1.04	0.90	0.80	0.55	0.61
Grand Junction	GJT	0.46	0.39	0.49	0.47	0.46	0.48	0.45	0.71	0.85	0.65	0.38	0.43
Colorado		0.75	0.63	0.68	0.63	0.73	1.01	0.84	0.68	0.95	0.82	0.69	0.70
		0.36	0.45	0.97	1.41	2.56	2.75	2.62	2.15	1.47	0.86	0.48	0.43
Goodland,	GLD	0.31	0.48	0.71	1.24	1.26	1.78	1.52	1.28	1.37	0.95	0.56	0.40
Kansas		0.87	1.07	0.73	0.88	0.49	0.65	0.58	0.60	0.94	1.11	1.18	0.93
		0.25	0.35	0.68	1.36	2.15	1.98	2.74	2.42	1.24	0.71	0.40	0.30
Colo. Springs	COS	0.22	0.35	0.50	1.34	1.66	1.63	1.41	1.32	0.97	0.75	0.45	0.37
Colorado		0.86	0.99	0.74	0.98	0.77	0.82	0.51	0.55	0.78	1.06	1.14	1.24
		0.98	1.01	1.93	3.35	4.31	5.12	3.67	3.97	3.10	2.42	1.38	1.40
Topeka,	TOP	1.00	0.72	1.41	2.04	2.10	3.08	2.83	2.37	2.15	1.98	1.26	1.02
Kansas		1.02	0.71	0.73	0.61	0.49	0.60	0.77	0.60	0.70	0.82	0.91	0.73

Table 4. High Plains Monthly Precipitation Statistics — Continued

Station	Identifier	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		0.34	0.39	0.64	1.28	1.63	1.23	1.72	1.77	0.85	0.80	0.40	0.34
Pueblo Colorado	PUB	0.33	0.31	0.43	1.18	1.19	1.06	1.02	1.30	0.64	0.97	0.49	0.29
		0.97	0.79	0.66	0.92	0.73	0.87	0.59	0.73	0.75	1.21	1.22	0.86
		0.52	0.68	1.04	1.66	3.12	3.15	2.74	2.53	1.65	1.48	0.68	0.50
Dodge City Kansas	DDC	0.45	0.55	0.93	1.42	1.94	1.86	1.92	1.51	1.08	1.36	0.84	0.44
		0.86	0.82	0.89	0.86	0.62	0.59	0.70	0.60	0.65	0.92	1.23	0.88
		0.87	1.03	1.63	2.78	3.88	4.46	3.82	3.11	3.46	2.38	1.30	1.09
Witchita Kansas	ICT	1.02	0.66	1.18	2.36	2.34	2.75	2.85	2.15	2.57	1.75	1.33	0.89
		1.17	0.64	0.73	0.85	0.60	0.62	0.74	0.69	0.74	0.74	1.03	0.82
		0.65	0.92	1.44	2.07	4.08	4.63	3.20	3.18	2.96	1.68	0.94	0.72
Concordia, Kansas	CNK	0.55	0.68	0.96	1.34	2.42	2.87	2.33	2.13	2.14	1.43	1.05	0.55
		0.85	0.73	0.66	0.65	0.59	0.62	0.73	0.67	0.72	0.85	1.11	0.77
		0.26	0.24	0.31	0.60	0.69	0.57	1.21	1.13	0.81	0.64	0.25	0.33
Alamosa, Colorado	ALS	0.21	0.25	0.27	0.60	0.57	0.58	0.67	0.75	0.66	0.57	0.28	0.36
		0.82	1.06	0.88	1.00	0.82	1.01	0.55	0.66	0.81	0.89	1.14	1.10
		0.29	0.35	0.57	1.07	2.45	1.75	2.43	2.29	1.71	1.00	0.37	0.33
Clayton, New Mexico	CAO	0.35	0.27	0.64	1.40	1.99	1.18	1.64	1.35	1.74	1.12	0.50	0.34
		1.19	0.78	1.12	1.31	0.81	0.67	0.67	0.59	1.01	1.12	1.37	1.02

Tulsa, Oklahoma	TUL	1.61	1.74	2.38	3.90	4.98	4.63	3.24	3.03	4.61	3.21	2.10	1.81
		1.42	1.09	1.65	2.44	3.18	2.62	3.01	1.98	3.96	3.17	1.98	1.41
		0.88	0.63	0.69	0.63	0.64	0.56	0.93	0.65	0.86	0.99	0.95	0.78
Okla. City Oklahoma	OKC	1.26	1.40	1.95	3.22	4.96	4.37	2.59	2.81	3.51	2.53	1.51	1.36
		1.25	0.90	1.54	2.39	2.55	3.01	2.33	1.64	2.47	2.13	1.42	1.02
		0.99	0.64	0.79	0.74	0.52	0.69	0.90	0.58	0.71	0.84	0.94	0.75
Albuquerque, New Mexico	ABQ	0.32	0.35	0.42	0.46	0.60	0.65	1.35	1.41	0.93	0.75	0.37	0.51
		0.29	0.29	0.38	0.44	0.71	0.77	0.77	0.94	0.59	0.77	0.40	0.45
		0.88	0.81	0.91	0.97	1.18	1.18	0.57	0.67	0.63	1.03	1.10	0.88
Amarillo, Texas	AMA	0.58	0.59	0.77	1.16	2.97	3.36	2.46	2.78	1.98	1.63	0.64	0.67
		0.66	0.58	0.85	0.86	2.30	2.72	2.11	1.63	1.44	1.83	0.82	0.90
		1.12	0.98	1.10	0.74	0.77	0.81	0.86	0.59	0.73	1.13	1.28	1.35
Wichita Falls, Texas	SPS	1.07	1.23	1.60	2.73	4.33	3.14	1.99	2.08	2.93	2.61	1.41	1.36
		1.07	1.07	1.04	1.98	2.61	2.17	2.04	1.78	2.36	2.46	1.37	1.25
		1.00	0.87	0.65	0.72	0.60	0.69	1.03	0.86	0.81	0.94	0.98	0.92
Lubbock, Texas	LUB	0.57	0.55	0.82	1.05	3.07	2.68	2.02	1.89	2.47	1.85	0.56	0.59
		0.76	0.60	0.93	0.93	2.39	1.97	1.36	1.63	2.65	1.87	0.70	0.67
		1.33	1.11	1.14	0.88	0.78	0.73	0.67	0.86	1.07	1.01	1.24	1.13
Roswell, New Mexico	ROS	0.47	0.43	0.50	0.52	1.04	1.12	1.76	1.66	1.72	0.99	0.36	0.49
		0.49	0.40	0.65	0.76	1.24	0.99	1.38	1.16	1.80	1.17	0.46	0.62
		1.05	0.93	1.32	1.48	1.19	0.88	0.79	0.70	1.04	1.18	1.27	1.25

Table 4. High Plains Monthly Precipitation Statistics — Continued

Station	Identifier	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		2.14	2.54	2.83	4.26	4.61	3.15	1.93	2.11	3.28	3.04	2.68	2.53
Dallas,	DAL	1.87	1.70	1.99	3.40	3.05	2.62	2.15	2.08	2.56	2.69	2.40	2.04
Texas		0.87	0.67	0.70	0.80	0.66	0.83	1.11	0.99	0.78	0.88	0.89	0.80
		1.98	2.36	2.34	3.91	4.71	2.81	1.91	2.07	3.30	2.59	2.16	2.10
Fort Worth,	FTW	1.71	1.68	1.60	3.27	3.11	2.33	1.54	1.80	2.51	2.17	1.85	1.59
Texas		0.86	0.72	0.69	0.84	0.66	0.83	0.81	0.87	0.76	0.84	0.85	0.76
		0.95	1.05	1.05	2.31	4.13	2.86	2.28	2.02	2.54	2.31	1.26	1.14
Abilene,	ABI	1.00	0.85	0.92	1.54	2.67	2.23	2.14	2.08	2.43	1.97	1.12	1.02
Texas		1.04	0.81	0.88	0.66	0.65	0.78	0.94	1.03	0.96	0.85	0.89	0.89
		0.67	0.60	0.47	0.78	2.18	1.66	1.74	1.53	1.92	1.34	0.49	0.56
Midland,	MAF	1.07	0.72	0.64	0.78	1.66	1.35	1.75	1.27	1.69	1.19	0.59	0.65
Texas		1.60	1.20	1.31	1.01	0.76	0.81	1.01	0.83	0.88	0.89	1.20	1.17
		0.39	0.38	0.34	0.21	0.34	0.68	1.38	1.09	1.22	0.75	0.36	0.47
El Paso,	ELP	0.40	0.37	0.50	0.35	0.47	0.76	1.16	0.82	1.42	0.82	0.47	0.41
Texas		1.02	0.97	1.48	1.69	1.37	1.19	0.84	0.75	1.17	1.09	1.32	0.86
		0.84	0.82	0.77	1.89	2.68	1.84	1.41	1.65	3.23	1.91	1.04	0.81
San Angelo,	SJT	0.91	0.79	0.97	1.41	1.63	1.71	1.59	1.72	4.54	1.71	1.09	0.79
Texas		1.09	0.97	1.26	0.75	0.61	0.93	1.13	1.04	1.40	0.89	1.05	0.98

		2.09	2.40	2.34	3.69	4.52	2.79	1.81	1.63	3.25	2.42	2.45	2.32
Waco, Texas	ACO	1.58	1.40	1.65	2.78	3.10	2.66	2.05	1.48	2.69	1.74	1.97	1.67
		0.76	0.58	0.70	0.75	0.69	0.95	1.13	0.90	0.83	0.72	0.81	0.72
		2.18	2.59	1.91	3.25	3.85	3.34	1.99	2.22	3.61	2.85	2.15	2.40
Austin, Texas	AUS	2.17	1.50	1.28	2.36	2.60	3.16	2.15	1.86	2.19	2.76	1.79	1.60
		0.99	0.58	0.67	0.73	0.67	0.95	1.08	0.84	0.61	0.97	0.83	0.67
		4.15	4.08	3.24	4.01	4.57	4.48	6.53	5.45	5.52	3.10	3.79	4.93
Port Arthur, Texas	BUJ	2.38	2.64	2.66	2.64	4.30	3.80	4.92	3.89	4.48	3.48	2.50	2.41
		0.57	0.65	0.82	0.66	0.94	0.85	0.75	0.71	0.81	1.12	0.66	0.49
		3.54	3.27	2.54	3.25	4.90	4.08	4.12	4.04	4.58	3.74	3.84	4.25
Houston, Texas	HOU	2.31	2.13	2.16	2.17	3.82	3.44	3.19	3.44	3.10	4.17	3.28	2.46
		0.65	0.65	0.85	0.67	0.78	0.84	0.77	0.85	0.68	1.11	0.85	0.58
		1.66	1.81	1.56	2.57	3.47	2.89	1.82	2.56	3.61	2.56	1.67	1.68
San Antonio, Texas	SAT	1.74	1.27	1.11	2.08	2.70	2.31	2.03	2.32	3.39	2.35	1.40	1.39
		1.04	0.70	0.71	0.81	0.78	0.80	1.12	0.90	0.94	0.92	0.83	0.83
		0.70	0.92	0.71	1.56	2.34	2.21	1.18	1.60	3.06	2.19	0.70	0.70
Del Rio, Texas	DRO	0.79	1.26	0.69	1.56	1.99	2.66	1.49	1.80	3.17	2.23	0.76	0.78
		1.13	1.38	0.98	1.00	0.85	1.21	1.27	1.13	1.04	1.02	1.09	1.11
		3.18	2.75	2.55	2.59	2.93	3.44	4.51	4.28	5.63	2.70	3.51	3.91
Galveston, Texas	GUS	2.21	1.82	2.30	1.93	2.78	3.48	4.24	3.03	4.19	2.28	3.16	2.18
		0.70	0.66	0.90	0.74	0.95	1.01	0.94	0.71	0.74	0.85	0.90	0.56

Table 4. High Plains Monthly Precipitation Statistics — Continued

Station	Identifier	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Victoria, Texas	VCT	2.07	2.18	1.89	2.57	4.00	3.31	2.98	2.95	4.80	3.18	2.30	2.21
		2.13	1.45	1.66	2.24	3.57	2.09	2.63	2.20	3.20	3.39	1.93	1.39
		1.03	0.66	0.88	0.87	0.89	0.63	0.88	0.75	0.67	1.07	0.84	0.63
Corpus Christie, Texas	CRP	1.52	1.72	1.18	2.01	3.13	2.51	1.89	3.01	5.05	2.61	1.60	1.92
		1.87	1.38	0.96	1.94	2.43	2.26	2.04	2.83	4.27	2.50	1.76	2.05
		1.23	0.80	0.82	0.97	0.78	0.90	1.08	0.94	0.84	0.96	1.10	1.06
Brownsville, Texas	BRO	1.32	1.32	0.87	1.44	2.69	2.74	1.46	2.72	5.57	3.21	1.28	1.63
		1.31	1.76	0.96	1.54	1.92	2.96	1.55	2.40	3.98	3.16	1.20	1.94
		0.99	1.33	1.10	1.07	0.71	1.08	1.06	0.88	0.71	0.99	0.93	1.19

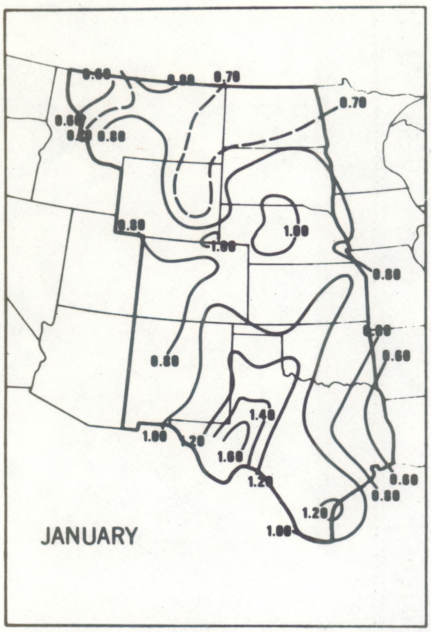


Figure 10. Distribution of coefficients of variation for January precipitation amounts in the High Plains.

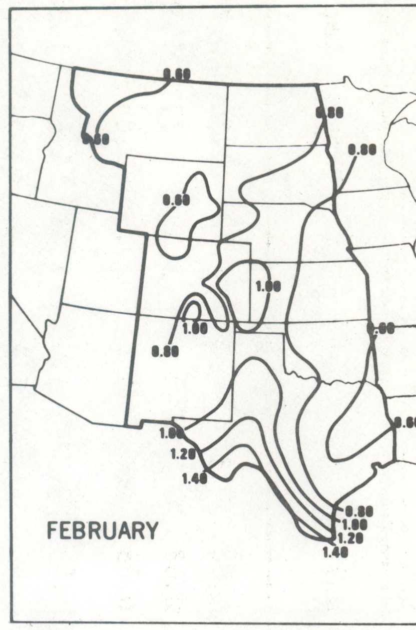


Figure 11. Distribution of coefficients of variation for February precipitation amounts in the High Plains.

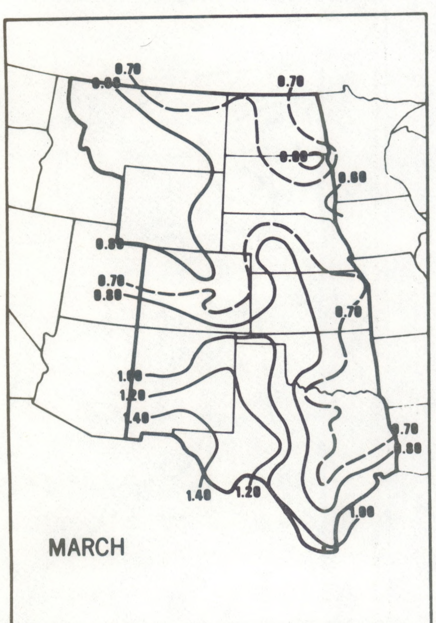


Figure 12. Distribution of coefficients of variation for March precipitation amounts in the High Plains.

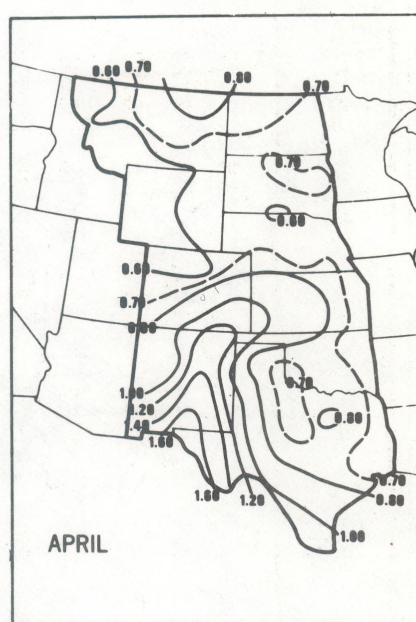


Figure 13. Distribution of coefficients of variation for April precipitation amounts in the High Plains.

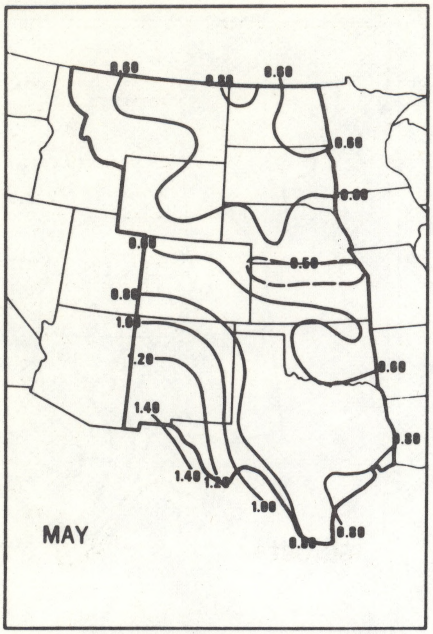


Figure 14. Distribution of coefficients of variation for May precipitation amounts in the High Plains.

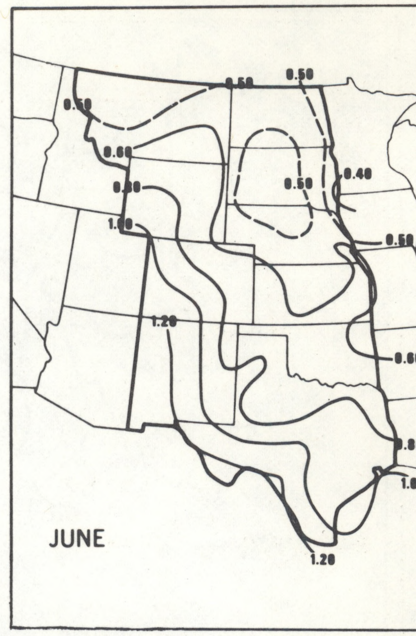


Figure 15. Distribution of coefficients of variation for June precipitation amounts in the High Plains.

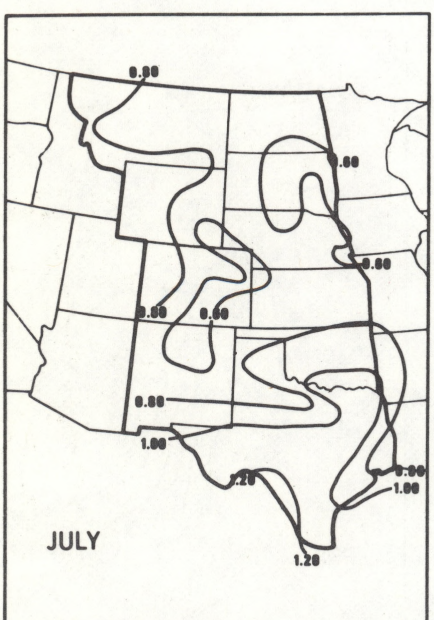


Figure 16. Distribution of coefficients of variation for July precipitation amounts in the High Plains.

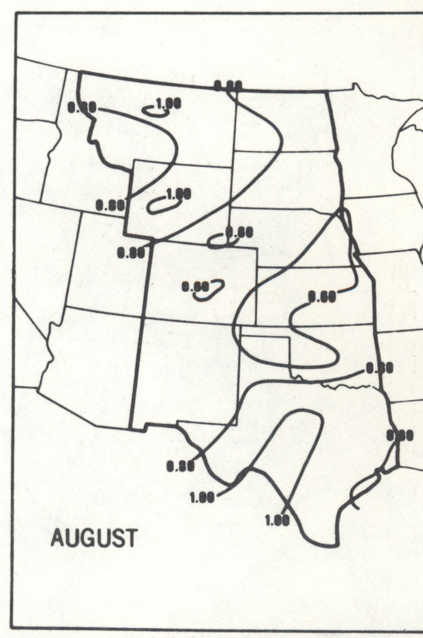


Figure 17. Distribution of coefficients of variation for August precipitation amounts in the High Plains.

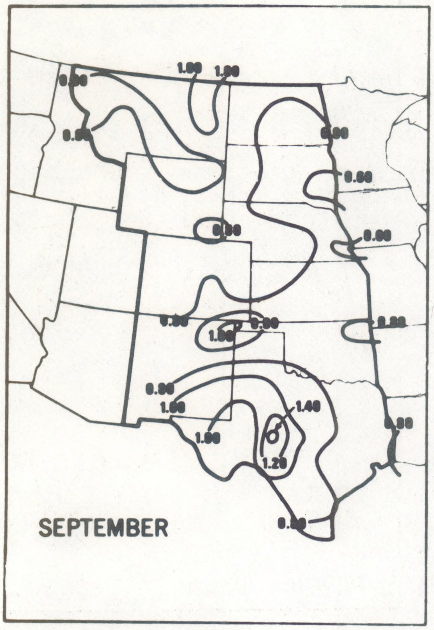


Figure 18. Distribution of coefficients of variation for September precipitation amounts in the High Plains.

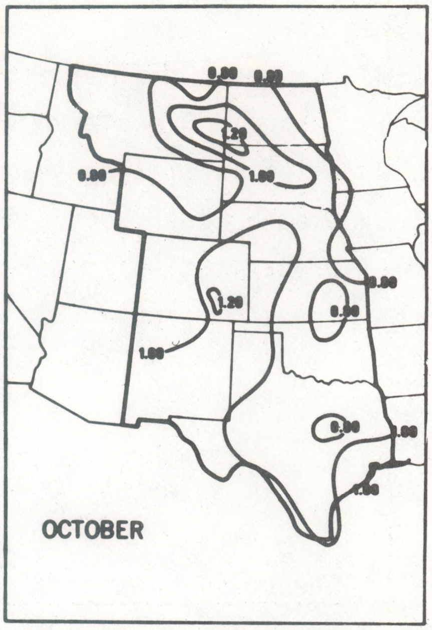


Figure 19. Distribution of coefficients of variation for October precipitation amounts in the High Plains.

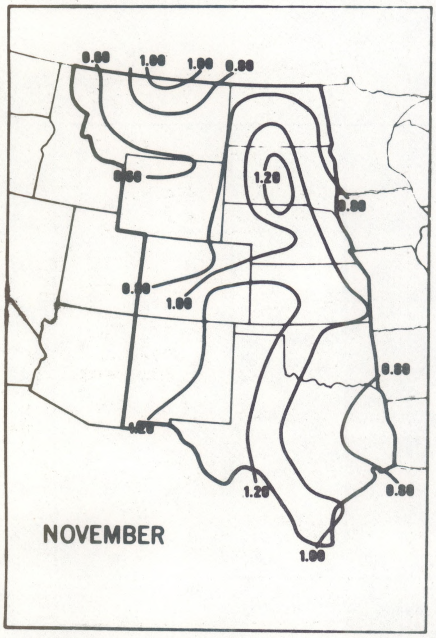


Figure 20. Distribution of coefficients of variation for November pricipitation amounts in the High Plains.

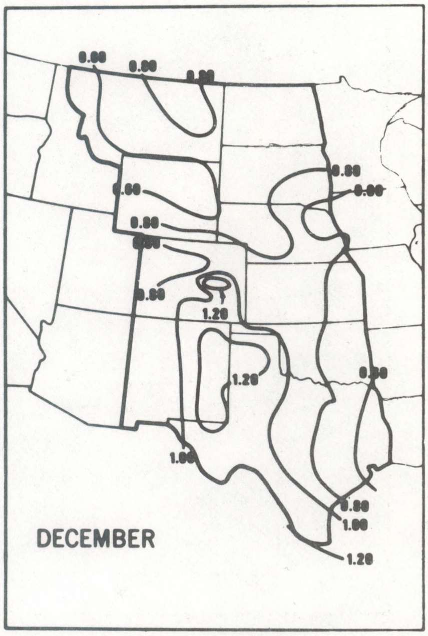


Figure 21. Distribution of coefficients of variation for December precipitation amounts in the High Plains.

30 year mean. Staver's work was based on that of Brooks and Carruthers (1953), in which they stated that rainfall amounts are sometimes positively skewed. A positive skew in the distribution implies that the median value is smaller than the arithmetic mean. Staver found a positively skewed distribution in the High Plains; this indicates that below-normal precipitation is more likely to occur in a given month than above-normal precipitation.

3.3 High Plains Precipitation Variability Compared with That of Other Sections of the USA

The coefficients of variation of High Plains annual precipitation vary over a wide range; the lowest is near 0.17 and the highest near 0.43. Figure 22 compares coefficients in the High Plains with those in other regions of the United States having similar annual amounts of precipitation.

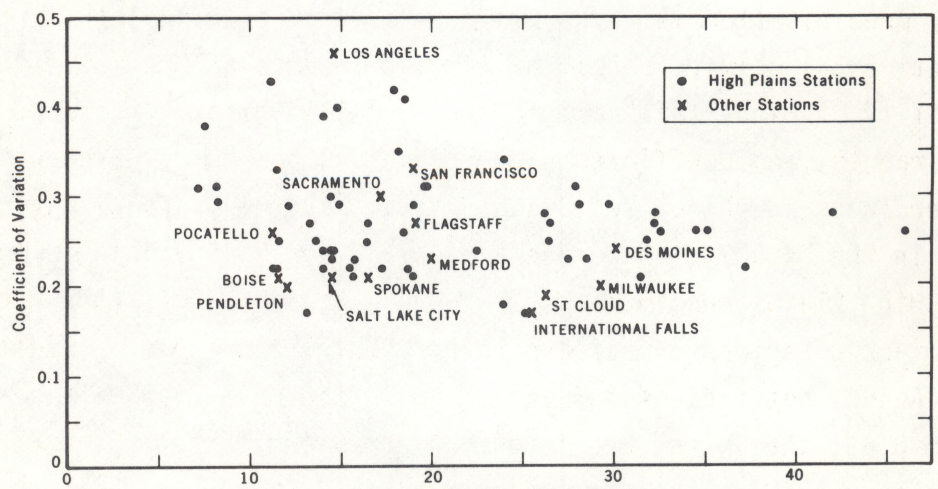


Figure 22. Coefficients of variation of annual precipitation amounts plotted against annual precipitation amounts for High Plains stations (dots) and for other stations outside the High Plains (X's).

The annual coefficients of variation in the semi-arid regions of eastern Washington, eastern Oregon, Idaho, and Utah and generally somewhat lower than in High Plains area having similar amounts of precipitation. The dry regions of California and the Southwest have higher coefficients than those for precipitation regimes in the High Plains.

Milwaukee, Wisconsin; St. Cloud, Minnesota; Des Moines, Iowa; and International Falls, Minnesota, have amounts of annual precipitation that correspond to lower latitude stations in the High Plains. The variability of these amounts is lower at the higher latitude stations, the difference in the coefficients is roughly 0.05 to 0.08.

Tables 5 through 7 show precipitation statistics for some stations outside the High Plains and can be compared with similar statistics in tables 1 to 3 for High Plains stations.

Monthly precipitation statistics for selected stations outside the High Plains are given in table 7 and can be compared with similar statistics in table 8 for High Plains stations.

4. CONCLUSIONS

The natural variability of High Plains annual, seasonal, and monthly precipitation is rather large — as one would expect for a temperate continental climate receiving limited amounts of precipitation. The variability of High Plains precipitation, shown through standard deviations, ranges, and coefficients of variation, can be compared with that of other areas in the United States. This study has shown that precipitation in the High Plains has less natural variability than in the Southwest. High Plains precipitation, however, does vary more than that in the semi-arid regions of eastern Washington, eastern Oregon, Idaho, and Utah. Annual coefficients of variation in the High Plains range from 0.17 to 0.43; the lowest are in the northern and eastern High Plains. Cold season coefficients range from 0.21 to 0.66 and the lowest coefficients are in the eastern and northwestern plains, the crop-growing season coefficients range from 0.20 to 0.51 with the lowest coefficients occurring in the eastern and northern plains.

Table 5. Annual Precipitation Statistics

Station	Period of Record (Years)	Mean Annual Precip. (Inches)	Range (Inches)	Standard Deviation (Inches)	Coefficient of Variation
Flagstaff, Arizona	40	19.07	9.90 - 36.59	5.06	.27
Los Angeles, California	40	14.64	4.08 - 31.28	6.79	.46
Sacramento, California	32	17.33	7.99 - 28.47	5.28	.30
San Francisco, California	40	19.04	9.20 - 32.91	6.29	.33
Boise, Idaho	40	11.46	6.64 - 16.40	2.43	.21
Pocatello, Idaho	40	11.15	5.34 - 16.83	2.86	.26
Des Moines, Iowa	40	30.08	17.07 - 42.88	6.24	.24
St. Cloud, Minnesota	40	26.23	18.19 - 39.32	4.97	.19
International Falls, Minnesota	32	25.36	17.23 - 34.35	4.43	.17
Medford, Oregon	40	20.04	10.42 - 29.09	4.68	.23
Pendleton, Oregon	40	12.06	6.77 - 17.73	2.47	.20
Salt Lake City, Utah	40	14.65	8.99 - 21.11	3.09	.21
Spokane, Washington	40	16.49	10.51 - 26.07	3.60	.21
Milwaukee, Wisconsin	40	29.25	19.10 - 41.86	5.79	.20

Table 6. Crop-Growing Season (Apr.-Sept.) Precipitation Statistics

Station	Period of Record (Years)	Mean Crop-Growing Season Precipitation (Inches)	Range (Inches)	Standard Deviation (Inches)	Coefficient of Variation
Flagstaff, Arizona	40	9.24	4.76 - 16.00	2.47	.27
Los Angeles, California	40	1.64	0.02 - 7.84	1.75	1.07
Sacramento, California	32	2.33	0.27 - 6.13	1.76	.76
San Francisco, Calfornia	40	2.13	0.46 - 7.09	1.75	.82
Boise, Idaho	40	4.21	1.20 - 8.06	1.60	.38
Pocatello, Idaho	40	5.18	1.78 - 9.79	1.83	.35
Des Moines, Iowa	40	21.02	11.68 - 28.27	4.61	.22
St. Cloud, Minnesota	40	19.73	14.16 - 30.90	4.40	.22
International Falls, Minnesota	32	18.67	10.97 - 29.81	4.34	.23
Medford, Oregon	40	4.41	1.73 - 7.68	1.80	.41
Pendleton, Oregon	40	4.27	1.77 - 9.51	1.61	.38
Salt Lake City, Utah	40	6.72	2.78 - 11.70	2.40	.36
Spokane, Washington	40	5.48	2.29 - 13.98	2.17	.40
Milwaukee, Wisconsin	40	18.09	9.70 - 26.92	4.83	.27

Table 7. Cold Season (Sept.-Apr.) Precipitation Statistics

Station	Period of Record (Years)	Mean Cold Season Precip. (Inches)	Range (Inches)	Standard Deviation (Inches)	Coefficient of Variation
Flagstaff, Arizona	40	12.79	4.80 - 31.06	4.83	.38
Los Angeles, California	40	14.43	3.98 - 31.24	6.84	.47
Sacramento, California	32	16.66	7.45 - 27.69	5.29	.32
San Francisco, California	40	18.48	8.61 - 32.29	6.27	.34
Boise, Idaho	40	8.84	5.81 - 13.23	1.82	.21
Pocatello, Idaho	40	7.76	4.08 - 14.17	2.35	.30
Des Moines, Iowa	40	14.85	6.74 - 28.56	4.73	.32
St. Cloud, Minnesota	40	11.21	5.66 - 19.82	3.35	.30
International Falls, Minnesota	32	11.72	4.40 - 17.05	2.77	.24
Medford, Oregon	40	17.31	8.47 - 26.92	4.22	.24
Pendleton, Oregon	40	9.44	5.80 - 14.74	1.97	.21
Salt Lake City, Utah	40	10.54	6.63 - 15.92	2.22	.21
Spokane, Washington	40	12.87	7.37 - 21.03	3.02	.23
Milwaukee, Wisconsin	40	16.71	10.81 - 26.73	4.11	.25

Table 8. Monthly Precipitation Statistics — Non-High Plains Stations

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1.80	1.69	1.70	1.26	0.56	0.56	2.38	2.78	1.70	1.43	1.13	2.09
Flagstaff,	1.55	1.24	1.47	1.11	0.51	0.73	1.27	1.35	1.50	1.34	1.07	1.83
Arizona	0.86	0.74	0.86	0.88	0.91	1.30	0.53	0.49	0.88	0.94	0.95	0.88
	2.99	3.12	2.18	1.15	0.12	0.06	0.00	0.03	0.28	0.35	1.64	2.73
Los Angeles,	3.15	3.35	2.07	1.33	0.26	0.11	0.01	0.08	0.95	0.55	2.31	2.45
California	1.05	1.08	0.95	1.16	2.23	2.03	3.56	2.41	3.39	1.58	1.41	0.90
	3.73	2.75	2.21	1.48	0.53	0.09	0.00	0.04	0.18	0.96	2.06	3.28
Sacramento,	2.38	2.37	1.33	1.39	0.62	0.17	0.02	0.13	0.37	1.42	1.77	2.59
California	0.64	0.86	0.60	0.94	1.16	1.78	3.59	2.96	2.11	1.47	0.86	0.79
	4.24	3.30	2.68	1.41	0.40	0.12	0.01	0.02	0.16	0.88	1.98	3.84
San Francisco,	2.63	2.65	1.97	1.54	0.61	0.22	0.02	0.06	0.42	1.27	1.68	2.53
California	0.62	0.80	0.74	1.09	1.52	1.76	3.71	2.41	2.61	1.45	0.85	0.66
	1.47	1.20	1.14	1.15	1.21	0.98	0.19	0.24	0.43	0.82	1.31	1.31
Boise,	0.85	0.58	0.76	0.78	0.90	0.79	0.25	0.43	0.54	0.57	0.67	0.72
Idaho	0.58	0.48	0.67	0.68	0.75	0.81	1.30	1.75	1.25	0.70	0.51	0.55
	1.19	0.88	1.01	1.14	1.17	1.13	0.48	0.60	0.65	0.84	1.01	1.05
Pocatello,	0.70	0.47	0.62	0.73	0.68	0.84	0.50	0.70	0.76	0.73	0.64	0.52
Idaho	0.59	0.53	0.61	0.64	0.58	0.74	1.03	1.17	1.17	0.87	0.63	0.50

Table 8. Monthly Precipitation Statistics — Non High Plains Stations — Continued

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1.20	1.09	2.11	2.66	4.04	4.63	3.11	3.45	3.13	2.08	1.53	1.05
Des Moines,	0.84	0.79	1.25	1.41	1.92	2.46	2.04	2.39	2.47	1.72	1.12	0.65
Iowa	0.70	0.73	0.59	0.53	0.48	0.53	0.65	0.69	0.79	0.82	0.73	0.62
	0.76	0.76	1.25	2.20	3.62	4.42	3.22	3.76	2.52	1.76	1.18	0.78
St. Cloud,	0.55	0.58	0.73	1.21	1.83	2.27	1.59	1.91	1.48	1.54	0.78	0.58
Minnesota	0.72	0.76	0.59	0.55	0.51	0.51	0.49	0.51	0.59	0.88	0.66	0.74
	0.84	0.72	1.07	1.68	2.66	3.78	3.92	3.29	3.35	1.83	1.30	0.93
International Falls,	0.51	0.45	0.67	0.81	1.53	1.95	1.91	2.12	1.67	1.35	0.67	0.42
Minnesota	0.61	0.64	0.62	0.49	0.58	0.51	0.49	0.64	0.50	0.74	0.52	0.45
	3.39	2.18	1.74	1.10	1.38	0.85	0.23	0.27	0.59	1.90	2.87	3.55
Medford,	1.87	1.36	1.13	0.75	1.11	0.78	0.42	0.37	0.52	1.79	1.99	2.37
Oregon	0.55	0.63	0.65	0.68	0.80	0.91	1.78	1.39	0.89	0.94	0.69	0.67
	1.51	1.14	1.08	1.05	1.08	1.02	0.24	0.29	0.60	1.08	1.45	1.53
Pendleton,	0.85	0.63	0.63	0.65	0.84	0.74	0.30	0.38	0.54	0.69	0.75	0.72
Oregon	0.56	0.55	0.58	0.62	0.78	0.73	1.26	1.33	0.90	0.64	0.52	0.47
	1.29	1.27	1.56	1.94	1.41	1.13	0.66	0.91	0.67	1.21	1.25	1.35
Salt Lake City,	0.71	0.67	0.88	0.95	0.99	0.97	0.64	0.92	0.63	0.88	0.65	0.76
Utah	0.55	0.53	0.56	0.49	0.70	0.85	0.97	1.01	0.93	0.73	0.52	0.57

	2.22	1.58	1.50	1.05	1.29	1.35	0.41	0.58	0.81	1.47	1.93	2.30
Spokane,	1.20	1.04	0.78	0.73	1.16	0.83	0.39	0.53	0.63	1.19	1.06	1.02
Washington	0.54	0.66	0.52	0.70	0.89	0.61	0.97	0.91	0.78	0.80	0.55	0.44
	1.75	1.31	2.24	2.65	2.94	3.58	3.12	2.90	2.89	2.07	2.07	1.72
Milwaukee,	0.98	0.78	0.99	1.07	1.52	1.98	1.81	1.75	2.43	1.45	1.38	0.91
Wisconsin	0.56	0.59	0.44	0.41	0.52	0.55	0.58	0.61	0.84	0.70	0.67	0.53

Monthly precipitation may vary considerably from year to year with the majority of monthly precipitation amounts usually falling below the monthly mean as computed over a period of 30 or 40 years. This indicates a positive skew in the distribution of monthly precipitation amounts.

The choice of a site and design for a High Plains weather modification experiment should depend not only on the temporal distribution of precipitation, as outlined in this report, but also on a more detailed study of its spatial distribution. A low spatial variability in precipitation may lead to different physical and statistical experiments than one designed solely on the basis of temporal variabilities.

5. REFERENCES

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