ABSTRACT OF THE THESIS OF

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Title CLOUDINESS IN THE WILLAMETTE VALLEY OF OREGON

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Temporal and spatial patterns of daytime cloudiness in the Willamette Valley of Oregon were studied by utilizing monthly and daily sky cover data published by the U. S. Weather Bureau for the Portland, Salem, and Eugene stations. The 15-year period, 1949 through 1963, was selected as the maximum reliable period length common to all three stations for accurate comparisons, for in the latter 1940's hourly observations of the number of tenths of the sky field of view obscurred by cloud cover for the time between sunrise and sunset were initiated. The measures of cloudiness used in this study, each of which is based on sky cover in tenths, include:

1. Percent sky cover.
2. Clear and cloudy days (0-5 and 6-10 tenths).
3. Cloudless and overcast days (0 and 10 tenths).
4. Clear, partly cloudy, and cloudy days (0-3, 4-7, and 8-10 tenths, respectively).

The average annual and monthly sky cover in tenths and the number of clear, partly cloudy, and cloudy days can be ascertained directly from Weather Bureau data sources. The principal objectives of this study, however, include the comparison of cloudiness among stations and data presentation which affords a more revealing image of the character of cloudiness. To achieve the latter, variation, persistence, and a range of temporal frameworks were employed as well as the liberal use of graphs and tables.

The Willamette Valley averages nearly 70 percent sky cover annually, and only July, August and September average less than 60 percent sky cover. During most months the three stations compare closely in the amount of cloudiness. In July and August, however, Portland averages ten percent more cloudiness than Eugene, and Salem has intermediate cloudiness characteristics.

Although overall annual cloudiness in the Willamette Valley may fluctuate as much as 15 percent between extremes, the three stations tend to be affected by the same cloudiness patterns for a given year. The winter half of the year, which is characteristically quite cloudy, shows the least variation in cloudiness, but the late spring and summer show monthly ranges between extremes approaching 50 percent sky cover.

The duration of periods of specified amounts of cloudiness indicates frequent changes in the amount of cloudiness, although

exceptionally long periods of cloudy weather in winter have occurred. The three stations experience the same periods of cloudiness throughout the year. Contrasts in the persistence of cloudiness among stations, however, are primarily reflected in the summer when Eugene has somewhat longer lasting periods of clear weather than Portland. Partial cloudiness tends to be a transitional rather than persistent cloudiness characteristic, for, despite the overall considerable cloudiness in the Willamette Valley, most clear (0-5 tenths) days that do occur tend to be cloudless or have only scattered cloudiness.

CLOUDINESS IN THE WILLAMETTE VALLEY OF OREGON

by

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CLOUDINESS IN THE WILLAMETTE VALLEY OF OREGON

I. INTRODUCTION

This study investigates the temporal and spatial variations of daytime cloudiness in the Willamette Valley of Oregon by a comparative analysis of data for the Portland, Salem, and Eugene Weather Bureau stations for the period 1949 through 1963. Studies of cloudiness may be carried out utilizing a wide variety of bases. The most noteworthy variables affecting the character of cloudiness study are selection of stations, length of data period and time units, and forms of cloudiness expression. Insight for the selection of bases in the present study was derived by an investigation of the development of cloudiness data collection, station setting and history, types of data available, and previous studies of cloudiness in the Willamette Valley.

Historical Summary of Data Collection

Prior to about 1945 cloudiness was expressed as the relative number of clear, partly cloudy, and cloudy days per month, generally an impressionistic estimate of sky cover with little standardization of observational technique between different observers. In the mid 1940's cloudiness measurement in terms of the number of tenths of the sky covered by clouds was initiated. In the latter 1940's these figures were based on four observations per day, of which two or

three were averaged to indicate the amount of sky cover between sunrise and sunset. Since 1949, hourly observations of sky cover have been recorded at the Portland, Salem, and Eugene Weather Bureau stations in the Willamette Valley.

Figure 1 has been included to show the number of clear days per year recorded at the Portland, Salem, and Eugene stations for the period 1920 through 1963 as an indicator of reliability in cloudiness observations. This graph indicates a much closer correlation between U. S. Weather Bureau observations than those taken by cooperative observers prior to the time the respective Weather Bureau stations were established. The Portland Weather Bureau station, in existence prior to 1920, shows a rather uniform, although slightly decreasing, amount of clear weather through 1963. The Salem Weather Bureau station, established in 1938, begins at this time to correlate much more closely with the Portland station. Similarly, the Eugene Weather Bureau station, established in 1942, begins to correlate much more closely in the annual number of clear days with both Portland and Salem. Some cooperative observers prior to 1920 went so far as to omit the partly cloudy category or commonly underestimated the number of partly cloudy days, thus giving rise to the exaggerated figures for clear and cloudy weather.

A number of substations in the Willamette Valley also have cloudiness records in terms of clear, partly cloudy, and cloudy days

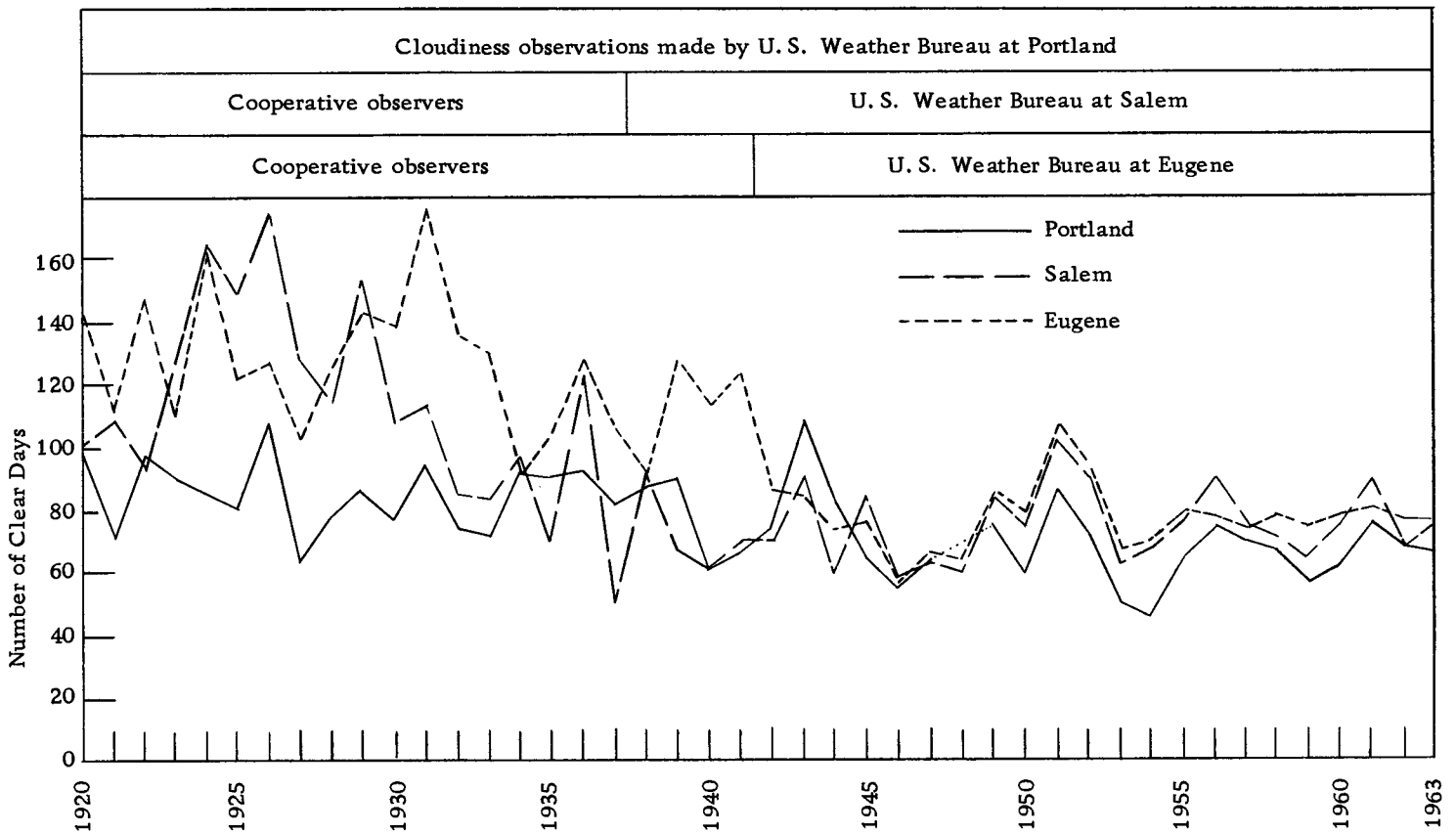

Figure 1. Annual number of clear (0-3 tenths sky cover) days at Portland, Salem, and Eugene from 1920 through 1963.

per month. Including Portland, Salem, and Eugene, six stations have records for 40 or more years, eleven for 30 or more years, seventeen for 20 or more years, and twenty-six for 10 or more years. Most of these records, however, are intermittent, and an accurate assessment of the spatial variations of cloudiness in the Willamette Valley based on the substations in supplement to the Portland, Salem, and Eugene stations would be difficult.

In 1949 there was a change in location of sky cover observations from downtown Portland to Portland International Airport, and these two localities may be sufficiently far apart to create an appreciable difference in sky cover. On the basis of the above several factors, the most accurate records of sky cover conditions are judged to be those of Portland, Salem, and Eugene during the period 1949 through 1963, hence the use of that period in this study.

Station Site and Situation

The map, Figure 2, shows the location of Portland, Salem, and Eugene and the major physiographic features which may affect their local climates. Thus, the map indicates the valley floor where there is a sharp change in relief to the Coastal Range foothills on the west and the Cascade foothills on the east.

Portland International Airport, 12 miles northeast of the main post office in Portland, is near the center of the Columbia River

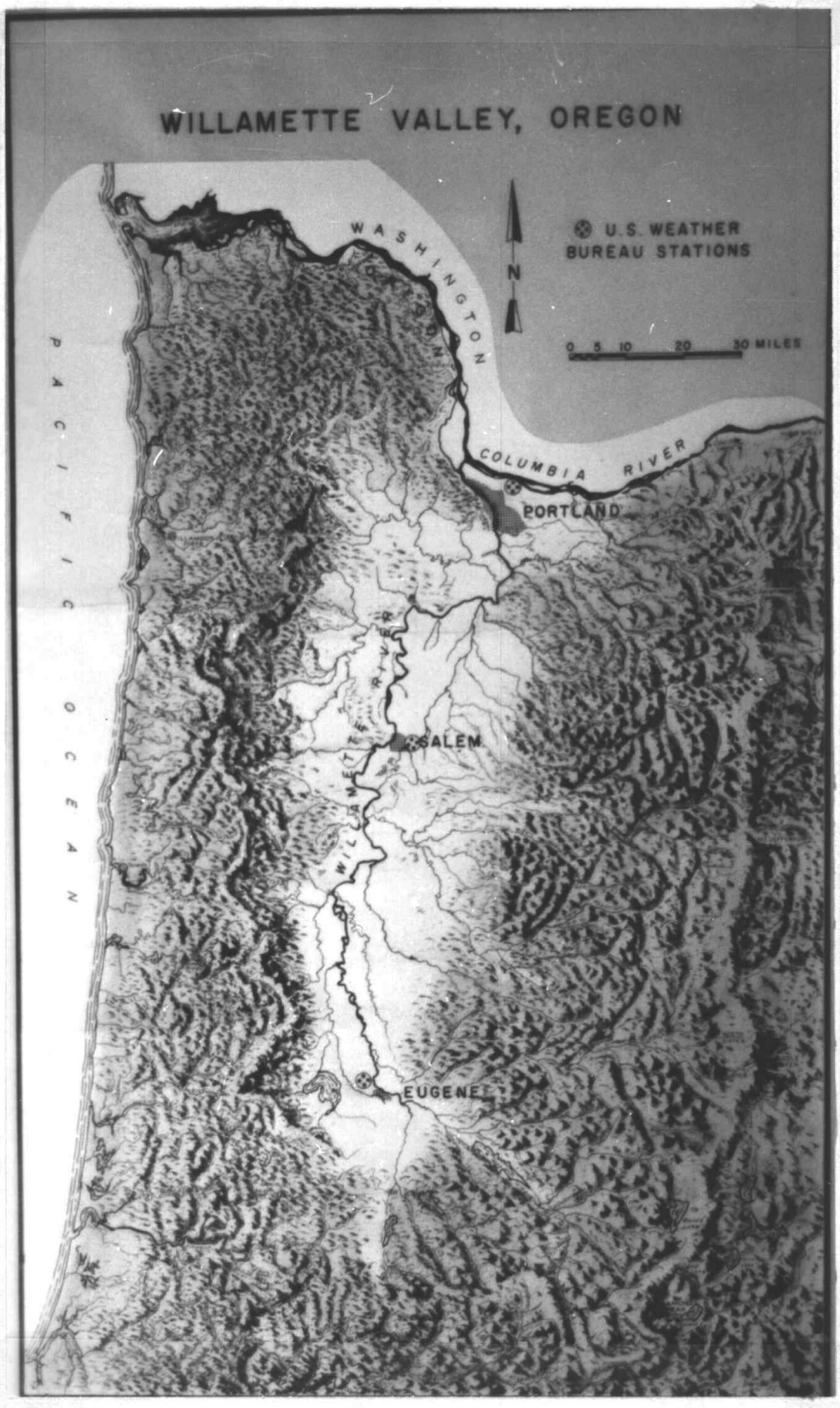

Figure 2. The Willamette Valley, Oregon.

Valley. The confluence of the Willamette River is eight miles west by northwest. Both the Cascade Range and the Coast Range are about 30 miles distant. The station elevation is 21 feet.

The Salem Weather Bureau station in the central Willamette Valley is located at McNary Field about three miles southwest of the Salem Post Office. The Cascade and Coast Ranges are 40 and 30 miles distant, respectively. The station elevation is 196 feet.

The Eugene Airport station is located about nine miles northwest of the city center. Foothills of the Cascade and Coast Ranges and the Umpqua River Divide are five to ten miles distant to the east, west and south of the station. The presence of numerous nearby water bodies contribute to heavy fogs in winter.

The Portland and Eugene Weather Bureau stations are roughly equidistant from the Salem Weather Bureau station, with Portland at the north end and Eugene near the southern end of the Willamette Valley. Consideration of these three stations, therefore, should give a fairly representative image of the variations in cloudiness along the valley, especially if the similarity implied in Figure 1 is borne out in more sophisticated data treatment.

Cloudiness Indicators

Three types of measurement utilized by the Weather Bureau which indicate the amount of daytime cloudiness include hourly visual

observation of amount of sky cover, continuous recording of the amount of bright sunshine by means of a photoelectric cell, and the continuous recording of the amount of solar radiation measured by means of the pyrheliometer. In the Willamette Valley, sky cover observations are made at all stations, bright sunshine is measured only at Portland, and solar radiation is measured only at Corvallis. Although the amount of solar radiation might prove useful as a supplement to sunshine and cloudiness analysis, the record at Corvallis, initiated in 1957, is of too short duration to be of value in this study.

On the whole, the two types of measurement, sky cover estimation and sunshine records, are somewhat comparable in value in indicating cloudiness; yet each has its strong points. Although visual estimation of tenths of sky cover is not truly accurate due to possibilities of human error, it is based on the full sky field of view. Hourly observations in tenths of the total sky cover are averaged between sunrise and sunset; therefore, the mean daily cloudiness, also in whole tenths, should be a fairly reliable figure. Difficulties in precisely estimating tenths of sky cover occur when the observer is confronted with erratic cloud distributions in the field of view. Sky cover is any atmospheric obscuration of the sky regardless of thickness; it includes massive clouds and fog as well as thin veils of cloud.

The principal advantage of the photoelectric sunshine recorder is that it gives a continuous record of the amount of sunshine in terms

of hours and minutes per day and allows computation of the percent of the possible amount of sunshine for a given day. The reciprocal value of the percent sunshine would theoretically be equal to the percent of daytime cloudiness. The sunshine recorder, however, does not measure accurately the state of the total sky field of view; scattered clouds may not affects its record.

A comparison of annual data for sky cover and bright sunshine at Portland indicates a tendency for the annual amount of sunshine measured by the sunshine recorder to be about 17 percent higher than the value obtained from the reciprocal value of cloudiness by visual observation.

Sources of Cloudiness Data

Data on cloudiness used in this study are published in two U. S. Weather Bureau climatological publications. Climatological Data, Oregon includes the number of clear, partly cloudy, and cloudy days per month and the monthly mean sky cover in tenths. The most useful form of data, that which shows the daily variations in cloudiness, is found in Local Climatological Data published monthly for the Portland, Salem, and Eugene Weather Bureau stations. These two publications are also sources for data on sunshine.

Previous Investigations

In a study entitled Oregon Sunshine, Sternes (1959) summarizes the climatic controls producing the general temporal patterns of cloudiness in Oregon, deals with an appraisal of the relative merits of different types of sunshine and cloudiness measurement, and presents small scale maps of Oregon showing the spatial variations of cloudiness in the State during different times of the year. He also has formulated regression equations showing the monthly relationships between sky cover in tenths and percent sunshine. The comparison is made for a number of Weather Bureau stations throughout the United States, and the computed values of percent sunshine are applied to stations in Oregon, other than Portland and Roseburg, which lack sunshine recorders. In another publication, Sternes (1948) also compares sunshine and cloudiness measurement methods but he delves primarily into a discussion of the superior applicability of solar radiation data for agricultural purposes, pointing out the need for additional pyrheliometer stations in Oregon. These two articles constitute the only previous studies relating to cloudiness in the Willamette Valley.

A literature search on methodology of cloudiness analysis has revealed a dearth of detailed sky cover evaluations in the United States. European climatologists apparently have been more concerned with studies of cloudiness. Among the countries most prolific

in cloudiness research are Great Britain, Germany, Austria, Poland, and the U.S.S.R. Most of the articles reviewed, however, do not go into any great detail other than citing average conditions of cloudiness.

Purpose

The principal objectives of this study are to indicate the overall temporal patterns of cloudiness and to provide data for estimating the prevailing conditions of daytime cloudiness for any given period of time during the year in the Willamette Valley. This study also serves to collate some forms of sky cover information which are otherwise scattered in several U.S. Weather Bureau publications.

Scope

The major considerations in the analysis include the average conditions of sky cover, measures of departure from the average, and the persistence of sky cover conditions. Mean conditions of sky cover and variation from the mean are calculated in terms of years and months for the period 1949 through 1963 at Portland, Salem, and Eugene; weekly temporal patterns are shown for Salem; and daily variations are shown for a sample year at all three stations. The shortest time unit used in this report, therefore, is the day. Persistence, the duration of periods of a specified amount of cloudiness, is expressed in terms of the month during which a given period began.

Variations in sky cover are illustrated in this report by utilizing four different expressions of cloudiness:

1. Percent sky cover.
2. A two-fold subdivision of clear (0-5 tenths) and cloudy (6-10 tenths) days.
3. Cloudless (0 tenths) and overcast (10 tenths) days.
4. A three-fold subdivision of clear (0-3 tenths), partly cloudy (4-7 tenths), and cloudy (8-10 tenths) days.

Percent sky cover, which is the sky cover figure in tenths multiplied by one hundred, indicates the overall amount of cloudiness. The frequency of occurrence of specified sky cover classes in terms of days per year, month, and week yields more information regarding the character of cloudiness which is indicated but cannot be determined fully from the percent cloudiness. The two and three-class subdivisions of cloudiness were found to be of about equal value in describing the character of cloudiness. To indicate this, and in the interest of completeness, both expressions are nonetheless included. The relative number of clear and cloudy days best indicates the psychologic impact of what constitutes clear and cloudy weather, while the three-fold classification of clear, partly cloudy, and cloudy days is a more refined subdivision long utilized by the Weather Bureau. The frequency of occurrence of cloudless and overcast days is an expression of the extreme conditions of cloudiness.

Data Considerations

Two aspects of the character of the data used deserve comment, the inequality of classes and the brief period of record employed. In the two-fold classification the clear and cloudy categories arbitrarily constitute zero through five and six through ten tenths sky cover, respectively. The boundary between two classes, therefore, is actually 55 percent (5.5 tenths), not 50 percent. On the tenths scale of cloudiness, 0-3, 4-7, and 8-10 comprise the respective quantifications adopted by the U. S. Weather Bureau for the clear, partly cloudy, and cloudy categories. It can be seen that this is not an equal subdivision, for the clear and partly cloudy classes each have four units, while the cloudy category has three units in the degree of cloudiness. Furthermore, the 0 and 10 tenths categories, used to indicate cloudless and overcast weather, are each half the value in degree of the other units. For example, zero tenths sky cover actually forms the class interval of 0.00 to 0.49 tenths, while one tenth sky cover ranges from 0.50 to 1.49 tenths. These are the forms, nonetheless, in which the data come.

It is recognized that 15 years (1949-1963) constitutes a minimal period for climatological studies. The fact that in this study at least one month of each year of the period at one or more of the stations has recorded an extreme (maximum or minimum) amount of cloudiness emphasizes this. The reasons for using this period of record, however, have been given. This report, therefore, should be recognized as being indicative rather than definitive in showing the temporal and spatial variations of cloudiness in the Willamette Valley.

II. ANNUAL AND MONTHLY MEAN CLOUDINESS

The mean annual and mean monthly percent sky cover were derived by averaging the figures published by the Weather Bureau for the 15-year period, 1949 through 1963. Finding the mean frequencies of occurrence of the various sky cover categories in days per year and month necessitated totaling the number of occurrences within each class interval for each month and calculating the average for the period. The mean annual and monthly frequency of occurrence are shown in terms of both days and percentage frequency of days. With adequate data coverage, percentage frequency is synonomous with empirical probability. It is also a somewhat better indicator of monthly trends than the number of days per month, particularly for graphical analysis, since the effect of unequal number of days per month is resolved into terms of percentage of the total.

Mean Annual Cloudiness

Percent Sky Cover

The Willamette Valley as well as all of Oregon west of the Cascade Range is commonly considered to be one of the cloudier regions of the United States. This may be verified by referring to the mean sky cover map in the National Atlas of the United States (U.S. Weather Bureau, 1960). The singlemost areally extensive

interval for the 48 States, 50 to 60 percent cloudiness, occupies most of the southeastern and central sectors of the country. Sky cover in the southwestern states generally ranges from less than 30 percent to 50 percent. Although the northern third of the United States experiences from 60 to 70 percent sky cover, areas with 70 percent or more mean annual cloudiness in the eastern half of the country are comparatively small and are confined principally to the more mountainous regions. The Pacific Northwest has the most extensive areas of 70 to 80 percent sky cover, including most of western Washington and northwestern Oregon.

The mean annual percent sky cover figures for Portland, Salem, and Eugene during the period 1949 through 1963, are 72 percent, 69 percent, and 68 percent, respectively. This indicates the uniformity of cloudiness in the Willamette Valley.

Frequency of Occurrence of Sky Cover Conditions

The character of annual cloudiness is considered by utilizing the three forms of cloudiness expression described in the introductory chapter. Figure 3 shows the mean annual number and percentage frequency of days of the various cloudiness classes.

The two-fold classification clear and cloudy reveals that about 30 percent of the total number of days per year are clear. More than a third of the days each year are overcast, while only one tenth are

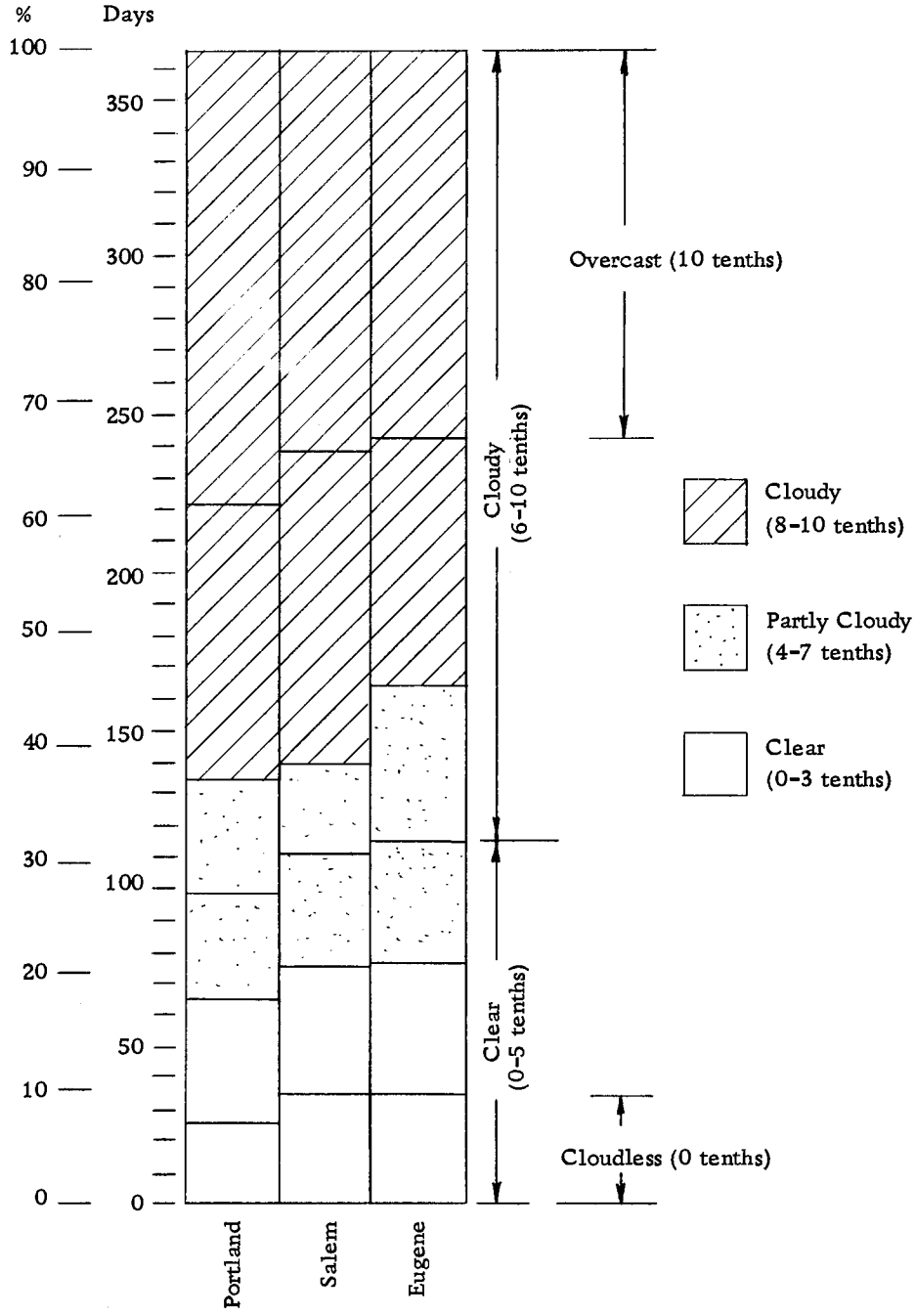

Figure 3. Mean frequency of occurrence of clear and cloudy; cloudless and overcast; and clear, partly cloudy, and cloudy days at Portland, Salem, and Eugene, 1949-1963.

cloudless; however, consideration of the three-fold classification reveals that 20 percent of the days are clear, another 20 percent are partly cloudy, and 60 percent are cloudy. It is of interest to note that partly cloudy days, which form more than a third of the tenth units, form a surprisingly low proportion of the annual sky cover condition, for more of a gradational pattern from cloudy to clear might be expected.

Figure 3, illustrating the interrelationships of the three cloudiness expressions among stations, clearly shows:

1. The very high proportion of days per year that are overcast in contrast to cloudless and a similar contrast between cloudy (8-10 tenths) and clear (0-3 tenths) days.
2. The marked similarity in cloudiness among stations.
3. The small percentage difference among stations that does occur is manifested by a decrease in cloudiness from north to south in the Willamette Valley.

Mean Monthly Cloudiness

Percent Sky Cover

Portland has the greatest amount of cloudiness each month of the year except from November through February when the figure is

equalled or only slightly exceeded by that for Salem or Eugene. During the six month period, October through March, there is only a three percent overall difference each month in average cloudiness between any two of the three stations. July shows the greatest divergence with a 14 percent difference in cloudiness between Portland and Eugene, followed by an 11 percent difference in August.

Table 1. Mean Monthly Percent Sky Cover at Portland, Salem, and Eugene, 1949-1963.

Station	J	F	M	A	M	J	J	A	S	O	N	D
Portland	84	84	83	76	74	69	46	53	56	73	81	89
Salem	84	83	81	72	72	65	36	46	55	70	79	89
Eugene	84	84	80	71	67	61	32	42	49	71	82	89

Figure 4 shows that although there is a general decrease in cloudiness from December through July, this decrease is not uniform. From January through March and from April to May the decrease is only a few percent. The decrease in cloudiness that occurs in the one month period June to July, however, is almost equal to the decrease during the six month period December through June. The increase in cloudiness from July through December also shows irregularities during the successive months. Although July through September are by far the clearest months, September has about 15 percent more cloudiness than July. The sharpest increase in cloudiness occurs from September to October, although the increase on through

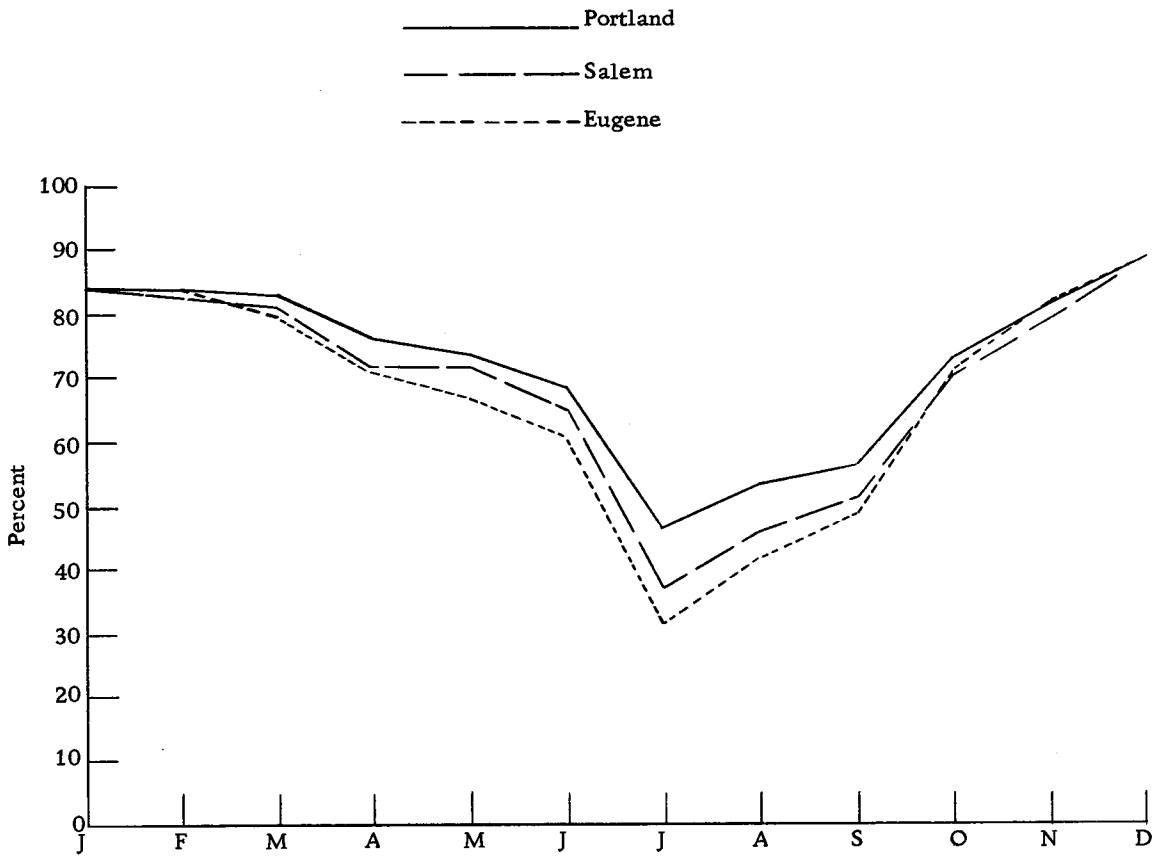

Figure 4. Mean monthly percent sky cover at Portland, Salem, and Eugene, 1949-1963.

December is also quite marked.

In ranking the months from the least cloudy to the most cloudy, the following sequence at all three stations may be observed: July, August, September, June, May or October, April, March or November, February, January, and December.

It has been noted that there is a definite, but small, decrease in cloudiness from north to south in the Willamette Valley, which is most notable from June through August when cloudiness in Portland exceeds that in Eugene each month by about 10 percent. The difference in cloudiness among stations during the winter half of the year, on the other hand, is only a few percent, with Eugene slightly exceeding Portland or Salem some months. This anomaly may well be attributed to the occurrence of frequent fogs at Eugene in winter. The mean annual number of foggy days at Portland, Salem, and Eugene is 31, 41 and 58 days, respectively, most of which occur during the winter months. Eugene, therefore, averages seven percent more cloudiness in the form of fog each year than Portland. Sky cover data do not necessarily provide a picture of the occurrence of large, regional cloud masses alone; local physiographic features, such as water bodies and landforms, may appreciably modify the amount of cloudiness.

Multi-Class Cloudiness Expressions

Clear and Cloudy Days

The two-fold classification, clear and cloudy, is described only in terms of clear days, for the monthly figures for cloudy weather are simply the reciprocal.

Table 2. Mean Monthly Number of Clear (0-5 tenths) Days at Portland, Salem, and Eugene, 1949-1963.

Station	J	F	M	A	M	J	J	A	S	O	N	D
Portland	4	4	4	6	7	10	18	16	15	8	6	3
Salem	4	4	5	7	8	10	20	18	16	9	5	2
Eugene	4	4	5	7	10	12	23	20	17	9	5	2

Figure 5 illustrates the considerable contrast in the number of clear days between the summer and winter months. From November through March less than 20 percent of the days each month are clear, while from July through September more than 50 percent of the days are clear. Table 2 shows that December, the cloudiest month, averages only two or three clear days; July, the clearest month, averages 18 to 23 clear days. The major contrasts among successive months include July with twice as many clear days as June, and October with only about half as many clear days as September

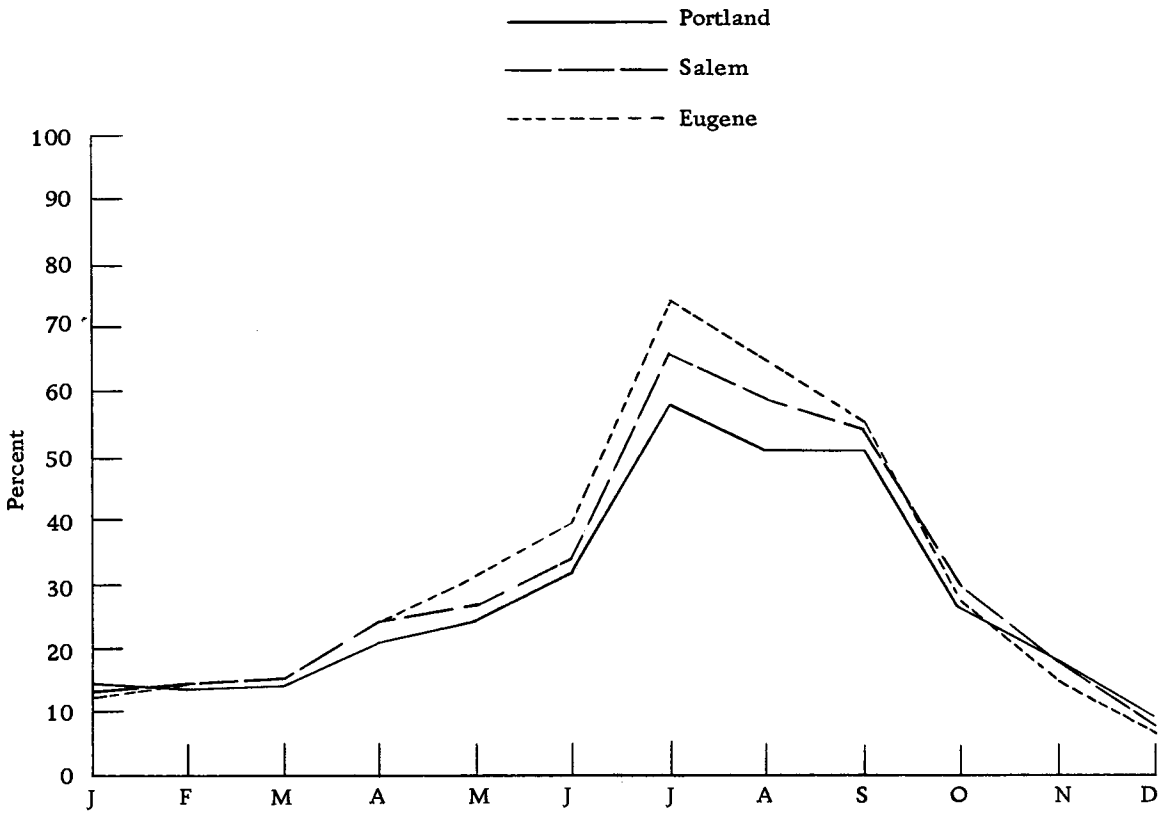

Figure 5. Mean monthly percentage frequency of clear (0-5 tenths) days at Portland, Salem, and Eugene, 1949-1963.

Cloudless and Overcast Days

During the eight month period, October through May, the three stations average only two or fewer cloudless days each month, with December ordinarily having no days with cloudless skies. In contrast, 20 to 40 percent of the days in July are cloudless, followed by August and September with 10 to 20 percent. Figure 6 shows that Portland has considerably fewer cloudless days than Salem and Eugene from June through August; during the remaining months there is little or no variation among stations. In July cloudless days constitute half the clear (0 to 5 tenths sky cover) days, and during the other months the proportion of cloudless to clear days may be as much as one in three. Although seemingly few in number, cloudless days actually form a rather high proportion of clear days.

Table 3. Mean Monthly Number of Cloudless (0 tenths) Days at Portland, Salem, and Eugene, 1949-1963.

Station	J	F	M	A	M	J	J	A	S	O	N	D
Portland	2	1	1	2	2	2	7	3	4	2	1	1
Salem	1	1	1	2	2	3	10	6	5	2	2	0
Eugene	1	1	1	3	2	4	12	7	5	2	1	0

Table 4 indicates that during the four month period, November through February one half or more of the days each month are overcast. It may be recalled that at best only one third of the days during

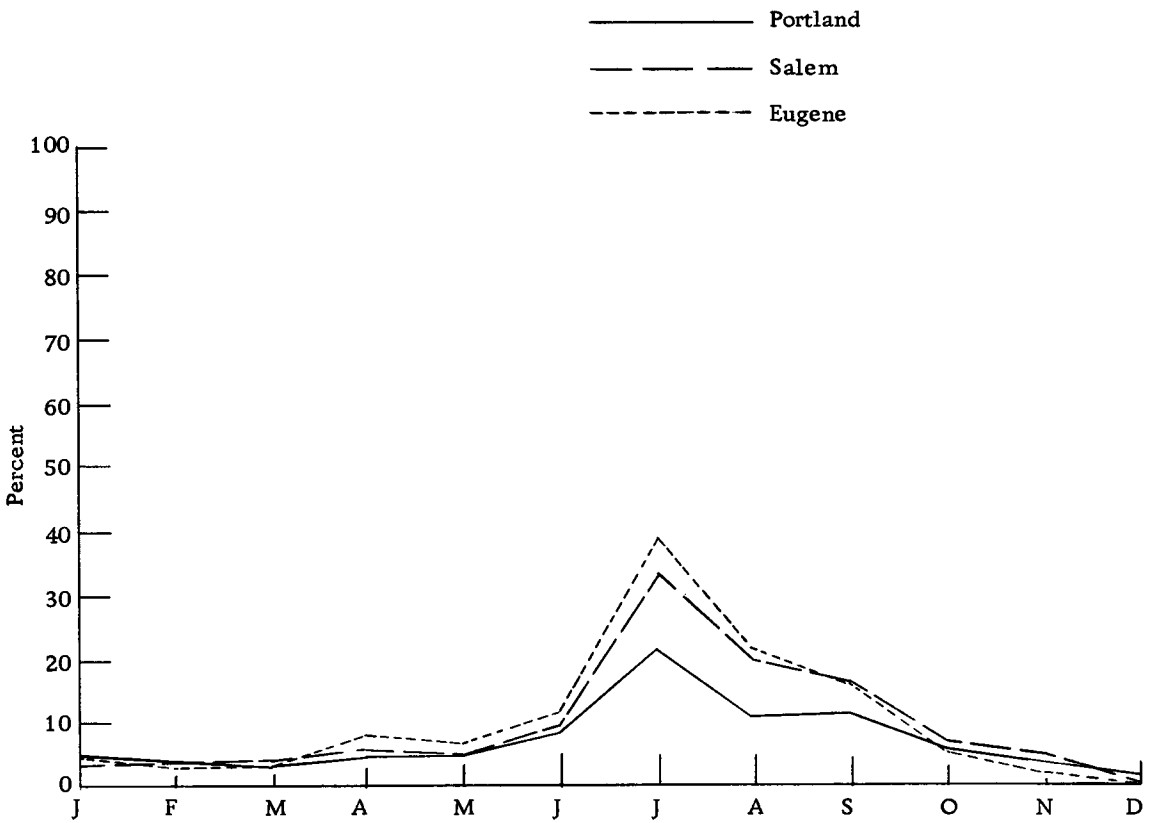

Figure 6. Mean monthly percentage frequency of cloudless days at Portland, Salem, and Eugene, 1949-1963.

July were cloudless. In December 60 percent of the days are overcast in contrast to about 10 percent in July. Figure 6 illustrates a general uniformity of change from month to month, except for June which equals May in the number of overcast days. The greatest variation among stations occurs during the spring and summer months when Portland exceeds Eugene by eight to ten percent more overcast days.

Table 4. Mean Monthly Number of Overcast (10 tenths) Days at Portland, Salem, and Eugene, 1949-1963.

	J	F	M	A	M	J	J	A	S	O	N	D
Portland	19	16	16	12	9	10	4	5	7	12	15	20
Salem	17	15	13	9	8	8	2	4	6	11	15	19
Eugene	18	15	13	9	8	7	1	3	4	11	15	20

Clear, Partly Cloudy, and Cloudy Days

The graphical configuration of the two classes of clear, Figures 5 and 8 (0-5 tenths and 0-3 tenths sky cover, respectively), is very similar, for the unit interval difference (4-5 tenths) between the two classes quantitatively forms a rather small proportion of the sky cover in the Willamette Valley.

Within the three-fold classification the greatest variation among stations occurs in July and August when Eugene exceeds Portland by 15 percent more clear days. Although the number of

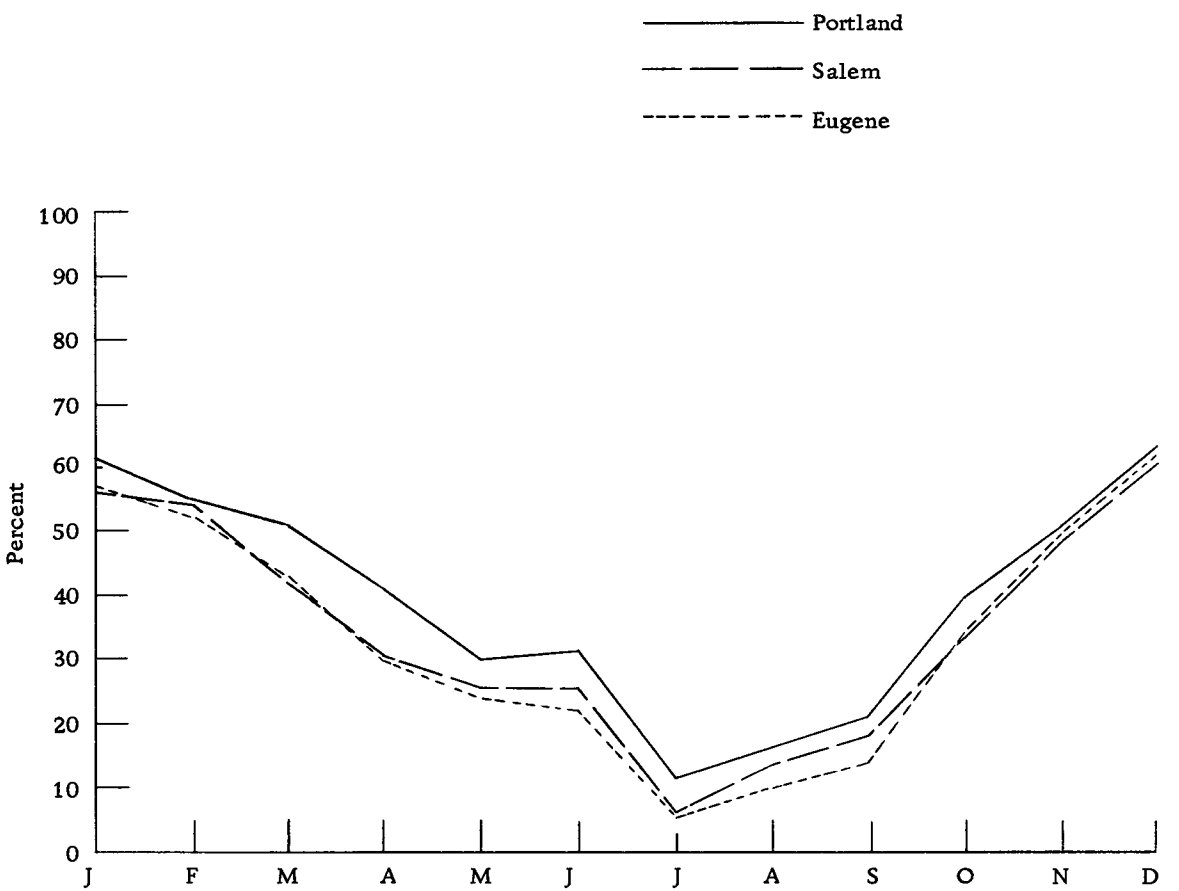

Figure 7. Mean monthly percentage frequency of overcast days at Portland, Salem, and Eugene, 1949-1963.

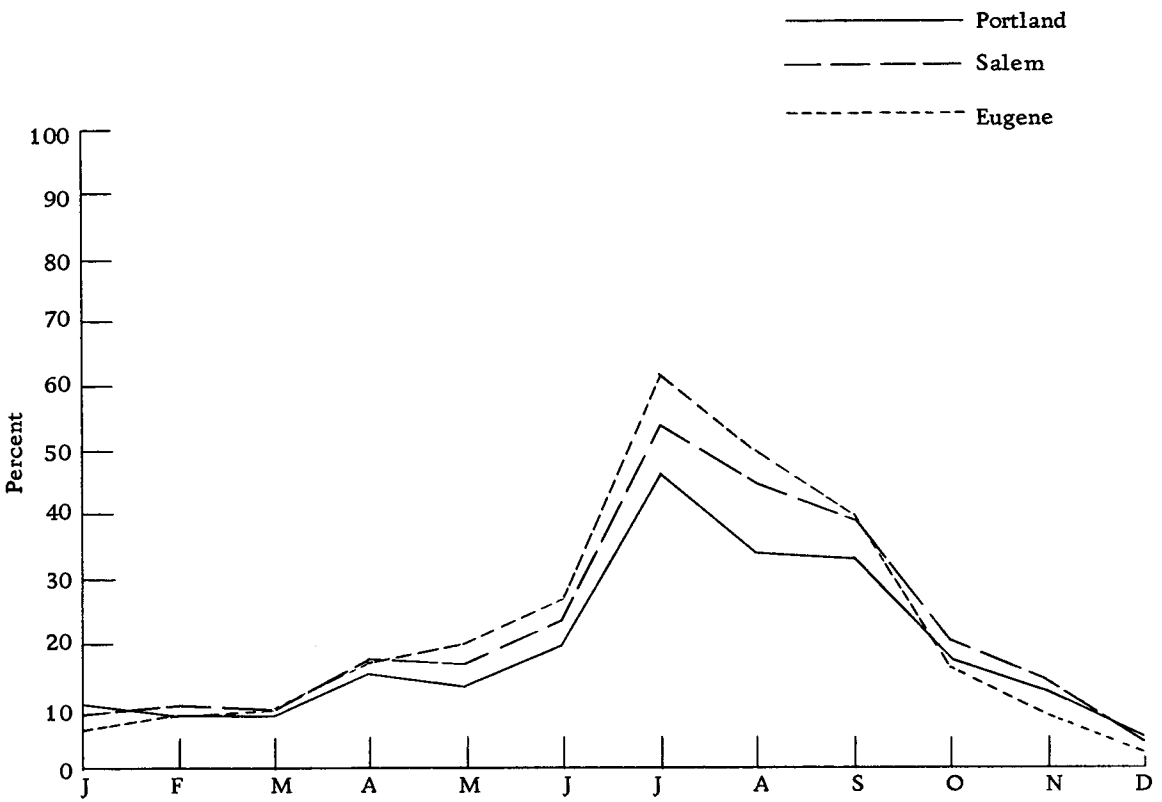

Figure 8. Mean monthly percentage frequency of clear (0-3 tenths) days at Portland, Salem, and Eugene, 1949-1963.

clear days decreases at a more rapid rate from July to September at Eugene than at Portland, both Eugene and Salem have clearer weather in September than Portland does in August. Similar relationships among stations can be found for other months.

Proportions of clear days include under 10 percent in winter, 10 to 30 percent in the spring and fall, and 30 to 50 percent during the summer months. December averages only one clear day at each station, while July averages 14 to 19 days.

In contrast to clear and cloudy days, the average monthly number of partly cloudy days throughout the year is limited to a rather narrow range of three to ten days (10 to 30 percent). Figure 9 shows a uniformity of trend among stations during the winter half of the year--an increase in partly cloudy days from January to April and a decrease from October to December. At Portland the partly cloudy day curve describes a modest peak in August, while at Salem and Eugene there is little monthly change during the warm part of the year.

For nine months of the year more than half the days each month are cloudy. This is in strong contrast to the situation for clear days, in which only one month qualifies. During the winter months 75 to 85 percent are cloudy. In consideration of the relatively large number of cloudy days in the Willamette Valley, the uniformity of monthly change among stations is striking; although variations of about ten

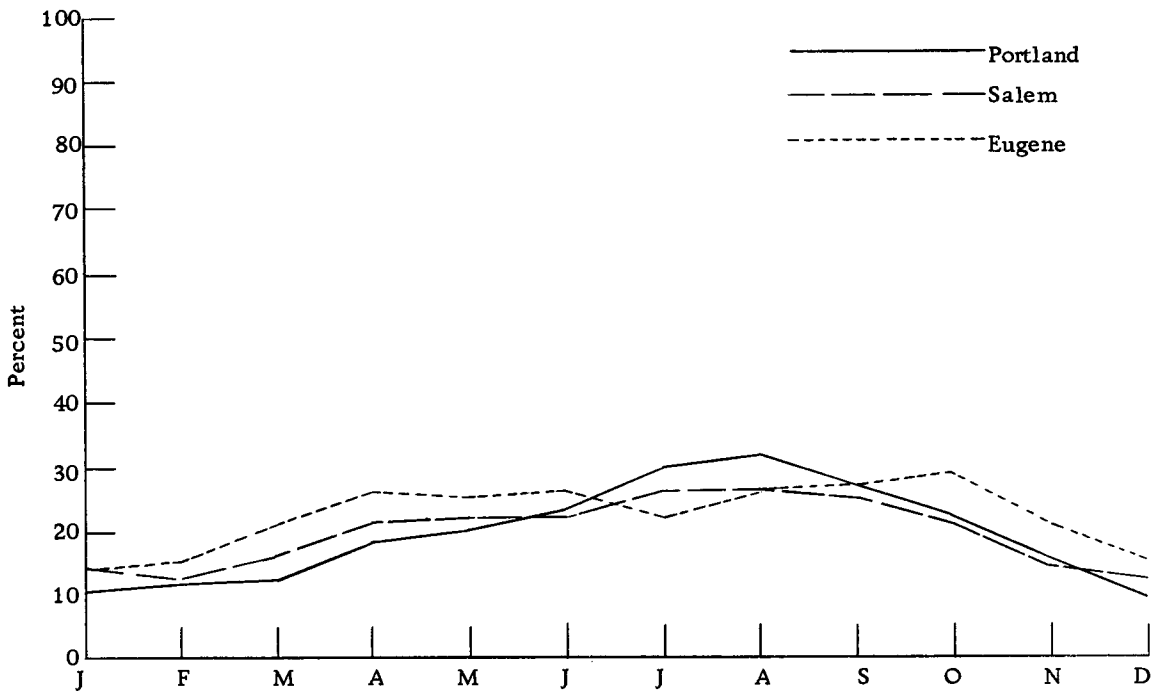

Figure 9. Mean monthly percentage frequency of partly cloudy (4-7 tenths) days at Portland, Salem, and Eugene, 1949-1963.

Table 5. Mean Monthly Number of Clear (0-3 tenths), Partly Cloudy (4-7 tenths), and Cloudy (8-10 tenths) Days at Portland, Salem, and Eugene, 1949-1963.

	J	F	M	A	M	J	J	A	S	O	N	D
						Portland						
Clear	3	2	2	5	4	6	14	11	10	5	4	1
Partly Cloudy	3	3	4	5	6	7	9	10	8	7	4	3
Cloudy	25	23	25	20	21	17	8	10	12	19	22	27
						Salem						
Clear	3	3	3	5	5	7	17	14	12	6	4	1
Partly Cloudy	4	3	5	6	7	7	8	8	7	7	4	4
Cloudy	24	22	23	19	19	16	6	9	11	18	22	26
						Eugene						
Clear	2	2	3	5	6	8	19	16	12	5	2	1
Partly Cloudy	4	4	6	8	8	8	7	8	8	9	6	4
Cloudy	24	22	22	17	17	14	5	7	10	17	22	26

percent occur between Portland and Eugene during the spring and summer months, Salem has an intermediate number of cloudy days. Since the number of partly cloudy days each month is comparatively uniform, Figure 10 (percentage frequency of cloudy days) tends to form an inverted mirror image of Figure 8 (clear days).

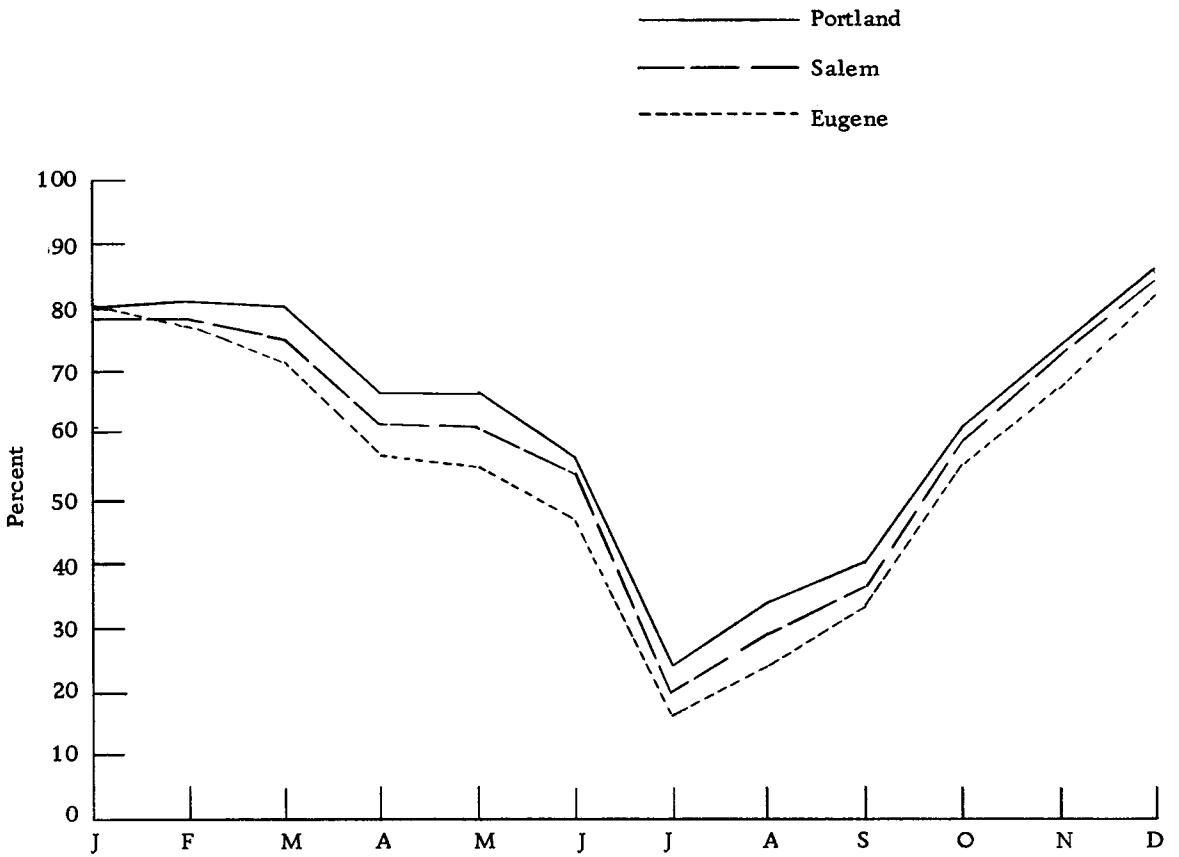

Figure 10. Mean monthly percentage frequency of cloudy (8-10 tenths) days at Portland, Salem, and Eugene, 1949-1963.

III. ANNUAL AND MONTHLY VARIATION IN CLOUDINESS

In the preceding chapter only the average conditions of sky cover are described, comparing Portland, Salem, and Eugene for the period 1949 through 1963. The present chapter is an analysis of the annual and monthly variation from the mean by the investigation of the extremes and the mean deviations of the sky cover conditions selected.

The annual and monthly mean deviations are calculated by finding the sum of the positive and negative deviations and dividing by 15, the number of years in the period selected. Although the figures thus derived are a useful expression of the overall average deviation for station and temporal comparisons, they do not indicate whether there is a tendency for smaller and more numerous deviations above the mean and larger and fewer deviations below the mean, or vice versa. The number of positive and negative deviations, therefore, are tabulated together with the mean deviations in Tables 6 through 9. The graphs in this chapter indicate the average deviation above and below the mean (mean positive and mean negative deviations) derived by separately finding the sums of positive and negative deviations and dividing each by the number of years represented.

Annual Variation

Percent Sky Cover

The annual percent sky cover at Portland, Salem, and Eugene from 1949 through 1963 is shown in Figure 11. The year-to-year variation in cloudiness among stations is remarkably uniform, with Portland generally exceeding Salem by two to six percent and Salem exceeding Eugene by three percent or less each year. In view of the rather uniform relationship among stations for most years, it is of interest to note that during two years Salem and Eugene had more cloudy weather than Portland.

At Portland, Salem, and Eugene the maximum ranges in cloudiness during the 15-year period are 65 to 77 percent, 64 to 74 percent, and 61 to 72 percent, respectively. The range between extremes, therefore, is much the same for each station--about 11 percent, and the overall range for all three stations is 16 percent.

The mean deviation at each station is only two or three percent. At Portland and Salem the number of deviations above and below the mean are about equal, but at Eugene there is a tendency for more numerous but smaller deviations below the mean and fewer but greater deviations above the mean.

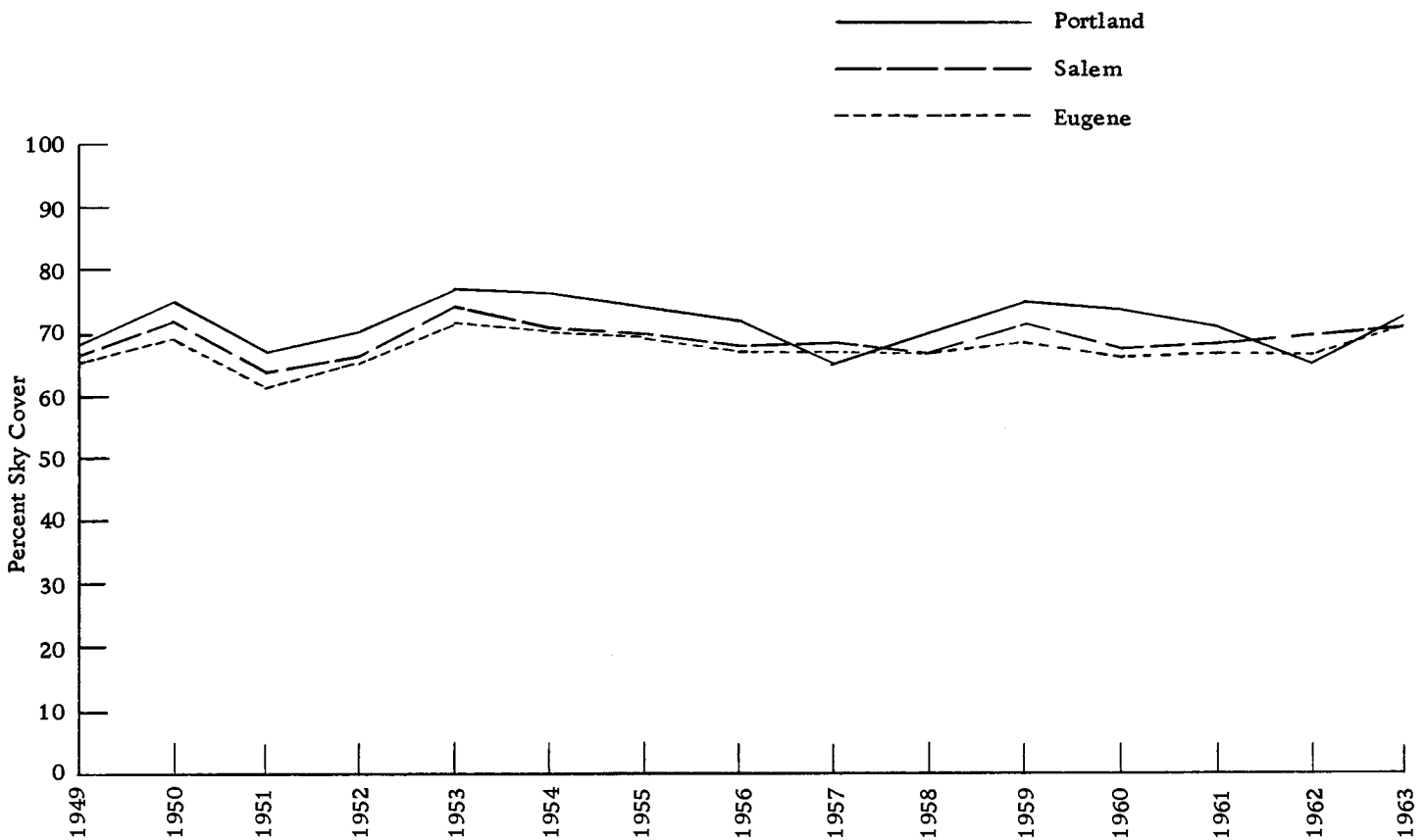

Figure 11. Annual percent sky cover at Portland, Salem and Eugene, 1949-1963.

Frequency of Occurrence of Sky Cover Conditions

Figure 12 is a comparison of the period mean, mean positive and mean negative deviations, and maximum and minimum frequency of occurrence of the selected sky cover conditions. The actual year-to-year fluctuation during the 15-year period is illustrated only for the number of clear days (0-5 tenths sky cover).

Clear and Cloudy Days

Figure 13 shows that Portland had the fewest clear days for the 15-year period, varying between 1 and 22 days from the other two stations each year. Eugene exceeded Salem in the number of clear days most years, but only by a maximum of 14 days. The range between extremes increases from 38 days at Portland to 48 days at Eugene, and the overall range among all three stations for the 15-year period is 74 days. The mean deviation for each station is about 9 days, indicating that the total number of clear and cloudy days does not change much from year to year.

Cloudless and Overcast Days

The extreme range in the annual number of cloudless days (Figure 12) for all three stations is 18 to 50 days, an inclusive range of nine percent of the total number of days per year. Eugene experiences a somewhat greater range between extremes than Portland,

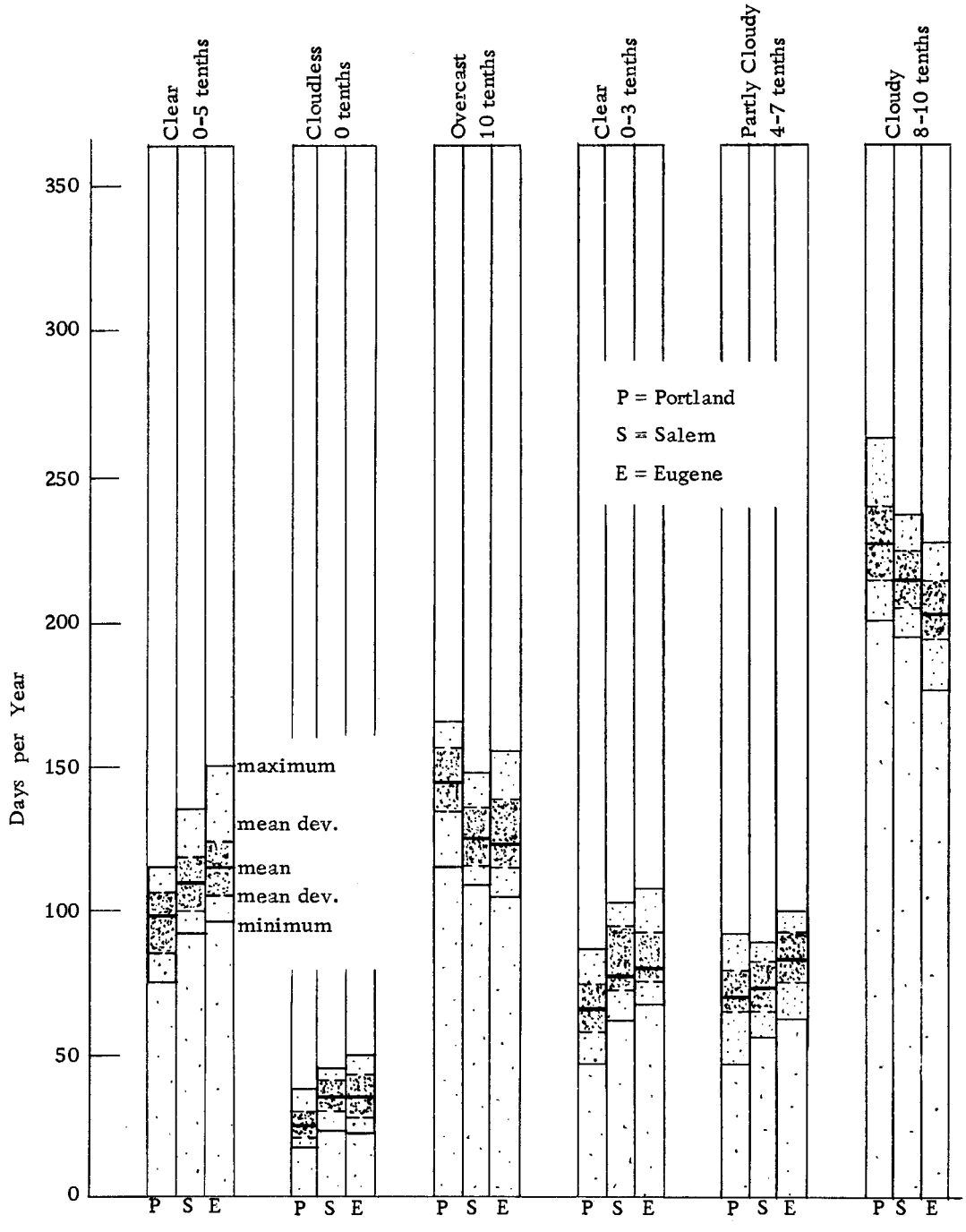

Figure 12. Annual mean, mean deviation, and maximum and minimum frequency of occurrence of sky cover conditions for the period 1949-1963.

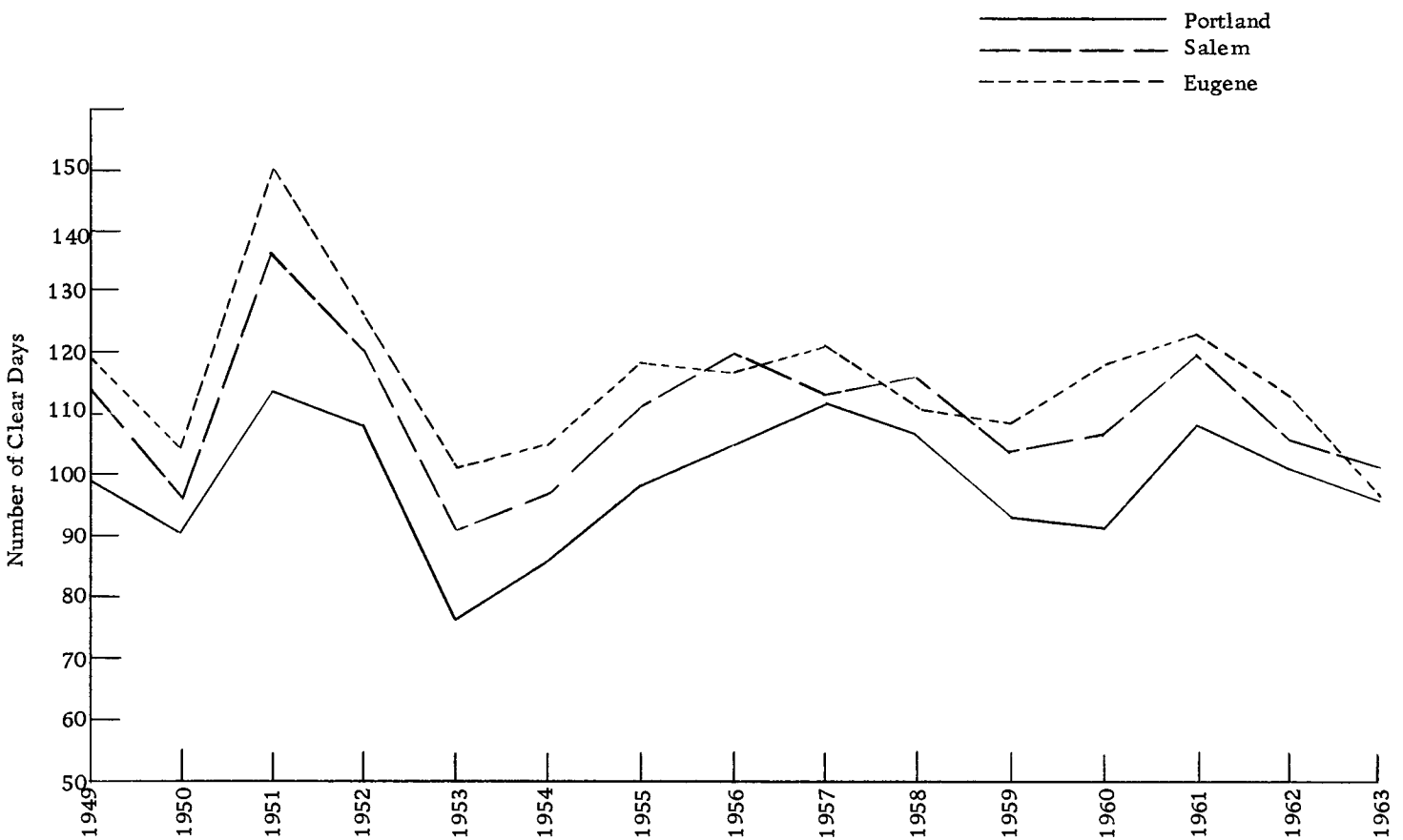

Figure 13. Annual number of clear (0-5 tenths) days at Portland, Salem, and Eugene, 1949-1963.

and the corresponding mean deviations for the two stations are eight and six days. The number of cloudless days, while forming a small proportion to the total days per year, does fluctuate from year to year; a maximum year can have more than twice as many cloudless days as the minimum year.

The extreme range in the annual number of overcast days for the 15-year period in the Willamette Valley is 106 to 165 days, an inclusive range of 16 percent of the total number of days per year. The individual stations have inclusive ranges varying from 10 to 14 percent. The mean deviation for the three stations is 10 to 12 days or about three percent. At Eugene two years had an unusually large number of overcast days.

Clear, Partly Cloudy, and Cloudy Days

For the three stations together the extreme range in the annual number of clear days (Figure 12) is 47 to 108 days or 17 percent of the total number of days per year. The mean deviations of six to nine days indicate modest variation in most years. Salem and Eugene have two or three times as many deviations below as above the mean, indicating the occasional occurrence of an unusually clear year.

The minimum and maximum annual number of partly cloudy days for the three stations are 47 and 100 days, a range of 14 percent.

Portland has the greatest range between extremes of 47 to 91 days or 12 percent. The mean deviation for each of the three stations is either seven or eight days. Partly cloudy days, therefore, have variations that are quantitatively similar to clear days.

The extreme range in the annual number of cloudy days at Portland, Salem, and Eugene is 177 to 263 days, an inclusive range of 24 percent. Portland has the greatest range of 200 to 263 days or 17 percent of the total number of days per year. Portland has a mean deviation of 13 days, while for Salem and Eugene the figure is 10 days. The latter two stations have nearly equal numbers of deviations above and below the mean, but Portland has a higher proportion of negative deviations. One year at Portland, however, had as many as 35 days above the mean.

Monthly Variation

Percent Sky Cover

The monthly extremes in percent sky cover at Portland, Salem, and Eugene for the period 1949 through 1963 are shown in Figure 14. From November through May the three stations vary from one another in range between extremes by less than ten percent. The greatest variation among stations has occurred in August when Portland has exceeded Eugene by 16 percent sky cover.

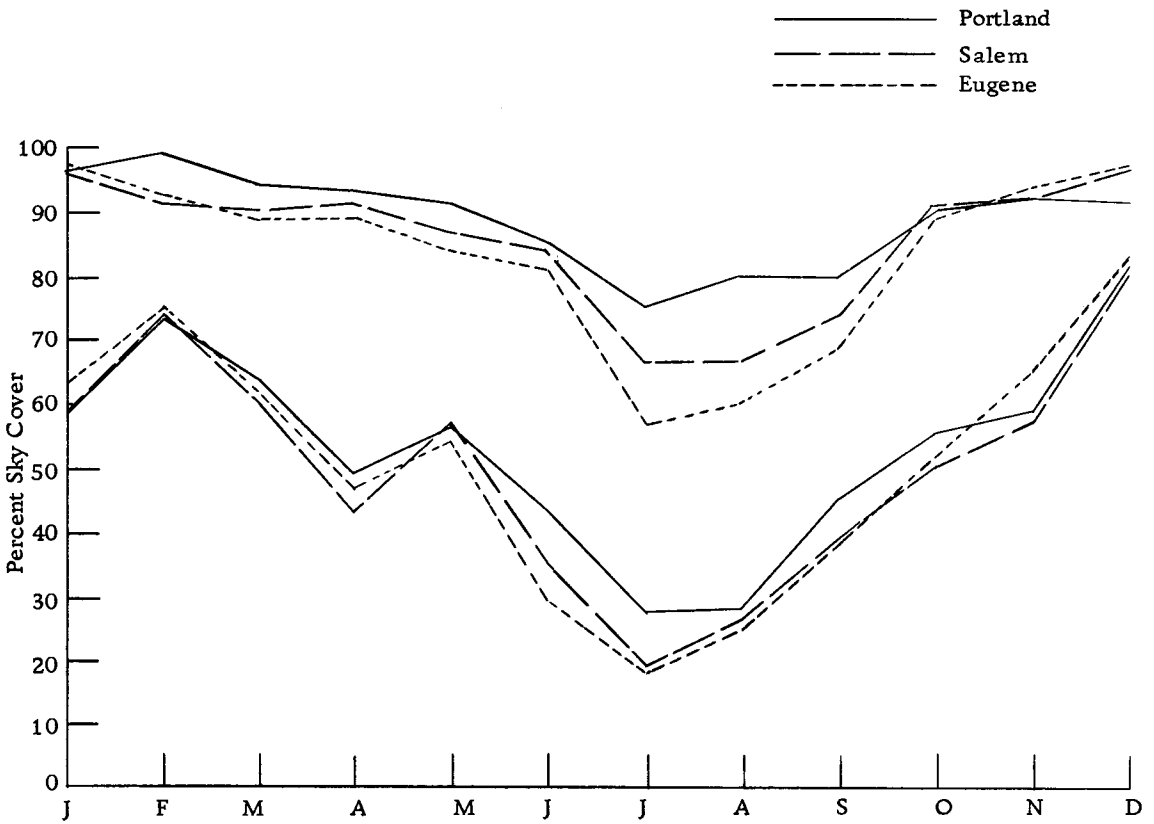

Figure 14. Monthly extremes in percent sky cover at Portland, Salem, and Eugene, 1949-1963.

Table 6. Monthly Mean Deviation and the Number of Years with Deviations Above and Below the Mean Percent Sky Cover at Portland, Salem, and Eugene During the Period 1949-1963.

	J	F	M	A	M	J	J	A	S	O	N	D
						Portland						
MD (%)	9	6	6	9	8	13	11	10	7	8	8	4
+ (Months)	9	8	8	9	6	10	6	9	6	8	9	9
- (Months)	5	7	5	6	9	5	9	5	9	7	6	5
						Salem						
MD (%)	8	5	6	9	7	14	11	9	6	8	9	4
+ (Months)	9	7	9	9	4	10	6	9	5	7	10	9
- (Months)	5	8	6	6	10	5	9	5	7	8	5	5
						Eugene						
MD (%)	8	5	5	8	8	14	9	9	6	7	7	3
+ (Months)	9	7	8	7	4	9	6	9	7	7	8	8
- (Months)	5	8	7	8	10	5	8	6	8	8	5	6

The range between extremes in sky cover is 25 to 50 percent from March through November, with June through September exhibiting the greatest interval between extremes. December and February show the smallest range between extremes, being quite cloudy during each of the 15 years of record.

Portland exceeds Salem and Eugene in maximum cloudiness most months of the year; in winter the three stations vary from one another by only a few percent. Portland varies from Eugene by about 20 percent in July and August. The maximum monthly cloudiness for the 15-year period has exceeded 80 percent during each of the nine months October through June. Even July, the clearest month, can experience considerable cloudiness; Eugene and Portland have had maxima of 55 and 75 percent, respectively.

The minimum figures of percent sky cover at the three stations vary from one another by less than 10 percent each month and range from about 20 to 30 percent in July to 80 percent in December. The three stations show more abrupt month-to-month changes in minimum cloudiness than maximum cloudiness. In February and May each station notably exceeds the minimum sky cover percentages of both the preceding and succeeding months.

The monthly mean deviations at Portland, Salem, and Eugene are shown in Table 6. The greatest mean deviation of 14 percent occurs in June, and the smallest mean deviation of about three

percent occurs in December. With few exceptions the mean deviations each month vary by only one percent among stations. While the three stations differ in the average monthly amount of cloudiness, particularly during the summer months, they correlate remarkably well in the degree of variation from the mean.

Figure 15 shows the relationships among the monthly means, mean positive and mean negative deviations, and extreme percent sky cover at Salem. December and February have not experienced periods of unusually clear weather during the 15-year period, while January had a minimum as low as 58 percent sky cover. Each of the summer months has been unusually cloudy.

Frequency of Occurrence of Sky Cover Conditions

Clear and Cloudy Days

The monthly extremes in the number of clear days at Portland, Salem, and Eugene are shown in Figure 16. Portland and Salem generally have a slightly greater monthly range between extremes than Eugene, but they do not differ from one another by more than five days. The three stations vary from highs of 15 to 20 clear days between extremes in April, June, July, and August to lows of five to ten days in February and December.

The greatest monthly variation among stations in the maximum

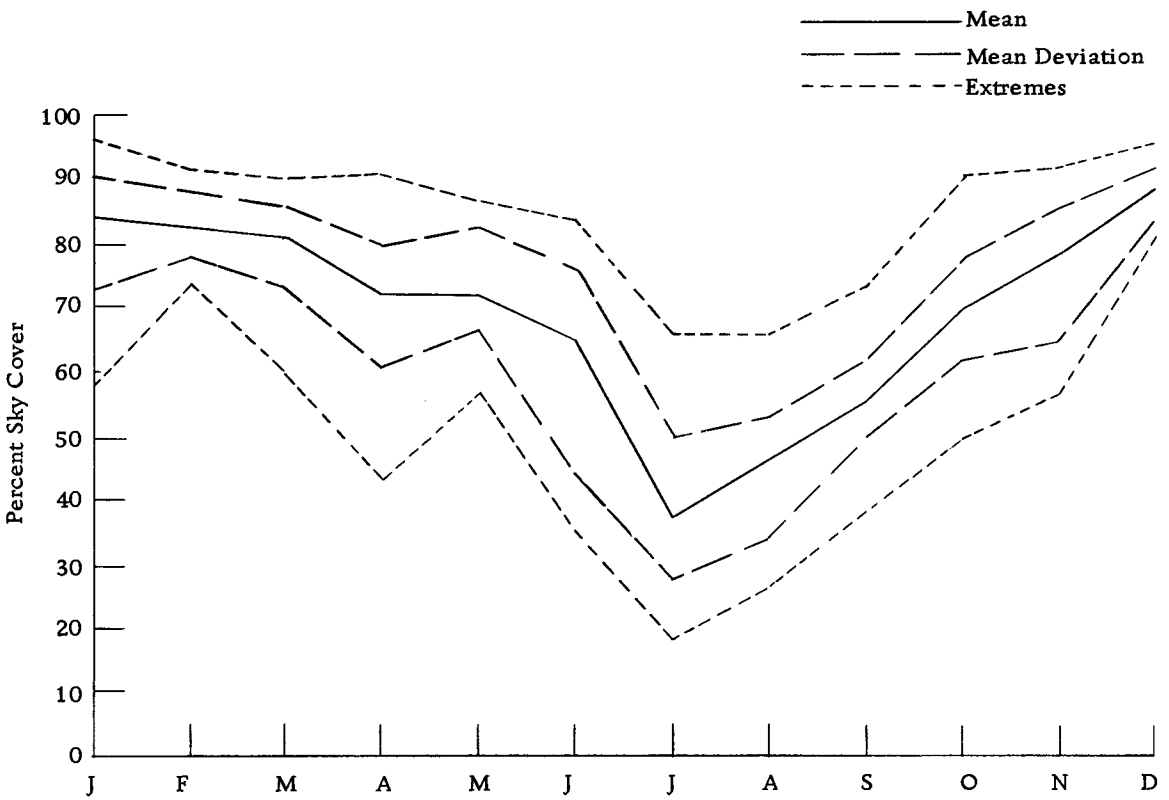

Figure 15. Monthly mean, mean deviation, and extreme percent sky cover at Salem, 1949-1963.

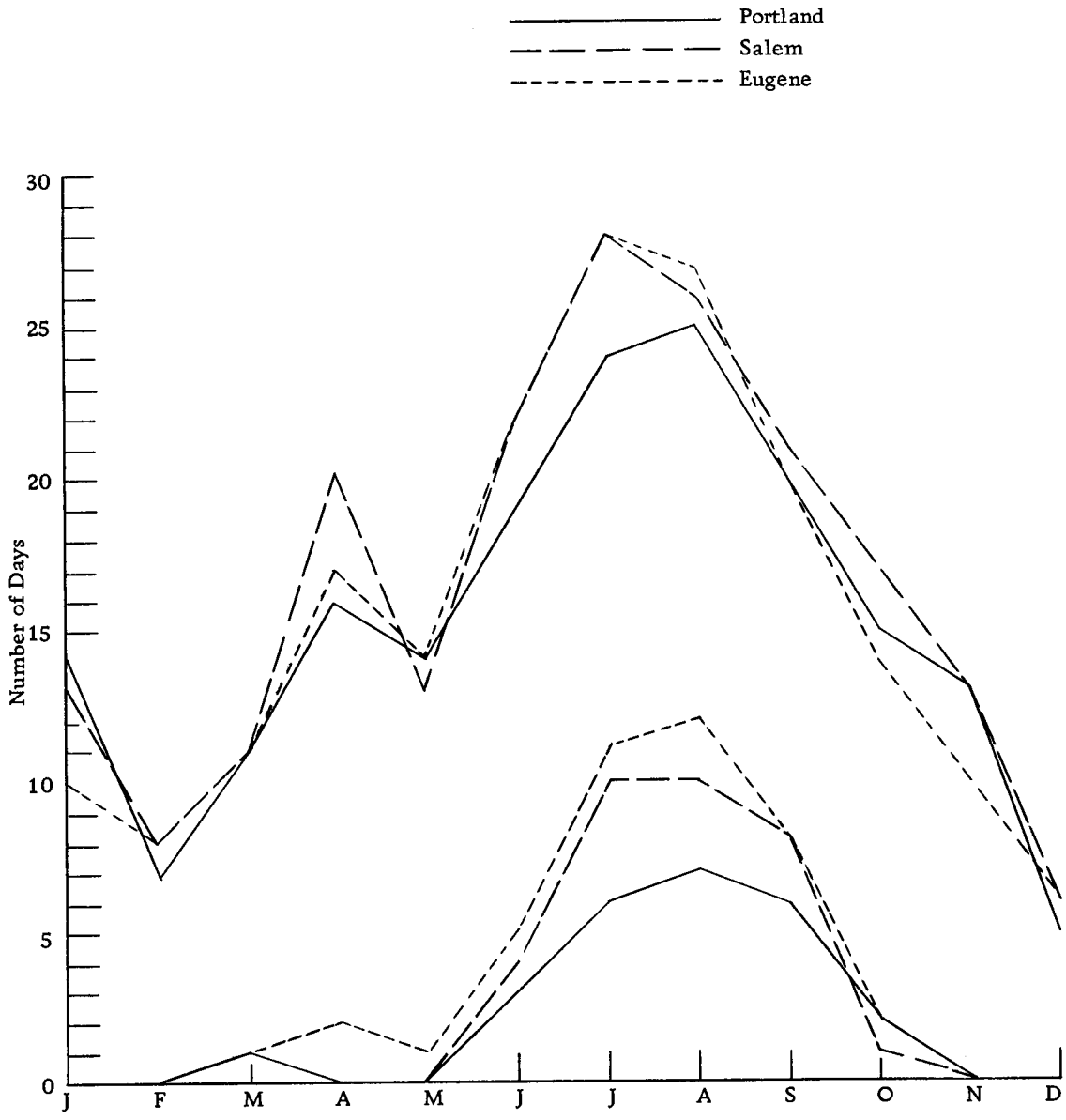

Figure 16. Monthly extremes in the number of clear (0-5 tenths) days at Portland, Salem, and Eugene, 1949-1963.

number of clear days in only four days. January and April have each had higher maxima than both the preceding and succeeding months. July and August have had as many as 24 to 28 clear days in July and August, while December and February have not exceeded five to eight clear days at any of the stations.

The greatest monthly variation among stations in the minimum number of clear days is six days in both July and August. Eight months, October through May, have had minima of two or fewer clear days, and each of the stations during the 15-year period has experienced no clear days during the months November through February. Even the summer months have been occasionally quite cloudy with two thirds or more days being cloudy.

Figure 17 shows the monthly mean positive and mean negative deviations in relation to the mean and extreme number of clear days at Salem. The highest monthly mean deviation of five clear days occurs in June, and with the supplement of Table 7 it can be seen that in some years this month was exceptionally clear. December, February, and March have mean deviations of only one or two days, while January, having experienced unusually clear weather, has a somewhat higher mean deviation. The three stations differ from one another each month by a mean deviation of not more than one day.

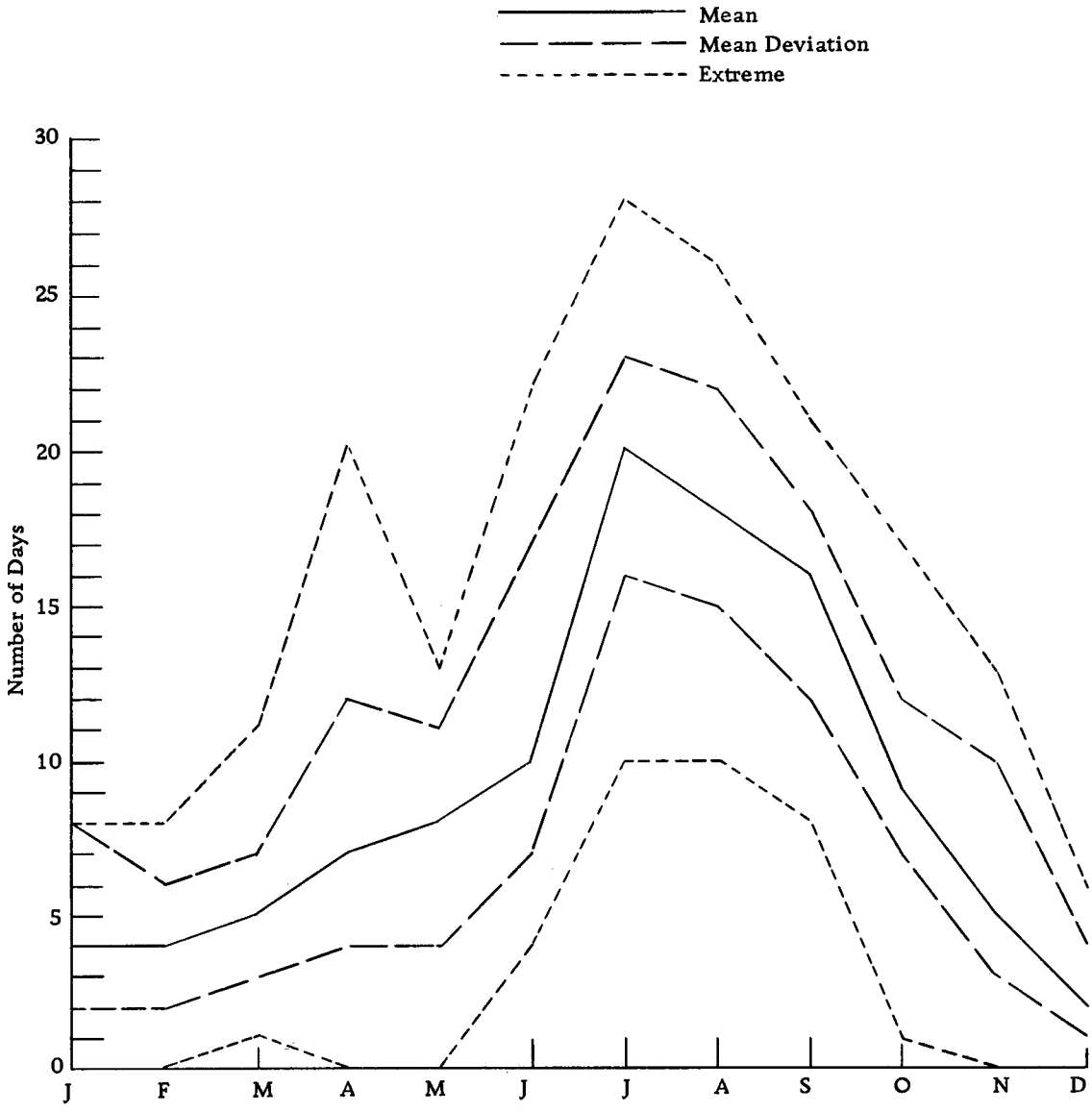

Figure 17. Monthly mean, mean deviation, and extreme number of clear (0-5 tenths) days at Salem, 1949-1963.

Table 7. Monthly Mean Deviation and the Relative Number of Years with Deviations Above and Below the Mean Number of Clear (0-5 tenths) Days at Portland, Salem, and Eugene During the Period 1949-1963.

	J	F	M	A	M	J	J	A	S	O	N	D
						Portland						
Mean Deviation (Days)	4	2	2	4	3	5	4	4	3	3	3	2
Positive Deviations (Months	5	6	8	6	8	5	8	5	6	5	5	6
Negative Deviations (Months)	10	7	6	7	5	10	5	9	6	8	9	8
						Salem						
Mean Deviation (Days)	3	2	2	4	3	5	4	4	3	3	3	1
Positive Deviations (Months)	6	7	6	6	9	5	8	6	9	5	5	4
Negative Deviations (Months)	9	6	7	8	6	10	5	7	4	7	9	5
						Eugene						
Mean Deviation (Days)	3	2	2	3	4	5	4	4	2	3	3	1
Positive Deviations (Months)	6	7	5	7	8	5	8	7	6	6	6	5
Negative Deviations (Months)	8	7	7	7	7	10	5	8	7	9	9	6

Cloudless and Overcast Days

The monthly extreme number of cloudless days at each of the three stations is shown in Figure 18. Most months have differences among stations of fewer than four days in the maximum number of cloudless days. In July, however, Eugene has had a maximum exceeding that of Portland by eight days (21 and 13 days, respectively). This constitutes an even greater variation than that of the number of clear (0-5 tenths sky cover) days among stations, showing that Portland tends to have more days of partial cloudiness than Salem or Eugene in July. From September through May the maximum number of cloudless days generally has been fewer than ten, with a low maximum of only two cloudless days in December. Nine months, October through June, have in some years experienced no cloudless days. The three summer months have had minimum extremes of five or fewer cloudless days.

The mean deviations, shown in Table 8, correlate within one day among stations each month except July. Months during the winter half of the year generally have mean deviations of one day. July, averaging a deviation of four cloudless days at Salem and Eugene, is the month with the greatest variation in contrast to June being the most variable in clear (0-5 tenths sky cover) weather. The proportion of cloudless to clear days, however, is comparatively small in June; hence, there cannot be as much variation as in July.

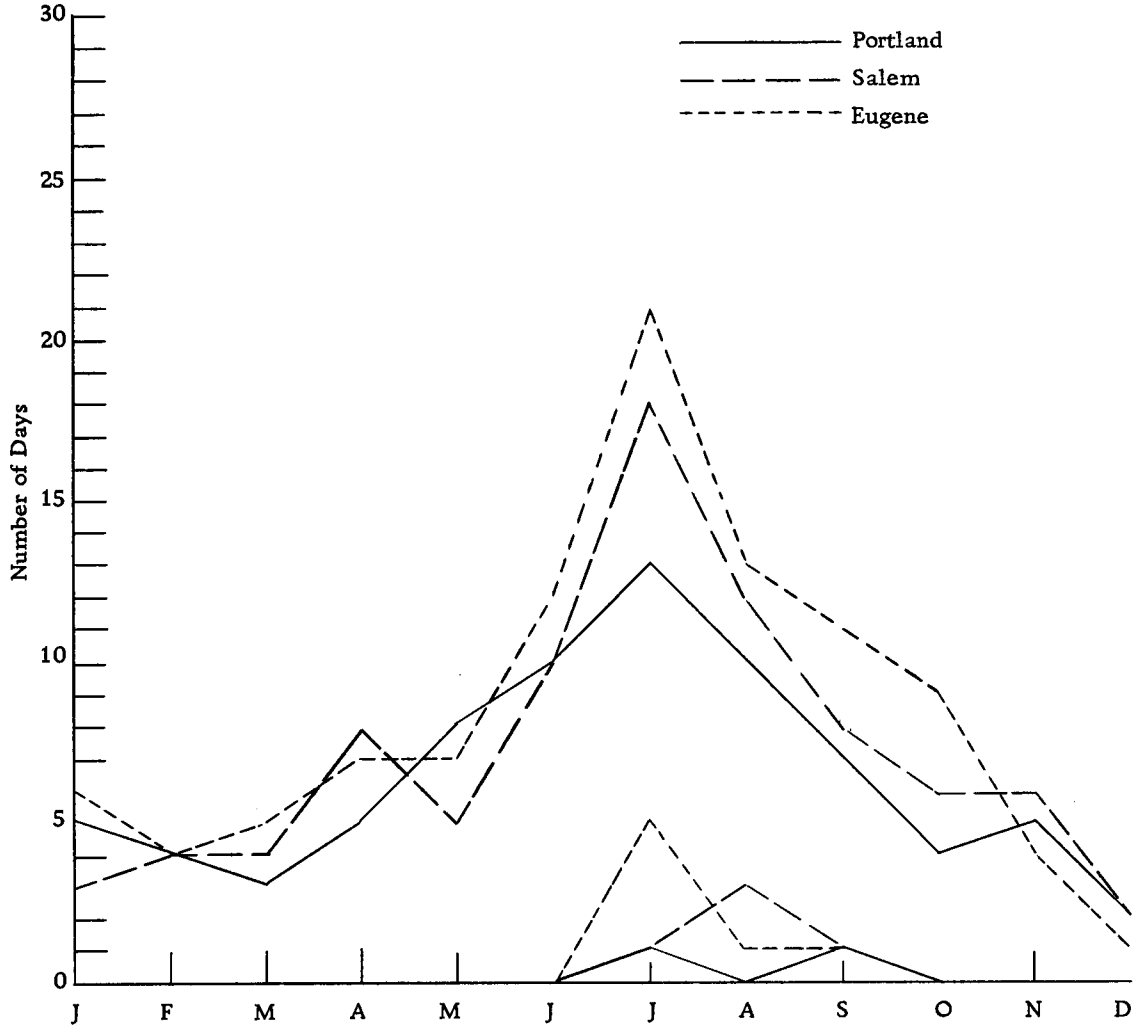

Figure 18. Monthly extreme number of cloudless days at Portland, Salem, and Eugene, 1949-1963.

Table 8. Monthly Mean Deviation and the Number of Years with Deviations Above and Below the Mean Number of Cloudless (0 tenths) and Overcast (10 tenths) Days at Portland, Salem, and Eugene During the Period 1949-1963.

	J	F	M	A	M	J	J	A	S	O	N	D
						Cloudless Days						
MD Portland	2	1	1	1	1	2	2	2	2	1	1	1
+	4	5	4	3	2	5	7	6	4	5	3	2
-	4	6	8	10	9	9	6	6	8	8	4	8
MD Salem	1	1	1	1	1	3	4	2	2	2	1	0
+	6	4	6	4	4	4	10	6	8	4	3	(3)
-	8	7	6	7	9	10	5	9	6	7	9	(12)
MD Eugene	1	1	1	1	1	3	4	3	2	2	1	0
+	4	2	3	3	7	5	6	5	5	2	3	(1)
-	8	8	7	7	5	9	6	8	8	10	9	(14)
						Overcast Days						
MD Portland	4	3	3	3	3	4	3	2	2	3	3	2
+	9	6	5	7	5	7	8	4	3	5	5	7
-	5	8	8	6	7	6	4	9	10	7	7	6
MD Salem	3	2	3	2	2	4	2	2	2	3	3	2
+	7	6	7	7	5	8	7	5	3	6	8	6
-	6	6	5	7	6	6	7	6	9	7	7	7
MD Eugene	4	2	3	2	3	3	1	2	1	3	3	3
	8	6	8	4	6	6	4	5	7	5	7	4
	5	7	5	7	7	8	10	5	5	9	8	9

The monthly extremes in the number of overcast days are shown in Figure 19. During most months of the year, Salem and Eugene correlate more closely with one another in the maxima than with Portland. In December and January the three stations have had highs of 22 to 26 overcast days. Portland has had as many as 26 overcast days in February, while Salem and Eugene have had maxima for the same month of 18 or 19 days. The greatest variation among stations, however, has occurred in September when Portland has had twice as many overcast days as Eugene. The low points of the maximum curves are in July and August.

The monthly minima show a greater degree of correlation among stations than the maxima, with the greatest variation for any month being only four days. At all three stations during the 15-year period no December has had fewer than about half the days qualifying in the overcast category of cloudiness, and February is not far behind. In contrast, at least one July at each station has had no overcast days.

The monthly mean deviations in number of overcast days at the three stations, shown in Table 8, vary between one and four days. For each month the three stations vary from one another by only one day except in July.

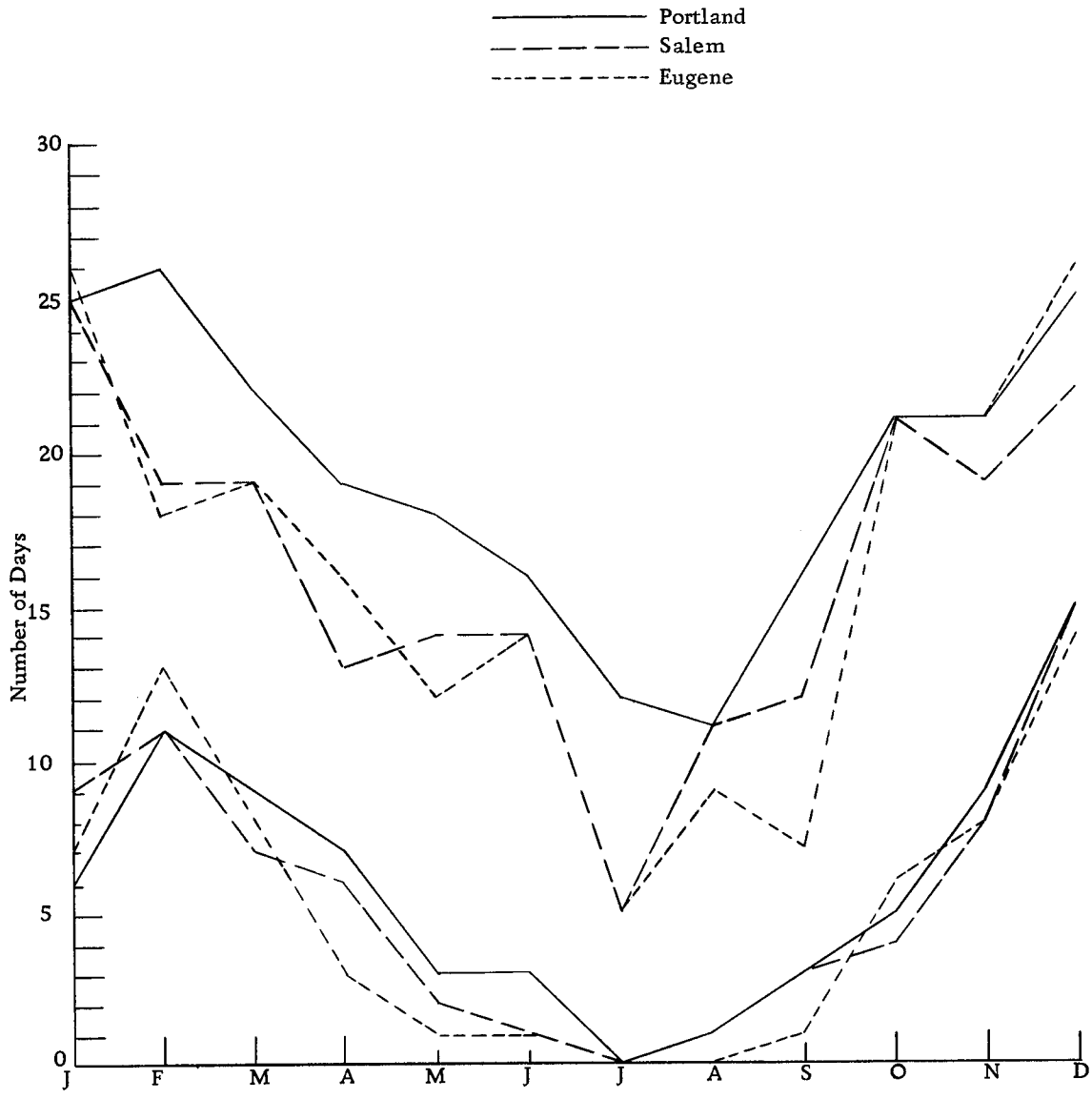

Figure 19. Monthly extreme number of overcast (10 tenths) days at Portland, Salem, and Eugene, 1949-1963.

Clear, Partly Cloudy, and Cloudy Days

Figures 20, 21 and 22 show, respectively, the monthly extreme number of clear, partly cloudy, and cloudy days at the three stations. Table 9 indicates the monthly mean deviations and the number of years with deviations above and below the monthly means for the three cloudiness categories.

The extreme curves for clear days of 0-3 tenths sky cover are very similar to the curves for clear days of 0-5 tenths sky cover. The greatest variation in the maximum among stations is a seven day difference between Salem and Eugene in November. July has had a notable high maximum of 23 to 27 clear days, while December has had a low maximum of only three to five clear days.

Portland and Eugene vary by seven days in the minimum number of clear days in August. Each station has experienced one or no clear days during each of the eight months October through May. Portland and Salem have had minima of two to seven clear days during the three clearest months, while at Eugene they range between six and eleven days.

The maximum curves for partly cloudy days show that the greatest variation among stations is in October when Eugene has exceeded Salem by seven days. During all other months of the year, the variation does not exceed four days. In some years during the

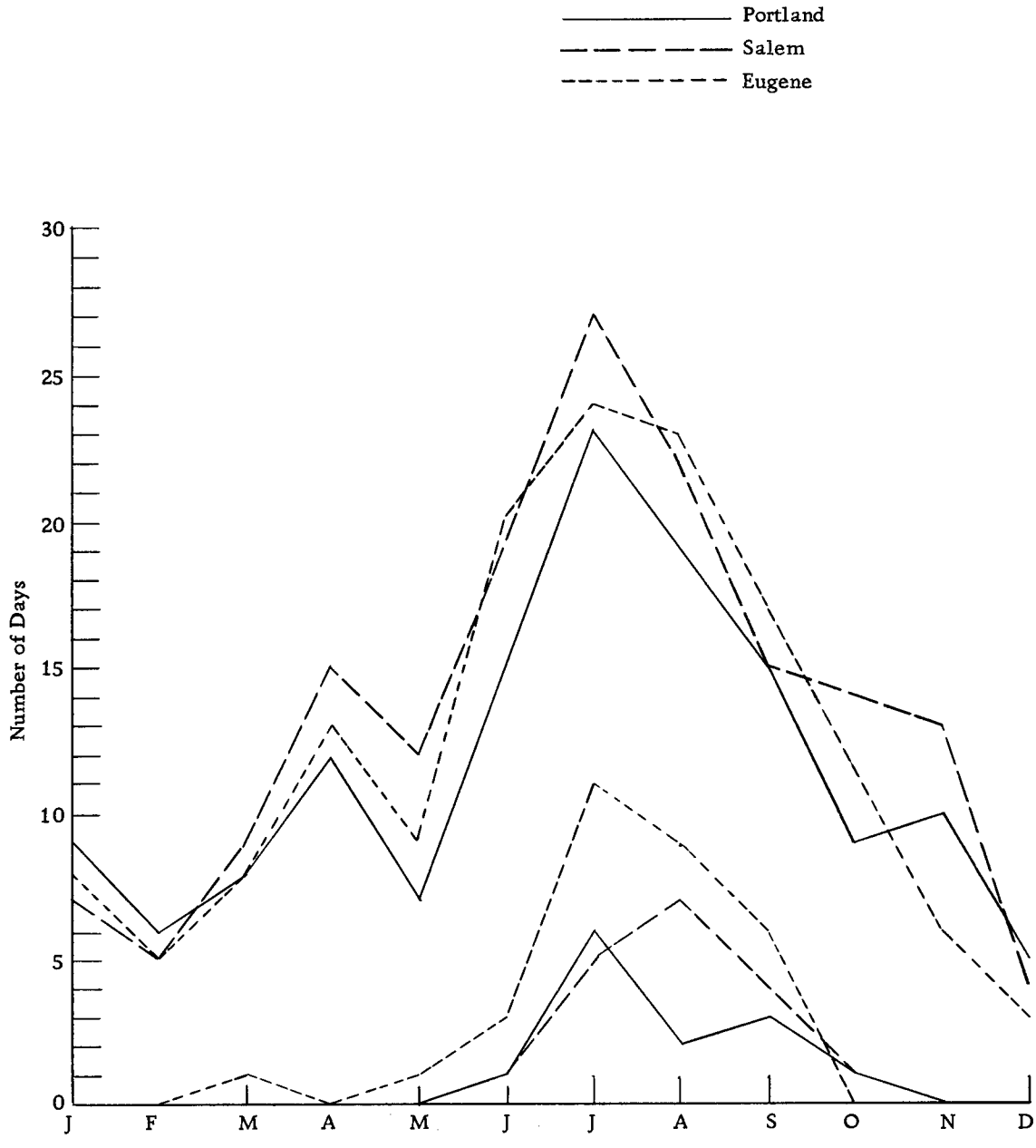

Figure 20. Monthly extreme number of clear (0-3 tenths) days at Portland, Salem, and Eugene, 1949-1963.

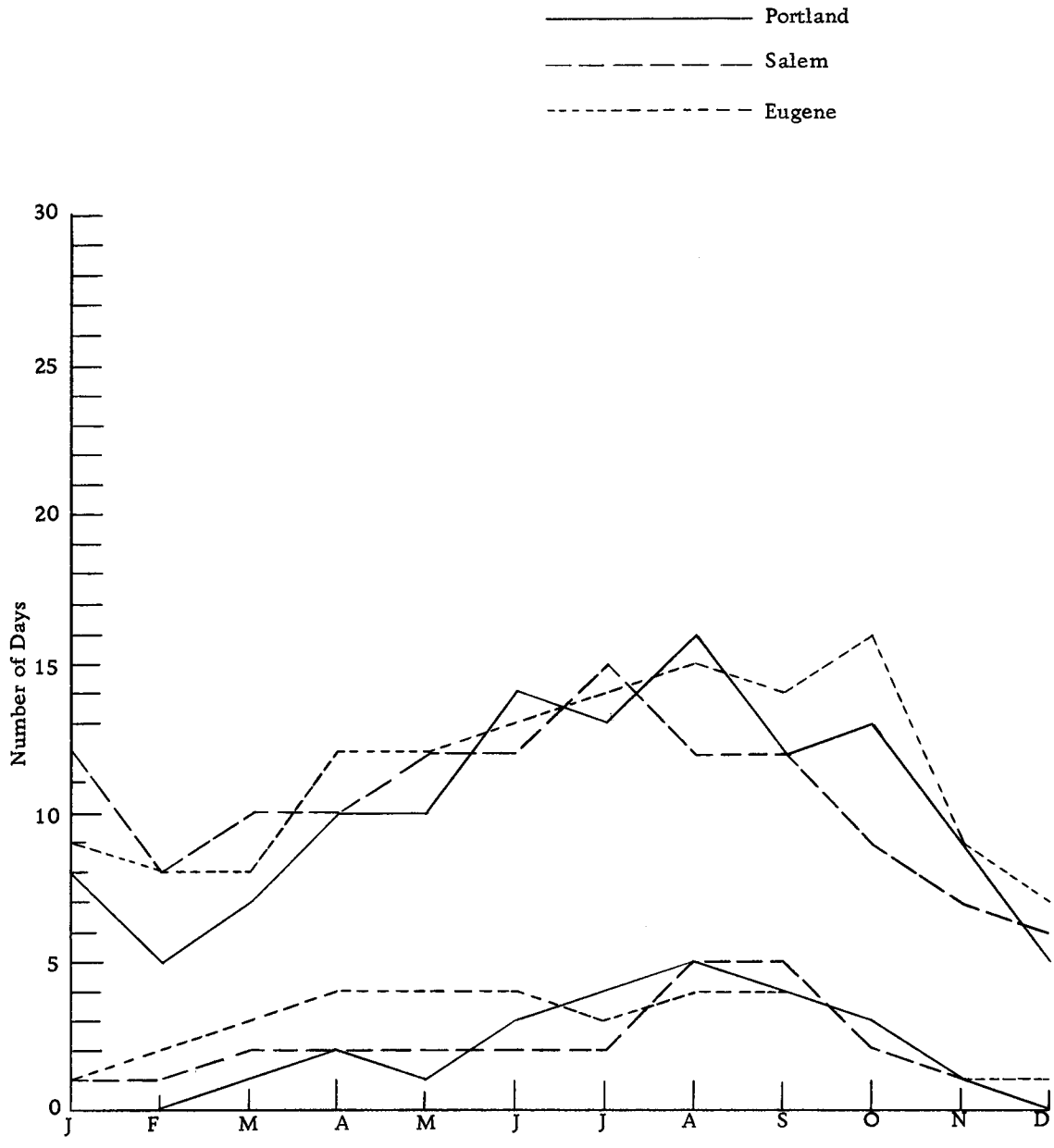

Figure 21. Monthly extreme number of partly cloudy (4-7 tenths) days at Portland, Salem, and Eugene, 1949-1963.

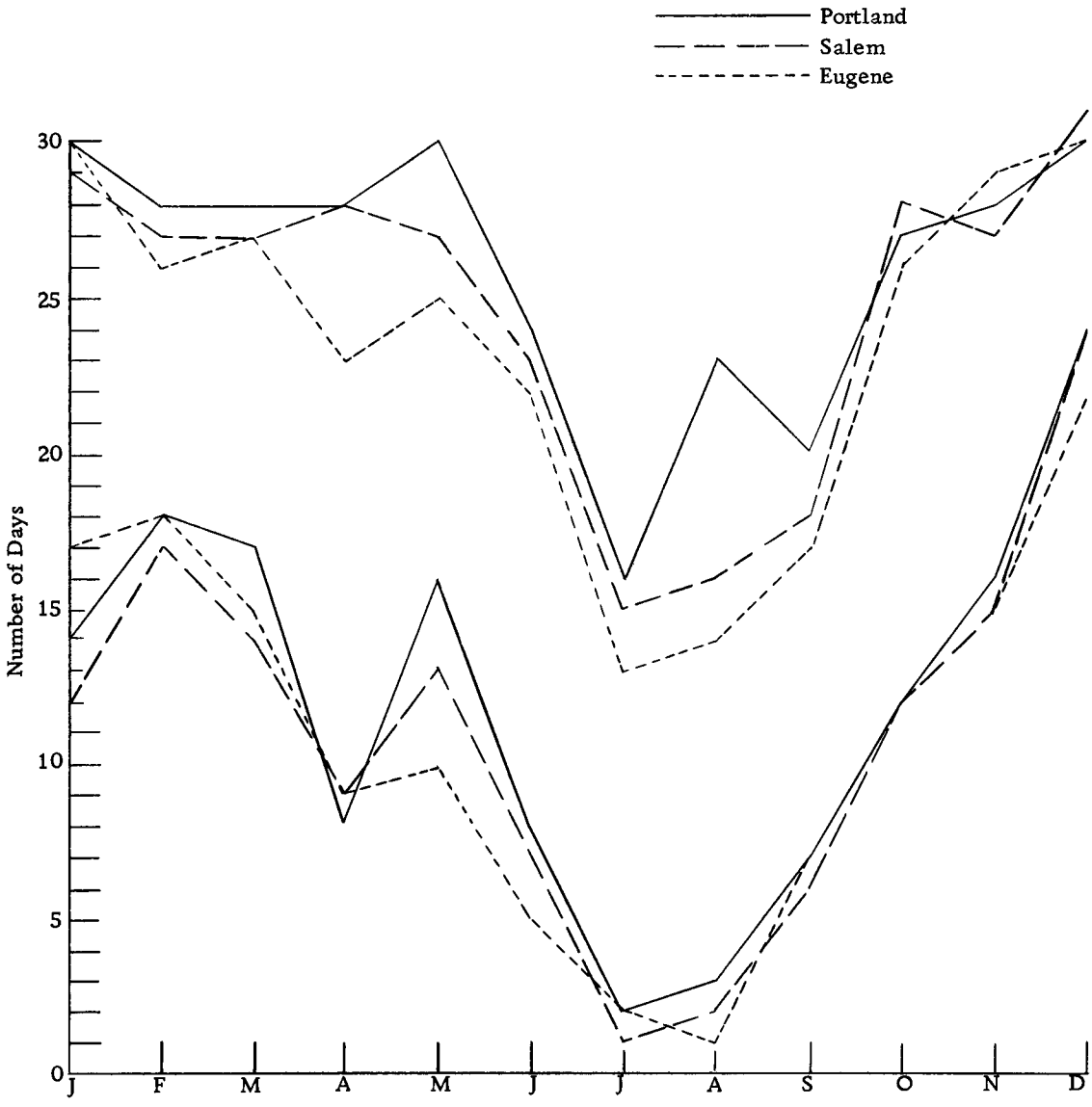

Figure 22. Monthly extreme number of cloudy (8-10 tenths) days at Portland, Salem, and Eugene, 1949-1963.

Table 9. Monthly Mean Deviation and the Number of Years with Deviations Above and Below the Mean Number of Clear (0-3 tenths), Partly Cloudy (4-7 tenths), and Cloudy (8-10 tenths) Days at Portland, Salem, and Eugene During the Period 1949-1963.

	Portland			Salem			Eugene		
	MD	+	-	MD	+	-	MD	+	-
				Clear Days					
Jan.	2	4	8	2	4	8	2	4	7
Feb.	2	6	5	2	5	6	2	6	5
Mar.	2	7	6	2	5	7	2	5	8
Apr.	2	4	7	3	7	7	2	5	6
May	2	7	6	3	6	7	2	8	5
June	4	5	9	4	6	9	4	6	8
July	3	8	5	5	7	6	4	7	8
Aug.	3	6	7	4	6	9	4	5	10
Sep.	3	6	6	3	8	7	2	7	6
Oct.	2	7	5	2	5	7	3	6	5
Nov.	2	4	8	3	5	8	2	5	6
Dec.	1	6	5	1	4	7	1	3	5
				Partly Cloudy Days					
Jan.	2	6	7	2	6	8	2	6	6
Feb.	1	7	4	1	6	4	1	6	5
Mar.	1	4	6	2	5	7	1	6	5
Apr.	2	6	5	2	7	6	2	5	7
May	2	8	5	3	6	9	2	6	7
June	2	4	7	2	6	7	2	7	6
July	3	8	5	3	6	8	2	5	9
Aug.	3	5	7	1	5	5	2	5	6
Sep.	2	7	6	2	8	7	2	5	7
Oct.	2	6	7	2	7	7	4	7	8
Nov.	2	6	5	1	7	5	2	9	4
Dec.	1	5	7	1	4	7	1	7	4
				Cloudy Days					
Jan.	4	9	4	4	8	5	3	6	4
Feb.	2	5	8	2	7	5	2	5	9
Mar.	2	7	7	3	8	5	2	6	5
Apr.	4	9	6	4	8	7	3	8	7
May	4	4	11	4	5	8	3	6	8
June	5	9	5	5	10	5	5	8	5
July	3	4	9	3	5	10	2	5	7
Aug.	4	7	8	3	7	6	3	8	4
Sep.	2	5	7	2	4	9	2	4	8
Oct.	3	7	7	3	6	8	3	6	8
Nov.	4	8	6	3	7	5	3	5	8
Dec.	2	5	7	2	7	5	2	5	9

warm part of the year, half the days each month have been partly cloudy. All stations have not had a monthly maximum of fewer than five partly cloudy days. The greatest variation among stations in the minimum number of partly cloudy days is only three. The monthly minima are most commonly between one and four days.

The greatest variation in the maximum number of cloudy days, with Portland exceeding Eugene, is nine days in August. Eight months of the year, October through May, have experienced at some time nearly a full month of cloudy weather, and in July as many as half the days have been cloudy.

The greatest variation among stations in the minimum monthly number of cloudy days is six. That December is unquestionably the cloudiest month is indicated by the fact that this month has not had fewer than 22 to 24 cloudy days during the 15-year period. July and August have contrastingly had minima of one to three cloudy days.

IV. PERSISTENCE OF CLOUDINESS CONDITIONS

Another important consideration in describing the character of cloudiness is persistence of occurrence. The present chapter, therefore, deals with the monthly frequency and duration of periods of specified sky cover conditions.

In this analysis of persistence the figures derived represent the month during which the period began, since periods of a given sky cover condition may begin at the end of one month and extend for a number of days into the following month.

All the graphs in this chapter are based upon the information summarized in Tables 10 and 12 through 16, which show the total monthly number of periods of various durations for each of the cloudiness categories at the three stations from 1949 through 1963. These figures were derived by examining Weather Bureau data for the day-to-day changes in sky cover. To facilitate analysis of persistence, graphs are presented showing the monthly number of cloudiness class periods of somewhat arbitrarily selected lengths, including 1-2, 3-4, 5-10, and more than 10 days duration. The ordinate scale of these graphs shows the total number of periods from 1949 through 1963 and indicates the average number of periods per month. From the information in the tables listed above, one can easily calculate the frequency of periods of duration class intervals other than

those which are presented in the graphs.

Care must be taken in interpreting the figures for maximum duration because only a slight change in day-to-day cloudiness may radically affect duration. For example, a clear day period (0-5 tenths sky cover) at Salem being twice as long as one at Portland could be caused by an intervening cloudy day of merely six tenths sky cover.

Clear Days

Figure 23 shows the monthly number of clear day periods of 1-2, 3-4, 5-10, and more than 10 days duration at Portland, Salem, and Eugene. Clear day periods of more than ten days duration are rare, occurring once every two or three years in July. Periods of five to ten days duration on the average occur once a month during July, August, and September at all three stations, and during June at Salem and Eugene. Clear day periods of more than four days duration are rare during the winter months, and they generally occur only once in three or more years during the spring and fall months. Even clear day periods of more than two days duration average less than one per month from November through March, while July and August average two or three periods.

The predominance of short clear day periods throughout the year is illustrated by the comparatively large number of periods of

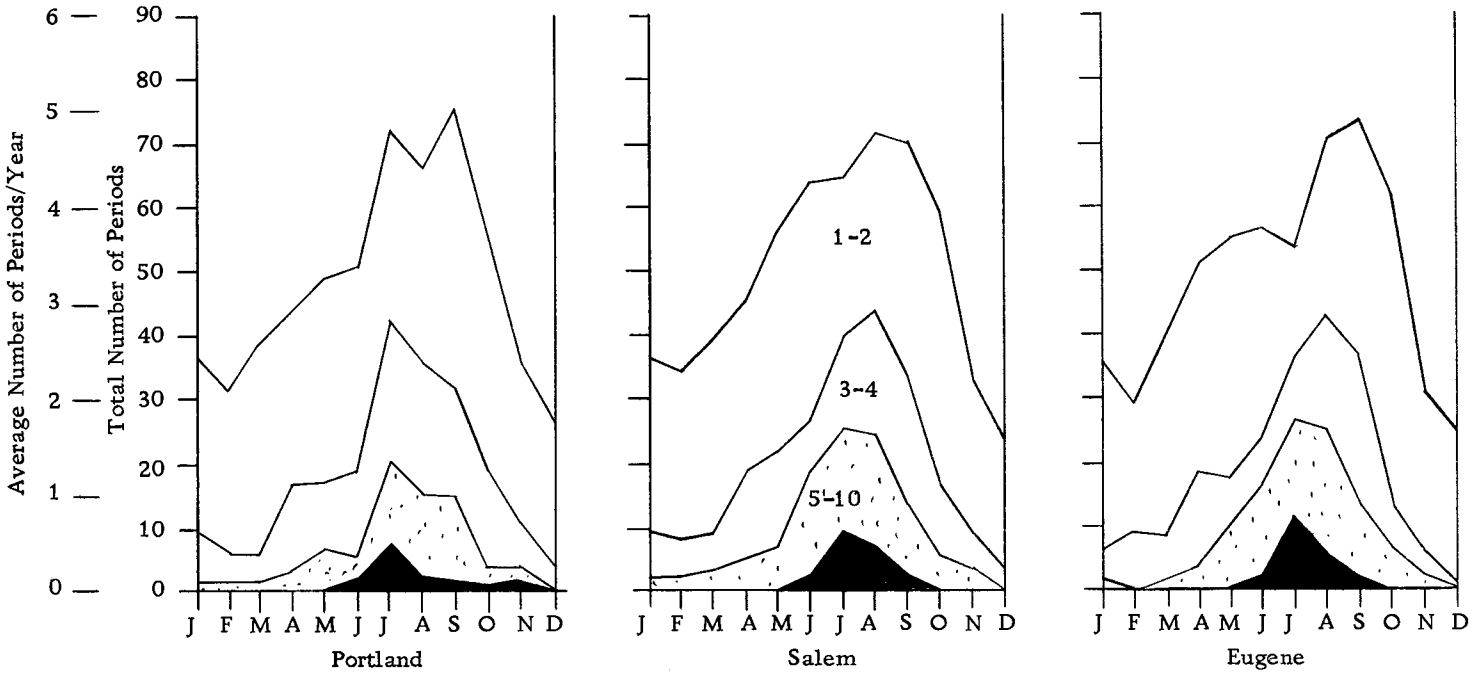

Figure 23. Monthly number of clear (0-5 tenths) day periods of 1-2, 3-4, 5-10, and more than 10 days duration at Portland, Salem, and Eugene, 1949-1963.

1-2 days duration in Figure 23. Each month averages at least one period of one or two days duration, while the spring and fall months average two or three periods.

The top curve in Figure 23, an expression of the total monthly number of periods from 1949 through 1963, indicates that each of the winter months averages only two clear day periods per year of only one or two days duration. In contrast, the summer months generally average at least two periods of one or two days duration, one period of three or four days duration, and nearly two periods of more than four days duration. A comparison of stations reveals that the total number of clear day periods correlates rather closely, but that periods of more than four days duration are more numerous at Eugene and Salem than at Portland.

The maximum duration of clear day periods beginning in a given month is represented by the length of the horizontal columns in Table 10. From September through June the three stations have varied from one another by only four or fewer clear days, but for a period beginning in July, Eugene has exceeded Portland by one of 14 days longer duration. Clear day periods at Salem beginning during the months January through May have had maxima of five to eight days. From June through September the maxima have been considerably higher with 15 to 19 days, decreasing sharply in October and November with eight days. During the 15-year period December has

Table 10. Frequency and Duration of Periods of Clear (0-5) Weather at Portland, Salem, and Eugene for the 15-year Period, 1949-1963.

	Duration in Days																			
	5						10							15						20
Portland																				
J	24	4	5	3	0	1														
F	19	6	3	2	1															
M	23	9	2	3	1															
A	17	9	10	4	2	0	1													
M	17	14	7	4	3	3														
J	21	10	5	9	1	2	0	0	0	0	0	0	1	0	0	0	1			
J	15	15	12	10	2	6	1	3	1	0	4	1	1	1						
A	16	15	11	9	4	2	3	0	3	1	1	1								
S	23	21	8	9	4	3	2	3	0	1	1									
O	29	9	11	4	0	2	1													
N	22	4	5	2	1	0	1	0	0	0	0	1								
D	18	5	4																	
Salem																				
J	23	5	5	1	1	1														
F	22	5	4	1	2															
M	25	6	2	3	3															
A	18	9	8	5	1	2	1	1												
M	23	11	10	5	2	3	1	1												
J	26	10	6	3	6	1	0	0	2	0	0	0	1	0	0	0	0	0	1	
J	10	15	8	6	5	4	3	3	0	1	3	1	1	0	3	0	0	0	1	
A	17	11	10	9	7	3	4	2	0	1	3	1	1	1	0	0	1			
S	17	20	7	13	5	2	1	2	1	0	0	1	0	0	1					
O	30	13	7	4	1	1	1	2												
N	17	7	4	2	0	0	1	2												
D	15	5	3																	
Eugene																				
J	22	7	4	1	1															
F	12	8	5	4																
M	28	5	4	2	2															
A	25	8	9	5	2	1	1													
M	27	11	3	4	4	1	2	3												
J	19	13	4	4	6	3	1	0	2	2	0	0	1	0	0	0	0	0	1	
J	9	8	5	5	1	3	3	5	1	1	3	2	1	1	0	2	0	1	0	---1 @ 28
A	17	11	7	10	6	4	5	3	2	0	0	2	1	0	1	0	0	0	1	
S	18	19	12	11	5	2	3	1	0	1	0	0	1							
O	34	15	6	1	1	2	1	2												
N	19	6	4	0	0	0	1	1												
D	18	6	1																	

never had a succession of more than three clear days.

Table 11 illustrates the year-to-year variation that may occur in the number of clear day periods and their average duration for each month, using the Salem station as the example. Quite a variety of combinations for any given month is evident.

Cloudless Days

No cloudless day periods of more than ten days duration have occurred in the Willamette Valley during the 15-year record. Figure 24 shows that periods of 5-10 days duration are rare at Portland, but in July Eugene averages two periods every three years. Salem and Eugene approximate two cloudless day periods of 3-4 days duration in July, while Portland averages fewer than one per year for this month. At all three stations there have been only one or two occurrences of periods of 3-4 days duration from October through May during the entire 15-year period. While most months average at least one cloudless day period of one or two days duration annually, December averages only one cloudless day every three or four years. July, on the other hand, averages a total of four or five cloudless day periods a year comprised of three periods of one or two days duration and two periods of more than two days duration.

The maximum duration of cloudless day periods, indicated in Table 12, forms a rather limited range for most months of the year.

Table 11. Monthly Frequency and Average Duration of Clear (0-5) Weather at Salem from 1949 through 1963.
(F = Frequency; D = Average Duration)

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D
1949	5	3	2	3	2	1	4	2	3	2	5	3	3	4	7	3	5	2	6	2	2	1	2	1
1950	1	1	1	2	1	1	2	2	6	2	3	4	3	6	5	5	6	3	0	0	4	1	0	0
1951	1	3	3	2	2	1	4	5	3	5	2	11	5	6	3	10	4	3	3	2	1	1	2	1
1952	0	0	1	1	3	1	6	2	3	3	3	2	3	7	4	5	3	8	3	4	3	3	2	1
1953	1	1	3	1	3	2	3	1	1	2	2	2	6	4	6	2	5	3	6	3	0	0	0	0
1954	1	2	5	1	5	2	5	2	6	2	3	1	5	4	4	2	4	3	3	3	0	0	1	2
1955	2	1	4	1	3	3	1	4	6	2	4	2	5	3	4	8	6	3	5	1	1	2	3	2
1956	4	2	1	1	2	3	5	2	4	3	4	3	4	5	5	5	6	2	2	2	3	4	1	1
1957	4	1	4	2	2	2	4	2	3	4	5	1	6	3	5	3	5	3	3	5	5	1	1	1
1958	1	1	1	2	4	1	2	4	3	3	3	3	2	5	5	4	4	5	5	1	1	4	2	2
1959	1	2	3	1	3	1	3	4	4	2	2	2	4	7	4	3	5	2	5	3	4	3	1	1
1960	3	1	2	3	2	3	0	0	0	0	4	5	3	8	3	8	5	3	4	2	2	2	3	2
1961	4	2	0	0	1	2	3	2	3	3	4	5	4	6	5	4	6	3	5	2	5	2	1	2
1962	2	3	3	2	3	2	3	2	3	1	9	2	6	3	5	5	2	4	4	2	1	2	2	2
1963	6	2	1	3	3	2	0	0	5	3	3	2	5	2	6	3	4	5	5	1	1	7	3	1

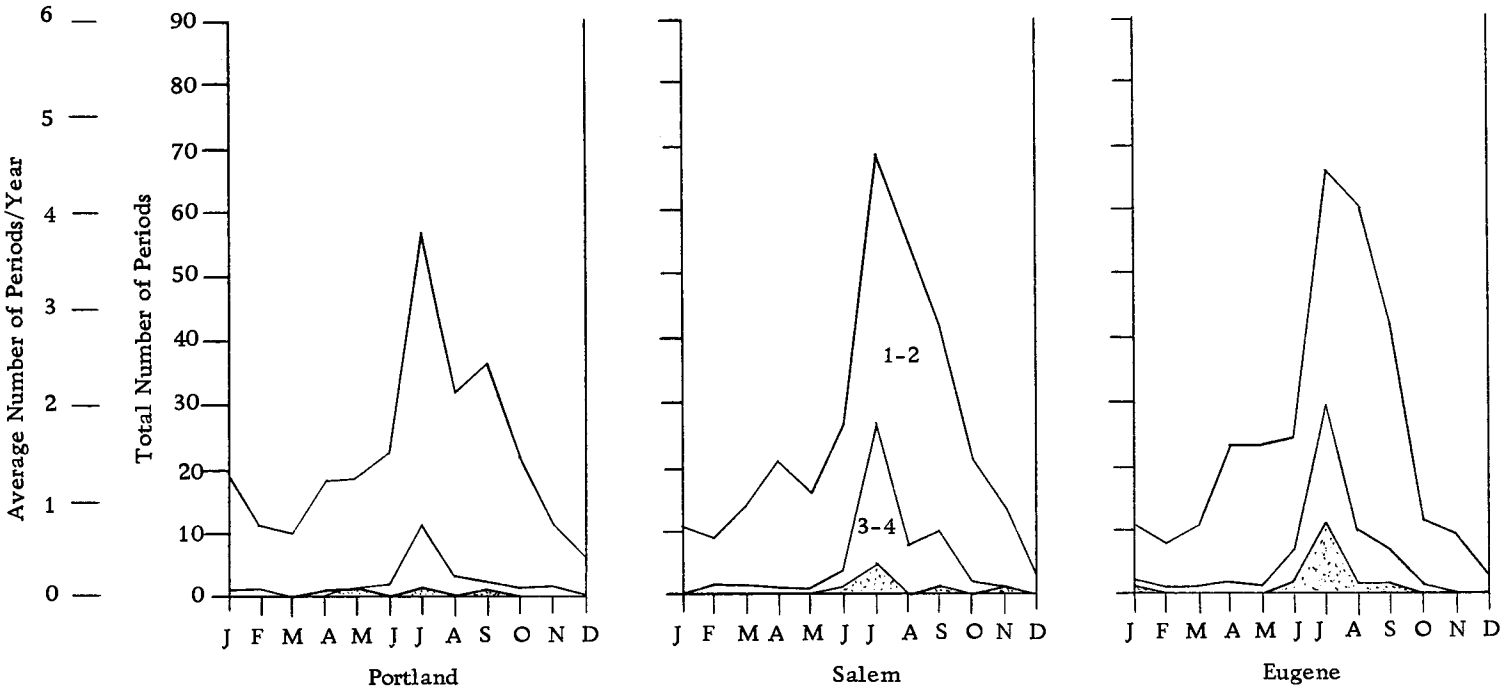

Figure 24. Monthly number of cloudless (0 tenths) day periods of 1-2, 3-4, and 5-10 days duration at Portland, Salem and Eugene, 1949-1963.

Table 12. Frequency and Duration of Periods of Cloudless Weather at Portland, Salem, and Eugene for the 15-year Period, 1949-1963.

	Duration in Days									
	1			5						10
Portland										
J	16	2	1							
F	7	3	0	1						
M	7	3								
A	14	3	1							
M	15	3	0	0	1					
J	16	5	1	1						
J	31	15	7	3	1					
A	18	11	2	1						
S	23	11	1	0	1					
O	15	6	1							
N	8	2	1							
D	5	1								
Salem										
J	7	4								
F	5	2	1	1						
M	10	2	2							
A	14	6	1							
M	11	4	1							
J	14	9	2	1	1					
J	25	16	17	5	2	1	1	0	1	
A	35	12	6	2						
S	24	8	7	2	1					
O	16	4	0	2						
N	8	5	0	0	0	1				
D	2	1								
Eugene										
J	8	1	1	0	1					
F	7	0	1							
M	8	2	0	1						
A	12	9	1	1						
M	14	8	1							
J	10	7	2	3	1	0	1			
J	23	13	11	8	5	2	2	0	1	1
A	39	11	7	1	0	2				
S	24	10	5	0	0	0	1	1		
O	11	0	1							
N	6	3								
D	3									

In December, Eugene has had a low maximum of only one cloudless day per month; in July this station has had a high maximum among stations of ten days duration. The Portland station demonstrates the least variation with maximum monthly durations of two to five days.

Overcast Days

Figure 25 shows that occurrences of overcast periods of more than ten days duration are rare. Periods of 5-10 days duration, however, normally occur once during each winter month. Each of the winter months averages about three overcast day periods of more than two days duration, while the summer months average no more than one period per month in two or three years.

In July, Salem and Eugene have had only a few occurrences of overcast day periods of more than two days duration during the 15-year period. The number of overcast day periods of one or two days duration considerably exceeds periods of longer duration. July ordinarily has one or two periods of one or two days duration, while December and January have three or four periods.

In winter the maximum lengths of overcast day periods have been 10 to 15 days. In summer the maximum durations that have occurred were three to five days at Salem and Eugene and five to nine days at Portland.

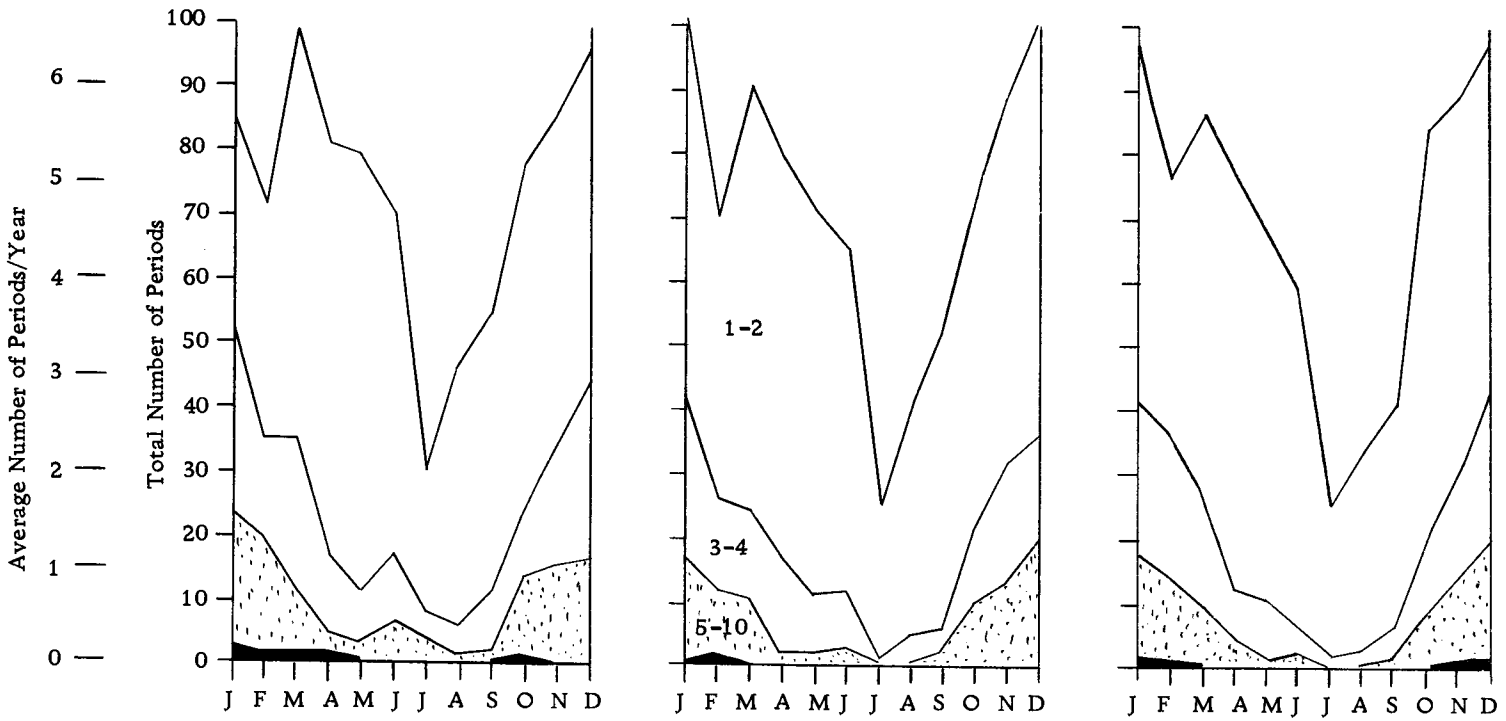

Figure 25. Monthly number of overcast (10 tenths) day periods at 1-2, 3-4, 5-10, and more than 10 days duration at Portland, Salem, and Eugene, 1949-1963.

Table 13. Frequency and Duration of Periods of Overcast Weather at Portland, Salem, and Eugene for the 15-year Period, 1949-1963.

	Duration in Days														
	1				5					10					15
							Portland								
J	26	7	15	15	8	3	4	4	0	1	0	1	1	1	
F	21	16	12	4	8	6	2	2	0	0	0	0	0	1	
M	39	24	17	6	5	3	1	1	0	1	1				
A	35	29	9	3	0	2	0	1	0	1	1				
M	47	21	6	2	2	1	0	1							
J	37	16	8	3	5	1									
J	17	5	3	1	2	1	0	0	1						
A	29	11	4	1	0	1									
S	30	13	7	3	2										
O	35	19	5	6	6	4	2	0	0	0	0	0	0	1	
N	30	22	9	10	7	3	4	0	0	1					
D	30	22	16	7	5	6	2	4	4						
							Salem								
J	39	21	10	15	7	4	3	2	1						
F	26	18	8	6	4	4	2	0	0	0	1	1			
M	45	21	10	4	5	2	2	0	1						
A	43	19	13	2	1	0	0	1							
M	42	18	7	2	1	1									
J	38	15	7	2	1	2									
J	18	6	1												
A	25	10	2	3											
S	32	14	2	2	2										
O	33	19	10	1	4	2	1	1	1	1					
N	38	20	12	7	5	2	2	1	2	1					
D	36	29	10	7	8	6	3	1	1						
							Eugene								
J	36	20	13	11	2	3	7	3	0	0	1	0	0	0	1
F	28	12	17	6	5	5	2	0	0	0	1				
M	39	21	13	4	4	2	2	0	1						
A	96	19	7	1	2	1	1								
M	41	17	6	3	1										
J	41	12	2	2	0	1	1								
J	21	2	1	1											
A	25	5	2	1											
S	25	9	5	0	1										
O	45	19	10	2	3	2	1	1	0	1					
N	41	17	11	6	5	3	0	4	1	0	0	1			
D	33	21	16	9	9	4	3	1	1	0	0	0	1		

Clear, Partly Cloudy, and Cloudy Days

Figure 26 indicates that each of the summer months averages four or five clear day periods, of which half are of one or two days duration and the other half are of three to ten days duration. Although the three stations have a nearly equal total number of periods each month, clear day periods at Salem and Eugene in summer are appreciably longer. During the rest of the year period numbers and lengths correlate closely for the three stations. Winter months average only one or two periods of one or two days duration per month. Maximum figures for the persistence of clear weather include the occurrence of ten or eleven day periods in July or August, four to eight day periods during most months of the year, and a maximum of only three consecutive days in December.

Figure 27 clearly illustrates that partly cloudy day periods are normally of very short duration. Occurrences of periods with more than four consecutive days are rare, and periods of 3-4 days duration average less than one per month except at Portland in July and August. By far the most partly cloudy periods have durations of only one or two days. Portland averages a high of six periods of one or two days duration in July, August, and September; Salem in August; and Eugene in September. The winter months average lows of two or three periods of one or two days duration. Maximum

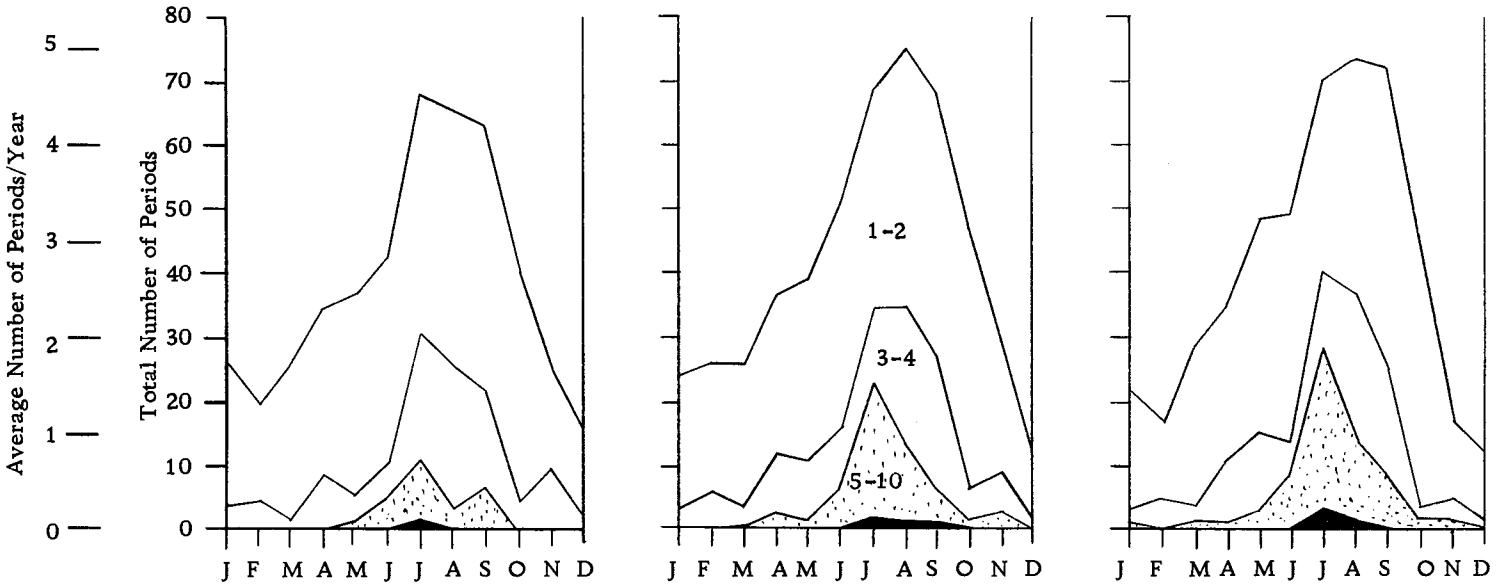

Figure 26. Monthly number of clear (0-3 tenths) day periods of 1-2, 3-4, 5-10, and more than 10 days duration at Portland, Salem, and Eugene, 1949-1963.

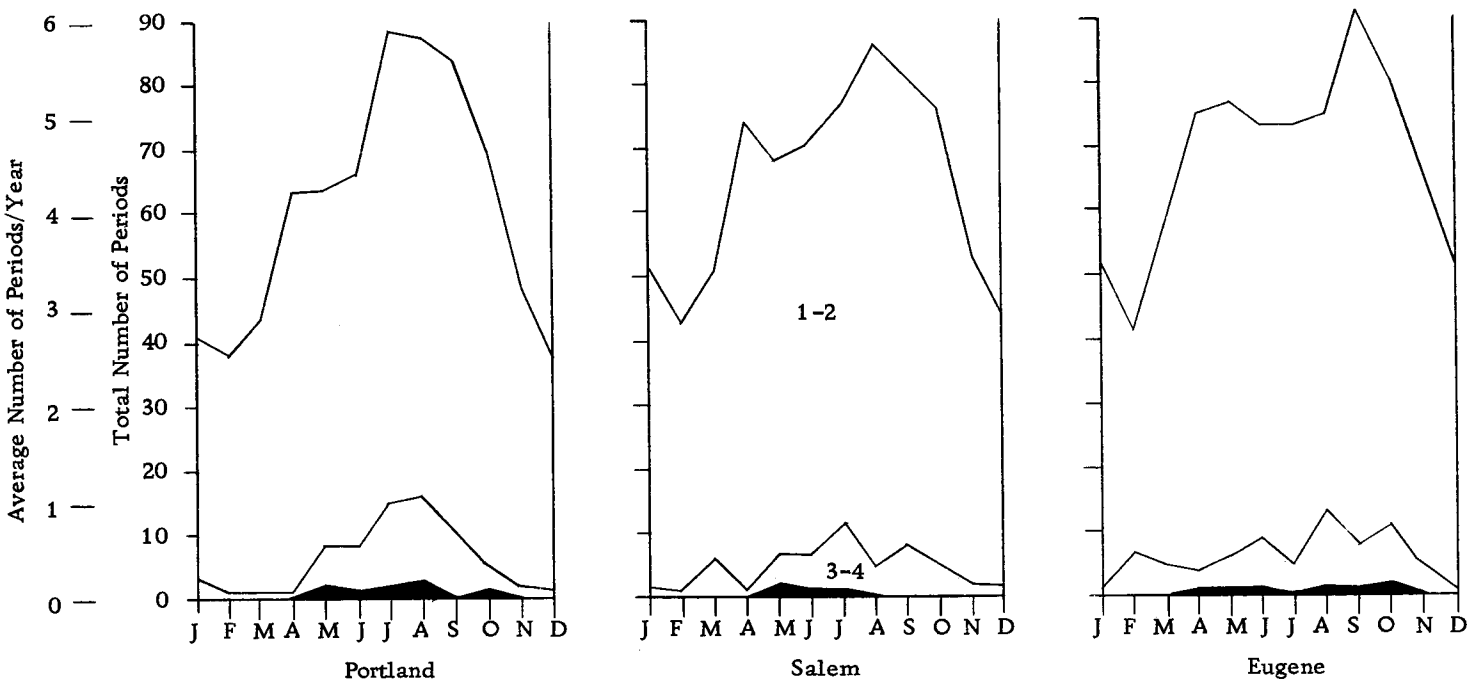

Figure 27. Monthly number of partly cloudy (4-7 tenths) day periods of 1-2, 3-4, and 5-10 days duration at Portland, Salem, and Eugene, 1949-1963.

Table 14. Frequency and Duration of Periods of Clear (0-3) Weather at Portland, Salem, and Eugene, for the 15-year Period, 1949-1963.

	Duration in Days											
	1			5						10		
Portland												
J	16	7	3	0	0	1						
F	12	3	3	1	1							
M	17	7	0	1	1							
A	15	11	8	1								
M	22	9	3	1	0	2						
J	19	13	3	2	3	3						
J	21	16	12	7	4	2	2	1	1	0	2	
A	24	16	14	8	0	2	1	0	1			
S	22	19	11	4	1	2	4					
O	24	12	4	1								
N	13	3	8	2								
D	11	3	2									
Salem												
J	14	4	3	0	1							
F	18	2	4	2								
M	17	5	1	2	1							
A	18	7	7	2	2	0	1					
M	22	6	5	4	0	2						
J	20	15	3	3	2	3	0	0	1	1		
J	21	13	6	6	6	8	2	3	2	0	1	1
A	23	17	16	5	7	2	1	2	1	0	1	
S	28	13	11	9	2	1	2	0	0	1	1	
O	30	10	2	3	1	0	1					
N	16	4	5	1	1	1	0	1				
D	8	3	1									
Eugene												
J	14	5	2	0	1							
F	5	7	4	1								
M	21	4	2	1	1							
A	12	12	6	4	0	1						
M	22	11	8	4	2	1						
J	21	14	3	2	3	4	0	1	1			
J	13	17	8	4	7	3	6	4	2	3	3	
A	23	13	10	13	4	3	3	3	0	0	0	1
S	26	21	11	6	4	2	0	1	0	1		
O	30	9	2	1	1							
N	10	2	3	1	1							
D	9	2	1									

Table 15. Frequency and Duration of Periods of Partly Cloudy (4-7) Weather at Portland, Salem, and Eugene for the 15-year Period, 1949-1963

	Duration in Days									
	1			5				10		
				Portland						
J	30	8	3							
F	32	5	1							
M	35	8	1							
A	49	13	1							
M	46	10	5	1	1	1				
J	48	11	6	1	1					
J	52	21	9	4	2					
A	55	16	9	4	0	1	2			
S	58	16	9	1						
O	51	14	3	1	0	0	1			
N	39	8	1	1						
D	32	4	1							
				Salem						
J	42	8	2							
F	34	8	1							
M	38	7	4	2						
A	54	19	1							
M	49	12	4	1	0	2				
J	46	18	6	0	1					
J	48	17	8	3	1					
A	59	22	2	3						
S	57	16	6	2						
O	56	14	4	1						
N	46	5	2							
D	36	6	2							
				Eugene						
J	41	10	1							
F	29	6	4	3						
M	42	12	2	3						
A	48	23	2	1	0	1				
M	54	16	4	2	1					
J	43	21	6	2	1					
J	54	14	4	1						
A	47	15	9	3	1					
S	70	13	6	1	0	0	0	0	1	
O	56	13	5	4	2					
N	49	14	4							
D	42	9	1							

Table 16. Frequency and Duration of Cloudy (8-10 tenths) Weather at Portland and Salem for the 15-year Period, 1949-1963. (See next page for Eugene)

	Duration in Days																														
	1				5					10					15					20					25					30		
															Portland																	
J	8	6	7	2	4	2	3	1	2	2	1	1	0	2	1	1	1	0	0	3	0	0	0	0	0	0	0	0	0			--- 2 @ 35
F	8	4	5	3	4	1	1	1	1	3	2	0	2	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0			--- 1 @ 54
M	8	7	8	4	2	4	1	1	1	5	1	0	3	4	0	0	2	0	1	0	0	0	1									
A	14	11	7	3	2	1	2	3	4	0	2	2	2	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1			
M	9	10	7	10	3	3	3	4	1	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	
J	11	12	7	7	5	5	1	2	3	1	1	0	1	0	0	1																
J	24	9	9	3	0	3	1	0	1	1																						
A	26	13	10	2	2	3	4	1	2																							
S	29	12	7	8	3	2	2	1	2																							
O	17	11	8	4	5	4	1	5	4	1	1	1	2	2	0	0	1															
N	12	10	6	2	2	4	2	0	2	1	0	0	1	3	1	1	0	1	2	1	0	0	0	0	0	0	0	0	1			--- 1 @ 38
D	5	4	3	4	4	4	2	3	1	2	1	0	0	1	1	1	0	2	1	1	1	0	1	0	0	0	0	0	1			--- 1 @ 35
															Salem																	
J	15	3	8	1	4	4	2	4	2	2	0	1	1	3	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0			--- 1 @ 34
F	9	5	2	3	4	2	3	1	2	1	2	3	1	1	0	1	0	1	0	0	1	0										--- 1 @ 46
M	12	8	7	4	4	7	1	1	4	5	0	1	2	1	2	1	1															
A	23	14	4	7	1	3	1	0	4	0	4	3	0	0	1	0	0	1	0	0	0	0	0	0	0	1						
M	13	11	7	9	5	1	2	3	0	2	1	1	0	0	1	0	1	2														
J	16	11	8	7	4	2	2	1	2	2	1	0	0	0	1																	
J	21	6	7	2	1	2	2																									
A	24	14	13	1	2	0	1	3																								
S	32	19	9	3	3	2	2	1	1																							
O	24	11	8	6	5	8	3	2	1	2	0	2	1	0	1	1																
N	15	9	5	6	4	4	2	2	2	4	2	1	3	1	0	0	1	0	0	0	0	0	1									
D	4	5	6	3	2	6	3	4	0	0	4	0	3	2	3	0	0	1	2	0												--- 1 @ 57

Table 16. Frequency and Duration of Cloudy (8-10) Weather at Eugene for the 15-year Period, 1949-1963.

	Duration in Days																												
	1				5					10					15					20					25				30
J	12	11	8	3	3	2	4	4	0	1	1	2	2	1	0	0	0	0	1	1	1	1	0	0	0	0	0	1	0 --- 1 @ 35
F	6	4	4	5	2	5	4	0	3	1	2	3	0	2	0	0	1	2	1										
M	13	16	12	3	1	6	3	5	3	3	0	0	2	2	0	1													
A	22	15	8	8	3	3	2	2	1	2	2	1	0	0	0	0	1	0	0	1									
M	17	16	11	7	4	3	1	3	0	0	3	0	0	0	2														
J	23	13	7	8	3	2	2	0	2	2	0	0	0	0	1														
J	24	9	5	2	0	1	1	0	1																				
A	26	7	10	1	2	0	1	2																					
S	37	15	9	5	2	2	1	1																					
O	29	18	8	7	8	6	3	2	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1						
N	19	7	6	7	7	3	1	1	1	0	2	3	2	1	0	0	0	0	2	0	0	1	0	0	1	0	0	0	0 --- 1 @ 37
D	9	3	10	5	5	4	5	4	4	3	0	2	1	1	1	0	0	0	1	0	0	1							

duration of partly cloudy day periods for various months is confined to the rather small interval of three to seven days.

The general impression obtained from Figure 28, the duration of cloudy day periods, is that most months average one to four periods of 1-2 days duration and one period each of 3-4 and 5-10 days duration. In addition, months during the winter half of the year ordinarily experience an average of about two cloudy day periods of more than ten days duration every three years. In two instances during the 15-year period, 1949-1963, cloudy weather in winter has persisted for nearly two months. Even the spring and fall months have had a few occurrences of cloudy day periods lasting a full month. The maximum duration of cloudy days in July, August, and September is seven to ten days, while all other months have had maxima of 15 days or more.

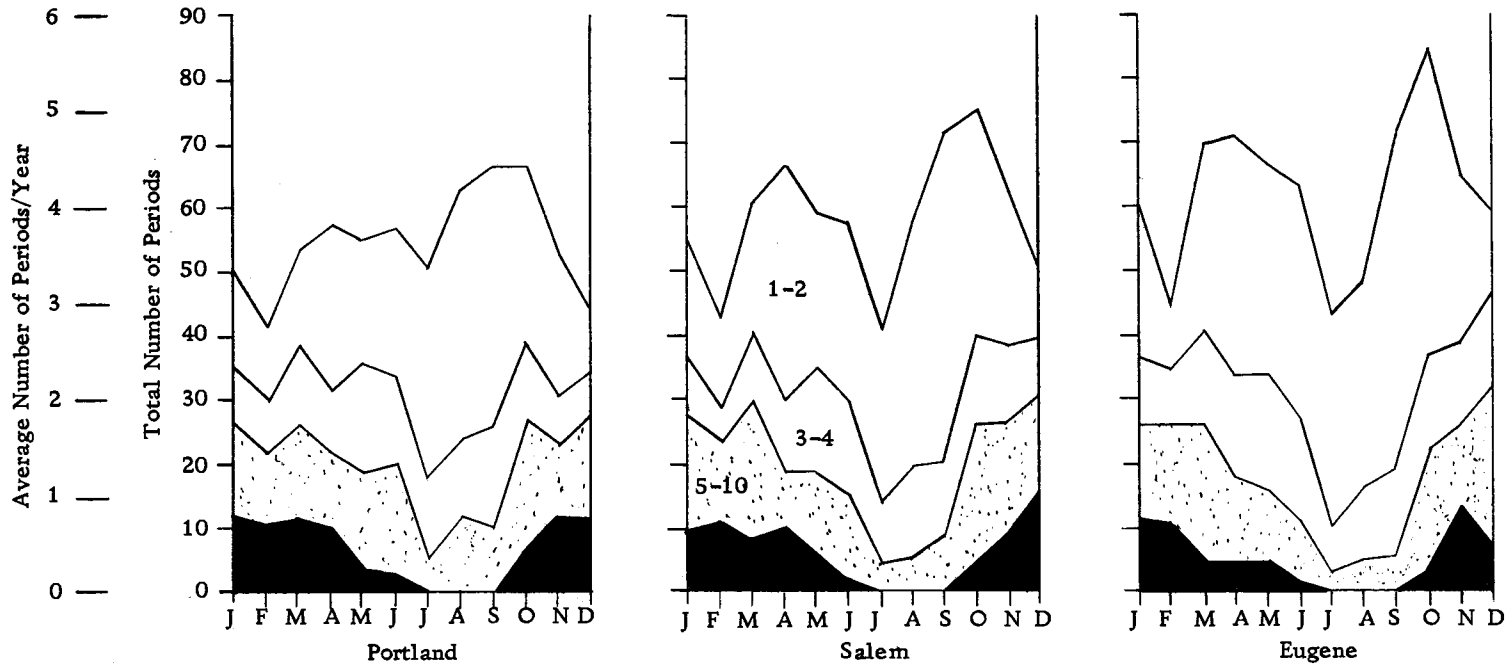

Figure 28. Monthly number of cloudy (8-10 tenths) day periods of 1-2, 3-4, 5-10, and more than 10 days duration at Portland, Salem, and Eugene, 1949-1963.

V. WEEKLY PATTERNS OF CLOUDINESS

An analysis of weekly patterns of cloudiness serves to show more closely what sky cover conditions prevail within each month. Weeks of the climatological year, which are the succession of seven day periods beginning March 1 and ending on February 27, are utilized. This system makes it possible to work with equal periods of time throughout the year, except for the last "week" which is of one or two days duration.

Comparison of stations will be omitted in this chapter. Salem, which has been shown to have sky cover conditions generally intermediate to those of Portland and Eugene, has been selected to indicate weekly sky cover in the Willamette Valley.

Percent Sky Cover

The weekly mean, mean deviation, and extremes of percent sky cover at Salem are shown in Figure 29. The general wide range in mean deviation and the extremes demonstrates that there is little correlation in the amount of sky cover for a given week in successive years; only during the winter months when the sky is dominantly overcast, particularly in December, are these ranges narrowed. The following discussion, therefore, deals exclusively with the mean percent sky cover fluctuations at Salem during successive months.

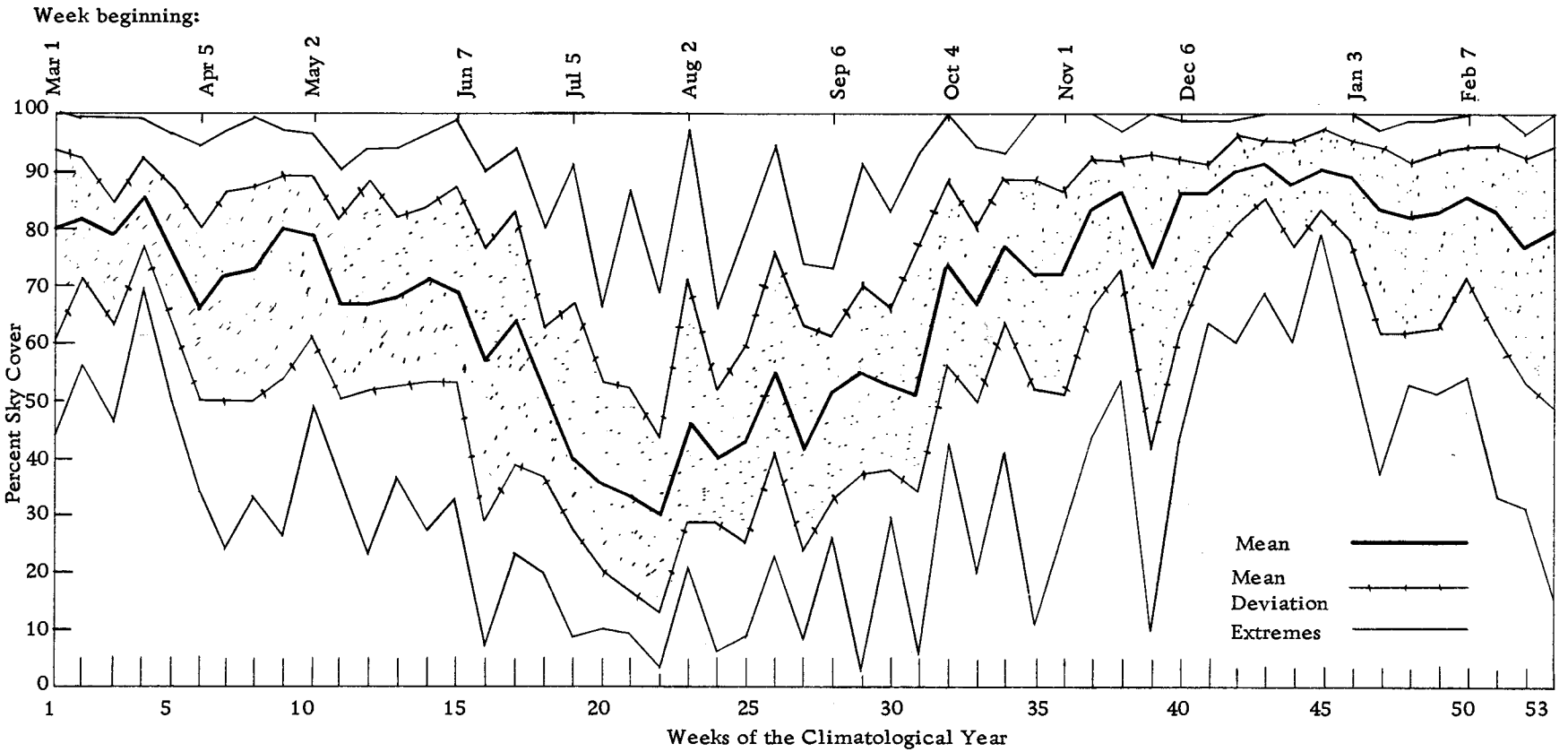

Figure 29. Weekly mean, mean deviation, and extreme percent sky cover at Salem, 1949-1963.

Although the amount of cloudiness from the first week of March through the end of July decreases from 80 to 30 percent, there is considerable weekly fluctuation. Among the more notable departures from the general decrease in cloudiness are weeks with highs of 80 percent sky cover the end of April and the first week of May, 70 percent the first two weeks of June, and 65 percent in the latter part of June. Weeks with rather low percentages of cloudiness include 65 percent sky cover the second week of April and mid-May, and about 50 percent in mid-June. Both the highs and the lows represent five to ten percent variations from the respective monthly means. From the latter part of June through the last week of July, cloudiness decreases steadily from 65 to 30 percent.

During August and September the mean weekly cloudiness varies between 40 and 55 percent. The most notable increase in cloudiness occurs at the beginning of October when during one week's time, cloudiness increases by about 20 percent. From October to the end of November there is a general increase from 70 to 85 percent. The last week of November averages ten percent less sky cover than the preceding and succeeding week. August, October, and December have weeks in which the departure from the mean monthly sky cover is five to ten percent. From the beginning of December through the latter part of February, the mean weekly sky cover varies only slightly--between 80 and 90 percent, with the high of about 90

percent persisting from mid-December to mid-January.

Clear and Cloudy Days

The mean and extreme weekly number of clear and cloudy days at Salem, Figure 30, shows that every week of the year averages at least two cloudy days as compared with 23 weeks averaging fewer than two clear days per week. Another indicator of the dominance of cloudy weather in the Willamette Valley is the fact that 37 weeks of the year have experienced a minimum of at least one day of cloudy weather during the 15-year period, while only eight weeks have had a minimum of at least one clear day. Even during the summer months there may occur week-long periods of cloudy weather.

The second week of November through the last week of March generally averages only one clear day per week; two weeks in mid-December average no clear days. From the second week of June through mid-July there is an increase of from three clear days to a high of five days persisting through the end of July. August and September average three or four clear days per week. From the last week of September to the first week of October there is a decrease from four to two clear days, constituting the most notable of the week-to-week changes in mean sky cover.

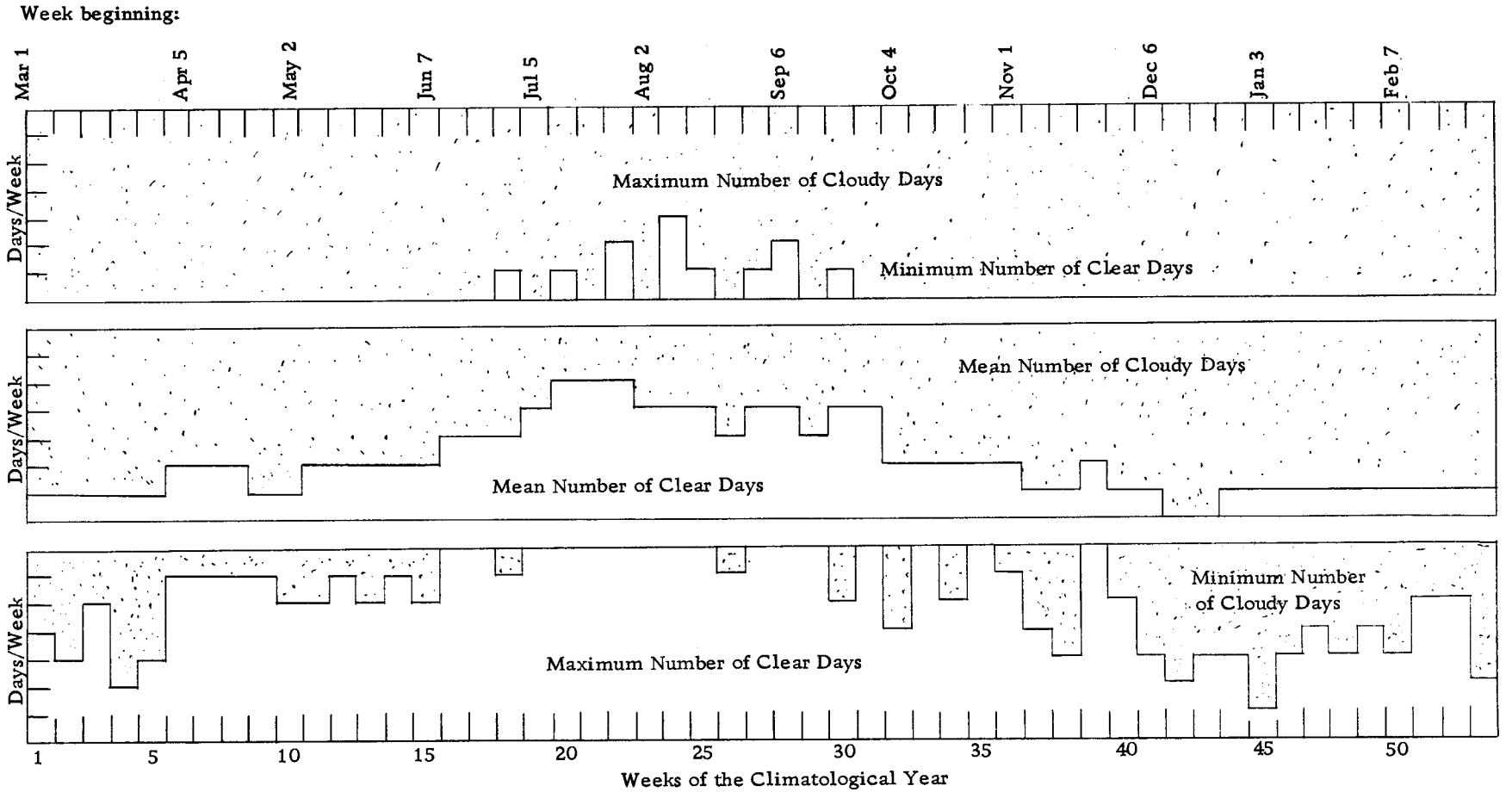

Figure 30. Mean and extreme weekly number of clear (0-5 tenths) and cloudy (6-10 tenths) days at Salem, 1949-1963.

Cloudless and Overcast Days

The graph of the mean weekly number of cloudless and overcast days at Salem, Figure 31, vividly illustrates the very large proportion of overcast days among the cloudiness categories as well as the contrast with the number of cloudless days.

The last week of July has a high of three cloudless days, following the two day average for the other weeks of July; only two other weeks in August average as much as two days. Two weeks, including mid-December and the first week of January, have average highs of five overcast days; otherwise, the maximum is represented by the October through mid-February average of four overcast days per week. Four weeks during the year average no overcast days, while 28 weeks average no cloudless days. About half the weeks each year average at least three overcast days per week.

Clear, Partly Cloudy, and Cloudy Days

The mean weekly number of clear, partly cloudy, and cloudy days at Salem is shown in Figure 32. Weeks of the climatological year average up to four clear days and one or two partly cloudy days, while the number of cloudy days is more variable. Nine weeks average no clear days, 32 weeks average a low of one partly cloudy day, and four weeks average a low of one cloudy day.

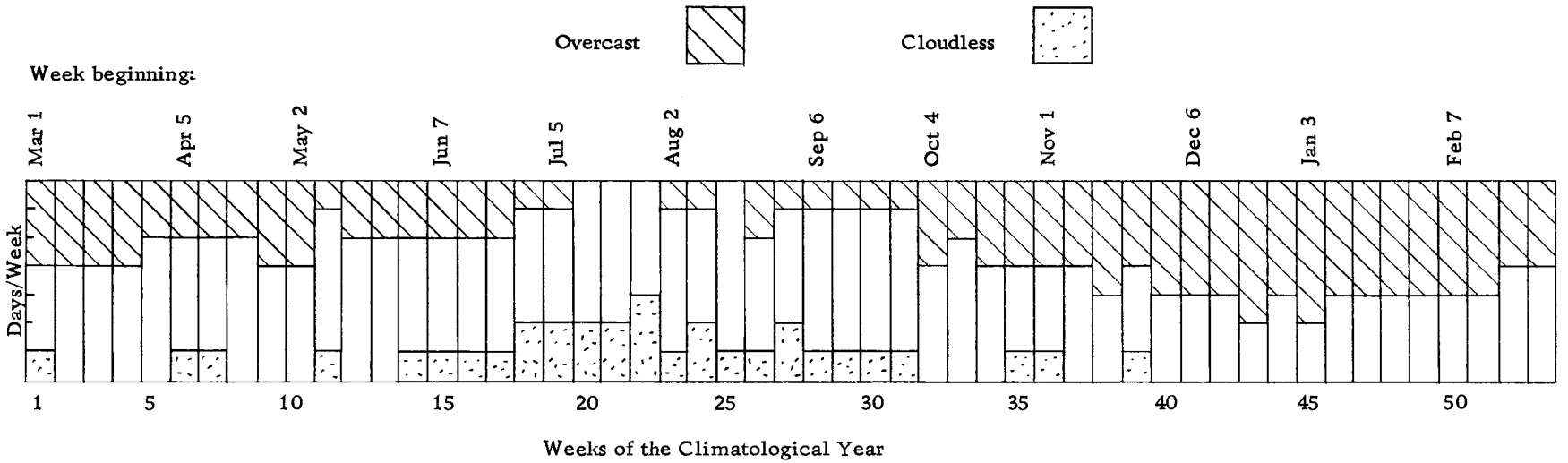

Figure 31. Mean weekly number of cloudless and overcast days at Salem, 1949-1963.

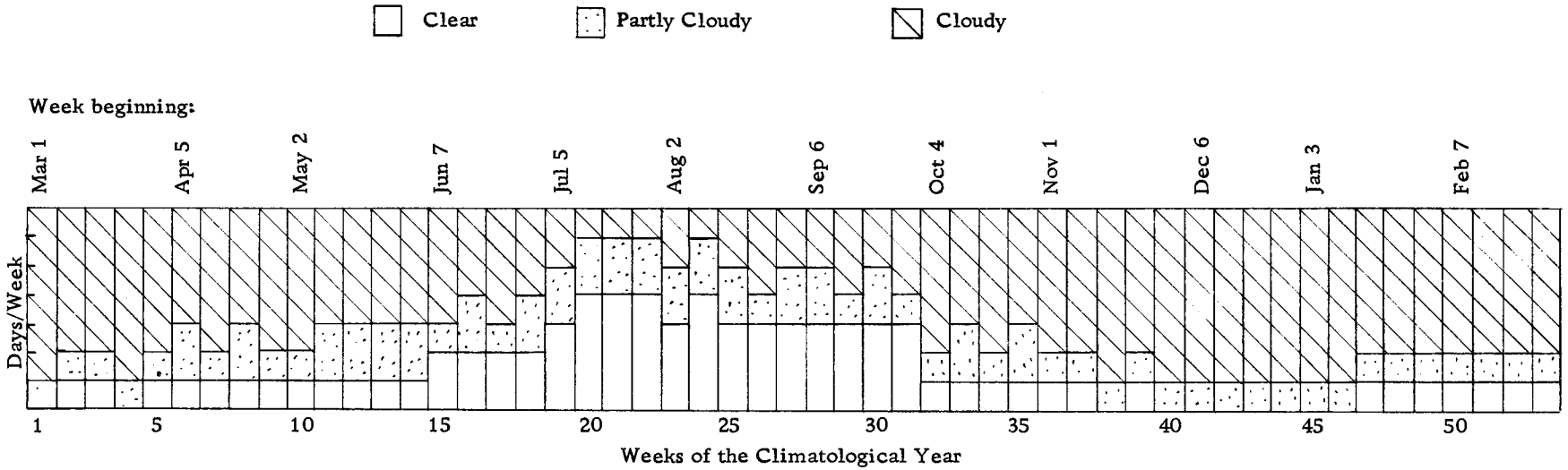

Figure 32. Mean weekly number of clear (0-3 tenths), partly cloudy (4-7 tenths), and cloudy (8-10 tenths) days at Salem, 1949-1963.

From October to the first week of June, the number of clear days per week is zero or one, with a seven week period averaging no clear days occurring from December to the second week of January. The remainder of June and the beginning of July average two clear days, increasing to four days the last two weeks of July. From August through September, the average number of clear days per week is three, except for four days the second week of August.

The number of partly cloudy days per week is one or two days throughout the year. From November through March, the weekly mean generally is one day, but from April through October weeks with two partly cloudy days are more common. The longest continuous period with two partly cloudy days per week is eight weeks from mid-June to mid-August.

From December to mid-January the number of cloudy days per week is at a high of six days, occurring also for one week in mid-November and the end of March; otherwise, from October to mid-June there is an average of four or five cloudy days each week. From mid-June through September the average is one to three cloudy days in most weeks. The last three weeks of July and the second week of August average a low of one day of cloudy weather.

VI. VARIATIONS IN CLOUDINESS DURING A SELECTED SAMPLE YEAR

The objectives of the present chapter include illustration of the day-to-day patterns of cloudiness in the Willamette Valley throughout a given sample year and comparison of the cloudiness characteristics of the sample year with the various sky cover conditions for the period 1949-1963, described in the previous chapters. Since this study was initiated, the complete record for 1964 has become available. The author, having experienced the Willamette Valley climate at that time, found it of interest to utilize this recent, non-summarized year for analysis.

The daily sky cover in tenths (sunrise to sunset) for Portland, Salem, and Eugene in 1964 is shown in Figure 33. The graph strikingly reveals that the three stations are simultaneously affected by the same periods of clear and cloudy weather and that they generally vary in a rather small degree from one another on a given day. The average daily variation among stations is one or two tenths sky cover, with values for August through November differing by the latter amount. The greatest diurnal variations among stations are nine tenths in November; seven tenths in March, July, August, and December; and three to six tenths during the remaining months--these occurrences serve to show that while large variations among stations are rare, they do occur.

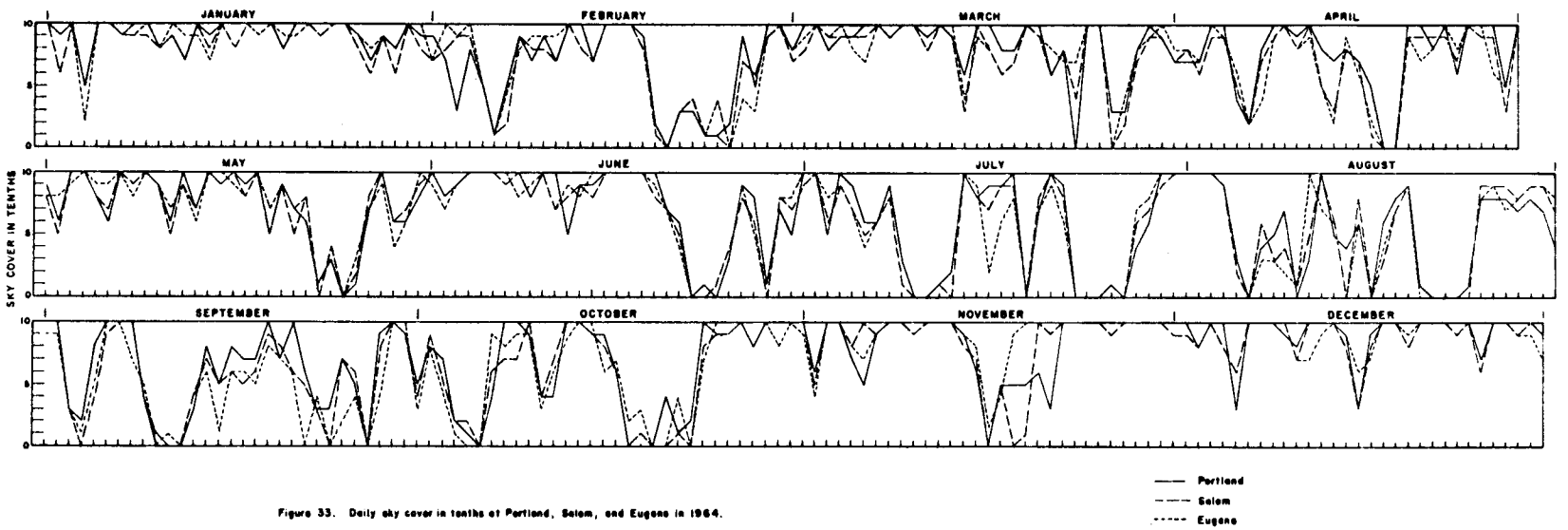

Figure 33. Daily sky cover in tenths at Portland, Salem, and Eugene in 1964.

Another feature illustrated by the graph is the tendency for the weather to be either quite cloudy or quite clear. It has been shown in previous chapters that periods of partly cloudy weather average durations of only one or two days.

Much of the following discussion is a comparison of the sample year with the period means and variation from the mean as a supplement to Figure 33 to enable the reader to visualize more easily the "normal" day-to-day variations in sky cover.

Percent Sky Cover

The annual percent sky cover at Portland, Salem, and Eugene in 1964 was 73, 70, and 70 percent, respectively. All three stations, therefore, had slightly greater than average cloudiness, but the figures are within the mean deviation for the 15-year period.

Table 17 is a comparison of the mean monthly percent sky cover figures for 1964 and the period means from 1949 through 1963. With the exception of February, July, and October, the percent sky cover each month of 1964 was within the mean deviation for the period. February was unusually clear, more than 20 percent below the mean and 10 to 13 percent below the minimum cloudiness for the period. July and October, however, were within the extremes, the former being 16 to 19 percent above the mean at Salem and Eugene, and the latter being 11 percent below the mean at each station.

Table 17. Mean Monthly Percent Sky Cover at Portland, Salem, and Eugene; A Comparison of 1964 with the Period 1949-1963.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
						Portland						
1949-1963	83.8	85.1	83.4	76.1	73.6	68.7	45.5	53.4	55.9	73.1	80.7	88.9
1964	92.3	62.8	83.9	76.0	73.5	75.0	56.1	56.4	61.3	61.6	82.0	91.9
Variation	+8.5	-22.3	+0.5	-0.1	-0.1	-6.3	+10.6	+3.0	+5.4	-11.5	+1.3	+3.0
						Salem						
1949-1963	83.8	82.7	80.9	72.3	71.5	65.3	36.9	45.8	51.1	69.6	78.9	88.9
1964	87.7	61.4	79.0	69.3	73.2	73.3	52.6	52.9	55.0	59.4	83.3	89.4
Variation	+3.9	-21.3	-019	-3.0	+1.7	+8.0	+15.7	+7.1	+3.9	-10.2	+4.4	+0.5
						Eugene						
1949-1963	84.3	83.6	80.1	71.1	67.1	60.7	31.8	41.5	49.3	70.9	81.9	89.4
1964	89.7	63.1	82.3	69.0	75.2	73.0	50.6	51.0	47.7	60.3	89.0	91.6
Variation	+5.4	-20.5	+2.2	-2.1	+8.1	+12.3	+18.8	+9.5	-1.6	-10.6	+7.1	+2.2

Clear and Cloudy Days

At all three stations in 1964, the mean monthly number of clear days was exceeded in February and October, and Salem exceeded the mean in April. The remaining months had fewer than the average number of clear days.

February had six to eight more clear days than the mean monthly number for the 15-year period or one to four days more than the maximum for the period. The remaining months varied within the period extremes. Months during which the number of clear days was between the period mean deviation and maximum include October at Portland; months during which they lay between the period mean deviation and the minimum are May at Eugene, July at all three stations, and August and December at Eugene.

The duration and frequency of clear weather periods can easily be visualized in Figure 33. It has been pointed out in Chapter IV that the monthly number of periods and their duration are quite variable from year-to-year. Eugene and Salem equalled or slightly exceeded the maximum monthly duration in February; otherwise, each station had two or more days fewer than the maximum monthly duration for the 15-year period.

Cloudless and Overcast Days

During each month except October of 1964, the number of

cloudless days at each station falls within the monthly mean deviation for the 15-year period. In October, however, the number of cloudless days lies within the extremes.

The number of overcast days each month of 1964 exhibits greater variation from the period mean than the number of cloudless days. In February, the three stations had eight to ten fewer overcast days than the mean, or four to six days below the minimum for the month, and Salem in April had one less day than the period minimum; during all other months the stations were within the period extremes. Overcast day occurrences between the mean deviation and extremes include March at Salem, July at Portland and Eugene, August at Portland, and November at Eugene.

Clear, Partly Cloudy, and Cloudy Days

In January of 1964, the three stations had slightly fewer than the average number of clear days. In February, the three stations were five to seven days above the mean and three or four days above the maximum for the period. March through June corresponded closely to the period means. Although July varied from three to seven clear days below average, the three stations were within the extreme range for the month. August and September were slightly cloudier than average. October was clearer than usual, deviating by three to five days above the mean, but still below the period maximum

for each station. In November and December, the variation from the period means was within the mean deviation for the two months.

The greatest variation of five days above the mean number of partly cloudy days occurred at Salem and Eugene in September; this, however, was within the period extremes. The monthly period extremes were exceeded only in February when Portland had four days above the mean or two days above the maximum.

In February, the three stations had 11 to 15 cloudy days below the mean, or seven to ten days below the period minimum for the month. During the remaining months, the number of cloudy days remained within the period extreme range. Months with cloudy day figures between the mean deviation and extremes include June at Eugene, July at Portland and Salem, August at Salem and Eugene, September at Eugene, October at Salem, and November at Eugene.

This chapter has indicated that while consideration of daily data for a specific year reveals that averages do not tell the whole story, they have told a representative story; the variations from the mean are not inordinate for such a short period. As with each of the preceding 15 years, a new extreme cloudiness value was registered in 1964; however, it would not appreciably affect the mean figure.

VII. SUMMARY AND CONCLUSIONS

Temporal and spatial patterns of cloudiness in the Willamette Valley of Oregon were studied by utilizing sky cover data for the Portland, Salem, and Eugene Weather Bureau stations between 1949 and 1963. Measures of cloudiness include percent sky cover and several classes involving the degree of cloudiness, each of which is based on the number of tenths of the sky field of view obscured by cloud cover for the time between sunrise and sunset. Average annual and monthly cloudiness in the form of sky cover in tenths and clear, partly cloudy, and cloudy days can be ascertained directly from U.S. Weather Bureau data sources. The principal contributions of this study, utilizing a select period of comparable reliability among stations, include the following:

1. The comparison of cloudiness at three locations in the Willamette Valley.
2. The use of additional parameters of cloudiness expression.
3. The use of a variety of temporal frameworks to present a more complete image of cloudiness.
4. The comparison of temporal expressions as to their utility.
5. The graphical summarization of cloudiness.

Mean

The Portland, Salem, and Eugene stations compare closely in

the amount of cloudiness, as well may be expected in a region having physiographic unity. Annual amounts of cloudiness indicate only a few percent difference among stations. Despite this similarity, there is a definite but small decrease in cloudiness from north to south in the Willamette Valley, with Salem having intermediate cloudiness characteristics. During winter, when the sky is cloudy for long periods of time, the three stations have nearly equal amounts of cloudiness; in July and August, however, Portland averages ten percent more cloudiness than Eugene.

July, August, and September are by far the clearest months, even though September averages considerably more cloudiness than July. The other nine months of the year, of which December is the cloudiest, each average more than 60 percent sky cover. The decrease in cloudiness from December to July is erratic, for some consecutive months have nearly equal amounts of cloudiness and the most notable of the monthly transitions is from June to July. From September through December, however, cloudiness increases rapidly and rather uniformly.

Variation

Although the amount of cloudiness in the Willamette Valley fluctuates from year to year, the annual difference in cloudiness among stations tends to remain the same. Annual extremes in the

Willamette Valley range from 61 to 77 percent, but the mean deviation for each station during the 15-year period is only a few percent.

Monthly mean deviations for most months are less than ten percent sky cover, but the monthly range between extremes is generally 25 to 50 percent, with the higher variations occurring in the late spring or summer. June, which on occasion has been exceptionally clear, is the most variable month.

Nine months, October through June, have had extremely cloudy weather, and even each of the summer months has had more than 60 percent cloudiness. The winter months, which are characteristically quite cloudy, correspondingly show the least variation in cloudiness. Only five months have had minima of less than 50 percent cloudiness. During each year of the 15-year period, a new maximum or minimum monthly figure was recorded at one or more stations; this reflects the shortness of the period considered.

Persistence

A great variety of combinations of the number of periods and their duration occur. Nevertheless, averages were utilized to provide a useful standard of comparison. Short periods of all cloudiness classes predominate all months of the year, with periods of more than one or two days duration becoming successively less frequent. The three stations correspond closely in the total number of periods

per month, but Eugene experiences periods in the clear and cloudless classes that are of slightly longer duration than those of Portland.

Summers average about five clear (0-5 tenths) day periods per month, of which two are five or more days duration. Most other months seldom experience clear day periods of more than four days duration. The maximum duration of clear day periods in summer is about two weeks, while December has never had a succession of more than three clear days.

During the 15-year period, Portland had no cloudless day periods of more than five days duration, while Eugene averages nearly one period of 5-10 days each year. Occurrences of overcast day periods of more than ten days duration are rare, but 5-10 day periods are common in winter.

Clear day periods of 0-3 tenths sky cover are only slightly longer than those of 0-5 tenths sky cover. By far the most partly cloudy periods are of one or two days duration, and the maximum duration is only one week. In contrast to other cloudiness classes, cloudy (8-10 tenths) day periods show a more equal distribution of period frequencies of 1-2, 3-4, and 5-10 days duration. Several occurrences are known of cloudy day periods as long or longer than a month; but, with the exception of summer, maximum periods of two weeks duration are most common.

Weekly and Daily Cloudiness

The wide range between weekly mean deviations and weekly extremes indicates little correlation in cloudiness on a weekly basis from year to year. Only the winter weeks, which are characteristically very cloudy, show a small range in variation. The mean weekly percent sky cover fluctuates as much as 10 percent from the means of the months represented. Mean weekly cloudiness figures, however, were supplemental in indicating more closely the character of cloudiness prevailing within a given month as well as for illustrating temporal contrasts throughout the year.

The illustration of daily cloudiness for the sample year 1964 shows that the stations generally vary from one another by only two tenths or less sky cover. The rare occasions in which there are large differences seem to point to local causes such as the occurrence of fog or other anomalous cloud conditions. Most days are either quite cloudy or relatively clear, for partial cloudiness of more than two days duration is uncommon. The sample year, with an unusually clear February, was no exception to the general rule of new extremes having been recorded for each of the preceding 15 years.

Conclusions

Throughout the year Portland, Salem, and Eugene are

simultaneously affected by the same regional cloud masses. In the winter half of the year the three stations have essentially the same amount of cloudiness, but in summer there is an appreciable decrease in cloudiness from north to south in the Willamette Valley which primarily reflects a southerly weakening in sky cover rather than local variations in cloudiness. Variations in the physical setting of stations, however, do create local modifications in the amount of cloudiness. For example, there is a southerly increase in the amount of fog, most of which occurs in winter, but this does not exclude the probability of clouds overlying the fog at this time of year. The similarities in cloudiness among stations are generally emphasized much more strongly than the dissimilarities.

The most striking feature of the temporal differences in the amount of cloudiness is the contrast between the clear summer months and the long cloudy season of eight or nine months. The clear and cloudless classes of cloudiness consequently form a small proportion of the annual sky cover character of the Willamette Valley. Partly cloudy days of 4-7 tenths sky cover annually number no more than clear days of 0-3 tenths sky cover. In the winter half of the year, therefore, considerable cloudiness prevails, much of which is overcast, while in the summer half of the year the weather alternates more frequently between clear and cloudy periods with partly cloudy days primarily representing a one or two day transition

between the two. In winter there are fewer changes between clear and cloudy weather, and clear weather periods last only a few days. Clear day periods of 0-3 tenths sky cover have a maximum duration of little more than a week, while cloudy day periods of 8-10 tenths sky cover have lasted as long as a month or more.

Considerable variation in temporal cloudiness patterns occurs from year to year. A minimal period of 15 years provides only an indicative picture of cloudiness. The basic character of cloudiness, however, is herein presented, and this study constitutes a useful framework from which more revealing future cloudiness data can be compared. The Willamette Valley, averaging 70 percent annual daytime sky cover and averaging less than 60 percent sky cover only three months of the year, may well be considered one of the cloudier regions of the United States.

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