Climatology

THE WINTER CLIMATE OF JUNEAU: A MEAN OF CONTRASTING REGIMES

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ABSTRACT

The historical record of daily-mean temperature for Juneau, Alaska is used, in concert with a basic understanding of the local weather patterns, to obtain a breakdown of the winter climate into three distinct regimes. These are: 1) a warm and wet maritime regime, 2) a cold and dry continental regime, and 3) a transition between these two. A decomposition of the frequency histogram of winter daily-mean temperatures into 3 normal distributions yields the fraction of occurrence and average temperature for each regime. Year to year variations are also discussed.

1. INTRODUCTION

Statistical averages are too frequently interpreted as the average weather or climate. It is true that for many places the 30-year average gives a fairly good representation of what the daily observer might expect. However, as will be shown here, this is not always the case. In areas that experience prolonged and pronounced weather regimes, climate can no longer be interpreted as a single element but instead must be considered in its individual components. Given a simple understanding of local weather patterns, a great deal of physical insight can be gleaned from the statistical average. In this paper, the climate of Juneau, Alaska is decomposed into its individual components, clearly showing the possibility of being misled by simple averages.

2. DISCUSSION

Fig. 1 shows a frequency histogram of daily mean temperatures at the Juneau Airport for the summer months June through August. The highest frequencies occur very close to the mean, suggesting that the distribution is gaussian in character with little skewness. This distribution could be statistically represented by a normal distribution according to the Central Limit Theorem and is representative of what is usually pictured when climatic means are discussed or mentioned (i.e. the mean value is most likely to occur).

Fig. 2 shows a second histogram which is for the winter months December through February. It is evident that this distribution is quite different from the one shown in Fig. 1. Note that the horizontal scale is double and the vertical scale half that in Fig. 1. There is a strong peak in the frequency at 35°F, nearly 10°F above the mean, with no real suggestion for a preference of the mean value to occur at all. It seems reasonable to ask "What is the reason for this irregular distribution?"

Most notable with regards to the climate of Juneau is the rather unique location of the station. Juneau is situated on the northeast coast of the Gulf of Alaska which makes it very vulnerable to Pacific storms and a strong maritime influence. This influence is clearly demonstrated by the commonly heavy rainfall amounts along this coastal zone (not shown).

On the flip side of the coin - just beyond the mountains to the northeast of Juneau - is a major source region for winter-season continental polar/arctic air masses. Although less frequent than the maritime influence, this extremely cold and dry air occasionally spills over the coastal mountains and drastically changes the coastal weather from mild and generally wet to clear and very cold. Weather can remain this way for many days, as long as the flow remains out of the northeast. It is during this pattern that some areas in the Juneau vicinity experience strong, bitterly cold winds, locally known as Taku Winds.

When the large-scale weather pattern readjusts, allowing warm moist air to move back over southeast Alaska, a period of transitional weather occurs. Initially, the cold dry air is deep and well established over the coastal area forcing the first advance of warm air to occur aloft. This overrunning pattern is warm-frontal in character and has an apparent synergism with an approaching synoptic-scale front. The blocking of the cold air against the coastal mountains and continuing low-level outflow from the interior are frequently responsible for a slow transition that may last for several days, particularly over the northern inner channels of the Alexander Archipelago and near the drainages of the Taku and Stikine Rivers. It is during these slow transitions that very heavy snowfalls occur at sea level.

Local forecasters have found a strong correlation between the duration of the transitional period and both the surface pressure gradient and the depth of arctic air over northwest Canada. A northeasterly pressure gradient (higher pressure inland) effectively prevents the intrusion of warm air into the lowest levels of the atmosphere. Additionally, if the dome of cold air in northwest Canada extends to an altitude higher than the elevation of the blocking coastal mountains (5000 ft), the cold air can spill directly over the mountains into Southeast Alaska without being restricted to the low drainages that cut through the coastal range. Usually, when the southwesterly flow aloft is strong enough, the cold air will be eroded and the lower levels will once again be characteristically maritime; however, some transitions

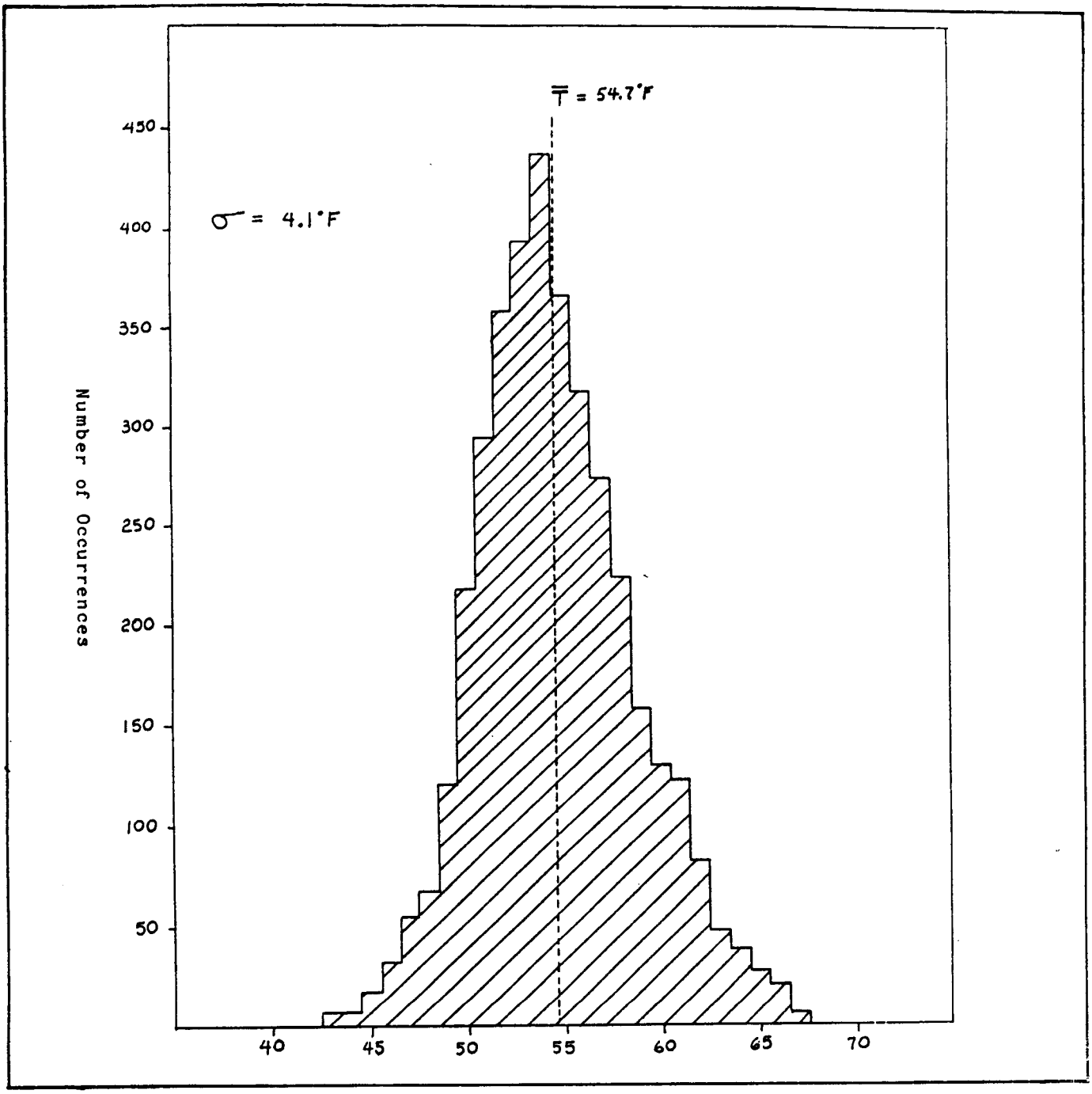

Figure 1. Distribution of Summer (June, July, August) Daily Mean Temperatures (°F) for the Years 1943 - 1984.

are never complete and the initial regime becomes reestablished after several days of 'transitional' weather.

The boundary between the moist maritime air and cold continental air is known locally as an arctic front, and is usually easily identified by a sharp contract in wind,, temperature, and moisture. The position and direction of motion (if any) of the arctic front is frequently the determining factor of the local weather. For a more detailed discussion of the arctic front and its associated weather in southeast Alaska, see Kanan (2).

Summarizing the above discussion, it can be stated that there are three basic components to the Juneau winter climate: 1) a relatively warm and wet maritime regime, 2) a cold and dry continental regime, and 3) a transition between these two. With this basic understanding it is now possible to return to Fig. 2 and deduce a viable explanation. If the assumption is made that each of these regimes

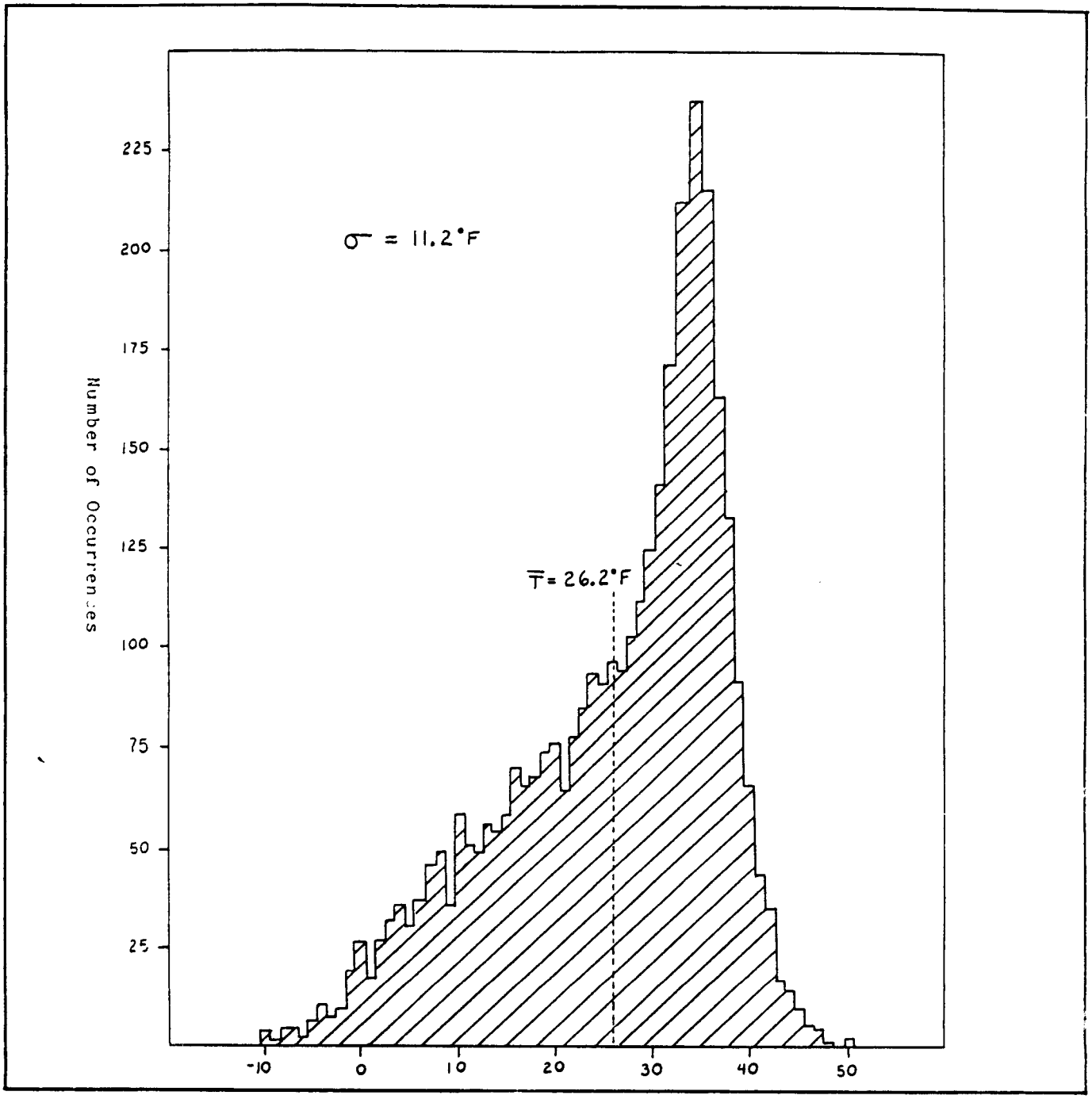

Figure 2. Distribution of Winter (December, January, February) Daily Mean Temperatures (°F) for the Years 1943 - 1984.

has a normal distribution (which seems reasonable) it should then be possible to reconstruct Fig. 2 as a sum of three normal curves or partial collectives (3).

The process used to determine the three normal distributions was simple and based upon a couple of assumptions. First, the maritime regime apparently has the strongest signature and is easily identified in the total distribution. The mean is very near 35°F. By assuming the part of the distribution above the mean is totally contributed by the maritime regime, the kurtosis of the distribution is known; by assuming no skewness, an approximate distribution can be extracted from the data set. The final decomposition is less clear, but by assuming the lowest part of the remaining distribution represents the left tail of the continental regime, a similar process yields the remaining two distributions. The author realizes that any set of curves obtained using this method is only one of many similar sets, but feels that some interesting points can still be inferred from such a

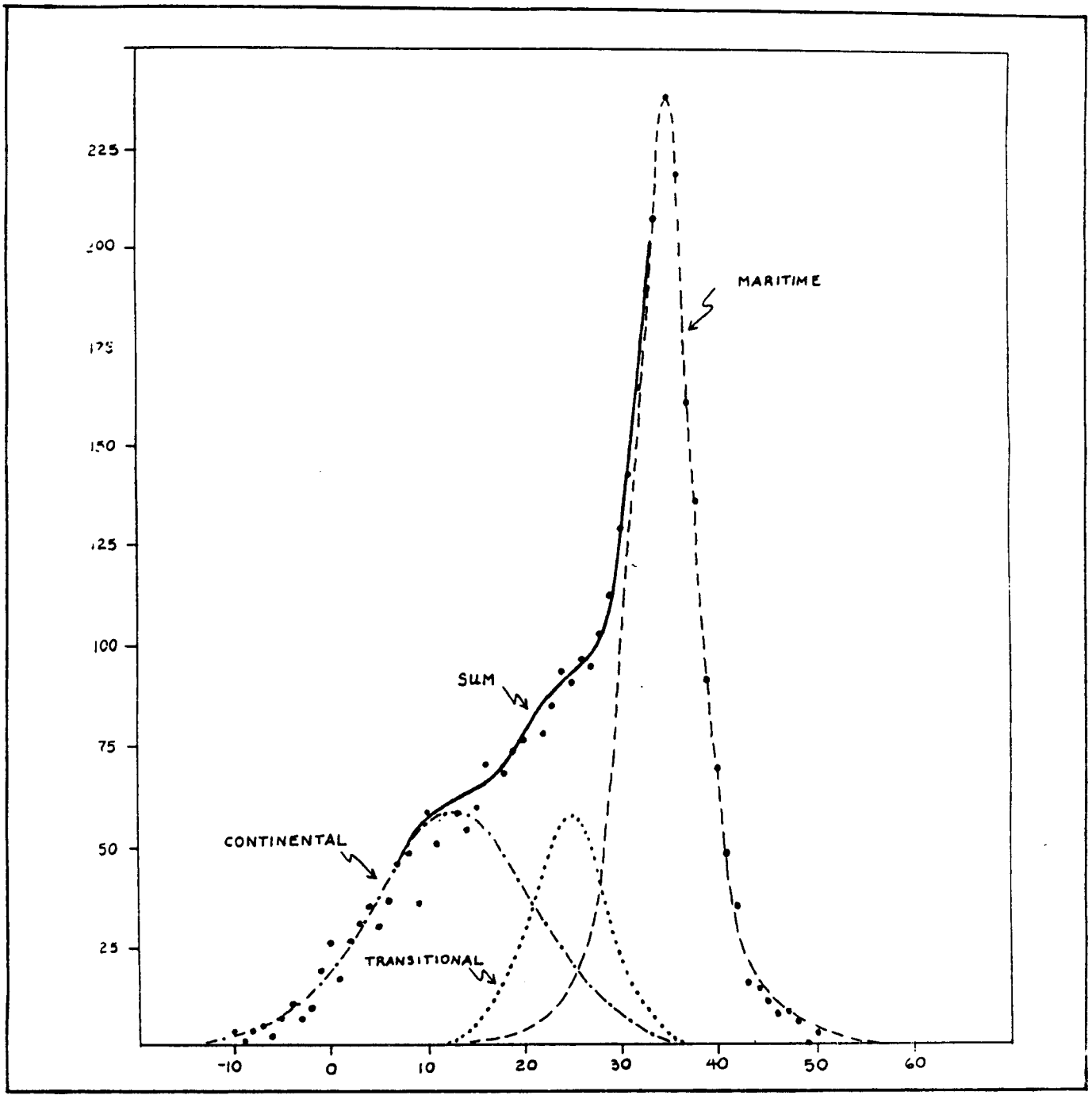

Figure 3. The approximate normal curves for the daily mean temperatures (°F) of the three climatic regimes and their sum. The observed distribution is displayed with dots.

set. A similar technique was utilized successfully by Bryson (4) in identifying air-mass frequency and origin over Canada.

Fig. 3 shows all three normal curves, each of which can be used to identify the characteristics of the individual regimes. The maritime partial collective gives a mean temperature of 35°F for that regime which occurs 53% of the winter (calculated by comparing areas under each of the normal curves to the total area). The mean for the continental regime is 13°F and occurs 32% of the time, with the transitional period averaging 25°F and 15%. It is interesting to note that the climatological mean is very near the peak in the transitional regime, which is the one that occurs the least.

As mentioned earlier, the individual regimes also have very different precipitation characteristics. The maritime regime is very wet and accounts for the majority of precipitation, while the continental

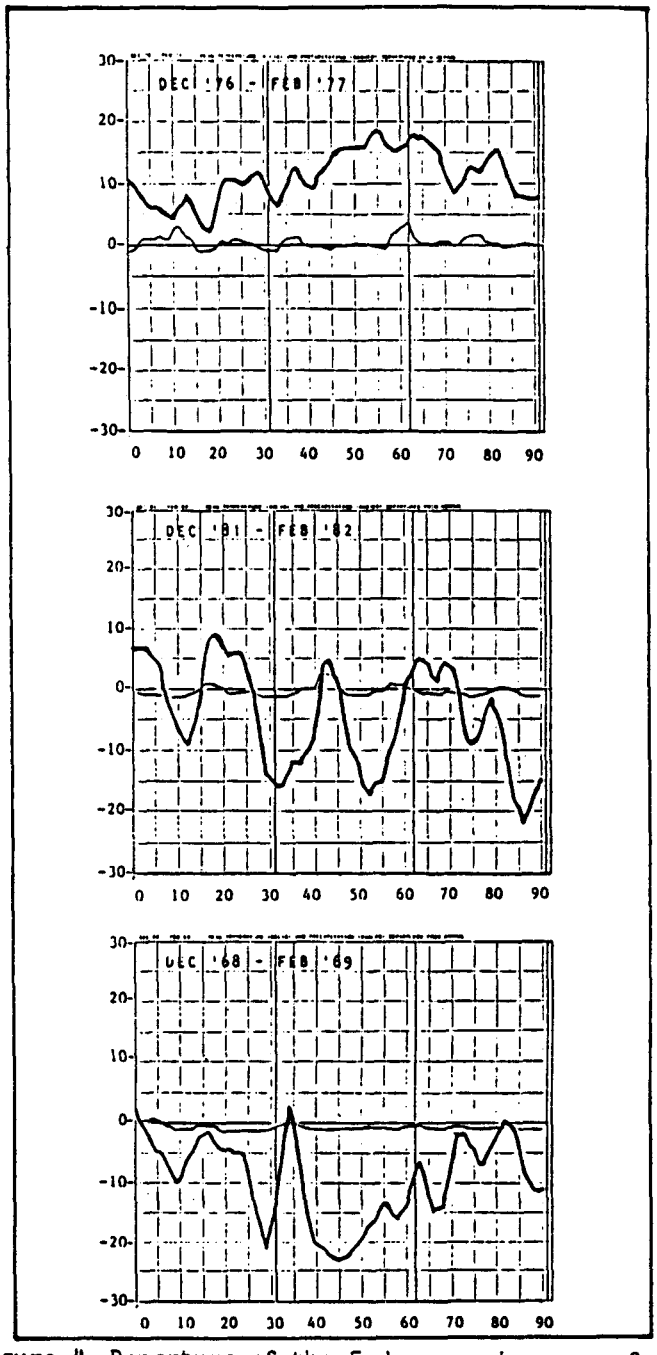

Figure 4. Departure of the 5-day running mean from the daily normals (centered on day 3). Bold solid line is daily-mean-temperature departures with the ordinate in °F. Light solid line is daily-precipitation departures with the ordinate in tenths of inches. Abscissa is labeled in Days after December 1.

regime is usually dry. The transitional period, particularly in the direction from arctic to maritime, is characteristically cool and wet, accounting for most of the snowfall that occurs at sea level.

Year to year variations are extreme, with several years (e.g. 1943-44 and 1976-77) never experiencing a major outbreak of arctic air while others (e.g. the early 70s) had an abundance of arctic outbreaks. Fig. 4 shows mean temperature and precipitation departures from normal for several different winter seasons. For southeast Alaska, the winter of 1976-77, noteworthy over all of North America for the presistent and extreme departures from normal, was dominated by a mild maritime flow with abundant rainfall. The winter of 1981-82 experienced frequent transitions between maritime and continental regimes with large fluctuations in

temperature and heavy snowfalls at sea level. At Juneau, 69.2 inches of snow fell during the two transitional periods in January alone.

The winter of 1968-69, dominated by the continental regime, was characteristically cold and dry. Only 3.52 inches of precipitation fell furing the 3-month period, well below the average 11.50 inches. Snowfall for the 3-month period (80.9 inches) was slightly above average and fell during several transitional periods, only one of which was complete with the temperature rising to 35°F on January 3, 1969.

3. SUMMARY

It has been shown that the interpretation of climatological means should not always be based on a simple gaussian assumption. Specifically, the climate of Juneau was found to be composed of three regimes with contrasting means and frequencies that, only when statistically combined, give the climatological means which are in fact not the most frequently observed daily values.

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NOTES AND REFERENCES

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