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# REGIONAL PATTERNS ASSOCIATED WITH CLIMATIC CHANGE

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## 1. INTRODUCTION

The study of climatic change has received a great deal of attention in recent years. Most people involved in atmospheric science are confronted with the question, "What is happening to our climate?" This question is a very difficult one to address. Atmospheric scientists must be careful not to mislead the public by responding with statements regarding global or hemispheric climatic changes or trends, for large-scale climatic trends may not be valid for every region. The purpose of this paper is to demonstrate that a large-scale climatic change can be associated with substantially different changes in surface climatic elements across the United States.

## 2. DISCUSSION

Most climatologists are in agreement that any changes in climate will be manifested in a readjustment of the general circulation system of the atmosphere. Several miles above the earth's surface in the middle latitudes, air flows in a west-to-east direction forming the circumpolar vortex. The heart of this upper-level flow is commonly referred to as the polar jet stream. This band of strong flow is located above the area where the warm tropical air masses come in contact with the cooler polar air masses. During relatively warm climatic periods, air in the upper-level flow pattern tends to move in a fairly straight west-to-east (zonal) pattern around the globe. During cooler periods, this straight flow pattern breaks down into a sinuous (meridional) configuration. The weather patterns associated with these major circulation types can be substantially different in every respect. Regional temperature, pressure, moisture, and wind patterns are all directly linked to the configuration of the predominant circulation.

Kalnicky (1) provided convincing evidence that a significant shift in the atmospheric circulation pattern occurred in the early 1950's. For several decades prior to 1950, the upper-level pattern was predominantly the relatively straight, zonal type. Quite abruptly, the circulation system shifted into a meridional pattern that has persisted throughout the 1970's. An upper-level high pressure ridge formed over the Rockies and an upper-level low pressure trough was created over the eastern half of the United States as the circulation shifted to a meridional pattern. Mitchell (2) demonstrated that a hemispheric warming trend stopped and a cooling trend was initiated in association with the shift in circulation. This paper will examine the surface climatic changes associated with the circulation shift of the early 1950's.

## 3. PROCEDURES

Surface climatological data were gathered for 151 climatological stations in the coterminous United States for the ten zonal years (1939-1949) and the ten meridional years (1955-1965) that immediately followed the major circulation shift.

Winter data were exclusively utilized due to the relatively steep latitudinal climatic gradient occurring during low-sun months which accentuates changes in regional climatic patterns.

For available climatic elements, t-scores indicating the standardized amount change between the zonal and meridional periods were computed for each station. The t-scores for each climatic element were plotted on a map of the United States. The resulting pattern was smoothed using trend-surface analysis to eliminate climatic "noise" and isolate the more important climatic "signal" in the change data.

## 4. RESULTS

The map illustrating temperature change (Figure 1) clearly indicates that distinctive regional patterns were associated with the climatic change of the early 1950's. As the configuration of the circulation system shifted to a meridional pattern, temperatures increased in the Rocky Mountain region while temperatures decreased sharply in the western Great Lakes area. These findings suggest that a higher frequency of warm air moved horizontally into the area dominated by the upper-level ridge. Colder air masses apparently were advected with a greater frequency into the Midwest region which was dominated by an upper-level trough.

The map of precipitation change reflects the same pattern in the upper-level circulation (Figure 2). The central United States became significantly drier, while the Northwest and south Atlantic coast became wetter as the meridional pattern became predominant. The decreased precipitation in the Plains was caused by convergence in the air flow of the upper atmosphere restricting vertical motions necessary for precipitation formation. Conversely, the location of the two regions of precipitation increase can be explained by their position relative to the upper-level troughs. Both of these regions are located slightly ahead of the

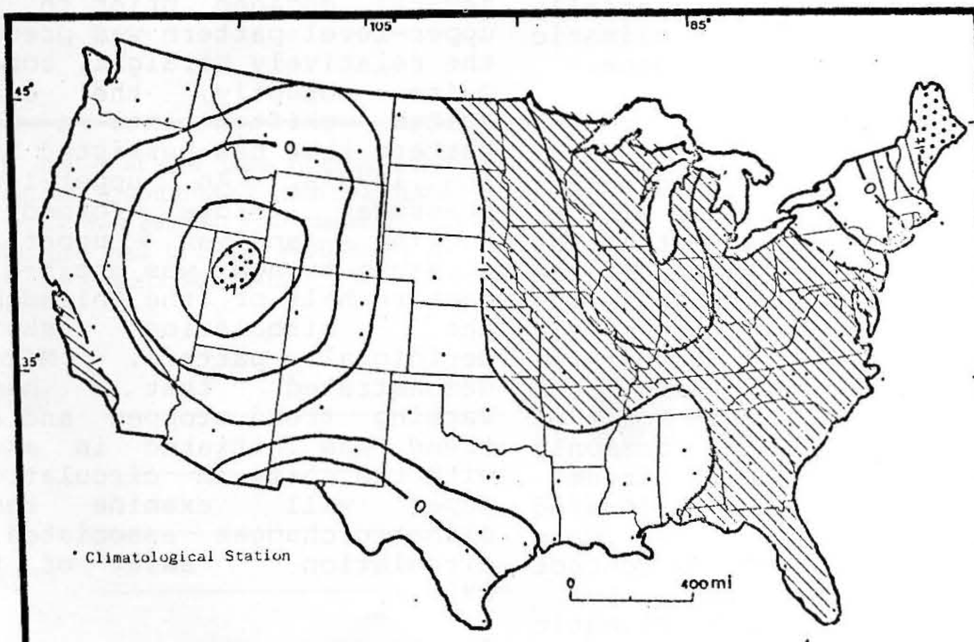


Fig. 1. Surface of Temperature Changes

troughs, where divergence in the upper-level air flow promoted vertical motion which enhanced the precipitation potential.

These analyses were not restricted to the commonly used climatic indices of temperature and precipitation. For example, a plot of wind speed changes (Figure 3) reflects the shift that occurred in the general circulation.

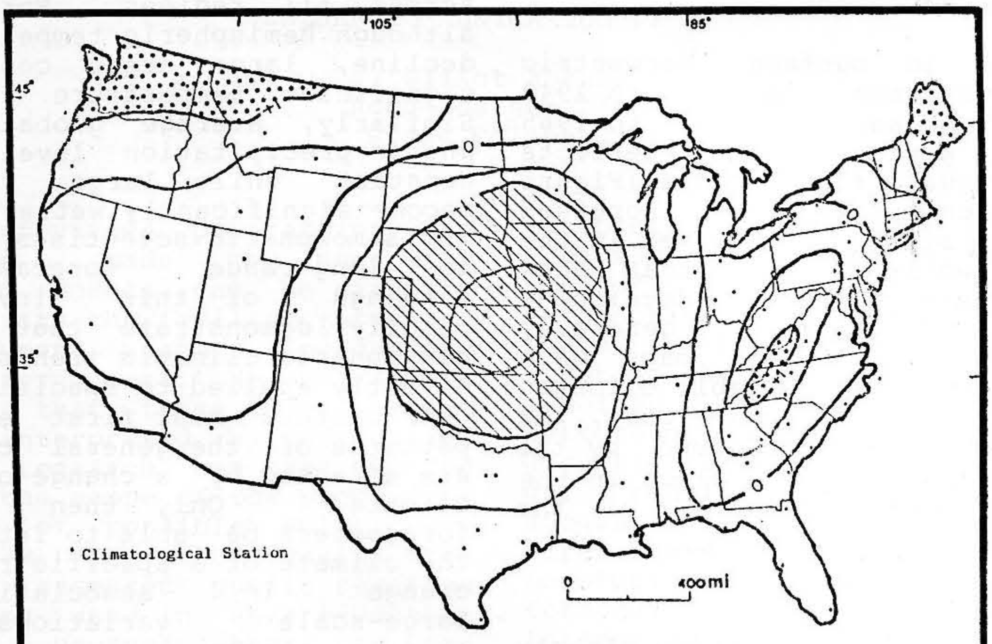


Fig. 2. Surface of Precipitation Changes

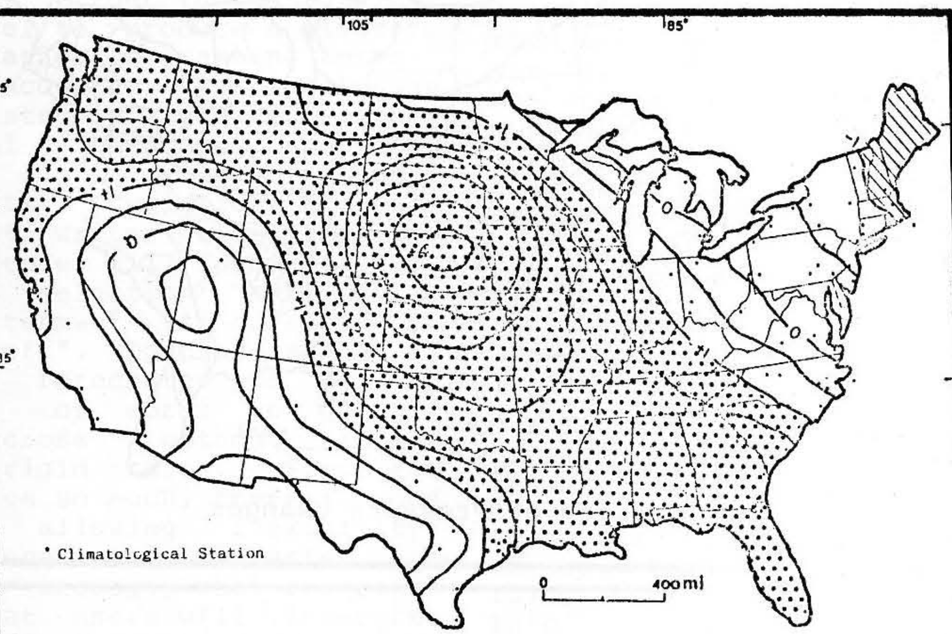


Fig. 3. Surface of Wind Speed Changes

With warming in the West and cooling in the Great Lakes region, the temperature gradient of the central Plains increased, forcing much higher wind speeds across the Plains. Beneath the ridge in the Rockies, the wind speeds decreased.

The change in surface barometric pressure between the 1939 to 1949 zonal period and the 1955 to 1965 meridional period strongly reflects the upper-level flow changes (Figure 4). Surface pressures increased beneath the ridge that formed in the Rockies, while in the Great Lakes region where a trough developed, surface pressures generally decreased. Similar maps were prepared for all available climatic elements, and in each case, the findings could be explained by the changes that took place in the general circulation of the atmosphere.

## 5. CONCLUSIONS

The findings of this study clearly demonstrate that a climatic change produces distinctly different surface climatic changes in the United States. These findings show that global or hemispheric trends in climate cannot be directly applied across all regions. For example, although hemispheric temperatures may decline, large areas could display significant temperature increases. Similarly, average global or hemispheric precipitation levels may stay constant while large regions may become significantly wetter or drier. For atmospheric scientists interested in long-range forecasting, the findings of this investigation clearly demonstrate that global or hemispheric climatic trends cannot be directly applied to specific regions. Forecasters must first examine how patterns of the general circulation are affected by a change or trend in climate. Only then will these forecasters be able to interpret how the climate of a specific region will change in association with large-scale variations in the climatic system.

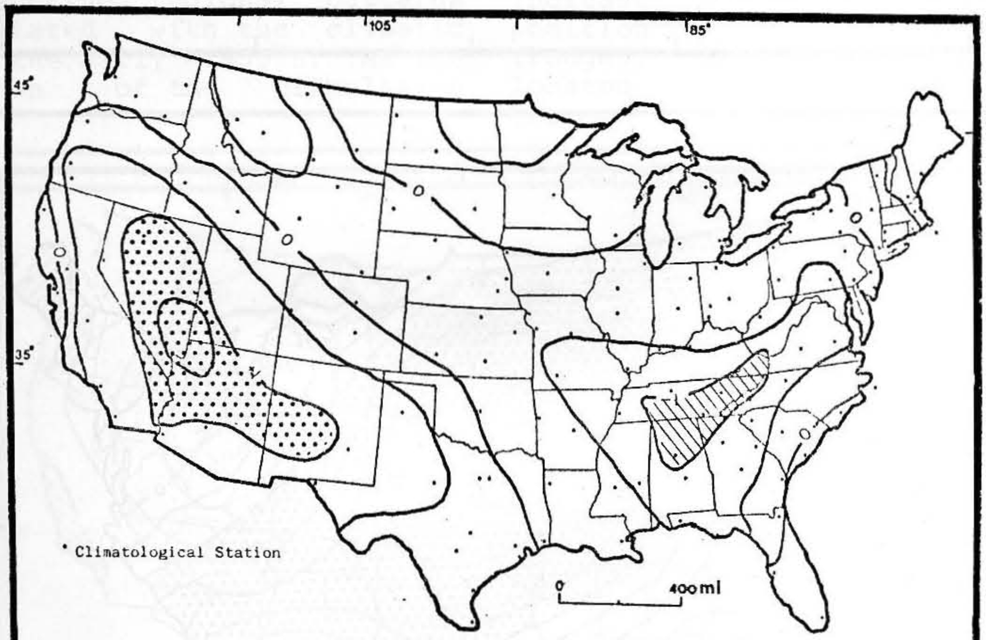


Fig. 4. Surface of Pressure Changes

## REFERENCES AND FOOTNOTES

(1) Kalnicky, R. A., 1974. Climatic Change Since 1950. Annals of the Association of American Geographers, vol. 64, pp. 100-112.

(2) Mitchell, J.M., 1963. On the World-Wide Pattern of Secular Temperature Change, in Changes of Climate (Paris: UNESCO), pp. 161-181.