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FURTHER COMMENTS ON THE CLIMATE OF THE MIDNINETEENTH CENTURY UNITED STATES COMPARED TO CURRENT NORMALS

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ABSTRACT

Evidence derived from the carefully screened temperature record at Eau Claire, Mich., and from radiosonde data at Sault Ste. Marie, Mich., supports the conclusion of Wahl and Lawson that a return to the temperature and circulation features of the early and mid-19th century in the eastern United States may be underway. Cooling trends at Eau Claire during the most recent decades have been accompanied by progressive lowering of the 700-mb surface at Sault Ste. Marie, and increased cold air advection into the southern Great Lakes area.

1. INTRODUCTION

Two recent studies (Wahl 1968, Wahl and Lawson 1970) have supplied valuable insights into the "normality" of the climate of the eastern United States as measured by the currently valid climatic averages of the 30-yr period 1931–60. These studies compared climatic data for the eastern United States for the periods 1830–49 and 1850–69 with normals from the 1931–60 period and found some well-defined and statistically valid contrasts in both temperature and precipitation. In general, a cooler, and in some areas, wetter, climate existed during the middle decades of the 19th century. These departures were related to weakened circulation (low zonal index) and westward displacement of the trough-ridge pattern over the Atlantic sector of the Northern Hemisphere as reported by Lamb and Johnson (1959) and by Lamb (1966). Wahl and Lawson indicated that, in later decades of the 19th century, a major change occurred and a warming trend was initiated in the eastern United States that culminated during the period 1931–60, from which our current normals are derived. This warmup accompanied eastward displacement of the trough-ridge pattern with a circulation change toward more vigorous westerlies (high zonal index), less meridionality, and longer wavelengths of smaller amplitude.

This note provides additional information which further confirms the suggestions made by Wahl and Lawson that the climate of the eastern United States has, during recent decades, been reverting toward temperature and circulation patterns characteristic of the mid-19th century, and in consequence the data from the 1931–60 period may be representative of a climatically "abnormal" interval.

2. RECENT CLIMATIC CHANGES WITHIN THE MIDWESTERN CORE ZONE

Wahl and Lawson indicated that the negative temperature departures during the two mid-19th century periods (1830–49, 1850–69) investigated appeared centered in the eastern and northern midwest. In attempting to verify, in a general way, their suggestion that a reestablishment of the climatic character of the last century is currently underway, they compared annual average temperatures at selected first-order stations for the most recent 10 yr available (1959–68) with the 1931–60 values. Although qualifying their conclusion since no specific efforts were made to select the stations carefully with respect to exposure, station history, etc., they found a tendency toward the departure patterns of the 1850s and 1860s.

The core zones of temperature departure identified for each mid-19th century period did not exactly correspond in location, but a composite map for both periods would put the region of maximum annual average negative temperature departure within a belt oriented east-west across the southern Great Lakes area (fig. 1). Because of its location with respect to mean trough-ridge positions downstream from the Rocky Mountains, this area may be expected to respond climatically to fluctuations in the circulation in an unambiguous manner. Therefore, it is useful to examine more closely temperature and circulation features during the past several decades specifically within this core region, focusing on the suggested recent cooling trend, and utilizing in this case a carefully screened instrumental record.

The instrumental record at Eau Claire, a cooperative station in the fruit district of southwestern Michigan near the heart of the core zone, is uniquely homogeneous. This substation is located about 14 mi east of Lake Michigan in high rolling country free from urban influences. Since its establishment at its present location in 1930, no instrumental site changes have occurred. The observer, Mr. William Teichman, a fruit farmer much interested in the weather, served continuously from 1930 until his death in 1968. The uniformity of instrumental site, freedom from extraneous environmental influence, and consistency of observer technique at Eau Claire make that record a particularly valuable one for investigation of climatic change on the order of a decade or so.

Monthly mean temperatures at Eau Claire were extracted from 1930, near the peak of the warm period, through 1968. Smoothing was accomplished by a simple equal-weighted moving average, and time-series curves

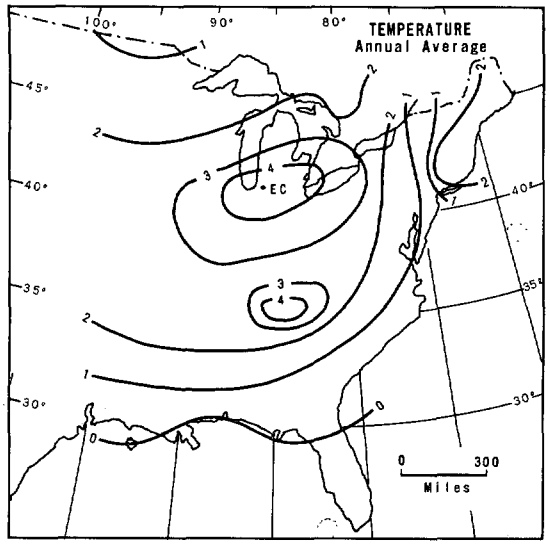

FIGURE 1.—Algebraic summation of temperature departures (°F) of the data of 1830–49 and 1850–69 from climatic normals for 1931–60. Values are negative. The location of Eau Claire, Mich. is shown as EC.

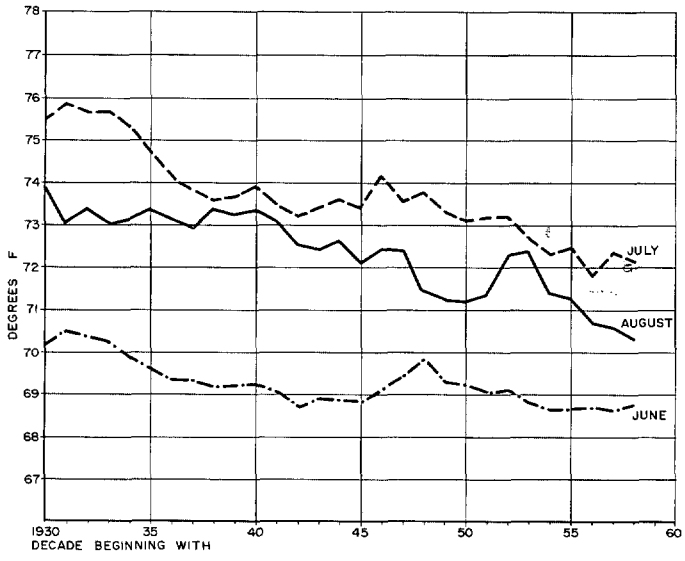

FIGURE 2.—Ten-yr moving averages of summer monthly mean temperatures at Eau Claire, Mich.

were plotted for each month of the year. Definite cooling tendencies appeared in summer and winter, particularly during seasonal extreme months of July and January. Figure 2 shows 10-yr moving averages of monthly temperatures for June, July, and August. All 3 mo show temperature declines since the height of the recent climatic optimum during the 1930s. July temperatures have decreased about 3.5°F since the decades beginning with the early 1930s, and August temperatures have decreased about 3°F since the decades beginning with the late 1930s and early 1940s.

Winter temperatures (fig. 3) evidenced less of a linear trend, with an upward swing in January and February

FIGURE 3.—Ten-yr moving averages of winter monthly mean temperatures at Eau Claire, Mich.

during the decade of the early 1940s and the early 1950s. However, marked cooling occurred during the later 1950s and 1960s with over a 4°F drop in decadal averages. Although the simple moving-average method of smoothing does not permit precise identification of inflection points because of phase shifting and loss of amplitude of some of the shorter fluctuations, it seems likely that the cooling at Eau Claire in the summer has been progressive since the early 1930s, and that winter temperatures have decreased markedly since the late 1940s and early 1950s.

No pronounced trends occurred during the transition months in spring and fall at Eau Claire, although Wahl and Lawson noted negative departures within the core zone during all seasons in the mid-19th century. However, the March temperature series appeared in phase with January and February, although less well defined, and the September data were similarly related to those of July and August.

As a next step, an evaluation was made of circulation changes associated with or responsible for these temperature drops. Both Lamb (1966, 1969) and Namias (1967, 1970) have presented evidence of a trend during the 1960s toward a return to the circulation patterns of the early and mid-19th century. Namias (1967, 1970) noted the deepening and intensification in recent years of the 700-mb trough off the Atlantic seaboard of North America. He cited negative mean 700-mb height departures over the eastern United States and positive departures over the West for the winters 1960-61 through 1969-70 which he related to large-scale air-sea coupling in the North Pacific.

To investigate circulation changes within or near the core zone, and because of difficulty in adapting digitized grid data for the 700-mb level (made available by the National Weather Service Extended Forecast Division) to Western Michigan University's computer system, it was decided to examine single station radiosonde data. Of the radiosonde stations near the core region, only Sault Ste. Marie had the necessary continuity of data.

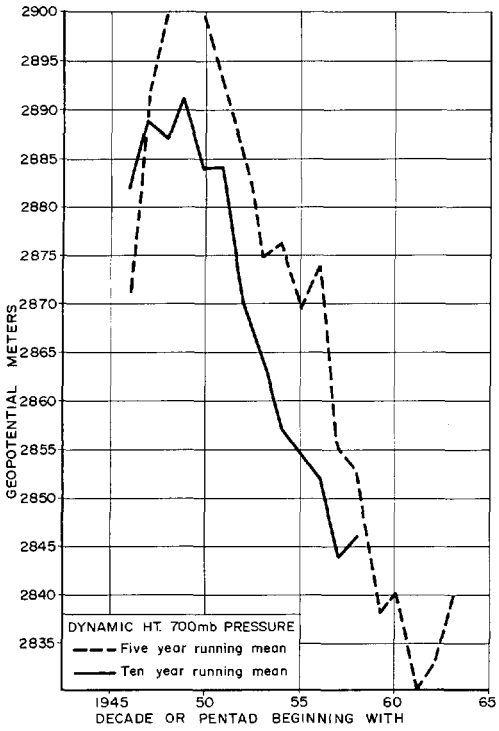

FIGURE 4.—Ten- and 5-yr moving averages of January mean heights of the 700-mb level at Sault Ste. Marie, Mich. (Peak about 2906 m in 1948.)

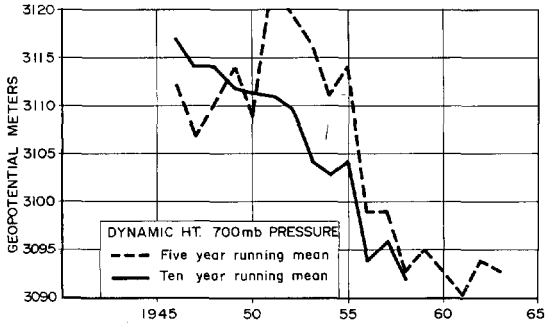

FIGURE 5.—Ten- and 5-yr moving averages of July mean heights of the 700-mb level at Sault Ste Marie, Mich. (Peak about 3123 m in 1952.)

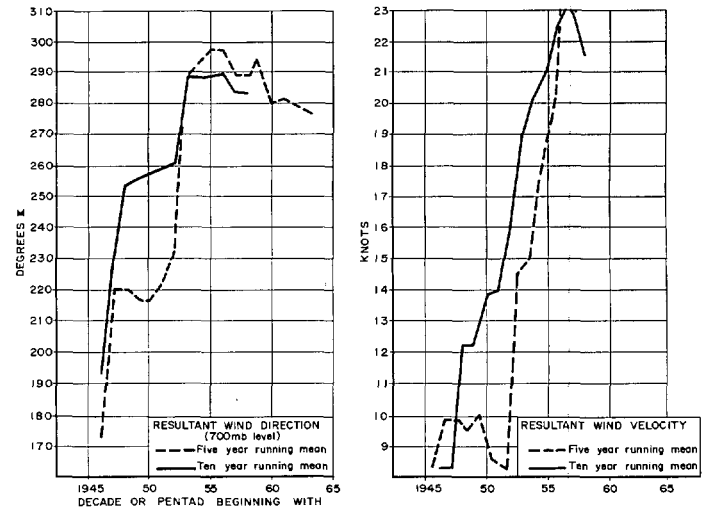

FIGURE 6.—Ten- and 5-yr moving averages of January mean resultant wind directions and speeds at Sault Ste. Marie, Mich. (Peak about 25 kt in 1960.)

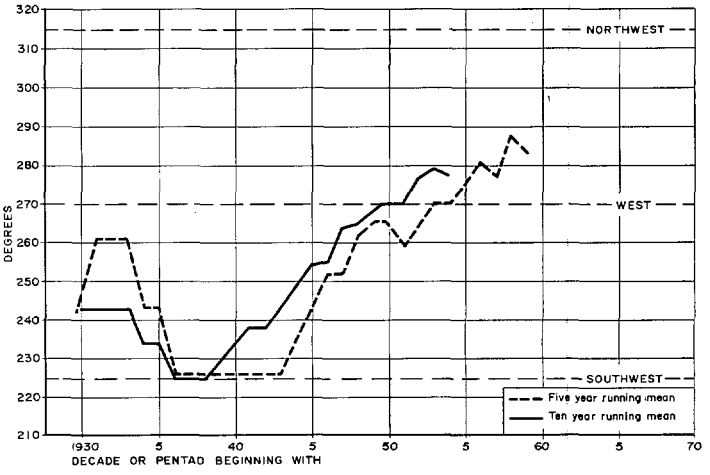

FIGURE 7.—Ten- and 5-yr moving averages of July prevailing winds, at Grand Rapids, Mich. Ordinate values are azimuths.

These data were extracted from *Climatological Data, National Summary*, and from the *Monthly Weather Review* for the period 1948–68. The smoothing method used was the same as for the temperature series.

Figures 4 and 5 show 10- and 5-yr moving averages of the heights of the 700-mb level at Sault Ste. Marie for January and July, the months with the sharpest temperature changes at Eau Claire. Progressive decrease of heights is evidenced for both months, and is particularly marked in January during the later decades. This decrease is in accord with the decreasing zonality of circulation and deepening of the mean 700-mb trough off the east coast of North America. With shortened distance between the eastern Midwest and the deepening western Atlantic trough (a situation reminiscent of the early and mid-19th century), increased cold air advection into the area occurs. Mean resultant winds at the 700-mb level over Sault Ste. Marie, plotted in figure 6, show a progressive shift to more northerly quadrants and higher velocities, although it is possible that the wind statistics during early years are biased because of the absence of radar tracking.

Surface wind data at Grand Rapids, Mich., a nearby first-order station, were also examined. Prevailing winds for both January and July, based on hourly values, were converted to azimuth values and plotted as 10- and 5-yr moving averages. January prevailing winds indicated a trend in phase with falling temperatures, that is, change toward more northerly directions since the 1950s. July prevailing winds (fig. 7) show a linear trend toward more northerly quadrants since the warm spell of the 1930s.

3. CONCLUSIONS

Evidence presented here supports the suggestion of Wahl and Lawson that a return to the temperature and circulation features of the early and mid-19th century in the eastern United States may well be underway. Examination of a carefully screened instrumental record within the core zone of temperature contrast recognized by Wahl and Lawson indicates progressive summer cooling since the 1930s and rapid winter cooling since the late 1940s and early 1950s. Examination of the changes in upper air circulation as represented by radiosonde data for Sault Ste. Marie indicates a deepening and probable westward progression of the 700-mb trough over the eastern United States during the past several decades. Surface prevailing winds at Grand Rapids have shown progressive shifts toward more northerly quadrants.

The possible ramifications of these tendencies must be given serious consideration, as Wahl has suggested. In southwestern Michigan, fruit growers have already commented on the change of climate which has become apparent to them during the past decade. While recent cool and cloudy summers have hampered summer recreational and tourist activities, winter sports industries have benefited from the large increases in lake-effect snow (Eichenlaub 1970) which probably have been caused, at least partly, by the colder winters.

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