

The New Decade and Changing Normals of Temperature and Precipitation in Indiana

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Introduction

"Normals" of temperature and precipitation, as well as their estimates, are ever changing to the disappointment of many who presume them to be climatological bench marks in meteorology. Reference to departures from normal regularly used by the news media, the heating and cooling industry, and by agriculturalists assume a semi-permanent fixed average, called the normal. Most countries adhere to the World Meteorological Organization definition of a temperature or precipitation normal as a 30-year average ending with the last complete decade. Continuous constant quality exposure of instruments at one location is required to prepare station normals. For climatological division or district normals, it is also assumed that the network or location of stations within the division, has not changed significantly. Temperature and precipitation normals are calculated at the end of each decade for the preceding 30-years and used as normals for the next ten years. What happens when the records of the 1970s replace those of the 1940s? The answer is the subject of this paper.

Data and Procedures

The easiest way to appraise the new normals is to consolidate the 1951-80 station averages into a revised area or division normal. A preliminary listing of the new station normals calculated by the National Climatic Center were used. Indiana is divided into nine climatic divisions as outlined in Figure 1. These division boundaries have been used in *Climatological Data, Indiana* (U.S.D.C., 1956-80) and other climatological publications since October 1956. They are also the same as the Crop Reporting Districts used by the U.S. Department of Agriculture in summarizing crop and livestock statistics.

Results and Discussion

Precipitation

Normals of total annual precipitation, average of 1951-1980, have undergone very little change from those of 1941-70, used in the 1970s, and even from those of 1931-60. The new normals to be used in the 1980s are given in Table 1. There are distribution changes within the year, however. In January in the southwest division precipitation totals decreased from 3.90 inches in 1931-60, to 3.28 in 1941-70, and 2.87 for the new normals. This winter decrease is offset by an increase in July, from 3.56 in the 1931-60 period, 4.32 in the 1951-80 period. The change is less in the other divisions. If true, this has important agricultural significance in Indiana. The state usually has an excess of winter precipitation and almost always has less precipitation than required in the summer. The southwest division has the greatest evaporation and has the highest drought probabilities.

Temperatures

New average divisional daily temperature normals, shown in Table 2, range from 23.0°F. in January in northwest Indiana to 30.2°F. in the southwest. The range in July is much less, from 73.1°F. in north central to 77.4° in southwest. Daily

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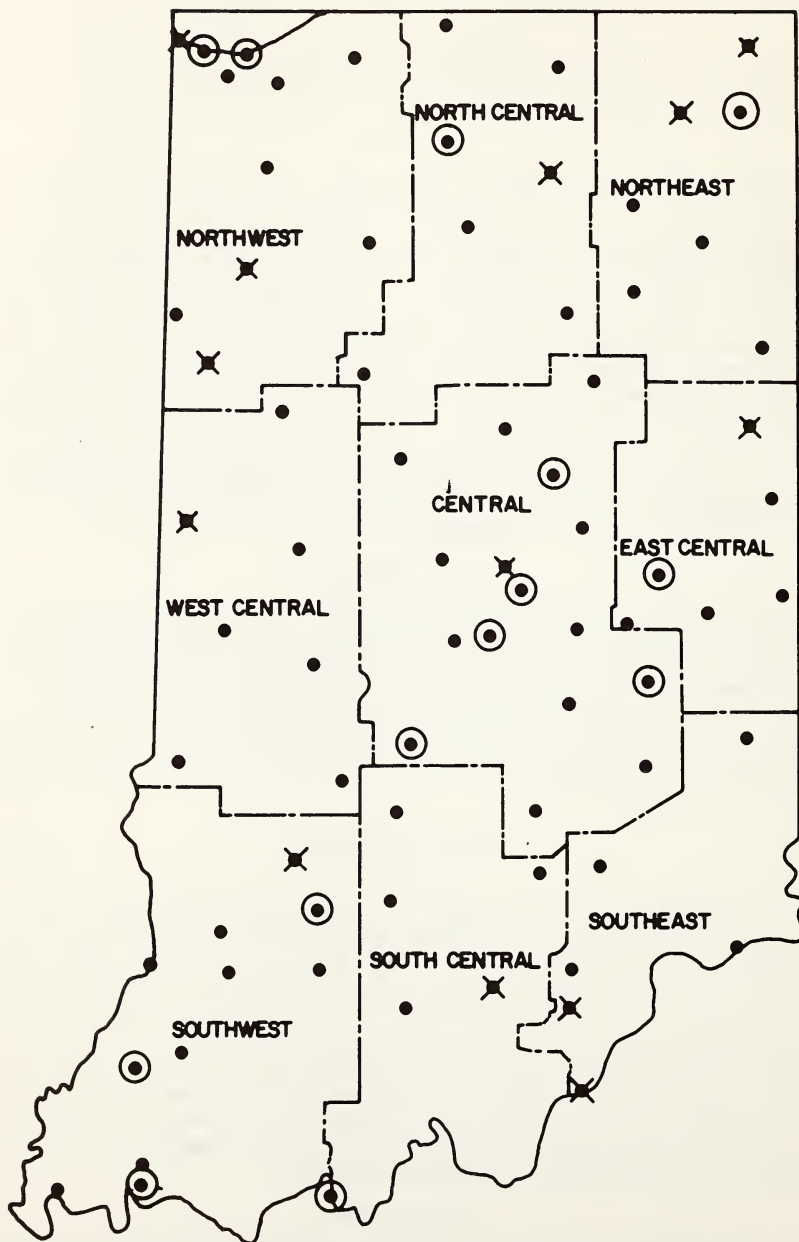


FIGURE 1. Temperature stations included in calculation of division normals. Deletions (X) and additions (O) from 1931-1960 to 1951-1980 normals.

TABLE 1. *Average Monthly Precipitation, Indiana Divisions, 1951-1980.*

Division	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Northwest	1.91	1.66	2.83	4.04	3.43	4.21	4.03	3.70	3.35	2.94	2.50	2.49	37.09
North Central	2.05	1.81	2.83	3.94	3.42	4.12	4.00	3.64	3.11	2.78	2.66	2.55	36.91
Northeast	2.10	1.84	2.97	3.65	3.55	3.77	3.68	3.26	2.84	2.52	2.72	2.53	35.43
West Central	2.36	2.12	3.37	3.92	4.09	4.51	4.41	3.62	2.94	2.56	3.01	2.83	39.74
Central	2.49	2.27	3.29	3.90	4.01	4.07	4.41	3.52	2.82	2.56	3.01	2.85	39.20
East Central	2.48	2.12	3.23	3.97	3.93	4.25	3.95	3.44	2.75	2.52	2.96	2.77	38.37
Southwest	2.87	2.73	4.38	3.98	4.40	3.92	4.32	3.44	2.90	2.50	3.44	3.36	42.24
South Central	3.17	2.80	4.31	4.00	4.47	4.32	4.58	3.64	2.95	2.57	3.52	3.39	43.72
Southeast	3.24	2.90	4.22	3.86	4.25	4.07	4.40	3.43	3.03	2.64	3.25	3.14	42.43

TABLE 2. *Average Daily Temperature, Indiana Divisions, 1951-1980.*

Divisions	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Northwest	23.0	27.0	37.0	49.6	60.2	69.6	73.4	71.7	65.2	54.1	40.6	28.9	50.0
North Central	23.4	26.9	36.8	49.6	60.1	69.6	73.1	71.1	64.6	53.1	40.4	29.2	49.7
Northeast	24.0	27.1	37.2	49.8	60.2	69.8	73.3	71.4	64.8	53.3	40.5	29.4	50.1
West Central	25.5	29.4	39.4	52.2	62.3	71.4	75.0	73.1	66.6	54.9	42.0	31.1	51.9
Central	25.6	28.9	38.9	51.4	61.6	70.6	74.1	72.2	65.9	54.0	41.5	30.9	51.3
East Central	24.7	27.7	37.8	49.9	60.2	69.4	73.0	71.2	64.5	52.6	40.6	30.1	50.1
Southwest	30.2	34.1	43.7	56.1	65.2	73.9	77.4	75.7	69.3	57.4	45.0	35.1	55.3
South Central	29.2	32.6	42.0	54.2	63.4	72.0	75.6	74.1	67.6	55.5	43.8	34.0	53.7
Southeast	29.4	32.7	42.2	54.1	63.5	72.1	75.8	74.2	67.8	55.6	43.8	34.3	53.8

mean temperatures are the averages of the daily maximum temperatures of Table 3, and daily minimum temperatures of Table 4.

A comparison of the new temperatures normals with those used the past ten years shows some very interesting changes. In Figure 2, the divisional temperature normals for 1951-80 and 1931-60 are shown as departures from the 1941-70 normals. For Central Indiana the departures are also shown for the 1921-50 normals. For practically all months and divisions lower temperatures are indicated by the 1951-80 normals. Those for January and February are the most drastic. No doubt the severe winters of 1977, 1978 and 1979 contributed greatly to reducing the average. The second dominant feature in Figure 2 is the minimal change during November and December in the western and northern divisions.

Sources of "Non-climatic" Trend

The configuration of climatological stations used to compute a divisional average changes from one decade to another. This introduces bias into the estimates of the "normal" climate. One source of bias concerns the rule that a station must operate continuously for 30 years or more. Otherwise, it is dropped from the group being used for determining the divisional average. On the other hand, stations newly attaining a record length of three decades enter the averaging process. With a north to south temperature and precipitation gradient existing there may be some increase in temperature and precipitation shown by the divisional average if there is a relative increase in stations in the southern part of the division. The opposite is true if there are relative additions of stations in the north. Changes in network configuration of stations used for the normals in 1951-80 from that in 1931-60 are shown in Figure 1.

Another bias that climatologists, working with once daily observations of

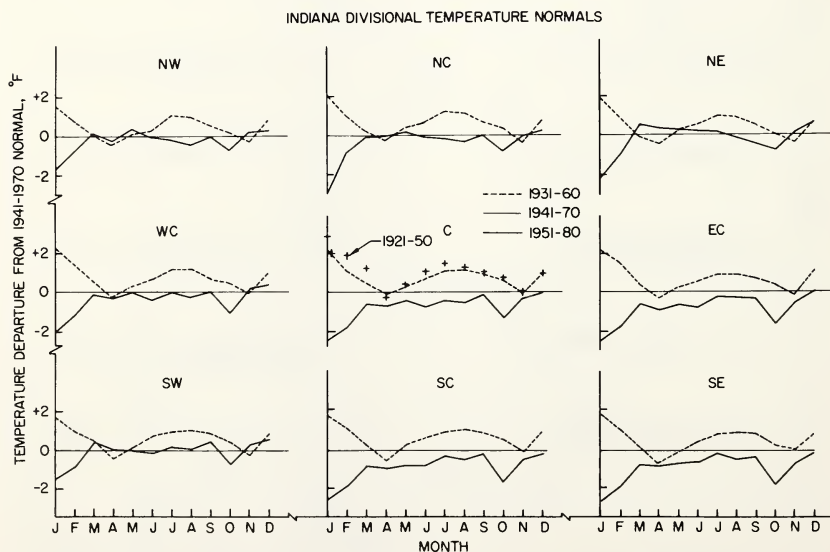


FIGURE 2. New normals of temperature (—) shown as departures from base line 1941-1970, departures for 1931-1960 (---), and for central Indiana, 1921-1950 (+ + +).

TABLE 3. *Average Daily Maximum Temperature, Indiana Divisions, 1951-1980.*

Divisions	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Northwest	31.2	35.6	46.0	60.4	71.9	81.3	84.5	82.8	76.9	65.3	49.3	36.5	60.1
North Central	31.6	35.8	46.2	60.9	72.1	81.5	84.7	82.8	76.9	64.9	49.3	36.9	60.3
Northeast	31.9	35.8	46.5	61.0	72.0	81.6	84.7	83.1	77.0	65.0	49.0	36.8	60.4
West Central	34.4	39.0	49.4	63.4	74.0	83.0	86.5	84.8	79.2	67.4	51.7	39.5	62.7
Central	34.3	38.3	48.7	62.6	73.1	82.0	85.4	83.8	78.3	66.4	51.1	39.2	61.9
East Central	33.7	37.2	47.7	61.3	72.0	81.1	84.7	83.3	77.2	65.2	50.2	38.5	61.0
Southwest	39.0	43.7	53.9	67.5	76.9	85.5	88.6	87.2	81.5	70.1	55.0	43.6	66.0
South Central	39.0	43.2	53.1	66.5	76.0	83.9	87.4	86.5	80.8	69.4	54.9	43.5	65.4
Southeast	38.8	43.1	53.3	66.4	76.0	84.0	87.4	86.3	80.7	69.0	54.5	43.4	65.2

TABLE 4. *Average Daily Minimum Temperature, Indiana Divisions, 1951-1980.*

Divisions	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Northwest	14.7	18.4	27.9	38.7	48.4	57.9	62.3	60.5	53.5	42.8	31.9	21.3	39.9
North Central	12.6	18.0	27.4	38.2	48.1	57.6	61.4	59.4	52.2	41.2	31.5	21.5	29.1
Northeast	16.1	18.4	27.8	38.6	48.4	57.9	61.8	59.7	52.6	41.6	32.0	22.0	39.7
West Central	16.6	19.8	29.4	40.9	50.5	59.2	63.4	61.3	54.0	42.3	32.2	22.6	41.1
Central	16.8	19.5	29.0	40.2	50.0	59.2	62.8	60.5	53.4	41.6	31.9	22.6	40.6
East Central	15.7	18.2	27.8	38.4	48.4	57.6	61.2	59.0	51.8	40.0	30.9	21.7	39.2
Southwest	21.3	24.4	33.4	44.6	53.4	62.3	66.2	64.1	57.0	44.7	35.0	26.6	44.4
South Central	19.4	21.9	30.8	41.9	50.8	60.0	63.8	61.6	54.4	41.65	32.6	24.5	41.9
Southeast	20.0	22.3	31.1	41.8	51.0	60.2	64.1	62.1	54.8	42.2	33.0	25.0	42.3

maximum and minimum temperatures, relate to the change of observation time from evening hours to morning hours. Operational demands have tended to favor this shift of time in reading the instruments. It was shown by Schaal and Dale (1977) that this shift induces a lower mean minimum and mean temperature in computing the 24-hour (observational day) average temperature. The divisional temperature is in turn reduced, other factors remaining the same. For example, the lowest temperature in a 24-hour period is reported twice when the temperature at the beginning is much lower than at the end of the 24 hours which is often the case for a 7 a.m. observation time. If the observation time is 6 p.m. there is no carry-over minimum temperature, but there may be a carry-over maximum and an upward temperature bias. The obvious trend in Figure 3 contributes "non-climatic cooling" to the normals.

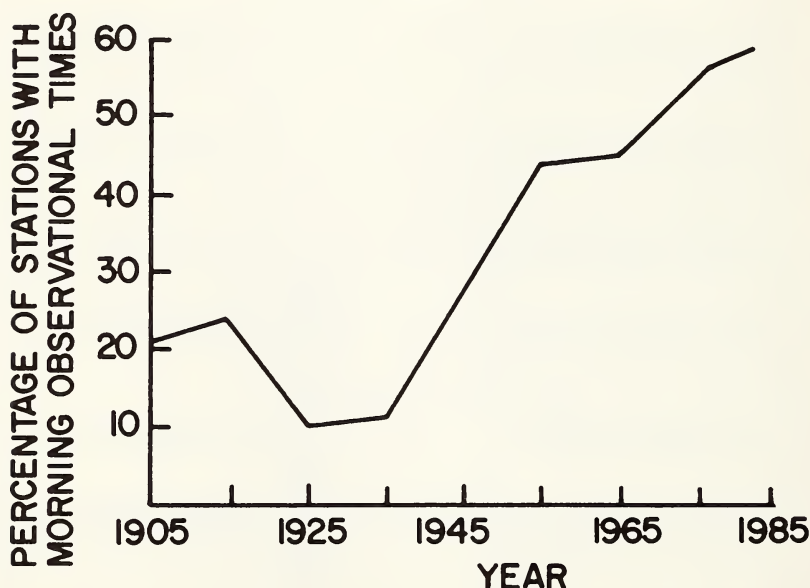


FIGURE 3. *Percentage of stations published with temperatures obtained with morning observational times. Climatological Data, Indiana, for indicated year.*

An endeavor to evaluate these temperatures biases caused by changes in observation times, instrumentation and network configuration was described by Nelson et al. (1979). Briefly, monthly divisional and temperature averages for summer months were adjusted using stations with consistently the same departures from the area mean temperature to adjust temperatures of other stations showing sharp changes from the division average within a few months. The divisional averages in *Climatological Data-Indiana* were then adjusted to the 1976 network configuration, and the average for the state was computed using area weighted division averages, National Climatic Center (1978). In Figure 4 from Nelson et al. (1979), August normals for 1931-60, 1941-70, and 1951-80 were plotted. They correspond closely to the corrected year-to-year August regression. The new temperature normals, at least for the state, seem to agree with the state adjusted

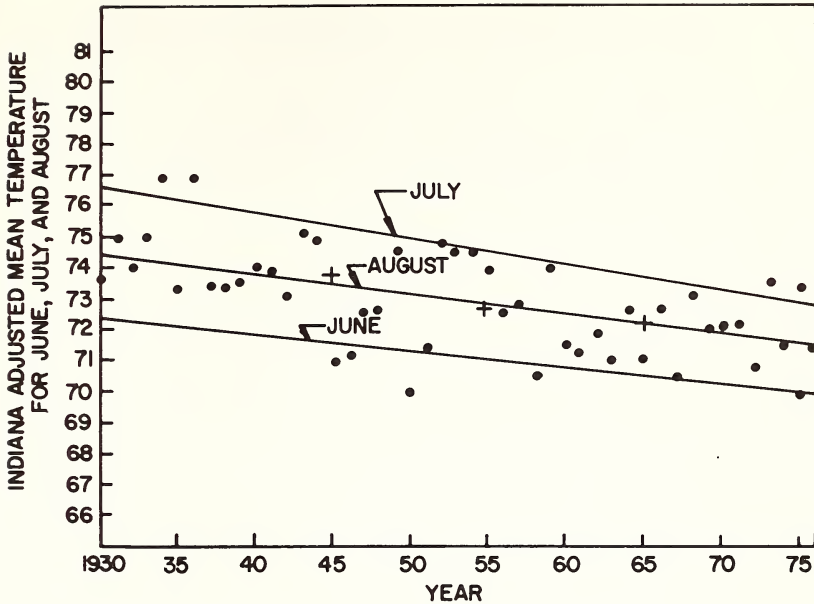


FIGURE 4. Indiana state average mean temperatures for June, July and August, 1930-76, calculated for a 1976 base, (Nelson et al. 1979). Lines represent separate regressions of indicated monthly mean temperature on year. State average mean temperature normals for August for 1931-1960, 1941-1970, and 1951-1980 plotted at middle of indicated 30-year period.

mean temperature series for August, showing a climatic cooling trend of about 2°F. for the last 30 years.

It is believed that the spatial variability of precipitation is so great that changes in network configuration are less important and the new normals are accepted as the best estimates available.

Conclusion

The use of the new temperature normals in the 1980s will likely result in an increase of above normal temperatures because the normal has been lowered from the previous one. The converse also is likely true: In recent years normals have been too high resulting in a bias toward reporting more below normal temperatures than warranted. Most impact will be felt in the more objectively-used heating degree day normals. Their greater accumulation through a season will raise the level of normalcy and result in more below normal heating degree day seasons than in recent past seasons.

Literature Cited

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