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THE 1988 DROUGHT AND HEAT WAVE IN THE MIDWEST... A VIEW FROM ONE LARGE METROPOLITAN AREA

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1. Introduction

In early April, 1988 the first analyses of the Drought Severity (Palmer) Index (National Weather Service, 1985) for the 1988 growing season showed two areas of extreme drought in the United States. One covered the far West; the other most of the southern Appalachian region. Moderate to severe drought conditions prevailed over a small part of the upper Midwest.

During April and May the Upper Midwest drought worsened and spread to the northern Great Plains, the Great Lakes and the mid Mississippi Valley. Rainfall averaged less than 50 percent of normal for most of Iowa and northern Missouri for the three month period of March through May, where moderate to severe drought conditions developed by early June.

As has often been the case in past droughts (Namias, 1982), a prolonged period of excessive heat accompanied the 1988 drought over the mid and upper Mississippi Valley.

The drought and heat wave of 1988 have been compared in many news stories and technical articles (e.g., National Weather Service, 1989) to the "Dust Bowl" period of the 1930's and the drought of the 1950's.

This study deals with the impact of the 1988 drought and heat wave on the St. Louis metropolitan area and how the event compares to previous such events. The study was limited to the one large metropolitan area for several reasons, one of the more practical being the availability of data.

Periods of excessive heat and drought can be most deadly in the inner city regions of the larger affected cities (Center for Disease Control, 1980 and 1984). In July of 1980 St. Louis was among the U.S. cities experiencing the highest heat-related mortality rates with 115 deaths and another 100 suspected heat-related fatalities (Allexenberg, 1981).

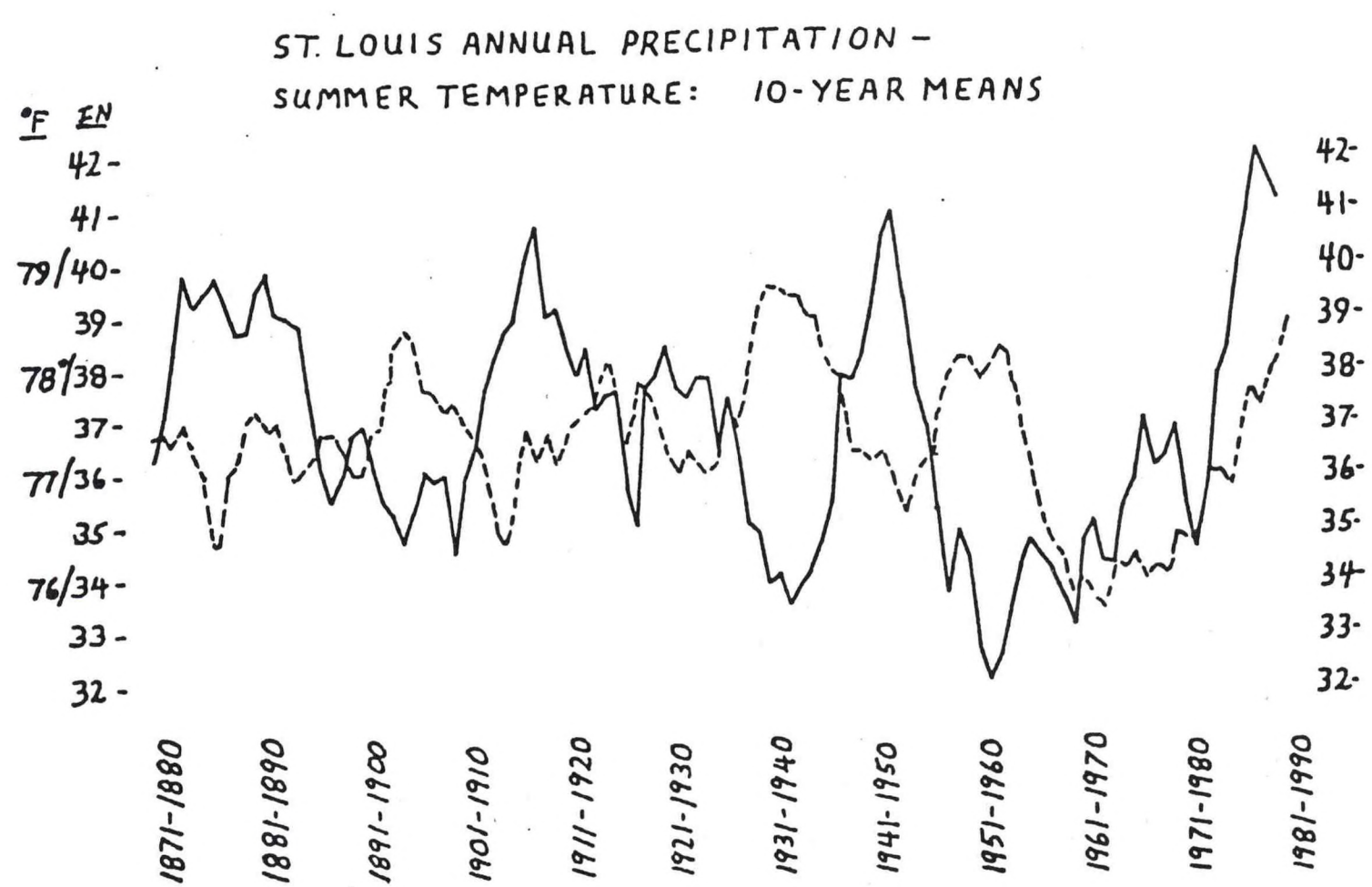

Fig. 1. 10-year running means of St. Louis precipitation (solid line) in inches and 10-year running means of summer (June through August) temperature (dashed line) in degrees F.

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The two primary aspects of the 1988 heat wave and drought in the St. Louis area that were examined are as follows:

a. St. Louis records were searched for season-to-season trends or patterns that might be evident in the 119 years of data. The drought and heat wave during the warm season of 1988 was a relatively rare event, occurring within a longer-term wet but warm period and between two abnormally wet cool seasons.

b. The socio-economic impact of the 1988 heat wave and drought was not quite so serious in the St. Louis area as in previous droughts and heat waves, especially those of the mid 1930's, the early 1950's and, most recently, 1980 and 1983. Wet antecedent conditions and contingency programs which grew out of the disastrous heat wave of 1980 were the main factors reducing the impact of the 1988 event on the metropolitan area.

2. Data

Monthly mean temperatures and monthly precipitation totals are available for St. Louis back to 1870. Observations from 1870 through 1929 are from downtown locations while those since 1929 are from Lambert International Airport, approximately 19 km northwest of the downtown area, in the "close-in" suburbs.

For most of this study the monthly data were combined into two six-month groups, the "cool season" of October through the following March and the "warm season" of April through September. The warm season period generally coincides with the growing season and normally accounts for about 58 percent of the annual precipitation. Monthly mean temperatures were averaged and monthly precipitation totals summed over each six-month period.

River stages for the Mississippi River at St. Louis are available back to 1861. At a zero gage reading the minimum river depth is approximately 3.5 m through the main channel.

3. Season Rankings and Correlations

Rankings of warm and cool season precipitation (not shown) and comparisons (Fig. 1) of annual precipitation totals with summer temperatures (June through August statistics, smoothed by computing 10-year means) show three periods of prolonged drought and excessive summer heat in St. Louis. The first is at the turn of the century, the second during the 1930's to early 1940's and the third during the early and mid 1950's.

These and several other warm, dry periods such as the early 1870's, the early and mid 1890's, and, most recently, 1980 were all characterized by a season-to-season persistence of abnormally dry (and usually warm) weather. In these cases, the impact of the hot, dry warm season was made worse by dry antecedent conditions.

Other significantly hot, dry periods stand out in rankings of the hottest and/or driest warm seasons (e.g., 1913, 1914, the mid 1960's, 1983, and 1988). However, they occurred within longer-term wet and/or cool periods.

The hot, dry April through September of 1988 in St. Louis was preceded by the sixth "wettest" October through March (604.9 mm, or 66 percent above normal), which included the fourth wettest winter period (December through February) on record.

These facts lead to some interesting questions:

(1) Are the driest warm seasons also the hottest?

(2) Are there any season-to-season correlations for precipitation and temperature anomalies?

(3) Are any of these correlations strong enough to allow seasonal predictions?

To answer these questions, the top 40 (top one-third of record) of the warmest, coolest, wettest and driest warm and cool seasons were examined.

Of the 40 driest warm seasons, 24 were also found among the 40 hottest, while only nine were among the 40 coolest. A strong correlation between dry weather and excessive heat was also found to be the case in Missouri during the summer of 1980 (McCarthy, 1984) and in previous hot summers in the central U.S. (Madden and Williams, 1978 and Namias, 1982). The converse is also suggested by these data, with 18 of the "wettest" warm seasons also the coolest, but only five of the wettest ranking among the hottest.

Even though investigations into the persistence of seasonal temperatures have generally found few significant correlations (e.g., Namias, 1978), results in Figure 2 suggest a slight tendency for persistence from cool season to warm season. The strongest tendency is for warm, dry patterns to persist from cool season to warm season.

For example, of the 40 driest cool seasons on record, 21 were followed by abnormally dry warm seasons but only nine by wet warm seasons. Of the 40 warmest cool seasons, 20 were followed by hot warm seasons but only 13 by significantly cooler than normal warm seasons. From Figure 2 there also appears to be some tendency for cool warm seasons to follow cold cool seasons.

If one were to attempt a prediction for an upcoming warm season using only this single-station climatology, a persistence forecast would probably be the most reasonable. Prior to the warm season of 1988, the most logical forecast would have been for wetter and cooler than normal weather or, to be "safer," near to above normal precipitation and near to below normal temperature.

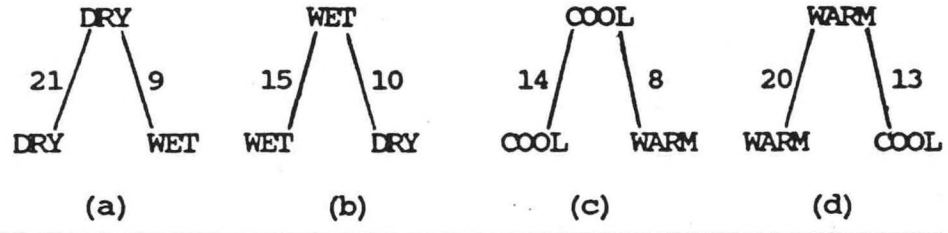

Fig. 2. Cool season to warm season persistence of (a and b) precipitation and (c and d) temperature anomalies. Numbers indicate how many top-40 driest, wettest, coolest and warmest cool seasons are followed by top-40 driest, wettest, coolest and warmest cool seasons (from 119 years of St. Louis data).

4. The 1988 Drought in St. Louis

In spite of the fact that St. Louis had just completed its sixth wettest cool season on record in March of 1988 and that dry warm seasons have followed wet cool seasons only 25 percent of the time, the upper Midwest drought quickly spread south to St. Louis during April. Rainfall for the month was only 29.5 mm, 32 percent of normal and the fourth lowest amount for any April on record back to 1870.

After the driest April/May combination on record (66.4 mm, only 37 percent of normal), early crops were already under stress. The Mississippi River dropped to 0.8 m in May, the lowest level for the month of May since 1934. Excessive heat had not yet become a problem for area residents however. The April/May mean temperature of 17.3°C was the 26th highest on record for that two-month period.

By the end of July, the cumulative rainfall (April through July) had reached only 194.4 mm, the fifth driest April through July period on record and just 55 percent of normal. Excessive heat had become a factor with 14 deaths in the St. Louis area. The first 100°F temperature in the month of June since 1954 occurred on the 22nd of the month. The Mississippi dropped to -0.4 m at the St. Louis gage, the lowest July level since 1940. Navigation delays were frequent.

There was no significant relief from the drought and excessive heat through August, and by the end of September, 1988 had taken its place among the hottest, driest warm seasons on record in St. Louis. The entire period from April through September ranked fifth among the hottest (1.7°C above normal) and fifth among the driest (200 mm below normal) April through September periods on record. Rainfall was 60 percent of normal and below-zero gage readings on the Mississippi were common. At least 21 deaths in the area were attributed to the excessive heat.

It was generally conceded (e.g., Missouri Crop and Livestock Reporting Service) that very wet antecedent conditions helped lessen the impact of the 1988 drought on crops, livestock and ground water supplies, even though harvests in the area were below normal.

Heat related illnesses and deaths in the St. Louis area were significantly fewer than in previous excessively hot years, most recently the summer of 1980. Even though the 1988 warm season ranked fifth among the hottest on record and the 1988 summer ranked eighth hottest, there were not so many daily extremes as in past excessively hot years (only three daily maximum temperature records set, 65 days of 90°F or higher, including 12 days of 100°F or higher).

In addition, local and state government agencies were prepared in 1988 with contingency plans, public advisory procedures and communications routines, both among agencies and with the National Weather Service. Briefings for state and local officials were conducted weekly by the St. Louis Forecast Office early in the warm season, then daily as excessive heat continued through the summer.

The media played a key role in disseminating heat warnings and alerts issued by local government agencies and in educating the public about the dangers of heat stress and the ways to avoid it. Nearly all elements of the media in the area have adopted the Heat Index (apparent temperature) in the interest of conveying consistent weather data to the public.

Much of the increased attention placed on the hazards of excessive heat in the St. Louis area is a result of the deadly summer of 1980. It was the summer of 1980 that brought the hazards of excessive heat to the forefront in many parts of the country and prompted the National Weather Service to promote the use of the apparent temperature (Steadman, 1979) as its official Heat Index.

5. Implications for 1989

The 1988/89 cool season brought another reversal in the weather pattern for St. Louis. October of 1988 was the eighth coolest on record and November the fifth wettest. Fall precipitation was enough to bring the precipitation total for 1988 in St. Louis back to normal.

This most recent cool season ranked 14th among wettest October through March periods but 40th among warmest cool seasons (almost in the near-normal class). Single-station climatology might suggest a 1989 warm season forecast of near-normal temperatures and above normal precipitation, however at the start of the 1989 growing season St. Louis remained just south of an area of severe to extreme drought, from northeast Kansas, across northern Missouri, Iowa and northwest Illinois. Rainfall in much of the drought area from April 1988 through March 1989 was only 50 to 60 percent of normal (NWS Weekly Climate Bulletin, 1989).

Looking again at the warm-season precipitation rankings from the 119 years of St. Louis weather records, this time at persistence of precipitation

anomalies from one warm season to the next warm season, 13 of the top 40 driest warm seasons were followed by another dry warm season, while ten were followed by a wet warm season.

Season-to-season correlations are not strong enough, especially in view of the proximity of severe to extreme drought conditions, to make a case for a wet growing season in the St. Louis area in 1989. Long range forecasts based on past statistics are not likely to show consistent reliability, at least for the St. Louis area.

6. Acknowledgements

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