K·STATE Research and Extension

# Temperature Trends and Changes in Frost Dates from 1895 to 2015

## Kansas Climate Basics

Air temperatures affect crop and livestock production across Kansas. Its mid-continent and mid-latitude location contributes to an approximate 50 degree Fahrenheit seasonal difference between winter and summer temperatures. Strong seasonality is an important climate characteristic in Kansas. Better understanding of long-term variations and changes in temperatures and frost dates will help producers plan future agricultural production in Kansas.

## Temperature trends in Kansas

From 1895 to 2015, the average Kansas temperature was 54.8 degrees Fahrenheit. With the exception of the extreme heat of the 1930s Dust Bowl, air temperatures over last two decades have been among the warmest on record for Kansas. Figure 1 illustrates the swings in annual temperature over the past 121 years. The statewide annual average temperature varied from a low of 52.3 degrees Fahrenheit in 1912 to a high of 58.8 degrees Fahrenheit in 2012. A 6.5 degree Fahrenheit temperature swing is one factor that makes the Kansas agricultural economy vulnerable to climate variability and change.

One observation from analysis of the last 121 years was that the minimum temperatures (overnight low temperatures) have warmed more than the daily maximum temperatures. There is no statistically significant trend in maximum daily temperatures over last 121 years. There is, however, a statistically significant warming rate in minimum temperatures of 0.137 ± 0.07 degree Fahrenheit per decade. The Kansas average temperature increase, 0.104 ± 0.08 degree Fahrenheit per decade, was mainly driven by the rise in minimum temperatures.

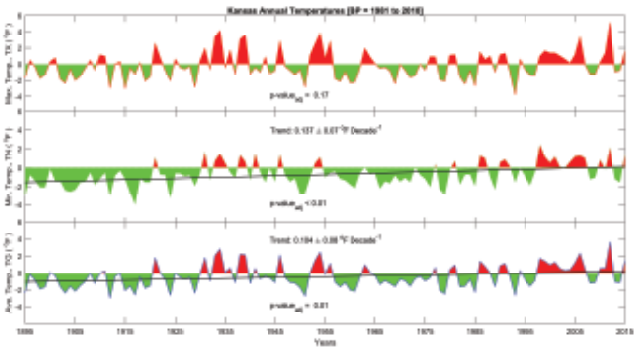

**Figure 1.** *Kansas temperatures 1895 to 2015: maximum temperatures (top panel); minimum temperatures (middle panel); and average temperatures (bottom panel). The base period used is 1981 to 2010. When long-term trends are statistically significant, the trend rates are displayed (black lines).*

## Changes in frost dates and frost-free season length in Kansas

The number of days that the minimum daily temperature falls below freezing (a frost day, using 32 degrees Fahrenheit as a threshold) is an important indicator for crop production. Length of the frost-free season and changes in the length of that season have a direct implication for crop production in Kansas. Figure 2 provides a comparison of the first frost dates in the fall, using two recent 30-year periods, 1951 through 1980 and 1981 through 2010. Changes in first fall frost dates between those two periods were greatest in eastern Kansas. In that region, the first frost dates of 1951 through 1980 (30 years) were earlier in autumn than in 1981 through 2010 (30 years). The northwestern areas in Kansas, however, had an earlier first frost date in the more recent 1981 through 2010 period.

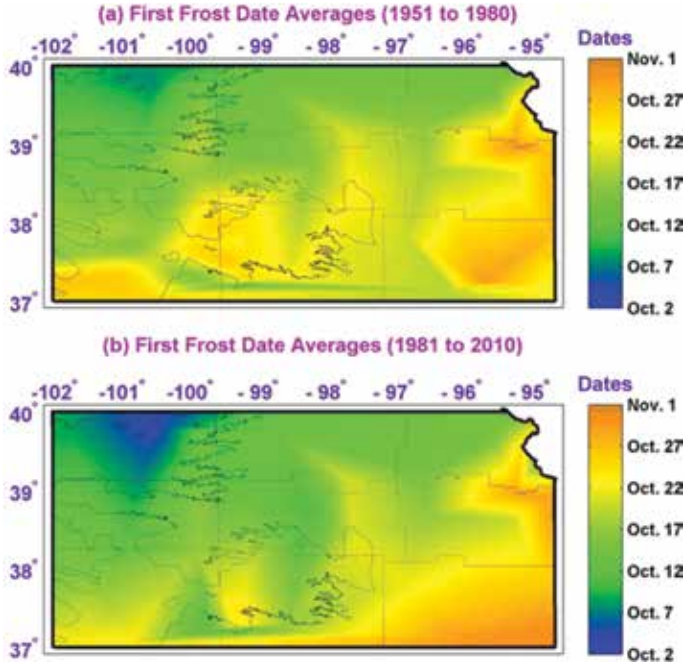


**Figure 2.** *Average first frost dates in Kansas from 1951–1980 (a) and 1981–2010 (b).*

For the last frost date in spring in Kansas, the changing pattern across the state is consistent with the changing pattern of the first frost date. Changes in climate are producing earlier last frost dates for eastern Kansas. Last frost dates in southeast Kansas occurred earlier in the 1981 through 2010 period and earlier date areas covered more area compared to the 1951 through 1980 period (Figure 3).

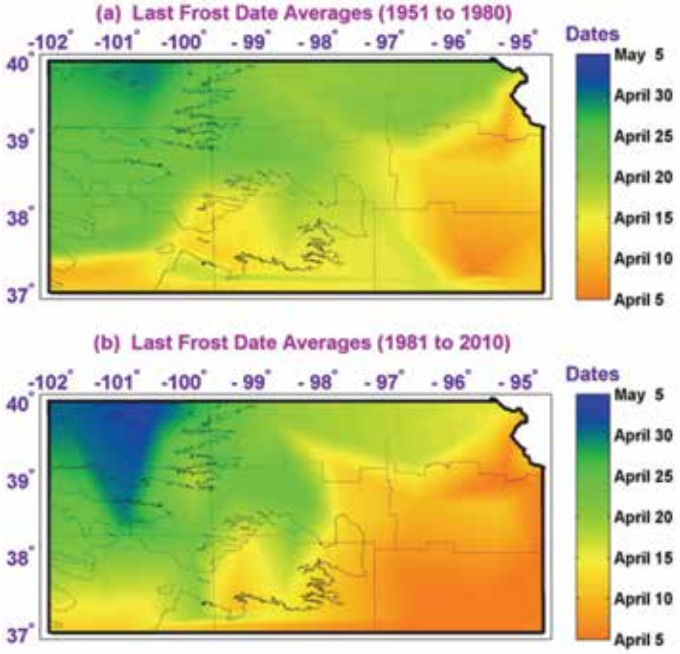


**Figure 3.** *Average last frost dates in Kansas from 1951-1980 (a) and 1981-2010 (b).*

The distinct patterns of first and last frost dates across Kansas result in the shortest growing season in western Kansas (170 days) and a longer average growing season in central Kansas (182 days) and eastern Kansas (189 days) (Figure 4). These long-term averages are changing. The frost-free season length in all regions of Kansas exhibits a statistically significant increase from 1901 to 2014 at a rate of 0.99 ± 0.79 days per decade in western Kansas, 0.94 ± 0.90 days per decade in central Kansas, and 1.47 ± 0.74 days per decade in eastern Kansas (Figure 4).

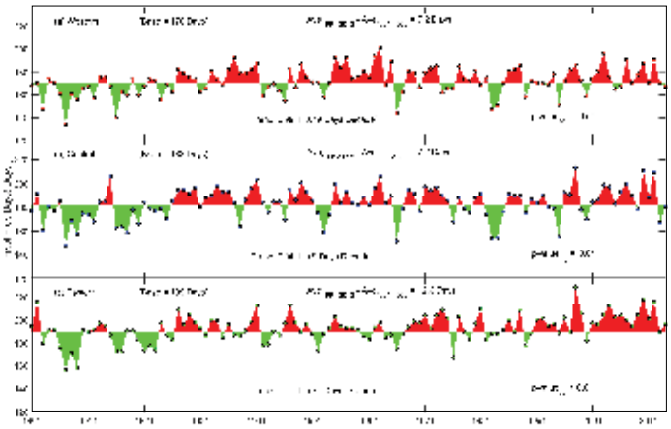

**Figure 4.** *Time series of the frost-free season length in Kansas from 1901 to 2014: western (a), central (b), and eastern (c) Kansas. The base indicates average number of frost-free days calculated from 1901 to 1960 (60-year period as a base period). The Ave 1991-2012 – Ave 1901-1960 is the difference of frost-free season length between 1991-2012 and 1901-1960.*

A longer frost-free growing season could give Kansas producers an opportunity to explore cropping alternatives. This longer season could increase yields if other biotic (insects, diseases) and abiotic (heat, drought) stresses do not limit crop growth and development.

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