

Historical Heat Analysis for Oklahoma City

Prepared for 2023 OKC Urban Heat Island Mapping Campaign by Darrian Bertrand and Rachel Riley, Southern Climate Impacts Planning Program, University of Oklahoma

Oklahoma City (OKC) has always experienced extreme heat due to the geography and climate of the region. The south-central U.S. has high natural climate variability, and there is not a strong historical trend of summertime or annual temperature changes like other areas of the country. However, extreme heat is still a present and future threat in our region and OKC, especially as population increases and strains energy and water resources. Unless otherwise specified, data presented in this report were retrieved from SC-ACIS, the Applied Climate Information System.

OKC Station Selection

This report synthesizes the historical temperature information for OKC, using weather stations at the Will Rogers World Airport (“Will Rogers” hereafter), the Wiley Post Airport (“Wiley Post” hereafter), and the Oklahoma City East Mesonet station (“OKC East” hereafter; Figure 1). While the Will Rogers station is typically the primary source of weather data for OKC and has the longest observational record, multiple stations were used for this analysis to provide multiple perspectives across the city. The Will Rogers station includes data since 1948 and is located in an open area in southwest OKC that may be less affected by urban heat island effects compared to other locations with more impervious surfaces (Figure 2, top). The Wiley Post station includes data since 1996 and is located in northwest OKC between Lake Overholser and Lake Hefner in an open area that is surrounded by dense neighborhoods (Figure 2, middle). The OKC East station includes data since 2008 and is located in east-central OKC. It is the closest station to downtown OKC and near I-35, I-40, and the North Canadian River (Figure 2, bottom).

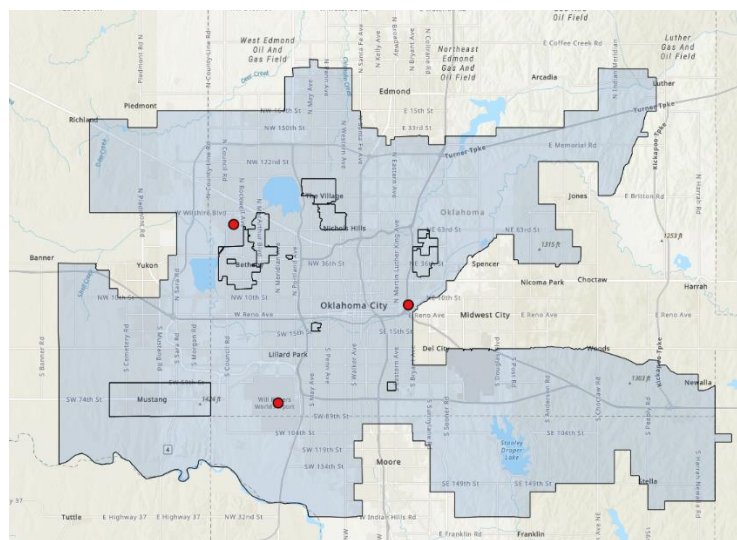


Figure 1. Red dots indicate locations of weather stations used in historical heat analysis.



Figure 2. Satellite imagery for areas surrounding the Will Rogers World Airport station (top left), Wiley Post Airport station (top right), and Oklahoma City East Mesonet station (bottom); red point surrounded by white circle indicates station location.

Average Temperatures and Heat Climatologies

Temperatures in central Oklahoma have fluctuated between warmer and cooler periods since the observational record began in 1895. Figure 3 shows the annual average summer temperature (black dots) in central Oklahoma from 1895-present. Red shaded areas represent periods where temperatures were above the long-term average, blue shaded areas represent periods of below average temperatures, and the horizontal line represents the long-term average. Periods when very hot temperatures occurred include the 1930s, 1950s, and early 2010s.

The normal, or the standard 30-year average (1991-2020 period), monthly high temperature in Oklahoma City is 71.4°F, recorded at the long-term Will Rogers station. At this station, the normal summer high temperature (i.e., June, July, August) is 91°F. July is the hottest month, with a normal high temperature of 93°F. With a shorter period of record from 1996-2022, the

average summer high temperature at the Wiley Post station is 92°F, and July is also the hottest month with an average high temperature of 94°F. The normal summer low temperature in OKC is 69°F at Will Rogers, while the 1996-2022 average summer low at Wiley Post is 71°F. To compare all three stations, the average summer maximum and minimum temperatures for the last 10 years (2013-2022) are shown in Figure 4, where it is evident that Wiley Post typically records warmer temperatures than the other stations.

On average, OKC first observes 90°F in early May (May 7 at Will Rogers, May 9 at Wiley Post) and last observes 90°F at the end of September (September 28 at Will Rogers, September 30 at Wiley Post). OKC typically reaches 95°F in early to mid-June (June 7 at Wiley Post, June 14 at Will Rogers) and the last day to reach this threshold is usually September 8. 100°F is typically reached in July (July 9 at Wiley Post, July 10 at Will Rogers) and the last day to reach 100°F is toward the end of August (August 20 at Wiley Post, August 21 at Will Rogers).

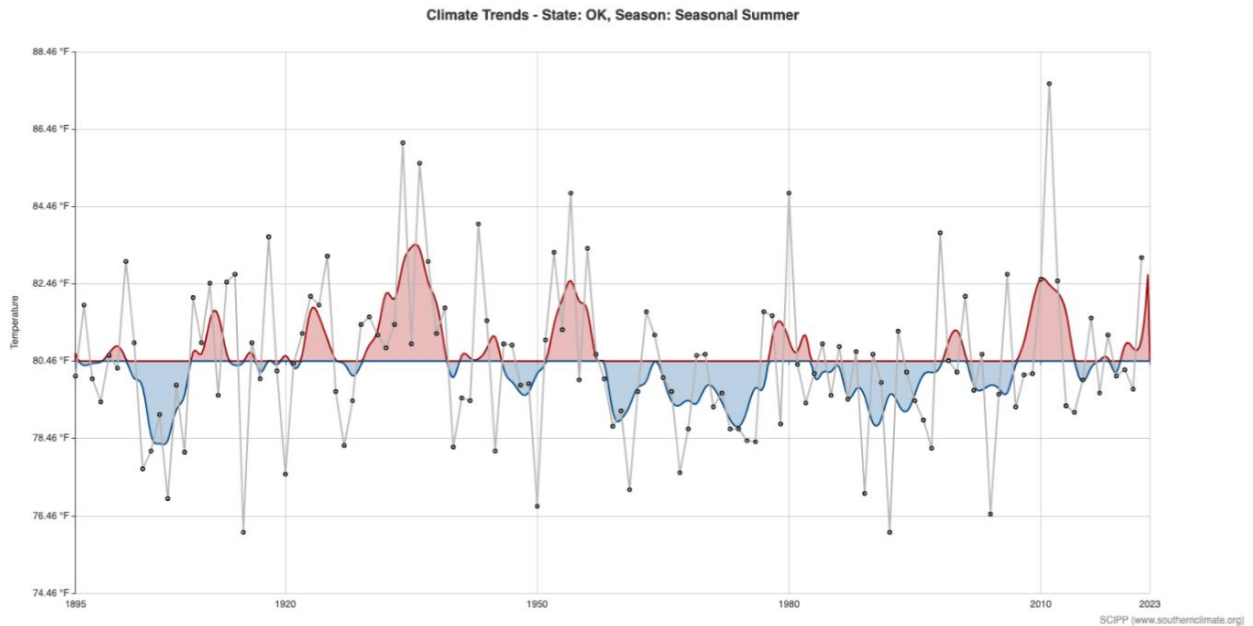


Figure 3. Annual average summer temperatures (black points) in central Oklahoma from 1895-2022, where the red areas represent periods of warmer than average temperatures, blue areas represent periods of below average temperatures, and the horizontal black line represents the long-term average.

Source: SCIPP, <https://charts.climate.lsu.edu/trends/>

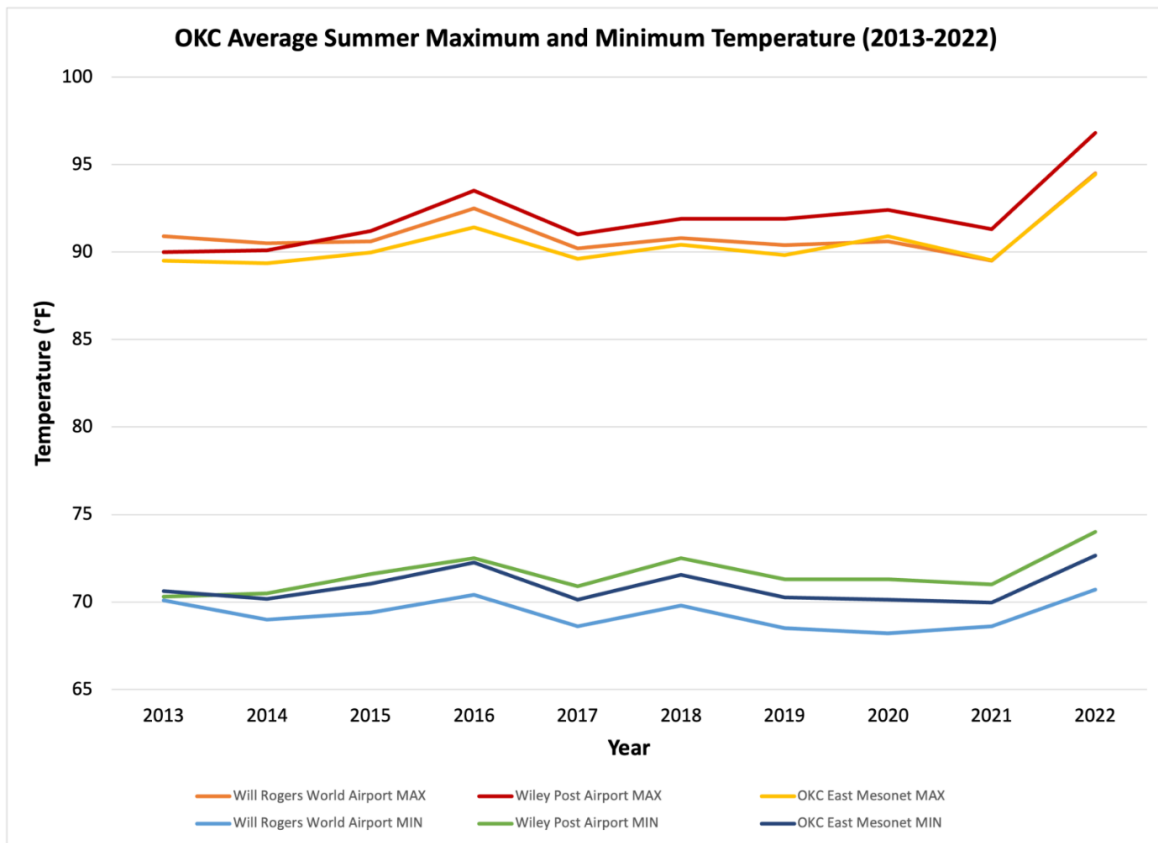


Figure 4. Average summer maximum and minimum temperatures at all three OKC stations from the most recent 10-year period (2013-2022).

Air temperature alone does not always tell the full story. According to the National Weather Service¹, heat index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature in the shade. According to the Midwest Regional Climate Center’s Heat Index Tool², on average central Oklahoma observes 14 to 28 days per year with a heat index $\geq 100^{\circ}\text{F}$, 3 to 7 days per year with a heat index $\geq 105^{\circ}\text{F}$, and 0 to 1 day per year with a heat index $\geq 110^{\circ}\text{F}$.

Heat Records

The summers of 2011 and 2012 broke records with extreme heat and exceptional drought across the state of Oklahoma. Summer 2022 also broke heat records. Table 1 shows the top three single day high temperature records across the three selected stations in OKC. While many high temperature records are tied across multiple dates, most records occurred in August 2011 and 2012 and July 2022. Low temperature records are shown in Table 2. While Oklahoma is accustomed to hot maximum temperatures, warm nighttime low temperatures are especially

¹ <https://www.weather.gov/ama/heatindex>

² <https://mrcc.purdue.edu/clim/heatIndex/index.jsp>

dangerous and impactful to human and animal health and the energy grid. When the body cannot properly cool off at night, heat stress can occur, and the energy grid can be strained from increased demand at night. Warmest low temperature records occurred during the years 2011, 2012, and 2022, when temperatures did not drop below 81°F or greater. See table 2.

Table 1. Top 3 Single Day High Temperature Records in OKC

Record	Will Rogers		Wiley Post		OKC East	
	Date	Temperature	Date	Temperature	Date	Temperature
1	8/03/12	113°F	7/19/22*	112°F	8/03/12*	112°F
2	8/02/12*	112°F	8/02/12*	111°F	8/02/12	111°F
3	7/19/22*	110°F	8/05/11	110°F	7/19/22*	110°F

*Shows most recent observation with the record tied across multiple dates, all of which were in 2011 and 2012.

Table 2. Top 3 Single Day Warmest Low Temperature Records in OKC

Record	Will Rogers		Wiley Post		OKC East	
	Date	Temperature	Date	Temperature	Date	Temperature
1	8/03/12	84°F	8/03/12*	85°F	8/02/12	87°F
2	7/20/22*	82°F	8/04/22*	84°F	8/05/11	86°F
3	8/06/11*	81°F	7/21/22*	83°F	8/02/11	85°F

*Shows most recent observation with the record tied across multiple dates, most of which were in 2011 and 2012.

When extreme heat persists for multiple days, risks and impacts to the health and energy sectors increase. The longest consecutive streak of days with high temperatures greater than or equal to 100°F is 25 days and ended on 7/24/2011 at Wiley Post. Will Rogers' longest streak is 19 days which ended on 7/19/1966. The longest streak at OKC East is 12 days, ending on both 7/24/2011 and 8/06/2011. Table 3 shows the top three greatest number of consecutive days where high temperatures were greater than or equal to 100°F at all three stations. Table 4 shows the temperature steaks at the 95°F threshold. When reflecting on this data, it is important to recall that temperature data for the 1930s, a warm and dry period across the state of Oklahoma, is not represented by the OKC weather stations. Data limitations prohibit the analysis of temperature streak days prior to 1948.

Table 3. Top 3 Streaks of Consecutive Days with High Temperature $\geq 100^{\circ}\text{F}$ in OKC

Rank	Will Rogers		Wiley Post		OKC East	
	End Date	Streak (Days)	End Date	Streak (Days)	End Date	Streak (Days)
1	7/19/1966	19	7/24/2011	25	7/25/2011 8/06/2011	12
2	8/04/2012	18	8/04/2012	18	8/04/2012	9
3	9/04/2000	17	7/28/2022	15	7/07/2011	8

Table 4. Top 3 Streaks of Consecutive Days with High Temperature $\geq 95^{\circ}\text{F}$ in OKC

Rank	Will Rogers		Wiley Post		OKC East	
	End Date	Streak (Days)	End Date	Streak (Days)	End Date	Streak (Days)
1	8/10/2011	43	8/10/2011	43	8/06/2011	39
2	8/27/1980	35	8/12/2012	33	8/09/2012	24
3	8/12/2012	33	7/28/2022	29	9/03/2011	20

Temperature Trends

SCIPP's Temperature Trends Dashboard was used to determine if any trends were present for average annual temperature; average annual summer temperature (high and low); days per year with high temperatures greater than or equal to 90°F , 95°F , and 100°F ; days per year with maximum low temperatures greater than or equal to 70°F , 75°F , and 80°F ; and annual average cooling degree days. Due to station selection criteria, only the Will Rogers station data was available within the tool. All trends are based on the 1970-2022 time period³. Within this tool, solid trend lines represent statistically significant trends and dashed trend lines represent statistically insignificant trends.

The yearly average temperature in OKC shows a significant increasing trend since 1970. However, much of this increase is attributed to winter and fall warming. When looking at summer average temperatures, no significant trend in high temperatures has been observed but a statistically significant increase in summer low temperatures has been observed (Figure 5).

³ Relatively short, climatologically speaking. For example, the tool does not display data from the 1930s and 1950s which were warm periods across Oklahoma. 1970 was chosen as the start year to maximize the number of stations in which users could view local data across the South Central region. To view temperature trends further back in time, users are encouraged to use other tools such as SCIPP's Historical Climate Trends Tool, which begins in 1895 and provides regional and state perspectives.



Summer Average Temperature, 1970-2022

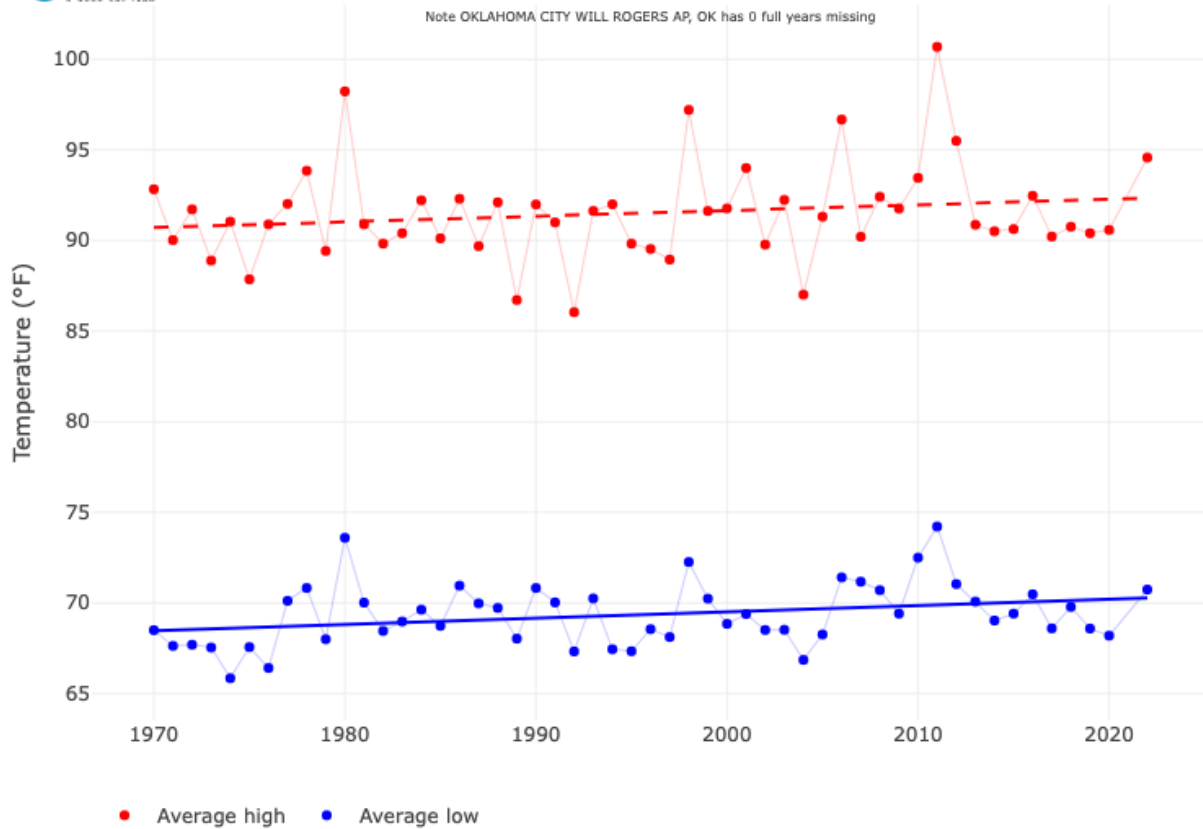


Figure 5. Average annual summer high (red) and low (blue) temperature at the Will Rogers World Airport station in OKC from 1970-2022, where solid (dashed) trend lines indicate a significant (insignificant) trend. Source: SCIPP, https://scipprisa.shinyapps.io/SCIPP_temp_dash/.

The tool also displays trends in the annual number of days with high temperatures above 90°F, 95°F, and 100°F and low temperatures above 70°F, 75°F, and 80°F. While all of these thresholds have occurred in OKC throughout the historical record, there is no significant trend for any of these variables since 1970 (Figures 6 and 7). Oklahoma experiences high natural temperature variability and has always observed extreme heat. But, even though the high temperature extreme heat indicators have not changed much in OKC over time, public health risks may increase given population increases and greater demand on energy and water resources.

With respect to energy demand, cooling degree days is an indicator used to approximate the amount of energy needed to cool buildings. Energy use has economic and environmental implications. Thus, cooling degree day trends can inform energy demands and potential strain on the energy grid. It is important to note, however, that energy use is affected by a variety of factors such as changes in energy efficiency, individual behavior, and the prevalence of cooling technologies. The indicator only provides a general approximation of energy demand and its effects. Since 1970, there has been a significant increasing trend in cooling degree days in OKC, indicating an increase in the energy needed for air conditioning (Figure 8).

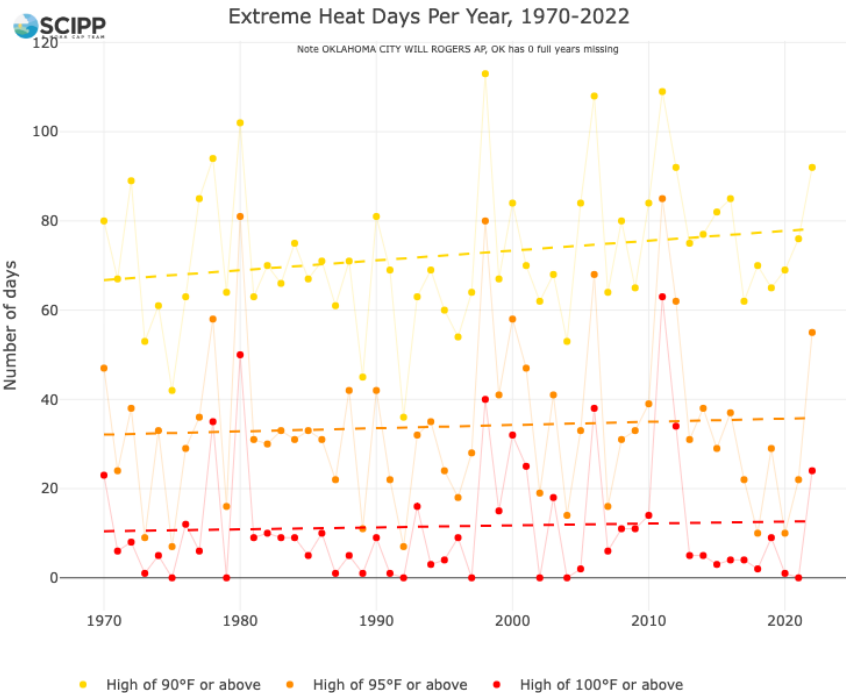


Figure 6. Days per year with high temperatures greater than or equal to 90°F (yellow), 95°F (orange), and 100°F (red) at the Will Rogers World Airport station in OKC from 1970-2022; solid (dashed) trend lines indicate a significant (insignificant) trend. Source: SCIPP, https://scipprisa.shinyapps.io/SCIPP_temp_dash/.

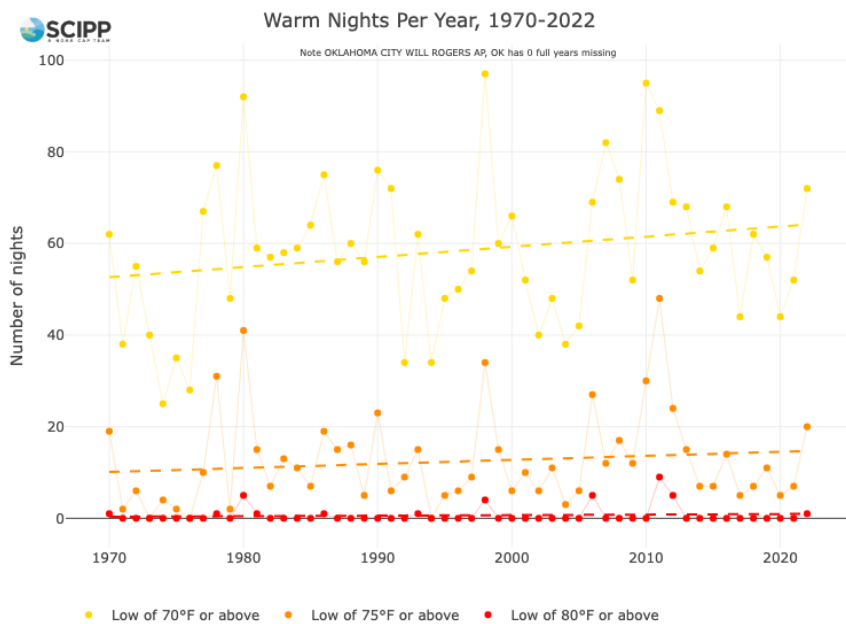


Figure 7. Days per year with low temperatures greater than or equal to 70°F (yellow), 75°F (orange), and 80°F (red) at the Will Rogers World Airport station in OKC from 1970-2022; solid (dashed) trend lines indicate a significant (insignificant) trend. Source: SCIPP, https://scipprisa.shinyapps.io/SCIPP_temp_dash/.



Heating and Cooling Degree Days Per Year, 1970-2022

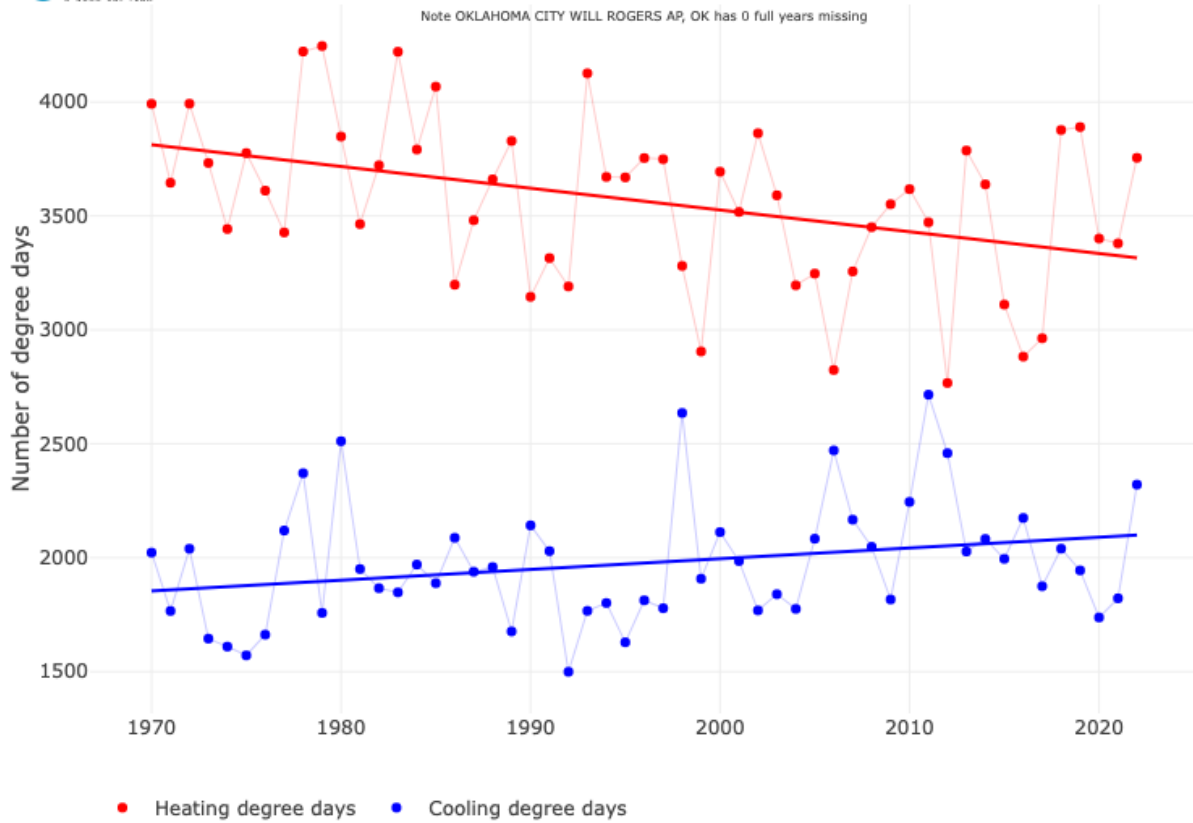


Figure 8. Annual number of heating (red) and cooling (blue) degree days at the Will Rogers World Airport station in OKC from 1970-2022; both trend lines show significant trends. Source: Source: SCIPP, https://scipprisa.shinyapps.io/SCIPP_temp_dash/.