# The July 2005 Denver Heat Wave: How Unusual Was It?

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***Abstract***

*In mid July 2005, very hot temperatures developed over the Rocky Mountains and western Great Plains. This paper summarizes the heat wave and places it in historical perspective. The core of the heat wave was centered near Denver where several weather stations approached or exceeded their all-time record high temperatures on 20-21 July. Denver International Airport rose to 105°F on 20 July and two National Weather Service (NWS) Cooperative stations in the Denver metro area reached 108°F exceeding any previous records for the city. Based on 5-day running mean temperatures, this heat wave ranks first for Denver, Edgewater/Lakewood, and Fort Collins. For July as a whole, the month was not the warmest on record, however, due to sharply cooler weather shortly after the heat wave. An alternative method for evaluating heat waves − moist enthalpy which combines temperature and humidity − provides a markedly different perspective and shows the Denver heat wave to be less extreme due to very low humidity accompanying the event.*

# 1. Introduction

Extremely hot weather developed over the Western U.S. during July 2005. An unusually late onset of the summer monsoon allowed for numerous high temperature records to be broken from California and Arizona eastward into Colorado and New Mexico (Weekly Weather and Crop Bulletin 2005). At Tucson, for example, (NWS - Tucson 2005) the monsoon had the second latest arrival in the period since 1949 (only 1987 was later), resulting in a tied record for the longest string of 100°F+ readings (39 days; op. cit.). Beginning 13 July, brief episodes of extreme heat were observed over the northern Rockies (Wyoming and Montana). Then from 19-23 July, temperatures soared daily to 100°F and above from the Front Range of Colorado across the northern and Central Great Plains (NWS NOAA 2005). The Denver-Boulder NWS Office (2005) summarized July 2005 as the second hottest (the hottest average month remains July 1934) and the third driest since 1872. This assessment was based on data collected at Denver International Airport (DIA) where six record high temperatures were set, each at or above 100°F (Fig. 1). The high of 105°F observed on 20 July 2005 tied that of 8 August 1878 for the all-time highest temperature ever recorded at Denver's primary weather station. There were 25 days with maximum temperatures at 90°F or higher, which tied with the third most since 1963 (1964 had 27 days). Were it not for a strong cold front and sharply cooler temperatures later in the month, July could have been the hottest on record. The 500 hPa analysis for the five-day average from 20 July through 24 July is shown (Fig. 2) to illustrate the average synoptic pattern with this event. The upper level ridge over Colorado was anomalous by more than 70 gpm, which reflects the warmth of the air column underneath this level rather than surface pressure anomalies.

This heat wave resulted in considerable news coverage and some public debate regarding just how extreme this event was and the integrity of the data used to assess it, e.g., Denver

Channel 7 (2005) and Rocky Mountain News (2005). One question regarding the hot temperatures at DIA is whether the instrument is properly sited. This is not always the case (Davey and Pielke 2004). The DIA site's exposure (see Fig. 3) was examined for this study and shown to have a good exposure, such that its record high temperatures cannot be attributed to local conditions. The DIA site began taking observations in March 1995 (lat 39°49'58"N and long 104°39'27"W). The temperature sensor was moved ¼ mile north in June 2003 from the original location and another 1 mile north in 2004 to make room for a new runway (personal communication, Byron Louis, NWS, 2006).

The purpose of this paper is to examine the heat wave in greater detail to better assess its place in Colorado climate history. Several different approaches to assessing heat are presented below, including the monthly average temperature surrounding the heat wave, the number of days above commonly used temperature thresholds, the highest daily temperature, the five-day running average of mean daily temperatures, and the highest value of moist enthalpy.

The evaluation of moist enthalpy (also known as the "effective temperature") is a new approach to assess heat waves, and permits the incorporation of the contribution of water vapor content to the heat of the air in units of Joules. Although historic records of surface water vapor content are comparatively short, they allow for a revealing perspective on recent Colorado heat waves. It should be noted that the occurrence of a single extreme heat wave in a limited geographic region cannot be used to prove or disprove the existence of a recent "global warming" fingerprint, even though moist enthalpy is a better metric for measuring heat content change than surface temperature alone.

## 2. Climatological Analysis

### a. Monthly Mean, Maximum and Minimum Temperature

Table 1 displays the July 2005 monthly maximum, minimum and mean temperatures and period of record across Colorado for selected long-term stations. The locations of these long-term weather stations are shown in Fig. 4. The rank for the period of record is also given.

Despite selecting the best of Colorado's long-term climate monitoring stations in Table 1, nearly all of them have experienced station moves, changes in thermometers and changes in the landscape and environments around the station all of which can impact rankings. Nevertheless, it is apparent that 2005 July monthly temperatures were hot statewide but were most anomalous in the Denver area and the Front Range urban corridor from Fort Collins to Pueblo.

### b. Number of Days Above A Temperature Threshold

Table 2 presents the number of days during July 2005 with daily maximum temperatures greater than or equal to 90°F and 100°F, respectively, and where these rank in the period-of-record for each available station. The information we have is more limited than for the monthly averages, but it does show that in terms of days greater than or equal to 100°F, Denver Stapleton tied and Lakewood exceeded the record number. Both sites, however, had fewer days at this level than DIA.

While it was clearly hot statewide, the number of days with temperatures of 90°F or higher were not exceptional. The number of days of 100°F or greater were more impressive with most locations ranking in the top 5 years. The only stations showing the most days ever recorded with temperatures of 100°F or higher were in the immediate Denver area (DIA, Stapleton and Lakewood).

**c. Highest Daily Temperature**

Table 3 presents the highest maximum temperature reached in July 2005, the date of occurrence and its ranking with respect to previous highest July temperatures. Also shown is the highest recorded temperature for any day in July and the year it occurred. For stations where July 2005 was the highest, the previous highest temperature and date of occurrence are shown. The absolute (or the all-time record) highest recorded temperature and the date it occurred is also shown, and for some stations this occurs in late June or early August. In addition to DIA, several sites reported their highest temperature ever (Denver Stapleton, Fort Collins, Grand Junction, Leroy, Waterdale, and Lakewood). Fort Collins, Waterdale, Leroy, and Grand Junction have temperature records that extend back through the 20$^{th}$ century.

The highest temperatures in Colorado during major heat waves are usually found at lower elevation stations east of the Rockies and in the Colorado River valley of western Colorado near the Utah border. This was generally the case in July 2005, but of note were the very high temperatures at the base of the Rockies from Fort Collins to Pueblo (Fig. 4). At the same time that DIA reported the record-tying 105°F, two stations within urbanized areas hit 108°F: Denver Water Department and Northglenn (Fig. 5). These are the highest temperatures ever measured in the Denver metropolitan area but these two stations have only been in existence since 1997 and 1984, respectively.

**d. Running Five-Day Averages of Mean Daily Temperatures**

There are arguably better ways to define heat waves than with mean monthly temperatures or with individual daily extreme values. The impacts from heat waves are often cumulative – the result of consecutive days of extreme heat. A centered 5-day running average computed from daily maximum and minimum temperatures captures these cumulative effects (Fig. 6).

For a few selected stations near Denver, CO, July mean daily temperatures were computed for the available record. For each day with a mean daily temperature greater than or equal to an extreme threshold value, a centered 5-day average was computed (Figs. 7-9). This value was chosen based on local experience to represent only days of extreme heat. Since 1950, for example, Fort Collins has only had one mean daily temperature of 83°F or above while the combined Denver and Lakewood stations have had 33 and 21 such days, respectively. Therefore, we picked 80°F for the Fort Collins threshold to show periods of extreme heat, while an 83°F threshold was used for Denver and Lakewood.

This analysis shows the July 2005 heat wave as the most extreme on record for these stations when applying this particular criterion. The number of days above the local threshold was comparable to other heat waves at each station, but the highest 5-day running mean exceeded any previous values for all three stations. For the combined Denver station, the highest 5-day running mean of 84.8 was nearly 1.5°F higher than any previous record.

## 3. An Alternative Metric for Evaluating the July 2005 Heat Wave

The surface air temperature is often used to quantify how hot it is. However, temperature is not actually a measure of heat, since heat is energy, and energy is measured in Joules, not degrees. To obtain the *heat content* of the surface air, one should compute the moist enthalpy, which requires three standard observed quantities: the air temperature, dewpoint temperature (or relative humidity), and the surface pressure (Pielke *et al* 2004, Davey *et al* 2005). Moist enthalpy is expressed as:

$$H = c_p T + L_v q \qquad (1)$$

where $c_p$ is the specific heat of air at constant pressure and was approximated as 1005 J kg$^{-1}$ K$^{-1}$, $T$ is the observed air temperature (in K), $L_v$ is the latent heat of vaporization and is equal to 2.430x10$^6$ J kg$^{-1}$ (at 30°C), and $q$ is the specific humidity (in kg kg$^{-1}$), which can be found from the dewpoint temperature and surface pressure via the following relation:

$$q = \frac{0.622e}{p - 0.378e} \text{, where } e = 6.112\exp\left(\frac{17.67T_d}{T_d + 243.5}\right). \qquad (2)$$

In the previous equations, $e$ is the saturated vapor pressure (in hPa), $p$ is the surface pressure (in hPa), and $T_d$ is the dewpoint temperature (in °C). To scale the enthalpy into degrees for easy comparison to air temperature, divide by $c_p$:

$$\frac{H}{c_p} = T_E = T + \frac{L_v q}{c_p} \qquad (3)$$

Here, $T_E$ is called the effective temperature and has units of Kelvin. It is clear that the effective temperature will always be greater than or equal to the air temperature. The two are only equal when there is no moisture in the air, and the difference between the two becomes greater as the humidity increases. In other words, $T_E$ has contributions from both sensible and latent heat, and the latter should not be ignored when evaluating the intensity of heat waves.

The NWS has adopted a "heat index" (Steadman 1979) to assess the severity of predicted heat waves, but this measure is different from the effective temperature that is used in our study. In particular, the NWS heat index is designed to model the human response to heat, and requires additional observations of radiation and wind speed to be properly computed. It is therefore much more complicated than the effective temperature, which is based solely on heat content in Joules.

Using automated hourly observations at two stations encompassing three recent heat waves, one will see that there is a difference in the heat waves when effective temperature is used as the metric instead of air temperature. The two stations used in this section are Fort Collins, CO, and Denver International Airport, CO (FCL and DIA), and the three heat waves occurred during July of 2002, 2003, and 2005. It should be noted that the data presented here are the automated hourly observations, not the official observations. The FCL station is located amidst irrigated grass, some trees, and further away are parking lots and buildings. The DIA station is in an open field near the airport's runways. In Fig. 10a-c, only the peak values of $T$ and $T_E$ are plotted on each day during July 2002, 2003, and 2005 (hourly data not shown). The average of each curve is given in the legend.

Although not as obvious in 2002 and 2003, one feature that stands out in 2005 is that $T$ is typically higher at DIA, but $T_E$ is typically higher at FCL. This is actually true in all three years if one considers the average values provided in the legends, and is likely due to the different environments in which the two sensors record (irrigated grass versus open prairie), as mentioned earlier.

There is a notable difference in the heat waves depending on which metric one uses, air temperature or effective temperature. Table 4 reveals that the days with highest $T$ are typically not the days with highest $T_E$, and vice versa. All times are Mountain Daylight Time, and $T$ and $T_E$ are in °F. In each month, the top five days with highest air temperature are shown, along with the date and time at which the peak occurred, as well as the effective temperature at that time.

The second set of numbers for each month is the top five days with highest effective temperature, along with the date and time at which the peak occurred, as well as the air temperature at that time. To put the effective temperatures in context, the highest value observed at FCL during a ten-year period (1996-2005) was 150.4°F, which occurred on 6 July 1999.

The time at which the air temperature reaches a maximum and the time at which the effective temperature reaches a maximum often do not coincide due to boundary layer mixing in the late afternoon. In fact, the maximum $T_E$ typically occurs a few hours before the maximum $T$. Fig. 11 shows this temporal difference very clearly. It is a composite of the top five hottest days in each of the three years considered here, for FCL (see the left side of Table 4 for the fifteen days that go into making this composite). Both quantities have a minimum just before sunrise, but the effective temperature peaks at approximately 1100 Local Time, while the air temperature peaks at approximately 1500 Local Time.

## 4. Conclusions

Several different metrics are shown here for comparing heat wave severity and ranking the recent July 2005 Colorado heat wave: monthly temperatures, frequency of temperatures above specified threshold values, daily temperature extremes, 5-day running means and moist enthalpy. Based on daily temperature extremes, July 2005 was a record heat wave for several locations. New all-time records included 108°F at Northglenn and Denver Water Department, 105°F on 20 July 2005 at DIA (tying an old record previously set in 1878), and 103°F at Fort Collins on 21 July. The heat wave was persistent, and record or near-record 5-day running means were observed near Denver. Also, several stations reported the greatest number of days of 100°F or higher.

However, in terms of frequency of monthly temperatures and daily temperatures of 90°F or above, July 2005 was not exceptional. Cooler weather earlier in the month, and a notable cold front in late July cut the duration of this heat wave short. Finally, a new metric for assessing heat, moist enthalpy, showed significantly different results. Very low humidities reduced the peak moist enthalpy values of the July 2005 heat wave compared to earlier heat waves in 2002 and 2003, despite higher temperatures. Cooler but more humid locations (like Fort Collins) actually have greater heat (effective temperature) when compared to the relatively hot but dry conditions observed at DIA. Based on the moist enthalpy diagnostic, the 2005 heat wave was not exceptional.

The diversity of observations of the heat wave suggests that we need to address the question, should we record temperatures that register the full impact of heat waves that affect people both in terms of human health impacts (mortality) and electrical power consumption (air conditioning) inside the "urban heat island," or should we keep the observing sites out at airports where we get a more objective record of regional temperatures that are often substantially lower than those affecting the majority of the population? Over the past 50 years, data have been collected at airports, but the value of also retaining urban observation sites is clear.

## Acknowledgements

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**Figure Captions**

Figure 1. Daily high and low temperatures for July 2005 from four official weather stations in Colorado – Colorado Springs (airport), Denver (airport), Fort Collins (Colorado State University) and Grand Junction (airport).

Figure 2. Five-day average 500 hPa geopotential height map for 20-24 July 2005. Image was provided by the NOAA-CIRES Climate Diagnostics Center in Boulder, Colorado, from their web site (http://www.cdc.noaa.gov).

Figure 3. Denver International Airport ASOS Site photos, courtesy of the National Weather Service, Denver/Boulder Office.

Figure 4. Locations of the weather stations used in this study and their highest recorded daily maximum temperature for July 2005.

Figure 5. Highest daily maximum temperatures (°F) for July 2005 for selected stations in northern Colorado. Background shading shows topography, with a thick contour highlighting the 6500-foot elevation.

Figure 6. Centered 5-day running average of mean daily temperature for Denver International Airport for July 2005.

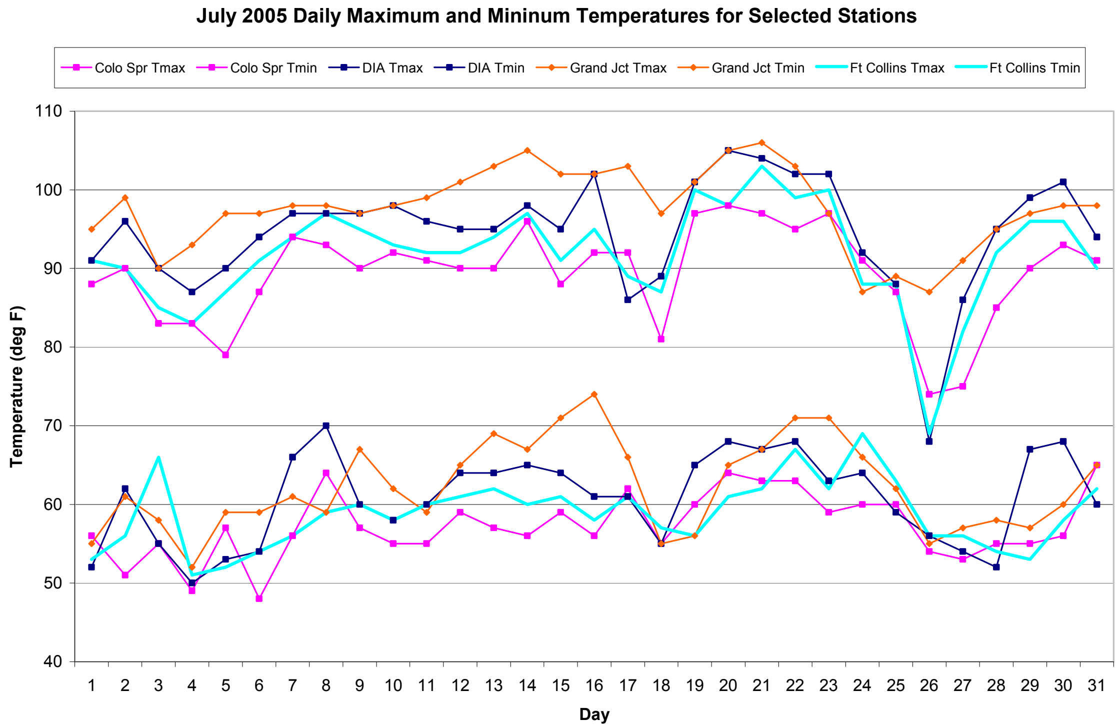
Figure 7. Time series, 1872-2005, of 5-day centered mean daily temperatures (°F) for each day with a mean temperature (average of the high and low for the day) of 83°F or higher. This time series incorporates data from the original downtown Denver weather station from 1872-1950 with Denver Stapleton data (1950-1995) and Denver International airport (1995-2005).

Figure 8. Time series of 5-day centered mean daily temperatures (°F) for each day with a mean temperature (average of the high and low for the day) of 83°F or higher. This time series incorporates data from the Edgewater, CO cooperative weather station 1948-1962 and the nearby Lakewood, CO cooperative station from 1962-2005.

Figure 9. Time series, 1889 – 2005, of 5-day centered mean daily temperatures (°F) for the Fort Collins, CO weather station for each day with a mean temperature (average of the high and low for the day) of 80°F or higher. The threshold of 80°F or higher was used because there were no days above 83°F.

Figure 10. Hourly data from automated weather stations at FCL and DIA are used to pick and calculate the highest air temperature and effective temperature for each day in July 2002 (a), July 2003 (b), and July 2005 (c). In all three months, the average high air temperature is higher at DIA, while the average high effective temperature is higher at FCL.

Figure 11. A daily composite of air temperature (red line) and effective temperature (blue line) for Fort Collins. The composite is created by averaging hourly data during the five days with highest air temperature in each of the three years considered in this section – fifteen days total. This shows the pattern of heating and cooling on the station's extreme hottest days. Note how the effective temperature peaks approximately four hours before the air temperature peaks. Typically, the hottest days are characterized by exceptionally low relative humidity in the late afternoon, which explains the premature drop in effective temperature.

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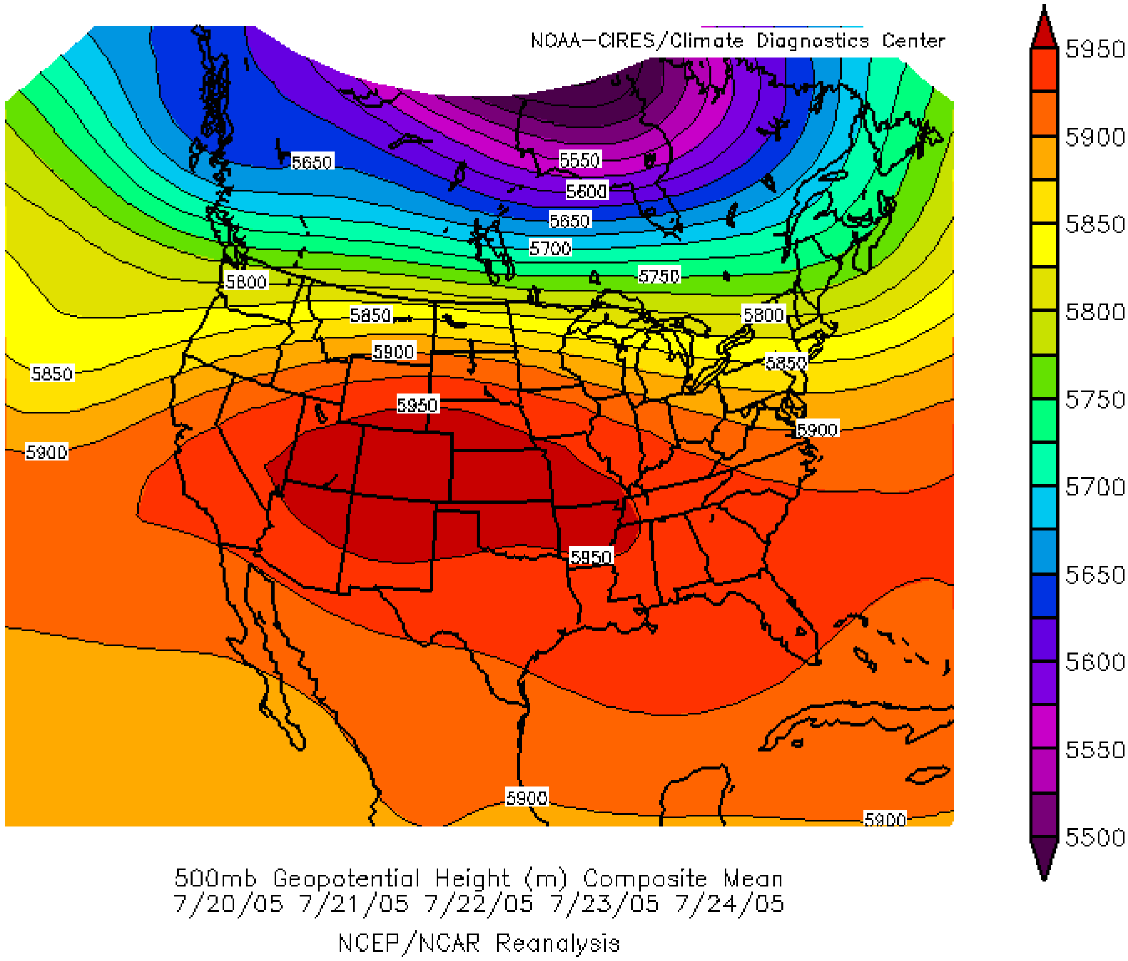


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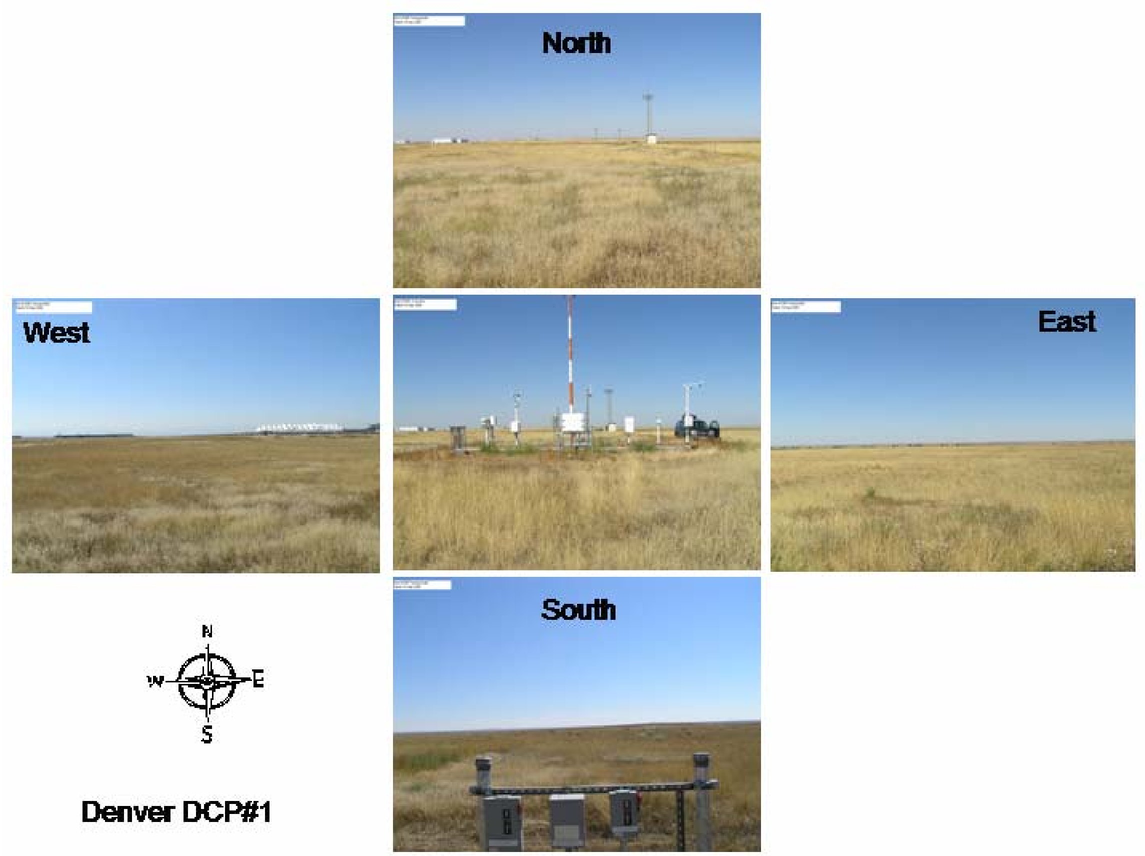


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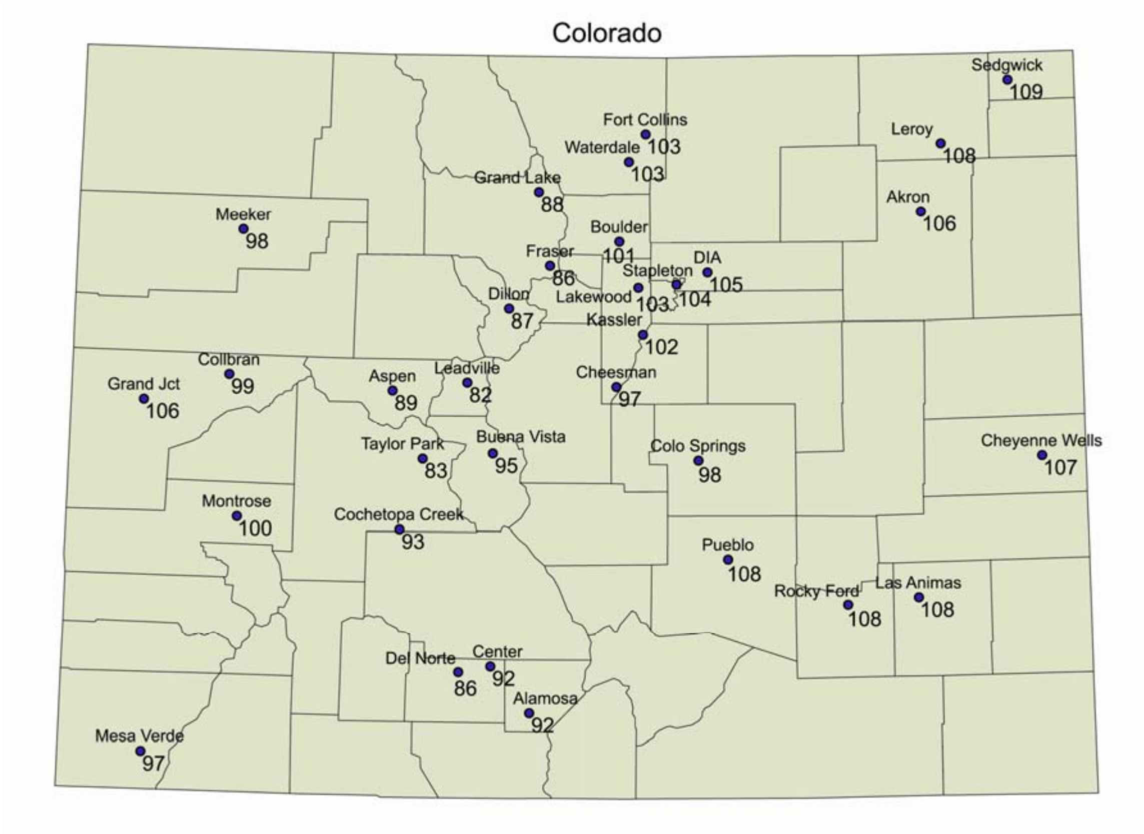


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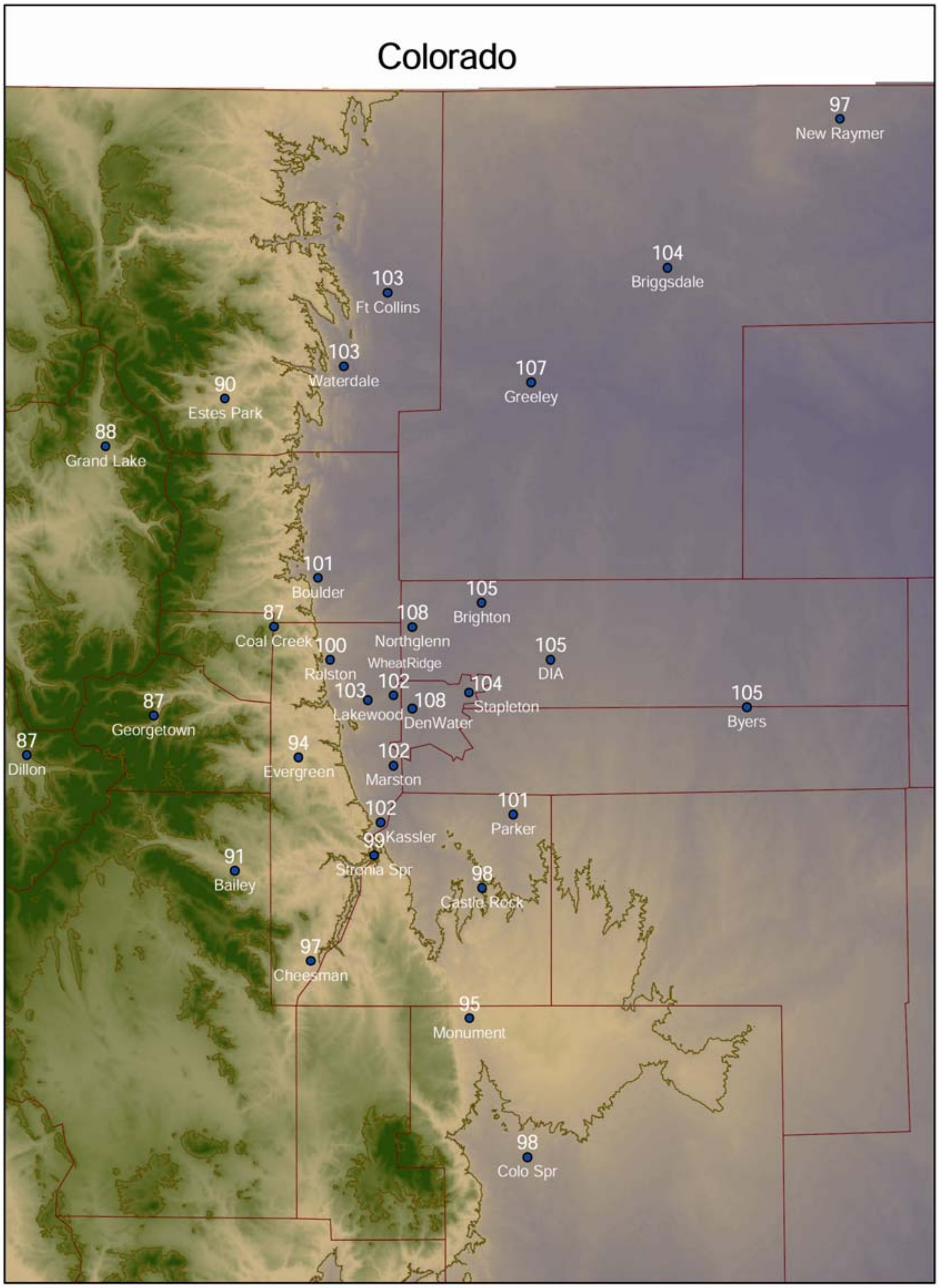


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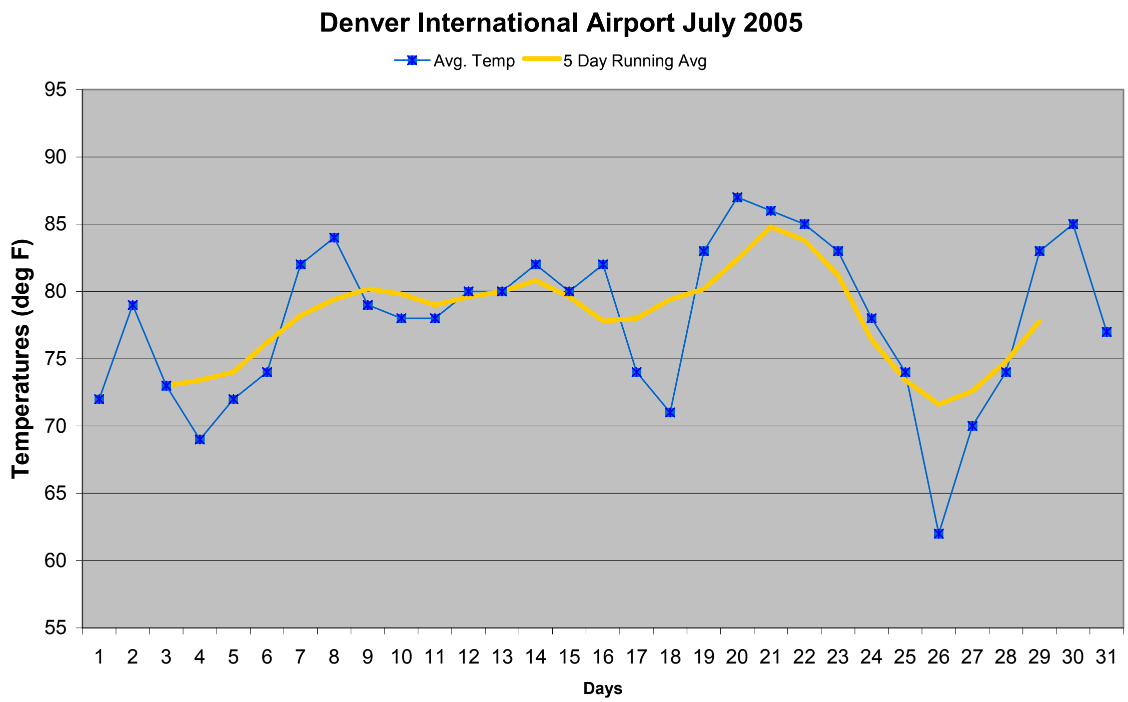


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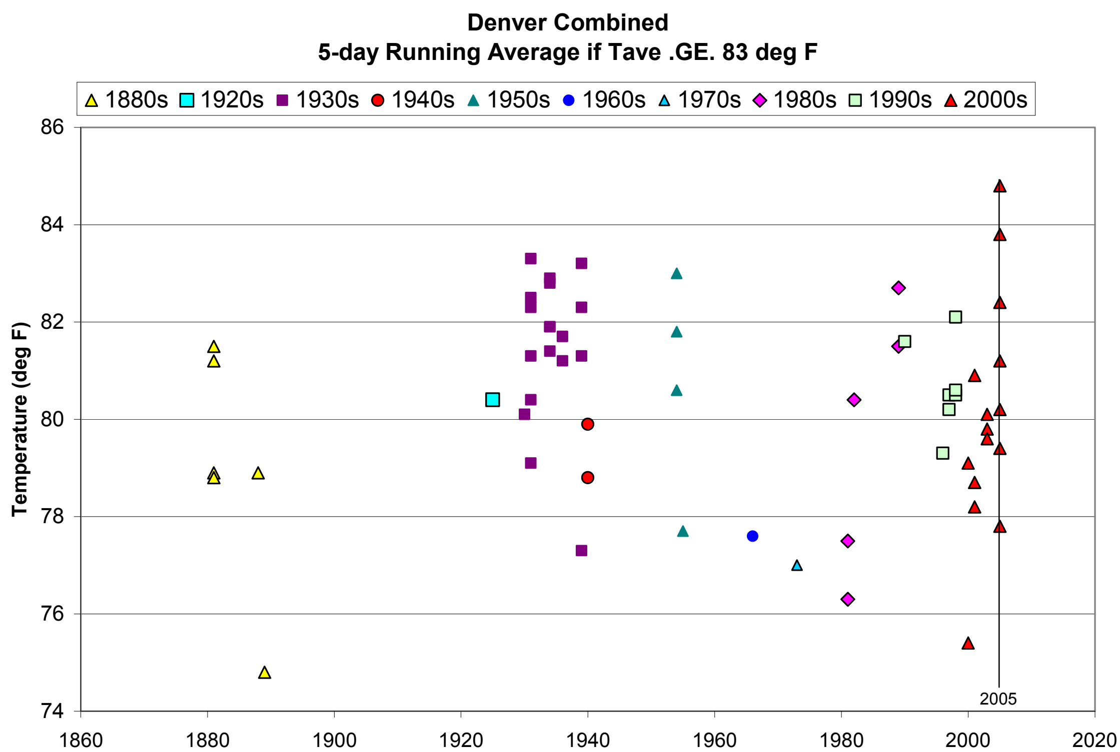


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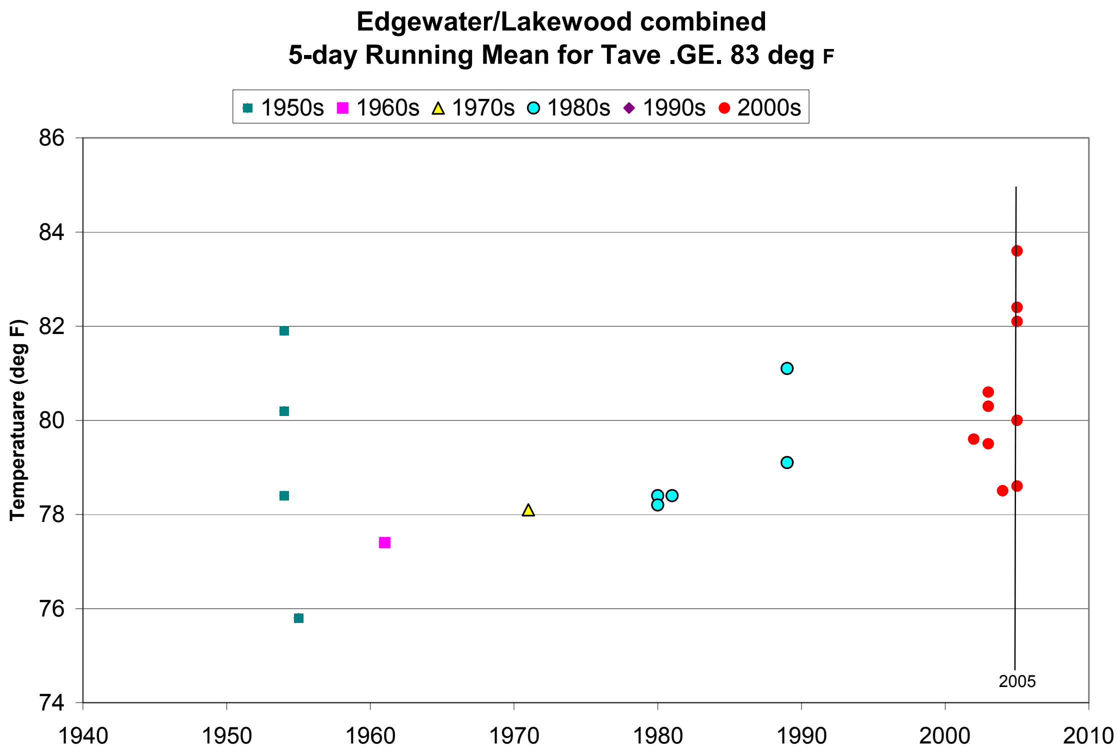


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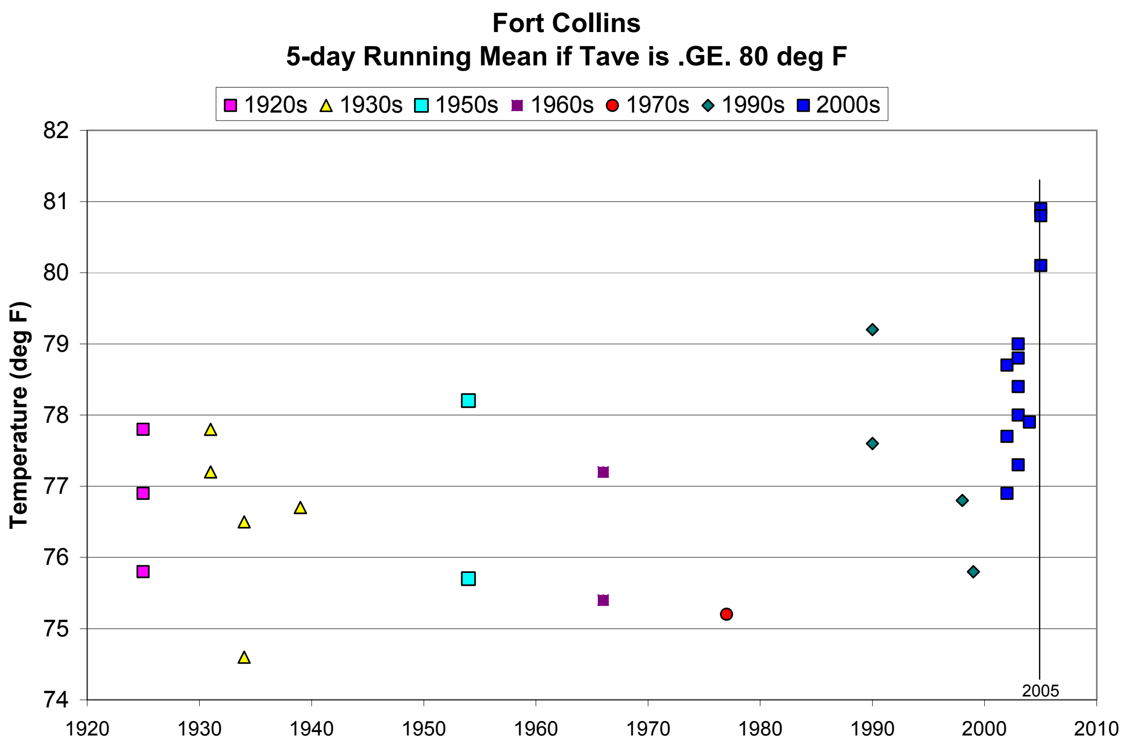


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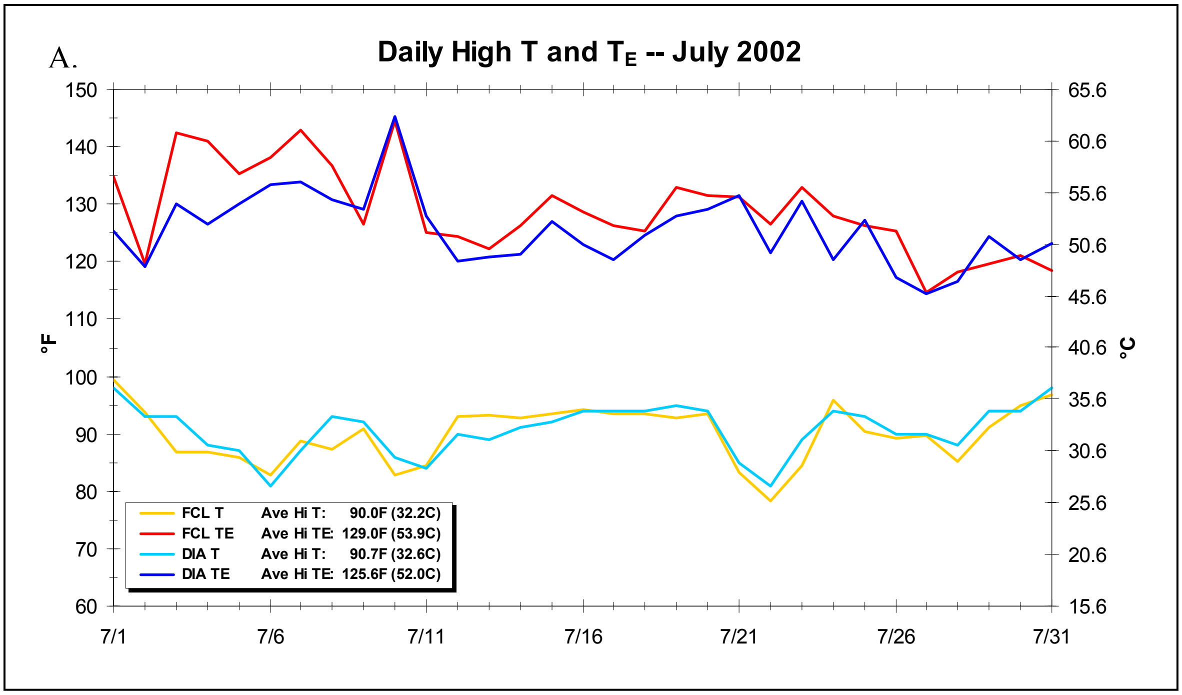
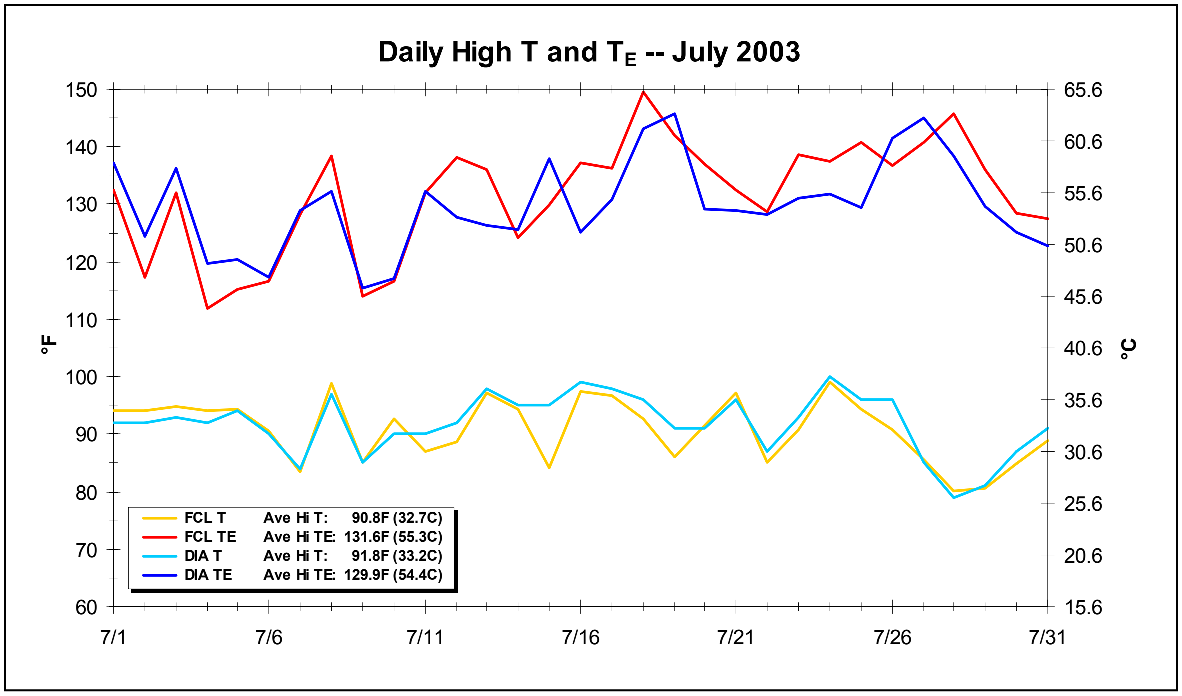
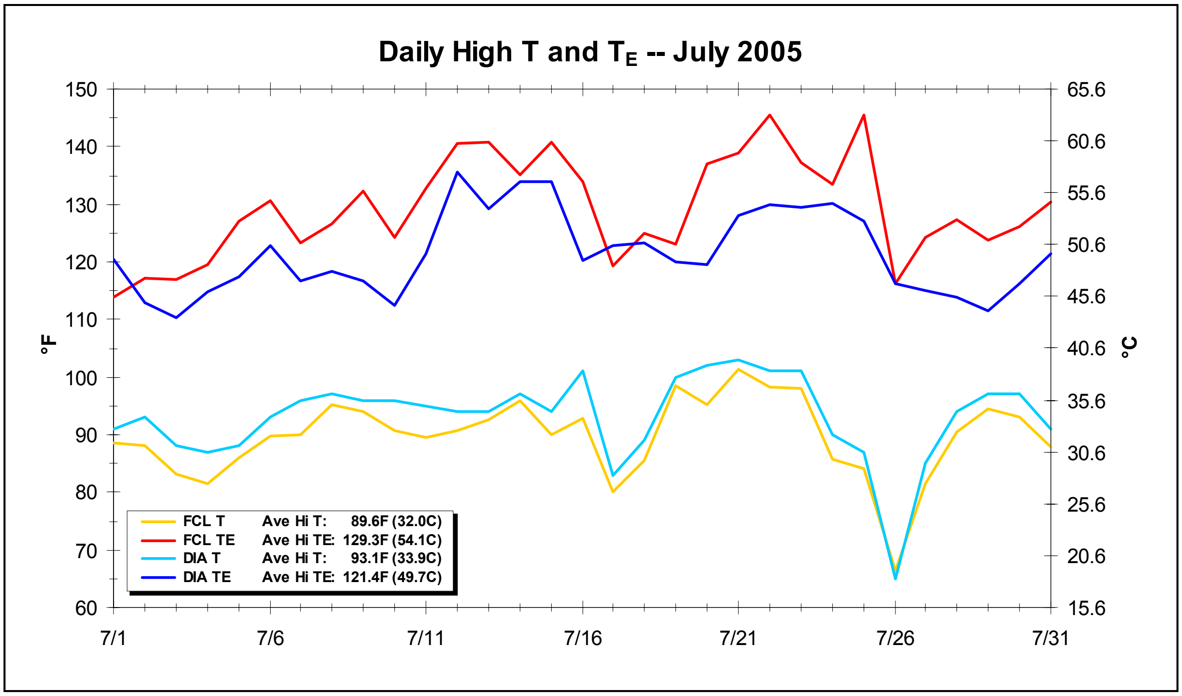
A.


Daily High T and $T_E$ -- July 2002
°F
°C
150
140
130
120
110
100
90
80
70
60
65.6
60.6
55.6
50.6
45.6
40.6
35.6
30.6
25.6
20.6
15.6
7/1
7/6
7/11
7/16
7/21
7/26
7/31
FCL T Ave Hi T: 90.0F (32.2C)
FCL TE Ave Hi TE: 129.0F (53.9C)
DIA T Ave Hi T: 90.7F (32.6C)
DIA TE Ave Hi TE: 125.6F (52.0C)

B.


Daily High T and $T_E$ -- July 2003
°F
°C
150
140
130
120
110
100
90
80
70
60
65.6
60.6
55.6
50.6
45.6
40.6
35.6
30.6
25.6
20.6
15.6
7/1
7/6
7/11
7/16
7/21
7/26
7/31
FCL T Ave Hi T: 90.8F (32.7C)
FCL TE Ave Hi TE: 131.6F (55.3C)
DIA T Ave Hi T: 91.8F (33.2C)
DIA TE Ave Hi TE: 129.9F (54.4C)

c.

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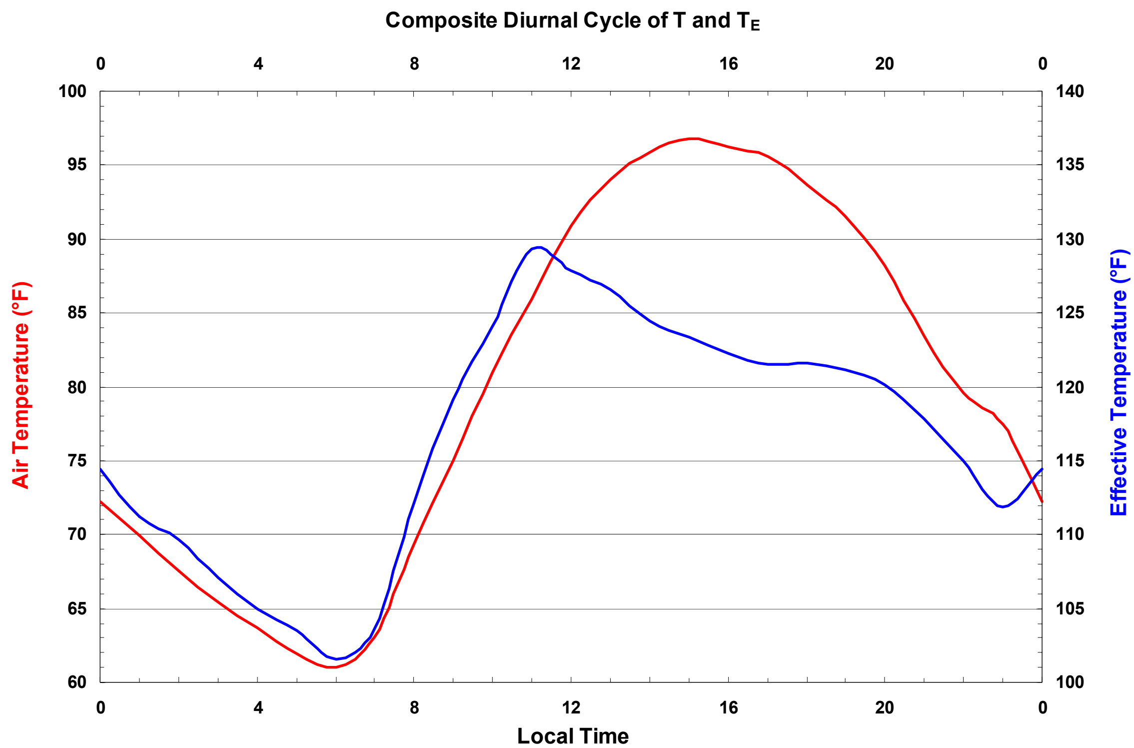


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| **Table 1.** Monthly average maximum, minimum and mean temperatures for selected stations for July 2005 for period of record. Most stations are NWS Cooperative Stations (Coop), but for the larger cities data come from the NWS Automated Surface Observing Sites (ASOS). | | | | | | |
|---|---|---|---|---|---|---|
| Climatic Stations | Elevation (feet) | Type of Station | Period of Record (POR) | July 2005 Temperature | | |
| | | | | Max (Rank) | Min (Rank) | Mean (Rank) |
| Akron 4E | 4550 | Coop | 1905-2005 | 93.3(5+) | 61.0(2) | 77.2(2) |
| Alamosa | 7533 | ASOS | 1948-2005 | 86.9(1) | 45.7(47) | 66.3(8) |
| Aspen / 1SW combined*) | 7936/8163 | Coop | 1914-2005 | 81.1(16) | 48.7(5) | 64.9(6) |
| Boulder | 5484 | Coop | 1893-2005 | 91.6(4) | 58.5(53) | 75.1(21) |
| Buena Vista | 7946 | Coop | 1905-2005 | 87.2(5) | 50.8(2) | 69.0(3+) |
| Center 4 SSW | 7673 | Coop | 1942-2005 | 84.1(7) | 46.5(28) | 65.3(5) |
| Cheesman | 6880 | Coop | 1902-2005 | 87.7(9) | 52.5(11) | 70.1(4) |
| Cheyenne Wells | 4250 | Coop | 1897-2005 | 93.1(26+) | 59.4(54+) | 76(34+) |
| Cochetopa Creek | 8000 | Coop | 1947-2005 | 86.1(3) | 41.4(33+) | 63.8(6+) |
| Collbran / 2SW (combined*) | 5980/6100 | Coop | 1901-2005 | 92.0(8) | 52.3(40) | 72.1(14+) |
| Colorado Springs WSO | 6181 | ASOS | 1948-2005 | 89.3(5) | 57.2(26) | 73.3(9) |
| Del Norte 2E | 7864 | Coop | 1920-2005 | 79.6(32) | 45.8(77) | 62.7(52) |
| Denver Intl Airport | 5414 | ASOS | 1995-2005 | 94.5(1) | 60.8(4) | 77.7(1) |
| Denver Stapleton | 5286 | Coop | 1948-2005 | 92.6 (3) | 60.1(13) | 76.4(6+) |
| Denver (combined*) | 5325/5286 | C/A | 1872-2005 | 94.5(1) | 60.8(33) | 77.7(2) |
| Dillon | 9065 | Coop | 1910-2005 | 78.2(6) | 37.4(42+) | 57.8(11) |
| Fort Collins | 5001 | Coop | 1895-2005 | 91.7(2+) | 58.8(10+) | 75.4(3) |
| Fraser (combined*) | 8560/8563 | Coop | 1910-2005 | 78.7(3) | 35.8(27+) | 57.3(8) |
| Grand Junction WSO | 4858 | ASOS | 1900-2005 | 97.7(3+) | 62.2(93+) | 80.0(21) |
| Grand Lake 1NW | 8720 | Coop | 1940-2005 | 80.9 (5) | 39.8(16) | 60.2(6) |
| Kassler | 5587 | Coop | 1918-2005 | 91.9(2) | 61.3(12+) | 76.6(5) |
| Lakewood | 5640 | Coop | 1962-2005 | 93.5(1) | 60.0(7) | 76.8(2) |
| Lakewood/Edgewater (combined*) | 5640/5453 | Coop | 1902-2005 | 93.5(5) | 60.0(11) | 76.8(5+) |
| Las Animas | 3890 | Coop | 1893-2005 | 97.5(24+) | 62.8(23) | 80.1(22) |
| Leadville | 9938 | Coop | 1976-2005 | 74.6(6) | 39.4(4+) | 57.0(15+) |
| Leadville (combined*) | 9941/9938 | Coop | 1949-1982 | 74.6(6) | 39.4(24+) | 57.0(14+) |
| Leroy 7WSW | 4470 | Coop | 1893-2005 | 93.5(7) | 60.3(14+) | 77.0(8) |
| Meeker | 6180 | Coop | 1894-2005 | 89.3(10) | 48.1(22) | 68.7(12+) |
| Mesa Verde NP | 7115 | Coop | 1923-2005 | 88.5(23+) | 59.0(15) | 73.8(17) |
| Montrose No. 2 | 5785 | Coop | 1896-2005 | 92.7(5+) | 54.1(80+) | 73.4(32+) |
| Pueblo WSO | 4720 | ASOS | 1954-2005 | 97.7(2) | 58.9(37+) | 78.3(12) |
| Rocky Ford 2SE | 4170 | Coop | 1892-2005 | 98.7(1) | 54.2(111) | 76.5(44) |
| Sedgwick | 3990 | Coop | 1959-2005 | 94.7(4) | 60.9(14) | 77.8(8+) |
| Taylor Park | 9206 | Coop | 1941-2005 | 74.7(4+) | 41.7(17+) | 58.2(7+) |
| Waterdale (Loveland) | 5230 | Coop | 1902-2005 | 91.6(6) | 57.0(9) | 74.3(6) |

+ means that temperature tied previous years
* Data combined for Aspen 1914-1979; Aspen 1SW 1980-2005
* Data combined for Collbran 1901-1999; Collbran 2SW 2000-2005
* Data combined for Denver City 1872-1950; Denver Stapleton 1950-1994; DIA 1995-2005
* Data combined for Fraser 1910-1973; 1989-2005
* Data combined for Edgewater 1908-1961; Lakewood 1962-2005
* Data combined for Leadville 1949-1975; Leadville 1976-2005

| **Table 2.** The number of days during July 2005 where daily maximum temperatures equaled or exceeded 90°F and 100°F for selected weather stations in Colorado. The rankings, with respect to the period of record, are shown in parentheses. | | | | |
|---|---|---|---|---|
| Climatic Stations | Elevation (feet) | Period of Record (POR) | Number of Days | |
| | | | .GE. 90 (Rank) | .GE. 100F (Rank) |
| Akron 4E | 4550 | 1905-2005 | 21(12+) | 6(4+) |
| Alamosa | 7533 | 1948-2005 | 9(2+) | 0 |
| Aspen / 1SW (combined*) | 7936/8163 | 1914-2005 | 0 | 0 |
| Boulder | 5484 | 1893-2005 | 22(6+) | 1(7) |
| Buena Vista | 7946 | 1905-2005 | 11(5) | 0 |
| Center 4 SSW | 7673 | 1942-2005 | 3(4) | 0 |
| Cheesman | 6880 | 1902-2005 | 12(10) | 0 |
| Cheyenne Wells | 4250 | 1897-2005 | 22 | 5 |
| Cochetopa Creek | 8000 | 1947-2005 | 6(3+) | 0 |
| Collbran/2SW (combined*) | 5980/6100 | 1901-2005 | 23(8+) | 0 |
| Colorado Springs WSO | 6181 | 1948-2005 | 20(2+) | 0 |
| Del Norte 2E | 7864 | 1920-2005 | 0 | 0 |
| Denver Intl Airport | 5414 | 1995-2005 | 25(2) | 7(1) |
| Denver Stapleton | 5286 | 1948-2005 | 22(6+) | 5(1+) |
| Denver (combined*) | 5325/5286 | 1872-2005 | 25(3+) | 7(1) |
| Dillon | 9065 | 1910-2005 | 0 | 0 |
| Fort Collins | 5001 | 1895-2005 | 22(2+) | 3(2) |
| Fraser (combined*) | 8560/8563 | 1910-2005 | 0 | 0 |
| Grand Junction WSO | 4858 | 1900-2005 | 28(12+) | 10(5+) |
| Grand Lake 1NW | 8720 | 1940-2005 | 0 | 0 |
| Kassler | 5587 | 1918-2005 | 20(5+) | 3(3+) |
| Lakewood | 5640 | 1962-2005 | 22(2) | 6(1) |
| Lakewood/Edgewater (combined*) | 5640/5453 | 1902-2005 | 22(7+) | 6(3+) |
| Las Animas | 3890 | 1893-2005 | 27(33+) | 12(26+) |
| Leadville | 9938 | 1976-2005 | 0 | 0 |
| Leadville (combined*) | 9941/9938 | 1949-1982 | 0 | 0 |
| Leroy 7WSW | 4470 | 1893-2005 | 22(11+) | 6(6+) |
| Meeker | 6180 | 1894-2005 | 13(17+) | 0 |
| Mesa Verde NP | 7115 | 1923-2005 | 12(32+) | 0 |
| Montrose No. 2 | 5785 | 1896-2005 | 23(12+) | 2(4+) |
| Pueblo WSO | 4720 | 1954-2005 | 28(7+) | 12(2+) |
| Rocky Ford 2SE | 4170 | 1892-2005 | 29(8+) | 16(3) |
| Sedgwick | 3990 | 1959-2005 | 25(4+) | 8(3+) |
| Taylor Park | 9206 | 1941-2005 | 0 | 0 |
| Waterdale (near Loveland) | 5230 | 1902-2005 | 22(7+) | 3(4+) |

+ means that temperature tied previous years
* Data combined for Aspen 1914-1979; Aspen 1SW 1980-2005
* Data combined for Collbran 1901-1999; Collbran 2SW 2000-2005
* Data combined for Denver City 1872-1950; Denver Stapleton 1950-1994; DIA 1995-2005
* Data combined for Fraser 1910-1973; 1989-2005
* Data combined for Edgewater 1908-1961; Lakewood 1962-2005
* Data combined for Leadville 1949-1975; Leadville 1976-2005

**Table 3.** The highest maximum temperature, the rank for its period-of-record, the date it occurred and time of observation for July 2005 compared to the highest recorded temperature for all July's and the year it occurred or for stations where July 2005 was the highest, then the previous highest temperature and date of occurrence are shown. The last two columns show the absolute highest temperature for the station and date(s) of occurrence.

| Climatic Stations | Period of Record (POR) | Time of Obs LST | Record Temperature | | | | | Absolute Temperature | |
|---|---|---|---|---|---|---|---|---|---|
| | | | July 2005 Highest Max Temp | Jul 2005 Highest Max Temp Rank | Date of July 2005 Tmax | Highest Recorded Temp, or previous record | Year | Absolute Temperature | Month and Year |
| Akron 4E | 1905-2005 | 08 | 106 | 2+ | 21st | 107 | 1989 | 107 | 1989/07/09 |
| Alamosa | 1948-2005 | 24 | 92 | 4+ | 17,19,20, 21 | 96 | 1989 | 96 | 1989/07/05 |
| Aspen / 1SW (combined*) | 1914-2005 | 08 | 89 | 12+ | 22nd | 94 | 1917 | 94 | 1917/07/27 |
| Boulder | 1893-2005 | 17 | 101 | 3+ | 21st | 104 | 1954 | 104 | 1954/06/23 |
| Buena Vista | 1905-2005 | 08 | 95 | 5+ | 22nd | 102 | 1927 | 102 | 1927/07/13 |
| Center 4 SSW | 1942-2005 | 24 | 92 | 4+ | 20th | 94 | 1954 | 95 | 1954/06/21 |
| Cheesman | 1902-2005 | 07 | 97 | 6+ | 22nd | 99 | 1936, 1939 | 99 | 1954/06/23; 1936/07/23; 1939/07/12 |
| Cheyenne Wells | 1897-2005 | 17 | 107 | 3 | 20th | 109 | 1936 | 109 | 1936/07/24 |
| Cochetopa Creek | 1947-2005 | 08 | 93 | 3+ | 23rd | 94 | 2002, 2003 | 94 | 2002/07/14; 2003/07/19 |
| Collbran / 2SW (combined*) | 1901-2005 | 08 | 99 | 2+ | 21st | 100 | 2003 | 100 | 1902/08/02; 2003/07/14 |
| Colorado Springs WSO | 1948-2005 | 24 | 98 | 5 | 20th | 100 | 1954, 2003 | 100 | 1954/06/23; 2003/07/24 |
| Del Norte 2E | 1920-2005 | 07 | 86 | 32+ | 15/20th | 91 | 1940, 1951 | 91 | 1940/07/24; 1951/07/07 |
| Denver Intl Airport | 1995-2005 | 24 | 105 | 1 | 20th | 101 | 2000, 01, 03 | 105 | 2005/07/20 |
| Denver Stapleton | 1948-2005 | 06 | 104 | 1 | 21st | 103 | 1973, 1989 | 104 | 1994/06/26; 2005/07/21 |
| Denver (combined*) | 1872-2005 | | 105 | 1 | 20th | 103 | 1973, 1989 | 105 | 1878/08/08; 2005/07/20 |
| Dillon | 1910-2005 | 07 | 87 | 2 | 21st | 89 | 1939 | 89 | 1939/07/12 |
| Fort Collins | 1895-2005 | 19 | 103 | 1 | 21st | 102 | 1925 | 103 | 2005/07/21 |
| Fraser (combined*) | 1910-2005 | 16 | 86 | 5+ | 21st | 94 | 1939 | 98 | 1969/08/01 |
| Grand Junction WSO | 1900-2005 | 24 | 106 | 1 | 21st | 105 | 1925, 1971, 1976, 2002, 2003 | 106 | 2005/07/21 |
| Grand Lake 1NW | 1940-2005 | 16 | 88 | 7+ | 12th | 92 | 1978 | 92 | 1978/07/15 |
| Kassler | 1918-2005 | 07 | 102 | 3+ | 21/22nd | 103 | 1990 | 105 | 1994/06/27; 2005/07/21 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Lakewood | 1962-2005 | 07 | 103 | 1 | 21st | 101 | 1989 | 104 | 1994/06/27 |
| Lakewood/ Edgewater (combined*) | 1902-2005 | | 103 | 4+ | 21st | 106 | 1939, 1954 | 106 | 1954/06/23; 1938/08/01; 1939/07/20 |
| Las Animas | 1893-2005 | 24 | 108 | 12+ | 20th | 114 | 1933 | 114 | 1933/07/01 |
| Leadville | 1976-2005 | 17 | 82 | 5 | | 85 | 1963, 2003 | 86 | 1954/06/23 |
| Leadville (combined*) | 1949-1982 | | 82 | 8+ | | 85 | 1963, 2003 | 85 | 2003/07/18; 1963/07/19 |
| Leroy 7WSW | 1893-2005 | 07 | 108 | 1+ | 21st | 108 | 1990, 2005 | 108 | 1990/07/02; 2005/07/21 |
| Meeker | 1894-2005 | 08 | 98 | 5+ | 22nd | 103 | 1900 | 103 | 1900/07/11 |
| Mesa Verde NP | 1923-2005 | 08 | 97 | 12+ | 21st | 102 | 1936 | 102 | 1936/07/24 |
| Montrose No. 2 | 1896-2005 | 08 | 100 | 5+ | 21/22nd | 103 | 1931 | 106 | 1947/08/01 |
| Pueblo WSO | 1954-2005 | 24 | 108 | 2 | 20th | 109 | 2003 | 109 | 2003/07/13 |
| Rocky Ford 2SE | 1892-2005 | 17 | 108 | 1 | 20th | 107 | 1960, 2003 | 108 | 2005/07/20 |
| Sedgwick | 1959-2005 | 07 | 109 | | 20th | 114 | 1954 | 114 | 1954/07/11 |
| Taylor Park | 1941-2005 | 17 | 83 | 2+ | 21st | 86 | 1942 | 86 | 1942/07/15 |
| Waterdale (near Loveland) | 1902-2005 | 08 | 103 | 2 | 22nd | 104 | 1934 | 104 | 1934/07/13 |

+ means that temperature tied previous years

* Data combined for Aspen 1914-1979; Aspen 1SW 1980-2005
* Data combined for Collbran 1901-1999; Collbran 2SW 2000-2005
* Data combined for Denver City 1872-1950; Denver Stapleton 1950-1994; DIA 1995-2005
* Data combined for Fraser 1910-1973; 1989-2005
* Data combined for Edgewater 1908-1961; Lakewood 1962-2005
* Data combined for Leadville 1949-1975; Leadville 1976-2005

**Table 4.** In each of the three recent heat waves – July 2002, July 2003, July 2005 – the top five days with highest air temperature are given. The date and time at which those temperatures occurred are given, followed by the effective air temperature at that time. Similarly, the top five days with highest effective temperature are given. The date and time at which those temperatures occurred are given, followed by the air temperature at that time. Times are in MDT, and temperatures are in °F. Rarely do the two sets of records coincide.

| FCL JULY 2002 | | | | DIA JULY 2002 | | | |
|---|---|---|---|---|---|---|---|
| *HIGHEST T* | *DATE* | *TIME* | $T_E$ | *HIGHEST T* | *DATE* | *TIME* | $T_E$ |
| 99.4 | 7/1 | 1500 | 117.7 | 98.0 | 7/31 | 1553 | 123.3 |
| 96.8 | 7/31 | 1700 | 117.5 | 98.0 | 7/1 | 1353 | 125.3 |
| 95.8 | 7/24 | 1600 | 121.7 | 95.0 | 7/19 | 1653 | 124.6 |
| 94.9 | 7/30 | 1600 | 116.0 | 94.0 | 7/30 | 1353 | 118.2 |
| 94.3 | 7/16 | 1700 | 119.3 | 94.0 | 7/29 | 1553 | 117.3 |
| *HIGHEST* $T_E$ | *DATE* | *TIME* | *T* | *HIGHEST* $T_E$ | *DATE* | *TIME* | *T* |
| 144.5 | 7/10 | 1600 | 82.9 | 145.3 | 7/10 | 1253 | 86.0 |
| 142.8 | 7/7 | 1300 | 84.5 | 133.9 | 7/7 | 1653 | 86.0 |
| 142.3 | 7/3 | 1300 | 84.2 | 133.5 | 7/6 | 1353 | 76.0 |
| 141.0 | 7/4 | 1300 | 81.1 | 131.6 | 7/21 | 1653 | 78.0 |
| 138.2 | 7/6 | 1400 | 79.2 | 130.8 | 7/8 | 1953 | 80.0 |
| **FCL JULY 2003** | | | | **DIA JULY 2003** | | | |
| *HIGHEST T* | *DATE* | *TIME* | $T_E$ | *HIGHEST T* | *DATE* | *TIME* | $T_E$ |
| 99.0 | 7/24 | 1400 | 123.5 | 100.0 | 7/24 | 1353 | 131.9 |
| 98.8 | 7/8 | 1700 | 119.8 | 99.0 | 7/16 | 1153 | 124.1 |
| 97.5 | 7/16 | 1600 | 129.0 | 98.0 | 7/13 | 1253 | 125.3 |
| 97.3 | 7/13 | 1400 | 116.9 | 98.0 | 7/17 | 1253 | 131.0 |
| 97.2 | 7/21 | 1500 | 123.8 | 97.0 | 7/8 | 1453 | 121.4 |
| *HIGHEST* $T_E$ | *DATE* | *TIME* | *T* | *HIGHEST* $T_E$ | *DATE* | *TIME* | *T* |
| 149.5 | 7/18 | 1300 | 90.0 | 145.7 | 7/19 | 1653 | 84.0 |
| 145.7 | 7/28 | 1600 | 78.5 | 145.1 | 7/27 | 1053 | 79.0 |
| 142.0 | 7/19 | 1300 | 83.1 | 143.3 | 7/18 | 0953 | 86.0 |
| 140.8 | 7/27 | 1400 | 85.0 | 141.6 | 7/26 | 1653 | 90.0 |
| 140.7 | 7/25 | 1500 | 92.1 | 138.5 | 7/28 | 1253 | 77.0 |
| **FCL JULY 2005** | | | | **DIA JULY 2005** | | | |
| *HIGHEST T* | *DATE* | *TIME* | $T_E$ | *HIGHEST T* | *DATE* | *TIME* | $T_E$ |
| 101.3 | 7/21 | 1700 | 128.3 | 103.0 | 7/21 | 1353 | 123.6 |
| 98.5 | 7/19 | 1700 | 116.7 | 102.0 | 7/20 | 1053 | 118.9 |
| 98.2 | 7/22 | 1700 | 130.5 | 101.0 | 7/23 | 1353 | 127.3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 98.1 | 7/23 | 1500 | 136.7 | 101.0 | 7/22 | 1253 | 122.5 |
| 95.8 | 7/14 | 1500 | 132.4 | 101.0 | 7/16 | 1353 | 120.1 |
| *HIGHEST $T_E$* | *DATE* | *TIME* | *T* | *HIGHEST $T_E$* | *DATE* | *TIME* | *T* |
| 145.5 | 7/22 | 1400 | 92.3 | 135.7 | 7/12 | 1153 | 88.0 |
| 145.4 | 7/25 | 1200 | 77.6 | 134.0 | 7/14 | 1453 | 97.0 |
| 140.9 | 7/13 | 1300 | 86.5 | 133.9 | 7/15 | 1253 | 94.0 |
| 140.9 | 7/15 | 1500 | 88.6 | 130.2 | 7/24 | 1053 | 84.0 |
| 140.6 | 7/12 | 1400 | 86.8 | 129.9 | 7/22 | 1053 | 93.0 |