Secular Variations in Objectively Defined Climatological Seasons in the United States

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Abstract

Statistically significant increases in lower tropospheric and surface temperatures have been reliably documented over the period from the mid-1970s to the present. Many questions have been raised regarding the effects these increases may already have had on a variety of climatological factors. This thesis investigated the potential effect of global and continental scale temperature increases on the timing of the climatological seasons, based on records from 30 locations of varying characteristics in the contiguous United States. To accomplish this, Summer and Winter were defined by the warmest/coldest 91-day periods within each year (across calendar boundaries for winter). The resulting objective seasons were analyzed for secular trends of season start dates and season mean temperatures across the period 1974–2017. Additional relationships investigated included objective seasons compared to fixed season temperatures and analyses broken down by station characteristics. Mixed results were obtained from these analyses regarding statistically significant (α=0.05) relationships, except for the consistently close relationship between objective and fixed season temperatures. As would thus be expected, most stations showed significant secular temperature trends (upward) in the objective seasons. Despite the paucity of significant results regarding secular trends in the objectively defined seasons, the objective season development in this work opens the door for additional investigations regarding other relationships and effects with early or late onset of winter and summer, as well as the implications for shorter or longer transitional seasons.

Acknowledgements

The members of my committee brought this process to completion, and I am most grateful to them for their guidance and support. Steve Macko and Howie Epstein, in particular, had enough faith in me to expend a big chunk of their time, energy and chips with the Dean, to breathe life into my graduate program. In return for their efforts, I have promised that the next stray kitties I rescue will be named after them. Hank Shugart also helped keep me functioning over the years, even letting me become part of his family when I had none. Additional valuable and quite welcome comments and insights came from Bob Davis, John Porter and Bruce Hayden.

While writing this thesis, I reflected deeply on my time as an active grad student and on those who joined me that semester. We worked, learned, laughed, danced, cried, celebrated, suffered, and triumphed together—it was the best time of my life. Since then, the grad students in this department have continued to inspire. Their hard work, dedication to learning and science, and incredible achievements go hand-in-hand with their camaraderie and joie de vivre. Their arrival, growth and departure, represent the flow of life itself, and I can never thank them enough for the richness they've brought to mine. They give me great faith in the future.

Over the years, innumerable others have contributed to my academic and personal growth, often in unexpected ways—faculty, staff, students, family, and friends. I cannot list you all here, but you mean a great deal to me. Amy's accomplishments and dedication to her work helped inspire me to dust off some lazy neurons and knock this thing out! My dear friend, you will always be missed, and It gladdens my heart just to think of you.

And Susan—wife, guardian angel, best friend, unconditional supporter, and true love. Without her, I'd have no thesis, no degree, and no direction.

Sincerest of thanks and my undying gratitude are extended to all.

The Honor Men

The University of Virginia writes her highest degree on the souls of her sons. The parchment page of scholarship—the colored ribbon of a society—the jeweled emblem of a fraternity—the orange symbol of athletic prowess—all these, a year hence, will be at best the mementos of happy hours—like the withered flower pressed between the pages of a book for sentiment's sake.

But—
If you live a long, long time, and hold honesty of conscience
above honesty of purse,
And turn aside without ostentation to aid the weak,
And treasure ideals more than raw ambition,
And track no man to his undeserved hurt,
And pursue no woman to her tears,
And love the beauty of noble music and mist-veiled mountains
and blossoming valleys and great monuments—
If you live a long time and, keeping faith in all these things
hour by hour, still see that the sun guilds your path with
real gold and that the moon floats in dream silver,

Then—
Remembering the purple shadows on the lawn, the majesty
of the colonnades, and the dream of your youth, you may
say in reverence and thankfulness:
"I have worn the honors of Honor. I graduated from Virginia."

— James Hay, Jr., 1903

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Introduction

Global scale climate change has brought about large increases in overall surface temperatures averaged worldwide with a highly significant trend (Lawrimore, *et al*. 2011). The current period of rapid warming began in the mid 1970s and coincides with rapid increases in anthropogenic emissions of radiatively active gasses (IPCC, 2013). These significant and steep trends in temperatures are also clearly seen at the smaller spatial extent of the 48 contiguous United States (US48), over the same period of time. Globally, the warming rate of annual average temperatures from 1974 through 2016 is approximately 0.32°F per decade and over the US48 it is approximately 0.52°F per decade (NOAA, 2017a).

The most recent release of 30-Year climatic normals (for the period 1981–2010) by the National Climatic Data Center (Arguez, *et al*. 2010) was followed closely by commentary that changes in the timing of plant growth was to be expected (Freeman, 2011). But the overall warming trend does (and will continue to) manifest itself as changes to the global ocean–atmosphere circulation. This translates to changes in circulation and dynamics from larger down to smaller and smaller scales. These effects are, therefore, not limited simply to generally increasing temperatures, but have been shown to drive changes in other climatological factors, such as precipitation (amounts, frequency distribution and spatial variation), storms (tropical and non-tropical) and winds (IPCC, 2013).

A warming of one or more seasons in at least some locations is to be expected based upon annual average temperature increases (Karl, *et al*. 1995). This work looked for evidence that those changes extend into the timing of seasons, as defined simply by the warmest days (summer) and the coldest days (winter) of the year.

The work here is to apply an objectively derived (based neither on regular cycles of solar radiation nor the calendar), climatologically based definition of seasons using each year's temperature data independently over a long period of record. Unique from previous analyses, this did not exclusively use data aggregated over large time periods or over large areas. A selected group of individual station records was used to generate seasonal characterizations on a year-by-year basis. The resulting output was examined for secular variations and any identifiable and significant trends.

Traditionally (and still in most venues outside of the field of climatology) seasons of the year have been defined astronomically, using the solstices and equinoxes as the seasonal boundaries (Taylor, 1954). Nonetheless, popular perceptions are that winter generally constitutes the coldest period of the year and summer the warmest.

The timing of these astronomical seasons, however, has been shown to not be well aligned with measures of climatological seasons. Climatological definitions of season begin and end dates focus on Summer and Winter. Spring and Fall are generally considered as transition seasons, representing the times of shifts in circulation characteristics, often vacillating between Winter and Summer patterns (Glickman, *et al*. 2000).

Several approaches to climatologically defined seasons have been developed. The most common is to simply define each season in whole month intervals. By selecting the three full calendar months with the coldest average temperatures, Winter becomes December through February. The three full months with the warmest average temperatures define Summer as June through August. Spring and Fall then default to March through May and September through November, respectively (Aguado and Burt, 2010). This has the clear advantage of being easily compatible with the long-established practice of compiling, summarizing, and archiving climatological data by month.

It has been shown that this simple method of establishing a begin/end to the seasons is quite reasonable, based upon the temperature means in the historical record. Trenberth (1983) compared astronomical seasons with climatological means of U.S. state average temperatures for 1931–1979 using a Fourier analysis. His conclusion was that the phase offset between the cycle of solar radiation intensity and the cyclic temperature averages strongly supported the use of monthly-based climatological seasons. Similar studies (North & Coakley, 1979; North, *et al*. 1983) of the average annual temperature cycle agreed with these results.

Allen and Sheridan (2015) found shifts in timing of seasons as defined by surface apparent temperature and synoptic scale circulation categorization. Bryson and Lahey (1958) suggested that there might be some useful relationships between the changing of seasons and a number of synoptic scale atmospheric singularities involving surface and/or upper air patterns.

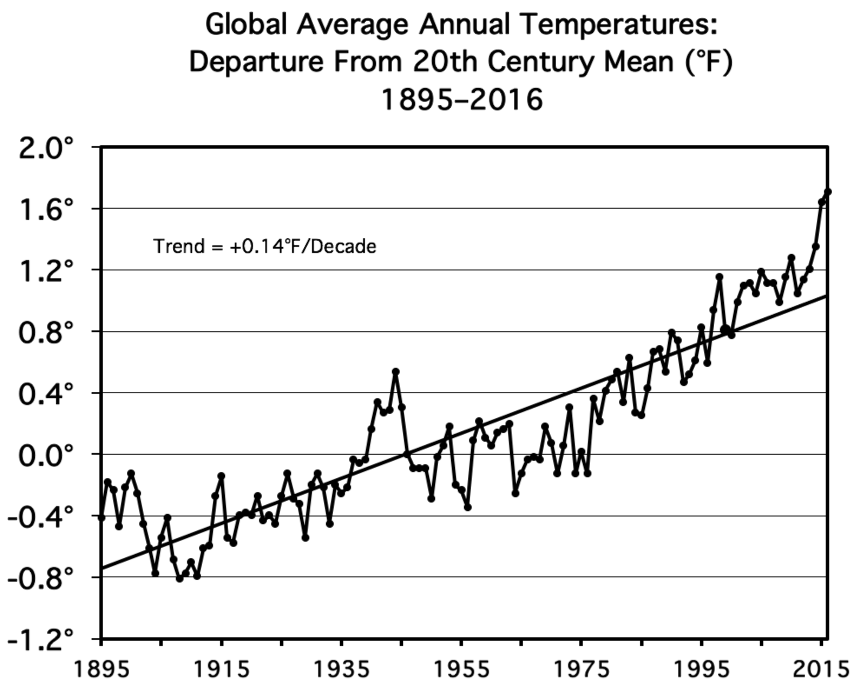
Any use of long-term averages, however, also fixes the start day of the winter and summer seasons (and, therefore, Spring and Fall). There is variability in the timing of these warmest and coldest periods from one year to the next. Farmers certainly know that to time agricultural activities purely by the calendar is to court disaster (Scott, 2014). Pezzulli, *et al*. (2005) argued that the complex forcings in the climate system mean that the seasons have no reason to be fixed in time, and Thomson (1995) contended that constraining the seasons to a fixed calendar was problematic for assessment of climate change.

In order to explore the question of potential changes in the timing of the seasons, a purely climatologically oriented definition of seasonality is needed—one that is not locked to the calendar and that is easily applied to a variety of locations. Essentially, the analysis discussed in the following section (page 7) used such a definition, but only applied it to long-term averages, and could not investigate secular changes.

Since its Latin beginnings, to the Old French "seison" (meaning "time of seeding"), to our modern English, season seems to have connoted when something is ready or appropriate, more so than an invariant point in time (Harper, 2017).

This work used a similar approach to defining climatological winter and summer and their beginning/ending dates. But, instead of simply using climatological normals to find one long-term average for each season, this analyzes each individual year from 1974 through 2017 (more specifically, summers from 1974 through 2016 and winters from 1974–75 through 2016–17), in 30 locations in the contiguous US primarily to look for secular variations in: 1.) the timing of the objectively defined seasons and 2.) the average temperatures of those seasons.

The primary hypothesis in this thesis is that there have been secular changes in the onset of the summer and winter seasons over the period of rapid warming and that these may be detectable in at least some locations in the US48 by applying this objective definition of the seasons. The concurrent examination of timing and of temperature trends in the objective seasons may provide another independently derived approach to finding and characterizing known overall temperature trends in different regimes of the US48.



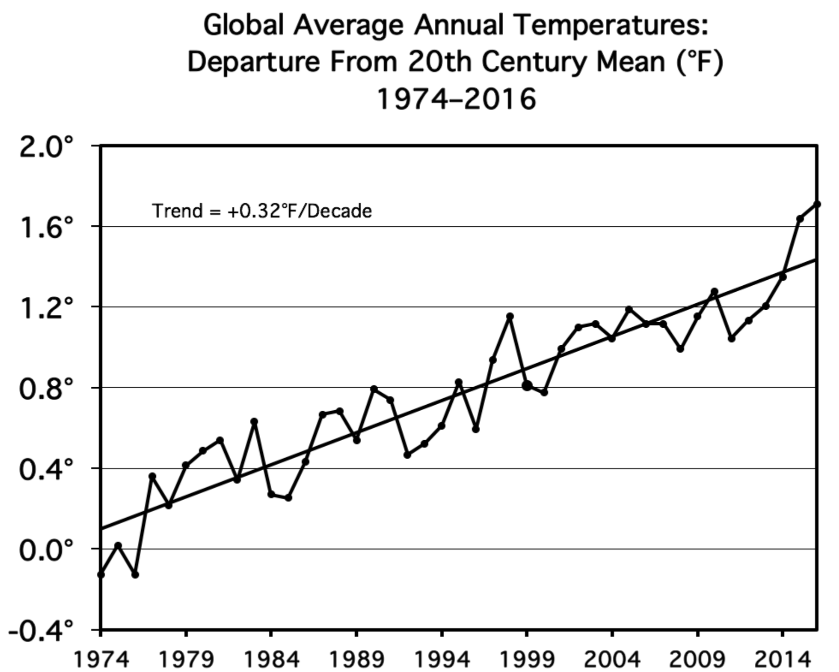


Figure 1. Comparison of the Global Annual Temperature record from 1895 to 2016 (Top) with that from 1974 to 2016 (Bottom). Note that the longer period not only has a lower rate of temperature increase overall, it also shows a distinct period (mid-1930s through mid-1970s) during which the trend flattened out. It is the period from 1974 on that shows the continuous, strong upward trend.

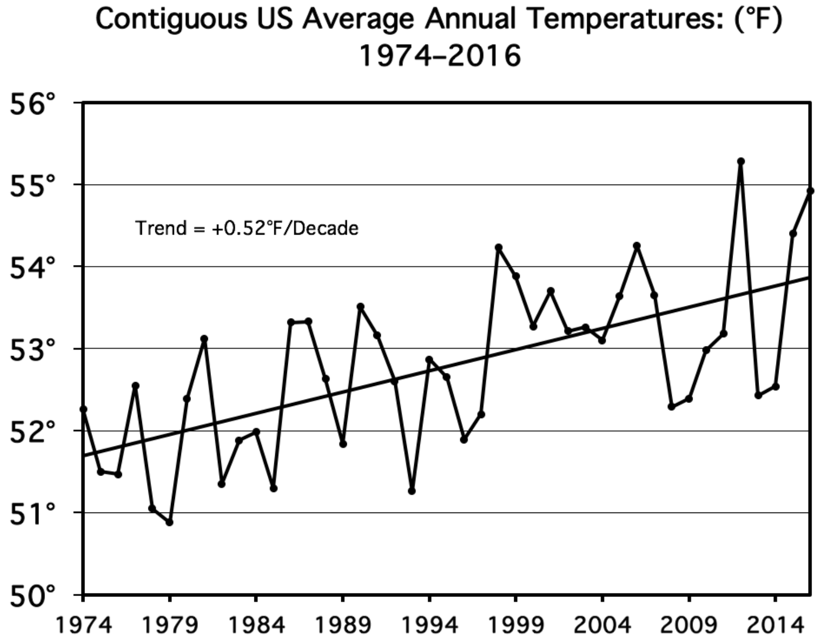


Figure 2. The US48 Annual Average Temperatures show a similar, but even steeper trend for the 1974–2016 period, although the variability about that trend is greater.

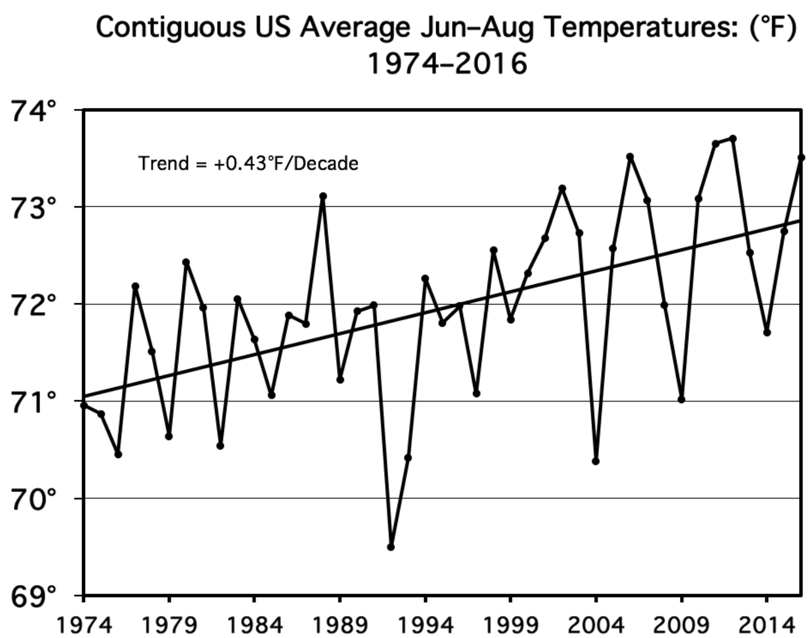


Figure 3. A steep increase is seen in US48 June–August Temperatures, with even greater variability. This uses a strictly calendar-based definition of the Summer season that cannot respond to shifts in timing (regarding either interannual variation or trend in onset).

Objective Long-Term Normal Seasons

The preliminary study in this section was conducted to outline a procedure for developing objectively defined seasons—in this case for long-term "normal" seasons that, although not based on pre-defined calendar days, nonetheless are fixed, by the summary data to specific days of the year. Here, daily temperatures (NOAA, 2006) for the period 1981–2010 were obtained via the xmACIS data system (Eggleston, 2017) for the NOAA Cooperative Weather Observing Network (NOAA, 2000) station at McCormick Observatory in Charlottesville, VA (Charlottesville 2W).

This 30-year interval is the same as is used for the current climatological normals period established by the National Climatic Data Center (Durre, *et al.* 2013). From these, the long-term averages for each day of the year were calculated. In this case, the published daily normal values were not used, since those values are smoothed throughout each month (Arguez, *et al*. 2011). They, therefore, have lost some of the variability desired for the development of these objectively defined seasons directly from the observations. To search for potentially different seasonal periods, that temperature variation must remain in the dataset. In addition, the Charlottesville 2W station is known to be of extremely high quality, consistency and completeness over this normals period.

The resulting dataset was examined to find the coldest consecutive 91-day period and the warmest consecutive 91-day period. The lengths of these periods were chosen to coincide with the number of days to be used in the main part of this thesis. Additionally, February 29th was removed from the analysis, since its variance is dissimilar from all the other days, owing to occurrence one-fourth as often. This and slight differences in the number of days per season (compared to those used in the calendar-based seasons) are of no noticeable consequence. Even the astronomically defined seasons can differ in length over the years by as much as four days.

Charlottesville, VA — McCormick Observatory (Charlottesville 2W)

Running 91-Day Averages of Thirty-Year Means For Each Day

Warm Period (Summer) Analysis

Month & Day of Period Start	Average of 91-Day Period (°F)
Mar 1	71.56
Mar 2	71.72
Mar 3	71.85
Mar 4	71.99
•	•
•	•
•	•
June 6	75.32
June 7	75.33
•	•
•	•
•	•
July 1	73.73

Table 1. Example of the running means procedure for the generation of a long-term seasonal average start date. Here, the daily averages ("normals") are examined to find the warmest days of the year. This will define the average climatological summer period; and not by a pre-determined, even month, calendar period. Winter temperatures are handled similarly, looking for the coldest 91-day running mean.

Instead of the standard winter and summer calendar-based dates (December 1 – February 28 and June 1 – August 31), as in the published Climatological Normals, the running averages method found that the coldest 91-day averaged period was actually December 5th through March 6th, and the warmest 91-day averaged period was June 7th through September 5th. Neither of these is far removed from the calendar month definition. By measuring it against this method, the “even calendar months” approach, is not necessarily a perfect match, but when seeking an easily used fixed time period, is shown to be superior to using the astronomical seasons. Nonetheless, this slightly different method of defining the "normal" seasons may prove more representative for aggregating or averaging observations (*e.g.*– temperature and precipitation) by season.

For the purpose of illustrating the running means technique, a selected segment of the analysis representative of this procedure is shown in Table 1.

Chapter 1. Individual Stations Analyses

Methods

For this investigation, a total of thirty surface climatological observing stations in the NOAA Cooperative Observing Network (NOAA, 2000) were chosen from locations around the forty-eight contiguous United States (US48). In order for this analysis to pick out any signal in the record, only those stations with a consistent and complete long-term period of record of temperature observations need be considered (Christy, 2002).

Each station selected had to have no missing data observations of daily maximum or minimum temperature during the months of May through September and for November through March; this for the complete analysis period from May 1974 through March 2017. These consecutive five-month periods ensured complete coverage of the 91 days required for each of the two seasons being counted with no likelihood of running past a data boundary. Indeed, all Winters and Summers fell well within these ranges.

The completeness of record was considered of primary importance, since it was felt that to miss a significantly anomalous few days in a given season might well mask an important variation in a given year. Since the object of this work was to "cast a broad net" for the identification of possible trends, it was important to include a wide range of stations with a number of different characteristics. These included latitude, elevation, population and proximity to a coast. The overarching goal here is to probe the value of this approach to objective season definition in an exploratory fashion. Results can then be used to fine-tune or direct further investigation along these lines.

The stations were, therefore, also selected to represent a broad range of climatic regimes across the US48. Since his original paper on the subject of Earth's climatic zones, Köppen's (1884), system of classification by both physical climatic and by vegetation factors is, in one form or another, arguably the most widely used (Peel, *et al.* 2007). As an Interesting historical footnote, Sanderson (1999) credits the idea of the systematic classification of climate by distinct zones to Pythagoras. Rubel and Kottek (2011) provide more background. Over the decades, a series of revisions have been made to the original (post-Pythagorean) map both by modifying the overall classifications themselves and by updating the climatic parameters that are used to define them (Geiger, 1954; Kottek, *et al*. 2006; Peel, *et al*. 2007). In addition to defining existing climates, the Köppen approach has been used to depict future climate scenarios by plugging model output into the defining parameters (Rubel and Kottek, 2011). The updated version, used here, has become known as the Köppen–Geiger system (Köppen as the originator of the approach and Geiger as developer of significant refinements) by Peel, *et al*. (2007), which incorporates improved data and contouring resolution over previous renditions.

Overall, the stations, that have the least amount of bias from non-climatic sources in their observations are those used in the NOAA's CRN (Climate Reference Network) (NOAA, 2002). These surface observing stations are, in general, of a high level of consistency regarding several key factors crucial to many types of long-term climatic analyses. Among these are station siting, instrument placement and upkeep, regional terrain and land-use, missing observations, and observer stability and consistency (NRC, 1999).

Probably the most studied considerations have been those regarding the station and equipment exposure within the immediate area (Fall, *et al*. 2011); the general or regional environs, including land-use changes and population increases (Karl, *et al*.

1988); and changes in instrumentation and measurement methods (Quayle, *et al*. 1991; Hubbard and Lin, 2006). Unfortunately, the CRN dataset only contains observations for quite a small number of stations and only goes back to 2002 at the most. This renders it unfeasible for this purpose. Once mean daily temperatures are calculated, all further temperature analyses will use mean values, which Peterson (2006) does suggest are less affected by poor siting than either the maximum or minimum temperatures alone.

Another dataset, though not chosen from a very select subset of long-term stations, does undergo careful checks for homogeneity and consistency. These are the stations in the Global Historical Climatology Network (GHCN) (Peterson, *et al*. 1998), of which the U.S. HCN is a subset. Nonetheless, the adjustments, which are applied to the data from these stations, must be carefully and constantly developed. Menne, *et al*. (2012) have suggested that the successes with processing of the monthly data made it a better tool for examining climatic change than the daily data.

Most non-airport stations have observation times during the calendar day, which gives rise to a slight bias in the reported temperatures—higher for evening observing and lower for morning observing. These biases can be significant in considering long-term averages (Baker, 1975; Karl, *et al.* 1986). It is the consistency of observations over the period of record for a given station that is most important (Menne, *et al.* 2010).

Ultimately, all of the thirty stations used in these analyses are airport stations, and are also in the Cooperative Observing Network (NOAA, 2006). All but two are also in the archive of Local Climatological Data stations (NOAA, 2017c.). In common with many airport observing stations, these selected stations have excellent consistency of observations, with virtually no missing temperature observations over the entire period of record used. Additionally, all these stations use a midnight-to-midnight observing period, meaning that each observational day has maximum and minimum temperatures both occurring on the same calendar day. Since all thirty stations use this same scheduling, the often error-inducing "time of observation bias" is not of concern and need not be adjusted for (Vose, *et al*., 2003). All of the station type, location and elevation data were obtained online via the xmAcis data access system (Eggleston, 2017).

Another aspect of variation considered in the pool of stations chosen for this work is to have a mix of low and high elevation stations. It was also considered useful to have stations from both relatively low and relatively high population locations. Population statistics for these were taken from compilations of 2010 U.S. Census Bureau data (Wilson, *et al.*, 2011). Since the airport stations themselves tended not to be in the midst of the Metropolitan Statistical Area, the population numbers used were those for the locality in which the airport was located. In those cases where the urban area has grown so much as to totally engulf the airport, the population levels exceed the "Low Population" threshold (100,000) used in these analyses and they are considered in the "High Population" grouping.

Other desired characteristics included ranges of latitude, proximity to the coast, and general topography. The intent is to represent differences not only at synoptic scales, but also at more localized scales. Variations in the objective seasons at those locations can then be compared and contrasted along with their other characteristics. In this sense, the concerns for station biases due to these known characteristics are not an impediment to this analysis. This exploration of the technique here is intended to make a first cut at uncovering those characteristics that are salient.

The stations chosen for use in this work are shown in Table 2. This includes their population value, station elevation and the Köppen climate classification in which they are found. The latter is shown both as the three-letter code and in the three-part descriptive fashion. This classification letter code corresponds to the color-coded contours and legend on the station location map (Figure 4).

For this work, two seasons are derived, Summer and Winter. Each of these is set to a length of 91 days. Although this differs from the three calendar month durations, it allows for the most even *a priori* time period selection. A year of 365 days, divided by 4 seasons, yields 91.25 days per season.

This investigation is suitable for disclosing interannual variations of the seasons on the order of days, so an annual (non-systematic) fluctuation of 0.25 days will have no discernable effect. Likewise, the appearance of an extra day (February 29) every 4 years can be ignored, since this shift is wiped out over the leap-year cycle and not carried forward. In addition, the count of days included in a season is restarted fresh every year and errors such as these will not be accumulated.

For each station, the daily maximum and minimum temperatures were retrieved for the period of record from May 1, 1974 through March 31, 2017, using the xmAcis database. The maximum and minimum temperatures on each day were averaged together to arrive at the mean temperature for the day. This is the standard procedure used by NCEI (National Center for Environmental Information) for the calculation of daily mean temperatures (NOAA, 2002).

In generating Summer season data within a given year, the average temperature for a moving 91-day period was calculated. The first 91-day period begins on or about May 1st and subsequent 91-day periods started one day later until the last such period began on or about July 1st.

Station	State	Coop ID	Population (x 1,000)	Elev. (Ft.)	Koppen Climate Classification			
					Code	Description		
ALBUQUERQUE INTL AP	NM	290234	546	5,310	Bwk	Arid	Desert	Cold
ASHEVILLE AP	NC	310300	238	2,117	Cfb	Temp.	No Dry Seas.	Warm Sum.
BAKERSFIELD AP	CA	040442	347	489	Bsh	Arid	Steppe	Hot
BISMARCK MUNI AP	ND	320819	61	1,651	Dfb	Cold	No Dry Seas.	Warm Sum.
CARIBOU MUNI AP	ME	171175	8	624	Dfb	Cold	No Dry Seas.	Warm Sum.
CLEVELAND INTL AP	OH	331657	1,280	781	Dfa	Cold	No Dry Seas.	Hot Sum.
DAYTONA INTL AP	FL	082158	61	31	Cfa	Temp.	No Dry Seas.	Hot Sum.
EL PASO INTL AP	TX	412797	649	3,918	Bwk	Arid	Desert	Cold
ELKINS AP	WV	462718	7	1,979	Cfb	Temp.	No Dry Seas.	Warm Sum.
FORT SMITH REGL AP	AR	032574	86	449	Cfa	Temp.	No Dry Seas.	Hot Sum.
FRESNO INTL AP	CA	043257	495	333	Bsh	Arid	Steppe	Hot
GRAND JUNCTION WALKER FLD	CO	053488	147	4,858	Bsk	Arid	Steppe	Cold
INTERNATIONAL FALLS INTL AP	MN	214026	6	1,183	Dfb	Cold	No Dry Seas.	Warm Sum.
LAS VEGAS INTL AP	NV	264436	584	2,180	Bwh	Arid	Desert	Hot
LEWISTON NEZ PERCE CO AP	ID	105241	32	1,436	Bsk	Arid	Steppe	Cold
MEDFORD INTL AP	OR	355429	203	1,297	Csa	Temp.	Dry Summer	Hot Sum.
MEMPHIS INTL AP	TN	405954	25	254	Cfa	Temp.	No Dry Seas.	Hot Sum.
MIDLAND IINTL AP	TX	415890	111	2,862	Bsh	Arid	Steppe	Hot
MOBILE REGL AP	AL	015478	413	215	Cfa	Temp.	No Dry Seas.	Hot Sum.
PELLSTON REGL AP	MI	206438	1	705	Dfb	Cold	No Dry Seas.	Warm Sum.
PHILADELPHIA INTL AP	PA	366889	1,526	10	Cfa	Temp.	No Dry Seas.	Hot Sum.
PHOENIX AP	AZ	026481	1,446	1,107	Bwh	Arid	Desert	Hot
PIERRE RGNL AP	SD	396597	14	1,742	Bsk	Arid	Steppe	Cold
ROSWELL AIR PK	NM	297610	48	3,649	Bsk	Arid	Steppe	Cold
SALT LAKE CITY INTL AP	UT	427598	186	4,225	Bsk	Arid	Steppe	Cold
SAN ANGELO MATHIS FIELD	TX	417943	110	1,916	Bsh	Arid	Steppe	Hot
SAULT STE MARIE SAND. FLD	MI	207366	14	722	Dfb	Cold	No Dry Seas.	Warm Sum.
SEATTLE INTL AP	WA	457473	609	370	Csb	Temp.	Dry Summer	Warm Sum.
SPOKANE INTL AP	WA	457938	209	2,353	Dsb	Cold	Dry Summer	Warm Sum.
WATERLOO MUNI AP	IA	138706	68	868	Dfa	Cold	No Dry Seas.	Hot Sum.

Table 2. Stations used in these analyses, along with their approximate population, elevation, and Köppen Climate Classification type.

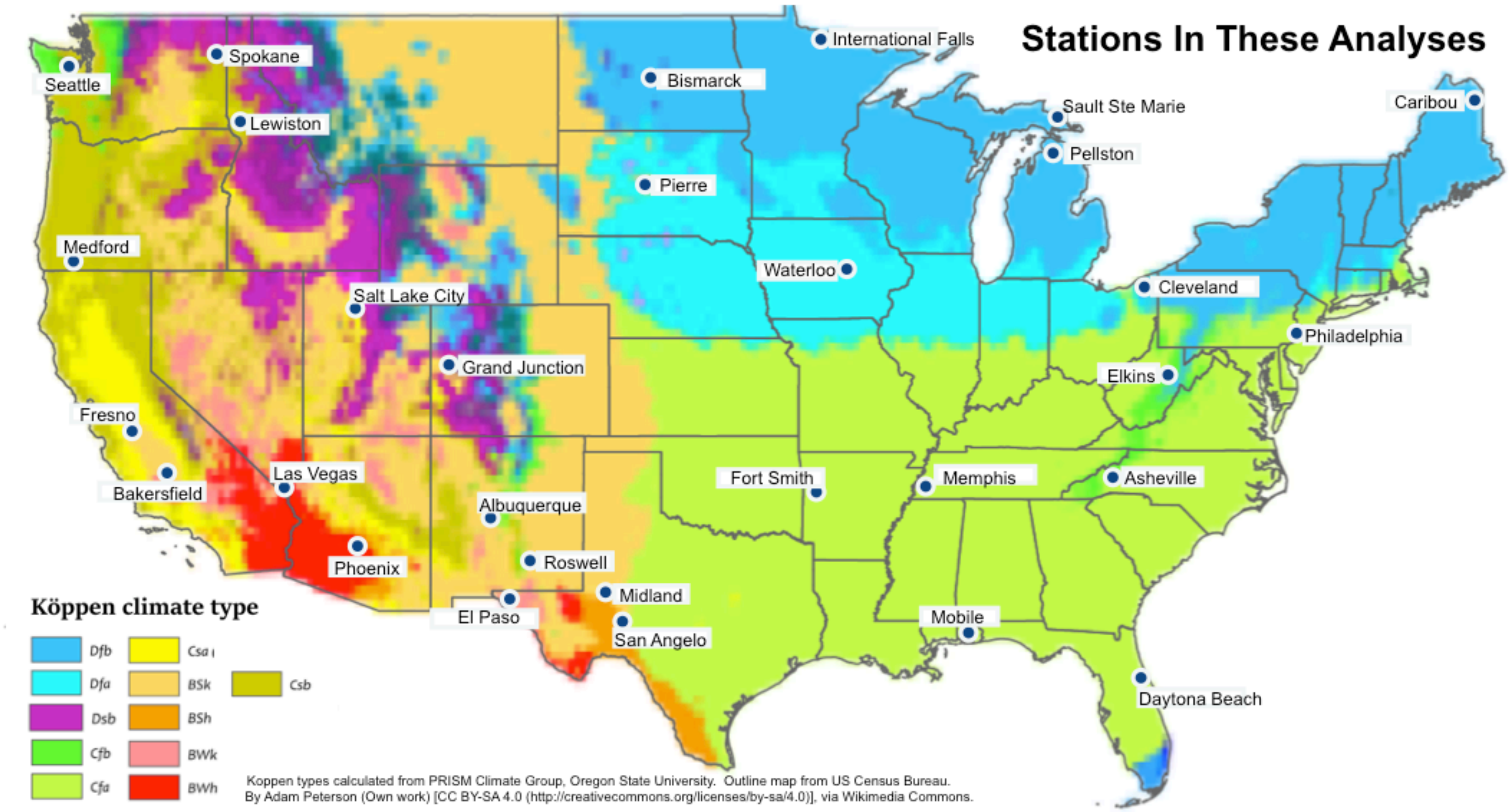


Figure 4. Map of the contiguous U.S., showing locations of stations used in these analyses, and their distribution throughout the Köppen Climate Classification types. The three-letter designators for the types are described in Table 2.

Fresno, CA Station   Warm Period (Summer)

Year	Month	Day	Daily Average Temperature (°F)	91-Day Average Temperature (°F)
1974	5	1	72.0	75.98
1974	5	2	64.0	76.13
1974	5	3	64.5	76.36
1974	5	4	65.0	76.60
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
1974	6	23	78.0	79.75
1974	6	24	77.5	79.76
1974	6	25	74.5	79.77
1974	6	26	74.0	79.79
1974	6	27	76.5	79.85
1974	6	28	80.0	79.81
1974	6	29	86.0	79.71
1974	6	30	85.5	79.58
1974	7	1	79.5	79.44

Table 3. Example of the running averages procedure for deriving the warmest 91-day period in a year (Summer) and its start date for the station at Fresno, CA. In this case, in the year 1974, the warmest 91-day period averaged 79.85°F and began on June 27. This is repeated for each year through 2016. The coolest 91-day period (Winter) is determined in similar fashion.

The average temperature for each 91-day period was paired with the start day for that period. The day paired with the highest average temperature was recorded as the start day of Summer for that station in that year. In addition, that corresponding temperature value was recorded as the average temperature for that year's Summer.

In the case of Winter, the average temperature for a moving 91-day period was calculated for a beginning day on or about November 1st, with the period being advanced by one day until the coldest 91-day period has been revealed. That period's average is, again, assigned to its start date. Since Winter spans a calendar year break, each winter is referred to by the first of the two years—even if the objective Winter season begins in the latter year. For example: If the Winter for 1974–75 is determined to begin on December 10, 1974: Winter, 1974 starts December 10. If Winter for 1975–76 is determined to begin on January 5, 1976: Winter, 1975 starts January 5. In all but a few cases, this keeps the start date appearing in its actual year.

For each of the stations examined, the datasets resulting from these procedures contain, for the years 1974 through 2016, the summer start day, summer average temperature, winter start day and winter average temperature. In all these calculations, sequential days of the year ("Julian Days") are used. In the case of winter, sequential days beyond 365 were sometimes applied. They are then converted back to standard calendar form for tabular and graphic display.

After the full dataset is assembled, a series of regression analyses were performed for each station relating the year of record to the season start date for both Summer and Winter. In each case, an f-test was run to check for significance (α=0.05) of the regression relationship.

Similarly, these regression analyses and f-tests were applied to the average Summer and Winter temperatures over the years, in order to look for any significant secular trends in the average temperatures of the objectively defined seasons. This differs from previous analyses of seasonal temperature trends because here the days included in the seasons have been allowed to shift from one year to the next.

Results

Season Start Trends

The results of the linear regression analyses of temporal trends in changes of the start date for these objectively defined Summer and Winter seasons over the forty-three years of data are summarized in Table 4. These are shown individually for each of the thirty stations.

Right pointing (left pointing) arrows indicate a trend toward later (earlier) season start dates — each as it applies to the respective seasons. Non-significant trends are shown in black and significant (≤ 0.05 level) trends are shown in red.

As is readily apparent, there are few stations that exhibited any signs of significant trends in seasonal start date over time. Only the stations, Caribou, ME (Figures 5a. and 5b.) and International Falls, MN (Figures 6a. and 6b., respectively) showed significant trends on both of the seasons. Interestingly enough, the trends were toward later start dates for both Summer and Winter seasons. This would also imply a shift toward later start dates of the transition seasons (Spring and Fall), without necessarily a reduction or increase in the length of either.

The two stations in Michigan, Pellston (Figures 7a. and 7b.) and Sault Ste. Marie (Figures 8a. and 8b.), both showed significant trends toward later Summer start dates, but no significant trends in Winter start dates. This would tend to suggest a lengthening of the Spring and a shortening of Fall for these locations.

In the western US48, both the Fresno (Figures 9a. and 9b.) and Spokane (Figures 10a. and 10b.) stations exhibited significant trends in Winter start dates (toward later dates), but no significant trends in the onset of Summer. This implies the opposite by-product of a trend toward a lengthening of Fall and shortening of Spring.

Temporal Trends of Start Dates for Objectively Defined Seasons

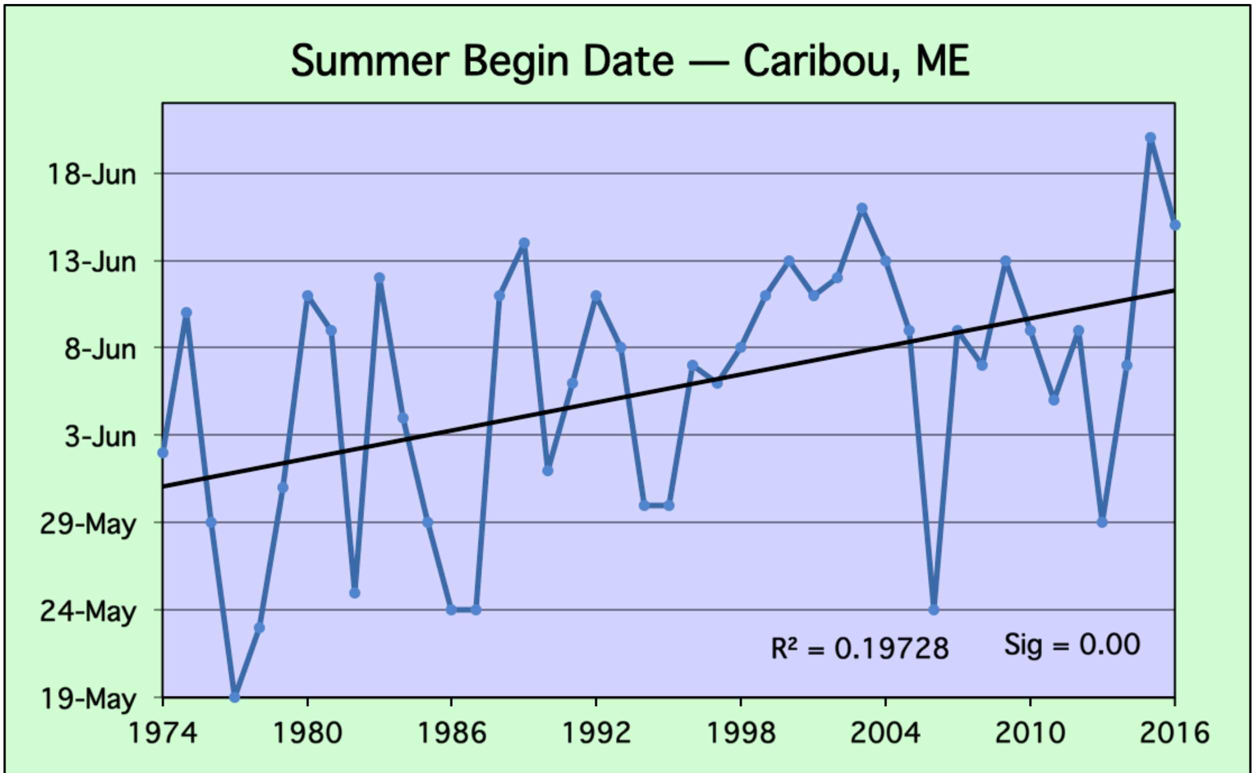
→	Indicates Significant Trend toward Later Start Date
←	Indicates Significant Trend toward Earlier Start Date
→	Indicates Non-Significant Trend toward Later Start Date
←	Indicates Non-Significant Trend toward Earlier Start Date

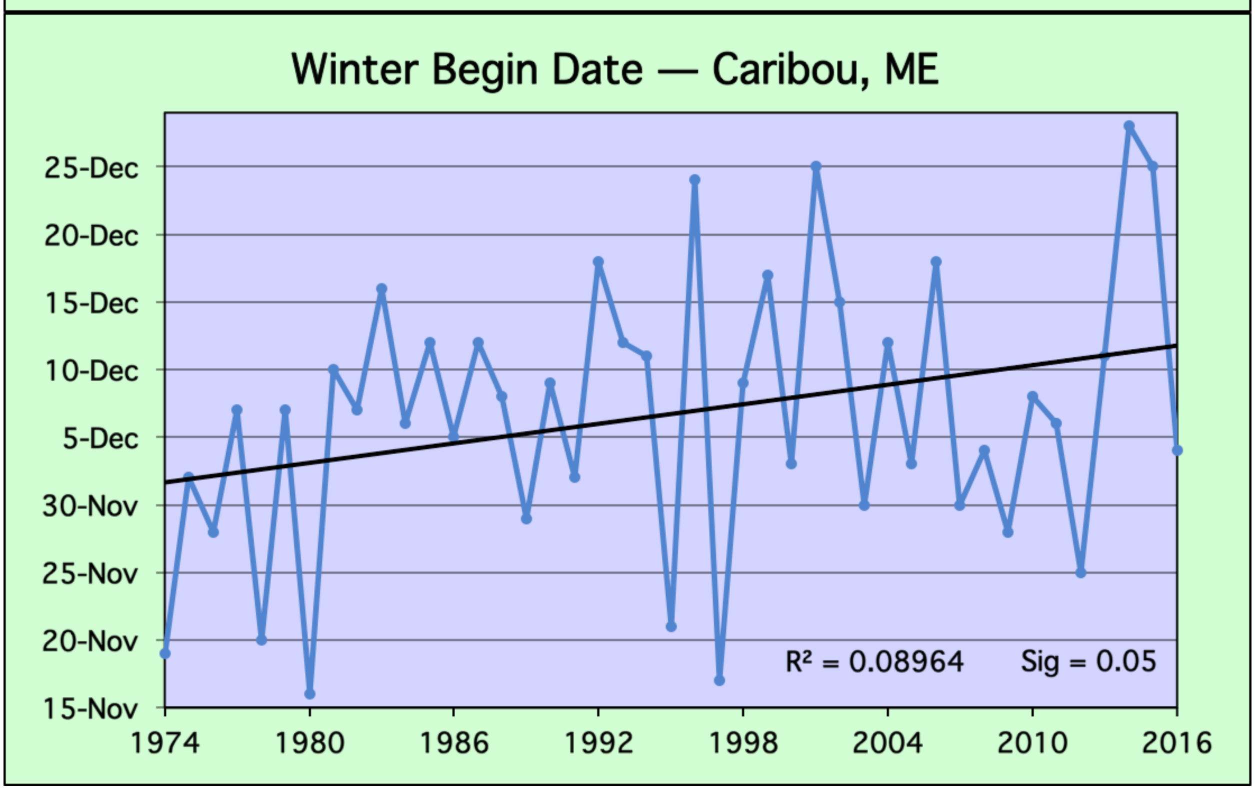
Station	Summer Start Date	Winter Start Date
ALBUQUERQUE	←	→
ASHEVILLE	←	→
BAKERSFIELD	←	→
BISMARCK	→	→
CARIBOU	**→**	**→**
CLEVELAND	→	→
DAYTONA BEACH	←	→
EL PASO	←	→
ELKINS	→	→
FORT SMITH	←	→
FRESNO	←	**→**
GRAND JUNCTION	←	→
INTERNATNL FALLS	**→**	**→**
LAS VEGAS	←	←
LEWISTON	→	→
MEDFORD	→	→
MEMPHIS	←	→
MIDLAND	→	→
MOBILE	→	→
PELLSTON	**→**	→
PHILADELPHIA	←	→
PHOENIX	→	→
PIERRE	→	→
ROSWELL	←	→
SALT LAKE CITY	←	←
SAN ANGELO	←	→
SAULT STE MARIE	**→**	→
SEATTLE	←	←
SPOKANE	→	**→**
WATERLOO	→	→

Table 4. Summary of the regression analyses for temporal trends of season start dates for each of the thirty stations. Trends are indicated as significant if they meet or exceed the 0.05 confidence level.

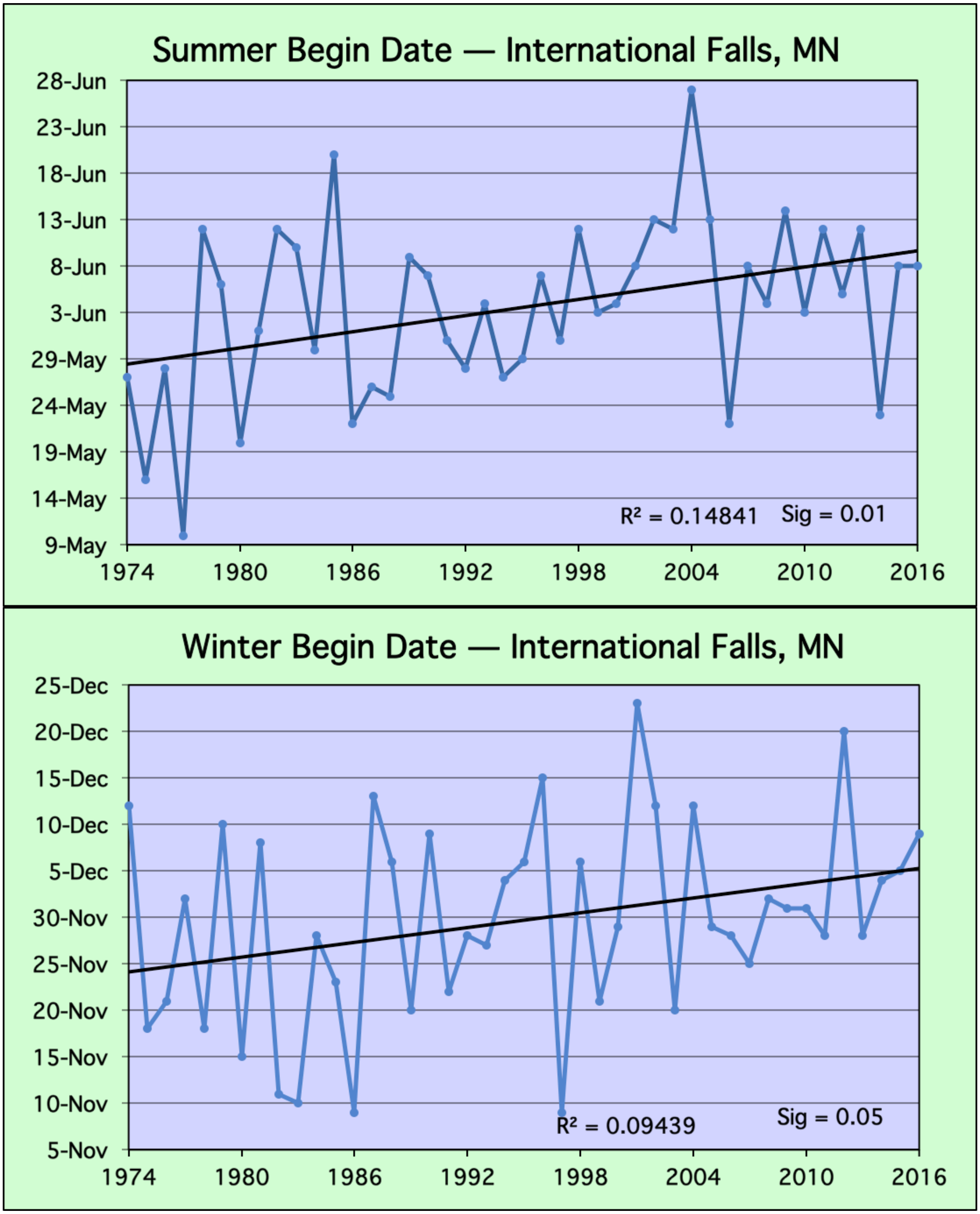
It is of interest to note that four of the coldest stations in the northern US48, along the Canadian border all have significant trends toward later Summer start dates. These four are all found in the Köppen classification zone denoted as Dfb (Cold, No Dry Season, Warm Summer). Additionally, these stations have a very low population in the jurisdiction immediately surrounding the airport—not altogether surprising, given the generally unpleasant Winter conditions found in those locations. The only two stations that exhibit significant trends in both Winter and Summer start dates (Caribou and International Falls) are a subset of this group.

The complete set of these charts for all thirty stations is found in Appendix A3.

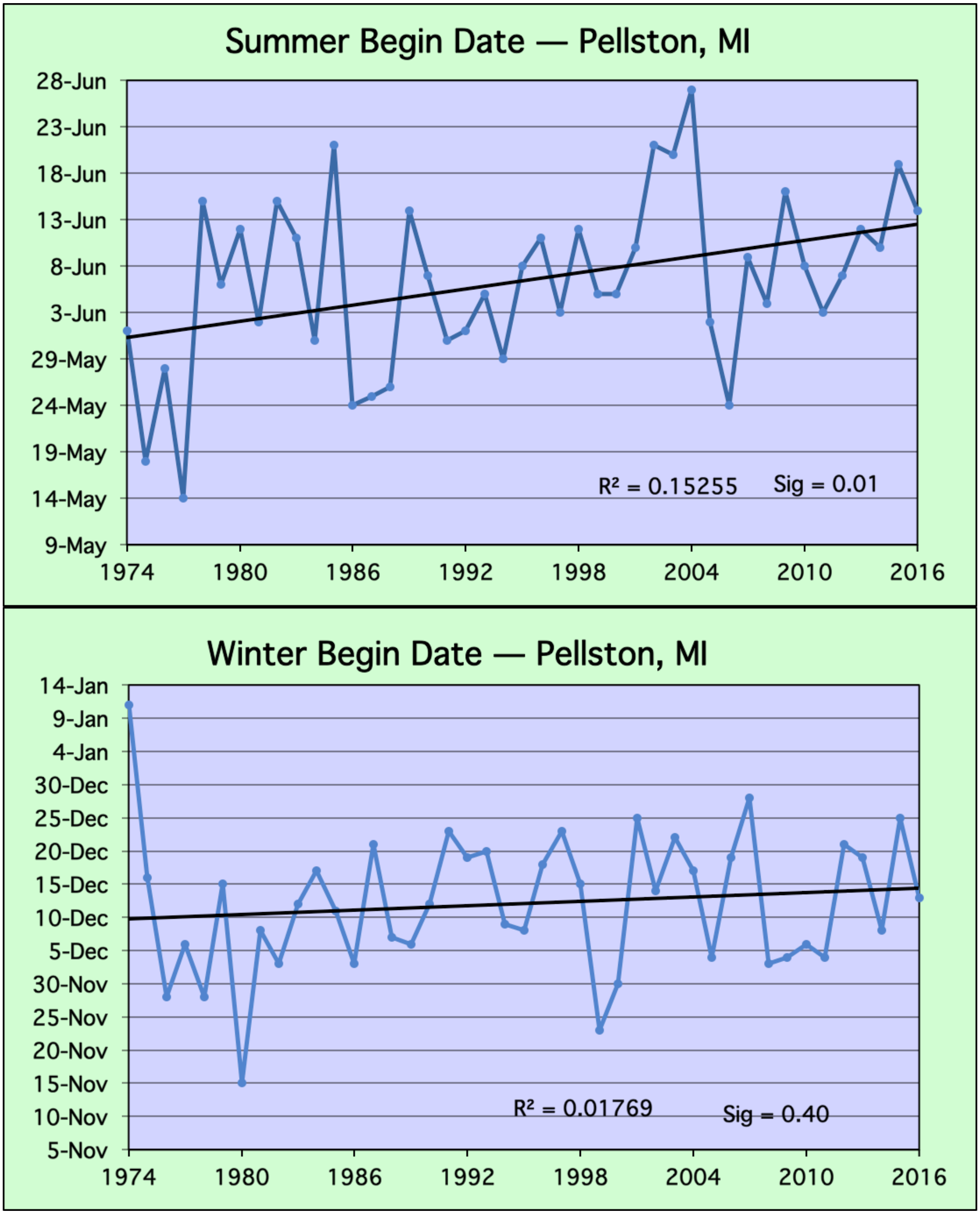




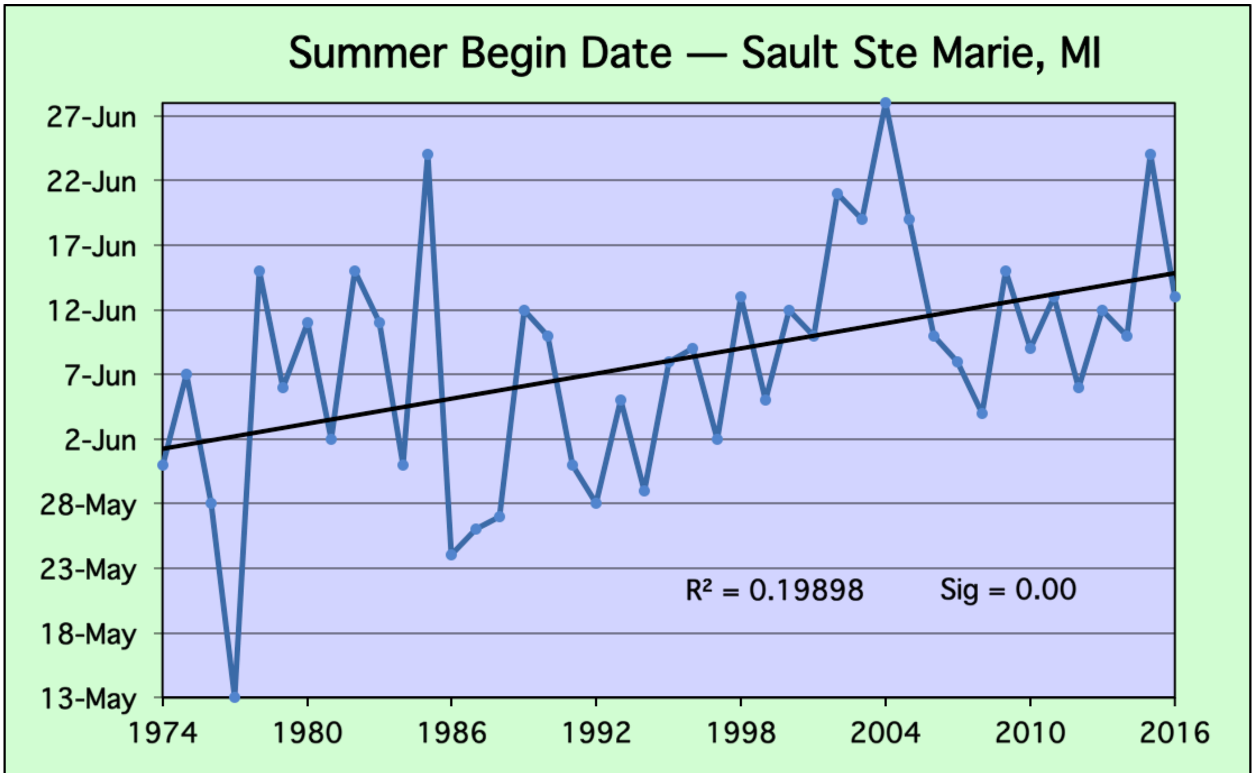
Figures 5a.(Top) & 5b.(Bottom) The Caribou, ME station shows statistically significant secular trends in both Summer and Winter start dates. ("Sig = 0.00" represents a significance of < 0.005.)

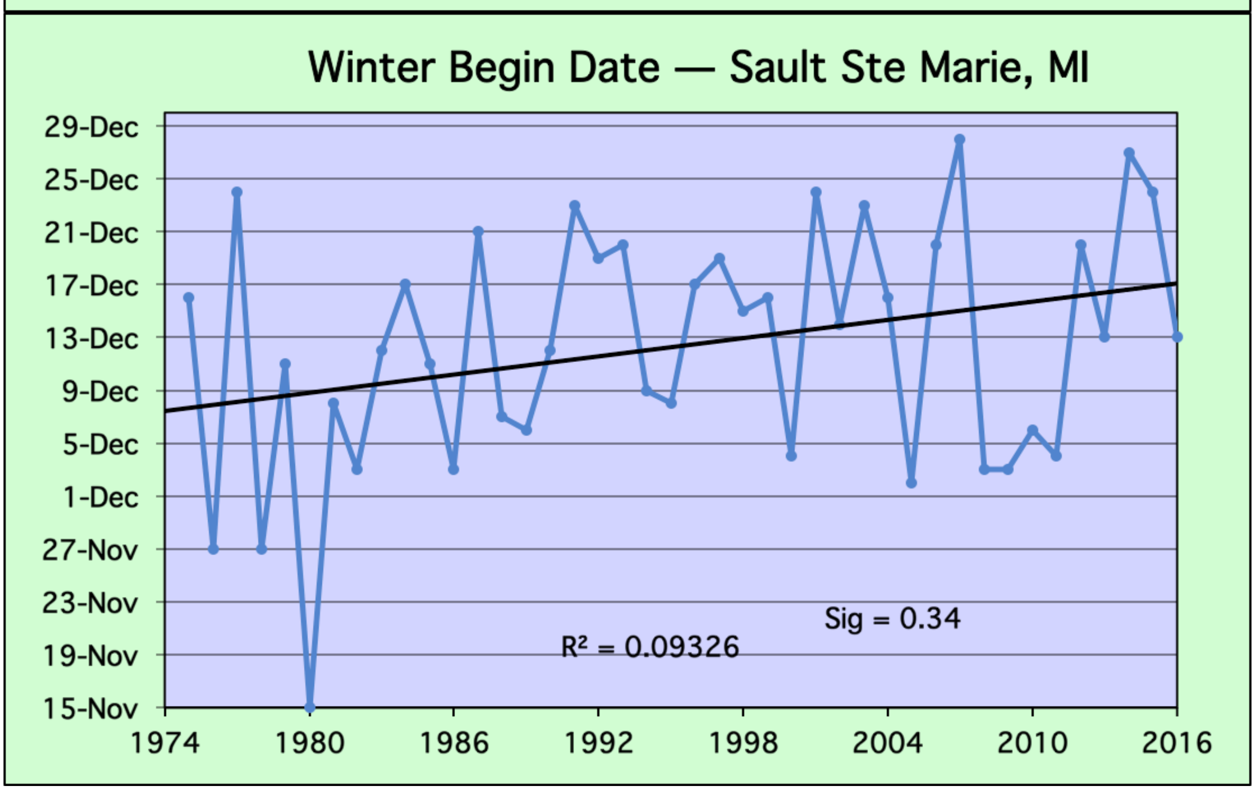


Figures 6a.(Top) & 6b.(Bottom) International Falls, MN station shows statistically significant secular trends in both Summer and Winter start dates.

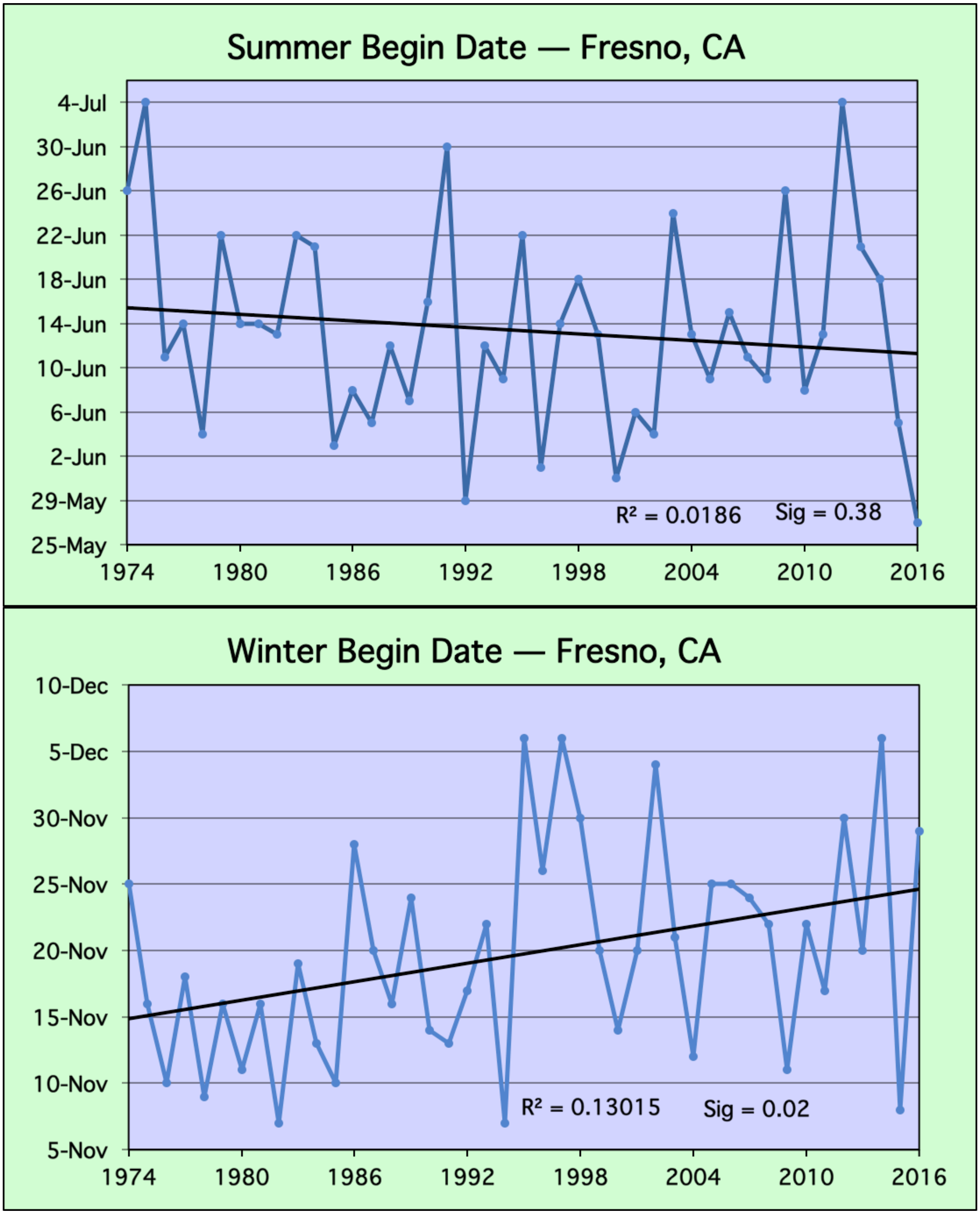


Figures 7a.(Top) & 7b.(Bottom) Pellston, MI station shows a statistically significant secular trend in Summer start date, but not in Winter start date.

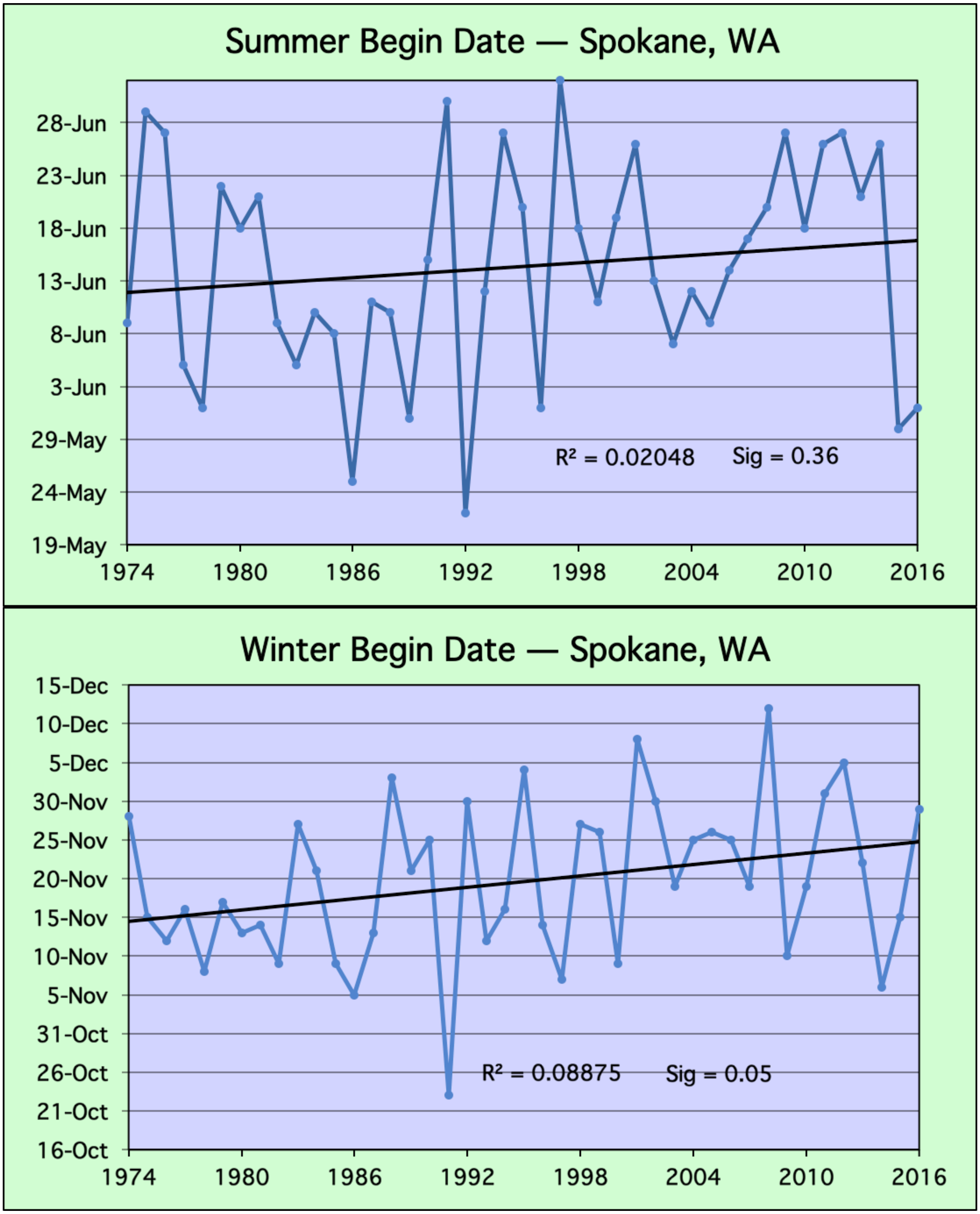




Figures 8a.(Top) & 8b.(Bottom) Sault Ste Marie, MI station shows a statistically significant secular trend in Summer start date, but not in Winter start date. ("Sig = 0.00" represents a significance of < 0.005.)



Figures 9a.(Top) & 9b.(Bottom) Fresno, CA station shows a statistically significant secular trend in Summer start date, but not in Winter start date.



Figures 10a.(Top) & 10b.(Bottom) Spokane, WA station shows a statistically significant secular trend in Summer start date, but not in Winter start date.

Results

Season Temperature Trends

Summarized results of the linear regression analyses of temporal trends in the average temperatures for these objectively defined Summer and Winter seasons over the forty-three years of data are given in Table 5. These are shown individually for each of the thirty stations.

Upward pointing arrows indicate a regression trend toward higher season temperatures over the time period, and downward pointing arrows show a downward trend in temperatures over time — each as it applies to the respective seasons. Non-significant trends are shown in black and significant (≤ 0.05 level) trends are shown in red.

In this case, it is apparent that in only a few (three) instances are the arrows pointing down and none of these is statistically significant at the 0.05 confidence level. A good majority (22) of the stations indicate a significant upward temperature trend in at least one season and 13 of the 30 do so in both seasons. This is not surprising, given the time period chosen, since warming surface temperatures have been generally observed at stations across the contiguous U.S. since 1974 (IPCC, 2013), and that the overall temperature trends seen in fixed seasons would be likely to appear in these objective seasons, also.

Perhaps the more interesting observation is that there are 8 stations that exhibit no significant trend in either Summer or Winter. Of those, two have *negative* trends (albeit not significant) in objectively defined Summer mean temperatures. These two anomalous stations (Pierre, SD and International Falls, MN) are (as in the case with the standouts from the objective season start analyses) both in the far northern portion of the contiguous US.

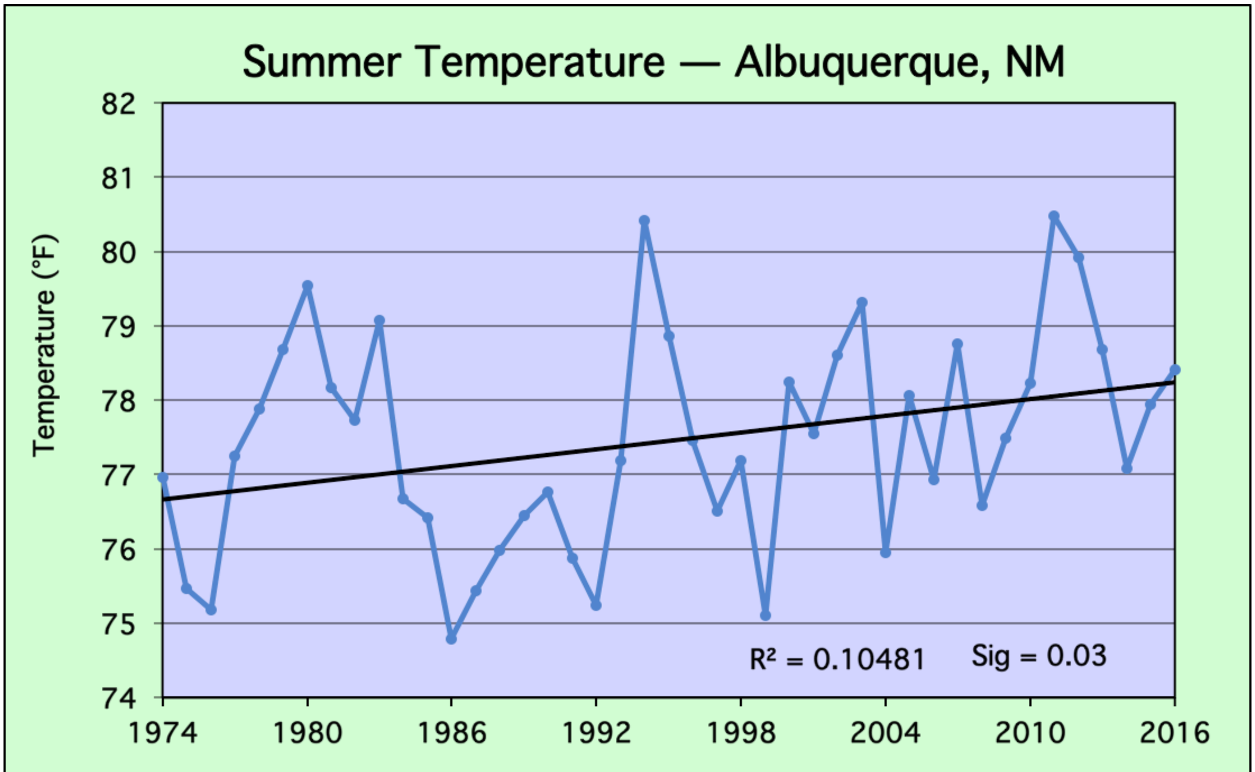
The complete set of these charts for all thirty stations is found in Appendix A3.

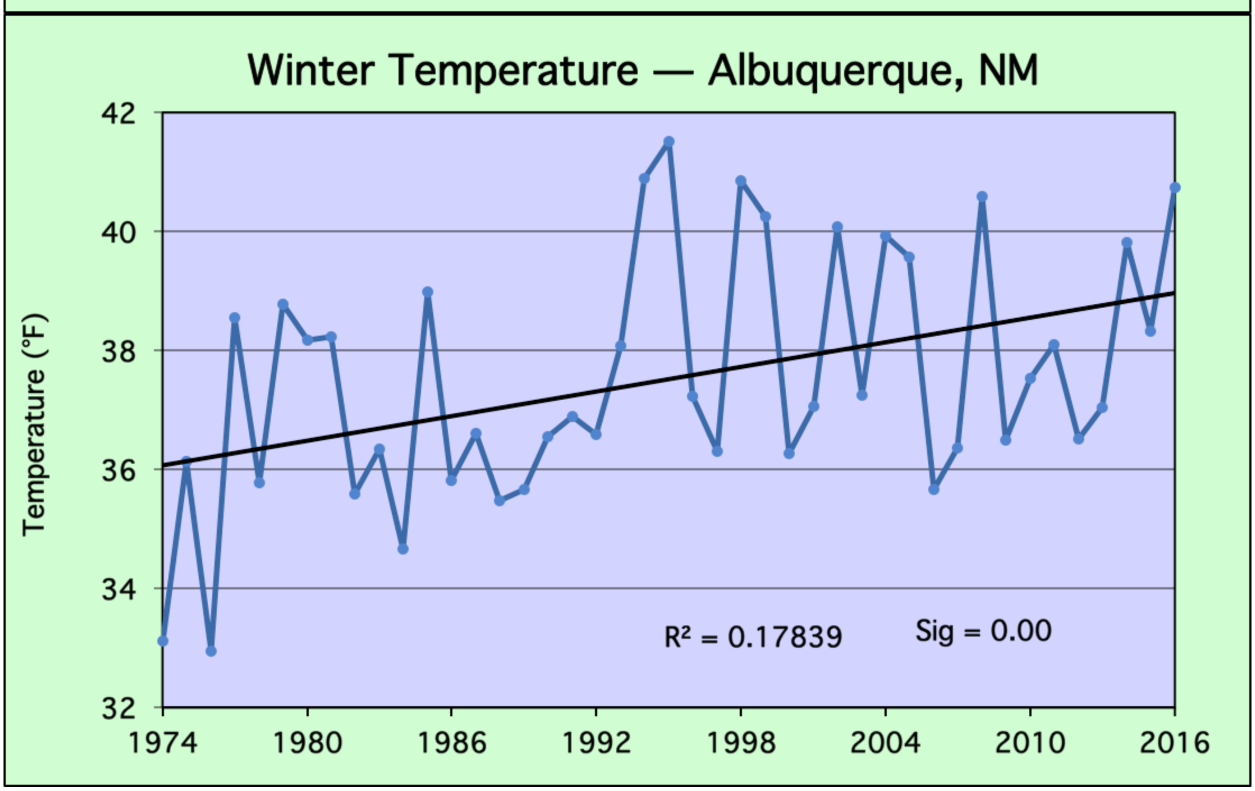
Temporal Trends of Average Temperatures for Objectively Defined Seasons

↑ (red)	Indicates Significant Trend toward Increasing Temp
↓ (red)	Indicates Significant Trend toward Decreasing Temp
↑	Indicates Non-Significant Trend toward Increasing Temp
↓	Indicates Non-Significant Trend toward Decreasing Temp

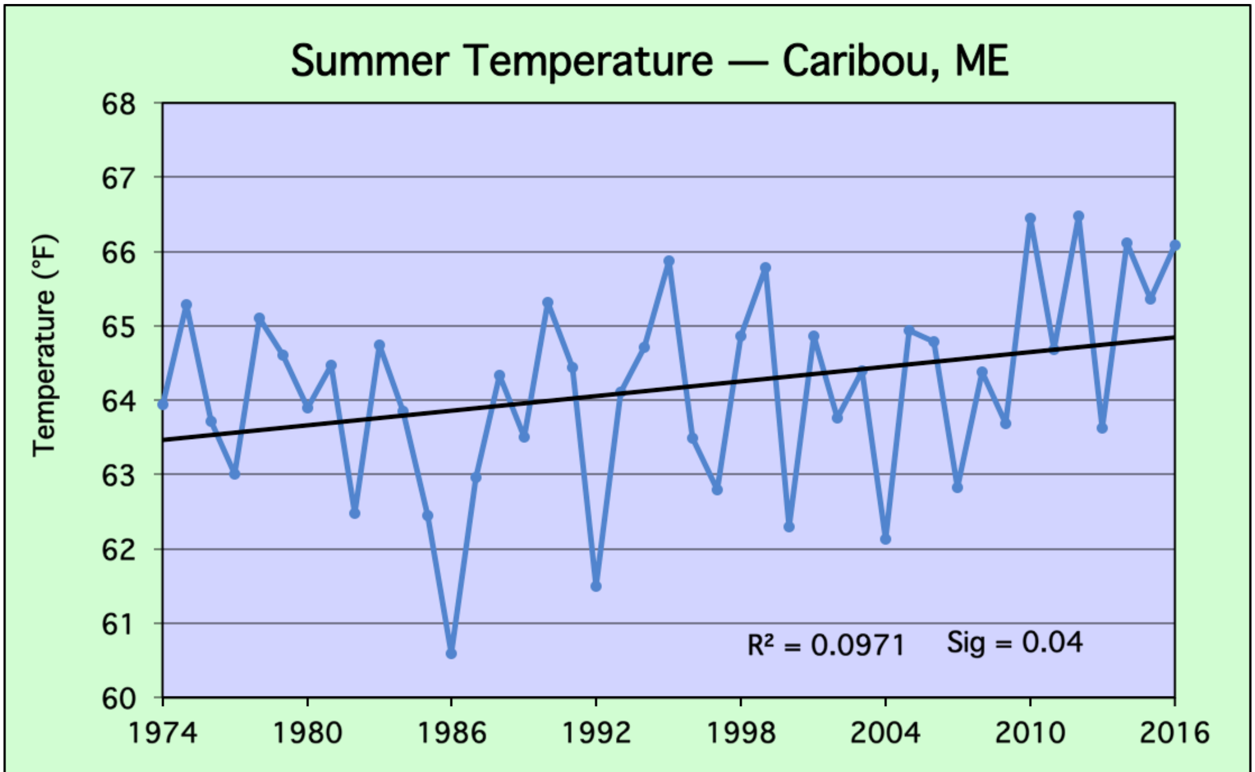
Station	Summer Mean Temperature	Winter Mean Temperature
ALBUQUERQUE	↑ (red)	↑ (red)
ASHEVILLE	↑	↑ (red)
BAKERSFIELD	↑	↑
BISMARCK	↑	↑
CARIBOU	↑ (red)	↑ (red)
CLEVELAND	↑ (red)	↑ (red)
DAYTONA BEACH	↑ (red)	↑ (red)
EL PASO	↑ (red)	↑ (red)
ELKINS	↑ (red)	↑ (red)
FORT SMITH	↑ (red)	↑ (red)
FRESNO	↑ (red)	↑ (red)
GRAND JUNCTION	↑	↓
INTERNATNL FALLS	↓	↑
LAS VEGAS	↑ (red)	↑ (red)
LEWISTON	↑ (red)	↑
MEDFORD	↑ (red)	↑ (red)
MEMPHIS	↑	↑ (red)
MIDLAND	↑ (red)	↑ (red)
MOBILE	↑	↑
PELLSTON	↑	↑
PHILADELPHIA	↑	↑ (red)
PHOENIX	↑ (red)	↑ (red)
PIERRE	↓	↑
ROSWELL	↑ (red)	↑
SALT LAKE CITY	↑ (red)	↑
SAN ANGELO	↑	↑ (red)
SAULT STE MARIE	↑ (red)	↑ (red)
SEATTLE	↑ (red)	↑
SPOKANE	↑ (red)	↑
WATERLOO	↑	↑

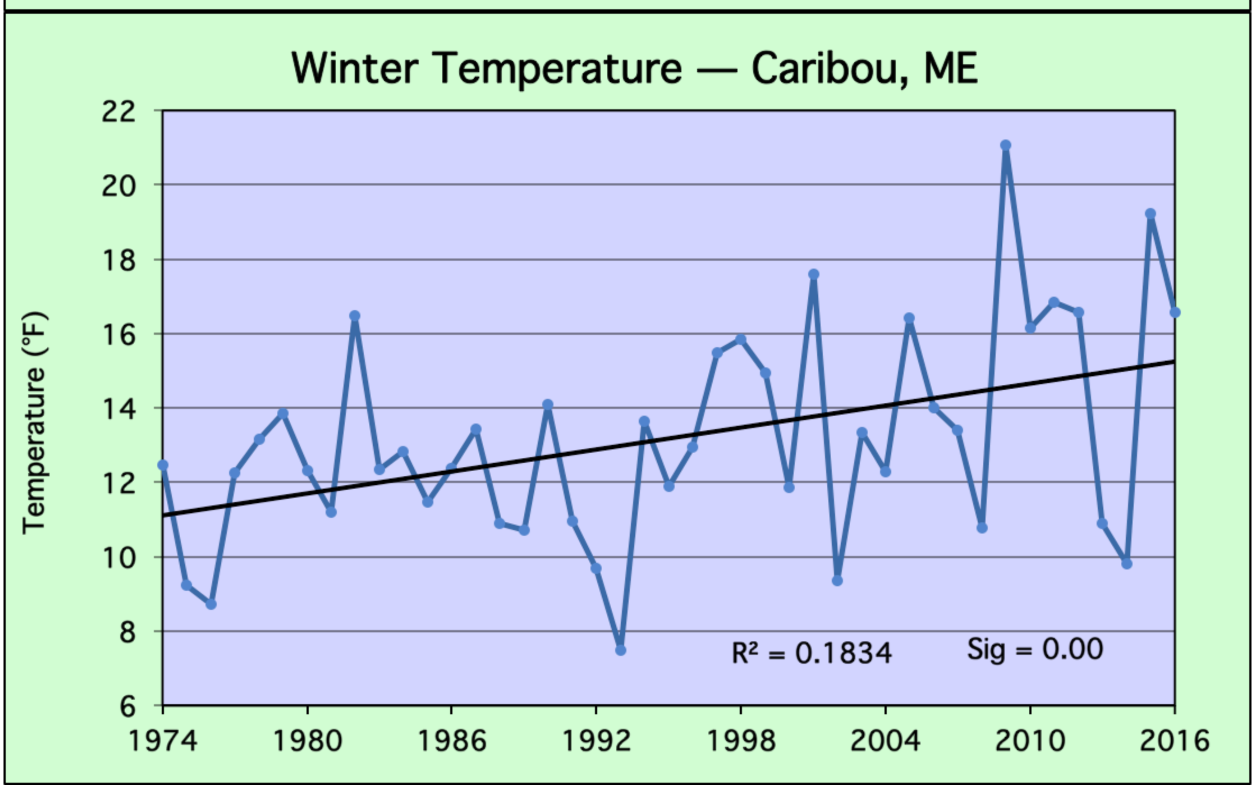
Table 5. Summary of the regression analyses for temporal trends of season mean temperatures—for each of the thirty stations. Trends are indicated as significant if they meet or exceed the 0.05 confidence level.



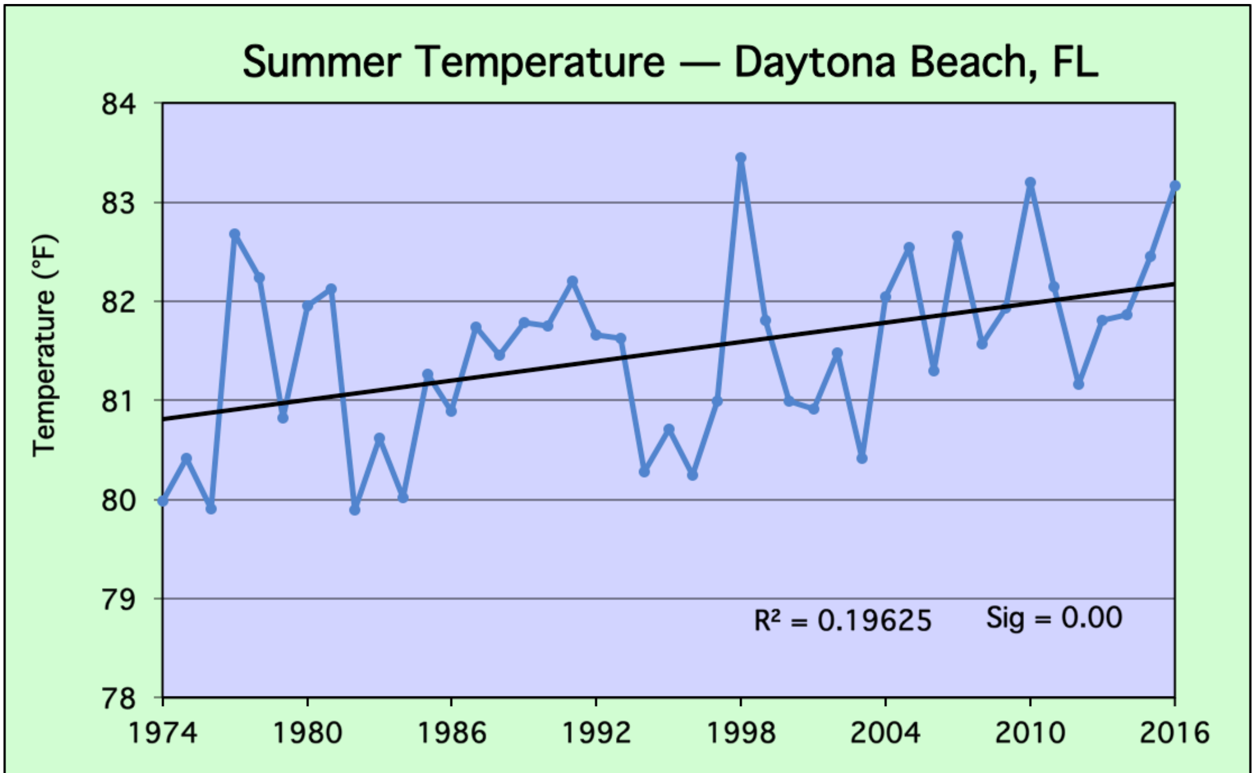


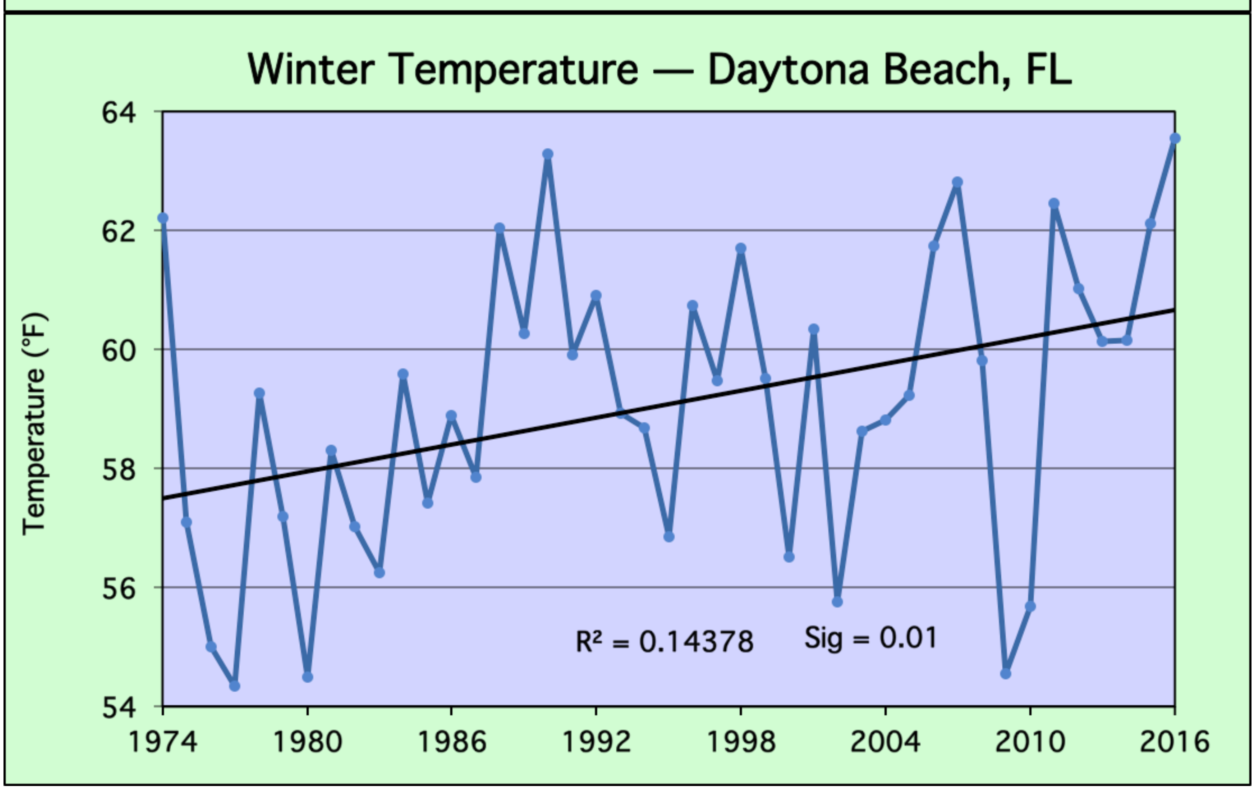
Figures 11a.(top) & 11b.(bottom) Albuquerque, NM station shows statistically significant secular trends in mean temperatures in Summer and Winter objective seasons. ("Sig = 0.00" represents a significance of < 0.005.)





Figures 12a.(top) & 12b.(bottom) Caribou, ME station also has statistically significant secular trends in mean temperatures in Summer and Winter objective seasons. ("Sig = 0.00" represents a significance of < 0.005.)





Figures 13a.(top) & 13b.(bottom) Daytona, FL station shows statistically significant secular trends in average temperatures in Summer and Winter objective seasons. ("Sig = 0.00" represents a significance of < 0.005.)

Results

Season Start & Temperature Trends Relationships

In order to assess the relationship between start dates of the objectively defined seasons and the mean temperatures of those seasons, a series of regression analyses was run on these parameters for each of the thirty stations chosen. Table 6. (below) summarized the results of those analyses as performed for these objectively defined Summer and Winter seasons over the forty-three years of data. This shows the results for each of the thirty individual stations.

Upward pointing arrows indicate a regression trend toward a later start date for the season with increasing mean season temperatures over the time period. Downward pointing arrows indicate a regression trend toward a later start date for the season with decreasing mean season temperatures over the time period.

As can be seen in the summary table, significant (probability level ≤ 0.05) relationships are only found in five of the seasonal analyses—four in the Summer season and one in Winter—and no station had significant relationships for both seasons.

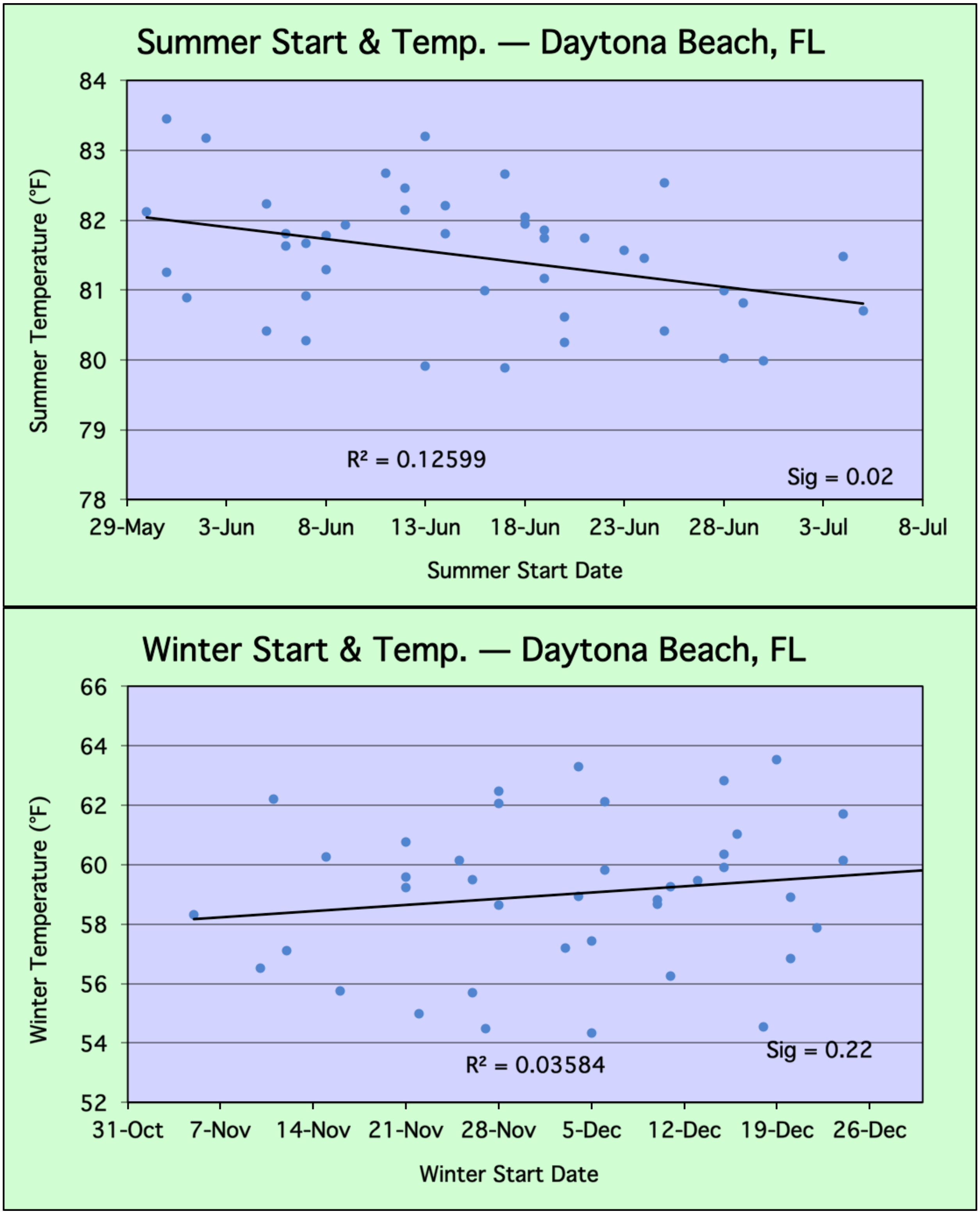
Some examples of these are given in the following figures (14a. & b. through 16a. & b.). These show the Summer and Winter relationships for Daytona Beach, FL; Fresno, CA; and Sault Ste. Marie, MI, respectively.

The complete set of these charts for all thirty stations is found in Appendix A4.

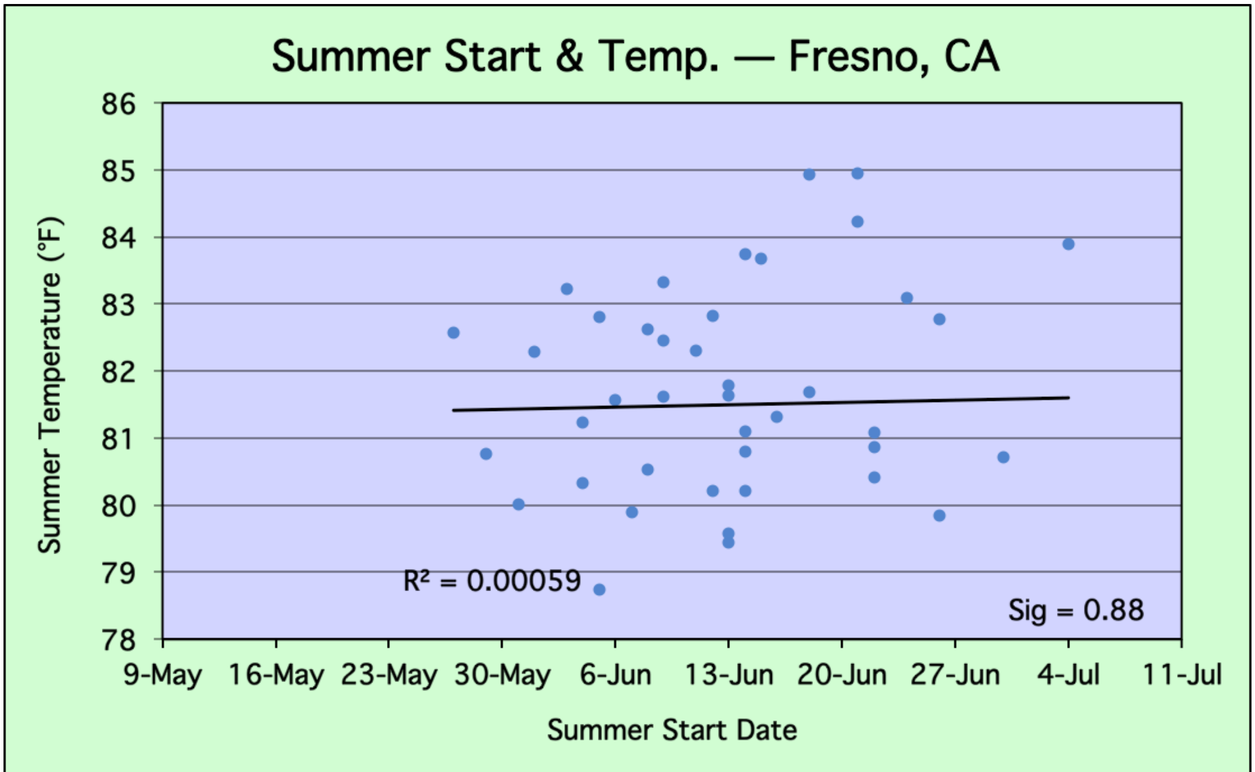
Table 6. Relationship Between Mean Temperatures
and Start Date of Objectively Defined Seasons

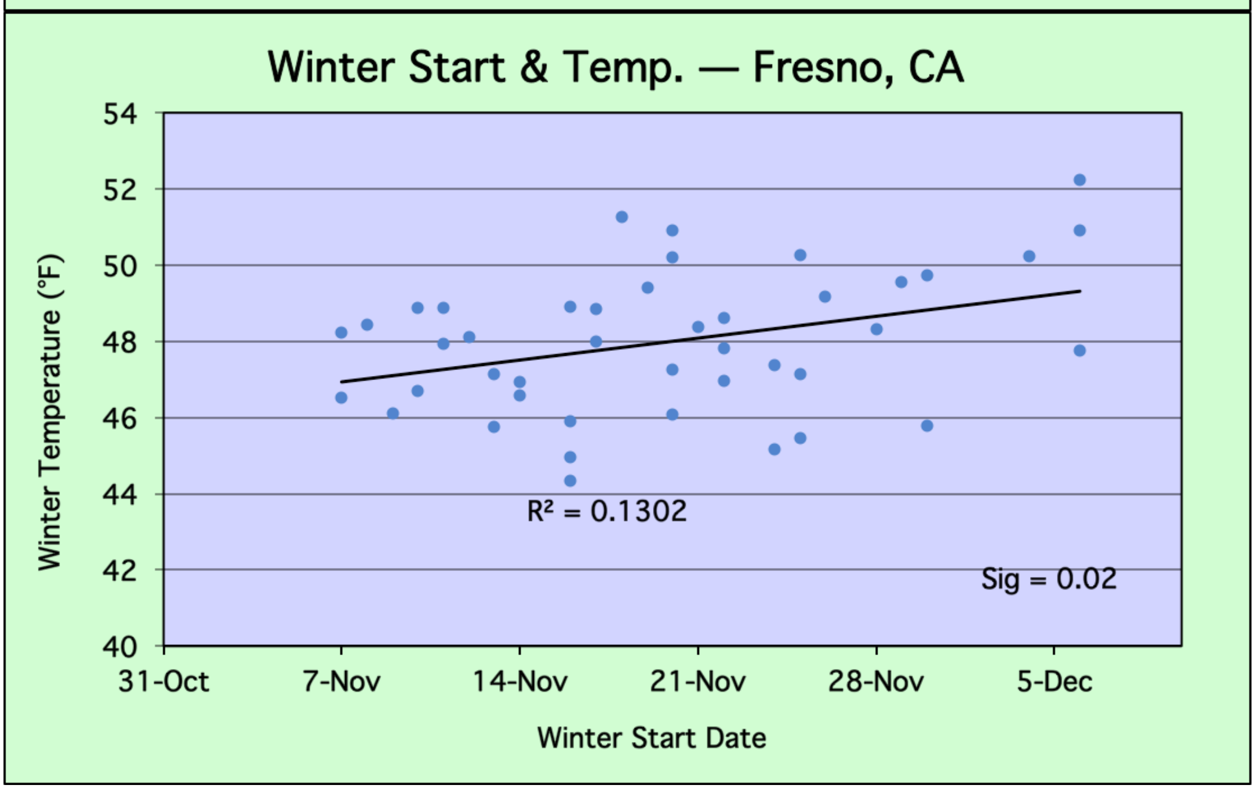
↑ (red)	Significant Relationship: Later Start With Higher Mean Temp
↓ (red)	Significant Relationship: Later Start With Lower Mean Temp
↑	Non-Significant Trend: Later Start With Higher Mean Temp
↓	Non-Significant Trend: Later Start With Lower Mean Temp

Station	Summer Start Date & Summer Mean Temperature	Winter Start Date & Winter Mean Temperature
ALBUQUERQUE	↓	↑
ASHEVILLE	↑	↑
BAKERSFIELD	↑	↑
BISMARCK	↑	↓
CARIBOU	↑	↓
CLEVELAND	↓	↓
DAYTONA BEACH	↓ (red)	↑
EL PASO	↓	↓
ELKINS	↑	↓
FORT SMITH	↑	↓
FRESNO	↑	↑ (red)
GRAND JUNCTION	↓	↓
INTERNATNL FALLS	↓ (red)	↓
LAS VEGAS	↓ (red)	↑
LEWISTON	↓	↓
MEDFORD	↑	↑
MEMPHIS	↑	↓
MIDLAND	↑	↑
MOBILE	↓	↓
PELLSTON	↓	↑
PHILADELPHIA	↓	↓
PHOENIX	↓	↑
PIERRE	↓	↓
ROSWELL	↑	↑
SALT LAKE CITY	↓	↓
SAN ANGELO	↓	↑
SAULT STE MARIE	↑ (red)	↑
SEATTLE	↓	↓
SPOKANE	↓	↓
WATERLOO	↑	↓

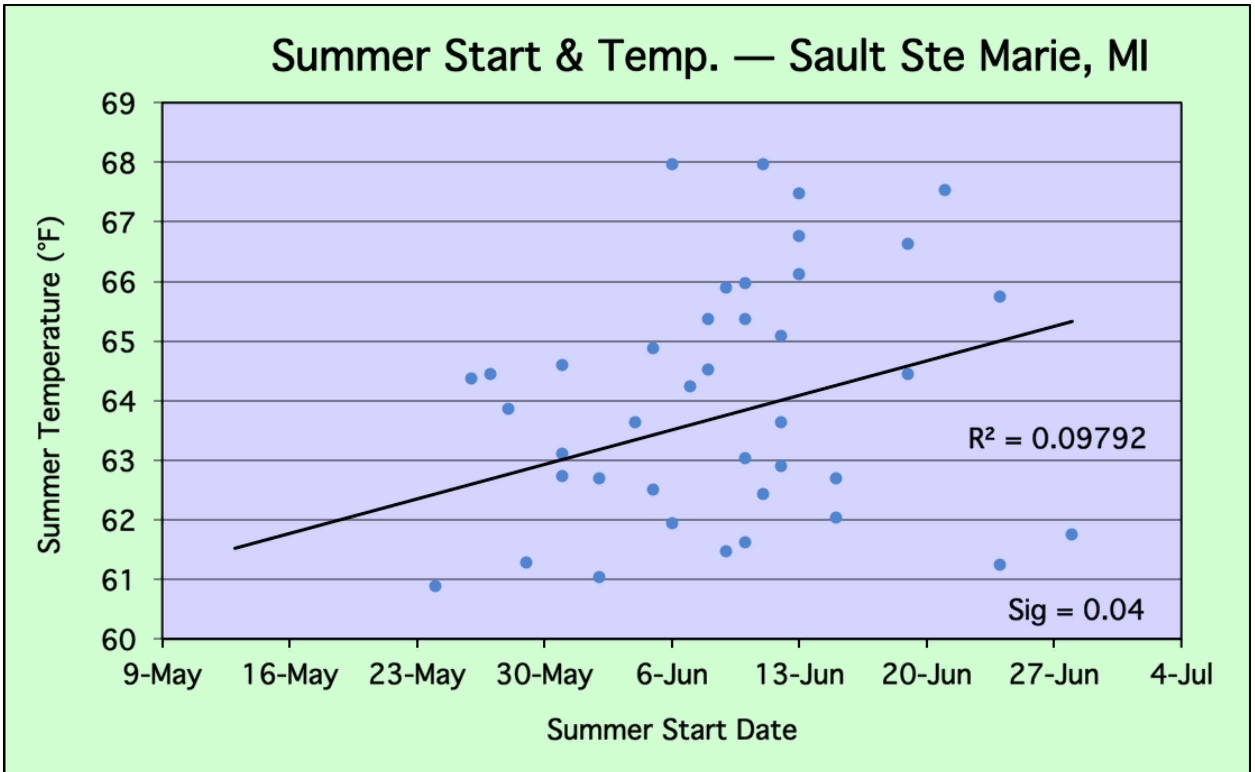


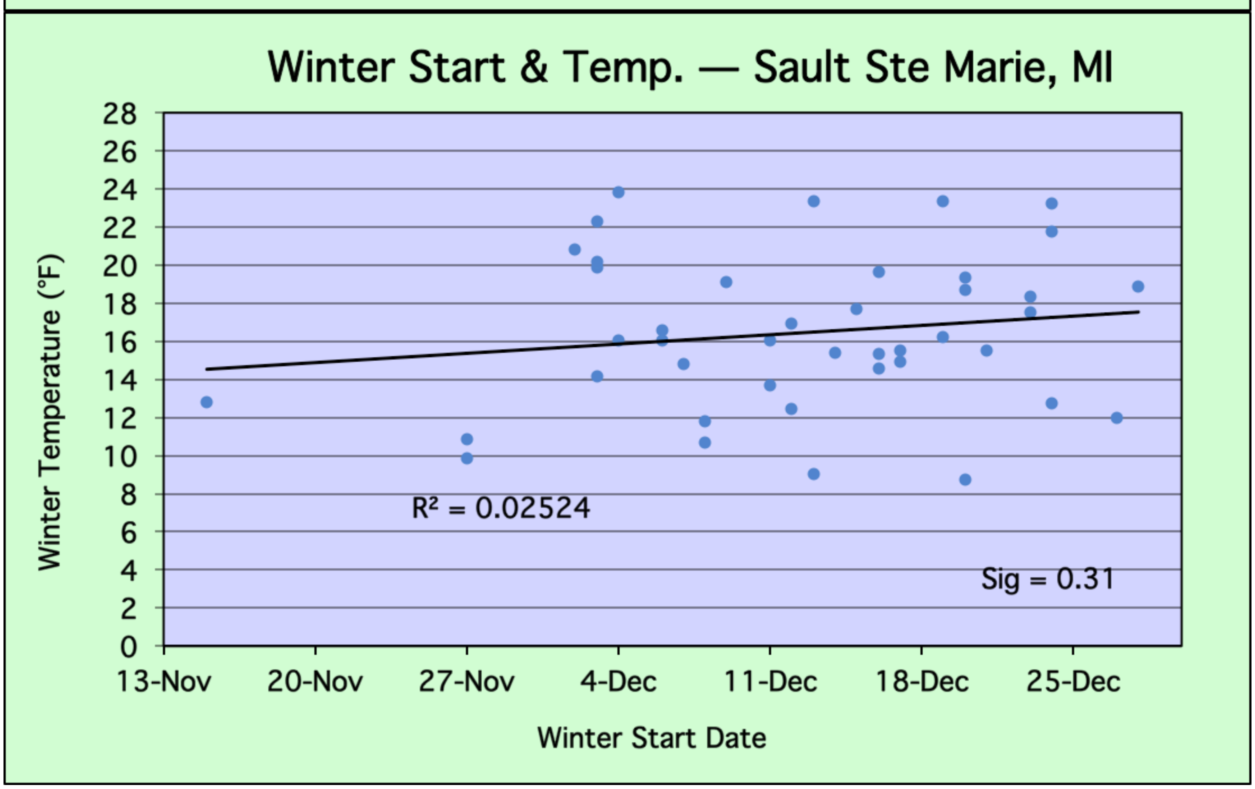
Figures 14a.(top) & 14b.(bottom) Daytona, FL station shows a statistically significant relationship between average temperatures and season start date in Summer, but not in Winter.





Figures 15a.(top) & 15b.(bottom) Fresno, CA station shows a statistically significant relationship between average temperatures and season start date in Winter, but not in Summer.





Figures 16a.(top) & 16b.(bottom) Sault Ste Marie, MI station shows a statistically significant relationship between average temperatures and season start date in Summer, but not in Winter.

Results

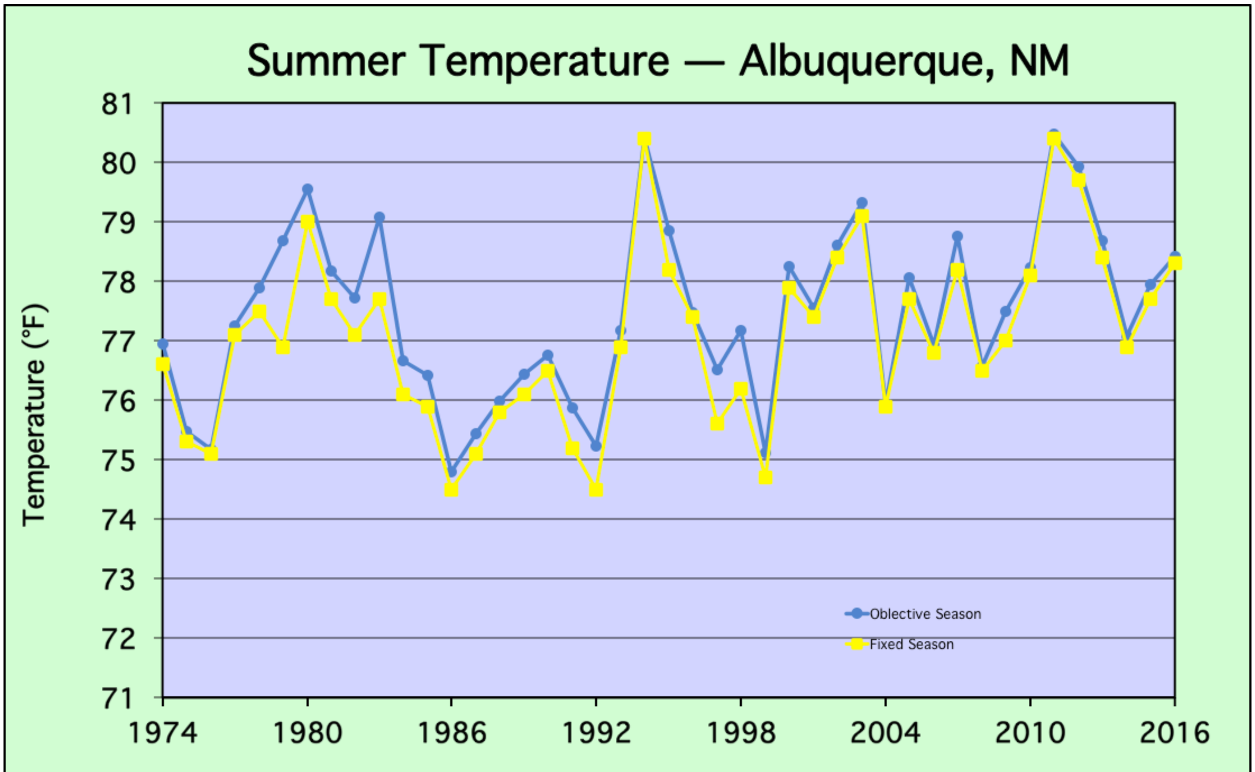
Objective and Fixed Season Comparisons

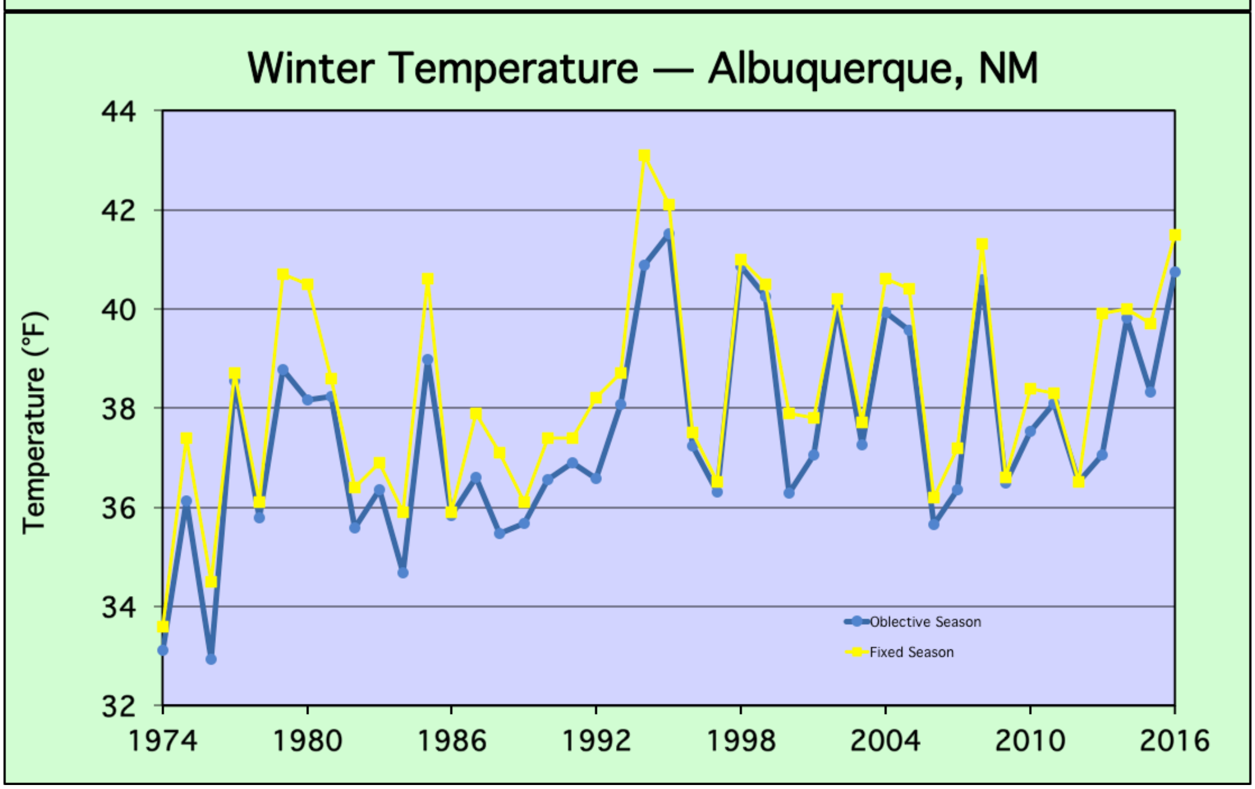
Of background interest is the relationship between the objectively defined seasons and the traditional fixed seasons. In this case, the "fixed" seasons will be taken as those most used by climatologists, based on the calendar months (June–August for Summer and December–February for Winter).

The only real comparisons that can be made are regarding the mean temperatures that result from each approach. Figures 17a. and 17b. show Summer and Winter seasonal temperatures, both plotted on the same axes. The objectively defined seasons are, in each case, plotted in blue, and the fixed seasons are plotted in yellow. As would be expected there is generally a great deal of similarity. Only a few years show appreciable differences, and these are more prevalent in Winter, when average temperature variations are usually highest (Hidore, *et al.* 2010).

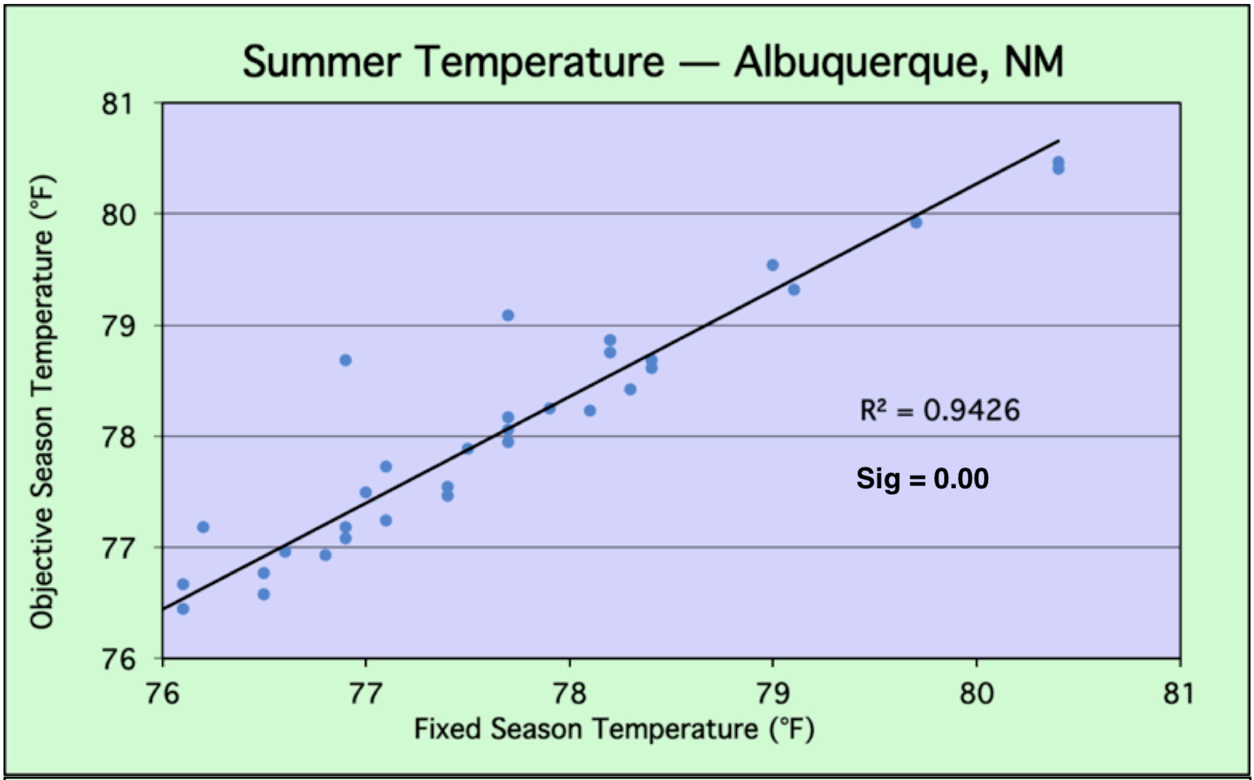
The charts in Figures 18a. and 18b. show the very strong correlation between the two methods of arriving at seasonal average temperatures. (Both of these are significant at the < 0.005 level.) In the case of the comparisons mentioned here, the only figures shown are for the station at Albuquerque, NM. These are absolutely representative of all the stations used regarding all salient points, and all regressions had the same significance level.

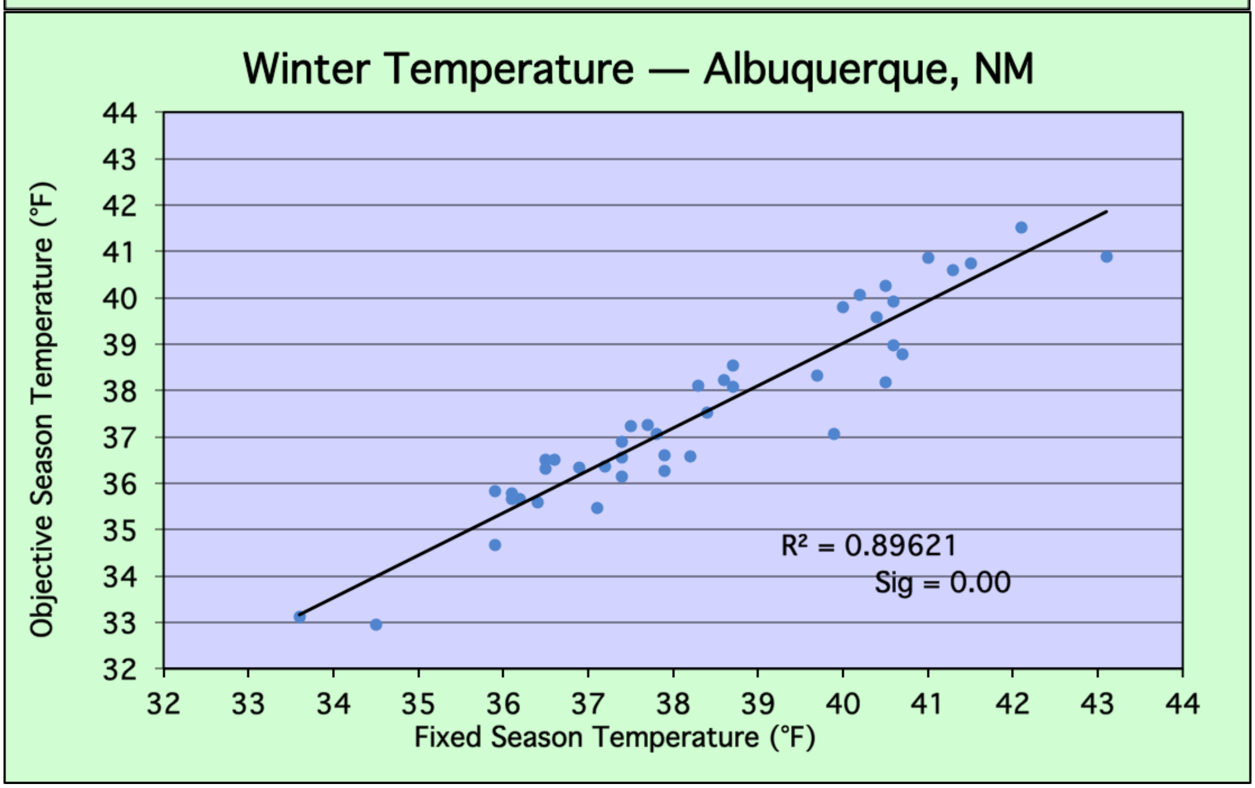
The differences between the two average temperature methods for the Summer and Winter seasons are seen in Table 7. The objective season is allowed to float in time to detect the most extreme temperature average (higher in Summer and lower in Winter). For any given year, it will be at or above the fixed season temperature for the Summer and at or below the fixed season temperature in the Winter.





Figures 17a.(top) & 17b.(bottom) Albuquerque, NM Illustrates the difference between the objective (Blue) and fixed season (Yellow) temperatures. The objective temperatures are equal or higher in the Summer (top) and equal to or lower in the Winter (bottom).





Figures 18a.(top) & 18b.(bottom) Albuquerque, NM shows the extremely close relationship between objective and fixed season temperatures in both Summer (top) and Winter (bottom). (Sig = 0.00 indicates significance <0.005.)

Table 7. Difference Between Objective and Fixed Season Temperatures (°F), Averaged Over the 1974-2016 Period

Station	State	Average Temp. Objective Over Fixed: Summer (°F)	Average Temp. Objective Below Fixed: Winter (°F)	Average Temp. Combined Difference (°F)
ALBUQUERQUE INTL AP	NM	0.40	0.84	1.24
ASHEVILLE AP	NC	0.42	0.57	0.99
BAKERSFIELD AP	CA	1.07	0.71	1.78
BISMARCK MUNI AP	ND	0.77	1.08	1.85
CARIBOU MUNI AP	ME	0.60	0.96	1.56
CLEVELAND INTL AP	OH	0.71	0.78	1.49
DAYTONA INTL AP	FL	0.37	0.71	1.08
EL PASO INTL AP	TX	0.29	0.92	1.21
ELKINS AP	WV	0.60	0.72	1.32
FORT SMITH REGL AP	AR	0.96	0.73	1.69
FRESNO INTL AP	CA	0.63	0.72	1.35
GRAND JUNCTION WALKER FLD	CO	0.66	0.97	1.63
INTERNATIONAL FALLS INTL AP	MN	0.71	0.91	1.62
LAS VEGAS INTL AP	NV	0.72	0.77	1.49
LEWISTON NEZ PERCE CO AP	ID	1.15	0.95	2.10
MEDFORD INTL AP	OR	1.23	0.95	2.18
MEMPHIS INTL AP	TN	0.47	0.71	1.18
MIDLAND IINTL AP	TX	0.40	0.88	1.28
MOBILE REGL AP	AL	0.33	0.75	1.08
PELLSTON REGL AP	MI	0.74	1.13	1.87
PHILADELPHIA INTL AP	PA	0.68	0.62	1.30
PHOENIX AP	AZ	0.69	0.68	1.37
PIERRE RGNL AP	SD	0.98	1.08	2.06
ROSWELL AIR PK	NM	0.35	0.94	1.29
SALT LAKE CITY INTL AP	UT	1.09	0.89	1.98
SAN ANGELO MATHIS FIELD	TX	0.45	0.87	1.32
SAULT STE MARIE SAND. FLD	MI	0.87	1.05	1.92
SEATTLE INTL AP	WA	0.86	0.63	1.49
SPOKANE INTL AP	WA	1.05	1.02	2.07
WATERLOO MUNI AP	IA	0.59	0.78	1.37
OVERALL AVERAGE		0.69	0.84	1.53

Chapter 2. Combined Stations Analyses

Methods

In this series of analyses, the parameters of the objective seasons (start date and mean temperature for the season) which had been calculated for each of the stations (and which had previously been examined independently for each station) are combined in different fashions.

Whereas the single-station approach from Chapter 1 allows for the discovery of relationships that may be unique to a station or a random group of stations, this aggregated station approach allows for the examination of the dataset in hopes of revealing relationships within station groups with certain preselected common characteristics.

Four different relationships within each grouping of stations were chosen. These were averaged across all of the stations included in each of the groups. Each of these involves a linear regression between the objectively defined seasonal (Summer and Winter) mean temperature and 1.) the mean start date of the seasons; 2.) the latest start date among the years of record; 3.) the earliest start date among the years of record; and 4.) the mean range of season start date (in days).

The aggregation of these stations was undertaken to perhaps reveal links between the seasonal timing and temperatures that were not altogether well represented in the individual station analyses. The following Tables 8 and 9 show the values of the calculated season start dates, date range and seasonal temperatures for Summer and Winter, respectively.

For the first set of analyses, all thirty stations were combined for Summer and for Winter seasons. The next set of analyses grouped the stations together by their main Köppen climate classification factor (largely based on the first letter of the Köppen system).

There were not enough stations to allow them to be grouped at a finer classification scale. Thus, three groups were developed: (Arid, Temperate, and Cold) in order to define the most distinctly different climatic regimes, and these three accommodated all of the stations. The results of this grouping are shown in Table 10.

The third grouping of stations was conducted on the basis of population. In this case, the stations were merely divided into "Low" population and "High" population groups; with census-based population (as discussed in the Introduction) levels of less than or greater than 100,000, respectively.

The last grouping examined was based on the station elevation. "Low" and "High" elevation groups were chosen based upon elevations less than or greater than 1,000 feet, respectively.

Table 8. Summary of Objective Seasons — Summer

Station	Mean Summer Start Date	Earliest Summer Start Date	Latest Summer Start Date	Range of Summer Start Dates	Summer Mean Temp (°F)
Albuquerque	6-Jun	19-May	18-Jun	30	77.5
Asheville	9-Jun	22-May	25-Jun	34	73.0
Bakersfield	15-Jun	29-May	10-Jul	42	82.7
Bismarck	5-Jun	7-May	21-Jun	45	69.1
Caribou	6-Jun	19-May	20-Jun	32	64.2
Cleveland	9-Jun	23-May	23-Jun	31	71.7
Daytona	15-Jun	30-May	5-Jul	36	81.5
El Paso	2-Jun	8-May	18-Jun	41	82.5
Elkins	9-Jun	18-May	23-Jun	36	68.9
Fort Smith	13-Jun	27-May	4-Jul	38	81.5
Fresno	10-Jun	28-May	24-Jun	27	81.4
Grand Junction	8-Jun	26-May	19-Jun	24	76.5
International Falls	4-Jun	10-May	27-Jun	48	64.2
Las Vegas	9-Jun	21-May	22-Jun	32	90.0
Lewiston	14-Jun	22-May	1-Jul	40	73.0
Medford	15-Jun	22-May	2-Jul	41	72.5
Memphis	8-Jun	27-May	23-Jun	27	82.0
Midland	3-Jun	9-May	20-Jun	42	81.9
Mobile	11-Jun	28-May	28-Jun	31	81.6
Pellston	6-Jun	14-May	27-Jun	44	65.2
Philadelphia	9-Jun	21-May	23-Jun	33	76.7
Phoenix	11-Jun	27-May	22-Jun	26	93.8
Pierre	8-Jun	25-May	21-Jun	27	73.6
Roswell	4-Jun	7-May	19-Jun	43	80.3
Salt Lake City	11-Jun	23-May	22-Jun	30	76.5
San Angelo	6-Jun	12-May	2-Jul	51	82.8
Sault Ste Marie	8-Jun	13-May	28-Jun	46	63.7
Seattle	16-Jun	28-May	1-Jul	34	65.2
Spokane	14-Jun	22-May	2-Jul	41	67.9
Waterloo	4-Jun	11-May	20-Jun	40	71.9

Table 9. Summary of Objective Seasons — Winter

Station	Mean Winter Start Date	Earliest Winter Start Date	Latest Winter Start Date	Range of Winter Start Dates	Winter Mean Temp (°F)
Albuquerque	21-Nov	5-Nov	8-Dec	33	37.5
Asheville	27-Nov	8-Nov	19-Dec	41	38.4
Bakersfield	20-Nov	2-Nov	8-Dec	36	49.5
Bismarck	28-Nov	28-Oct	21-Dec	54	14.3
Caribou	7-Dec	16-Nov	28-Dec	42	13.2
Cleveland	6-Dec	10-Nov	28-Dec	48	28.5
Daytona	6-Dec	5-Nov	13-Jan	69	59.1
El Paso	20-Nov	6-Nov	8-Dec	32	45.9
Elkins	30-Nov	10-Nov	23-Dec	43	30.2
Fort Smith	20-Nov	7-Nov	6-Dec	29	48.0
Fresno	23-Nov	30-Oct	9-Dec	40	40.6
Grand Junction	21-Nov	2-Nov	6-Dec	34	29.3
International Falls	30-Nov	9-Nov	23-Dec	44	7.1
Las Vegas	20-Nov	2-Nov	4-Dec	32	48.4
Lewiston	19-Nov	24-Oct	12-Dec	49	35.1
Medford	17-Nov	28-Oct	6-Dec	39	39.7
Memphis	26-Nov	31-Oct	11-Dec	41	42.8
Midland	22-Nov	29-Oct	14-Dec	46	44.9
Mobile	26-Nov	1-Nov	28-Dec	57	51.6
Pellston	12-Dec	15-Nov	11-Jan	57	18.9
Philadelphia	4-Dec	15-Nov	23-Dec	38	34.6
Phoenix	23-Nov	2-Nov	13-Dec	41	56.6
Pierre	28-Nov	28-Oct	24-Dec	57	20.7
Roswell	21-Nov	29-Oct	8-Dec	40	41.6
Salt Lake City	22-Nov	1-Nov	12-Dec	41	30.9
San Angelo	22-Nov	29-Oct	14-Dec	46	47.0
Sault Ste Marie	12-Dec	15-Nov	28-Dec	43	16.5
Seattle	23-Nov	28-Oct	21-Dec	54	41.3
Spokane	20-Nov	23-Oct	12-Dec	50	28.3
Waterloo	29-Nov	8-Nov	20-Dec	42	19.7

Results

This series of regressions was undertaken to see if any gross relationships could be discerned between the temperature regimes of the stations (as determined by the mean temperature of the objectively derived Winter or Summer season) and start dates of those seasons. In this case, the four variants of the start date parameter were chosen to see which, if any, would produce a useful signal.

Grouping of All Stations: Using these procedures, the only significant (at the 0.05 level or better) relationship found among the grouping of all thirty stations was that between the mean season start date and the mean season temperature for the Winter—lower temperatures with a later mean date (see Figure 21a.). This at least partially falls in line with the results of individual station analyses summarized in Table 4. There, virtually all stations show a trend to later winter start dates, but this trend is seen to be more pronounced among the colder stations.

Grouping of Stations By Major Climate Classification: Although the group containing the Arid classification stations was the largest, the relationships here were the poorest of all the climate-defined groups. Summer season regressions were the worst, with essentially no correlation between the combined temperature and start date parameters. Arid Winter correlations were notably better, but not deemed significant here. Again, a look back at the individual station regression summary (Table 4.) shows no significant Summer start date trends for any of the Arid (or even any fairly warm) locations.

The combination of the Temperate classification stations also proved to have little value in establishing good relationships between the temperature and timing of the seasons. In this classification, only the range of objectively defined Winter start dates even came close (with p=0.07) to having the needed level of significance of $p \leq 0.05$.

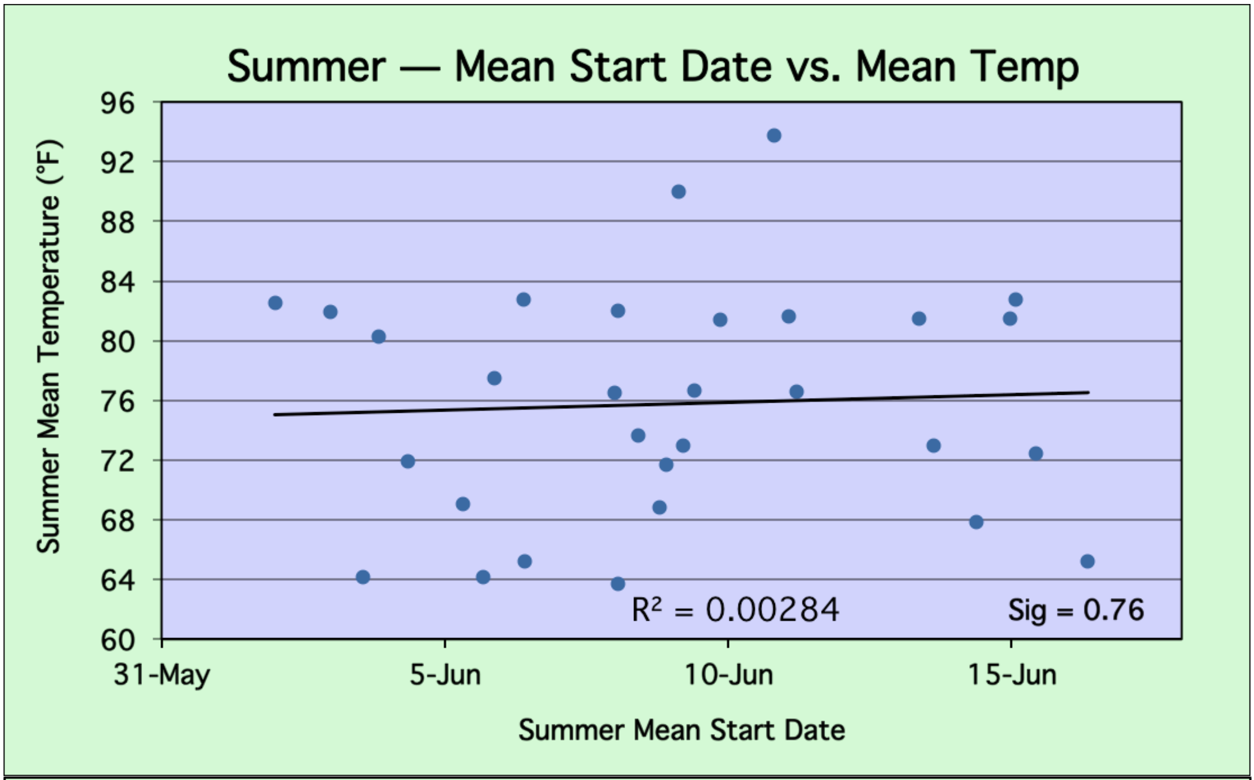
Perhaps more surprising was the group of stations in the Cold climate category. The Köppen classifications were: Dfb (cold with no wet season and warm Summers), Dfa (cold with no wet season and hot Summers), or Dsb (cold with dry Summers and warm Summers). Regression relationships here were quite poor, with none approaching any meaningful level of significance. Analyses shown earlier had indicated a tendency to favor such relationships for colder stations. Those relationships seemed to be most useful among the very coldest stations. Also, this station grouping suffered from having the fewest stations.

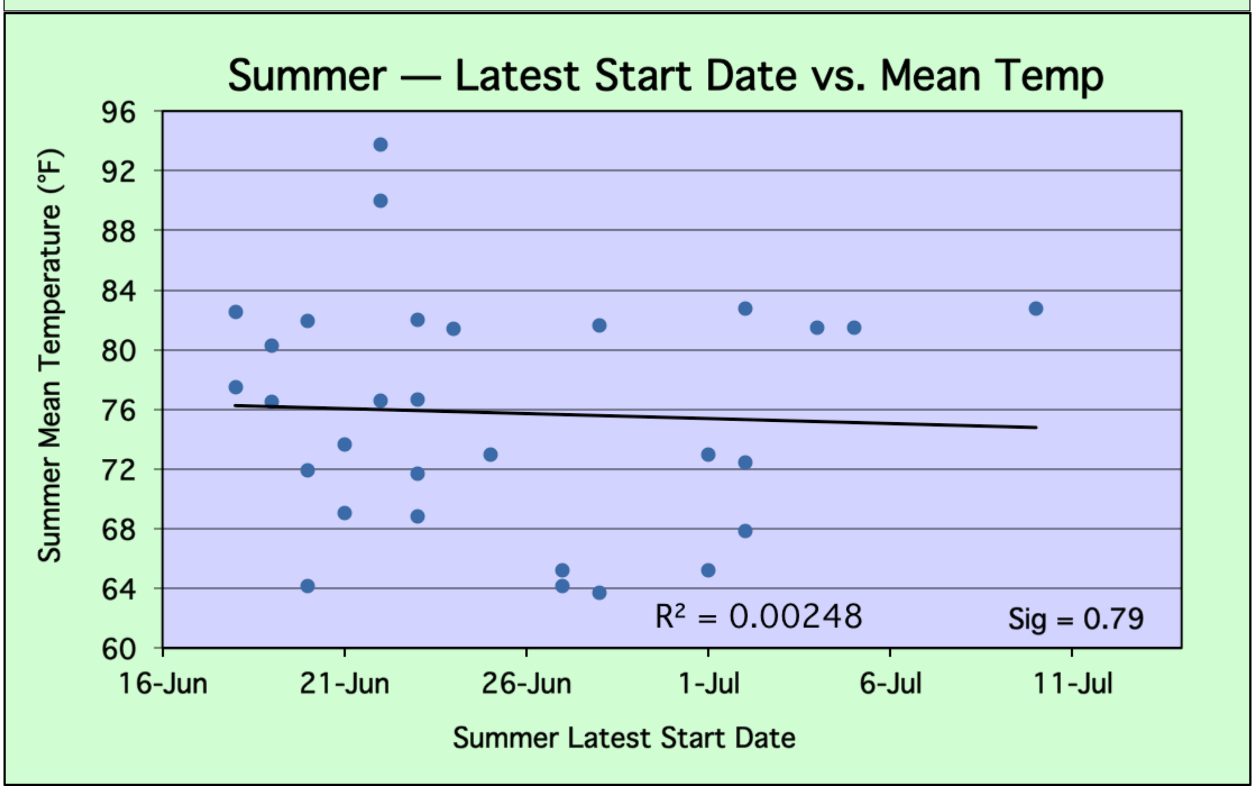
Grouping of Stations By Population Category: Placing the stations into the low and high population groups revealed no good heretofore hidden relationships. Of the regression series, only two came close to exhibiting significance: the Summer mean start dates for low (p = 0.08), and for high population (p = 0.10) categories.

Grouping of Stations By Elevation Category: The splitting of the stations into two elevation groups generally proved to be quite interesting, with significant relationships found among several of the combinations. For the Summer, no significant relationships emerged for the high elevation stations; however, in the objective Winter season, three of the four start date variation regressions gave significant results for the high elevation stations. These can be seen in Figures 43a., 43b. and 44b.: mean start date, latest start date, and start date range, respectively. All were at or below the 0.05 confidence level.

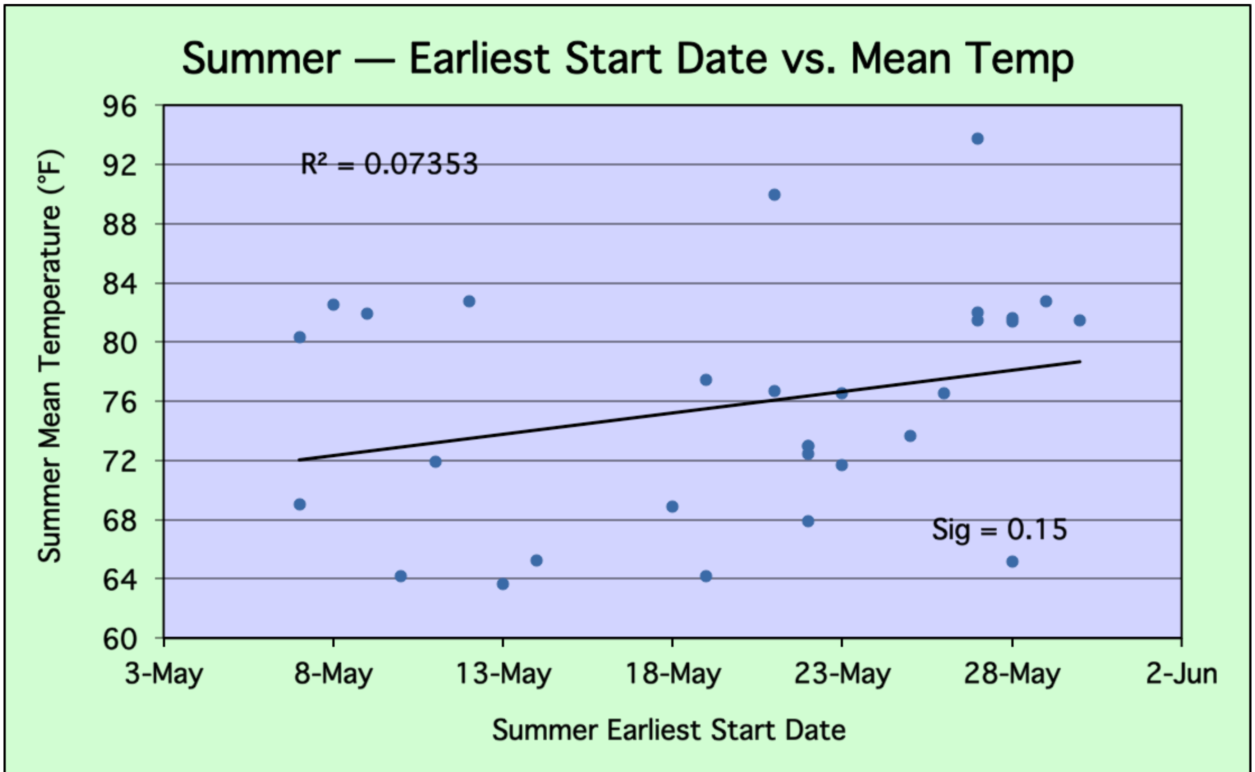
Low elevation stations fared even better, with the mean start date and earliest start date regressions showing significant relationship in both the Summer and Winter seasons (Figures 45a., 46a., 47a. and 48a.). Notably, the significant relationships for low elevation stations in the Summer season were all of the opposite sign (toward later start dates with higher mean temperatures) than the five other, Winter, elevation related trends (toward later start dates with lower mean temperatures). This would imply that, for lower elevation stations, the warmer ones would tend to start Summer later and the cooler ones would tend to start their Winters later.

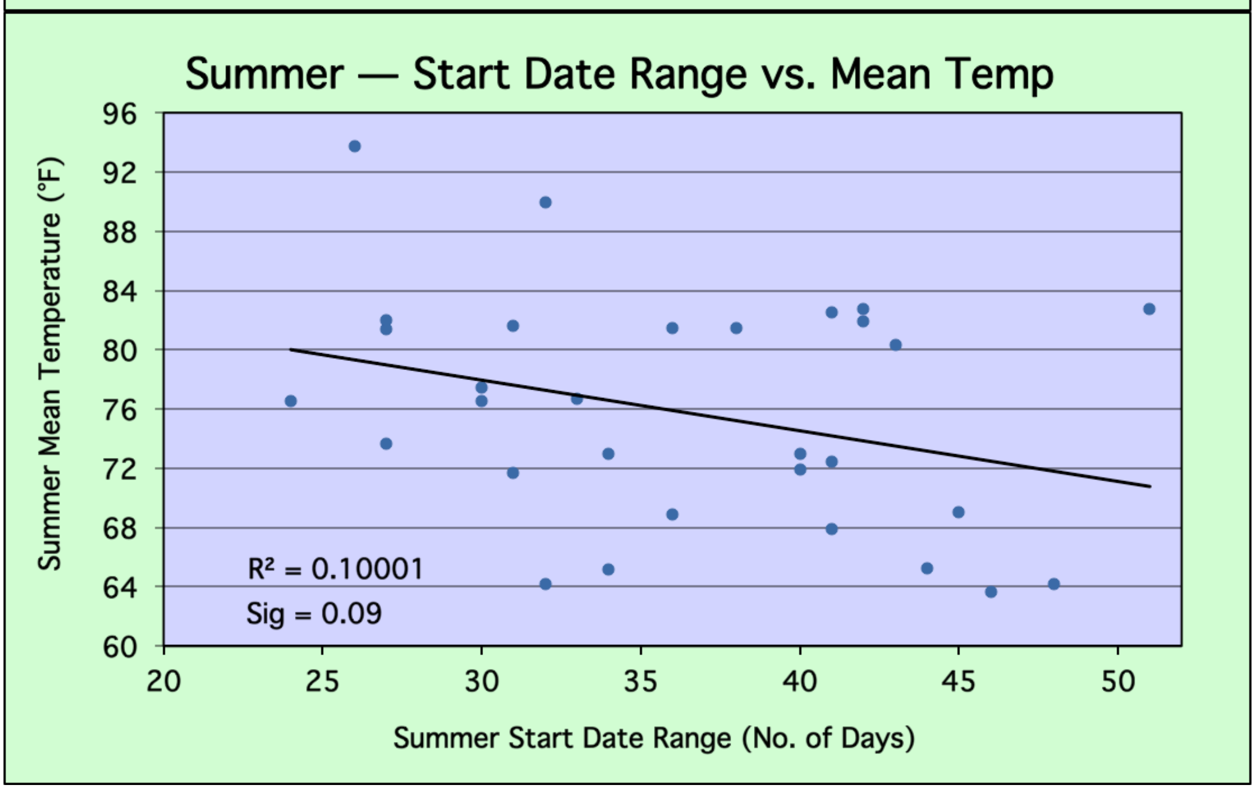
These results from the aggregation of stations are summarized in Table 13.



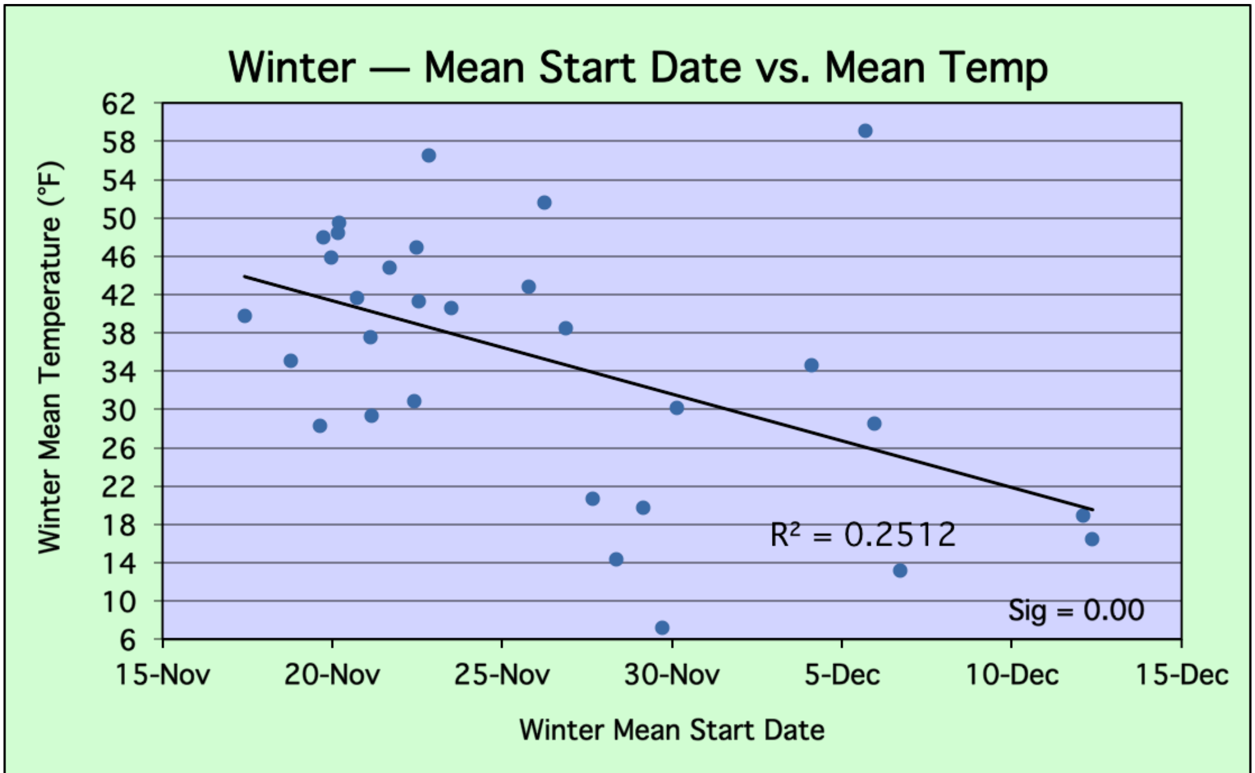


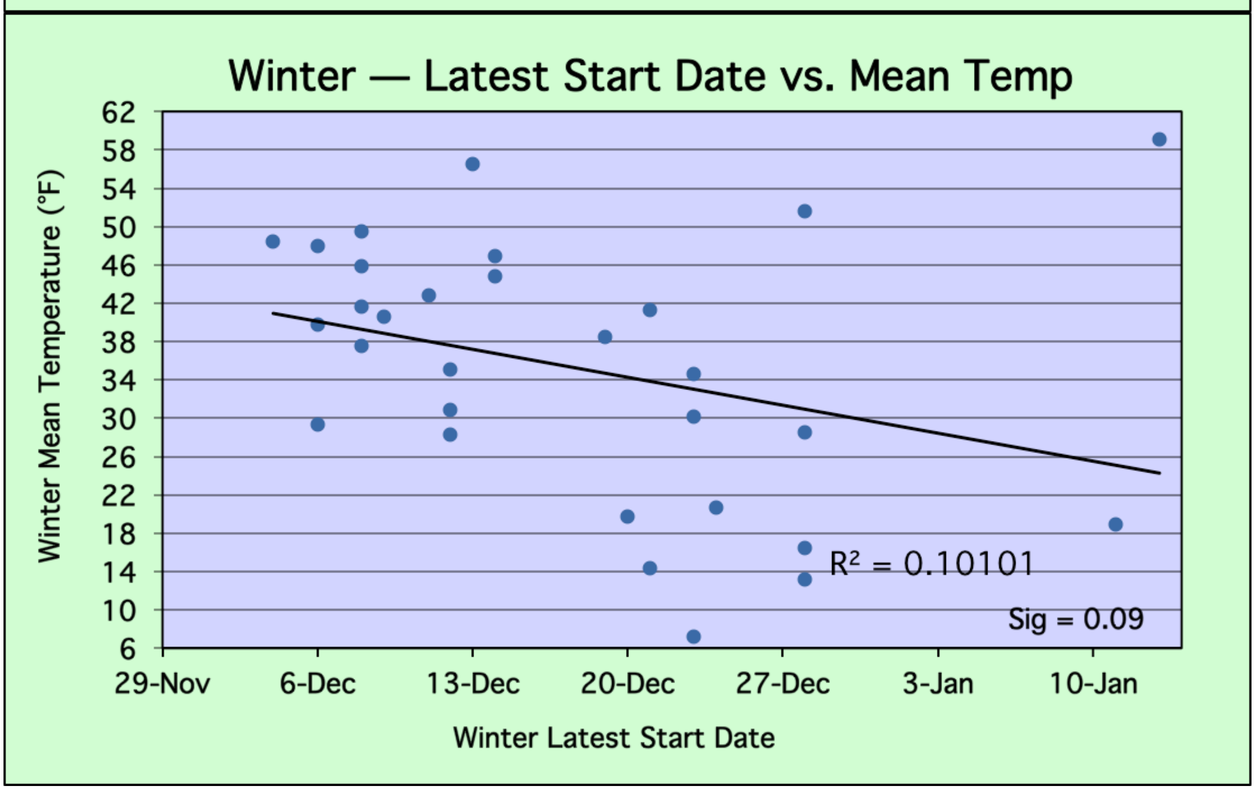
Figures 19a.(top) & 19b.(bottom). For the aggregation of all stations: relationships between the objective Summer season mean temperatures and: a.) Summer mean start date and b.) the latest Summer start date.



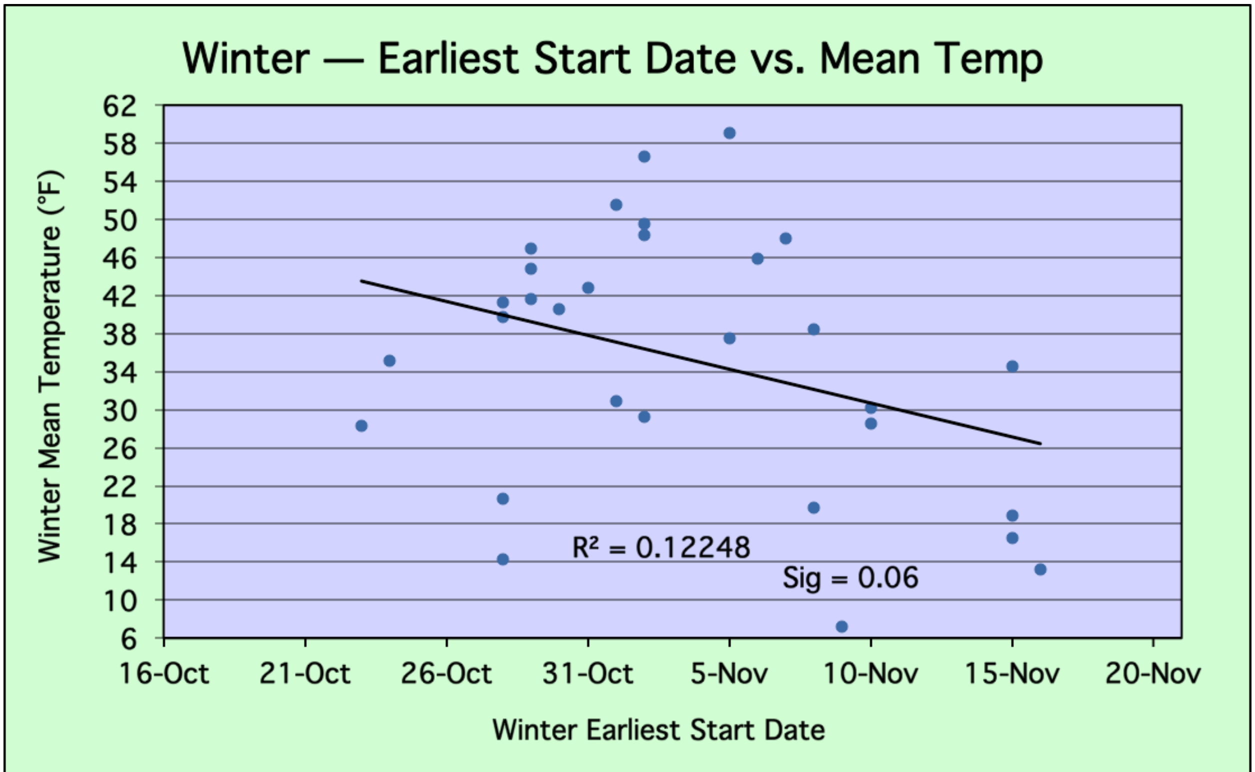


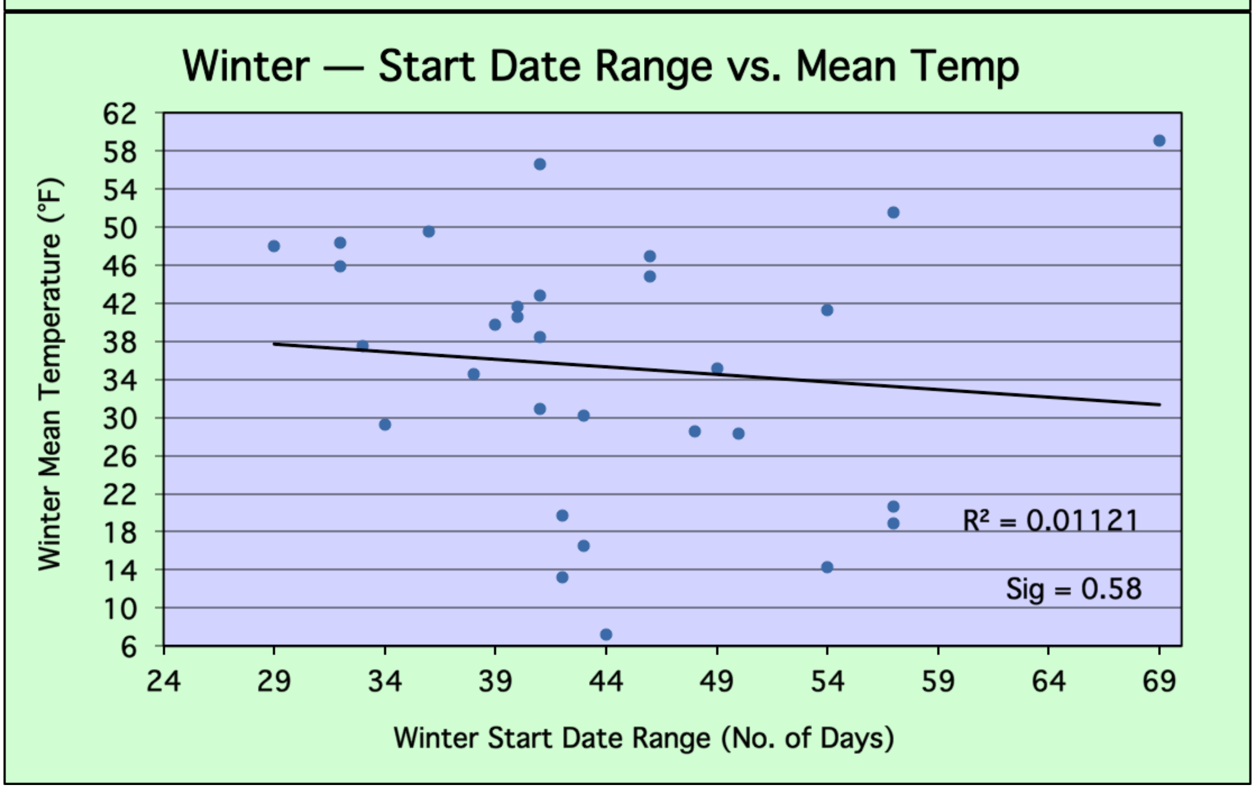
Figures 20a.(top) & 20b.(bottom). For the aggregation of all stations: relationships between the objective Summer season mean temperatures and: a.) the earliest Summer start date and b.) the range of Summer start dates.





Figures 21a.(top) & 21b.(bottom). For the aggregation of all stations: relationships between the objective Winter season mean temperatures and: a.) Winter mean start date and b.) the latest Winter start date. Sig=0.00 indicates Sig<0.005.

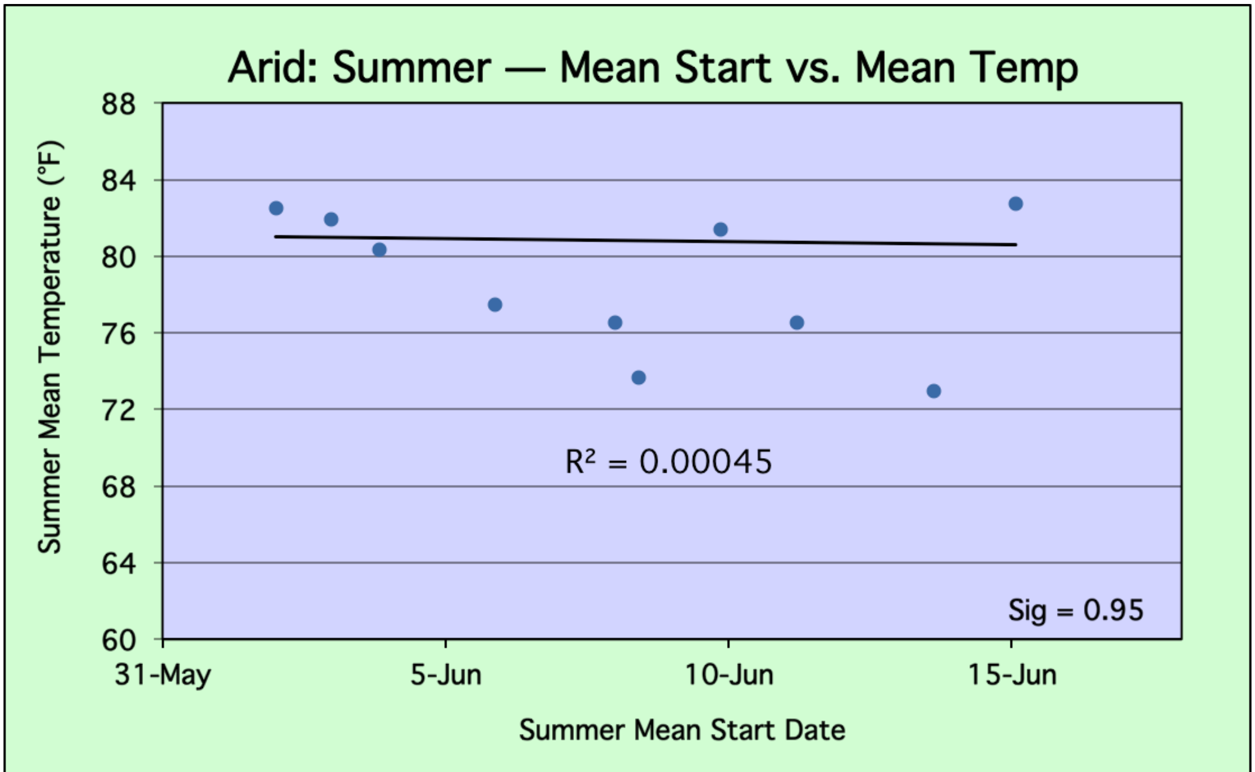


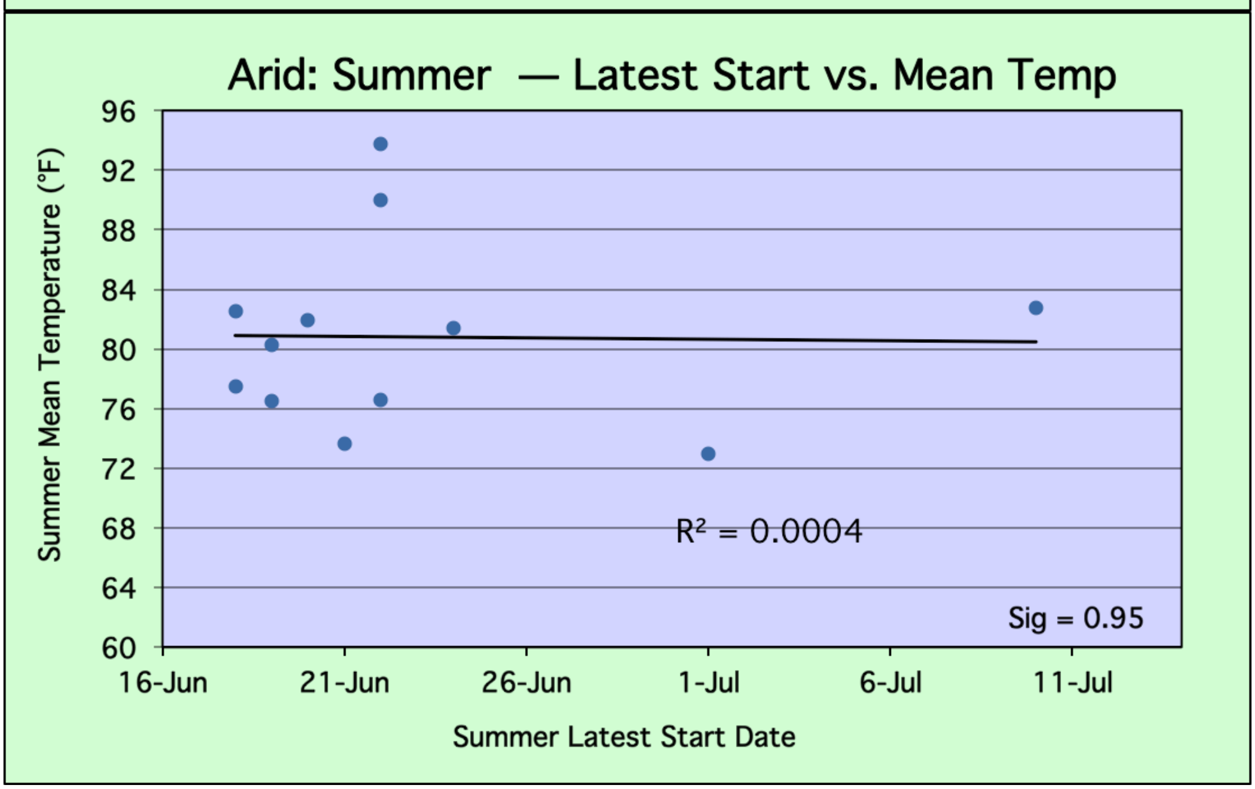


Figures 22a.(top) & 22b.(bottom). For the aggregation of all stations: relationships between the objective Winter season mean temperatures and: a.) the earliest Winter start date and b.) the range of Winter start dates.

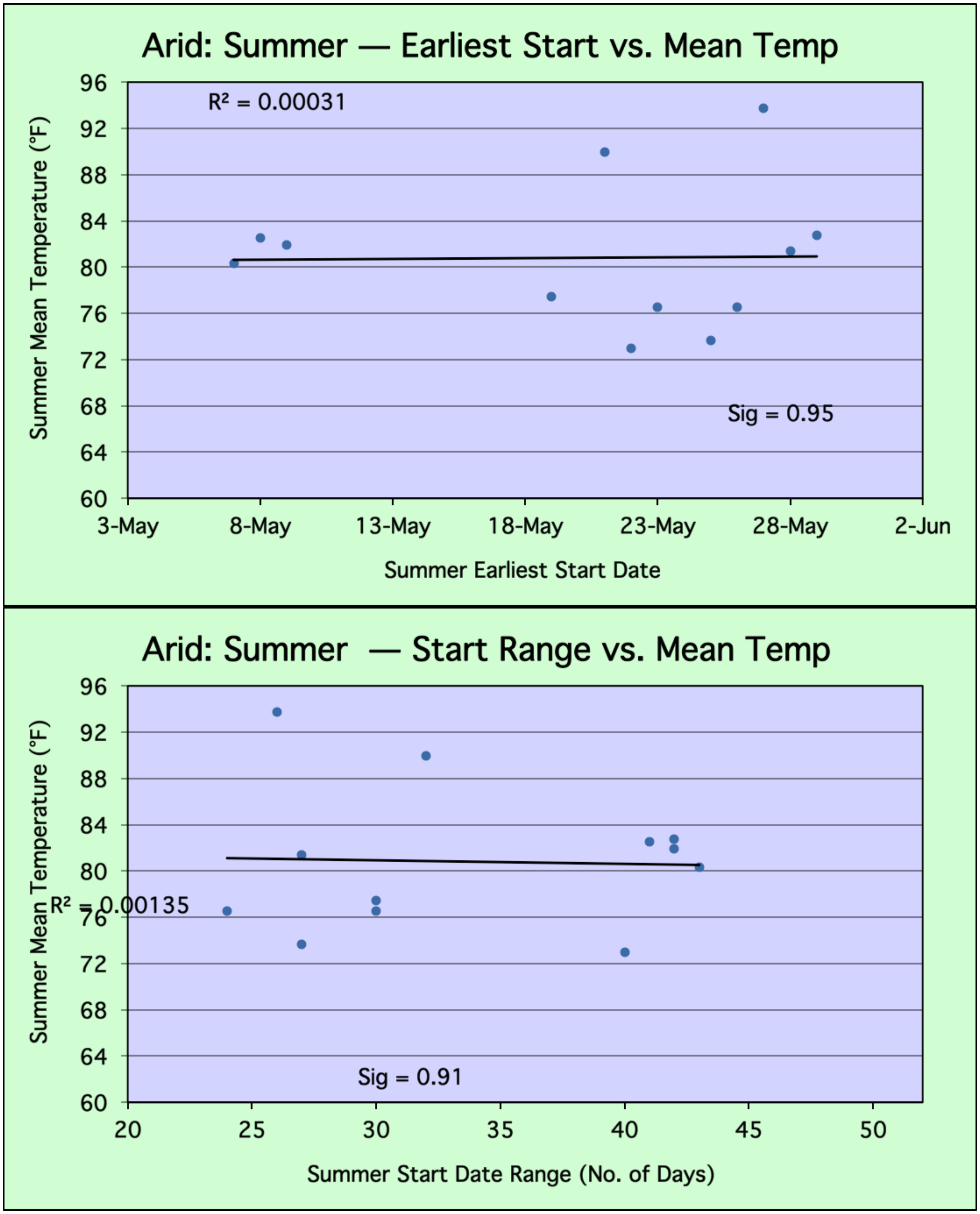
Station	State	Population (x 1,000)	Elev. (Ft.)	Koppen Climate Classification			
				Code	Description		
ARID:							
BAKERSFIELD	CA	347	489	Bsh	Arid	Steppe	Hot
FRESNO	CA	495	333	Bsh	Arid	Steppe	Hot
MIDLAND	TX	111	2,862	Bsh	Arid	Steppe	Hot
SAN ANGELO	TX	110	1,916	Bsh	Arid	Steppe	Hot
GRAND JUNCTION	CO	147	4,858	Bsk	Arid	Steppe	Cold
LEWISTON	ID	32	1,436	Bsk	Arid	Steppe	Cold
PIERRE	SD	14	1,742	Bsk	Arid	Steppe	Cold
ROSWELL	NM	48	3,649	Bsk	Arid	Steppe	Cold
SALT LAKE CITY	UT	186	4,225	Bsk	Arid	Steppe	Cold
LAS VEGAS	NV	584	2,180	Bwh	Arid	Desert	Hot
PHOENIX	AZ	1,446	1,107	Bwh	Arid	Desert	Hot
ALBUQUERQUE	NM	546	5,310	Bwk	Arid	Desert	Cold
EL PASO	TX	649	3,918	Bwk	Arid	Desert	Cold
TEMPERATE:							
DAYTONA BEACH	FL	61	31	Cfa	Temp.	No Dry Seas.	Hot Sum.
FORT SMITH	AR	86	449	Cfa	Temp.	No Dry Seas.	Hot Sum.
MEMPHIS	TN	25	254	Cfa	Temp.	No Dry Seas.	Hot Sum.
MOBILE	AL	413	215	Cfa	Temp.	No Dry Seas.	Hot Sum.
PHILADELPHIA	PA	1,526	10	Cfa	Temp.	No Dry Seas.	Hot Sum.
ASHEVILLE	NC	238	2,117	Cfb	Temp.	No Dry Seas.	Warm Sum.
ELKINS	WV	7	1,979	Cfb	Temp.	No Dry Seas.	Warm Sum.
MEDFORD	OR	203	1,297	Csa	Temp.	Dry Summer	Hot Sum.
SEATTLE	WA	609	370	Csb	Temp.	Dry Summer	Warm Sum.
COLD:							
CLEVELAND	OH	1,280	781	Dfa	Cold	No Dry Seas.	Hot Sum.
WATERLOO	IA	68	868	Dfa	Cold	No Dry Seas.	Hot Sum.
BISMARCK	ND	61	1,651	Dfb	Cold	No Dry Seas.	Warm Sum.
CARIBOU	ME	8	624	Dfb	Cold	No Dry Seas.	Warm Sum.
INTERNATIONAL FALLS	MN	6	1,183	Dfb	Cold	No Dry Seas.	Warm Sum.
PELLSTON	MI	1	705	Dfb	Cold	No Dry Seas.	Warm Sum.
SAULT STE MARIE	MI	14	722	Dfb	Cold	No Dry Seas.	Warm Sum.
SPOKANE	WA	209	2,353	Dsb	Cold	Dry Summer	Warm Sum.

Table 10. Listing of stations which were combined by main Köppen Climate Classification into Arid, Temperate and Cold categories for regression analyses.

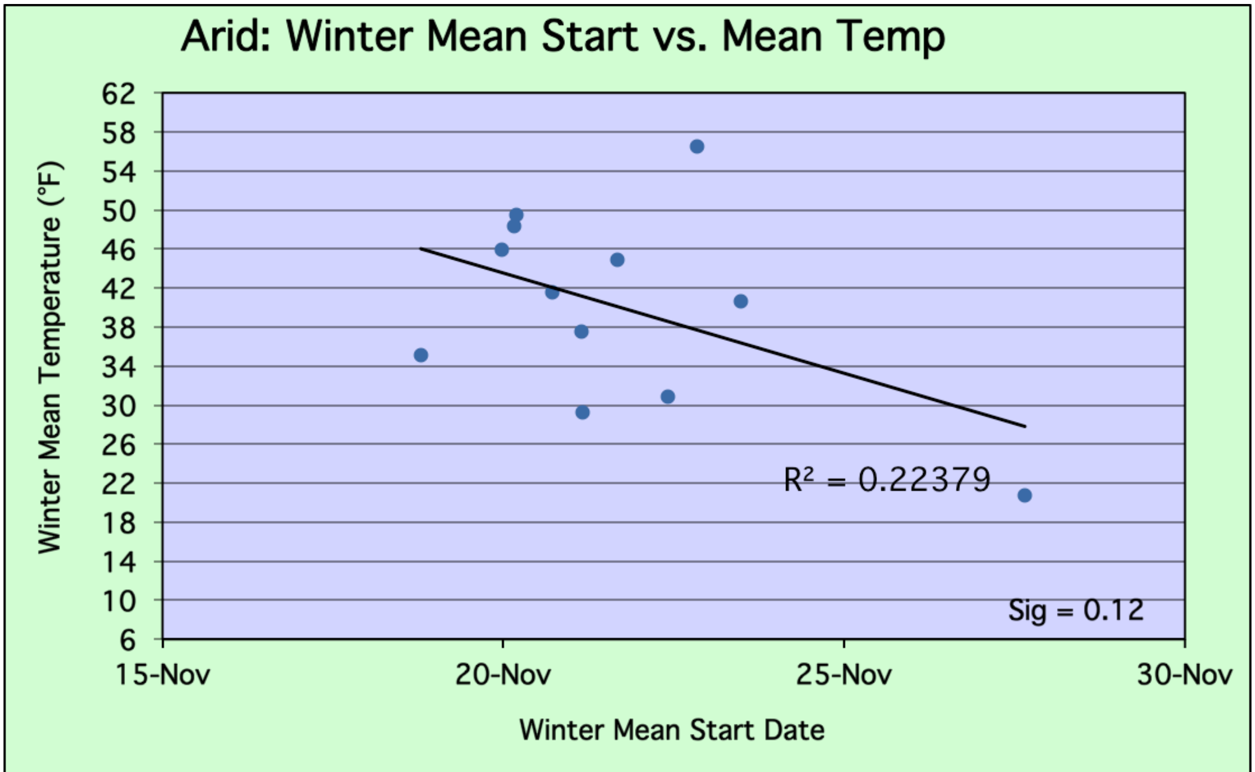


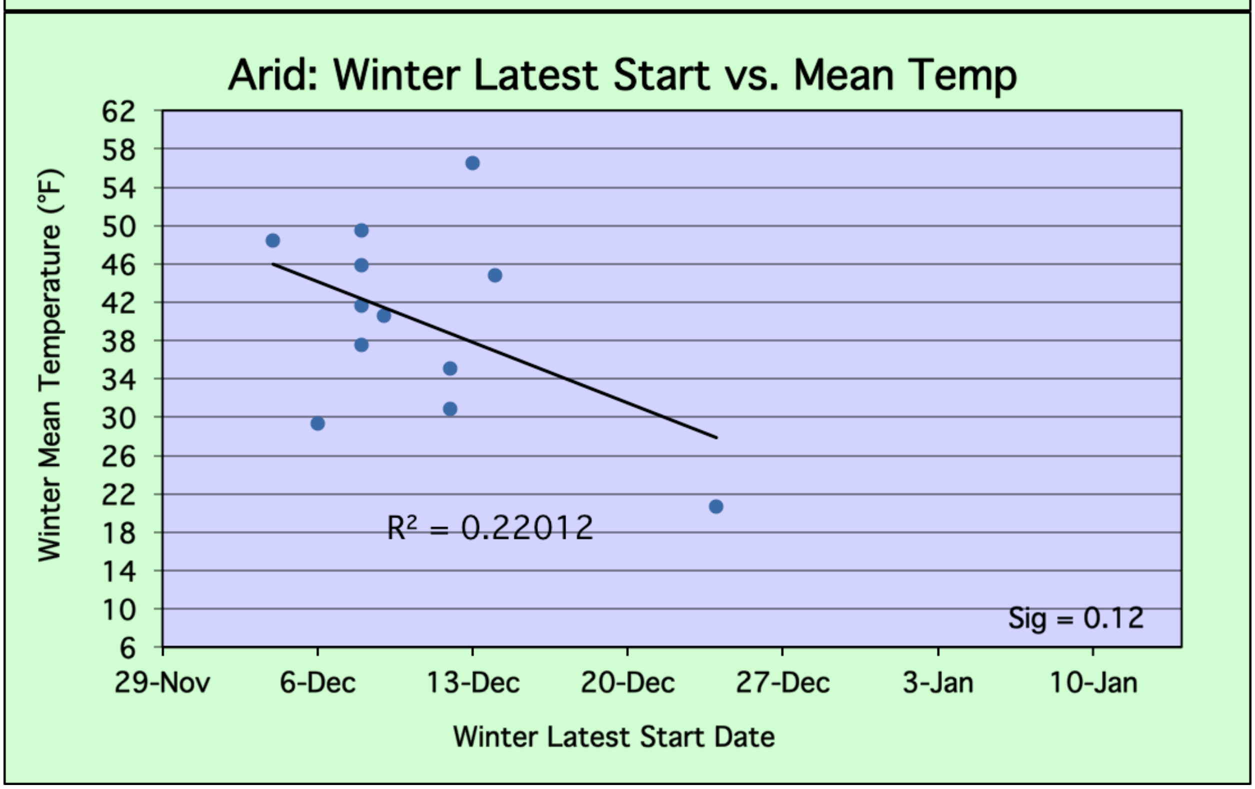


Figures 23a.(top) & 23b.(bottom). For the Arid classification stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) Summer mean start date and b.) the latest Summer start date.

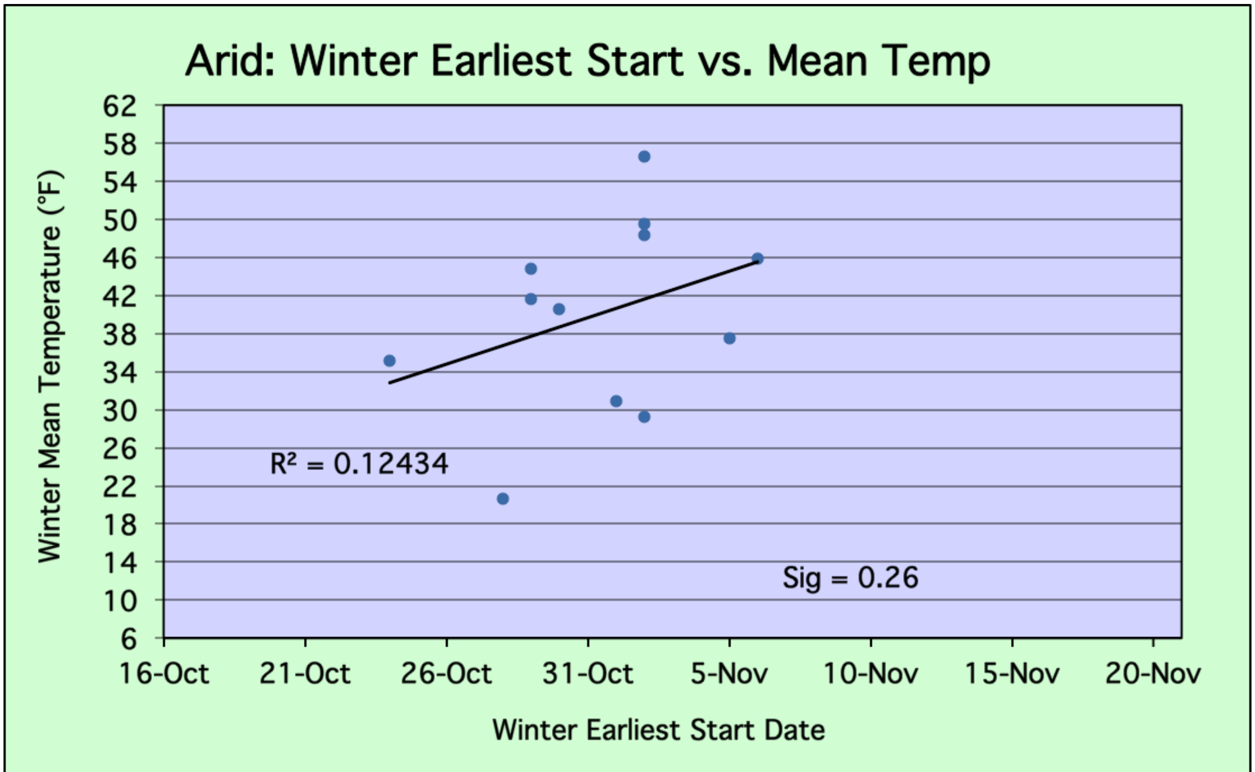


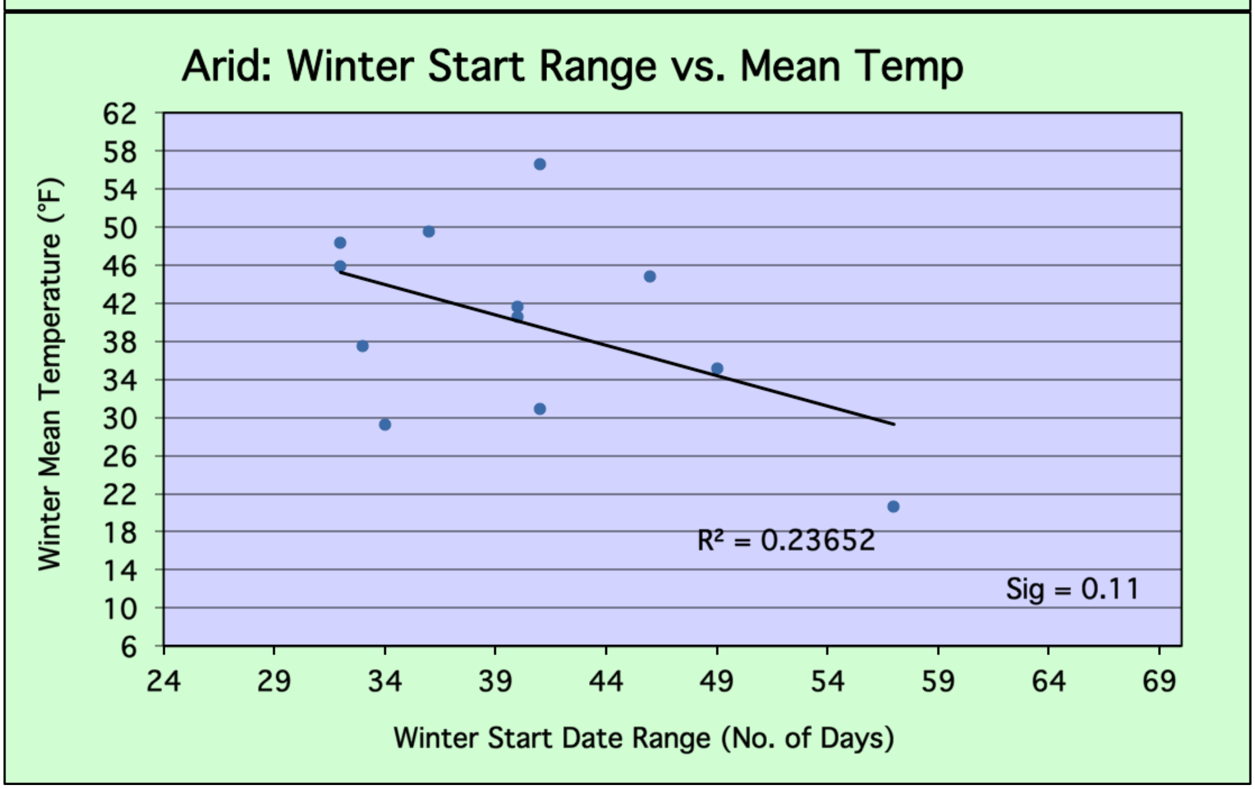
Figures 24a.(top) & 24b.(bottom). For the Arid classification stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) the earliest Summer start date and b.) the range of Summer start dates.



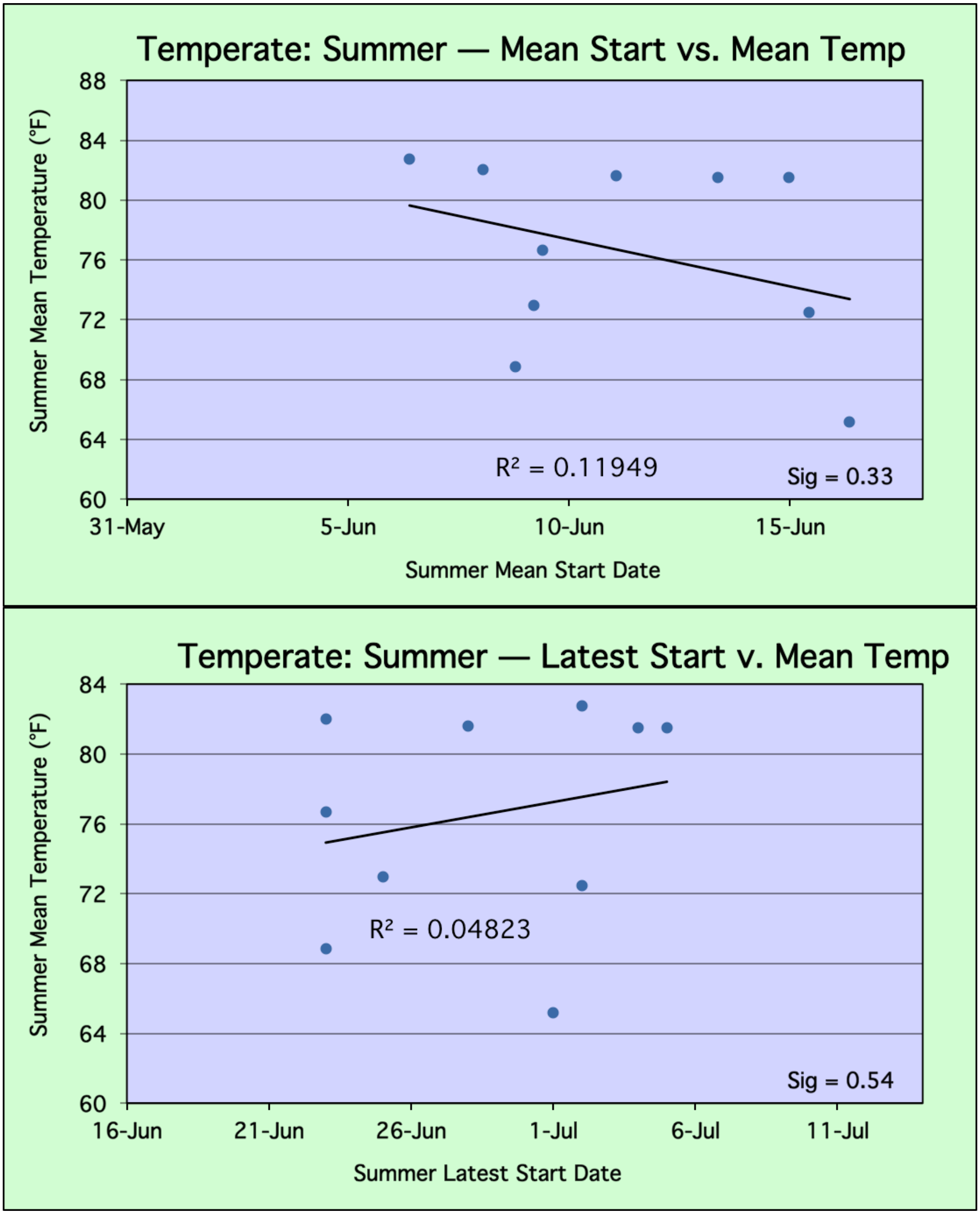


Figures 25a.(top) & 25b.(bottom). For the Arid classification stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) Winter mean start date and b.) the latest Winter start date.

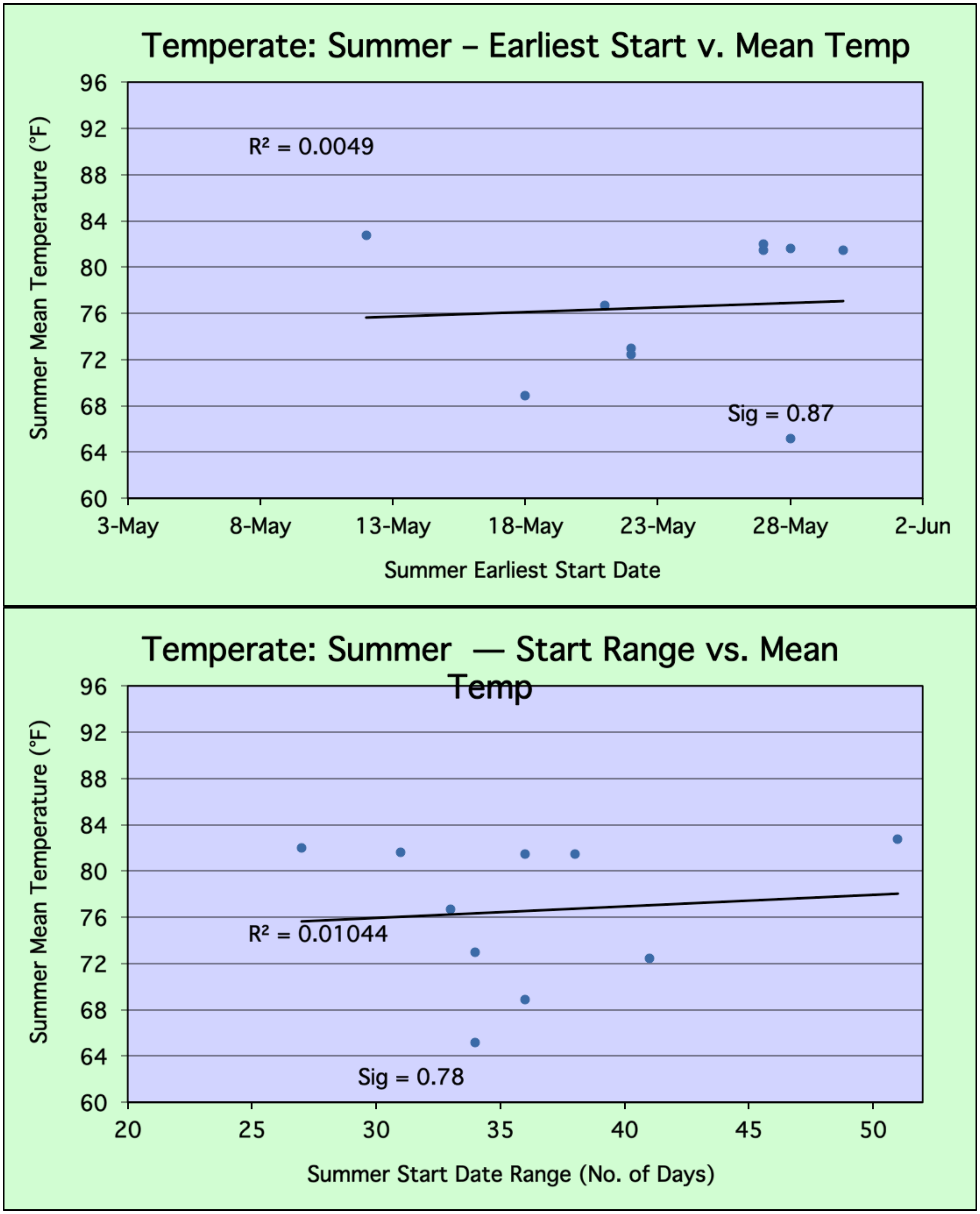




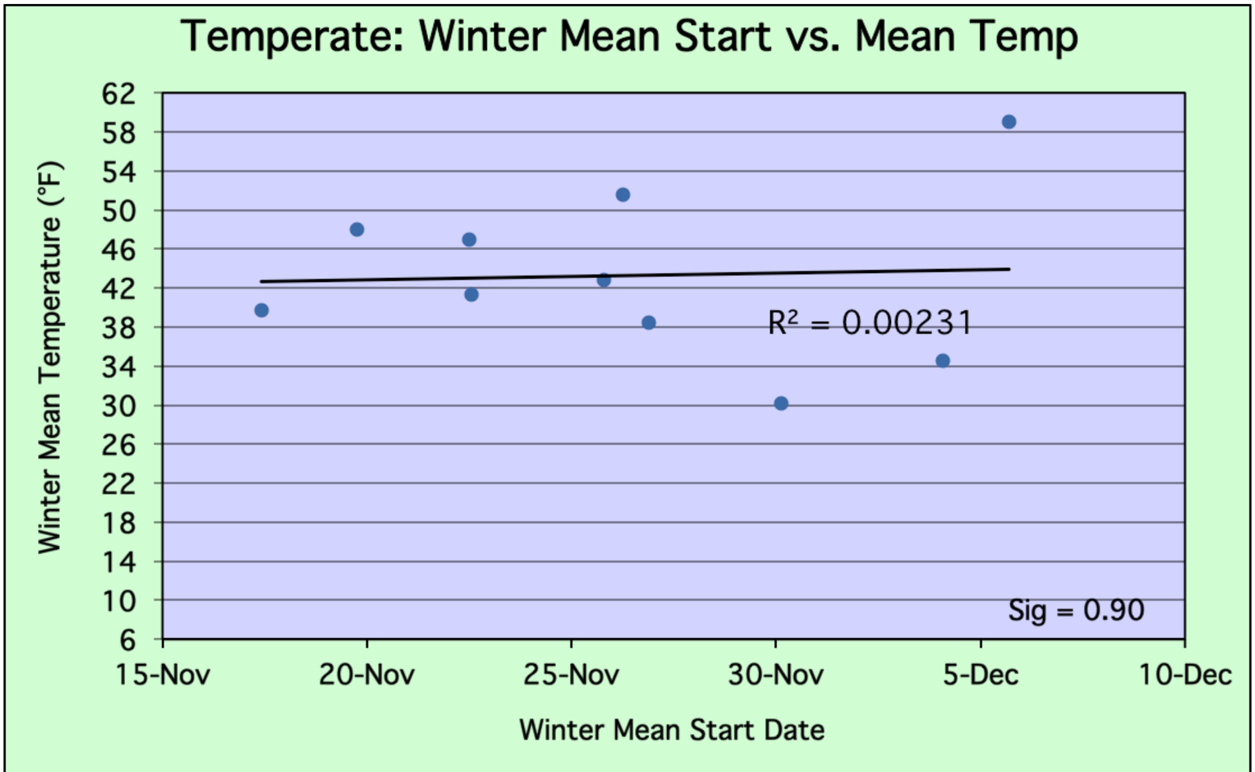
Figures 26a.(top) & 26b.(bottom). For the Arid classification stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) the earliest Winter start date and b.) the range of Winter start dates.

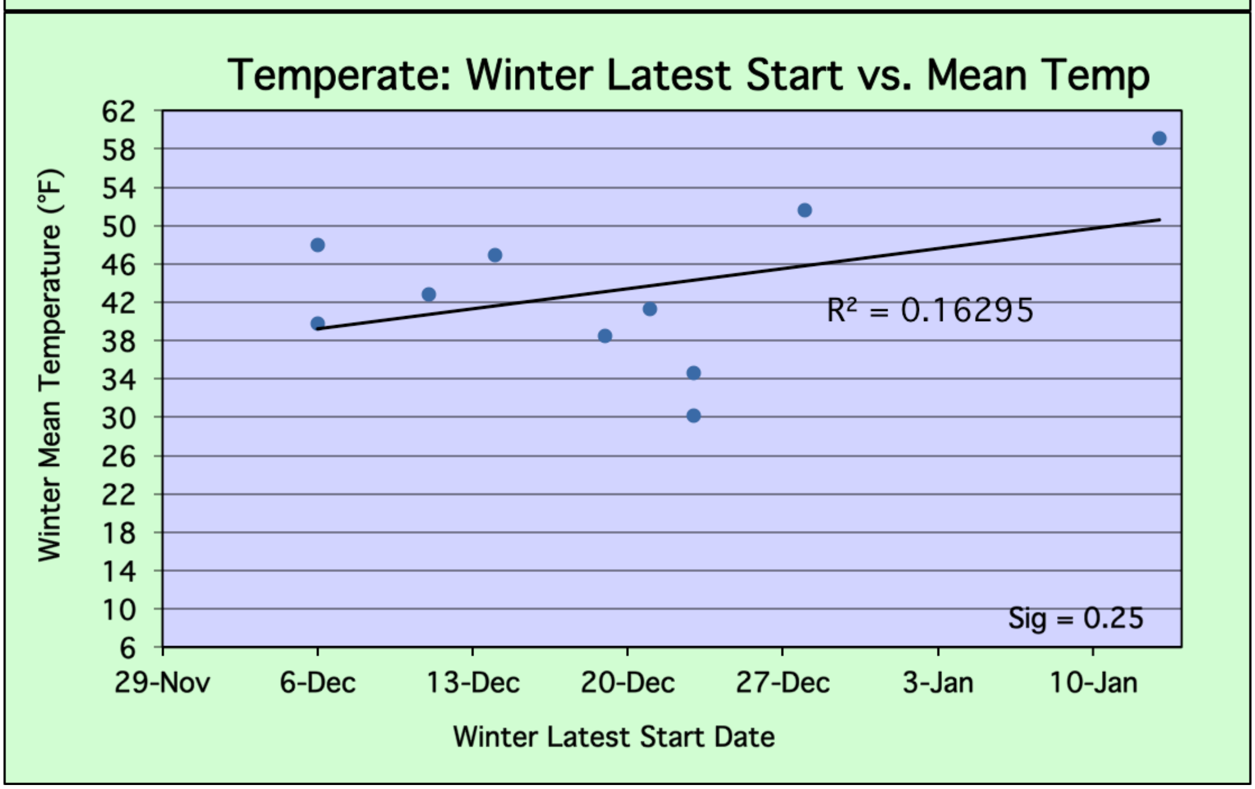


Figures 27a.(top) & 27b.(bottom). For the Temperate classification stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) Summer mean start date and b.) the latest Summer start date.

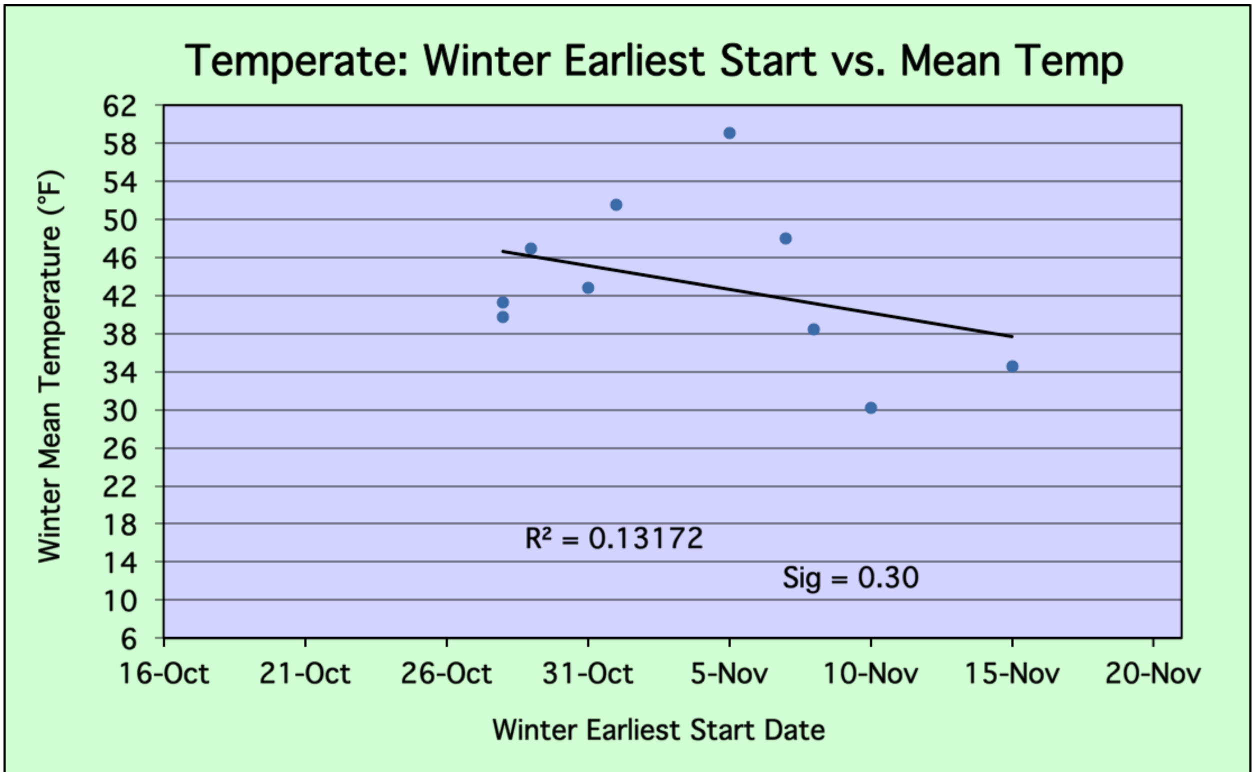


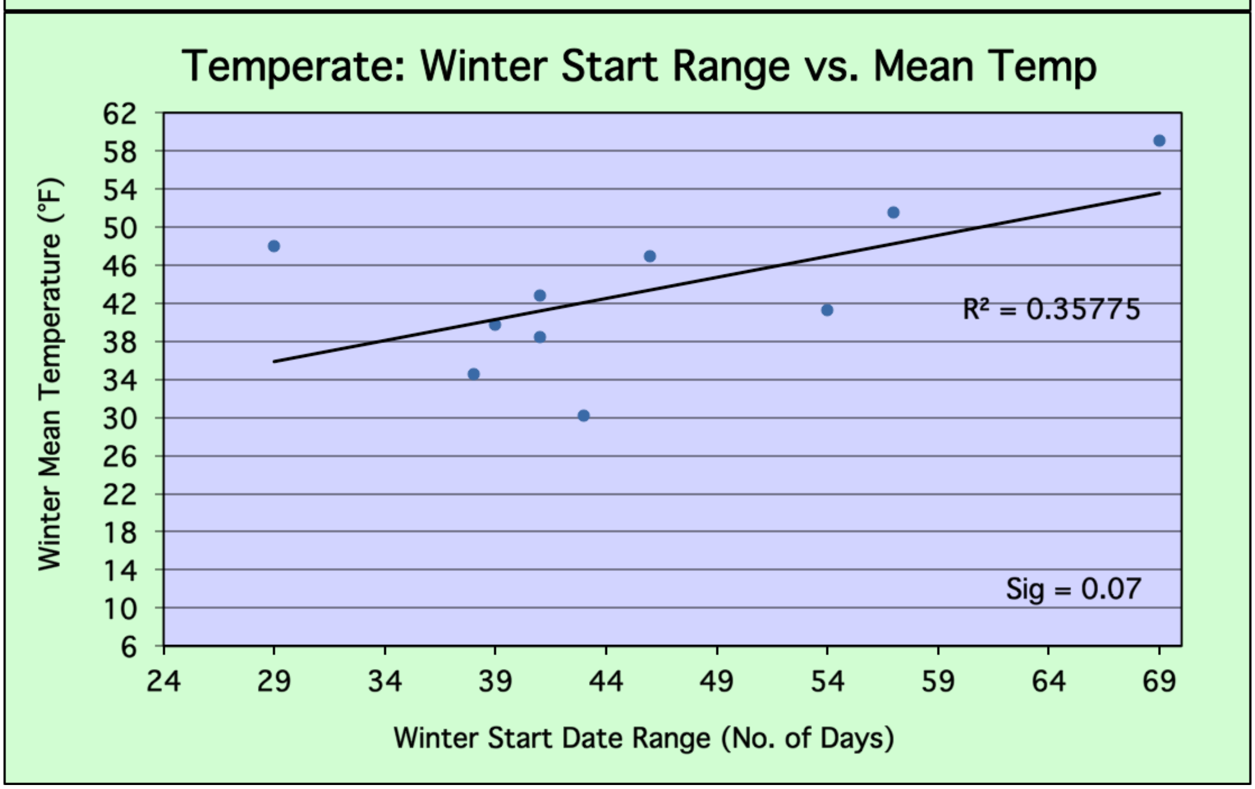
Figures 28a.(top) & 28b.(bottom). For the Temperate classification stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) the earliest Summer start date and b.) the range of Summer start dates.



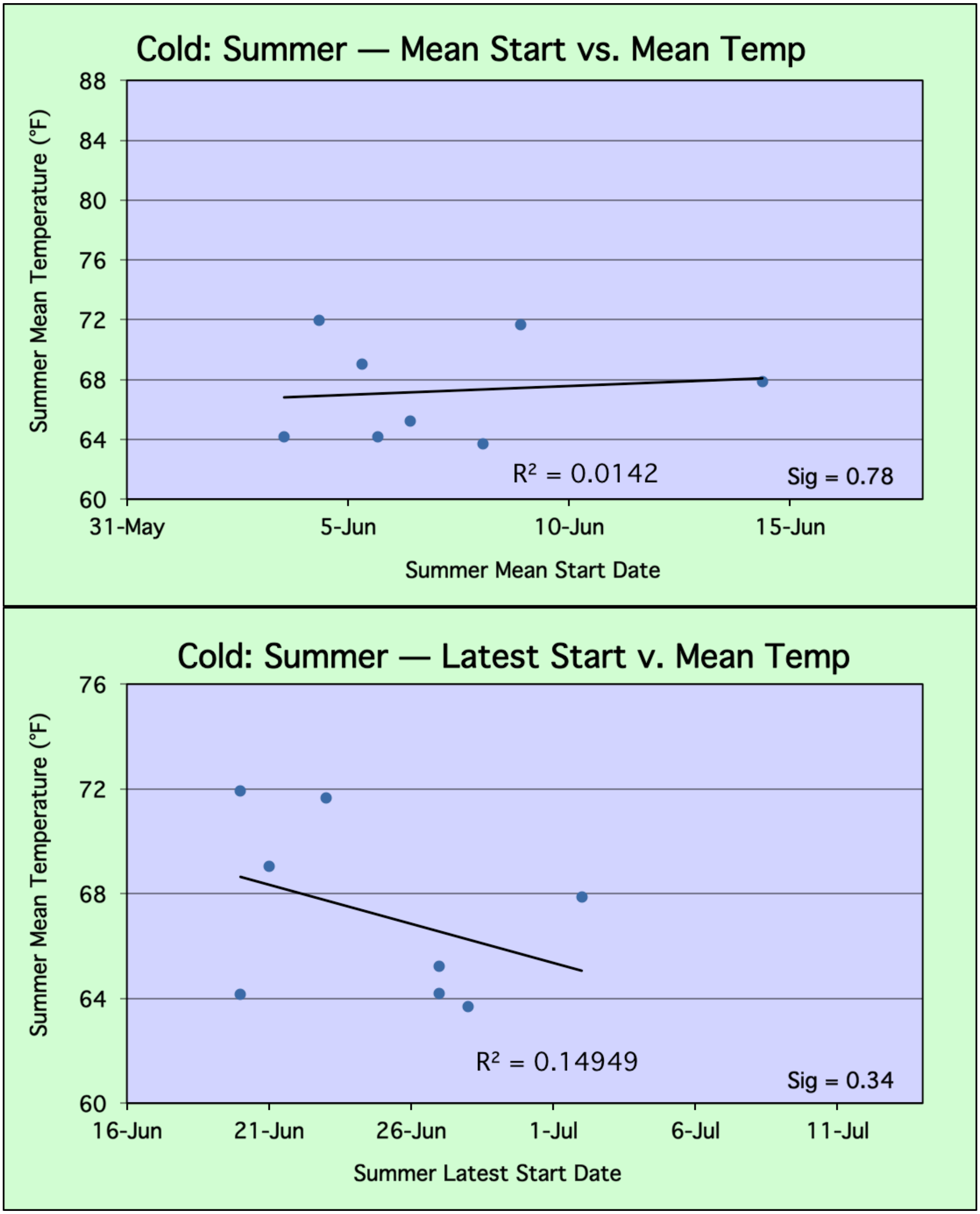


Figures 29a.(top) & 29b.(bottom). For the Temperate classification stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) Winter mean start date and b.) the latest Winter start date.

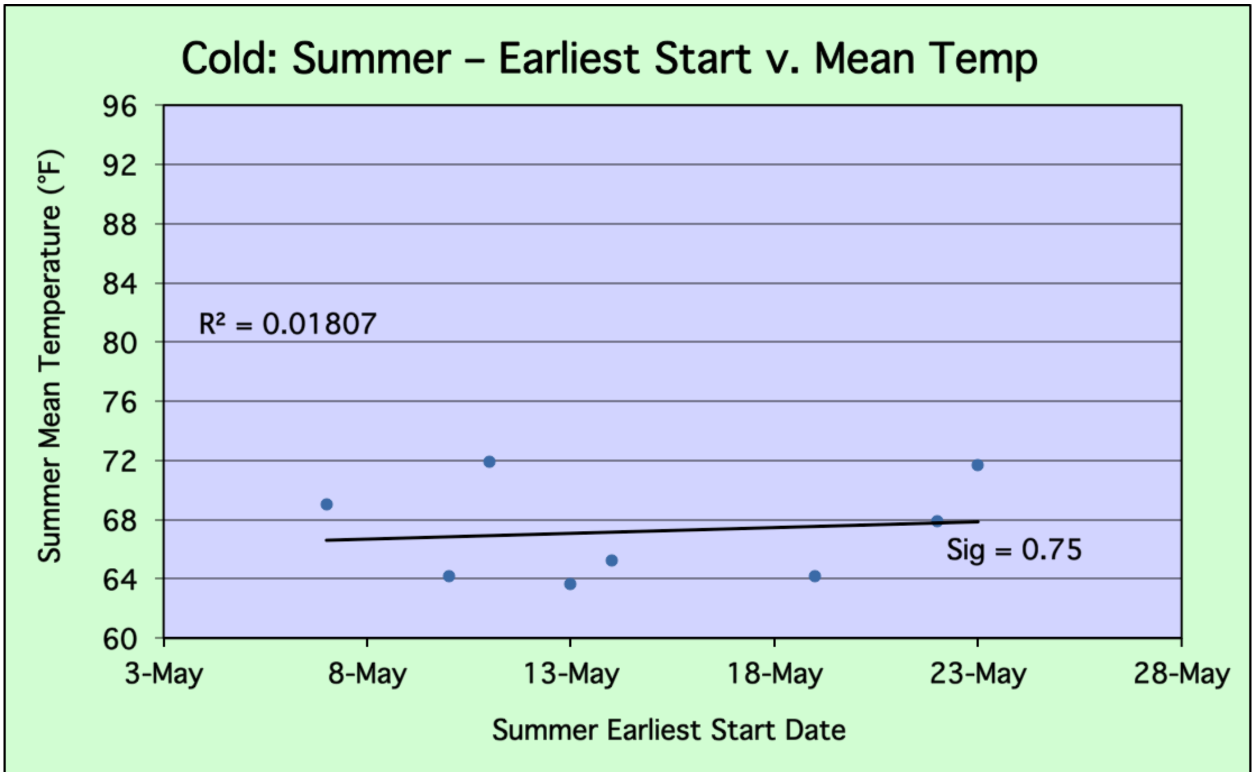


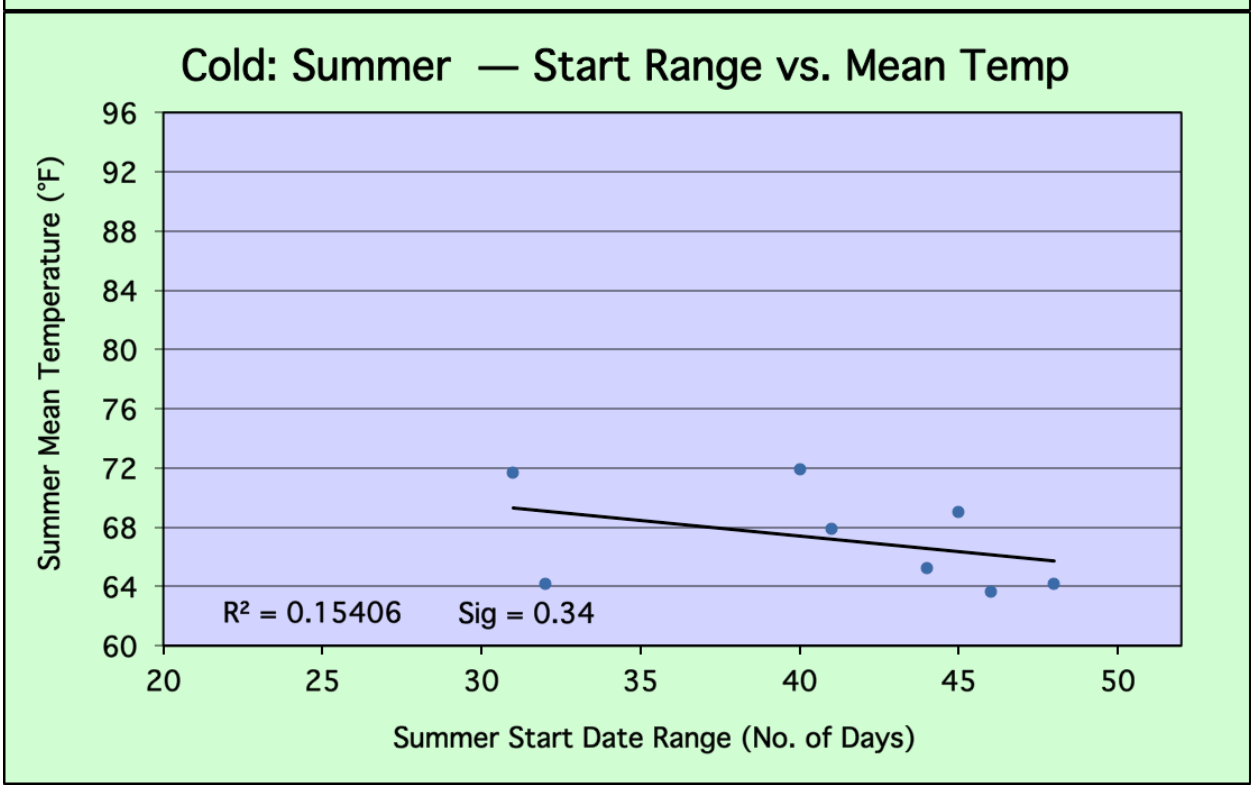


Figures 30a.(top) & 30b.(bottom). For the Temperate classification stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) the earliest Winter start date and b.) the range of Winter start dates.

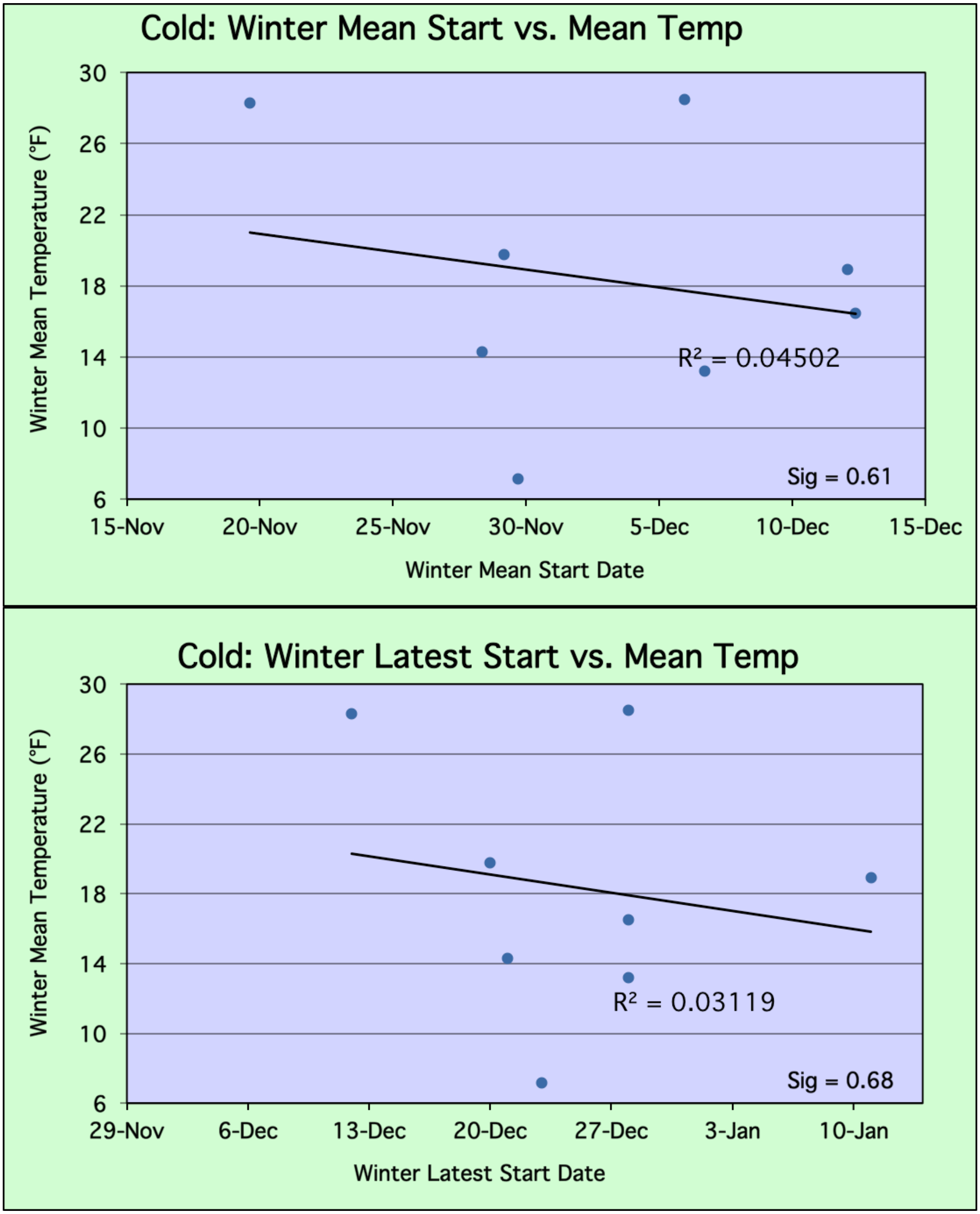


Figures 31a.(top) & 31b.(bottom). For the Cold classification stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) Summer mean start date and b.) the latest Summer start date.

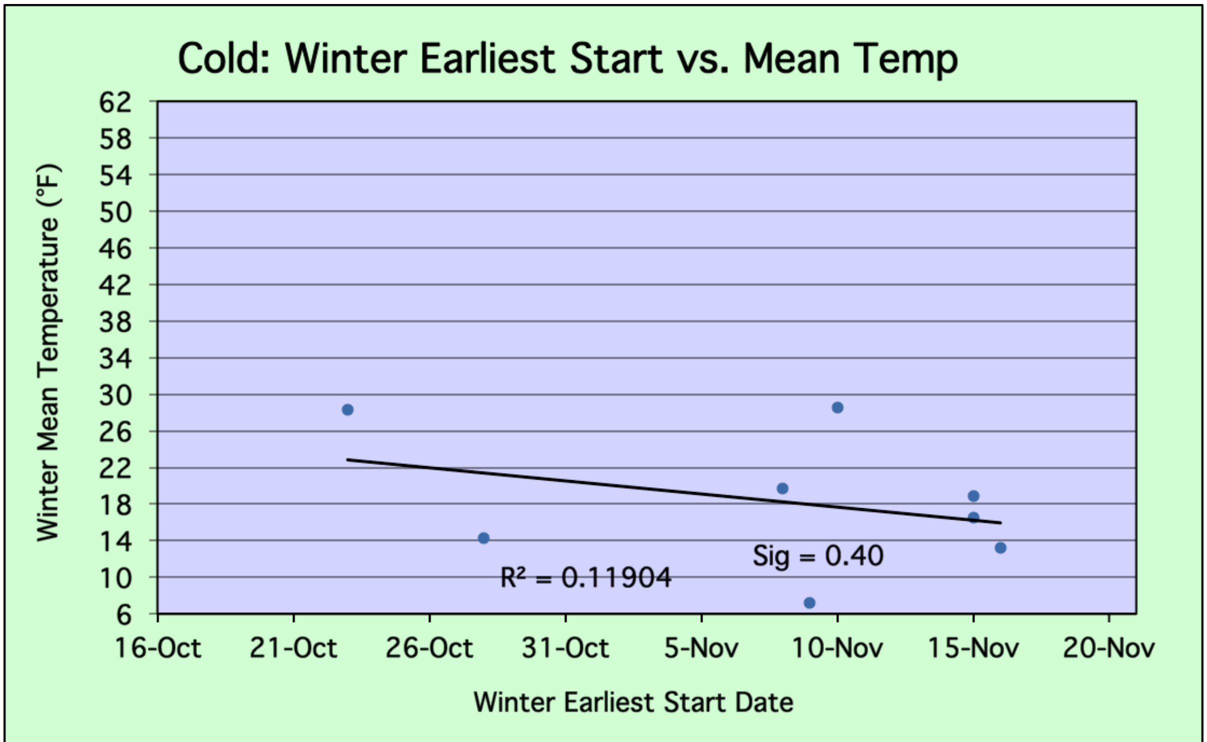


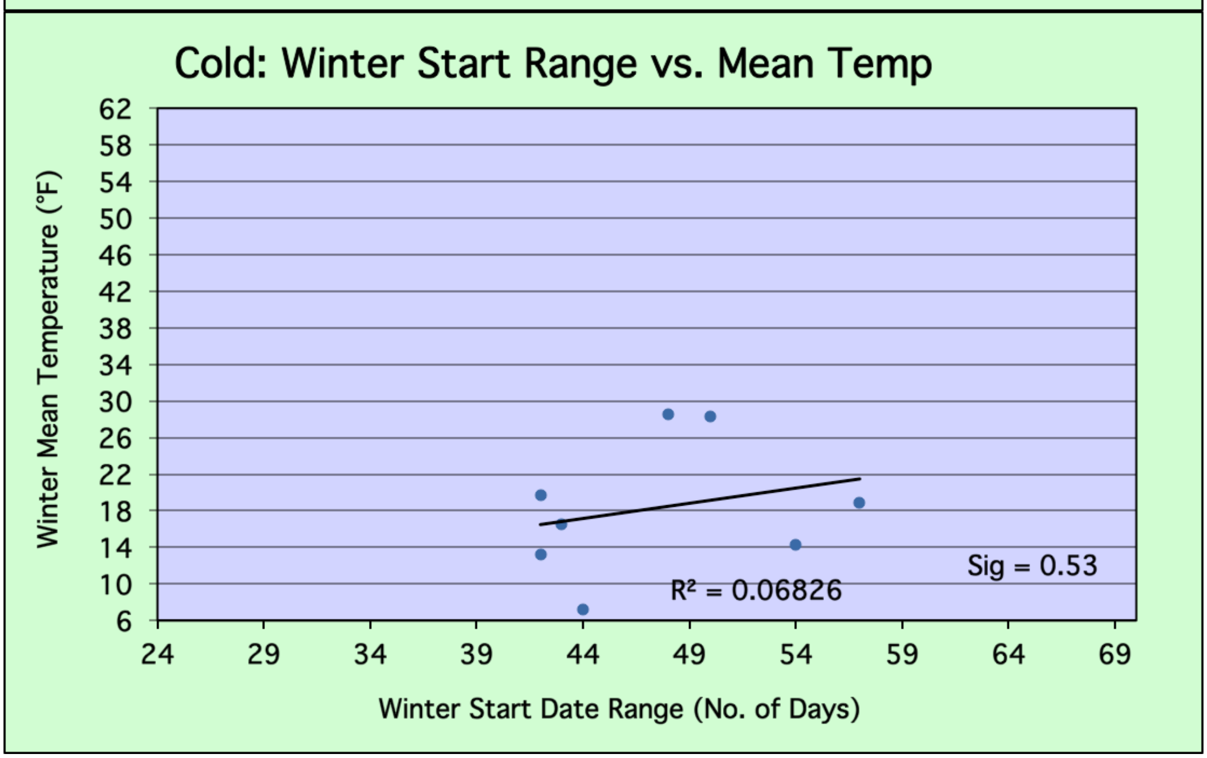


Figures 32a.(top) & 32b.(bottom). For the Cold classification stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) the earliest Summer start date and b.) the range of Summer start dates.



Figures 33a.(top) & 33b.(bottom). For the Cold classification stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) Winter mean start date and b.) the latest Winter start date.

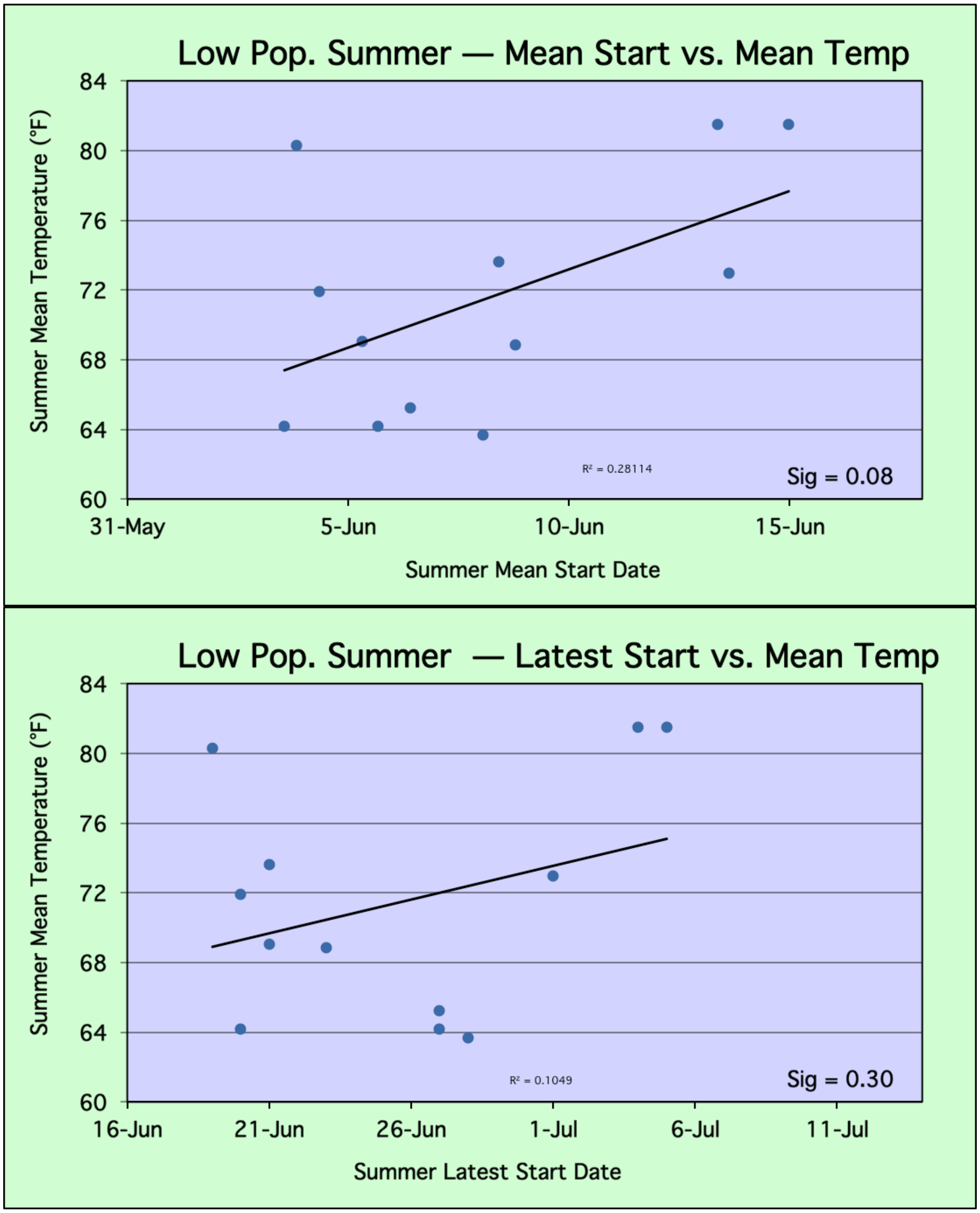




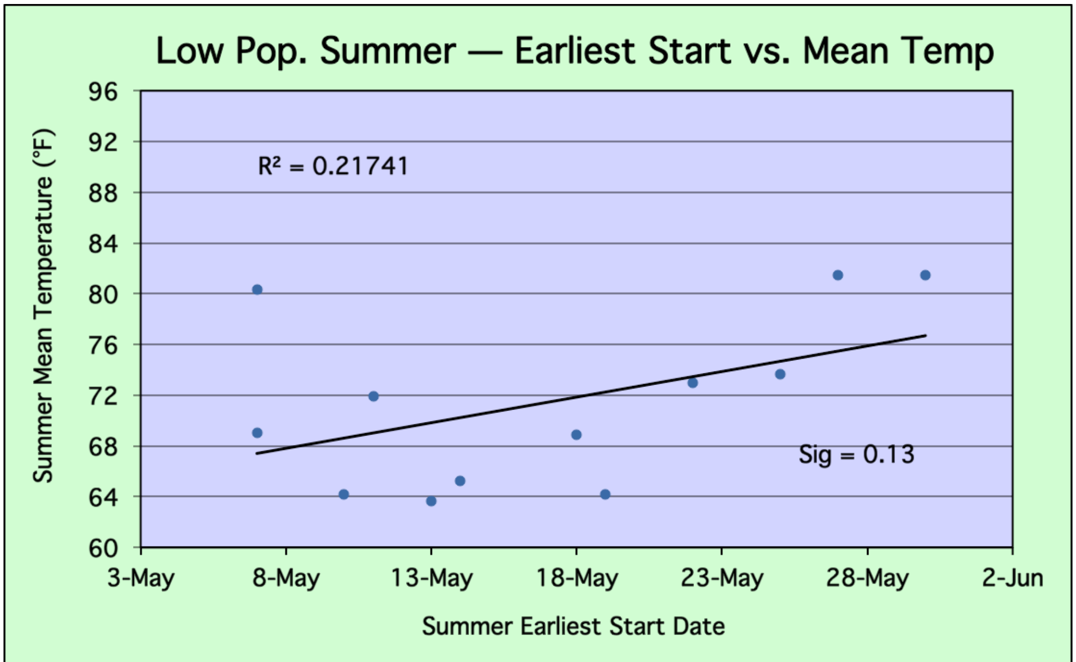
Figures 34a.(top) & 34b.(bottom). For the Cold classification stations (as defined in the text): relationships between the objective Winter season mean temperatures and a.) the earliest Winter start date and b.) the range of Winter start dates.

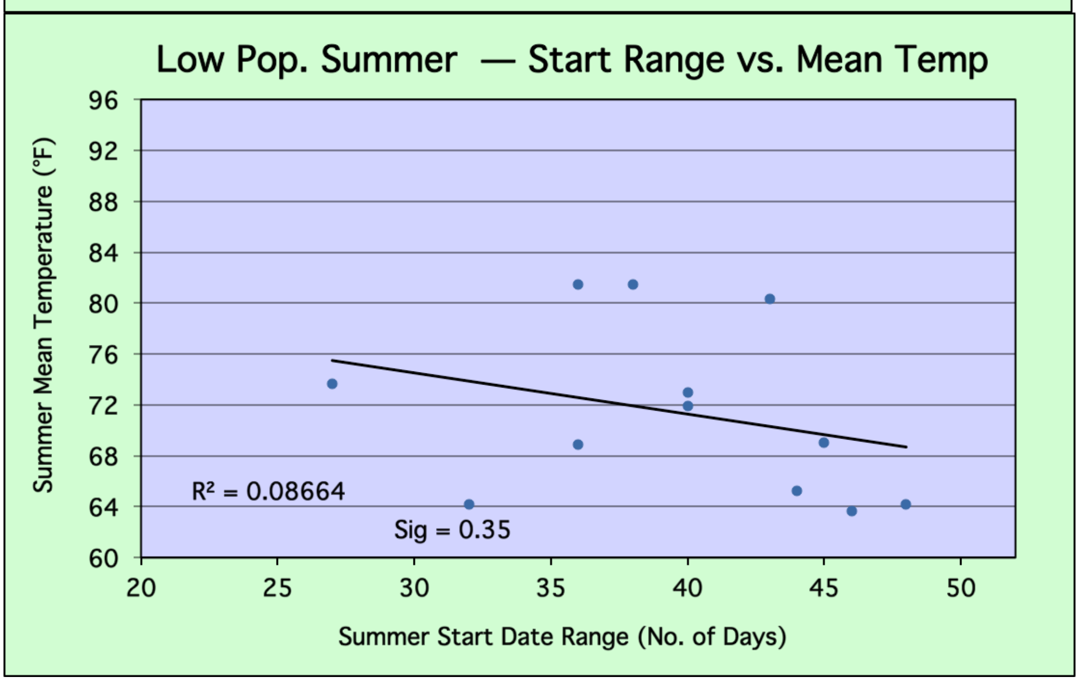
Station	State	Population (x 1,000)	Elev. (Ft.)	Koppen Climate Classification			
				Code	Description		
LOW POPULATION:							
BISMARCK	ND	61	1,651	Dfb	Cold	No Dry Seas.	Warm Sum.
CARIBOU	ME	8	624	Dfb	Cold	No Dry Seas.	Warm Sum.
DAYTONA BEACH	FL	61	31	Cfa	Temp.	No Dry Seas.	Hot Sum.
ELKINS	WV	7	1,979	Cfb	Temp.	No Dry Seas.	Warm Sum.
FORT SMITH	AR	86	449	Cfa	Temp.	No Dry Seas.	Hot Sum.
INTERNATIONAL FALLS	MN	6	1,183	Dfb	Cold	No Dry Seas.	Warm Sum.
LEWISTON	ID	32	1,436	Bsk	Arid	Steppe	Cold
PELLSTON	MI	1	705	Dfb	Cold	No Dry Seas.	Warm Sum.
PIERRE	SD	14	1,742	Bsk	Arid	Steppe	Cold
ROSWELL	NM	48	3,649	Bsk	Arid	Steppe	Cold
SAULT STE MARIE	MI	14	722	Dfb	Cold	No Dry Seas.	Warm Sum.
WATERLOO	IA	68	868	Dfa	Cold	No Dry Seas.	Hot Sum.
HIGH POPULATION:							
ASHEVILLE	NC	238	2,117	Cfb	Temp.	No Dry Seas.	Warm Sum.
ALBUQUERQUE	NM	546	5,310	Bwk	Arid	Desert	Cold
BAKERSFIELD	CA	347	489	Bsh	Arid	Steppe	Hot
CLEVELAND	OH	1,280	781	Dfa	Cold	No Dry Seas.	Hot Sum.
EL PASO	TX	649	3,918	Bwk	Arid	Desert	Cold
FRESNO	CA	495	333	Bsh	Arid	Steppe	Hot
GRAND JUNCTION	CO	147	4,858	Bsk	Arid	Steppe	Cold
LAS VEGAS	NV	584	2,180	Bwh	Arid	Desert	Hot
MEDFORD	OR	203	1,297	Csa	Temp.	Dry Summer	Hot Sum.
MEMPHIS	TN	25	254	Cfa	Temp.	No Dry Seas.	Hot Sum.
MIDLAND	TX	111	2,862	Bsh	Arid	Steppe	Hot
MOBILE	AL	413	215	Cfa	Temp.	No Dry Seas.	Hot Sum.
PHILADELPHIA	PA	1,526	10	Cfa	Temp.	No Dry Seas.	Hot Sum.
PHOENIX	AZ	1,446	1,107	Bwh	Arid	Desert	Hot
SALT LAKE CITY	UT	186	4,225	Bsk	Arid	Steppe	Cold
SAN ANGELO	TX	110	1,916	Bsh	Arid	Steppe	Hot
SEATTLE	WA	609	370	Csb	Temp.	Dry Summer	Warm Sum.
SPOKANE	WA	209	2,353	Dsb	Cold	Dry Summer	Warm Sum.

Table 11. Listing of stations that were combined by "High" and "Low" population Categories for regression analyses.

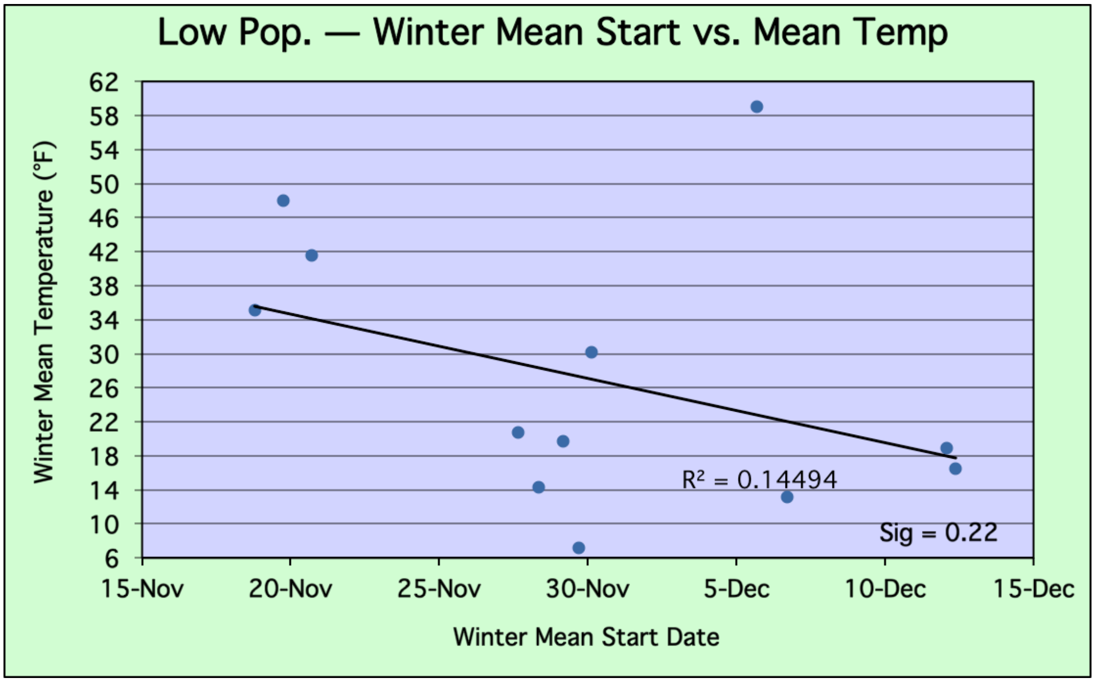


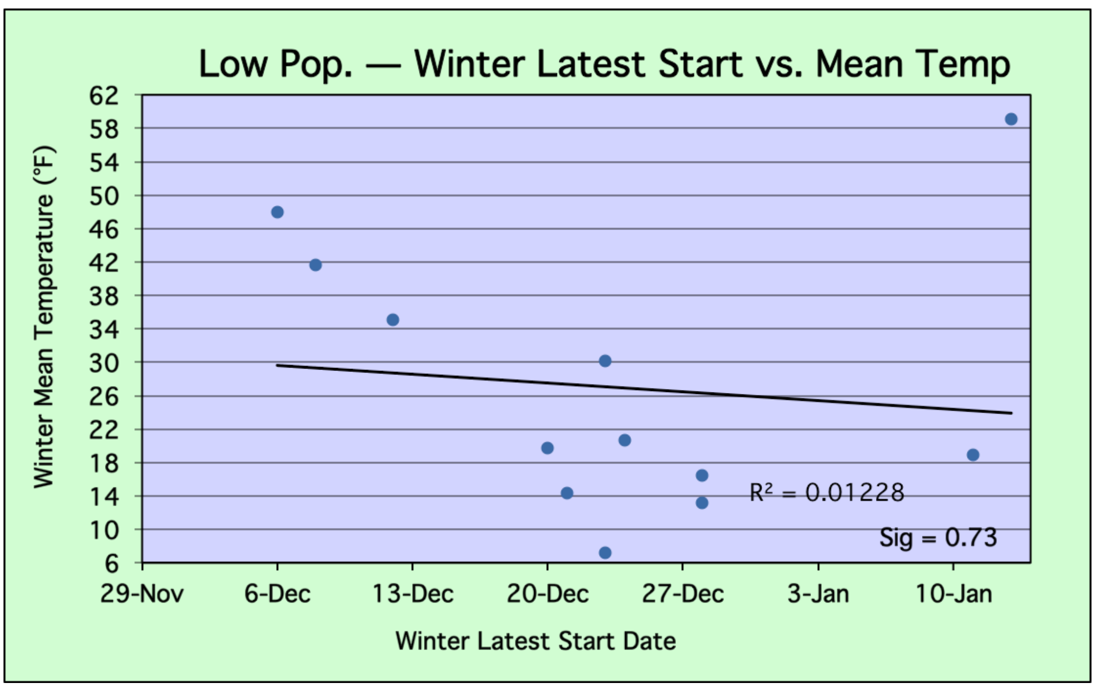
Figures 35a.(top) & 35b.(bottom). For the "Low Population" stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) Summer mean start date and b.) the latest Summer start date.



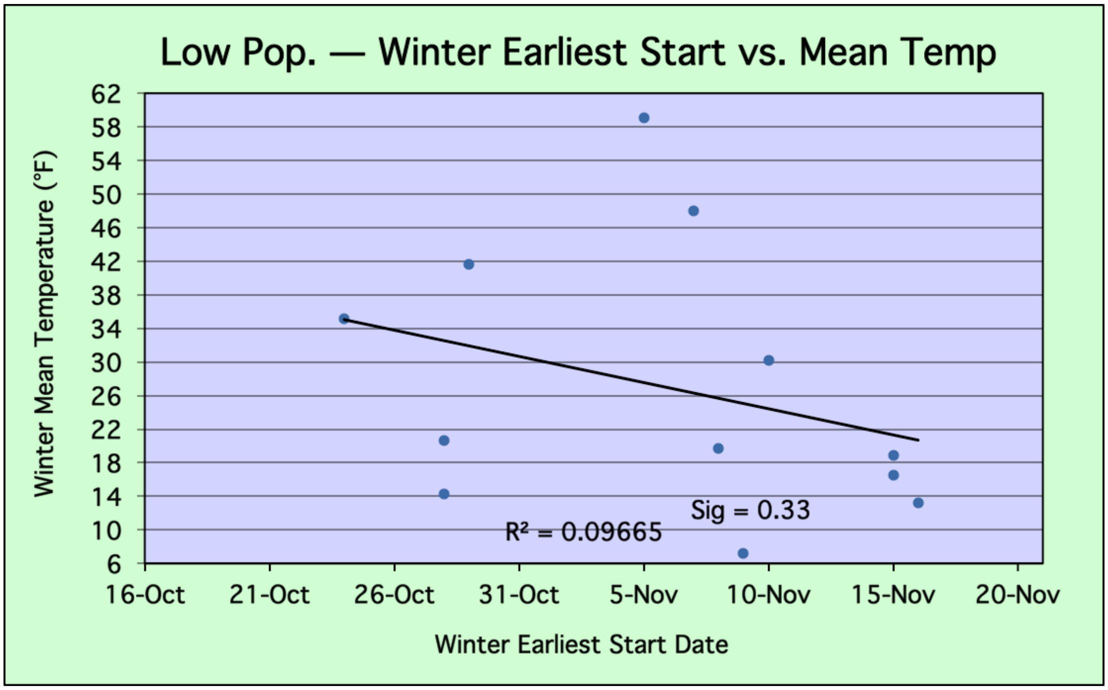


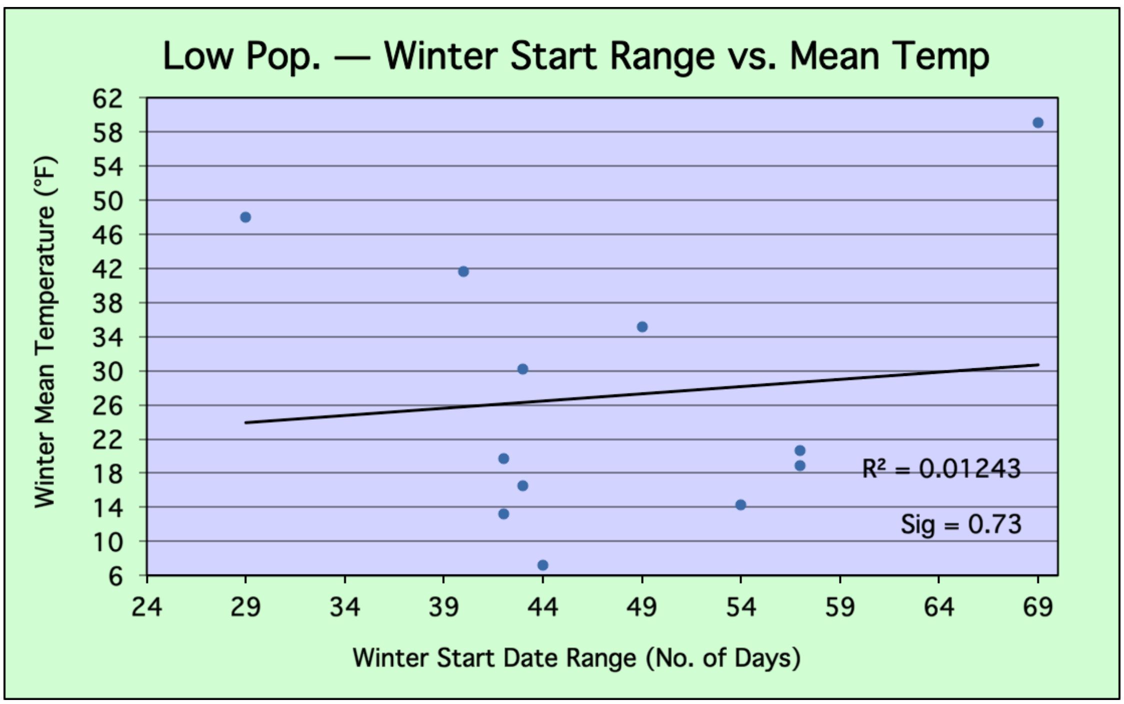
Figures 36a.(top) & 36b.(bottom). For the "Low Population" stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) the earliest Summer start date and b.) the range of Summer start dates.



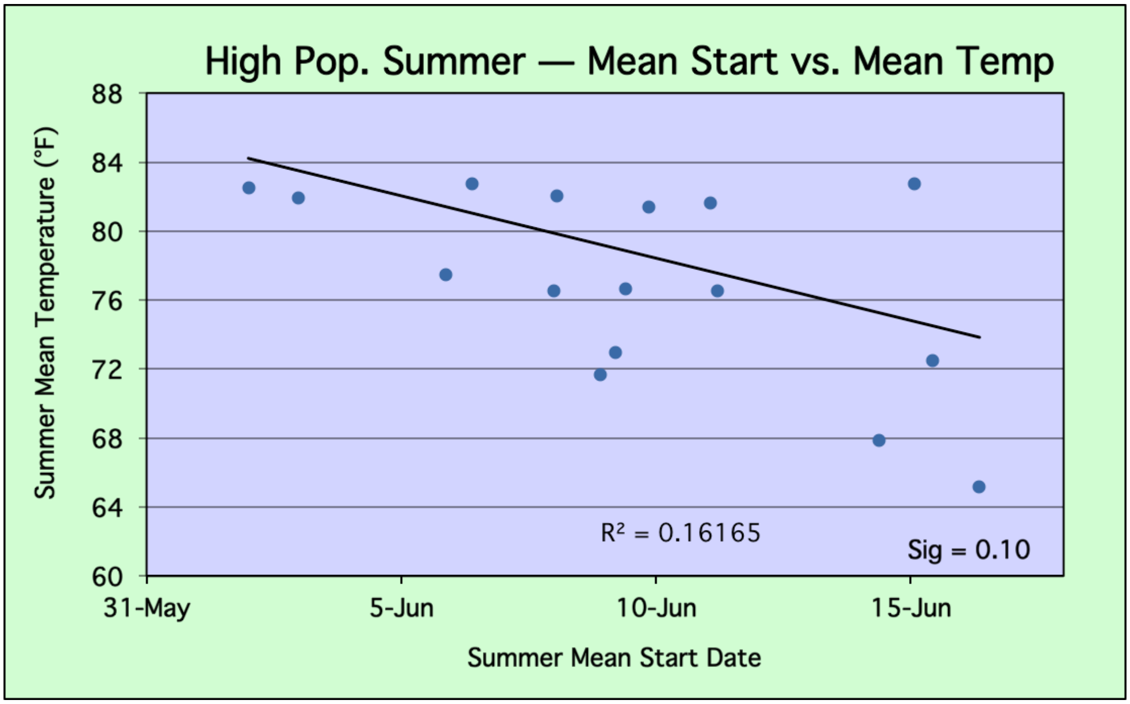


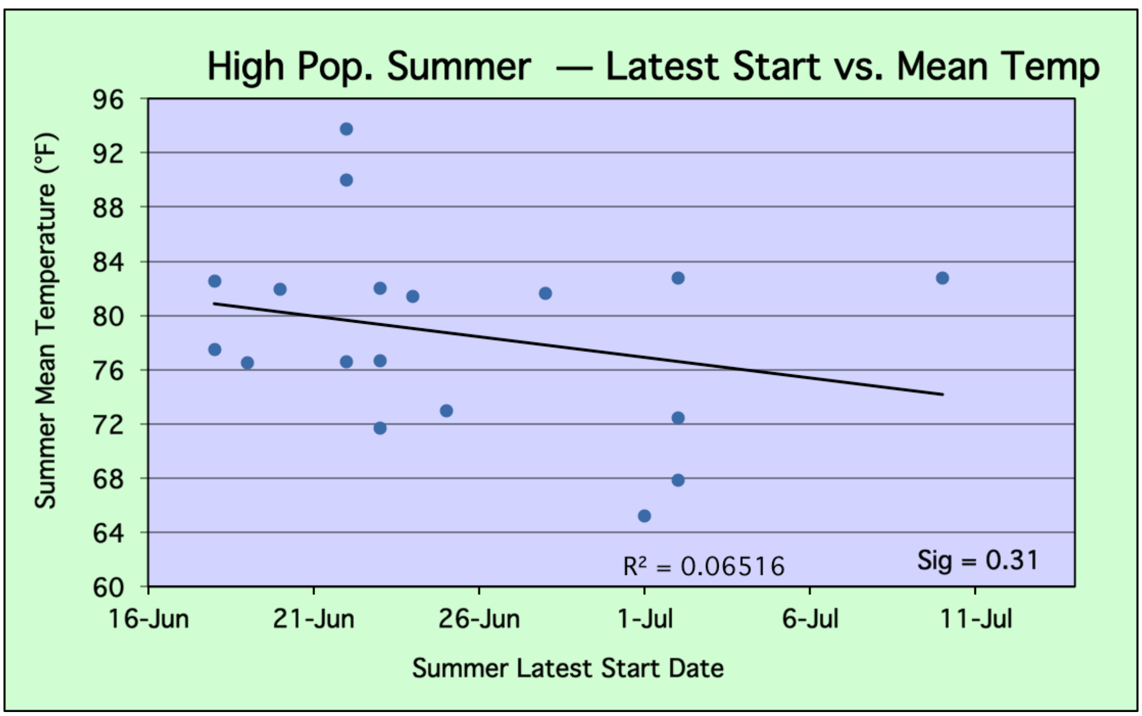
Figures 37a.(top) & 37b.(bottom). For the "Low Population" stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) Winter mean start date and b.) the latest Winter start date.



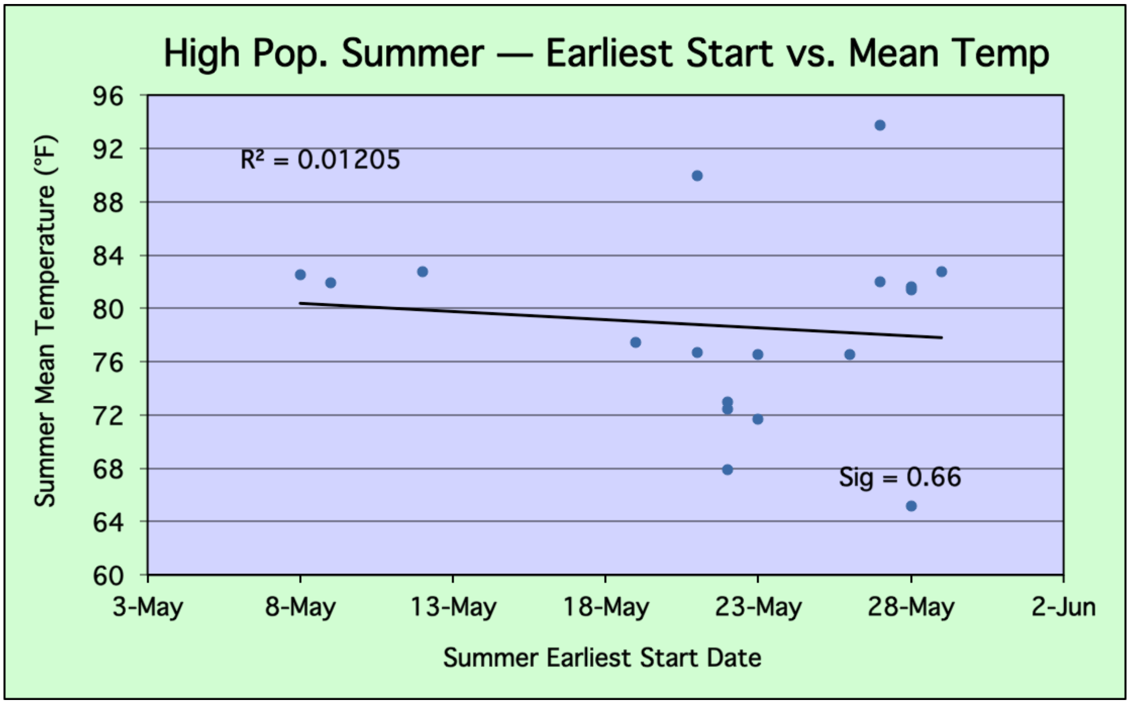


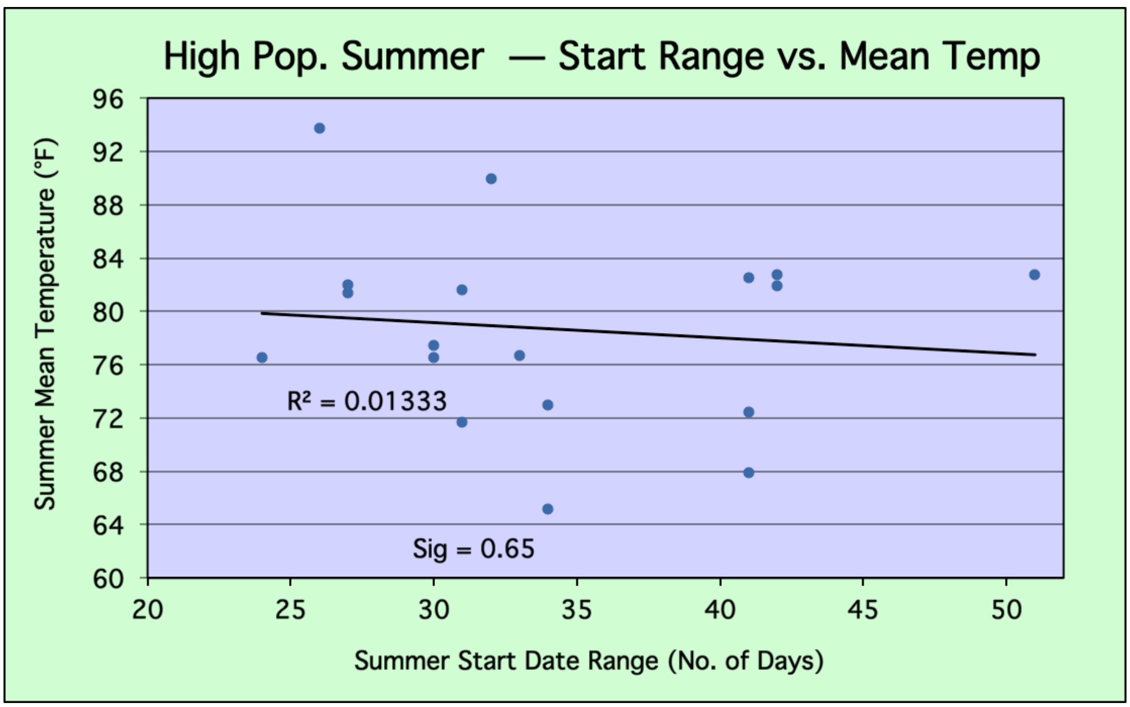
Figures 38a.(top) & 38b.(bottom). For the "Low Population" stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) the earliest Winter start date and b.) the range of Winter start dates.



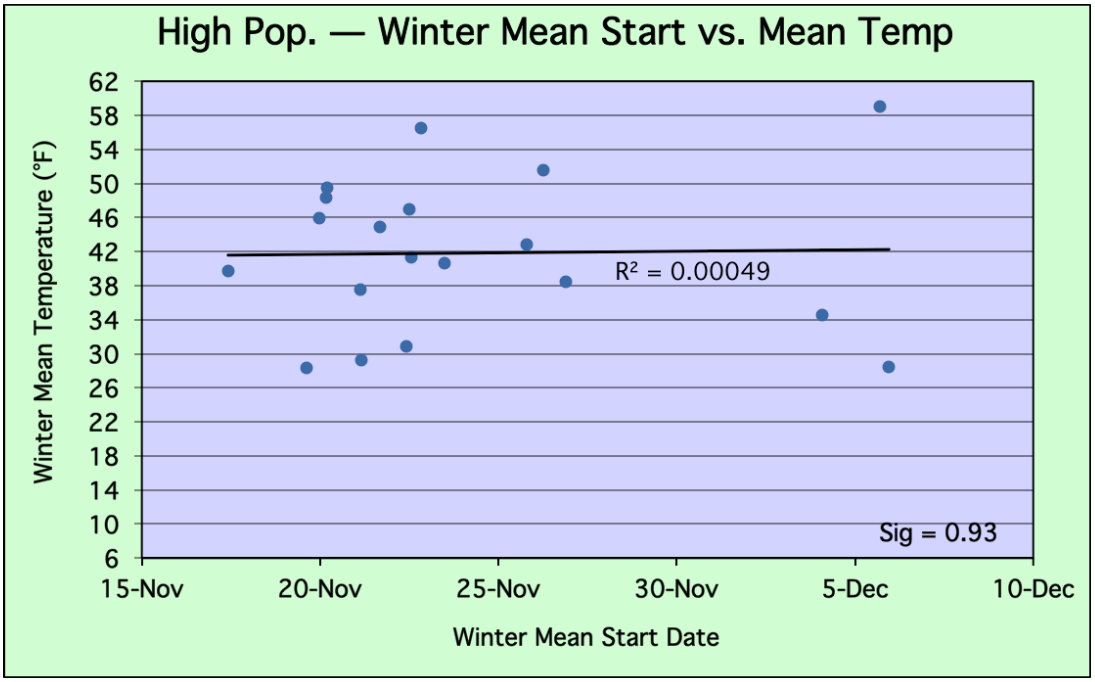


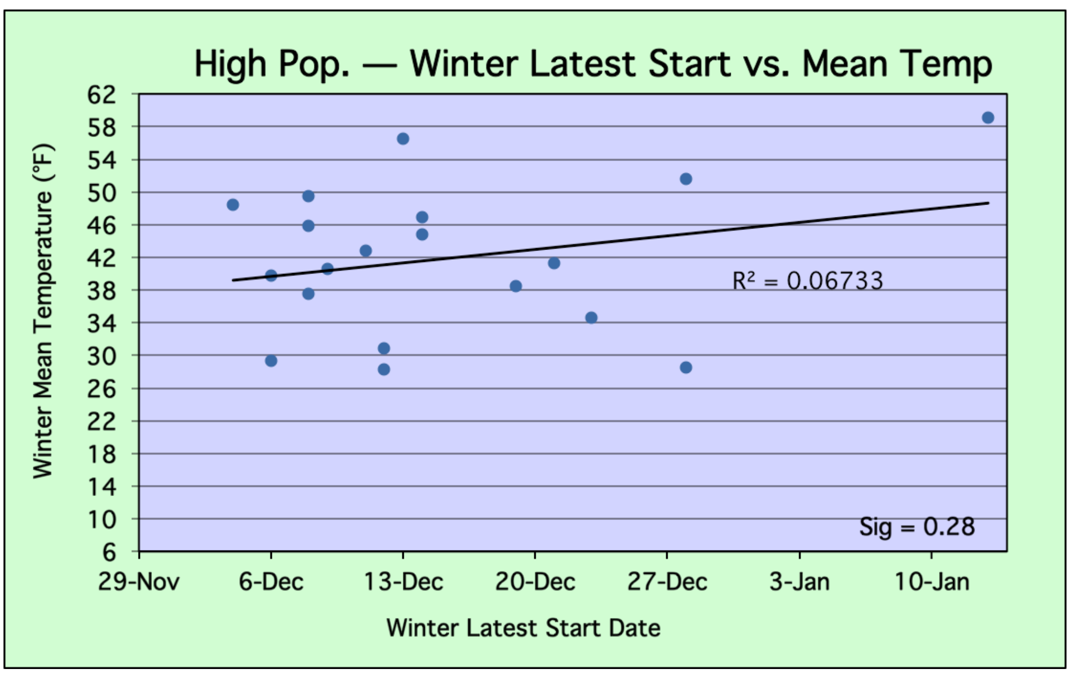
Figures 39a.(top) & 39b.(bottom). For the "High Population" stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) Summer mean start date and b.) the latest Summer start date.



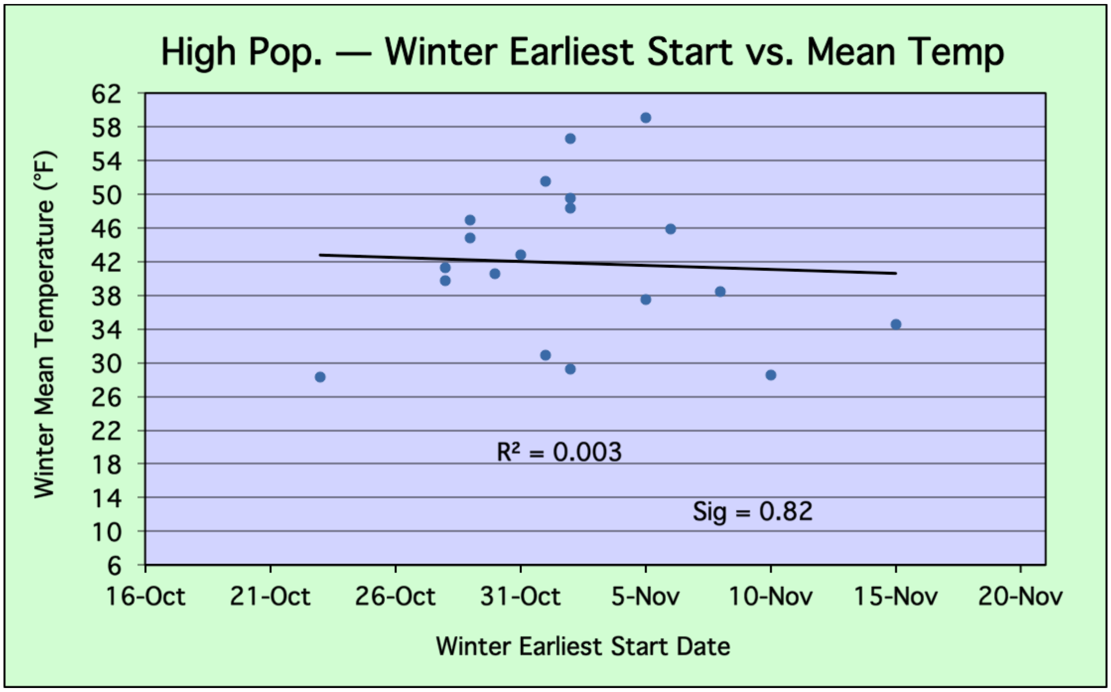


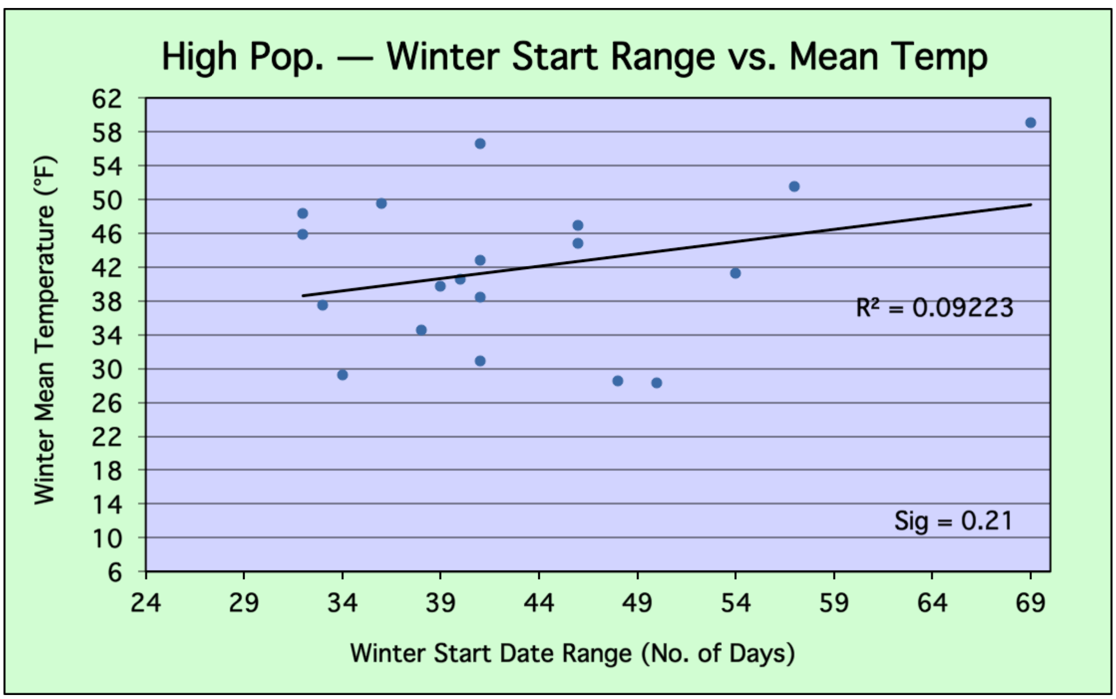
Figures 40a.(top) & 40b.(bottom). For the "High Population" stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) the earliest Summer start date and b.) the range of Summer start dates.





Figures 41a.(top) & 41b.(bottom). For the "High Population" stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) Winter mean start date and b.) the latest Winter start date.

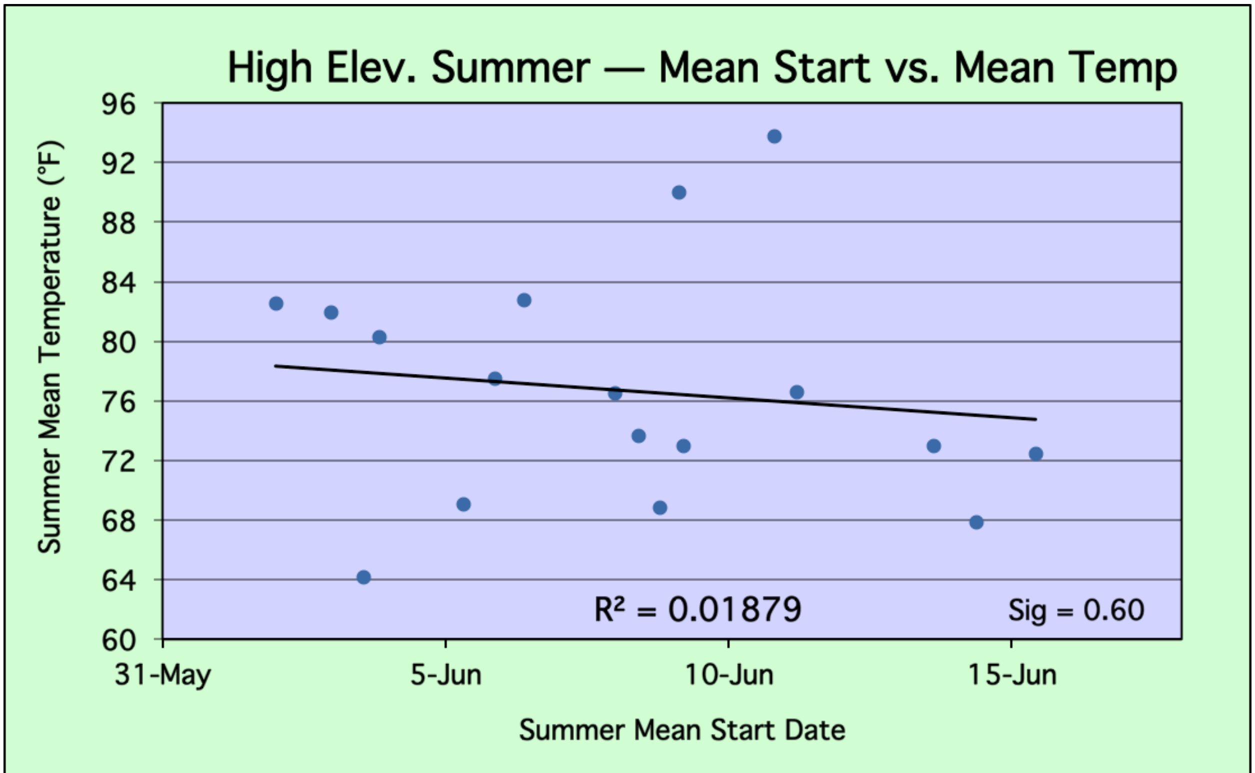


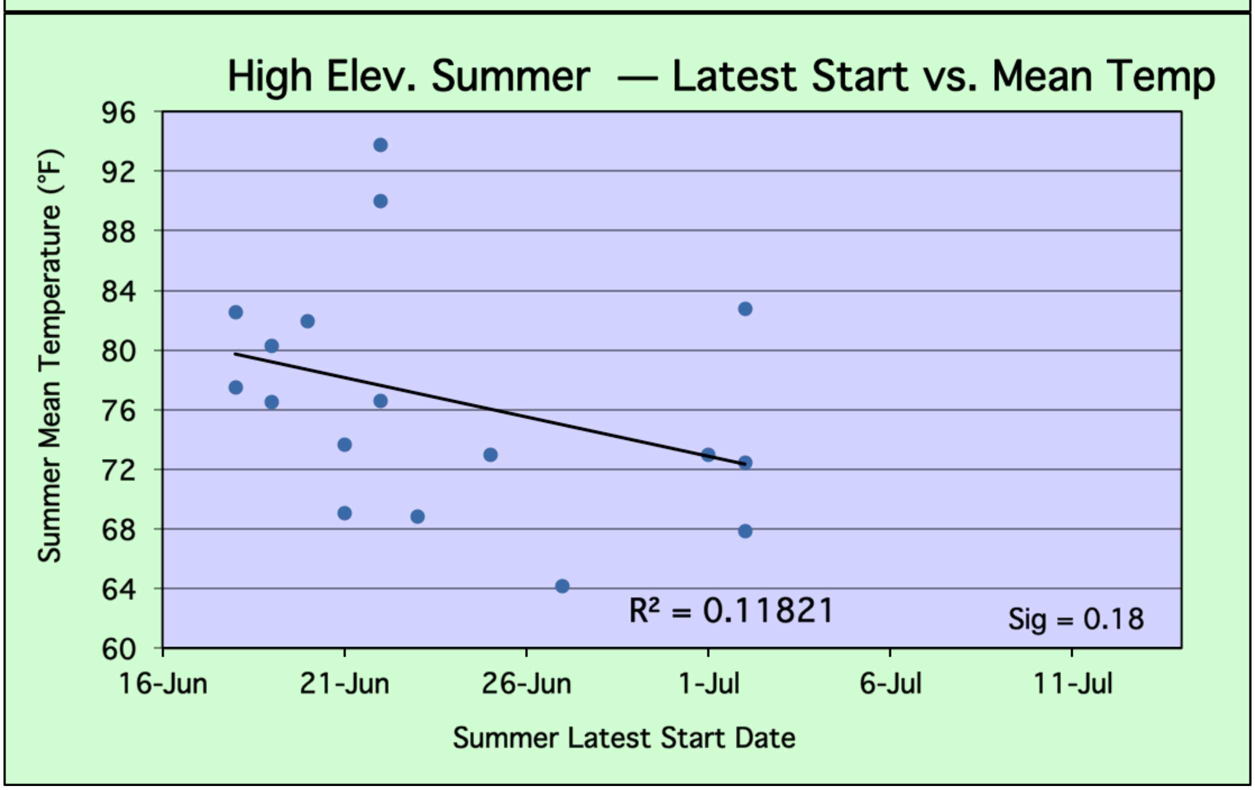


Figures 42a.(top) & 42b.(bottom). For the "High Population" stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) the earliest Winter start date and b.) the range of Winter start dates.

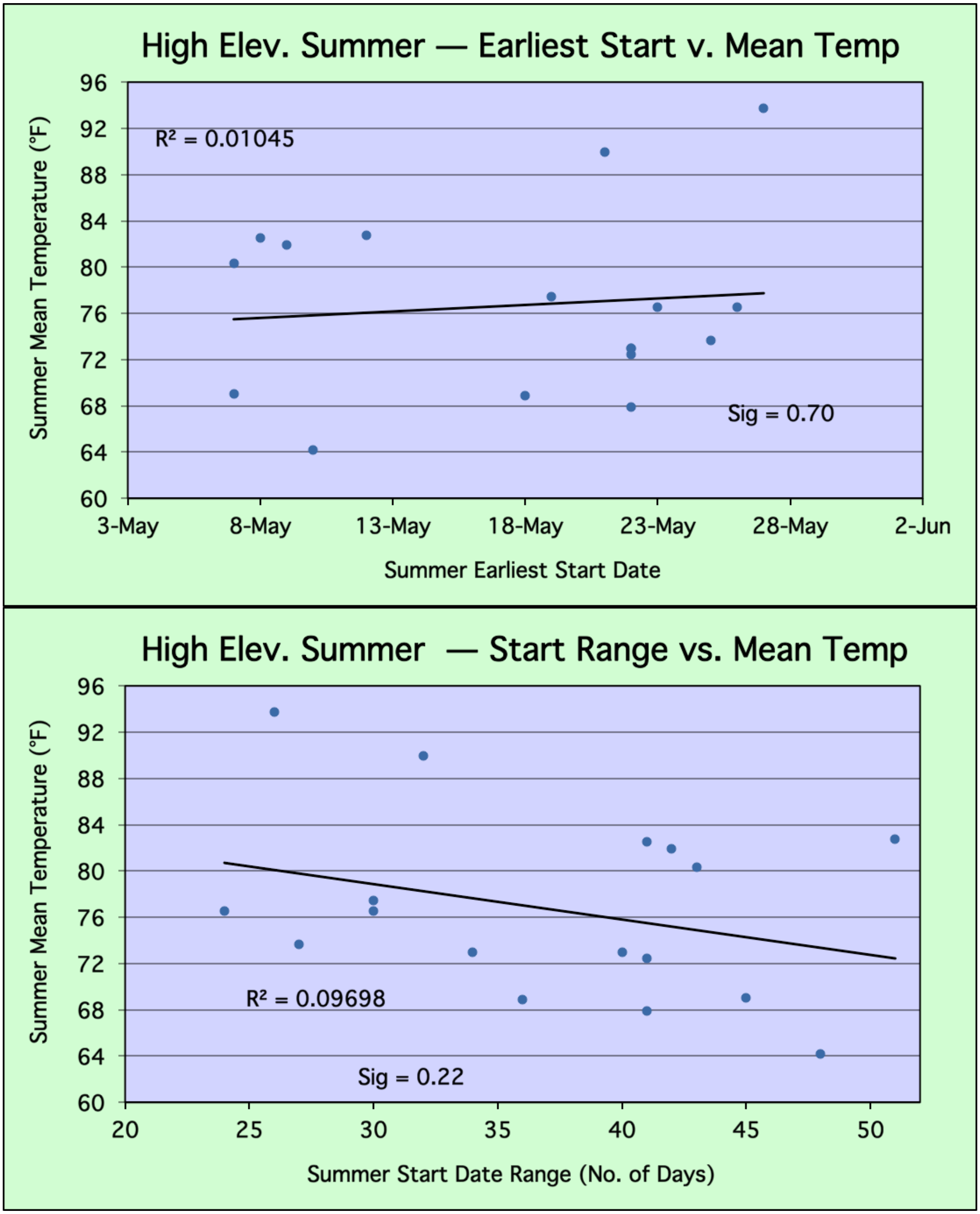
Station	State	Population (x 1,000)	Elev. (Ft.)	Koppen Climate Classification			
				Code	Description		
LOW ELEVATION:							
BAKERSFIELD	CA	347	489	Bsh	Arid	Steppe	Hot
CARIBOU	ME	8	624	Dfb	Cold	No Dry Seas.	Warm Sum.
CLEVELAND	OH	1,280	781	Dfa	Cold	No Dry Seas.	Hot Sum.
DAYTONA BEACH	FL	61	31	Cfa	Temp.	No Dry Seas.	Hot Sum.
FORT SMITH	AR	86	449	Cfa	Temp.	No Dry Seas.	Hot Sum.
FRESNO	CA	495	333	Bsh	Arid	Steppe	Hot
MEMPHIS	TN	25	254	Cfa	Temp.	No Dry Seas.	Hot Sum.
MOBILE	AL	413	215	Cfa	Temp.	No Dry Seas.	Hot Sum.
PHILADELPHIA	PA	1,526	10	Cfa	Temp.	No Dry Seas.	Hot Sum.
PELLSTON	MI	1	705	Dfb	Cold	No Dry Seas.	Warm Sum.
SAULT STE MARIE	MI	14	722	Dfb	Cold	No Dry Seas.	Warm Sum.
SEATTLE	WA	609	370	Csb	Temp.	Dry Summer	Warm Sum.
WATERLOO	IA	68	868	Dfa	Cold	No Dry Seas.	Hot Sum.
HIGH ELEVATION:							
ASHEVILLE	NC	238	2,117	Cfb	Temp.	No Dry Seas.	Warm Sum.
ALBUQUERQUE	NM	546	5,310	Bwk	Arid	Desert	Cold
BISMARCK	ND	61	1,651	Dfb	Cold	No Dry Seas.	Warm Sum.
ELKINS	WV	7	1,979	Cfb	Temp.	No Dry Seas.	Warm Sum.
EL PASO	TX	649	3,918	Bwk	Arid	Desert	Cold
GRAND JUNCTION	CO	147	4,858	Bsk	Arid	Steppe	Cold
INTERNATIONAL FALLS	MN	6	1,183	Dfb	Cold	No Dry Seas.	Warm Sum.
LAS VEGAS	NV	584	2,180	Bwh	Arid	Desert	Hot
LEWISTON	ID	32	1,436	Bsk	Arid	Steppe	Cold
MEDFORD	OR	203	1,297	Csa	Temp.	Dry Summer	Hot Sum.
MIDLAND	TX	111	2,862	Bsh	Arid	Steppe	Hot
PHOENIX	AZ	1,446	1,107	Bwh	Arid	Desert	Hot
PIERRE	SD	14	1,742	Bsk	Arid	Steppe	Cold
ROSWELL	NM	48	3,649	Bsk	Arid	Steppe	Cold
SALT LAKE CITY	UT	186	4,225	Bsk	Arid	Steppe	Cold
SAN ANGELO	TX	110	1,916	Bsh	Arid	Steppe	Hot
SPOKANE	WA	209	2,353	Dsb	Cold	Dry Summer	Warm Sum.

Table 12. Listing of stations that were combined by "High" and "Low" elevation categories for regression analyses.

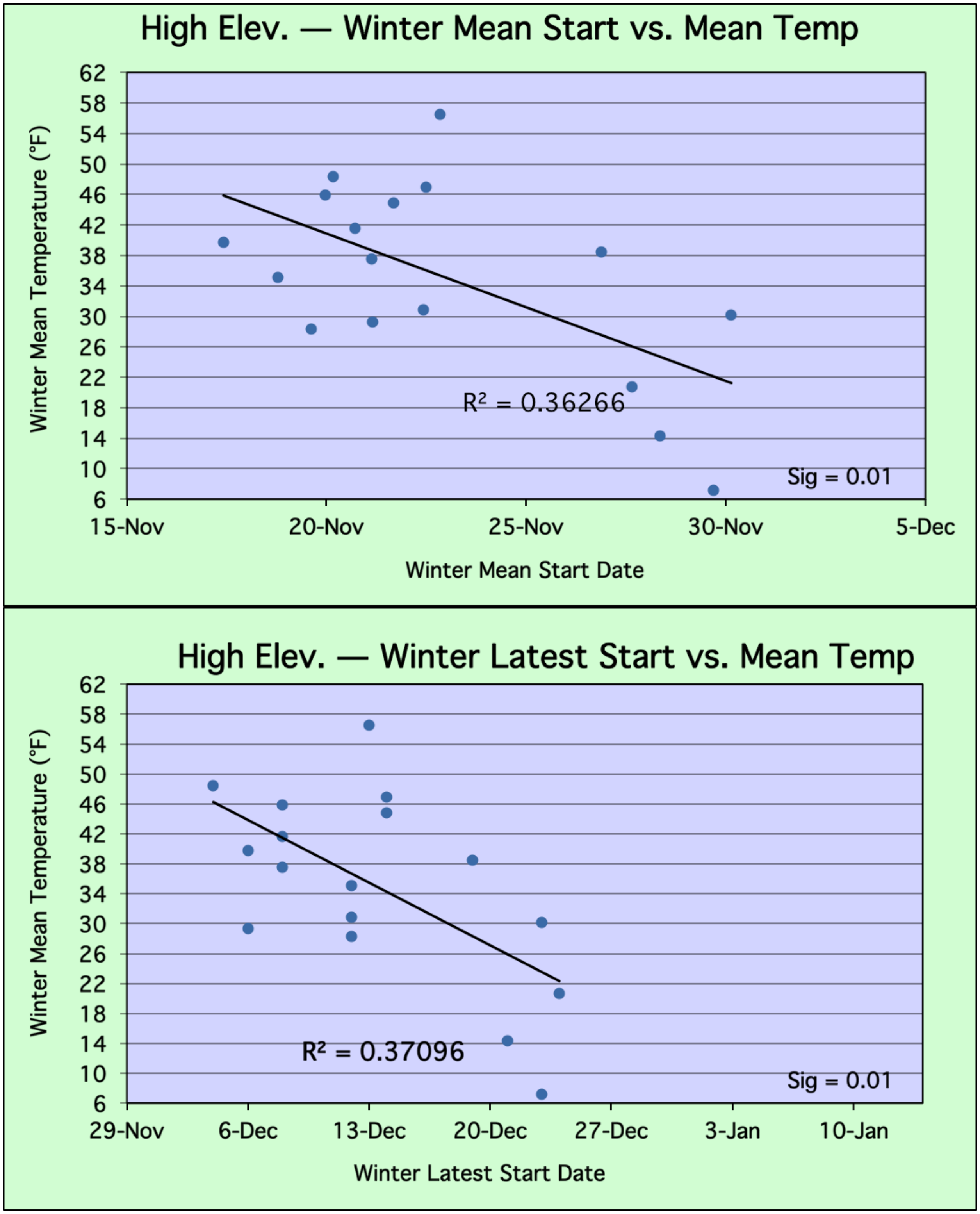




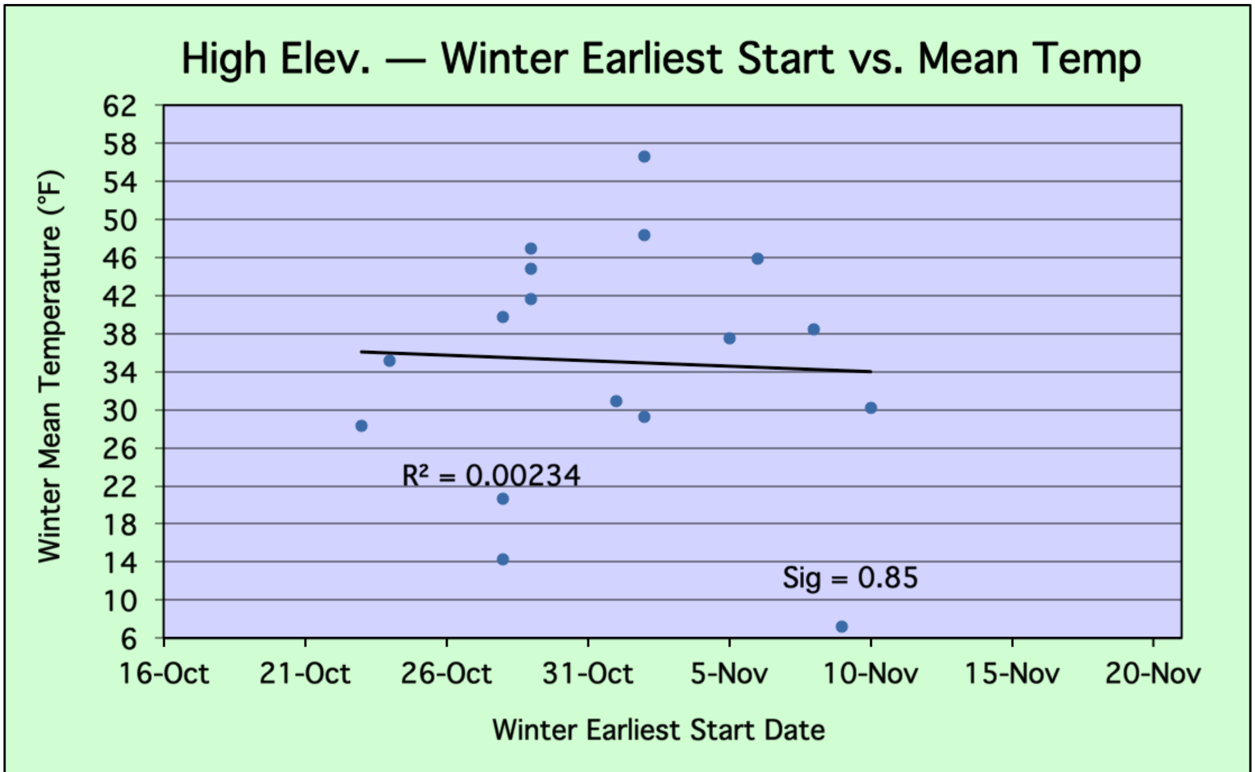
Figures 43a.(top) & 43b.(bottom). For the "High Elevation" stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) Summer mean start date and b.) the latest Summer start date.

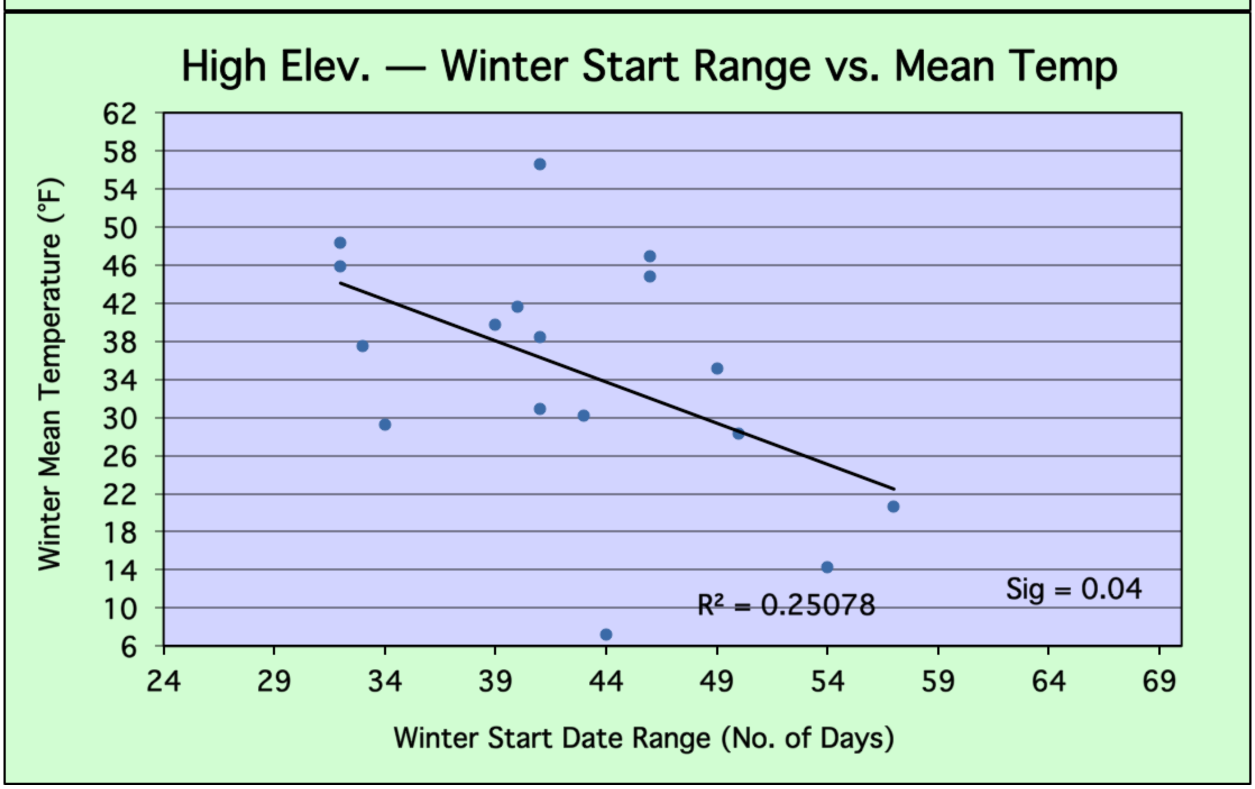


Figures 44a.(top) & 44b.(bottom). For the "High Elevation" stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) the earliest Summer start date and b.) the range of Summer start dates.

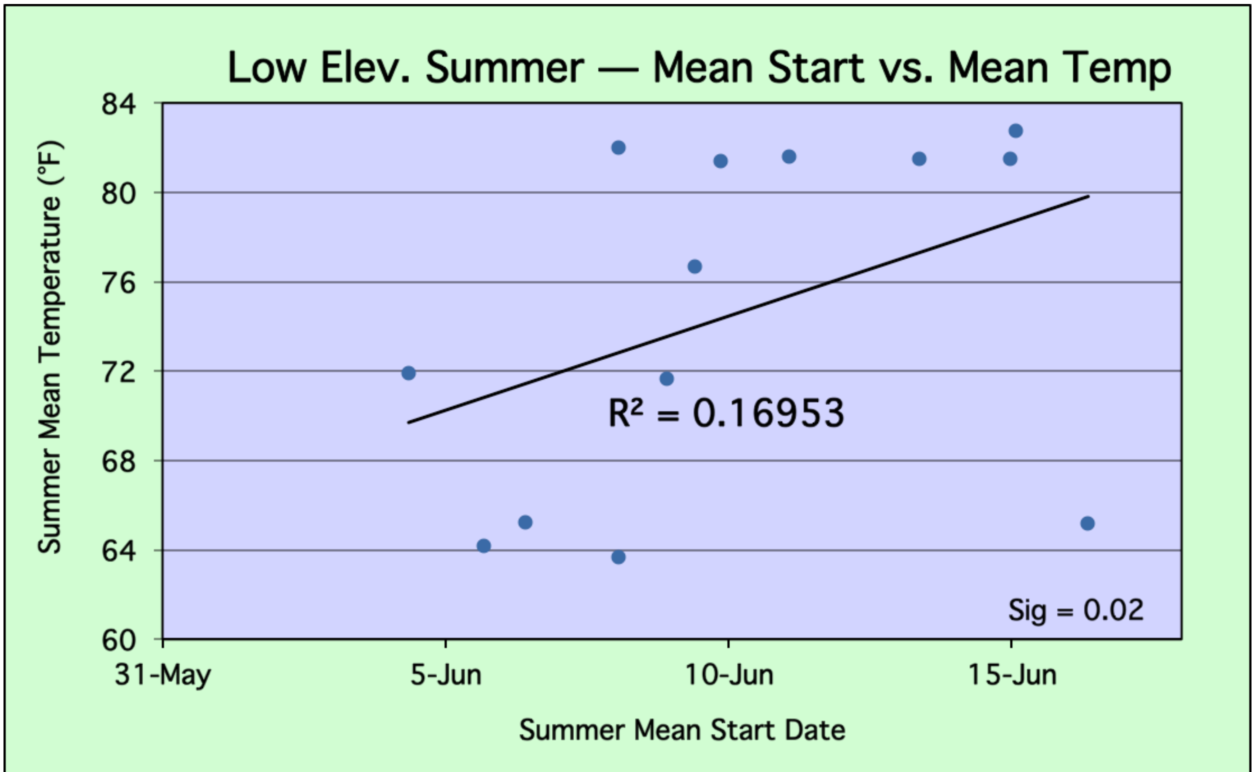


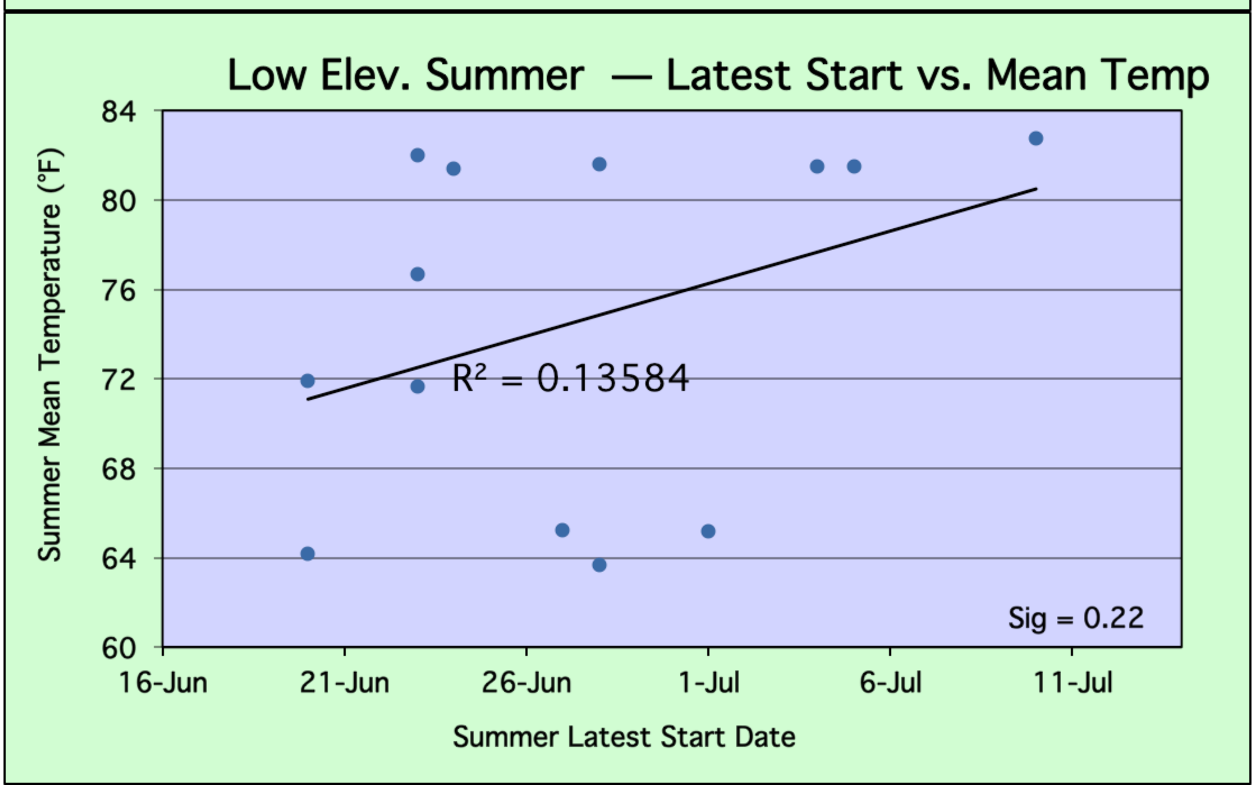
Figures 45a.(top) & 45b.(bottom). For the "High Elevation" stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) Winter mean start date and b.) the latest Winter start date.



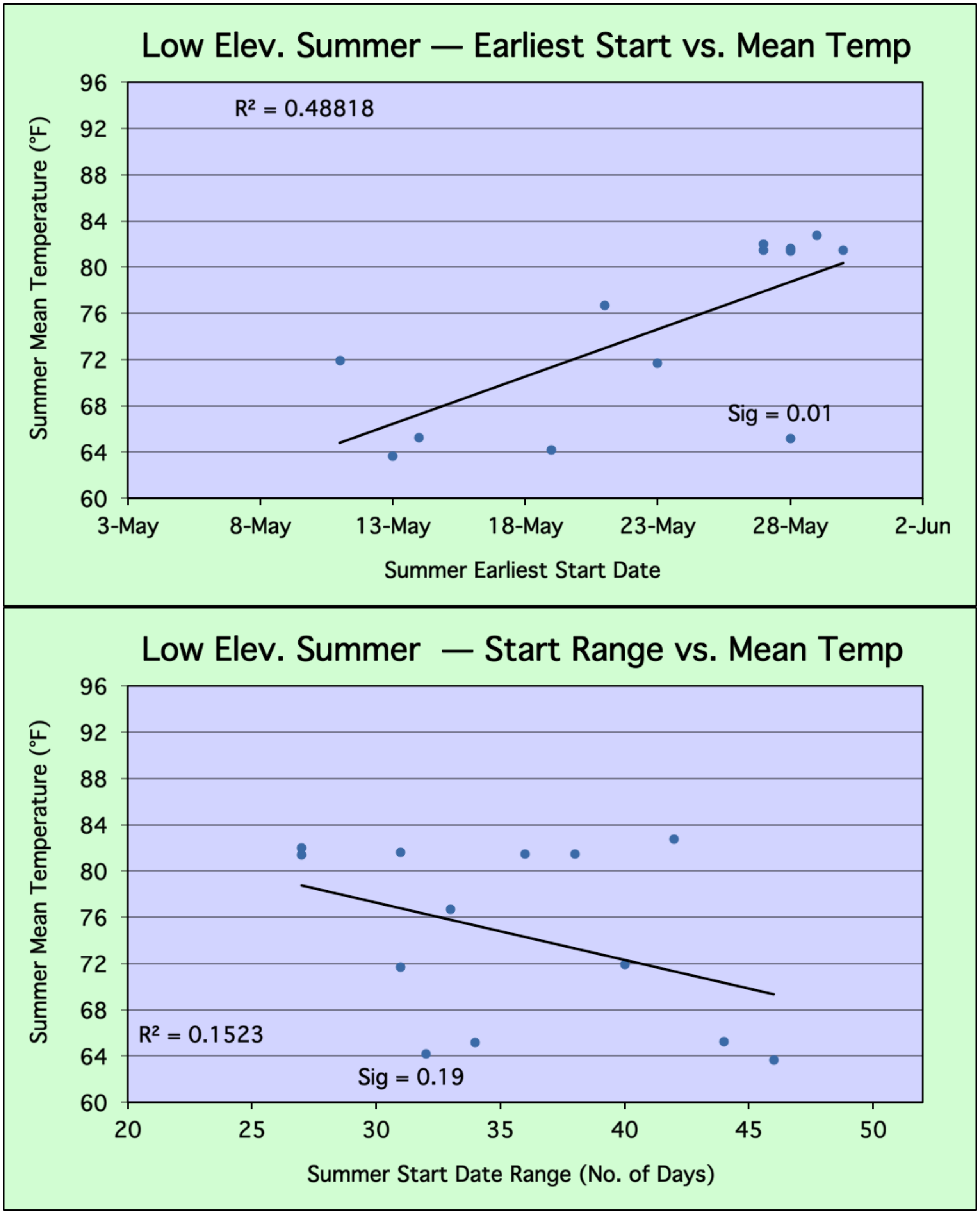


Figures 46a.(top) & 46b.(bottom). For the "High Elevation" stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) the earliest Winter start date and b.) the range of Winter start dates.

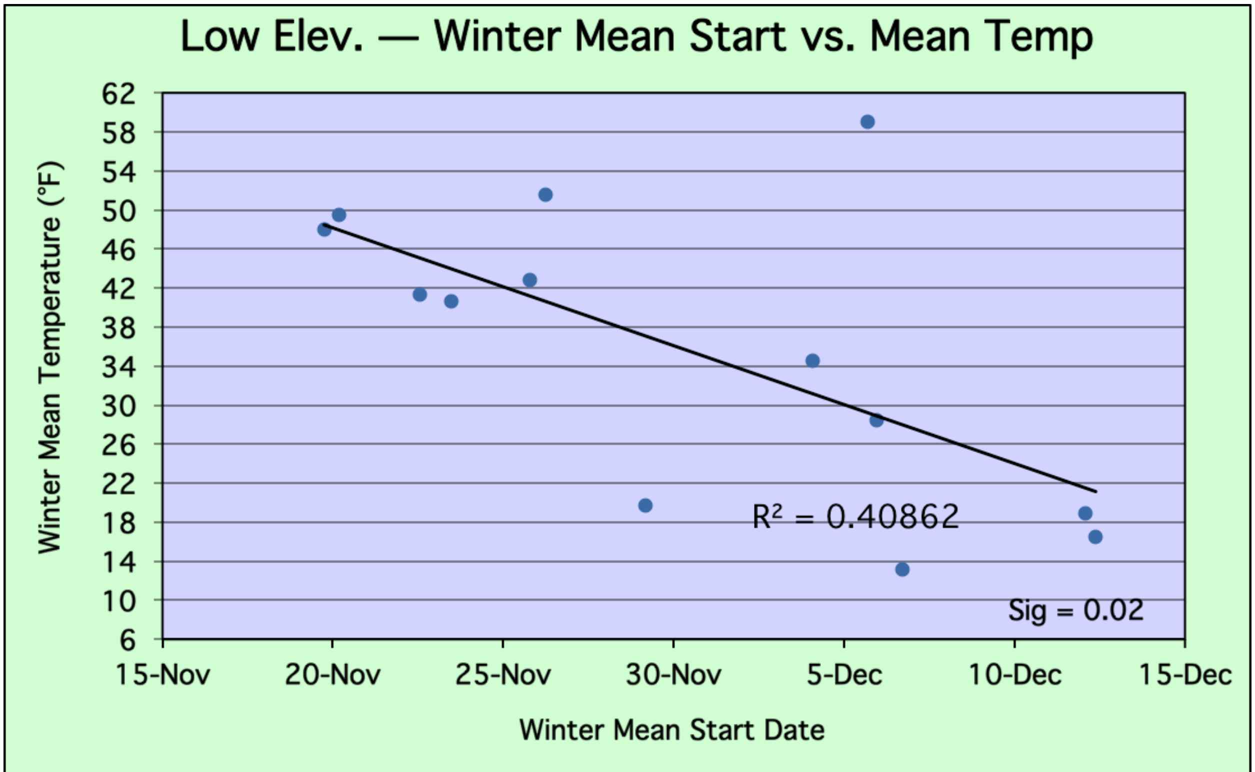


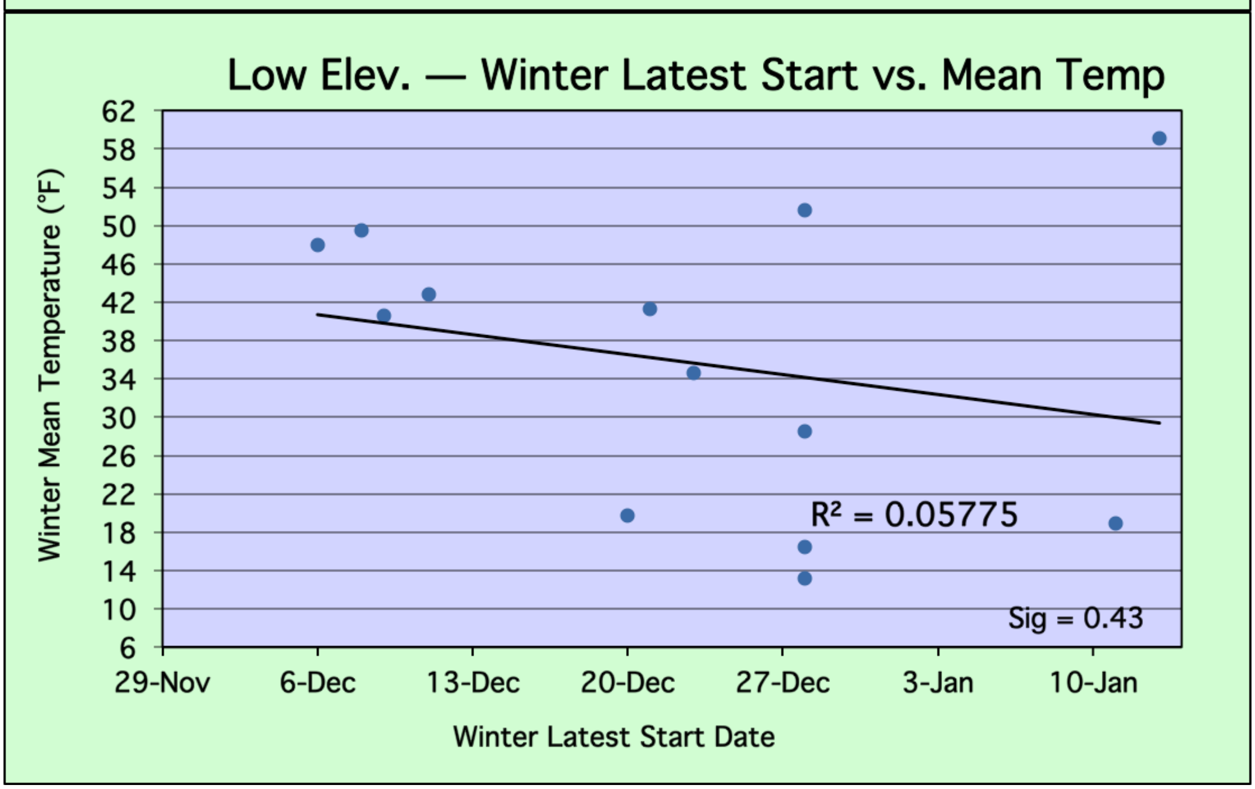


Figures 47a.(top) & 47b.(bottom). For the "Low Elevation" stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) Summer mean start date and b.) the latest Summer start date.

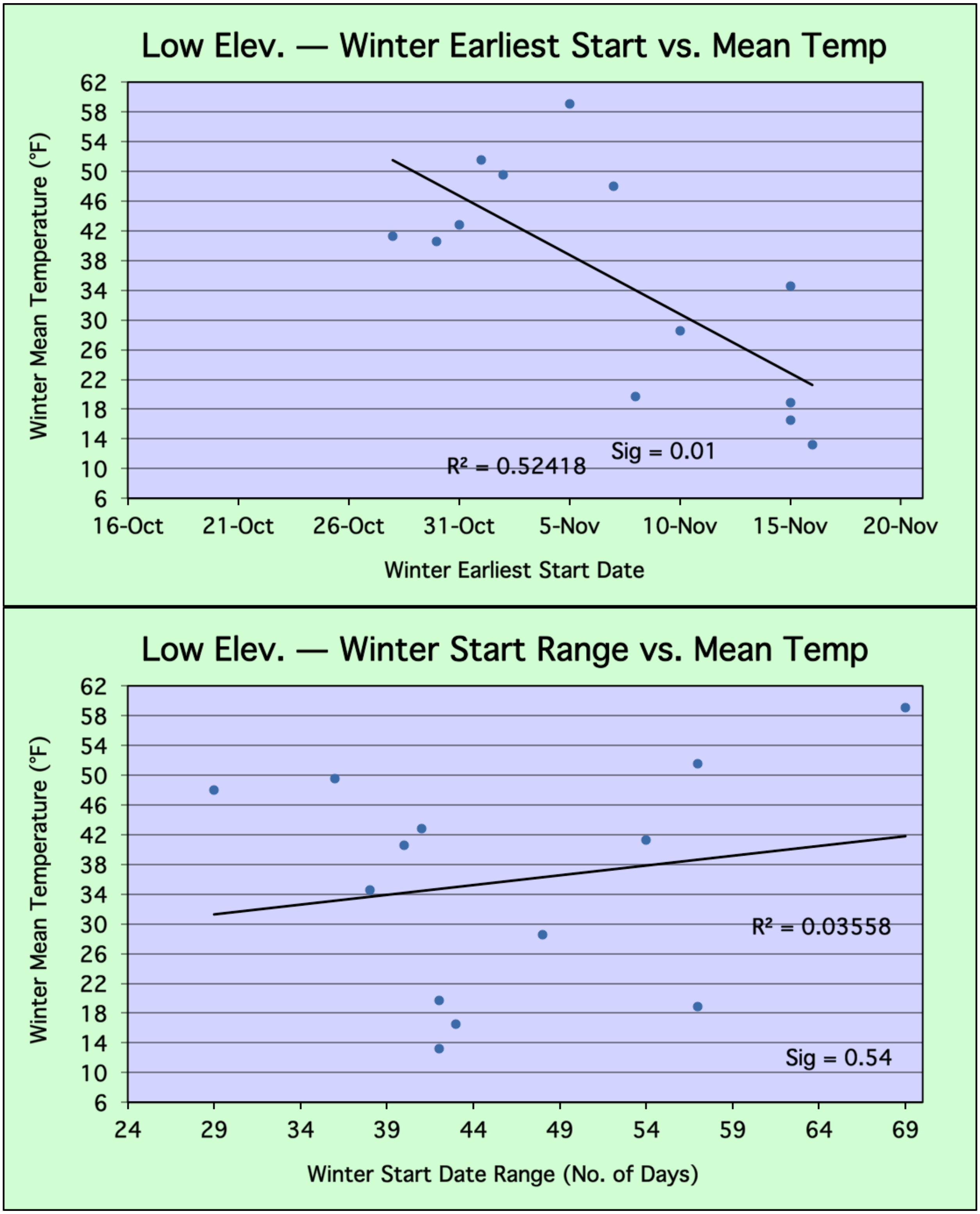


Figures 48a.(top) & 48b.(bottom). For the "Low Elevation" stations (as defined in the text): relationships between the objective Summer season mean temperatures and: a.) the earliest Summer start date and b.) the range of Summer start dates.





Figures 49a.(top) & 49b.(bottom). For the "Low Elevation" stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) Winter mean start date and b.) the latest Winter start date.



Figures 50a.(top) & 50b.(bottom). For the "Low Elevation" stations (as defined in the text): relationships between the objective Winter season mean temperatures and: a.) the earliest Winter start date and b.) the range of Winter start dates.

Table 13. Summary of aggregated station analyses, with relationships between mean objective season temperatures and season start dates for a.) all stations combined; b.) main climate classifications; c.) population groupings; and c.) elevation groupings.

↑ (red)	Significant Relationship: Later Start With Higher Mean Temp
↓ (red)	Significant Relationship: Later Start With Lower Mean Temp
↑	Indicates Non-Significant Trend (Increasing Temp or Later Start Date)
↓	Indicates Non-Significant Trend (Decreasing Temp or Earlier Start Date)

Station Groups	Summer Mean Start Date v. Mean Temp	Summer Latest Start Date v. Mean Temp	Summer Earliest Start Date v. Mean Temp	Summer Start Range v. Mean Temp
All Stations	↑	↓	↑	↓
Köppen Classification:				
Arid	↓	↓	↑	↓
Temperate	↓	↑	↑	↑
Cold	↑	↓	↑	↓
Population:				
Low (<100,000)	↑	↑	↑	↓
High (>100,000)	↓	↓	↓	↓
Elevation:				
Low (<1,000 Ft.)	↑ (red)	↑	↑ (red)	↓
High (>1,000 Ft.)	↓	↓	↑	↓

Station Groups	Winter Mean Start Date v. Mean Temp	Winter Latest Start Date v. Mean Temp	Winter Earliest Start Date v. Mean Temp	Winter Start Start Range v. Mean Temp
All Stations	↓ (red)	↓	↓	↓
Köppen Classification:				
Arid	↓	↓	↑	↓
Temperate	↑	↑	↓	↑
Cold	↓	↓	↓	↑
Population:				
Low (<100,000)	↓	↓	↓	↑
High (>100,000)	↑	↑	↓	↑
Elevation:				
Low (<1,000 Ft.)	↓ (red)	↓	↓ (red)	↑
High (>1,000 Ft.)	↓ (red)	↓ (red)	↓	↓ (red)

Conclusions & Future Work

Regarding the Original Hypothesis

Although the use of this technique for specifying objectively-defined did not produce clear-cut results in many of the analyses in all locations, it did show some significant abilities to identifying secular changes in some locations and, perhaps, in some more broadly defined areas. In the sense that this avenue of research was proven to be a useful tool in identifying secular changes in objectively defined climatological seasons, the results have been less than a universally definitive affirmation. Since this was intended as a "first expedition" into this line of inquiry, this comes as no particular surprise.

Major Caveats

The potential for spurious correlations should be recognized. A broad-based search for relationships, such as this, can easily give rise to false indications of significance. If $p \leq 0.05$, it only takes twenty random correlations to have this appear in at least one case.

Most weather observing stations used in these analyses have not been rigorously examined for factors that could influence the data. This can include, but not necessarily be limited to, changes in or deterioration of measuring equipment used, shifts in siting of the station or equipment, and land use or population changes near the station.

The elevations shown for each station give no indication of comparative relief or variations in local terrain. This can have a big effect on the ways in which the station elevation can be related to the seasonal characteristics. Without additional information, simply knowing the height above sea-level may not properly represent these relationships.

Rugged terrain, especially that found throughout the western U.S., causes climatic conditions to vary considerably over relatively short distances. For this reason, the actual Köppen climate classification types for any location may vary from what is indicated.

Determination of the warmest or coldest 91-day average for a given year can be extremely sensitive to small differences in the daily average temperatures at the very beginning and end of the chosen period. In order to separate one start date from adjacent ones, season average temperatures often have to be calculated to two decimal places. Since daily observations of maximum and minimum temperature are made to the nearest whole degree (F), this represents a level of precision not altogether supported. Within a reasonable level of certainty, the season start date as defined here could be shifted by one or two days. Fortunately, the significant changes seen are of a magnitude that can be supported by the observations.

Applicability

Perhaps the best attribute of this particular approach to the objective definition of seasons lies in its simplicity. It uses the daily temperature data itself and, in so doing, allows it to define the seasons by the parameters that have been naturally adopted for the concept, *i.e.*– Winter is the coldest period of the year and Summer is the warmest.

The definition of Summer and Winter seasons can certainly prove useful in and of itself. For any given year, it can be determined to what extent its temperature may have deviated from the value calculated for the typical fixed season. Likewise, a more adaptable start date for that particular season can be derived to answer questions such as, "Did Winter arrive early this year?" or "Was Spring unusually brief?". In this sense it can only be used in a post-event context, with no value in forecasting prior to, or even in the midst of a season.

This approach has been a good “first-cut” examination of the data in regard to this technique. First, a reasonable number of stations was used in the analyses, so that the opportunity would exist to perform whatever manipulations of the data presented themselves as potentially interesting. Second, the stations were chosen to represent a diverse set of characteristics, primarily climate classification, elevation, population, latitude, and proximity to the coast. The net result of this is that many of the individual stations chosen did not demonstrate significant results with this approach. Some did, however, and that provides some guidance as to where this may be usefully applied and expanded.

Future Work

This approach has revealed some avenues of further investigation where its usefulness may be maximized. In general, the stations which did seem to suggest more positive results in regard to identifying temporal trends and consistent responses with this method of defining seasons, were the colder stations used, particularly those located in the farther northern reaches of the contiguous U.S. along the Canadian border.

It can be seen in Figure 4. that relatively few stations showed any significant regression relationship of objectively defined season start date over time, either Summer or Winter. In the case of Summer, the four stations with significance were Caribou, ME; International Falls, MN; Pellston, MI; and Sault Ste. Marie, MI. Each of these stations has a long-term mean annual snowfall of 60 inches or more and notable snowfall in an average of nine months of the year.

Snowfall and the amount, extent, and duration of snow cover, both on an averaged basis and varying from year to year, can have a profound effect on atmospheric radiation processes and thereby the temperature near the ground surface (Leathers and

Robinson, 1993). The temporal trend toward the reduction of overall Northern Hemisphere snow cover, especially in the Spring season (Rupp, *et al.* 2013) could well be a contributor to some of the relationships seen here and others yet to be found.

In addition to the suggestion that snowfall may play a roll in the response of the seasonal temperatures to this technique, colder locations, whether or not especially snowy, have shown a tendency for better correlations. The four stations mentioned above are all in the Cold climatic classification. The trend toward later start dates for Summer could well be due to later or more severe cold outbreaks in the early Spring period. Of the stations with a significant trend toward a later start to Winter, three of the four such stations are classified as Cold: Caribou, ME; International Falls, MN; and Spokane, WA.

From the standpoint of making the most out of this approach to defining and analyzing seasons, these observations suggest, it might be most useful to expand the number of stations used in such work. In particular, this will make it more likely that meaningful results will be obtained when the stations are grouped into different categories. The most profitable additions would seem to be those in the colder and snowier locations in North America. That would obviously call for an expansion of this work to Canadian and Alaskan stations.

Based on the limited results from the grouping of stations (see Table 13.), it seems likely that selecting additional stations in order to fill out a range of elevations would be an interesting avenue of investigation. Here, even when the available opportunity was only to divide stations into two relatively sparsely populated elevational groups, a measure of success was found. Sizeable expansion of the dataset might improve this even more and lead to finding additional elevational relationships.

It would, however be important to not only know the absolute elevation above sea level for each station, but also its relationship to the surrounding terrain. This might well include the elevation above a large plateau or tableland, surrounding areas of lower or higher elevation, the availability of an outlet for cold air drainage and relationship to upwind or downwind features.

The data used in this thesis, and any additional data collected can further be analyzed to determine the length of the transitional seasons (Spring and Fall) to look for changes or significant trends, in much the same way as Summer and Winter were examined. Existing data regarding objective season start dates could be used to calculate the resulting length of the transitional seasons. Also, the original station daily temperature data can be used to generate average temperatures for these variable length seasons. Not only can these be evaluated for trends in seasonal temperatures; but also, instead of looking for trends in season start date, the investigation could also be for trends in transitional season length.

Although this analysis allows flexibility in establishing the starting date for Summer and Winter, it, by definition, does not allow for variation in the length of those seasons. One way of examining the way in which the 91-day constraint may be affecting or confounding results would be to perform a sensitivity analysis. Running these analyses with differing season lengths (*e.g.*– 92-day, 90-day, 89-day, *etc*.) would potentially show where anomalies and changes in significance exist, and might suggest a better season length to use.

A potentially useful variation would be to redefine seasons, not by temperatures themselves, but by degree-days. An advantage of this would be that these can be calculated from the same basic daily temperature dataset. For the Summer season, this could represent the defined period over which the highest amount of accumulated warmth is seen. This would involve the establishment of a base temperature above which degree-days would begin to be counted. The Winter could be defined as the period with the largest amount of accumulated cold, by using an inverted degree-day measure of average temperatures below a certain threshhold (analagous to heating degree-days). Such research could also begin with a moving 91-day period and branch out to encompass transitional seasons and a sensitivity analysis of season length.

Beyond this, is a line of research that also uses the same basic dataset, but that anchors the definition of seasons to the phenology of plants or animals. Season start and/or stop dates can be chosen based on climatic conditions that act as determinants of their growth, survival, range or other important characteristics. Although this would probably not be applicable to four strictly climatologically based seasons, it would certainly be a method of looking for secular trends in the length and characteristics of these "applied definition" seasons.

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Appendix A1.
Glossary of Abbreviations

AP	Airport
Coop	Cooperative Observing Station
CRN	Climate Reference Network
FLD	Field
GHCN	Global Historical Climate Network
HCN	Historical Climate Network
IPCC	Intergovernmental Panel on Climate Change
NCDC	National Climatic Data Center
NCEI	National Center for Environmental Information (Formerly NCDC)
NOAA	National Oceanic and Atmospheric Administration
US48	The contiguous 48 United States

Appendix A2.
Objective Season Dataset

The following dataset was generated in the course of this thesis research and is summarized here for reference and use in additional analyses. It is grouped by each of the thirty contiguous U.S. stations that were used here.

Each station's data includes the following:

Year	The calendar year in which the objectively defined season *nominally* began. (If the Winter was determined to have started on or after January 1 of the following calendar year, it is assigned to the previous year.)
Sum St	The day on which the objectively defined Summer season started. This is given as the sequential day of the year (365-day year, no February 29).
Sum T	The average temperature (°F) of the objectively defined Summer season.
Wint St	The day on which the objectively defined Winter season started (Sequential day of the 365-day year).
Wint T	The average temperature (°F) of the objectively defined Winter season.

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	Albuquerque, NM				Asheville, NC			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	144	76.96	331	33.12	171	71.10	328	40.96
1975	155	75.47	323	36.13	165	72.04	317	37.61
1976	153	75.18	316	32.94	160	70.30	326	32.14
1977	151	77.24	331	38.55	163	73.99	340	32.23
1978	160	77.89	330	35.79	175	73.52	333	37.04
1979	165	78.68	319	38.77	168	71.69	336	38.89
1980	157	79.54	319	38.17	177	75.27	321	36.24
1981	156	78.17	323	38.23	156	73.73	325	36.27
1982	161	77.73	327	35.59	143	72.85	339	39.95
1983	168	79.08	326	36.35	166	75.16	347	35.96
1984	167	76.67	321	34.67	156	70.94	324	37.80
1985	157	76.42	318	38.98	151	70.99	336	36.83
1986	156	74.79	335	35.82	149	73.52	334	38.06
1987	161	75.44	325	36.60	151	73.64	334	37.05
1988	154	75.98	320	35.47	167	72.82	332	40.17
1989	161	76.45	331	35.67	168	72.04	320	39.55
1990	155	76.76	325	36.56	165	73.64	354	42.20
1991	165	75.87	325	36.88	171	72.98	328	42.21
1992	169	75.24	324	36.59	175	71.98	334	39.73
1993	163	77.18	329	38.07	159	74.95	324	36.30
1994	153	80.41	317	40.89	154	72.38	345	39.56
1995	163	78.86	343	41.52	154	73.07	325	36.48
1996	154	77.47	332	37.24	165	71.76	324	39.05
1997	168	76.52	336	36.30	163	71.13	316	39.44
1998	170	77.18	323	40.86	161	73.87	349	40.64
1999	165	75.11	325	40.25	161	72.74	330	40.02
2000	149	78.25	310	36.27	162	71.92	318	36.08
2001	158	77.54	327	37.05	164	72.62	346	40.49
2002	149	78.61	337	40.07	174	73.04	326	37.02
2003	149	79.32	327	37.26	158	71.90	333	36.73
2004	153	75.95	317	39.92	159	71.58	345	39.54
2005	164	78.06	329	39.58	155	73.06	321	39.59
2006	140	76.93	331	35.66	159	72.82	338	39.45
2007	166	78.75	326	36.36	167	73.42	348	40.60
2008	151	76.58	325	40.59	153	72.75	313	38.88
2009	163	77.49	333	36.49	152	71.68	339	33.53
2010	155	78.23	318	37.53	153	75.45	321	34.93
2011	156	80.47	330	38.10	150	75.32	333	42.80
2012	159	79.92	336	36.51	161	74.12	345	40.69
2013	158	78.68	326	37.05	158	72.36	323	36.90
2014	148	77.08	341	39.81	166	72.52	341	37.85
2015	166	77.95	315	38.32	164	74.77	337	41.58
2016	154	78.42	322	40.74	163	75.86	323	44.10

	Bakersfield, CA				Bismarck, ND			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	178	84.91	329	48.69	171	71.10	328	40.96
1975	188	83.65	321	49.87	165	72.04	317	37.61
1976	164	83.21	319	50.52	160	70.30	326	32.14
1977	166	85.78	323	55.99	163	73.99	340	32.23
1978	156	83.95	336	49.74	175	73.52	333	37.04
1979	175	83.15	322	53.36	168	71.69	336	38.89
1980	192	82.52	316	51.35	177	75.27	321	36.24
1981	167	86.30	321	50.25	156	73.73	325	36.27
1982	165	85.09	312	46.97	143	72.85	339	39.95
1983	175	80.86	331	49.57	166	75.16	347	35.96
1984	173	83.38	319	46.32	156	70.94	324	37.80
1985	155	81.87	315	48.42	151	70.99	336	36.83
1986	160	81.60	334	47.80	149	73.52	334	38.06
1987	157	78.80	325	48.31	151	73.64	334	37.05
1988	164	83.36	322	46.32	167	72.82	332	40.17
1989	159	80.12	327	46.50	168	72.04	320	39.55
1990	167	81.89	319	47.99	165	73.64	354	42.20
1991	182	81.79	318	48.07	171	72.98	328	42.21
1992	150	81.26	322	49.44	175	71.98	334	39.73
1993	165	81.54	328	48.71	159	74.95	324	36.30
1994	160	82.84	307	48.99	154	72.38	345	39.56
1995	174	81.53	341	51.66	154	73.07	325	36.48
1996	154	81.76	332	50.15	165	71.76	324	39.05
1997	166	79.92	342	48.44	163	71.13	316	39.44
1998	170	81.81	335	45.99	161	73.87	349	40.64
1999	171	78.73	325	50.66	161	72.74	330	40.02
2000	164	80.37	315	47.66	162	71.92	318	36.08
2001	158	81.92	325	47.74	164	72.62	346	40.49
2002	157	82.65	339	50.95	174	73.04	326	37.02
2003	176	84.18	320	50.91	158	71.90	333	36.73
2004	165	82.30	320	48.42	159	71.58	345	39.54
2005	161	83.03	330	51.25	155	73.06	321	39.59
2006	167	84.38	330	48.11	159	72.82	338	39.45
2007	163	82.75	327	48.60	167	73.42	348	40.60
2008	162	84.21	327	49.80	153	72.75	313	38.88
2009	178	83.96	318	49.85	152	71.68	339	33.53
2010	172	81.53	328	49.59	153	75.45	321	34.93
2011	164	82.94	308	49.92	150	75.32	333	42.80
2012	186	83.79	343	49.40	161	74.12	345	40.69
2013	173	84.07	325	51.51	158	72.36	323	36.90
2014	170	85.34	340	53.84	166	72.52	341	37.85
2015	164	84.23	313	50.12	164	74.77	337	41.58
2016	151	84.77	334	51.84	163	75.86	323	44.10

	Caribou, ME				Cleveland, OH			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	154	63.95	324	12.48	154	69.79	338	30.96
1975	162	65.29	337	9.24	161	71.47	326	28.47
1976	150	63.71	333	8.72	150	70.07	327	18.99
1977	140	63.00	342	12.25	164	70.31	340	21.12
1978	144	65.10	325	13.15	174	72.76	333	25.12
1979	152	64.60	342	13.85	159	70.26	347	26.04
1980	163	63.90	321	12.30	175	71.45	320	25.43
1981	161	64.48	345	11.19	156	70.19	343	24.18
1982	146	62.47	342	16.48	168	69.26	338	34.57
1983	164	64.75	351	12.35	163	74.10	349	24.07
1984	156	63.85	341	12.82	156	69.84	337	27.62
1985	150	62.46	347	11.46	164	68.95	342	25.95
1986	145	60.59	340	12.38	148	70.36	333	30.10
1987	145	62.97	347	13.43	146	72.94	356	27.94
1988	163	64.34	343	10.89	147	73.46	343	30.16
1989	166	63.50	334	10.72	164	71.59	341	29.51
1990	153	65.32	344	14.09	164	70.35	350	31.35
1991	158	64.45	337	10.96	169	73.25	349	32.57
1992	163	61.50	353	9.69	175	68.23	354	29.74
1993	160	64.12	347	7.49	158	72.97	353	24.47
1994	151	64.72	346	13.63	155	71.01	344	30.14
1995	151	65.87	326	11.88	160	75.09	343	25.39
1996	159	63.49	359	12.94	164	70.68	323	30.58
1997	158	62.79	322	15.48	163	69.27	315	34.65
1998	160	64.87	344	15.85	168	71.70	349	29.91
1999	163	65.79	352	14.95	156	72.09	328	30.44
2000	165	62.30	338	11.85	159	69.10	335	27.20
2001	163	64.87	360	17.60	162	71.82	358	33.89
2002	164	63.76	350	9.35	172	74.26	337	25.36
2003	168	64.39	335	13.34	167	71.57	333	28.23
2004	165	62.13	347	12.28	159	69.37	348	27.71
2005	161	64.93	338	16.42	155	74.43	336	32.16
2006	145	64.79	353	14.01	166	71.51	353	28.99
2007	161	62.82	335	13.39	163	71.65	346	29.91
2008	159	64.38	339	10.77	157	72.18	338	26.31
2009	165	63.68	333	21.06	168	70.71	339	28.71
2010	161	66.46	343	16.16	144	74.64	337	26.10
2011	157	64.68	341	16.84	156	73.80	340	34.54
2012	161	66.47	330	16.57	160	74.88	356	29.96
2013	150	63.63	346	10.89	165	72.13	358	23.81
2014	159	66.11	363	9.82	162	70.44	363	23.58
2015	172	65.37	360	19.24	161	71.55	340	34.10
2016	167	66.08	339	16.57	162	76.16	323	34.96

	Daytona, FL				Elkins, WV			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	182	79.99	316	62.21	156	65.49	320	30.51
1975	177	80.41	317	57.09	161	68.36	318	32.09
1976	165	79.91	327	54.99	158	67.04	327	22.53
1977	163	82.68	340	54.34	163	68.57	340	20.52
1978	157	82.24	346	59.26	175	69.36	328	27.49
1979	181	80.82	338	57.19	167	66.86	348	28.30
1980	170	81.95	332	54.49	175	69.56	320	26.35
1981	151	82.12	310	58.31	160	66.69	325	27.40
1982	169	79.89	369	57.02	139	66.87	340	32.65
1983	172	80.62	346	56.24	165	68.01	349	27.41
1984	180	80.02	326	59.58	156	66.96	324	29.71
1985	152	81.26	340	57.42	165	66.82	342	28.14
1986	153	80.88	355	58.89	148	68.41	338	30.57
1987	173	81.74	357	57.86	142	69.97	335	29.28
1988	176	81.45	333	62.05	157	68.92	336	32.08
1989	160	81.78	320	60.26	169	69.21	333	30.30
1990	171	81.75	339	63.30	166	69.43	334	34.66
1991	166	82.20	350	59.90	171	69.88	328	33.55
1992	159	81.66	379	60.92	175	67.55	354	31.99
1993	158	81.63	339	58.92	159	71.54	340	28.45
1994	159	80.28	345	58.68	155	69.55	345	32.20
1995	187	80.70	355	56.85	153	71.23	325	27.75
1996	172	80.25	326	60.75	158	67.70	323	32.98
1997	168	80.99	348	59.47	163	66.81	315	34.47
1998	152	83.45	359	61.70	160	68.47	357	31.43
1999	166	81.80	331	59.51	158	68.17	330	31.13
2000	180	80.99	315	56.51	164	67.59	318	27.53
2001	159	80.92	350	60.34	162	68.13	341	33.75
2002	186	81.48	321	55.76	175	69.85	332	27.44
2003	157	80.42	333	58.63	157	68.77	333	28.46
2004	170	82.05	345	58.82	160	68.35	348	33.16
2005	177	82.54	326	59.23	155	72.75	334	33.54
2006	160	81.30	374	61.74	165	68.69	338	30.34
2007	169	82.66	350	62.82	164	68.96	335	32.97
2008	175	81.57	341	59.82	156	68.05	330	30.42
2009	161	81.93	353	54.55	152	68.23	340	26.63
2010	165	83.20	331	55.69	155	71.31	331	27.27
2011	164	82.15	333	62.46	157	70.85	341	35.32
2012	171	81.16	351	61.02	160	71.06	356	31.73
2013	158	81.81	359	60.13	165	69.48	358	27.09
2014	171	81.86	330	60.15	159	69.04	341	27.60
2015	164	82.46	341	62.12	162	70.30	338	34.17
2016	154	83.17	354	63.54	172	72.13	323	36.42

	El Paso, TX				Fresno, CA			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	143	80.75	330	43.72	178	79.85	330	45.46
1975	154	80.57	316	44.91	186	76.76	321	44.97
1976	153	78.82	316	42.64	163	76.64	315	46.69
1977	158	82.11	333	47.75	166	81.10	323	51.25
1978	150	82.92	337	43.92	156	80.33	314	46.10
1979	164	81.94	318	44.82	174	80.87	321	48.90
1980	154	85.35	319	45.61	166	80.80	316	47.93
1981	157	81.96	323	46.70	166	83.74	321	45.90
1982	157	83.05	328	44.07	165	79.58	312	46.51
1983	163	81.74	327	45.26	174	80.42	324	49.40
1984	155	80.43	321	42.48	173	84.95	318	45.76
1985	158	80.05	318	45.17	155	83.22	315	48.88
1986	156	79.63	328	43.21	160	82.62	333	48.33
1987	163	79.79	329	42.79	157	78.75	325	46.09
1988	154	79.10	323	44.37	164	82.82	321	44.35
1989	141	81.07	330	44.49	159	79.89	329	45.16
1990	154	81.29	332	46.41	168	81.32	319	46.59
1991	161	79.45	324	46.17	182	80.72	318	47.15
1992	162	83.22	323	46.51	150	80.76	322	47.99
1993	150	83.65	319	46.78	164	80.21	327	46.96
1994	151	87.79	317	49.46	161	81.62	312	48.24
1995	162	82.23	343	48.70	174	81.08	341	50.91
1996	129	82.63	331	45.88	153	82.29	331	49.18
1997	170	82.09	336	44.84	166	80.21	341	47.76
1998	163	82.26	324	48.65	170	81.69	335	45.79
1999	167	81.10	326	48.18	165	79.45	325	50.19
2000	166	82.41	311	43.73	152	80.02	319	46.93
2001	147	82.99	328	44.73	158	81.56	325	47.25
2002	159	83.98	316	46.99	156	81.24	339	50.25
2003	151	83.51	327	45.18	176	83.09	326	48.38
2004	135	81.55	317	46.37	165	81.64	317	48.11
2005	154	83.19	320	48.69	161	82.46	330	50.26
2006	137	82.48	331	45.19	167	83.67	330	47.14
2007	153	82.43	326	46.62	163	82.31	329	47.37
2008	145	82.02	328	48.90	161	83.33	327	47.82
2009	155	84.35	333	45.24	178	82.77	316	48.88
2010	146	84.45	320	45.91	160	80.54	327	48.61
2011	156	86.76	327	46.10	165	81.78	322	48.84
2012	158	84.52	336	45.81	186	83.89	335	49.73
2013	148	84.27	326	45.71	173	84.24	325	50.90
2014	148	84.29	311	47.99	170	84.93	341	52.23
2015	161	84.90	320	47.03	157	82.81	313	48.45
2016	154	84.77	326	50.59	148	82.57	334	49.55

	Ft. Smith, AR				Grand Junction, CO			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	153	77.27	333	40.31	163	77.35	330	26.18
1975	164	78.97	315	39.97	164	74.67	313	27.07
1976	161	76.71	315	34.27	170	75.54	321	28.40
1977	160	81.84	339	32.65	148	79.23	324	32.01
1978	173	83.55	338	33.05	160	76.22	332	18.64
1979	159	78.35	326	39.53	164	76.21	318	29.99
1980	175	84.98	320	39.08	160	76.32	318	36.95
1981	158	79.91	342	37.57	157	77.85	322	29.21
1982	170	79.45	317	41.81	162	77.27	315	34.98
1983	171	81.32	328	35.35	169	78.06	330	27.15
1984	156	80.35	321	38.42	163	76.14	322	31.51
1985	165	80.77	323	40.26	157	76.32	317	33.20
1986	149	81.13	315	41.94	150	75.34	335	32.05
1987	161	81.13	331	39.60	156	74.20	328	24.03
1988	169	83.04	342	40.15	155	78.13	329	25.24
1989	165	79.23	332	41.53	160	76.12	331	30.29
1990	160	82.34	332	40.63	168	77.38	325	22.25
1991	168	80.98	304	44.41	158	76.20	324	26.69
1992	162	77.89	331	40.56	169	74.22	323	29.80
1993	157	83.61	320	40.62	163	74.20	328	30.70
1994	152	80.13	343	41.94	163	79.67	317	33.92
1995	159	81.17	325	39.42	170	76.29	341	34.81
1996	162	79.30	321	41.77	157	77.18	332	31.65
1997	172	79.94	338	43.57	165	74.43	336	32.25
1998	161	84.88	342	44.44	171	76.46	334	31.87
1999	157	81.85	327	44.82	163	74.47	322	33.36
2000	167	83.08	311	36.47	148	77.60	316	29.92
2001	160	83.05	340	41.22	158	76.70	339	28.23
2002	171	81.41	337	40.16	150	78.05	329	33.92
2003	164	80.76	327	41.46	158	78.55	326	25.79
2004	158	77.86	325	44.55	155	75.52	324	33.08
2005	176	82.65	332	43.32	165	75.67	329	31.29
2006	158	82.46	334	42.88	154	76.88	332	28.43
2007	163	81.34	343	41.48	166	79.05	325	25.08
2008	154	80.84	311	41.72	164	76.63	326	29.06
2009	151	80.38	337	37.44	166	76.05	333	22.13
2010	153	85.17	318	40.04	153	76.45	327	29.05
2011	156	88.37	331	45.36	157	76.63	337	31.80
2012	160	85.75	344	43.74	154	79.08	339	23.80
2013	164	82.35	328	36.99	160	77.21	326	22.17
2014	163	80.16	341	39.85	147	74.17	307	32.71
2015	161	82.24	323	45.54	165	74.75	321	25.99
2016	162	83.20	323	45.74	155	76.92	322	33.60

	International Falls, MN				Las Vegas, NV			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	148	64.79	347	8.69	163	89.20	330	45.75
1975	137	64.85	323	6.01	158	87.27	322	48.18
1976	149	65.56	326	0.05	168	85.33	331	48.16
1977	131	64.15	337	0.46	163	90.57	324	50.45
1978	164	63.59	323	-3.98	158	89.73	316	43.57
1979	158	62.43	345	7.43	173	88.38	322	48.57
1980	141	66.26	320	7.18	160	89.54	318	51.08
1981	153	66.12	343	0.12	157	90.78	323	47.17
1982	164	62.45	316	13.30	162	86.81	313	46.26
1983	162	67.98	315	4.85	168	86.27	325	47.78
1984	151	65.07	333	2.57	163	86.45	322	44.22
1985	172	60.15	328	3.84	156	90.43	317	48.99
1986	143	63.98	314	14.91	161	89.15	335	47.19
1987	147	65.53	348	6.47	159	87.45	317	45.60
1988	146	68.06	341	3.62	163	89.42	323	44.86
1989	161	65.92	325	7.06	160	89.09	330	46.77
1990	159	65.41	344	6.51	169	89.31	325	46.20
1991	152	66.84	327	12.91	158	87.41	324	47.83
1992	149	59.42	333	7.47	171	88.07	324	46.05
1993	156	63.10	332	3.46	165	88.61	328	47.29
1994	148	63.94	339	10.51	162	92.65	307	47.88
1995	150	67.10	341	1.58	174	91.02	337	50.63
1996	159	65.90	350	4.51	155	90.97	331	49.12
1997	152	62.44	314	17.03	168	88.27	336	47.95
1998	164	64.68	341	10.34	171	89.46	330	50.03
1999	155	63.54	326	12.59	164	88.34	336	51.12
2000	156	62.71	334	5.55	142	91.25	315	48.24
2001	160	65.66	358	13.55	158	90.32	327	46.89
2002	165	66.59	347	7.24	157	91.54	339	50.90
2003	164	64.68	325	7.63	147	91.34	326	47.69
2004	179	59.71	347	7.05	155	90.30	324	50.49
2005	165	63.48	334	12.96	162	90.93	329	50.55
2006	143	64.97	333	10.20	153	92.11	330	48.93
2007	160	63.81	330	5.58	165	93.51	325	47.16
2008	156	61.26	337	1.12	164	92.42	327	49.63
2009	166	60.65	336	7.69	174	91.41	319	48.86
2010	155	63.98	336	4.98	151	91.91	328	49.75
2011	164	64.35	333	17.20	162	91.60	334	50.12
2012	157	64.92	355	7.14	163	91.68	335	48.75
2013	164	63.73	333	-3.66	151	91.78	325	50.19
2014	144	62.68	339	7.47	157	90.71	319	53.96
2015	160	63.78	340	14.02	164	92.53	313	48.94
2016	160	63.88	344	12.26	154	93.21	321	51.25

	Lewiston, ID				Medford, OR			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	161	73.96	331	35.45	178	71.87	329	38.57
1975	181	71.63	320	35.95	184	70.03	320	38.73
1976	179	71.12	315	34.22	165	68.34	317	35.51
1977	157	74.57	321	36.47	167	73.09	321	42.57
1978	156	70.92	314	25.14	154	70.00	312	35.13
1979	175	74.12	323	34.04	174	70.74	314	39.53
1980	167	69.57	317	38.08	165	69.35	316	39.45
1981	171	72.97	319	34.74	170	72.60	321	38.95
1982	162	73.45	314	37.10	161	71.41	310	39.71
1983	157	70.94	325	33.23	143	69.02	323	40.12
1984	163	72.58	327	30.15	173	71.69	317	37.88
1985	158	72.49	321	29.52	153	72.09	313	38.95
1986	149	72.90	310	35.51	160	73.21	332	39.70
1987	155	71.72	329	35.08	154	71.78	325	40.14
1988	162	73.31	338	32.01	165	73.93	321	37.51
1989	152	71.54	326	39.35	151	69.56	326	37.81
1990	168	76.04	318	36.96	168	73.60	305	37.03
1991	183	71.07	298	37.79	182	72.80	315	40.66
1992	143	72.96	335	30.80	169	73.45	333	39.10
1993	164	68.09	317	35.70	164	68.33	318	39.00
1994	171	73.95	321	35.61	179	73.04	302	40.75
1995	173	70.99	339	34.23	175	71.74	335	43.72
1996	165	71.19	319	34.68	153	72.36	329	41.15
1997	164	71.86	316	37.41	165	71.38	341	41.49
1998	171	75.74	338	37.39	169	74.32	332	38.53
1999	163	71.31	331	37.86	178	71.36	325	41.23
2000	171	71.28	314	33.33	172	71.48	314	38.80
2001	171	73.35	343	36.35	178	72.45	324	40.96
2002	165	72.56	331	38.49	172	72.91	334	42.80
2003	159	75.19	303	36.08	158	74.09	317	42.18
2004	164	74.35	330	37.88	164	74.26	321	39.98
2005	161	73.23	326	36.58	170	73.34	326	41.08
2006	166	74.99	320	34.64	166	74.52	333	39.21
2007	169	74.59	323	35.17	165	72.92	323	38.26
2008	172	73.11	347	33.96	171	73.91	320	39.02
2009	179	73.75	315	36.88	178	74.32	312	40.77
2010	173	71.31	324	35.36	172	72.14	324	40.80
2011	178	72.34	335	36.19	177	72.68	335	39.12
2012	172	74.95	339	37.26	181	73.77	340	39.08
2013	173	76.22	326	31.71	173	74.99	324	36.55
2014	174	75.34	311	37.92	177	76.64	320	44.90
2015	151	77.02	320	37.55	155	76.70	311	42.40
2016	154	72.52	334	30.52	151	73.93	334	39.56

	Memphis, TN				Midland, TX			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	154	78.97	330	45.55	143	81.87	333	46.18
1975	164	80.97	315	43.08	156	79.10	314	46.69
1976	160	79.31	315	38.13	149	77.69	315	42.67
1977	161	83.48	340	36.35	159	83.88	339	43.37
1978	174	82.13	342	37.77	159	80.08	331	40.95
1979	158	80.82	332	42.29	165	80.46	325	44.80
1980	175	86.86	320	42.30	154	82.22	319	43.18
1981	152	82.99	342	39.10	158	81.31	335	45.79
1982	168	82.51	338	44.88	156	81.70	327	43.57
1983	164	83.15	346	38.88	166	83.31	327	41.41
1984	155	80.74	322	41.58	155	80.46	321	42.03
1985	166	80.43	335	41.96	165	81.58	319	45.16
1986	149	82.69	331	42.75	155	79.33	335	44.45
1987	148	82.23	332	41.59	162	79.75	329	42.11
1988	150	82.14	343	43.75	149	78.71	324	43.69
1989	166	80.48	332	44.10	162	81.54	330	44.65
1990	160	82.57	333	44.72	154	81.30	332	44.81
1991	170	81.98	305	45.92	130	79.14	303	44.55
1992	162	79.12	332	42.92	163	78.75	324	44.52
1993	157	83.59	322	42.46	151	81.36	323	45.75
1994	153	80.90	344	43.26	149	83.26	343	47.36
1995	154	81.11	325	41.26	158	81.04	343	46.53
1996	163	80.07	323	43.90	133	83.58	328	44.15
1997	163	79.93	314	44.87	171	81.51	313	45.71
1998	160	83.52	342	46.24	138	85.23	329	48.74
1999	159	82.14	328	45.23	172	82.23	325	48.15
2000	160	83.65	318	38.25	170	83.65	311	42.11
2001	162	81.43	345	44.54	147	84.58	340	44.26
2002	169	82.04	334	41.30	159	83.59	331	44.68
2003	164	79.90	328	42.62	151	81.92	327	46.07
2004	159	79.27	344	46.34	137	80.54	316	46.37
2005	155	83.23	333	44.40	153	80.59	332	47.02
2006	150	83.17	324	44.26	139	83.04	331	43.05
2007	161	84.59	346	44.30	162	78.98	325	45.13
2008	154	81.47	311	42.84	138	82.49	310	46.71
2009	165	80.44	337	38.49	156	82.52	335	42.18
2010	155	85.43	318	41.03	155	82.53	320	43.68
2011	154	84.62	331	46.90	156	87.62	327	45.55
2012	160	83.69	345	45.07	160	84.50	336	46.66
2013	163	81.18	329	38.41	161	83.36	328	42.68
2014	163	80.38	342	40.48	155	83.52	349	44.80
2015	161	82.76	333	47.58	171	83.65	321	47.57
2016	162	84.67	323	48.01	162	84.18	322	49.70

	Mobile, AL				Pellston, MI			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	154	80.49	316	56.10	153	64.17	377	21.38
1975	165	81.59	316	51.66	139	66.07	351	18.62
1976	159	81.60	316	45.53	149	65.36	333	12.99
1977	161	83.47	340	44.94	135	64.01	341	15.33
1978	173	83.16	343	49.76	167	64.10	333	14.73
1979	167	80.77	327	51.87	158	63.34	350	17.98
1980	169	83.69	322	48.42	164	65.58	320	17.65
1981	159	83.24	336	50.76	154	65.31	343	14.47
1982	155	80.91	363	50.87	167	62.96	338	24.86
1983	163	80.37	346	48.05	163	69.64	347	16.91
1984	156	79.37	323	50.42	152	65.82	352	19.27
1985	150	80.16	336	51.09	173	63.57	346	16.37
1986	149	81.95	336	51.05	145	63.88	338	24.34
1987	170	81.21	332	50.96	146	67.95	356	17.96
1988	175	81.06	332	54.65	147	67.77	342	18.04
1989	168	81.24	319	52.03	166	65.32	341	18.89
1990	164	82.20	333	54.81	159	65.08	347	20.75
1991	171	81.32	306	52.58	152	67.25	358	22.26
1992	167	80.80	330	54.13	153	60.40	354	19.43
1993	155	82.01	322	50.29	157	65.60	355	12.42
1994	155	80.05	345	53.04	150	64.71	344	21.99
1995	174	82.24	325	49.95	160	68.59	343	15.40
1996	164	80.69	330	52.95	163	65.20	353	18.83
1997	177	81.00	338	51.40	155	63.91	358	25.25
1998	160	83.06	350	55.41	164	67.64	350	20.77
1999	162	81.79	316	53.53	157	67.31	328	22.73
2000	168	83.02	314	47.81	157	63.68	335	18.23
2001	165	80.65	348	51.43	162	65.13	360	22.08
2002	175	80.71	317	49.53	173	66.09	349	15.15
2003	158	81.30	333	50.52	172	64.32	357	19.37
2004	162	81.33	345	53.51	179	61.57	352	16.49
2005	180	81.78	320	52.93	154	67.29	339	22.43
2006	159	81.93	324	52.03	145	65.69	354	21.27
2007	158	82.05	348	52.82	161	65.32	363	19.65
2008	167	80.78	319	54.03	156	64.75	338	14.15
2009	160	81.82	339	47.19	168	62.18	339	19.78
2010	156	83.42	330	49.09	160	65.99	341	17.42
2011	151	84.12	332	56.07	155	65.82	339	25.37
2012	161	81.09	345	54.09	159	66.89	356	20.77
2013	162	81.07	331	47.74	164	64.82	354	9.19
2014	169	80.76	341	49.84	162	63.07	343	13.39
2015	162	82.35	337	54.90	171	65.30	360	24.18
2016	157	82.30	323	58.33	166	66.77	348	24.47

	Philadelphia, PA				Phoenix, AZ			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	156	75.06	344	36.91	163	92.90	331	52.01
1975	162	75.73	329	34.91	158	91.19	322	55.95
1976	158	75.47	327	27.17	164	90.55	317	55.93
1977	163	75.74	341	27.46	163	93.80	348	58.16
1978	169	76.30	330	31.57	159	92.90	330	52.15
1979	167	74.33	348	32.76	164	91.87	322	56.26
1980	175	78.12	320	30.66	162	92.96	318	59.19
1981	155	75.00	344	30.58	156	95.08	324	56.82
1982	167	74.17	343	35.99	162	92.92	326	55.83
1983	164	76.76	351	30.57	168	93.83	325	57.13
1984	156	74.43	323	34.20	173	91.29	319	54.09
1985	163	73.85	343	32.42	156	94.37	317	57.69
1986	149	76.07	339	34.05	162	93.62	335	56.84
1987	148	76.99	336	33.60	155	92.87	326	55.54
1988	163	77.60	343	34.86	165	95.01	320	55.39
1989	167	75.61	321	35.40	161	95.03	329	55.81
1990	167	76.19	334	39.04	166	93.03	325	57.75
1991	142	78.02	350	37.13	157	93.02	323	57.74
1992	175	74.31	354	35.59	171	92.25	324	56.41
1993	160	79.46	352	32.16	164	92.64	329	56.70
1994	155	78.44	345	36.68	162	94.00	307	55.69
1995	167	78.96	344	30.96	174	93.69	337	58.21
1996	163	74.85	324	36.35	154	93.88	334	56.52
1997	161	75.05	322	39.90	172	92.65	335	54.52
1998	169	76.95	349	36.35	172	93.41	323	56.84
1999	164	77.52	332	36.14	164	92.21	336	57.92
2000	158	74.04	335	33.56	148	93.38	345	55.71
2001	163	77.31	342	40.40	167	94.23	326	56.02
2002	175	78.26	335	31.35	158	95.30	337	58.70
2003	161	77.01	333	32.62	166	94.92	340	56.48
2004	166	75.04	348	33.91	166	93.27	326	57.08
2005	156	78.30	337	36.81	162	94.30	331	58.12
2006	147	77.05	353	35.85	154	94.62	332	55.39
2007	167	76.53	334	36.87	166	96.03	328	55.05
2008	158	77.15	339	34.12	161	94.31	327	57.95
2009	158	75.51	339	33.58	173	95.29	335	56.66
2010	161	79.82	337	32.83	174	94.69	327	56.64
2011	144	78.53	341	40.44	165	96.15	328	57.27
2012	161	79.02	356	37.07	159	94.64	344	55.74
2013	166	76.86	358	31.54	159	95.32	326	58.10
2014	164	76.42	342	31.76	160	93.95	318	60.01
2015	162	79.14	340	40.79	162	95.52	314	56.05
2016	168	79.80	324	39.74	154	94.68	331	57.96

	Pierre,SD				Roswell, NM			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	152	73.53	347	21.10	143	78.74	331	40.51
1975	163	74.34	321	22.55	154	77.43	314	43.21
1976	155	76.28	313	17.74	159	79.45	316	38.93
1977	152	72.49	339	9.51	158	83.04	340	41.77
1978	164	74.09	331	9.90	159	80.53	337	38.36
1979	162	71.52	345	22.96	164	78.80	324	40.00
1980	161	75.93	318	26.98	147	82.58	318	40.62
1981	166	73.13	342	16.37	157	78.29	334	42.32
1982	164	73.27	316	27.96	158	79.71	327	39.55
1983	161	77.44	324	19.39	168	81.02	327	39.52
1984	162	75.71	330	16.63	156	77.19	320	39.47
1985	158	72.77	326	16.21	165	79.02	319	42.75
1986	147	71.45	311	28.67	155	78.09	329	41.29
1987	157	73.25	330	20.20	162	78.58	329	39.26
1988	146	77.51	341	17.95	149	78.55	323	41.36
1989	161	74.90	325	23.32	162	80.31	331	41.81
1990	168	74.20	337	20.54	155	80.95	332	43.29
1991	161	75.20	302	28.01	155	79.02	303	41.70
1992	159	66.64	336	16.29	162	79.29	324	41.75
1993	157	68.77	333	16.74	151	81.08	319	41.99
1994	168	71.52	342	21.91	151	83.28	318	45.84
1995	164	73.87	343	17.93	160	81.09	343	44.70
1996	162	73.53	321	14.44	128	81.41	331	41.37
1997	168	72.91	353	26.64	171	79.50	313	38.53
1998	172	76.70	346	27.48	163	80.69	333	45.58
1999	153	74.46	326	28.61	169	79.03	326	44.30
2000	172	75.68	339	16.26	170	81.55	310	38.82
2001	160	75.17	359	25.30	147	81.74	339	42.14
2002	160	75.41	346	21.92	159	81.26	317	43.23
2003	163	74.61	325	21.05	151	80.13	327	42.30
2004	173	70.40	331	24.97	137	77.91	316	43.01
2005	164	75.87	331	26.75	153	80.02	332	44.37
2006	146	76.52	329	21.95	140	81.05	331	39.93
2007	160	75.19	330	19.37	161	79.31	325	42.59
2008	154	70.96	347	18.49	149	79.76	324	43.32
2009	167	70.18	336	13.71	156	80.58	334	38.90
2010	154	73.03	344	14.17	146	79.98	318	40.29
2011	164	72.49	337	26.89	156	84.60	327	40.97
2012	156	75.76	340	21.26	160	83.03	336	42.54
2013	165	73.07	331	15.91	159	81.68	325	39.43
2014	161	69.88	339	22.36	151	80.29	341	41.47
2015	157	72.49	321	24.40	171	81.76	321	41.52
2016	159	74.08	321	19.31	154	82.11	322	44.34

	Salt Lake City, UT				San Angelo, TX			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	163	76.92	331	31.26	148	81.74	329	46.60
1975	172	73.41	347	30.01	156	79.70	314	47.30
1976	170	73.46	331	29.98	161	79.02	315	43.40
1977	164	75.36	323	37.69	184	84.83	343	44.12
1978	160	75.03	330	26.97	161	81.89	331	42.08
1979	162	76.43	319	31.79	165	81.34	325	46.14
1980	168	74.49	318	32.76	156	84.79	319	46.20
1981	172	76.55	322	32.25	159	80.27	335	46.96
1982	162	75.68	314	33.48	168	82.49	327	45.97
1983	171	75.54	345	26.45	172	81.64	327	41.97
1984	173	76.43	335	26.65	156	82.39	321	43.81
1985	157	76.99	317	29.40	166	81.40	320	47.85
1986	161	75.31	334	30.64	157	81.13	328	46.41
1987	156	74.54	326	29.02	167	80.07	330	44.63
1988	161	78.03	328	24.71	155	80.70	342	47.28
1989	159	75.73	331	31.97	162	81.75	330	47.18
1990	169	77.87	325	26.70	144	81.32	332	46.52
1991	159	76.25	324	30.28	164	80.52	303	47.95
1992	144	74.56	324	26.47	163	81.45	325	47.13
1993	165	70.63	319	33.18	152	83.99	320	48.28
1994	163	79.64	306	32.82	155	84.73	343	48.66
1995	173	75.04	336	33.55	170	81.97	323	47.97
1996	157	77.69	335	34.78	133	83.76	328	45.89
1997	168	75.91	343	33.57	174	82.40	313	47.29
1998	171	76.27	339	33.85	137	84.85	340	50.75
1999	164	75.49	325	34.92	173	82.89	327	51.55
2000	153	77.51	315	29.46	165	85.66	311	43.98
2001	158	77.46	338	26.27	147	85.15	339	46.79
2002	164	77.39	339	36.03	159	82.48	332	46.57
2003	160	78.94	326	27.26	151	81.46	332	48.29
2004	154	74.74	324	33.00	149	80.71	333	48.78
2005	162	76.99	327	32.14	158	81.18	332	48.97
2006	152	77.79	327	28.97	148	84.07	333	45.54
2007	161	80.22	326	27.24	150	79.09	325	47.70
2008	164	77.26	326	32.21	140	83.66	310	49.53
2009	173	75.90	317	29.20	157	85.04	335	44.86
2010	174	75.49	326	30.52	155	85.79	318	47.32
2011	173	76.31	336	33.03	156	89.37	331	48.80
2012	163	80.06	339	27.29	160	86.30	341	49.99
2013	160	81.72	325	29.41	161	83.73	328	44.11
2014	171	75.97	307	37.23	163	83.05	349	47.03
2015	157	78.07	320	31.23	172	84.57	321	49.58
2016	155	80.57	334	31.95	162	84.56	322	51.43

	Sault Ste Marie				Seattle, WA			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	152	63.11		17.84	178	64.91	356	40.15
1975	159	64.25	351	14.58	180	64.65	345	40.53
1976	149	63.86	332	9.84	178	64.24	321	43.25
1977	134	59.52	359	12.73	156	65.79	321	43.27
1978	167	62.04	332	10.86	152	65.21	313	38.10
1979	158	61.94	346	16.06	174	65.09	323	39.95
1980	163	62.44	320	12.81	169	62.03	317	43.38
1981	154	61.03	343	10.71	173	64.81	330	40.80
1982	167	58.53	338	19.88	161	64.49	314	42.63
1983	163	67.97	347	12.46	157	63.26	332	41.07
1984	152	62.74	352	14.94	173	64.03	325	37.37
1985	176	61.25	346	13.68	160	64.91	314	38.55
1986	145	60.89	338	22.27	160	64.81	308	42.35
1987	147	64.37	356	15.51	176	65.10	328	40.68
1988	148	64.45	342	14.80	165	64.60	342	38.87
1989	164	63.64	341	16.06	175	64.73	344	41.55
1990	162	61.63	347	16.96	176	66.44	317	40.18
1991	152	64.59	358	18.33	179	65.54	326	44.14
1992	149	58.10	354	16.21	155	66.21	333	39.49
1993	157	62.51	355	8.76	163	63.30	320	41.63
1994	150	61.29	344	19.09	183	66.62	302	43.31
1995	160	64.52	343	11.81	174	65.54	336	41.69
1996	161	61.47	352	15.50	170	65.20	319	40.02
1997	154	62.70	354	23.35	178	64.86	340	42.81
1998	165	66.76	350	17.71	171	66.23	332	41.37
1999	157	64.88	351	19.62	175	62.98	354	41.73
2000	164	62.90	339	16.07	172	63.32	337	41.00
2001	162	65.97	359	21.77	168	62.77	354	40.91
2002	173	67.54	349	15.41	170	64.24	333	43.43
2003	171	64.45	358	17.50	157	66.00	323	41.41
2004	180	61.75	351	15.35	166	66.64	329	42.03
2005	171	66.64	337	20.85	167	64.86	326	43.77
2006	162	65.38	355	18.69	165	66.27	313	40.03
2007	160	65.38	363	18.90	169	65.49	323	39.73
2008	156	63.64	338	14.17	170	64.98	346	38.59
2009	167	62.70	338	20.16	149	66.37	316	43.53
2010	161	65.91	341	16.56	173	63.78	348	41.31
2011	165	66.12	339	23.82	178	64.92	308	40.53
2012	158	67.96	355	19.35	178	65.09	328	41.30
2013	164	65.09	348	9.06	167	68.35	326	41.46
2014	162	63.03	362	12.00	174	68.09	311	44.98
2015	176	65.74	359	23.27	154	69.38	313	43.01
2016	165	67.48	348	23.37	151	66.44	339	38.96

	Spokane, WA				Waterloo, IA			
Year	Sum St	Sum T	Wint St	Wint T	Sum St	Sum T	Wint St	Wint T
1974	161	68.21	333	26.28	148	70.40	349	19.25
1975	181	65.98	320	29.47	155	72.97	325	22.80
1976	179	66.03	317	27.45	156	70.95	314	10.63
1977	157	68.09	321	28.13	132	71.09	339	8.44
1978	153	65.69	313	17.33	165	72.41	332	10.93
1979	174	68.69	322	28.02	164	71.55	346	20.36
1980	170	64.80	318	31.67	161	72.90	319	20.85
1981	173	66.97	319	28.67	153	70.04	343	12.75
1982	161	69.08	314	30.69	166	70.65	317	26.93
1983	157	66.79	332	26.44	162	75.94	315	16.59
1984	162	67.32	326	22.04	155	71.14	333	18.15
1985	160	67.63	314	22.04	172	70.51	323	14.30
1986	146	67.87	310	28.90	148	70.99	313	24.11
1987	163	66.52	318	27.42	145	74.27	331	18.92
1988	162	67.92	338	25.42	146	75.93	341	20.45
1989	152	66.01	326	31.13	161	72.26	332	22.73
1990	167	68.80	330	28.20	162	72.36	337	18.52
1991	182	66.99	297	31.88	152	73.17	327	26.40
1992	143	68.89	335	23.26	151	67.17	352	20.42
1993	164	62.63	317	30.14	157	72.02	337	15.76
1994	179	68.84	321	30.88	149	70.36	343	21.15
1995	172	65.65	339	27.35	160	74.58	342	18.72
1996	153	66.33	319	27.10	162	71.83	322	17.53
1997	184	67.03	312	32.32	154	70.68	314	25.63
1998	170	71.59	332	31.73	169	71.95	349	23.41
1999	163	66.25	331	30.91	157	72.46	327	24.38
2000	171	65.67	314	25.59	157	71.04	336	14.68
2001	178	68.20	343	29.72	160	72.36	347	27.82
2002	165	67.36	335	33.54	162	73.48	345	21.85
2003	159	69.89	324	27.71	164	73.10	327	21.52
2004	164	69.55	330	30.93	158	68.36	347	23.36
2005	161	67.55	331	29.75	152	72.07	333	23.30
2006	166	69.81	330	28.19	147	72.32	333	21.64
2007	169	69.70	324	27.14	161	72.54	342	16.11
2008	172	68.29	347	25.52	155	71.49	335	16.60
2009	179	69.45	315	31.71	150	68.52	338	15.43
2010	170	66.39	324	28.68	143	73.07	334	17.35
2011	178	68.02	336	30.34	154	73.26	339	27.31
2012	179	69.32	340	29.70	158	74.71	355	21.30
2013	173	71.26	327	26.00	163	72.37	349	10.14
2014	178	70.61	311	32.10	157	70.46	340	19.50
2015	151	72.96	320	31.30	160	70.86	324	25.35
2016	153	68.37	334	24.13	160	72.58	323	25.68

Appendix A3.
Charts: Objective Season Start Dates and Mean Temperatures by Year for Each of the 30 Stations, Analyzed with Linear Regression

Each page in this appendix contains four charts for each station, showing the results of a least-squares linear regression as follows:

Objectively Defined Summer Season Begin Date by Year

Objectively Defined Winter Season Begin Date by Year

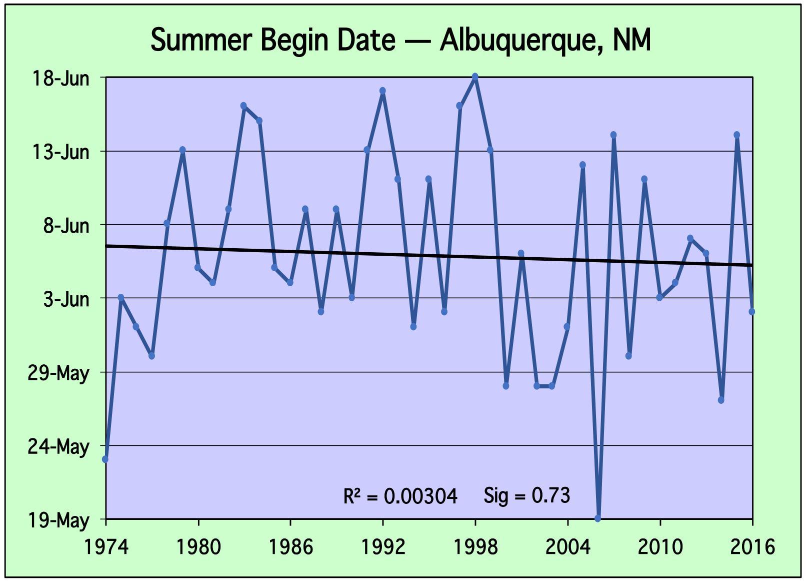
Average Temperature (°F) for the Objectively Defined Summer Season by Year

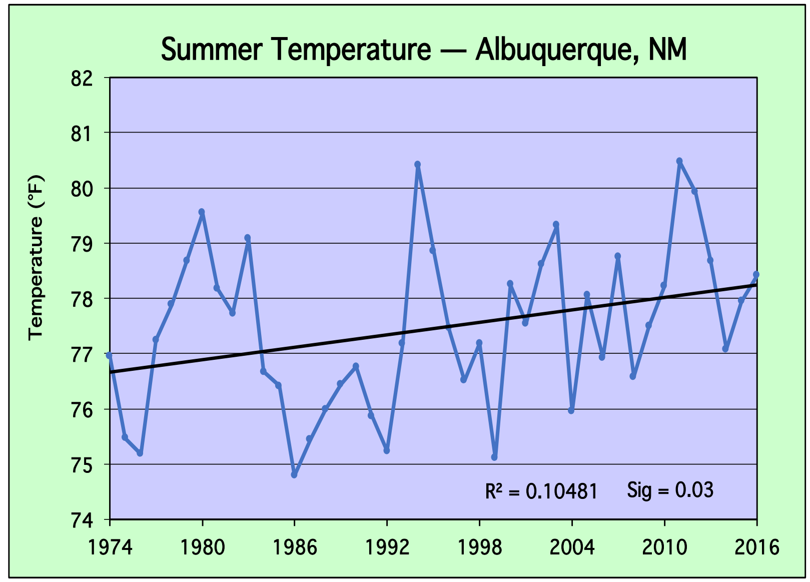
Average Temperature (°F) for the Objectively Defined Winter Season by Year

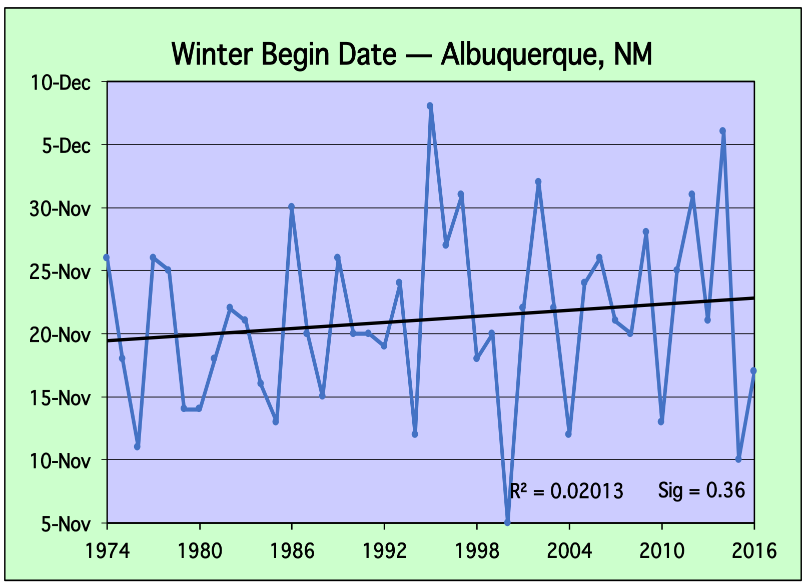
Each chart, displays the r-squared value along with the significence, based on a f-test (a significance of 0.00 indicates <0.005).

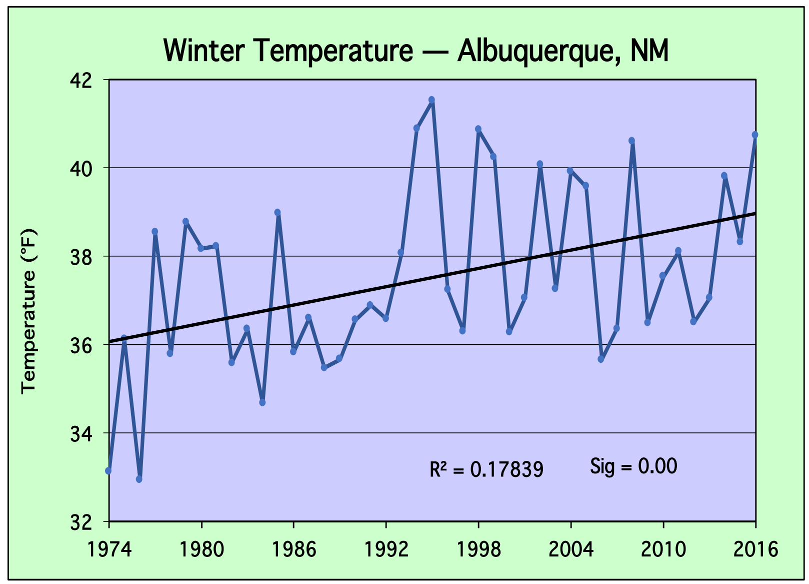
The following definitions are used:

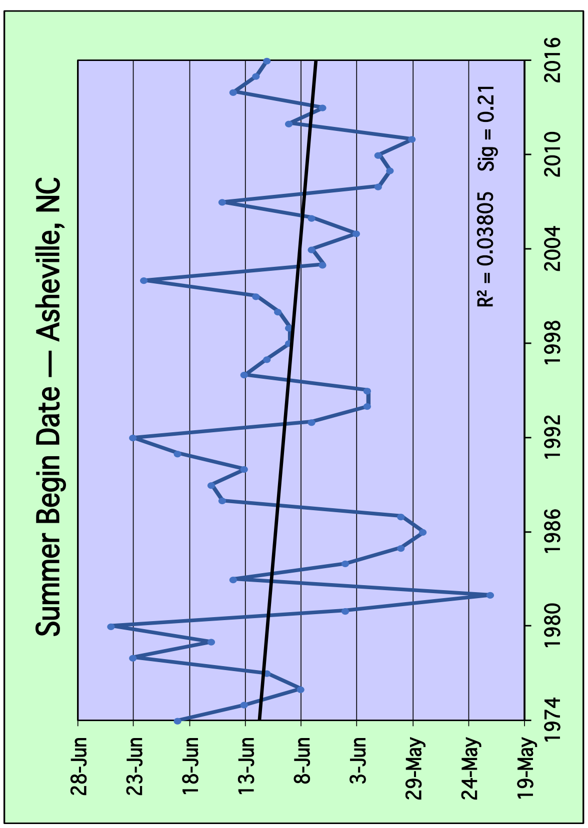
Year	The calendar year in which the objectively defined season *nominally* began. (If the Winter was determined to have started on or after January 1 of the following calendar year, it is assigned to the previous year.)
Summer Begin	The day on which the objectively defined Summer season started. This is given in Day–Month format.
Winter Begin	The day on which the objectively defined Summer season started. This is given in Day–Month format.
Summer Temperature	The average temperature (°F) of the objectively defined Summer season.
Winter Temperature	The average temperature (°F) of the objectively defined Winter season.

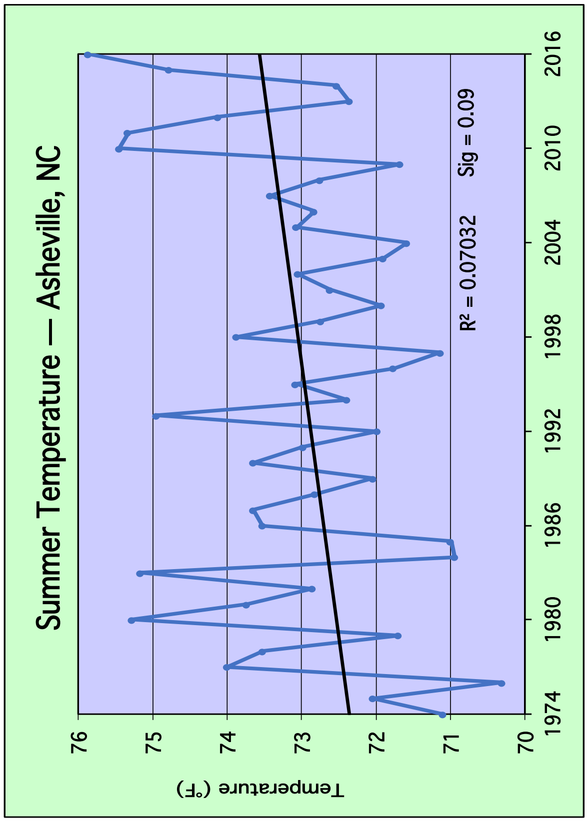

Summer Begin Date — Albuquerque, NM
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00304
Sig = 0.73

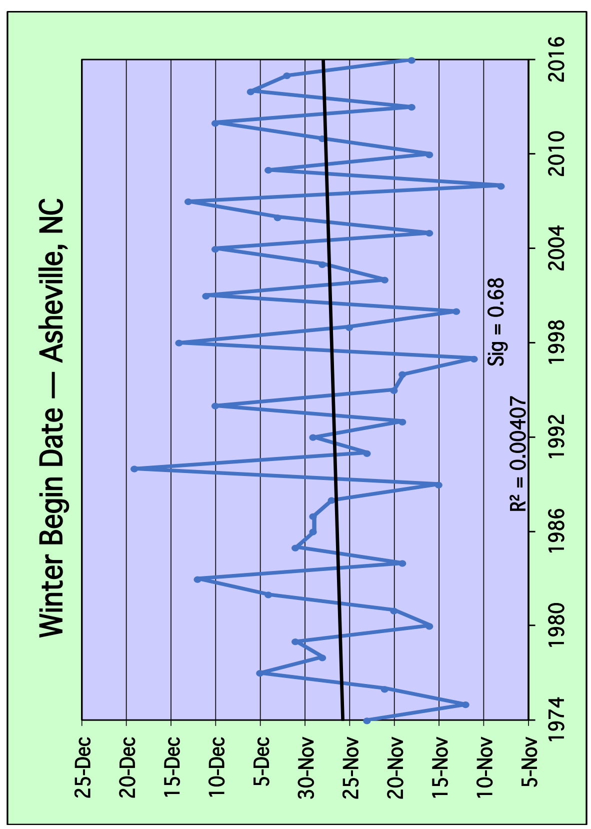

Summer Temperature — Albuquerque, NM
Temperature (°F)
82
81
80
79
78
77
76
75
74
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.10481
Sig = 0.03

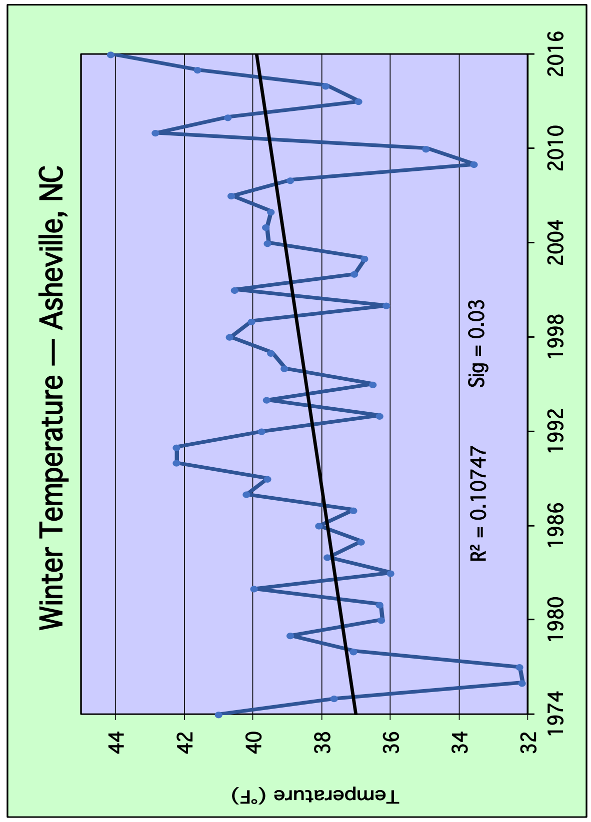

Winter Begin Date — Albuquerque, NM
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.02013
Sig = 0.36

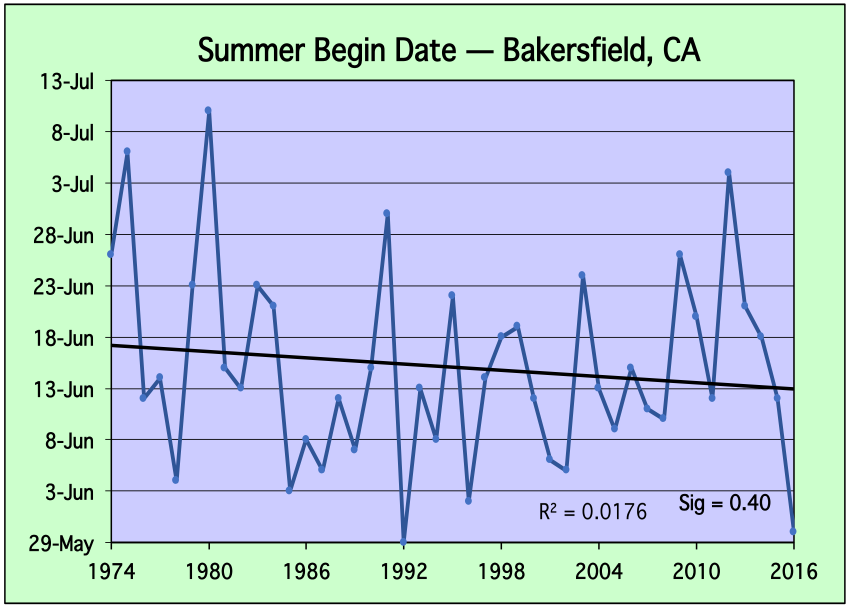

Winter Temperature — Albuquerque, NM
Temperature (°F)
42
40
38
36
34
32
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.17839
Sig = 0.00

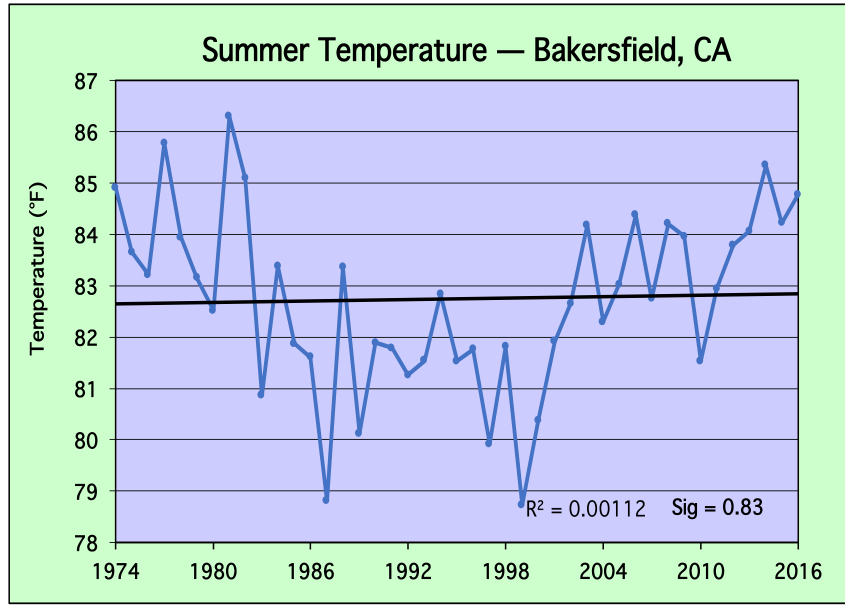

Summer Begin Date — Asheville, NC
R² = 0.03805 Sig = 0.21

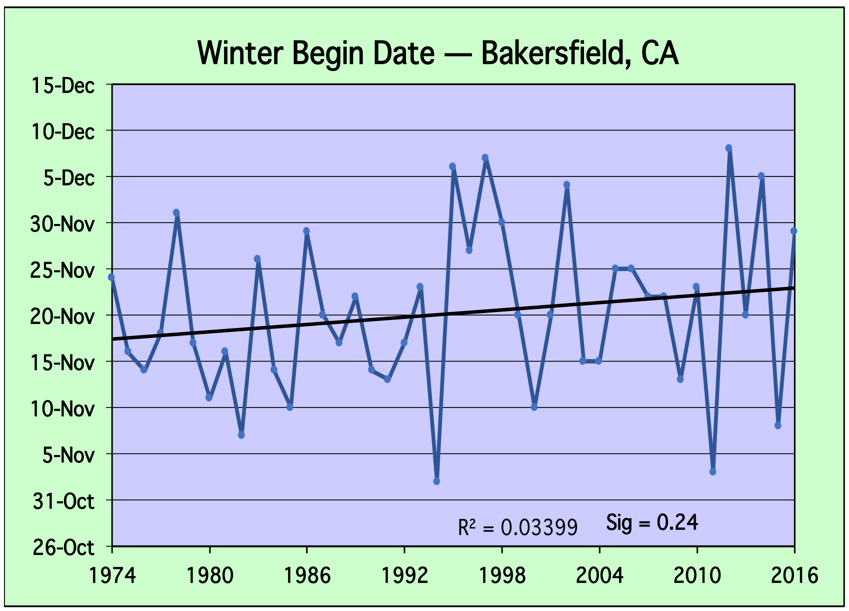

Summer Temperature — Asheville, NC
Temperature (°F)
R² = 0.07032 Sig = 0.09

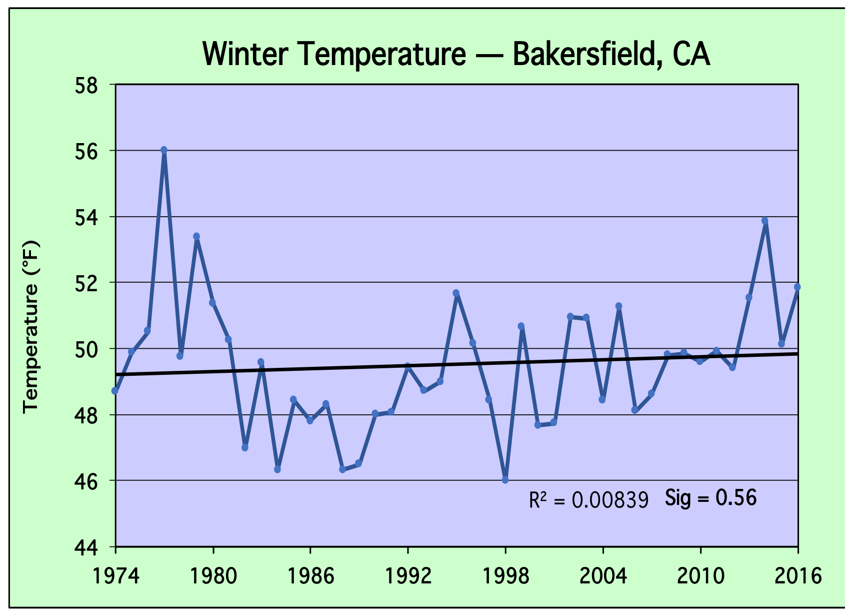

Winter Begin Date — Asheville, NC
R² = 0.00407 Sig = 0.68

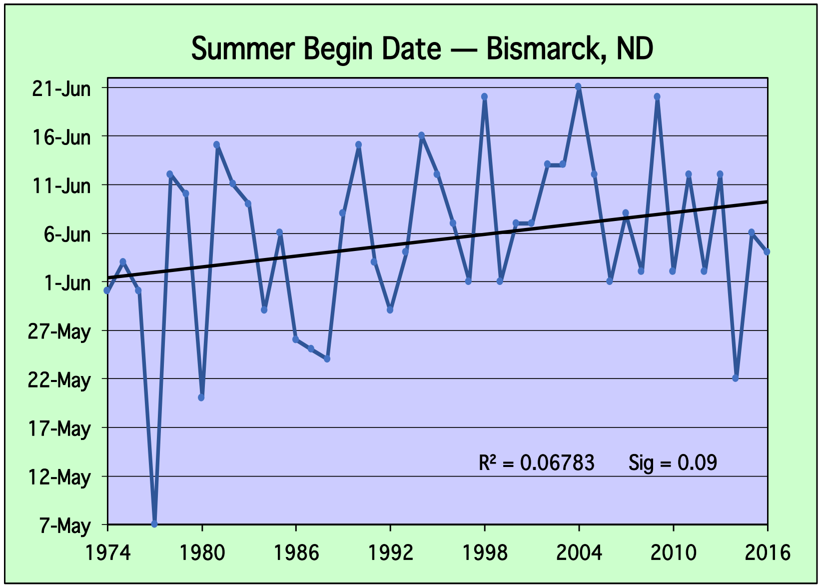

Winter Temperature — Asheville, NC
Temperature (°F)
R² = 0.10747 Sig = 0.03

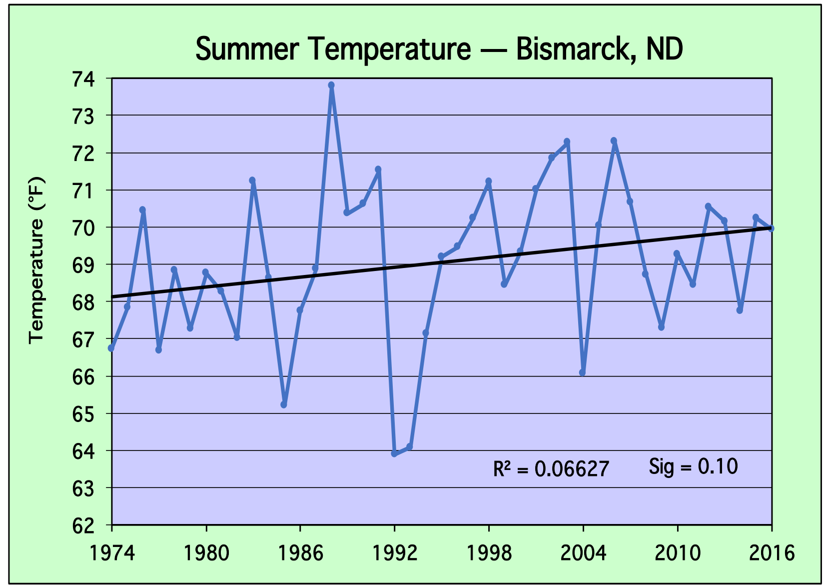

Summer Begin Date — Bakersfield, CA
13-Jul
8-Jul
3-Jul
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.0176
Sig = 0.40

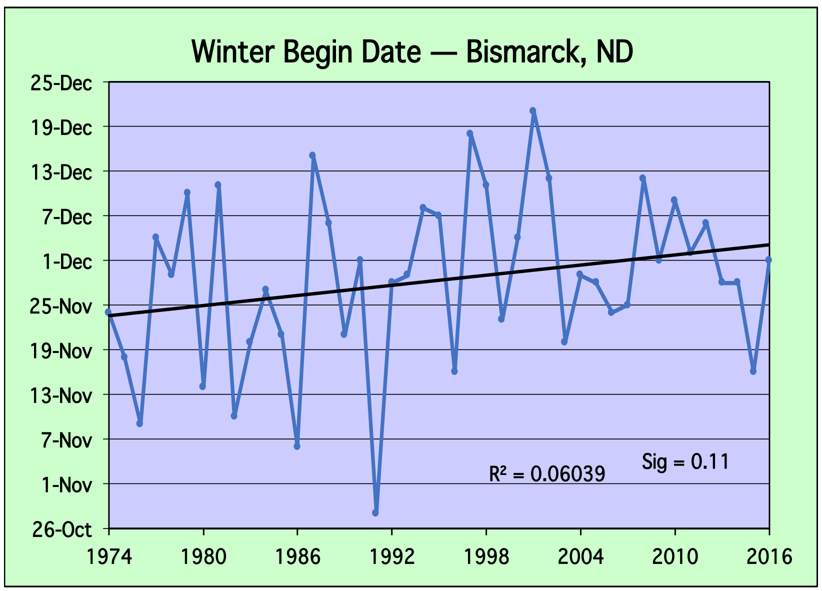

Summer Temperature — Bakersfield, CA
Temperature (°F)
87
86
85
84
83
82
81
80
79
78
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00112
Sig = 0.83

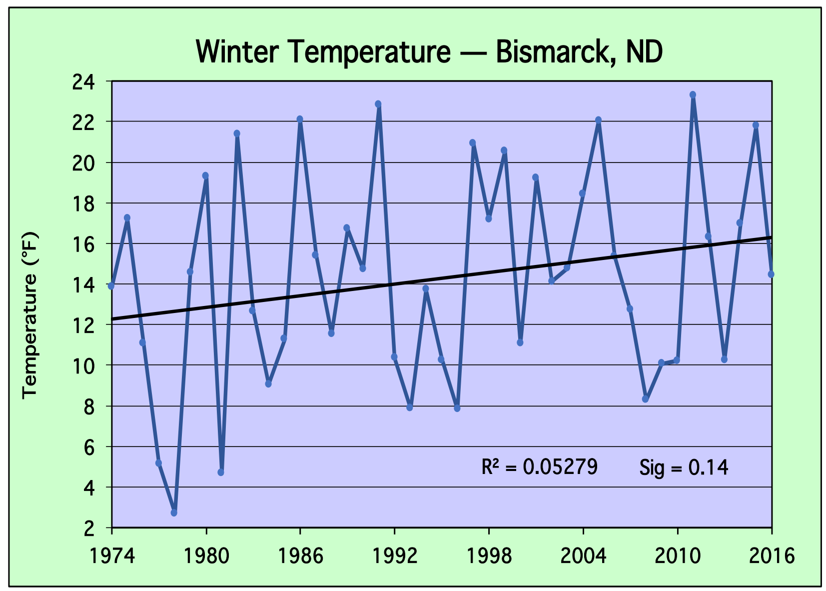

Winter Begin Date — Bakersfield, CA
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.03399
Sig = 0.24

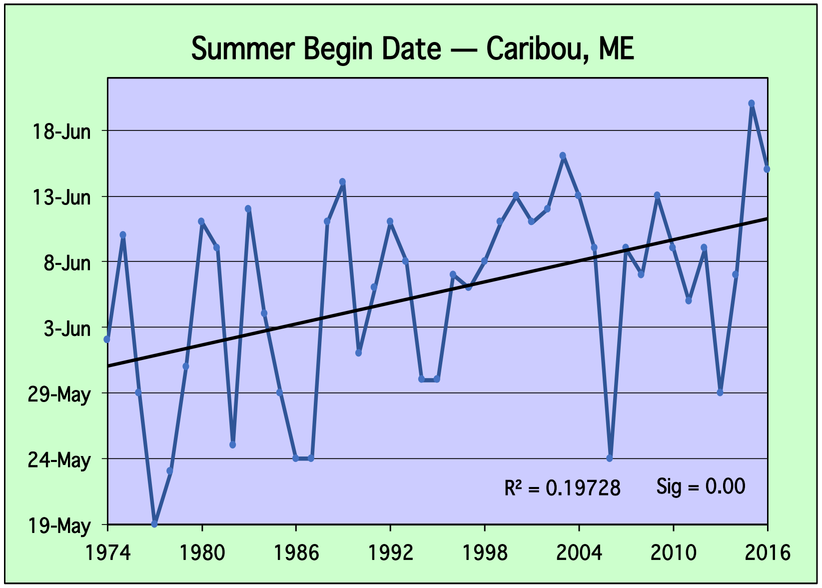

Winter Temperature — Bakersfield, CA
Temperature (°F)
58
56
54
52
50
48
46
44
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00839
Sig = 0.56

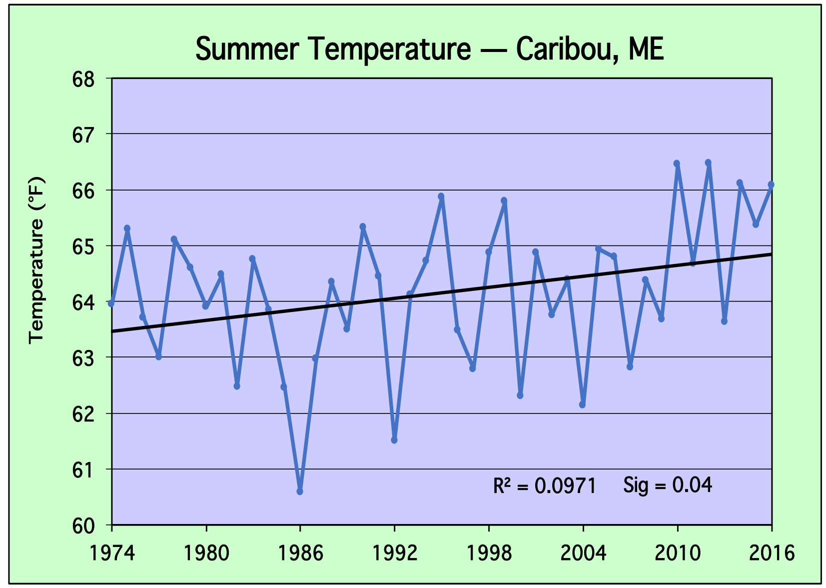

Summer Begin Date — Bismarck, ND
21-Jun
16-Jun
11-Jun
6-Jun
1-Jun
27-May
22-May
17-May
12-May
7-May
R² = 0.06783
Sig = 0.09
1974
1980
1986
1992
1998
2004
2010
2016

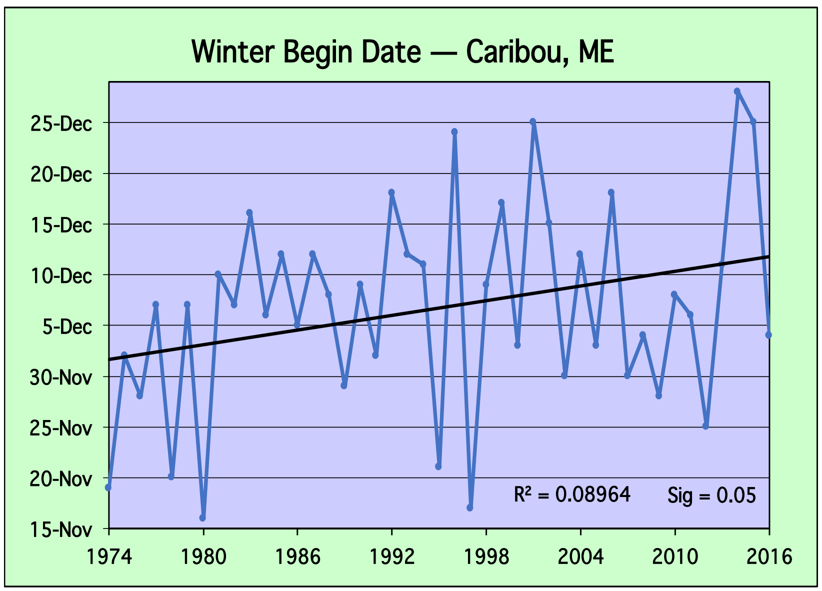

Summer Temperature — Bismarck, ND
Temperature (°F)
74
73
72
71
70
69
68
67
66
65
64
63
62
R² = 0.06627
Sig = 0.10
1974
1980
1986
1992
1998
2004
2010
2016

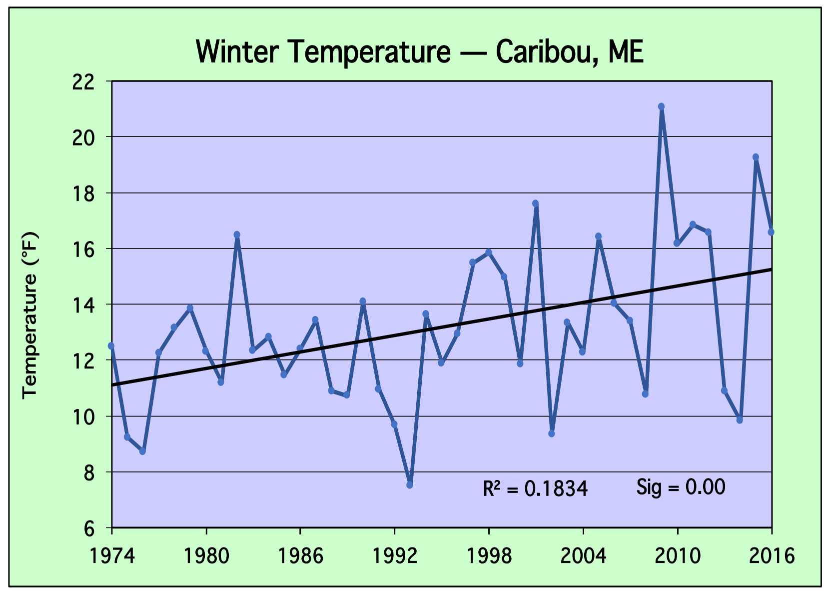

Winter Begin Date — Bismarck, ND
25-Dec
19-Dec
13-Dec
7-Dec
1-Dec
25-Nov
19-Nov
13-Nov
7-Nov
1-Nov
26-Oct
R² = 0.06039
Sig = 0.11
1974
1980
1986
1992
1998
2004
2010
2016

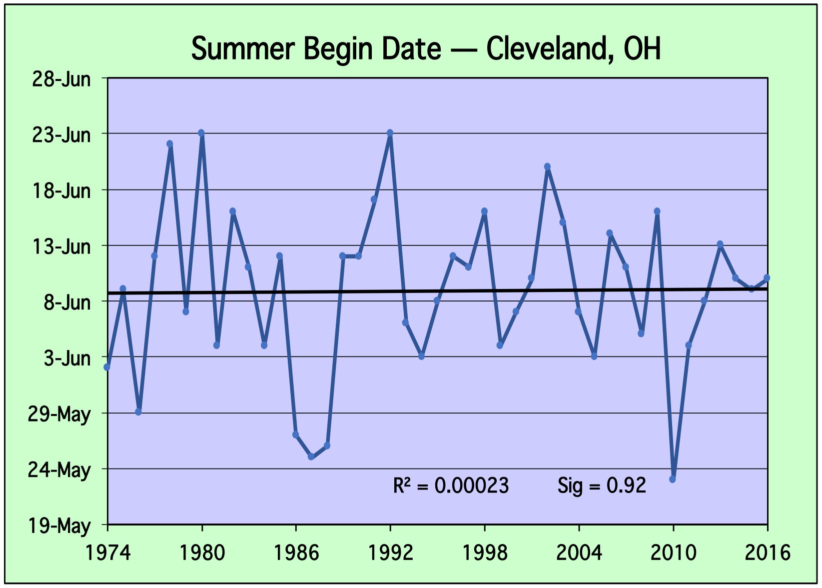

Winter Temperature — Bismarck, ND
Temperature (°F)
24
22
20
18
16
14
12
10
8
6
4
2
R² = 0.05279
Sig = 0.14
1974
1980
1986
1992
1998
2004
2010
2016

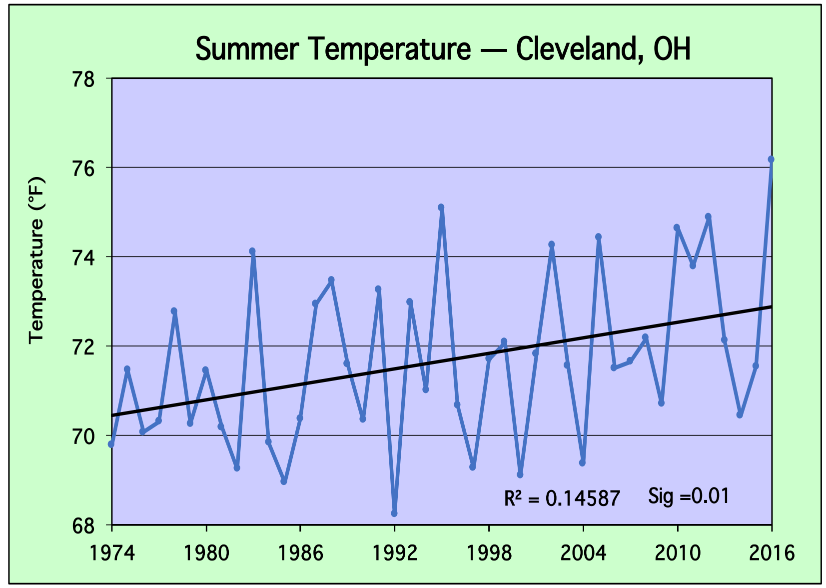

Summer Begin Date — Caribou, ME
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.19728
Sig = 0.00

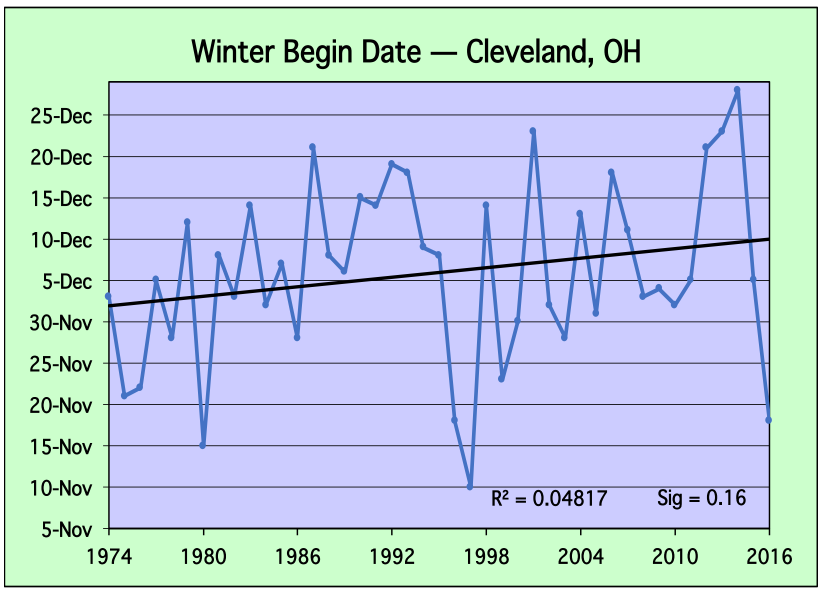

Summer Temperature — Caribou, ME
Temperature (°F)
68
67
66
65
64
63
62
61
60
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.0971
Sig = 0.04

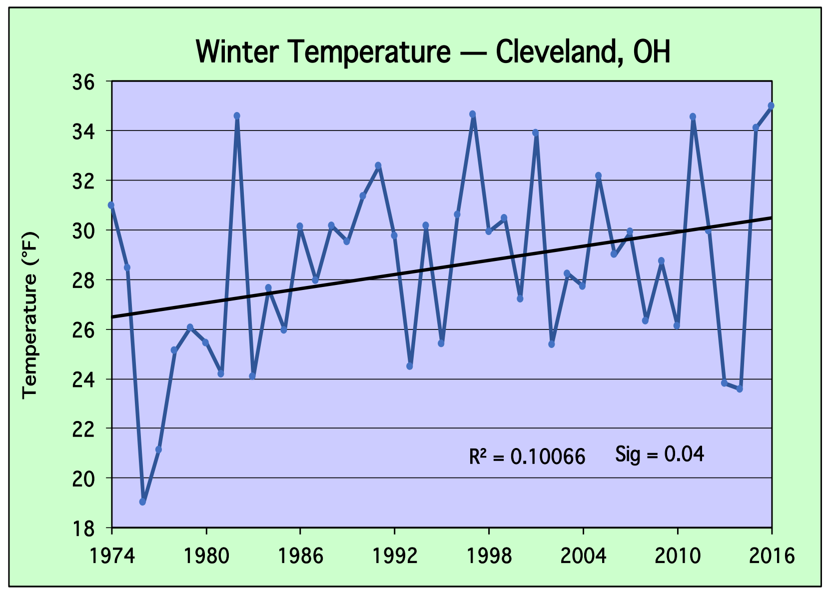

Winter Begin Date — Caribou, ME
25-Dec
20-Dec
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.08964
Sig = 0.05

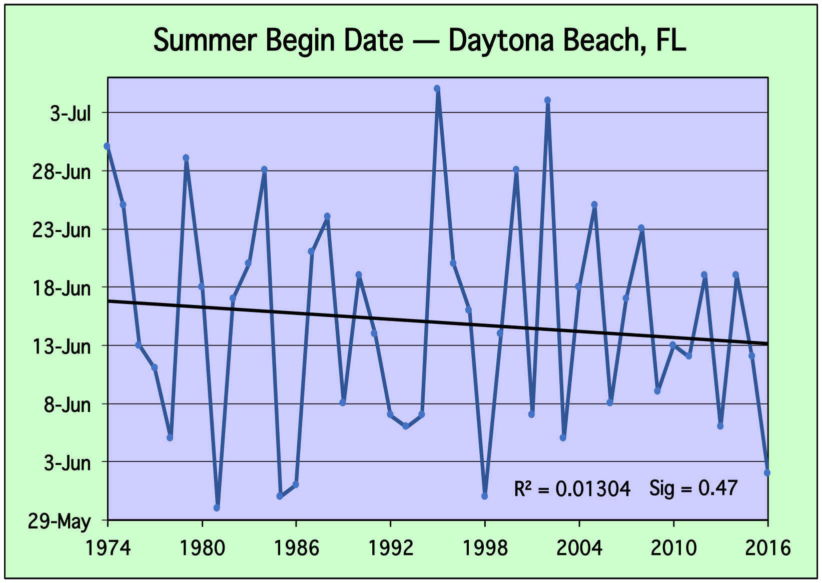

Winter Temperature — Caribou, ME
Temperature (°F)
22
20
18
16
14
12
10
8
6
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.1834
Sig = 0.00

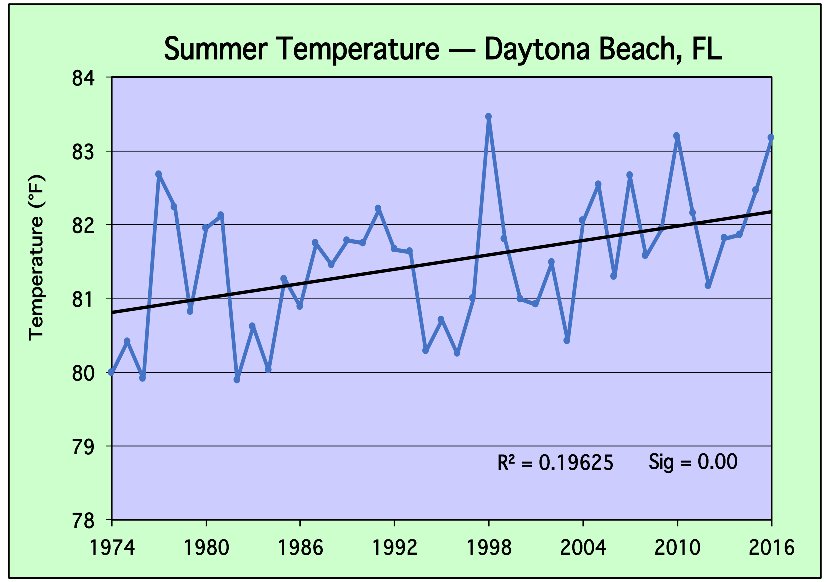

Summer Begin Date — Cleveland, OH
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00023
Sig = 0.92

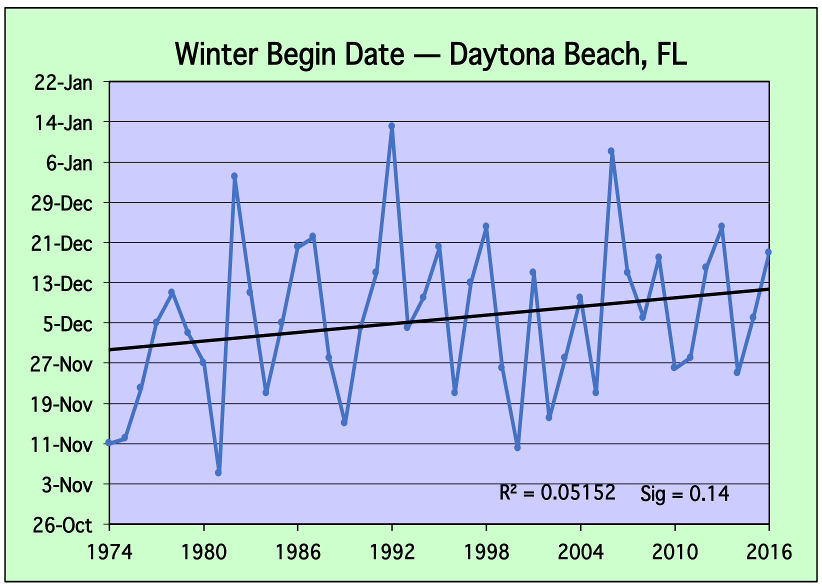

Summer Temperature — Cleveland, OH
Temperature (°F)
78
76
74
72
70
68
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.14587
Sig =0.01

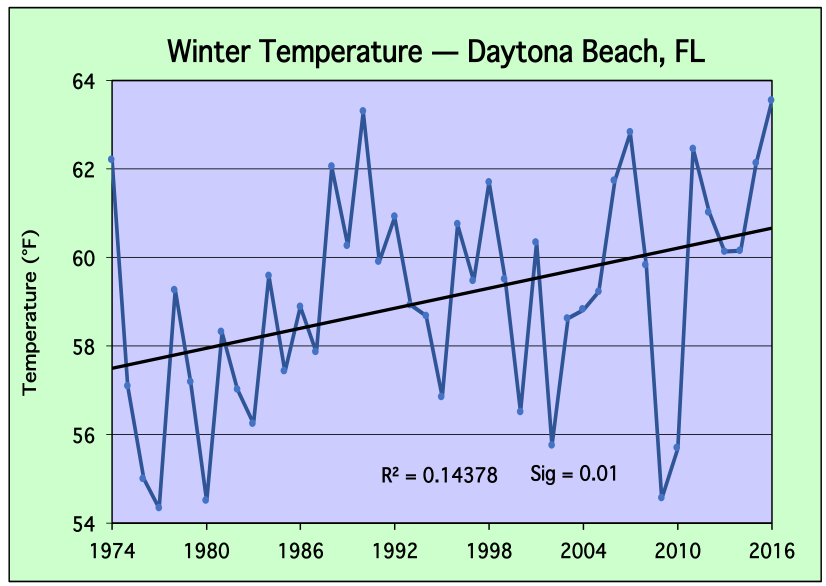

Winter Begin Date — Cleveland, OH
25-Dec
20-Dec
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.04817
Sig = 0.16

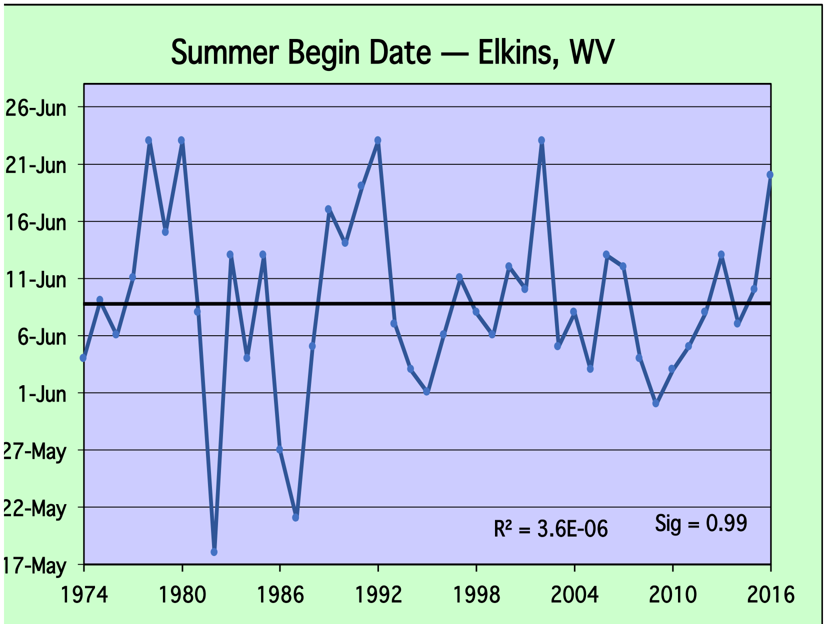

Winter Temperature — Cleveland, OH
Temperature (°F)
36
34
32
30
28
26
24
22
20
18
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.10066
Sig = 0.04

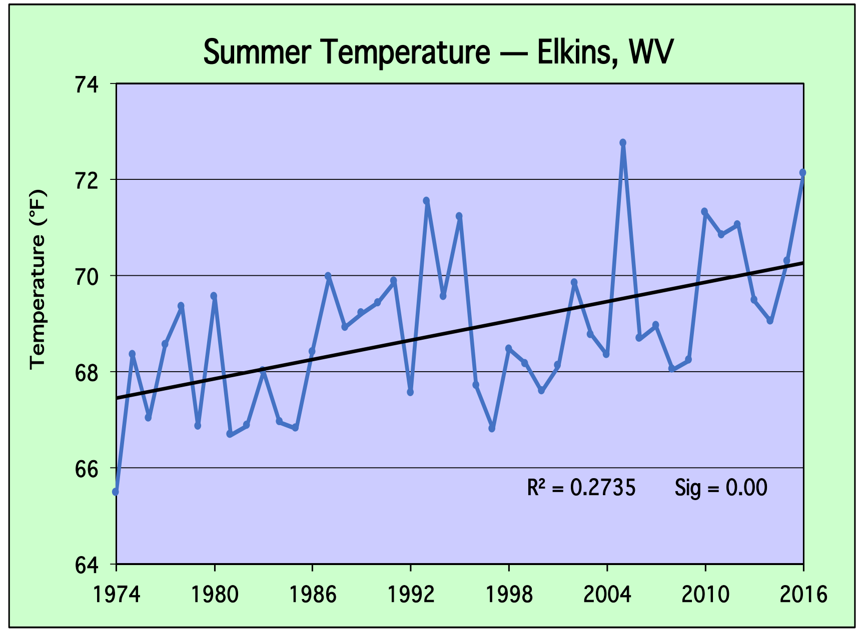

Summer Begin Date — Daytona Beach, FL
3-Jul
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.01304   Sig = 0.47

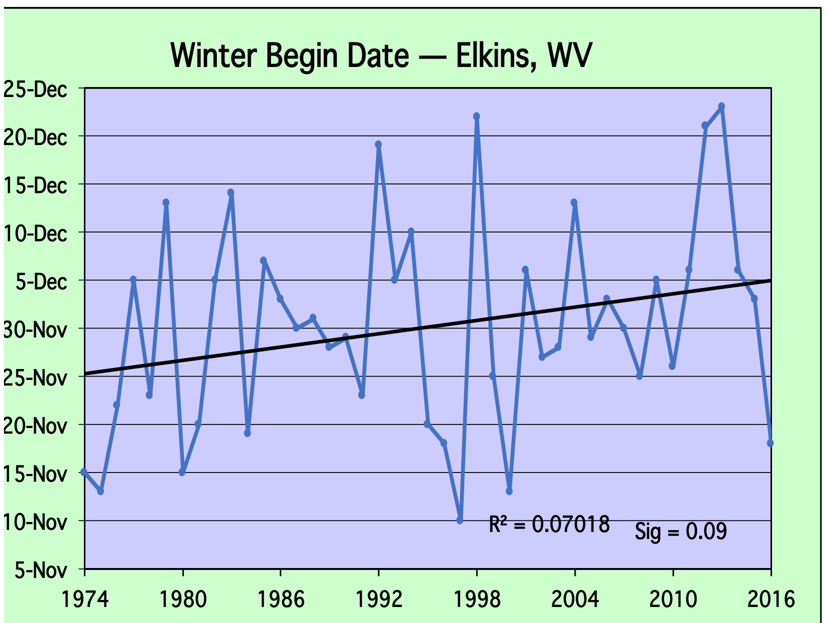

Summer Temperature — Daytona Beach, FL
Temperature (°F)
84
83
82
81
80
79
78
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.19625   Sig = 0.00

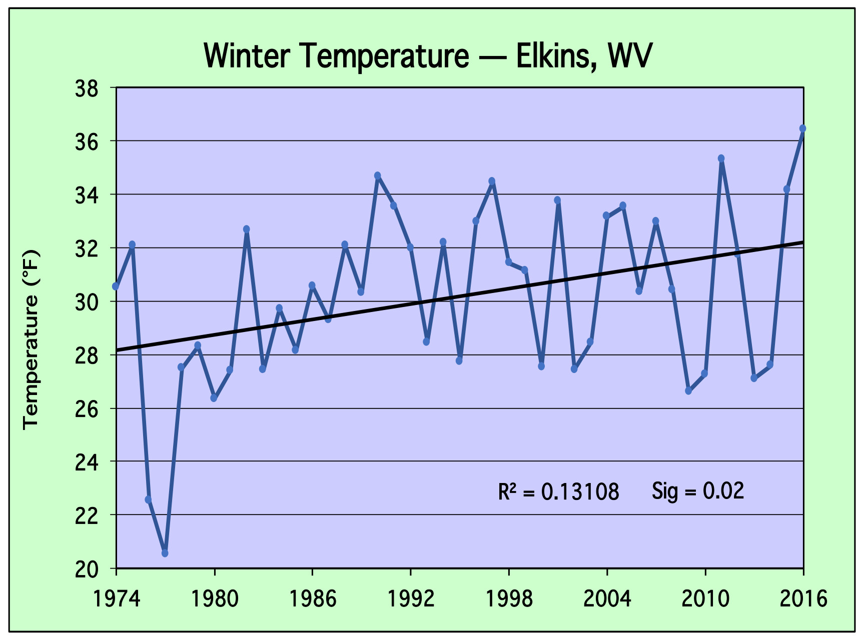

Winter Begin Date — Daytona Beach, FL
22-Jan
14-Jan
6-Jan
29-Dec
21-Dec
13-Dec
5-Dec
27-Nov
19-Nov
11-Nov
3-Nov
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.05152   Sig = 0.14

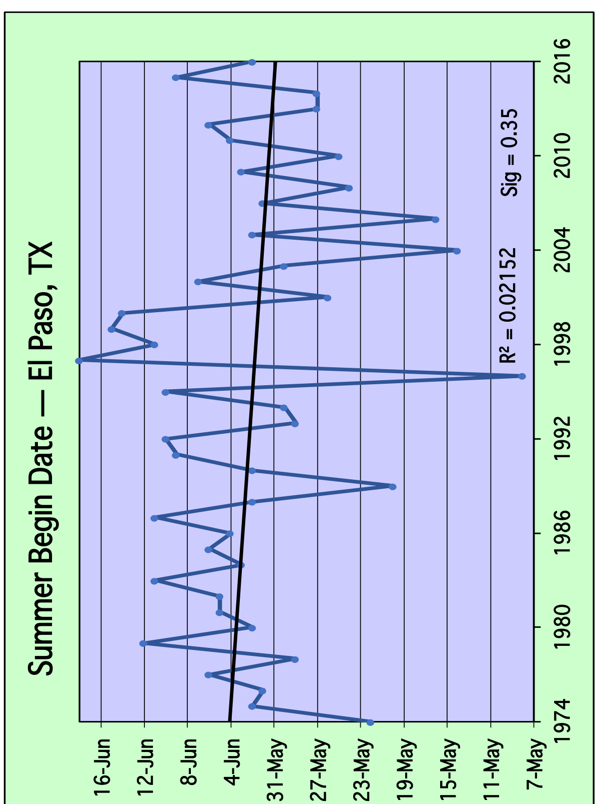

Winter Temperature — Daytona Beach, FL
Temperature (°F)
64
62
60
58
56
54
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.14378   Sig = 0.01

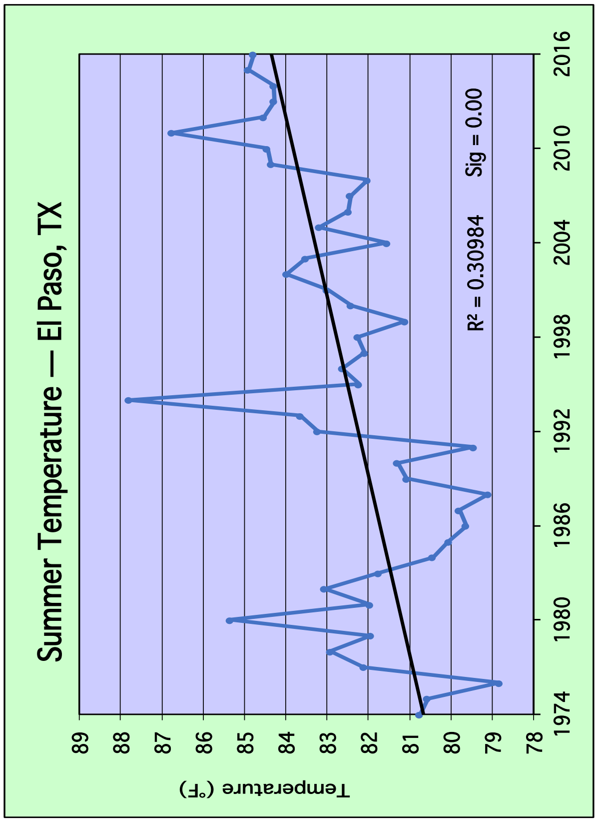

Summer Begin Date — Elkins, WV
26-Jun
21-Jun
16-Jun
11-Jun
6-Jun
1-Jun
27-May
22-May
17-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 3.6E-06
Sig = 0.99

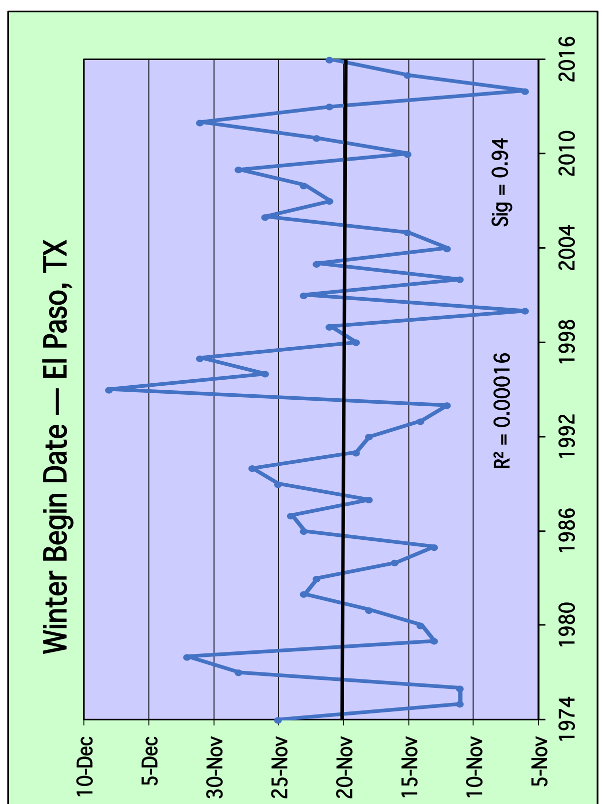

Summer Temperature — Elkins, WV
Temperature (°F)
74
72
70
68
66
64
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.2735
Sig = 0.00

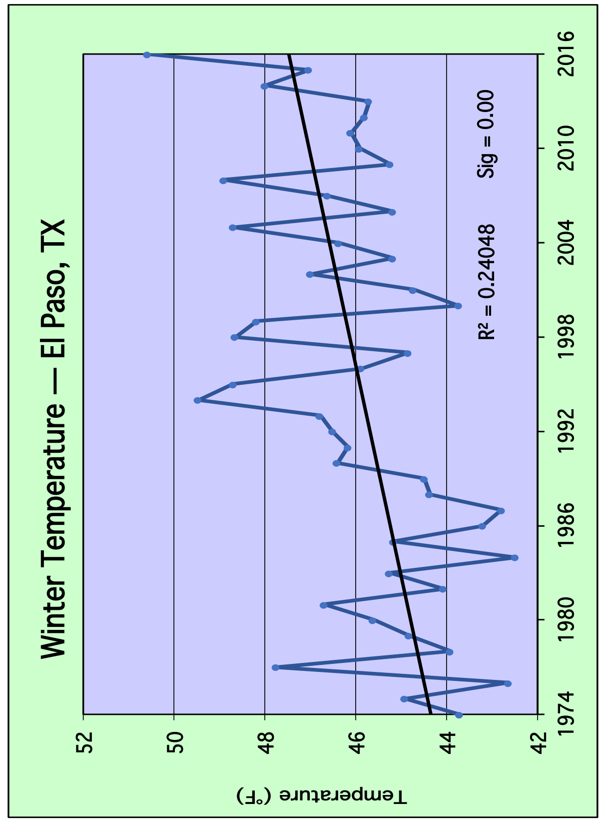

Winter Begin Date — Elkins, WV
25-Dec
20-Dec
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.07018
Sig = 0.09

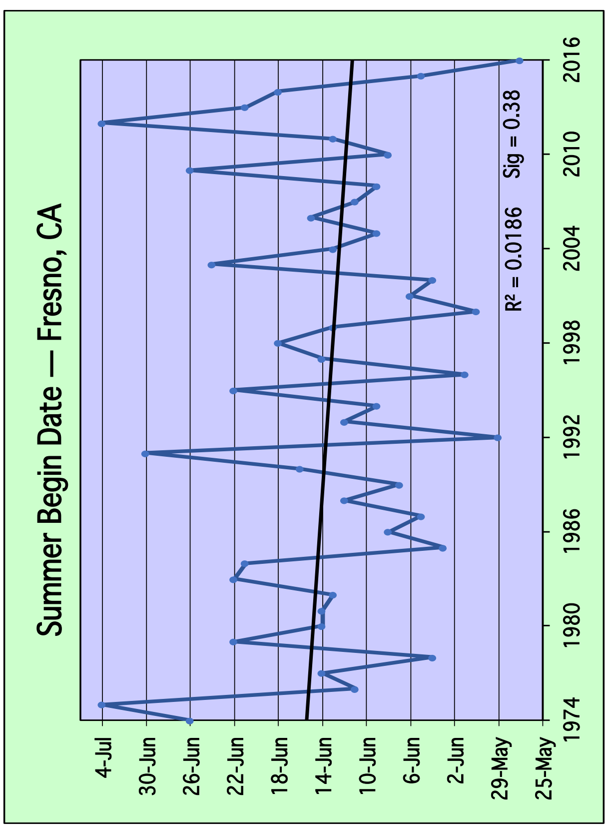

Winter Temperature — Elkins, WV
Temperature (°F)
38
36
34
32
30
28
26
24
22
20
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.13108
Sig = 0.02

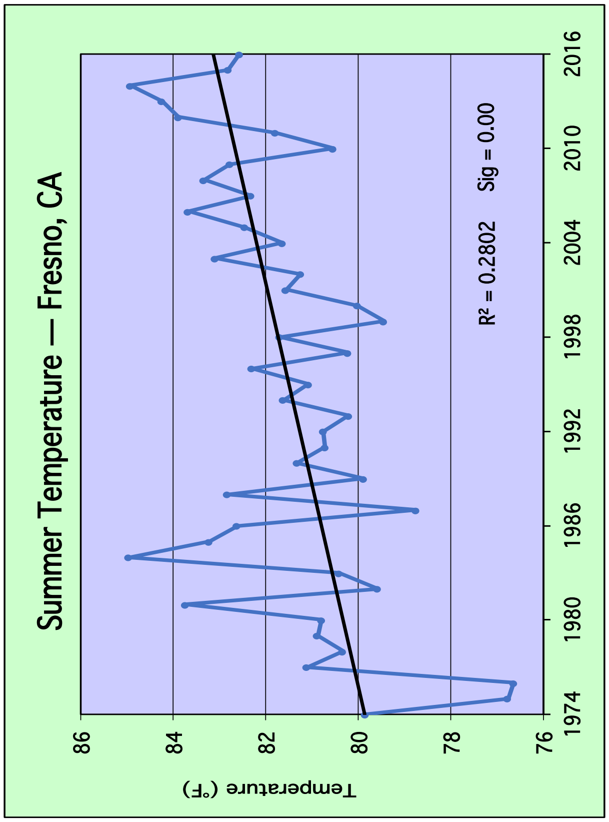

Summer Begin Date — El Paso, TX
R² = 0.02152
Sig = 0.35
16-Jun
12-Jun
8-Jun
4-Jun
31-May
27-May
23-May
19-May
15-May
11-May
7-May
1974
1980
1986
1992
1998
2004
2010
2016

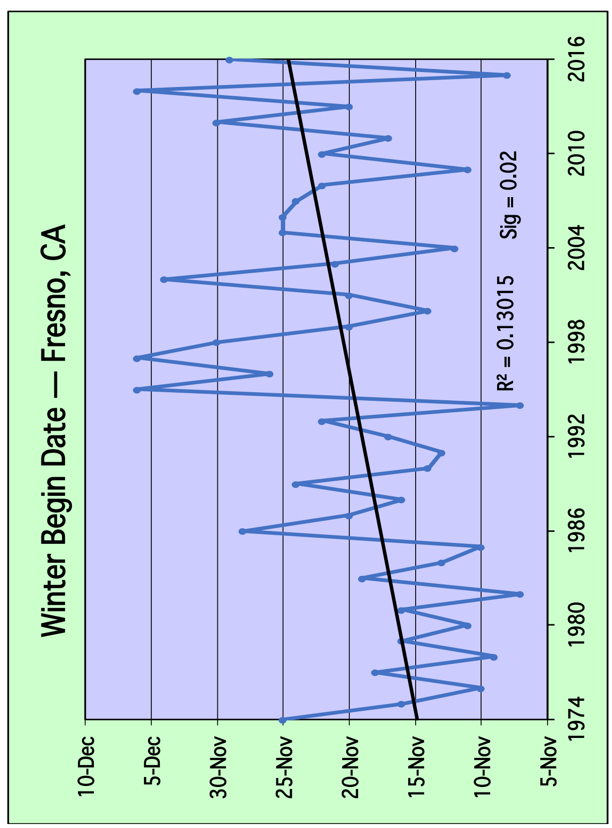

Summer Temperature — El Paso, TX
R² = 0.30984
Sig = 0.00
Temperature (°F)
89
88
87
86
85
84
83
82
81
80
79
78
1974
1980
1986
1992
1998
2004
2010
2016

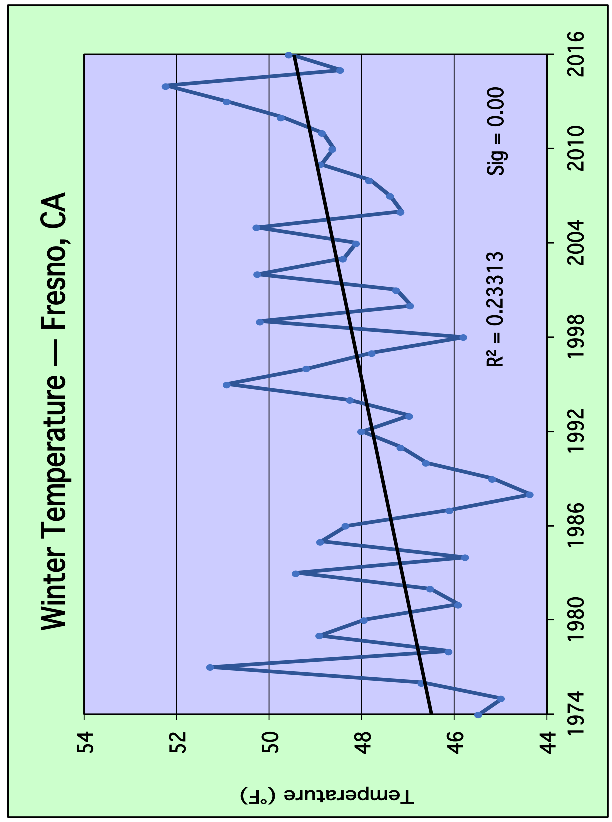

Winter Begin Date — El Paso, TX
R² = 0.00016
Sig = 0.94
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
1974
1980
1986
1992
1998
2004
2010
2016

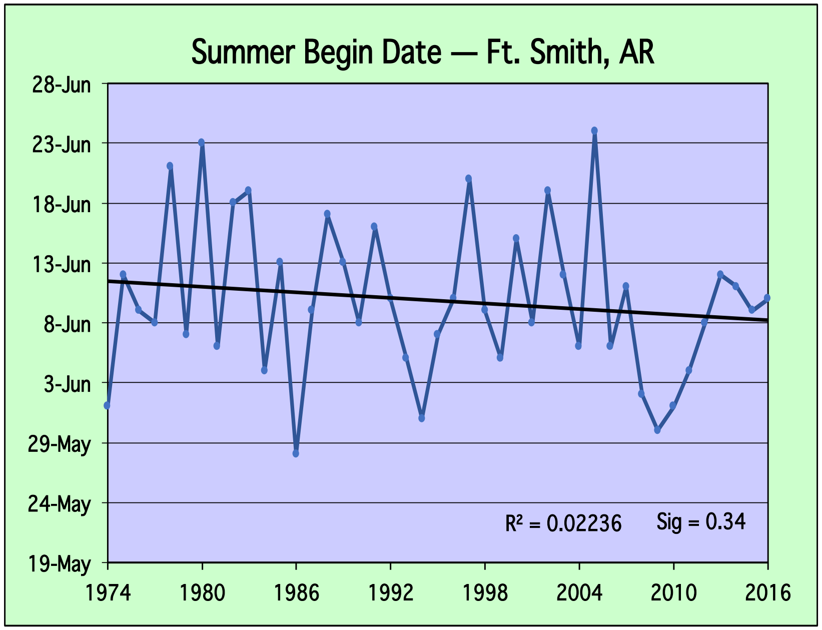

Winter Temperature — El Paso, TX
R² = 0.24048
Sig = 0.00
Temperature (°F)
52
50
48
46
44
42
1974
1980
1986
1992
1998
2004
2010
2016

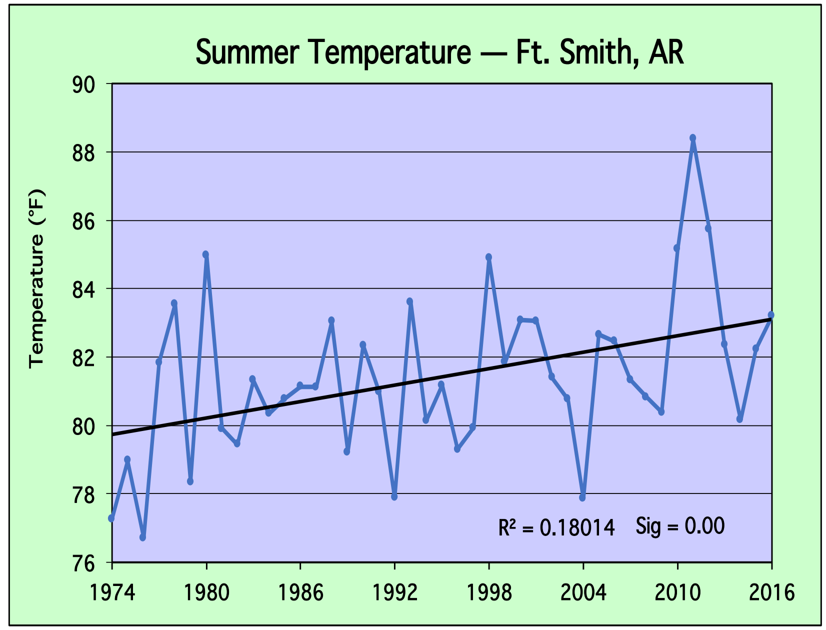

Summer Begin Date — Fresno, CA
R² = 0.0186
Sig = 0.38
4-Jul
30-Jun
26-Jun
22-Jun
18-Jun
14-Jun
10-Jun
6-Jun
2-Jun
29-May
25-May
1974
1980
1986
1992
1998
2004
2010
2016

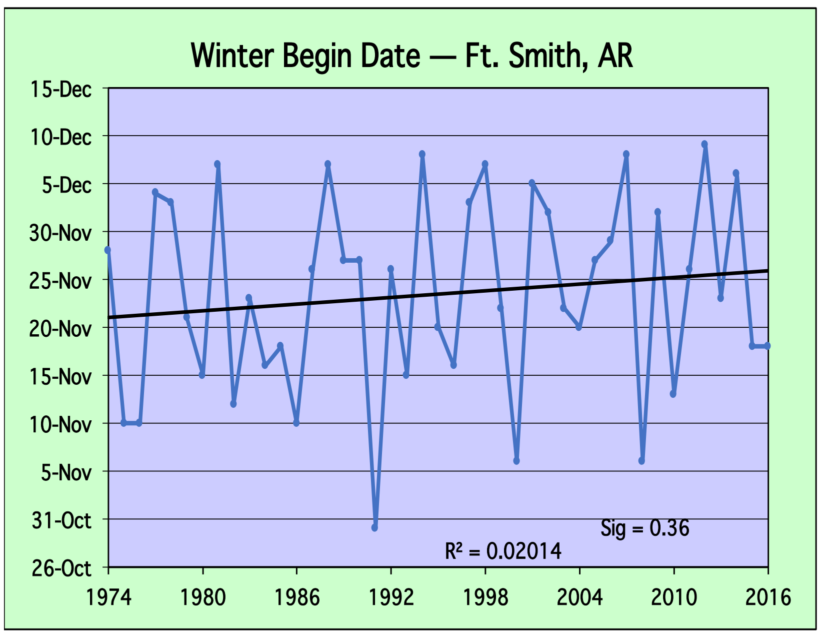

Summer Temperature — Fresno, CA
R² = 0.2802
Sig = 0.00
Temperature (°F)
86
84
82
80
78
76
1974
1980
1986
1992
1998
2004
2010
2016

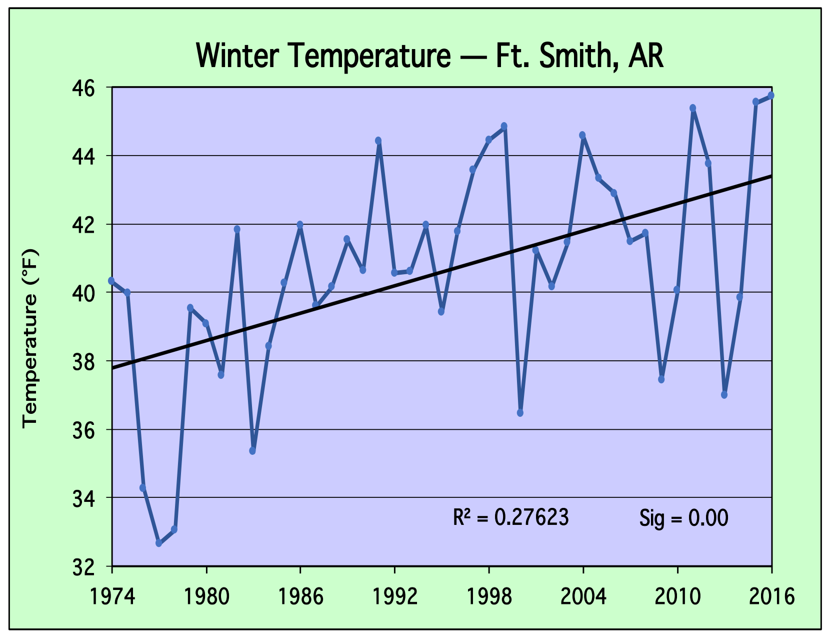

Winter Begin Date — Fresno, CA
R² = 0.13015
Sig = 0.02
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
1974
1980
1986
1992
1998
2004
2010
2016

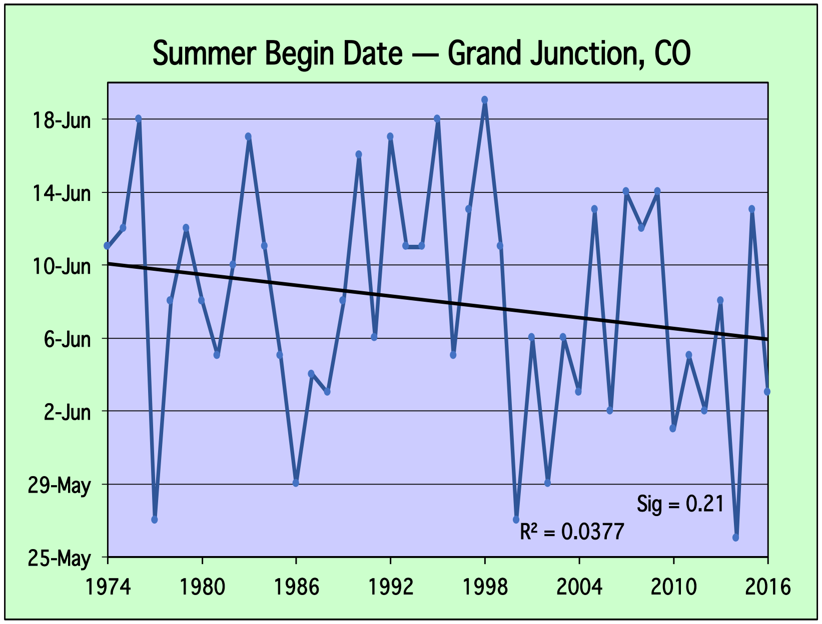

Winter Temperature — Fresno, CA
R² = 0.23313
Sig = 0.00
Temperature (°F)
54
52
50
48
46
44
1974
1980
1986
1992
1998
2004
2010
2016

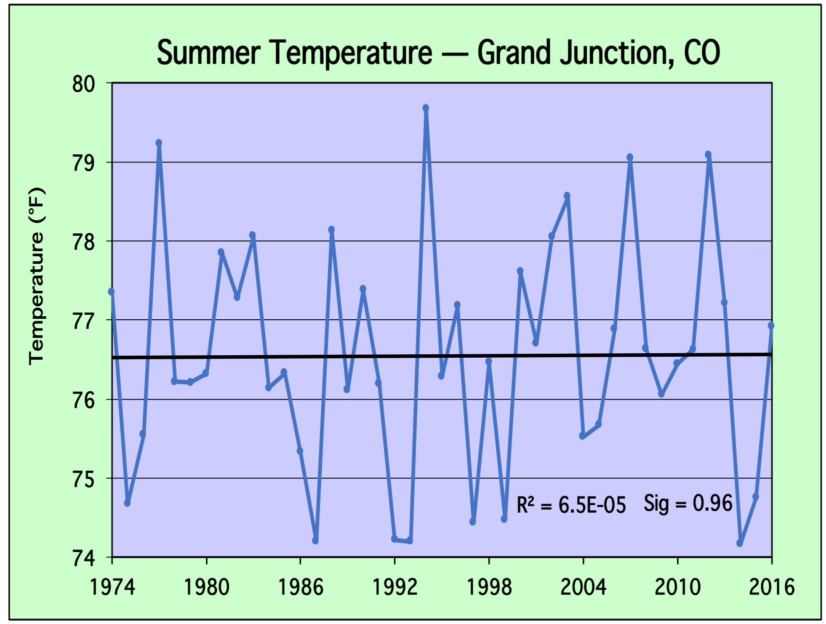

Summer Begin Date — Ft. Smith, AR
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.02236
Sig = 0.34

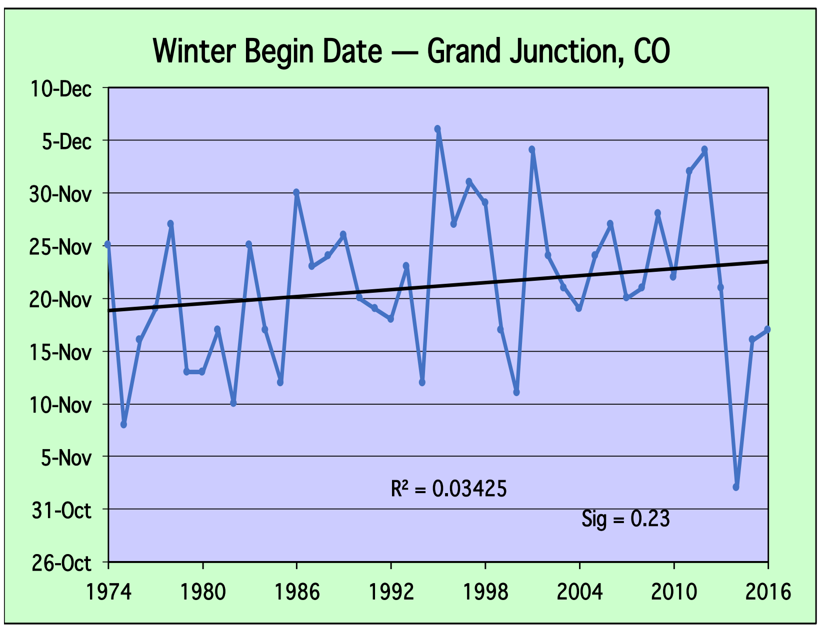

Summer Temperature — Ft. Smith, AR
Temperature (°F)
90
88
86
84
82
80
78
76
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.18014
Sig = 0.00

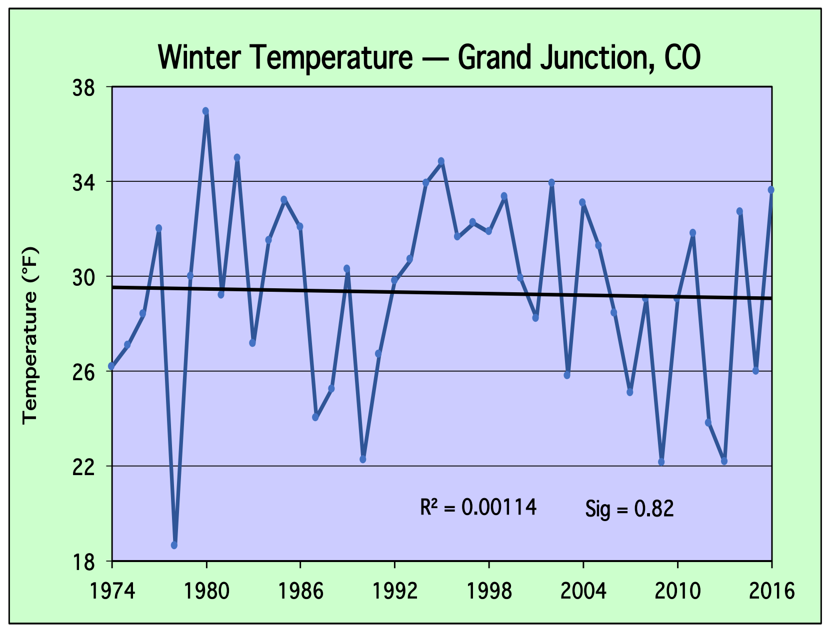

Winter Begin Date — Ft. Smith, AR
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
Sig = 0.36
R² = 0.02014

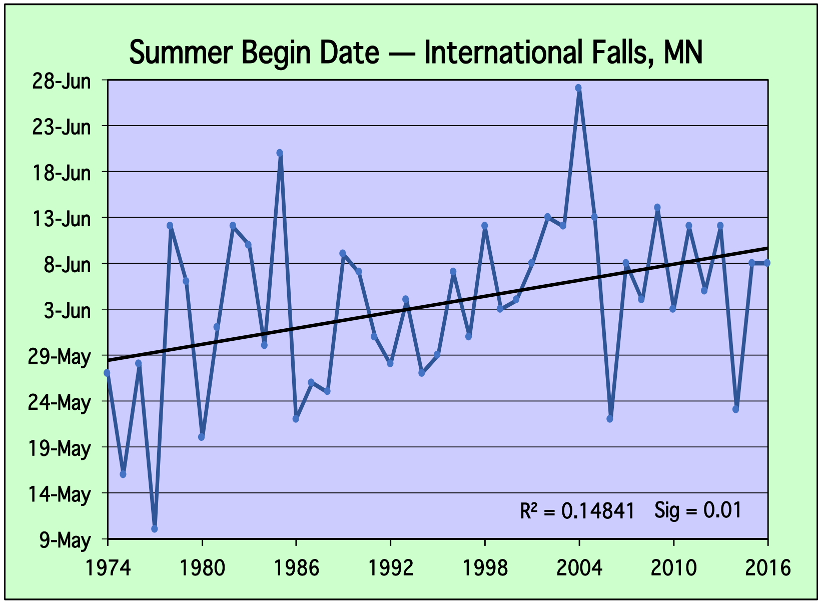

Winter Temperature — Ft. Smith, AR
Temperature (°F)
46
44
42
40
38
36
34
32
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.27623
Sig = 0.00

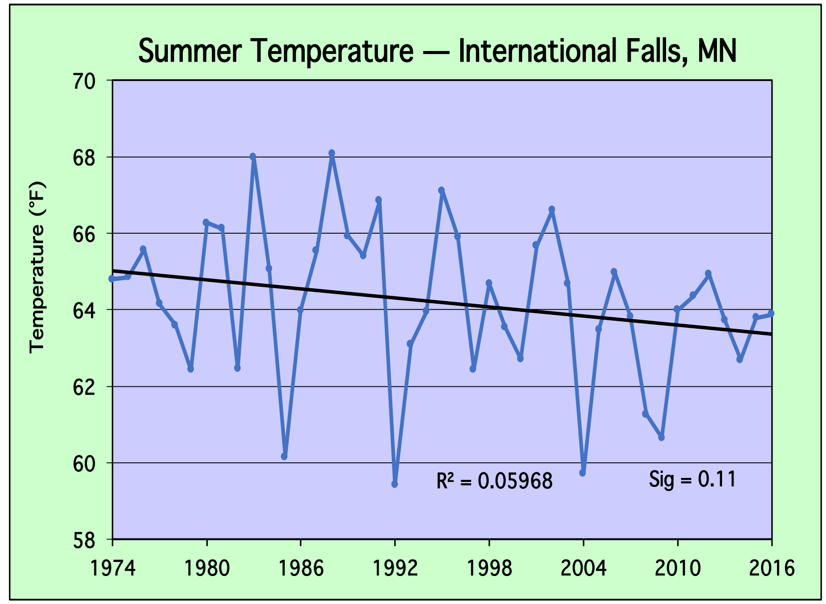

Summer Begin Date — Grand Junction, CO
18-Jun
14-Jun
10-Jun
6-Jun
2-Jun
29-May
25-May
1974
1980
1986
1992
1998
2004
2010
2016
Sig = 0.21
R² = 0.0377

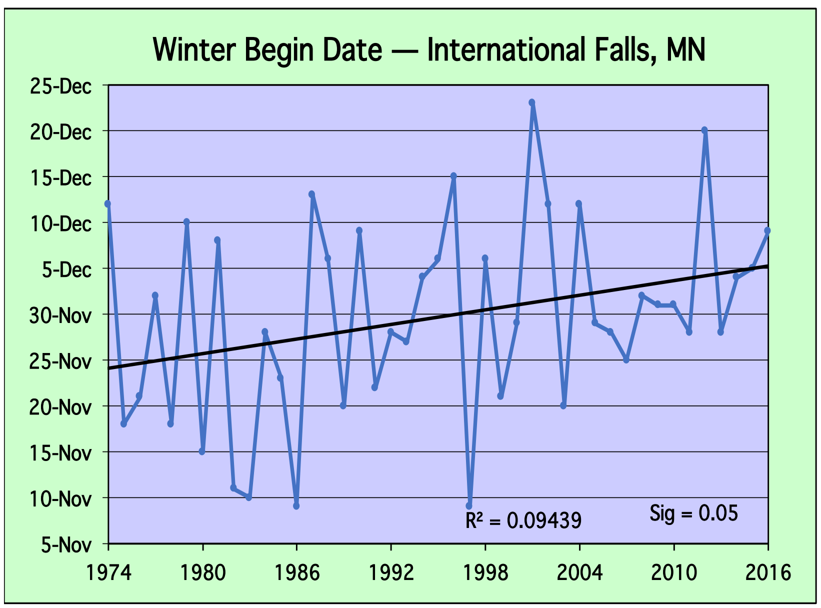

Summer Temperature — Grand Junction, CO
Temperature (°F)
80
79
78
77
76
75
74
1974
1980
1986
1992
1998
2004
2010
2016
R² = 6.5E-05
Sig = 0.96

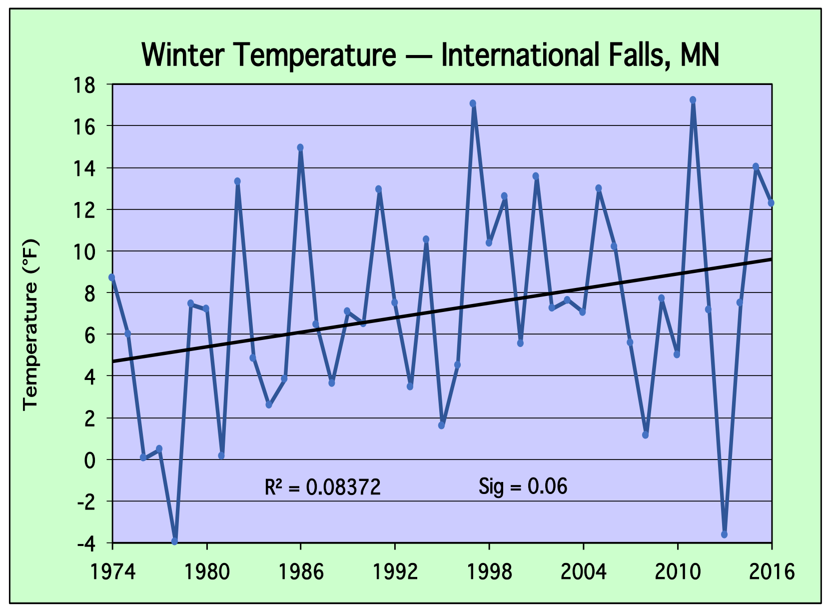

Winter Begin Date — Grand Junction, CO
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.03425
Sig = 0.23

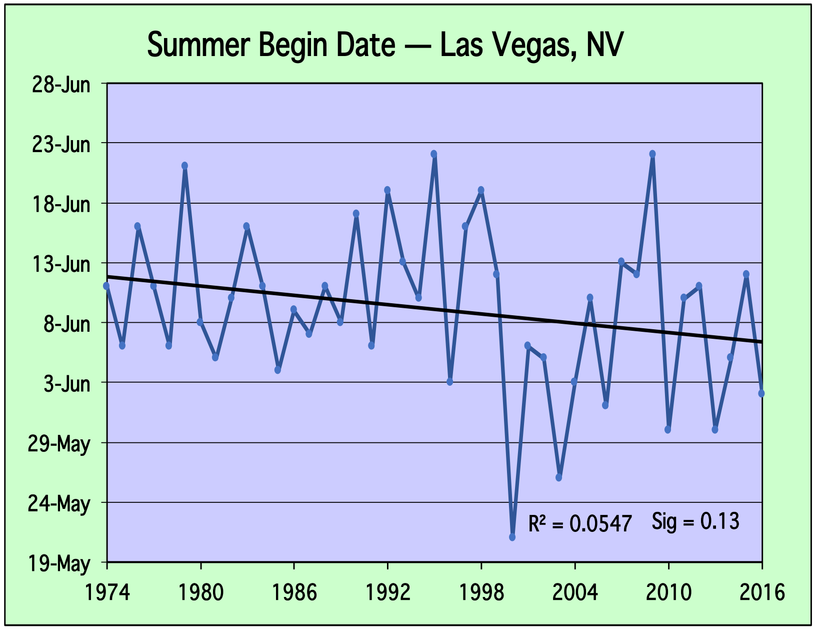

Winter Temperature — Grand Junction, CO
Temperature (°F)
38
34
30
26
22
18
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00114
Sig = 0.82

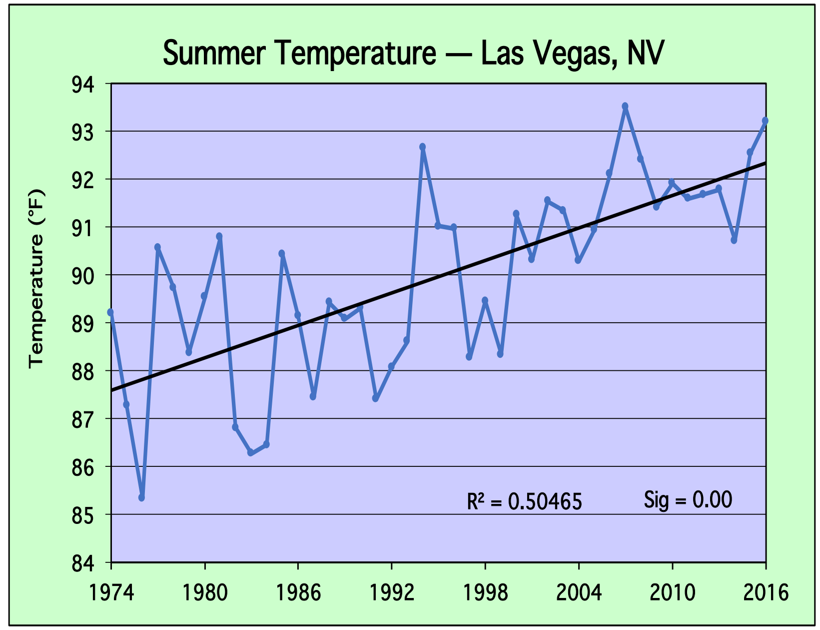

Summer Begin Date — International Falls, MN
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
14-May
9-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.14841
Sig = 0.01

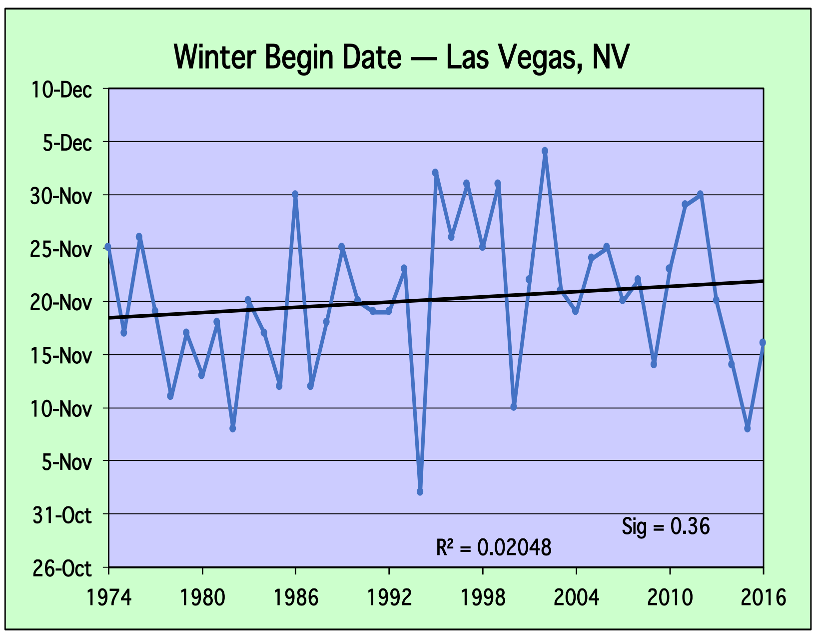

Summer Temperature — International Falls, MN
Temperature (°F)
70
68
66
64
62
60
58
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.05968
Sig = 0.11

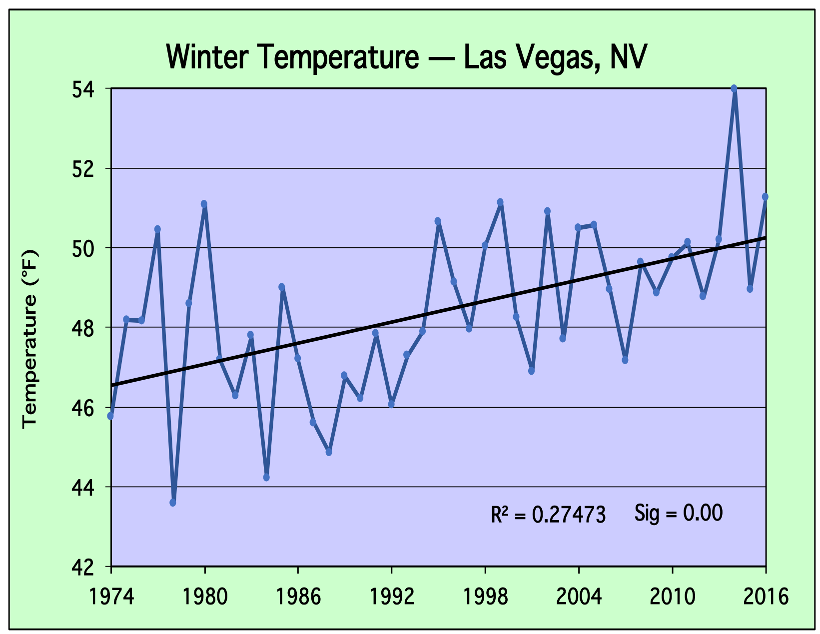

Winter Begin Date — International Falls, MN
25-Dec
20-Dec
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.09439
Sig = 0.05

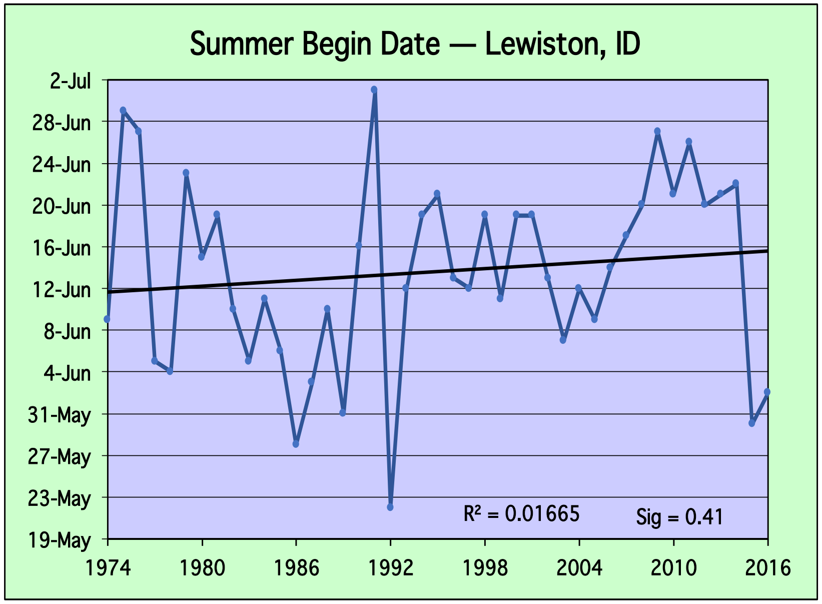

Winter Temperature — International Falls, MN
Temperature (°F)
18
16
14
12
10
8
6
4
2
0
-2
-4
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.08372
Sig = 0.06

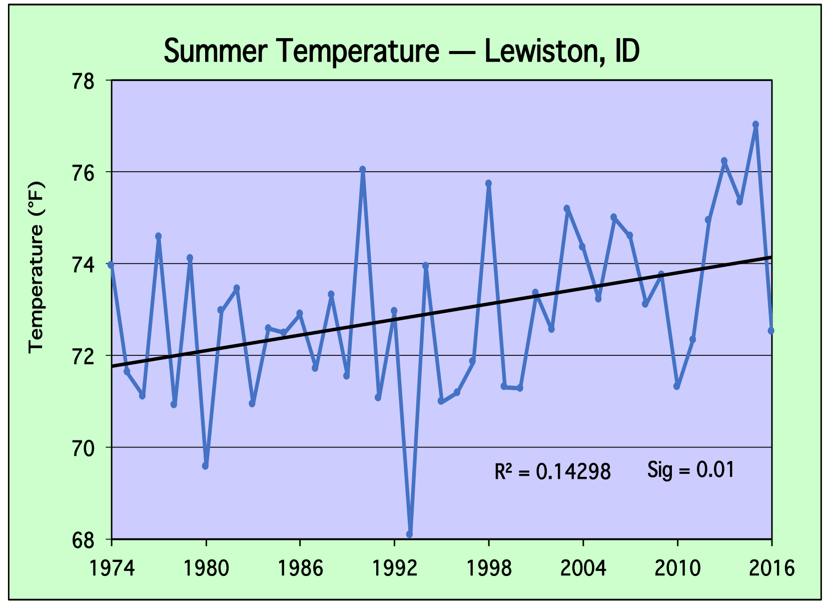

Summer Begin Date — Las Vegas, NV
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.0547
Sig = 0.13

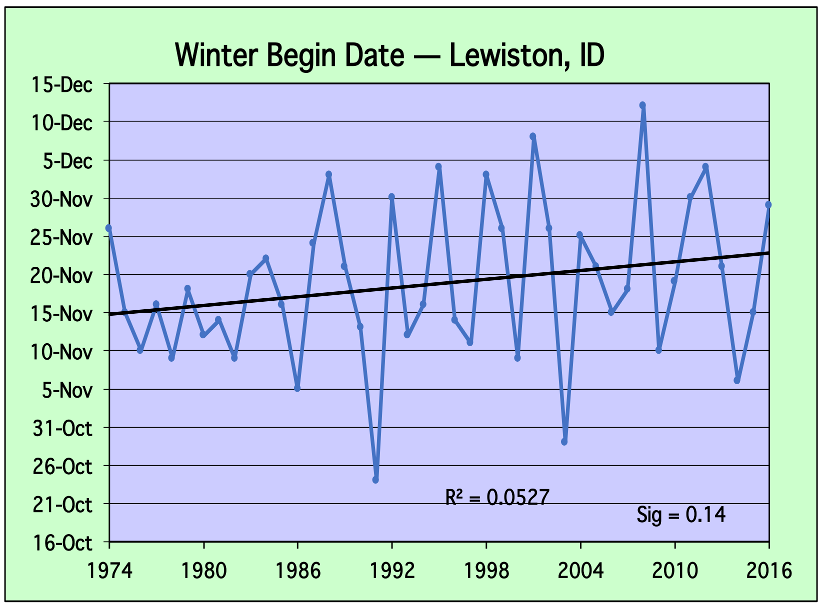

Summer Temperature — Las Vegas, NV
Temperature (°F)
94
93
92
91
90
89
88
87
86
85
84
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.50465
Sig = 0.00

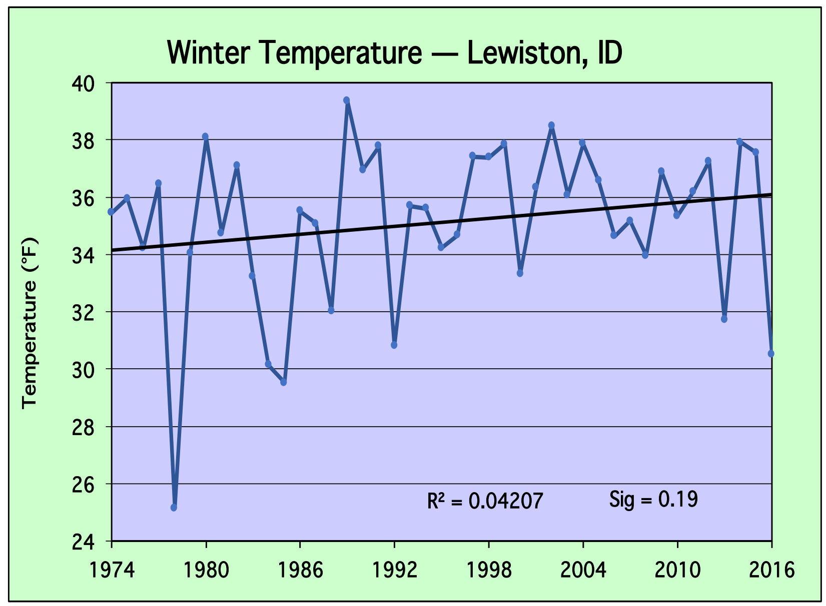

Winter Begin Date — Las Vegas, NV
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
Sig = 0.36
R² = 0.02048

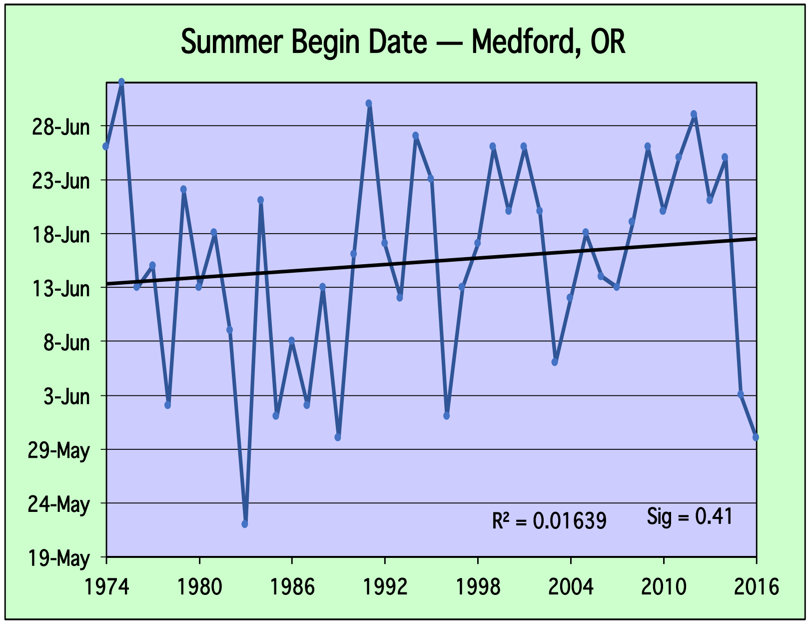

Winter Temperature — Las Vegas, NV
Temperature (°F)
54
52
50
48
46
44
42
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.27473
Sig = 0.00

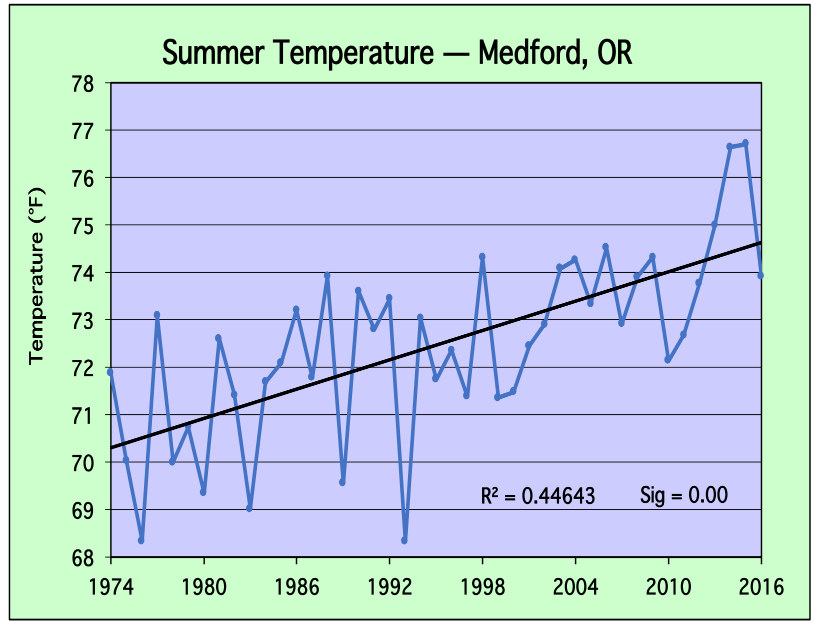

Summer Begin Date — Lewiston, ID
2-Jul
28-Jun
24-Jun
20-Jun
16-Jun
12-Jun
8-Jun
4-Jun
31-May
27-May
23-May
19-May
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.01665
Sig = 0.41

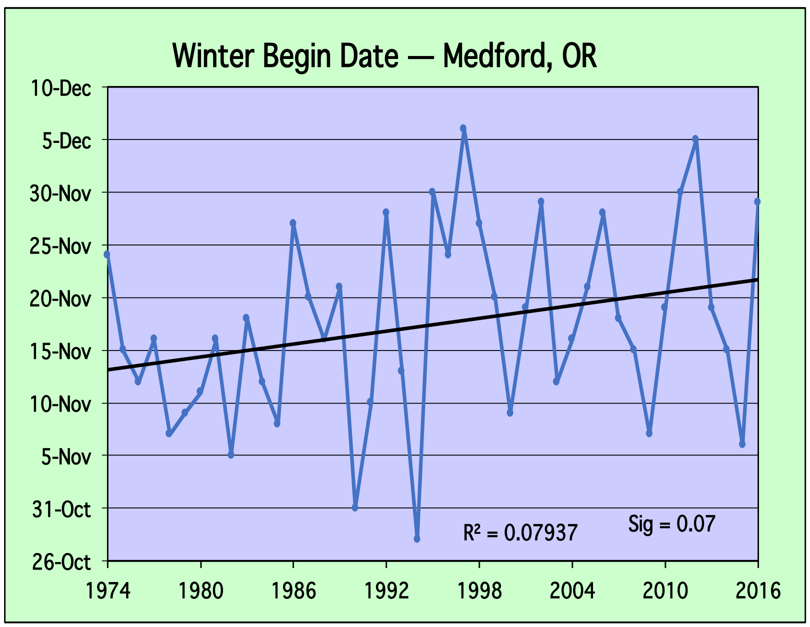

Summer Temperature — Lewiston, ID
Temperature (°F)
78 76 74 72 70 68
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.14298
Sig = 0.01

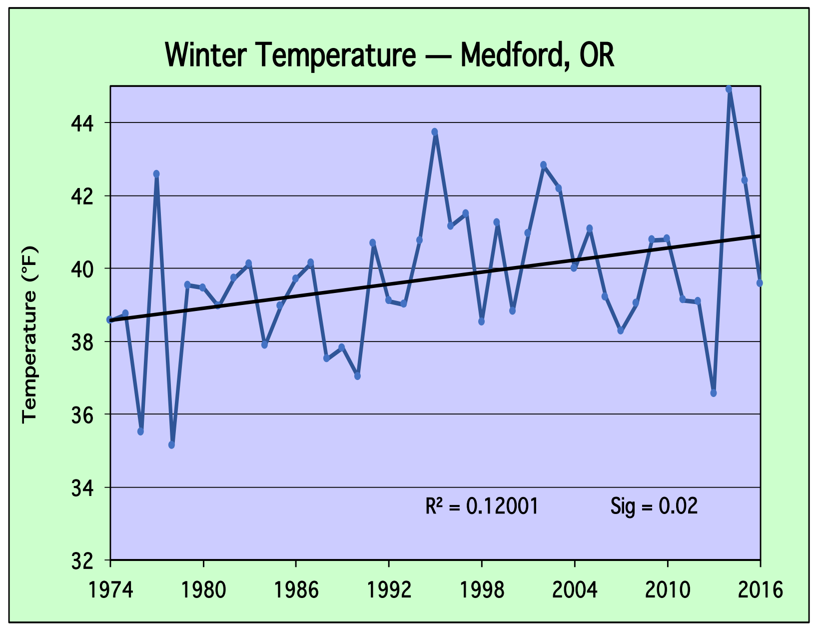

Winter Begin Date — Lewiston, ID
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
21-Oct
16-Oct
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.0527
Sig = 0.14

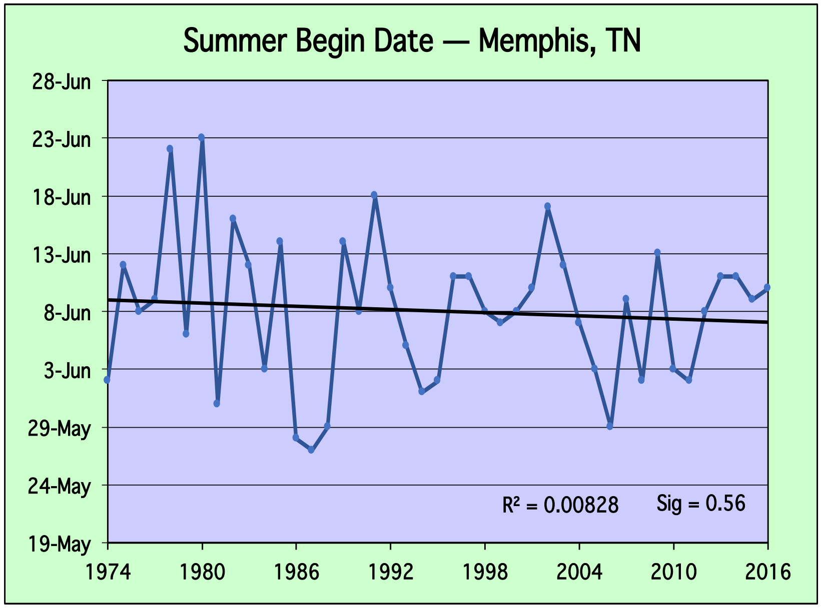

Winter Temperature — Lewiston, ID
Temperature (°F)
40 38 36 34 32 30 28 26 24
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.04207
Sig = 0.19

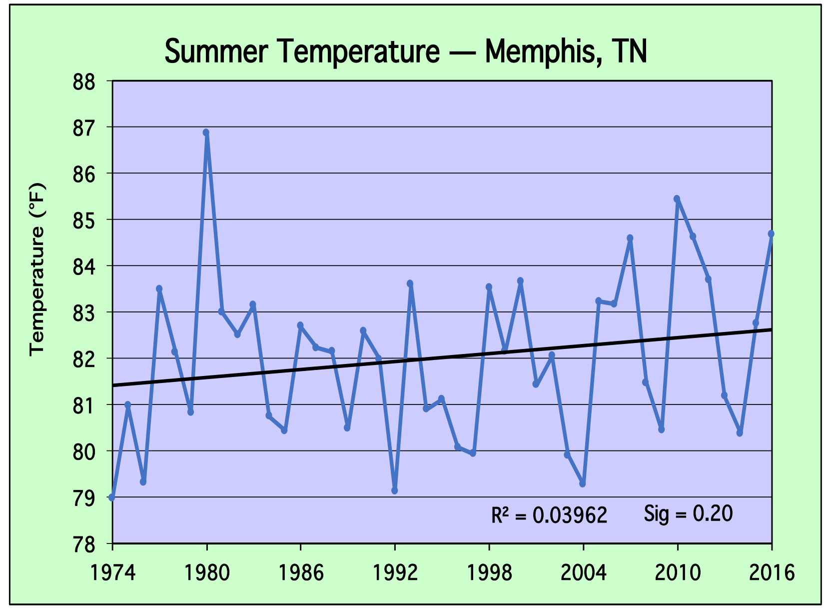

Summer Begin Date — Medford, OR
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.01639
Sig = 0.41

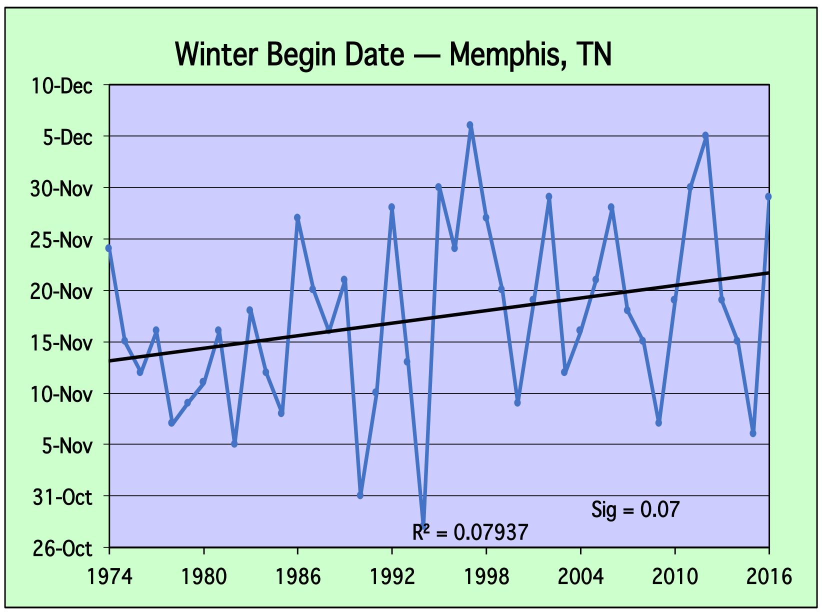

Summer Temperature — Medford, OR
Temperature (°F)
78
77
76
75
74
73
72
71
70
69
68
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.44643
Sig = 0.00

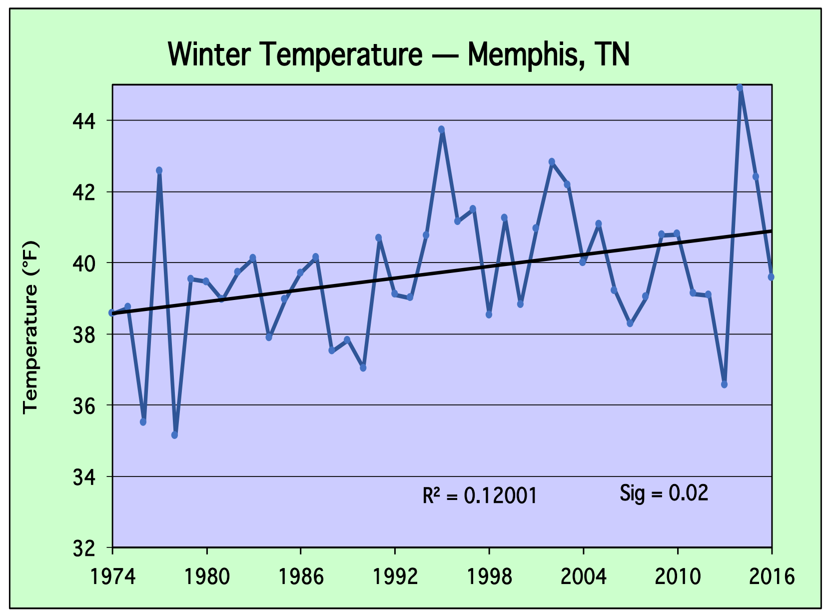

Winter Begin Date — Medford, OR
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.07937
Sig = 0.07

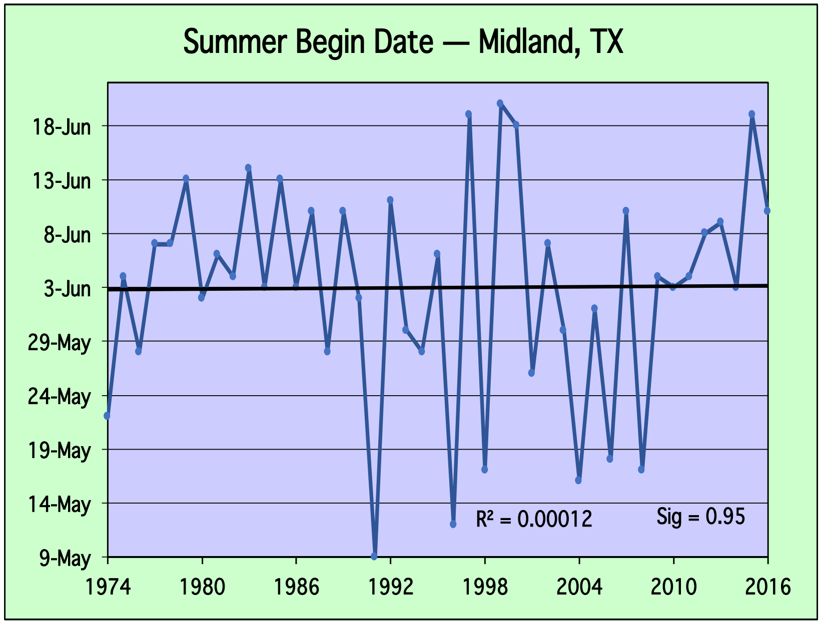

Winter Temperature — Medford, OR
Temperature (°F)
44
42
40
38
36
34
32
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.12001
Sig = 0.02

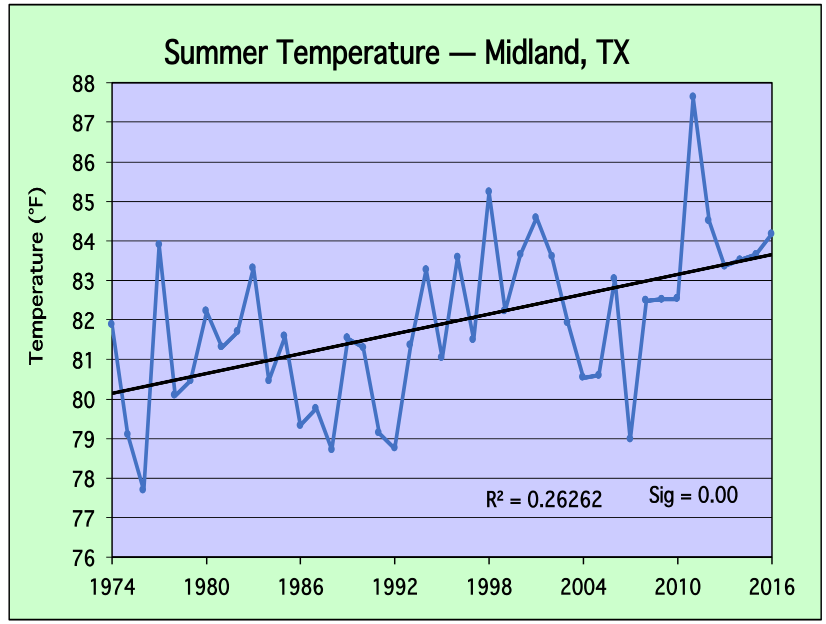

Summer Begin Date — Memphis, TN
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.00828
Sig = 0.56

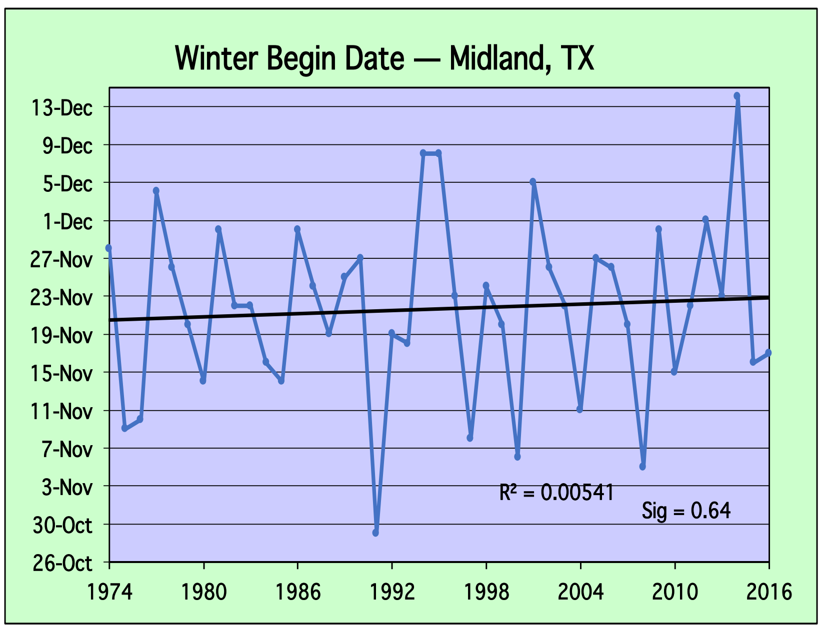

Summer Temperature — Memphis, TN
Temperature (°F)
88 87 86 85 84 83 82 81 80 79 78
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.03962
Sig = 0.20

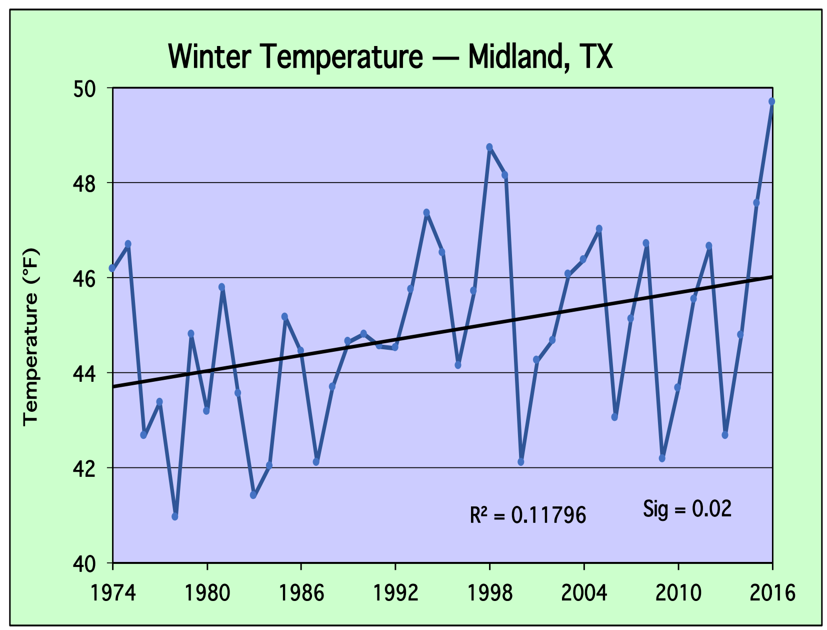

Winter Begin Date — Memphis, TN
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974 1980 1986 1992 1998 2004 2010 2016
Sig = 0.07
R² = 0.07937

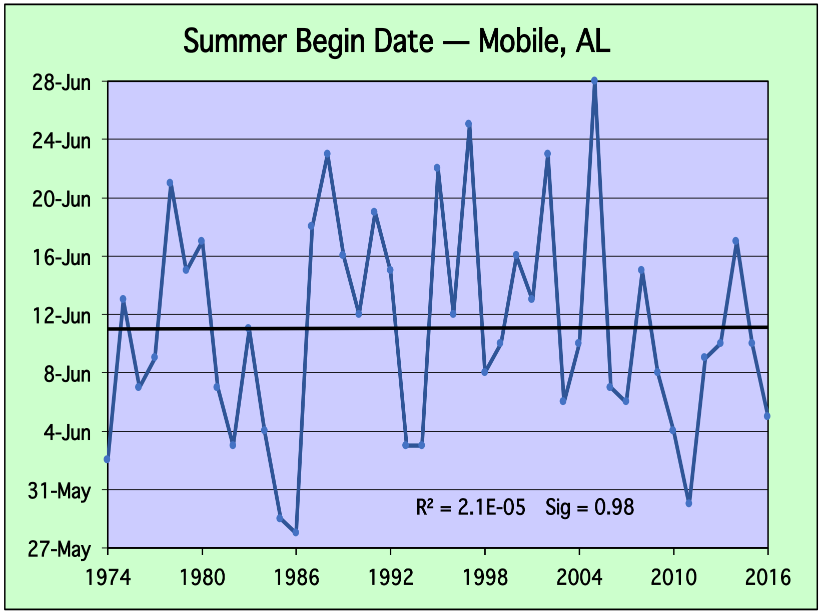

Winter Temperature — Memphis, TN
Temperature (°F)
44 42 40 38 36 34 32
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.12001
Sig = 0.02

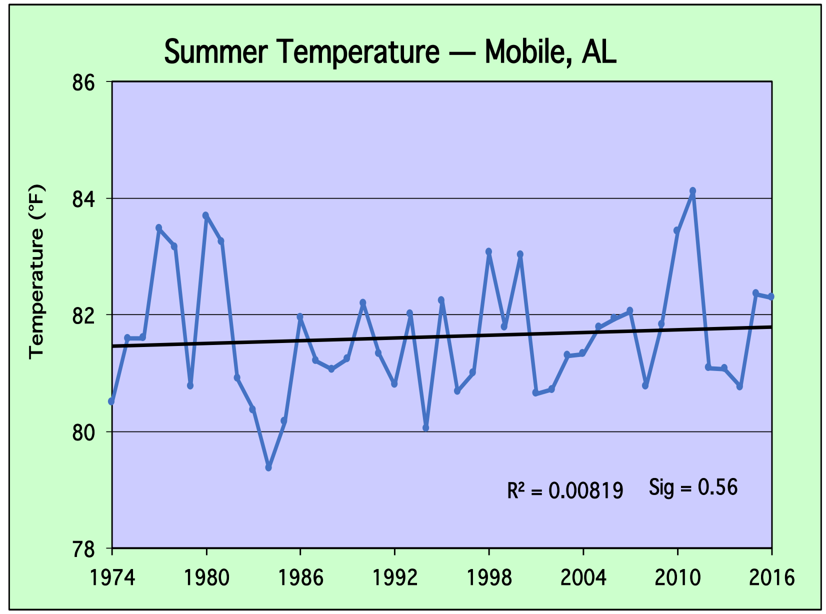

Summer Begin Date — Midland, TX
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
14-May
9-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00012
Sig = 0.95

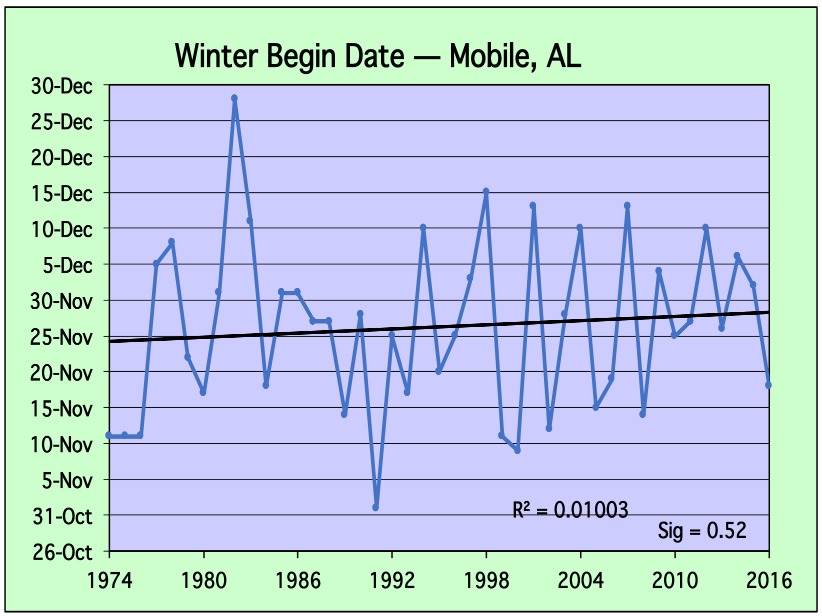

Summer Temperature — Midland, TX
Temperature (°F)
88
87
86
85
84
83
82
81
80
79
78
77
76
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.26262
Sig = 0.00

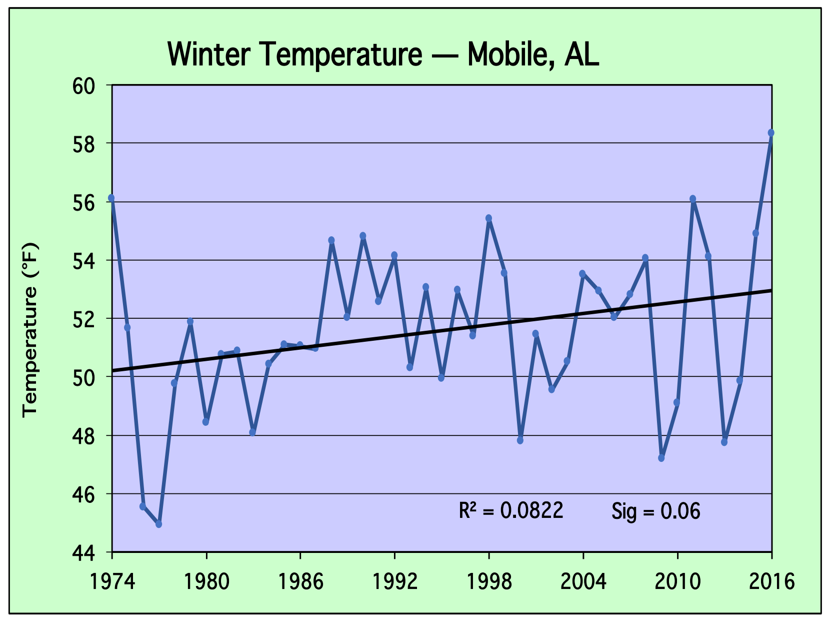

Winter Begin Date — Midland, TX
13-Dec
9-Dec
5-Dec
1-Dec
27-Nov
23-Nov
19-Nov
15-Nov
11-Nov
7-Nov
3-Nov
30-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00541
Sig = 0.64

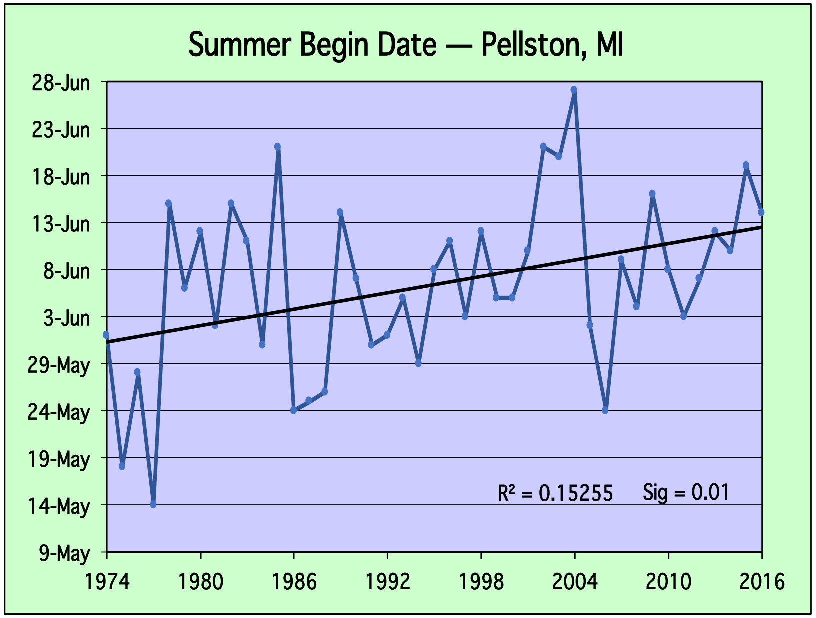

Winter Temperature — Midland, TX
Temperature (°F)
50
48
46
44
42
40
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.11796
Sig = 0.02

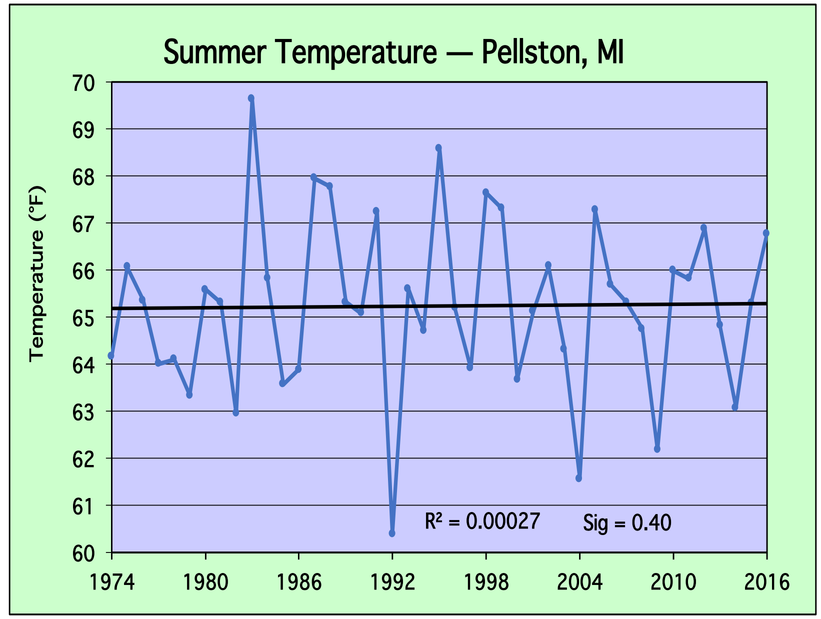

Summer Begin Date — Mobile, AL
28-Jun
24-Jun
20-Jun
16-Jun
12-Jun
8-Jun
4-Jun
31-May
27-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 2.1E-05 Sig = 0.98

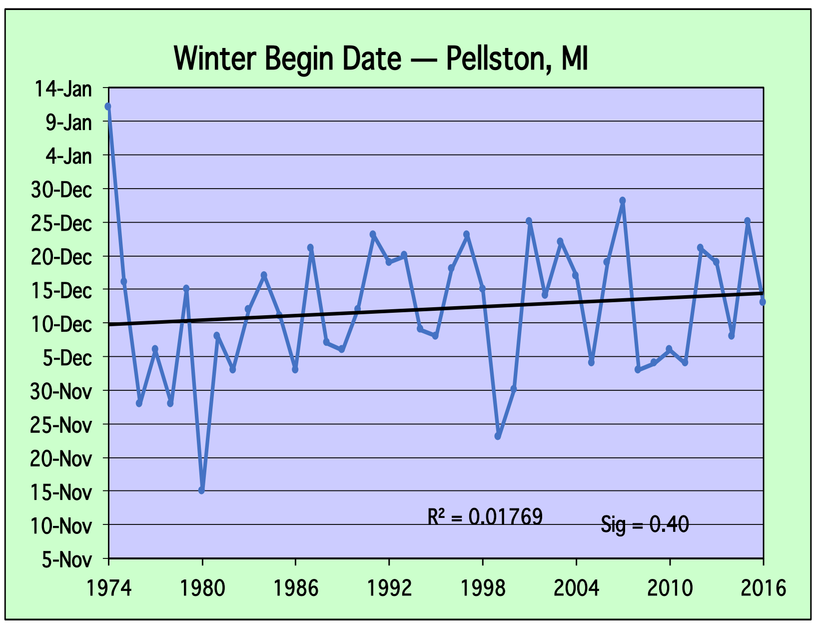

Summer Temperature — Mobile, AL
Temperature (°F)
86
84
82
80
78
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00819 Sig = 0.56

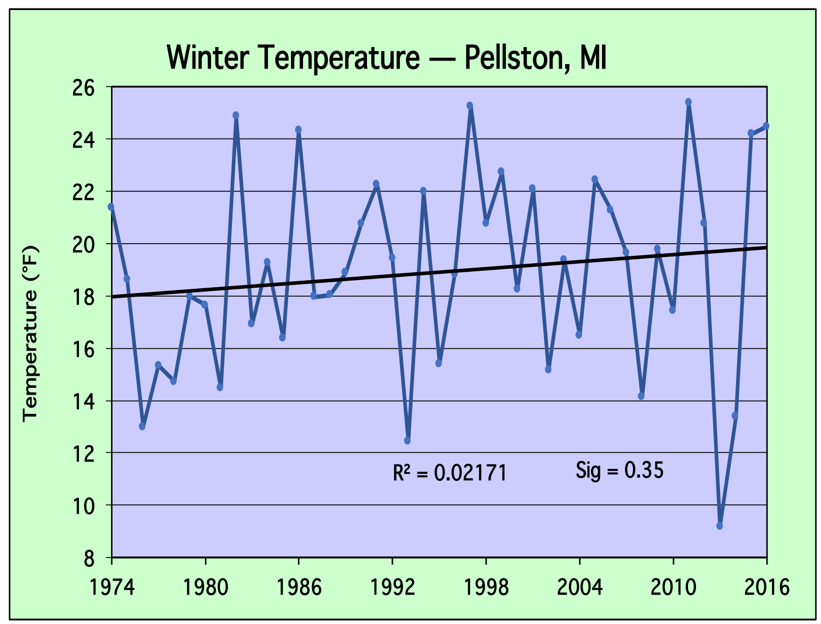

Winter Begin Date — Mobile, AL
30-Dec
25-Dec
20-Dec
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.01003
Sig = 0.52

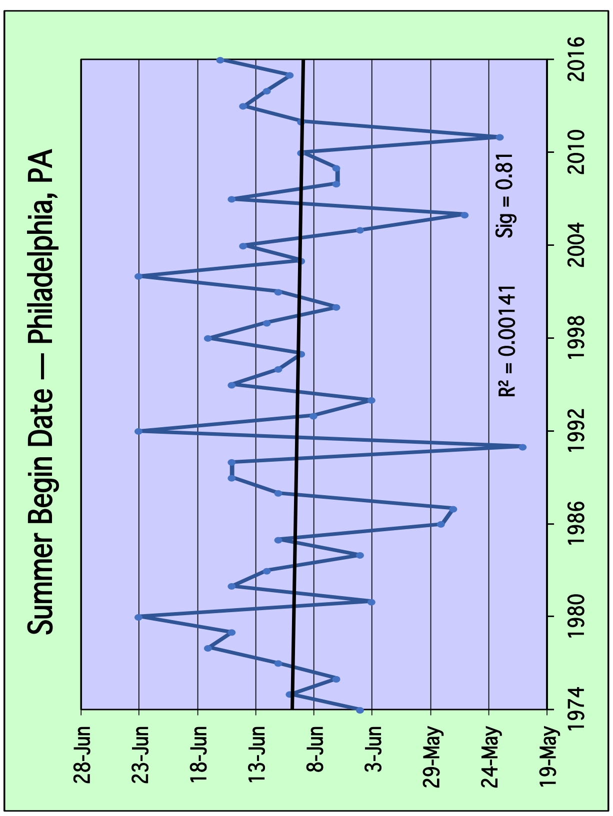

Winter Temperature — Mobile, AL
Temperature (°F)
60
58
56
54
52
50
48
46
44
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.0822 Sig = 0.06

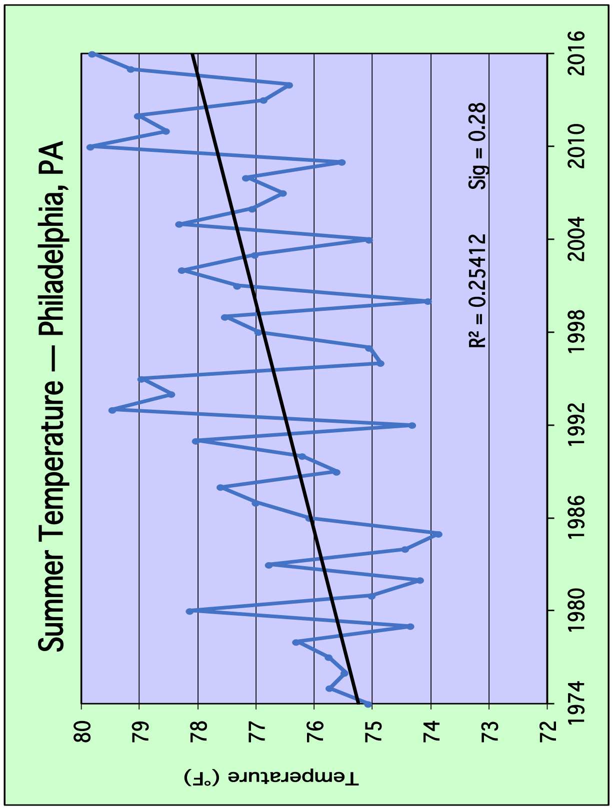

Summer Begin Date — Pellston, MI
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
14-May
9-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.15255
Sig = 0.01

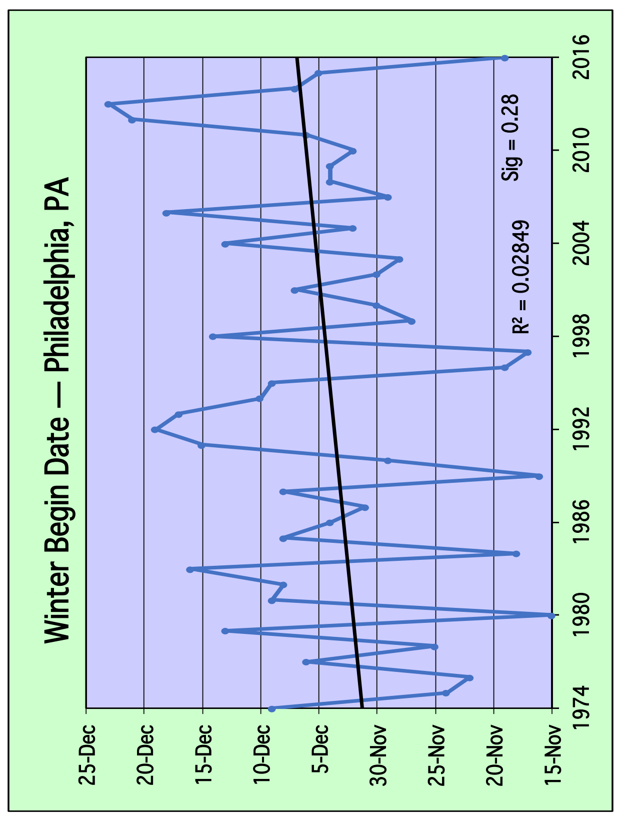

Summer Temperature — Pellston, MI
Temperature (°F)
70
69
68
67
66
65
64
63
62
61
60
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00027
Sig = 0.40

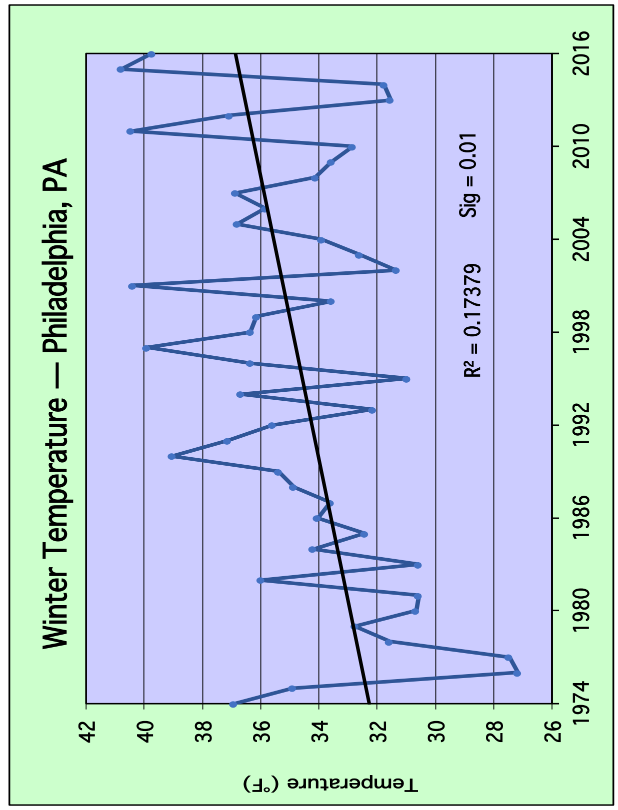

Winter Begin Date — Pellston, MI
14-Jan
9-Jan
4-Jan
30-Dec
25-Dec
20-Dec
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.01769
Sig = 0.40

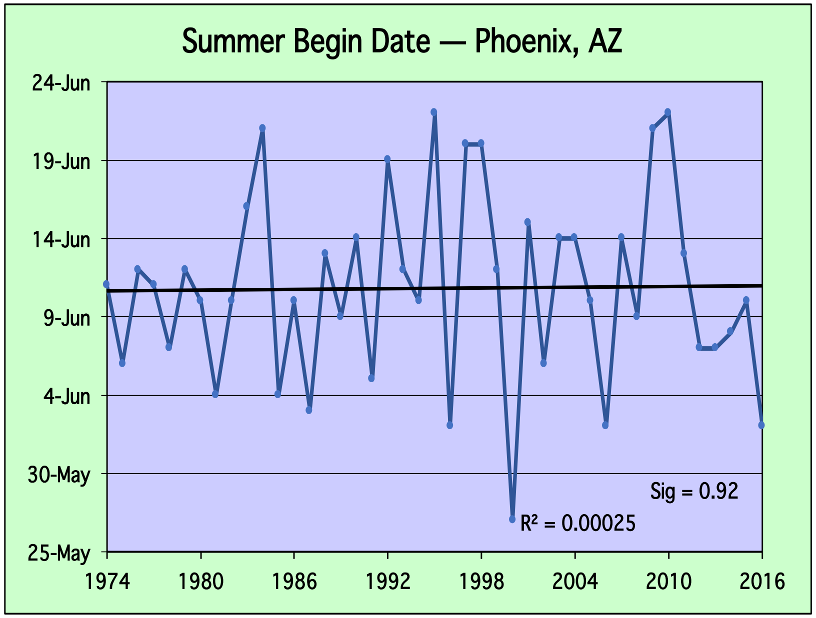

Winter Temperature — Pellston, MI
Temperature (°F)
26
24
22
20
18
16
14
12
10
8
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.02171
Sig = 0.35

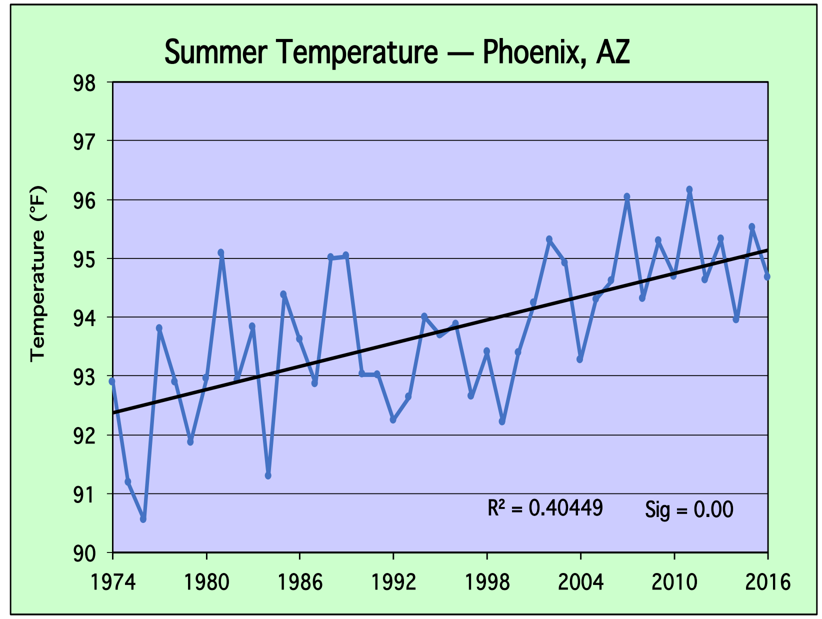

Summer Begin Date — Philadelphia, PA
R² = 0.00141
Sig = 0.81

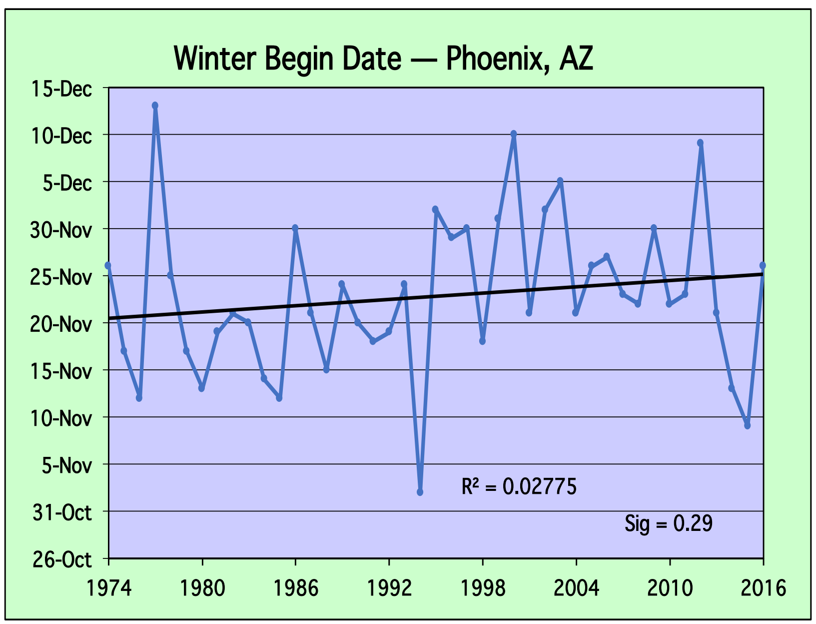

Summer Temperature — Philadelphia, PA
Temperature (°F)
R² = 0.25412
Sig = 0.28

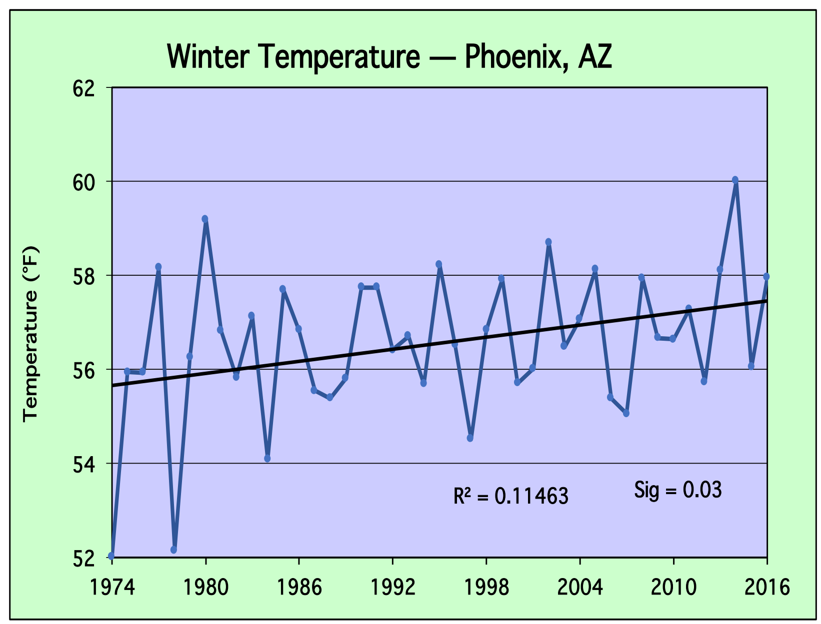

Winter Begin Date — Philadelphia, PA
R² = 0.02849
Sig = 0.28

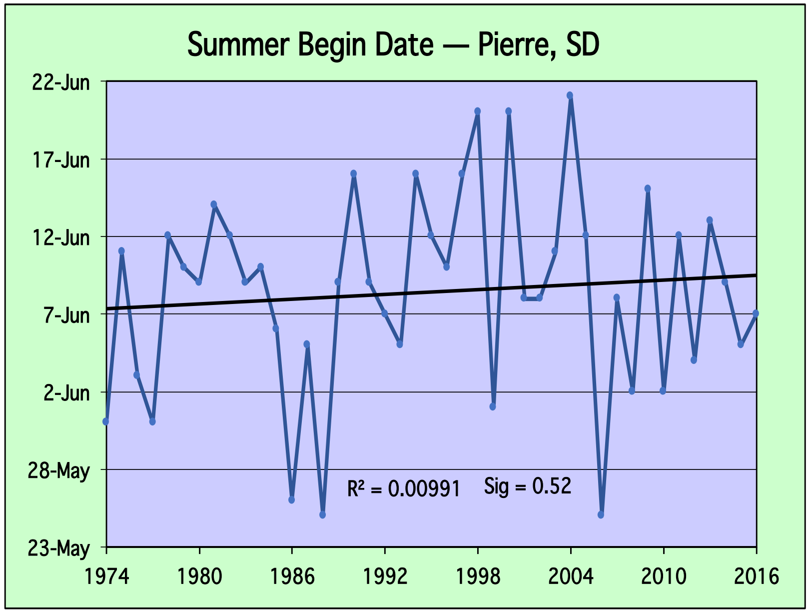

Winter Temperature — Philadelphia, PA
Temperature (°F)
R² = 0.17379
Sig = 0.01

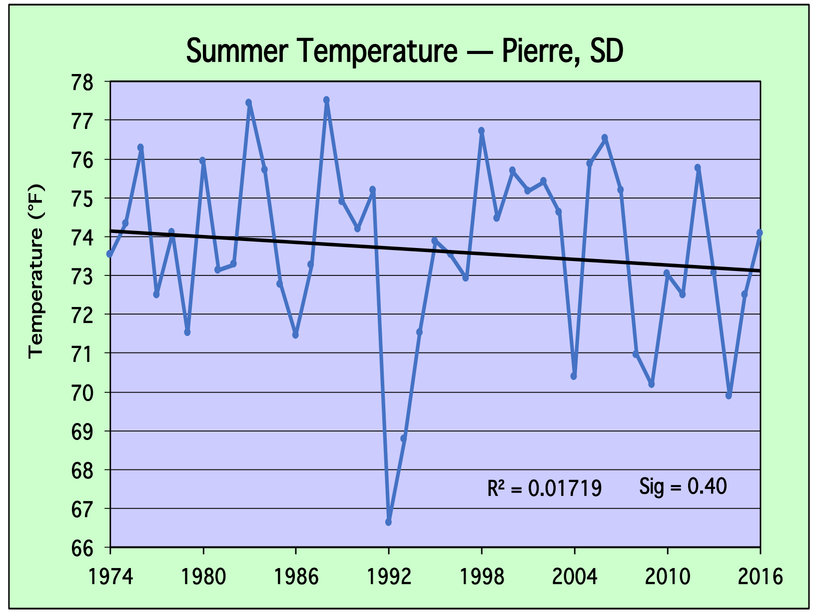

Summer Begin Date — Phoenix, AZ
24-Jun
19-Jun
14-Jun
9-Jun
4-Jun
30-May
25-May
1974
1980
1986
1992
1998
2004
2010
2016
Sig = 0.92
R² = 0.00025

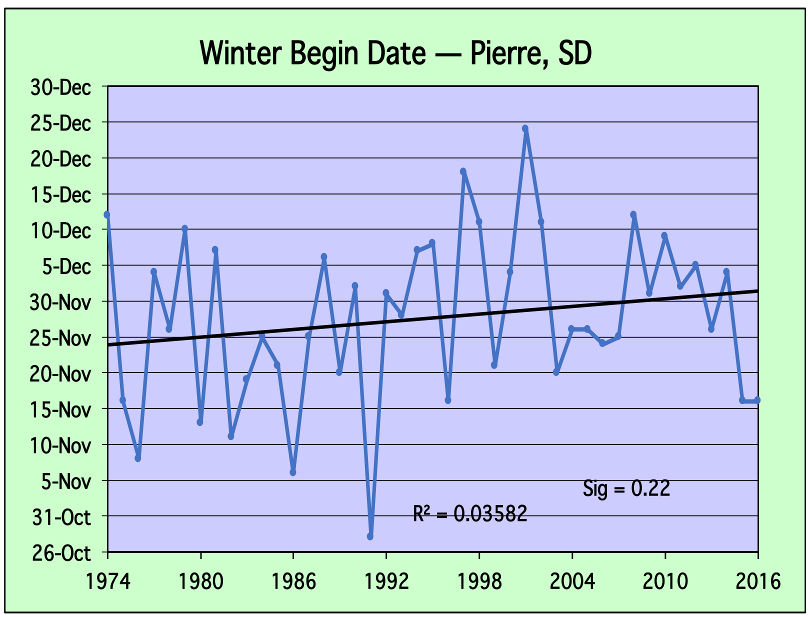

Summer Temperature — Phoenix, AZ
Temperature (°F)
98
97
96
95
94
93
92
91
90
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.40449
Sig = 0.00

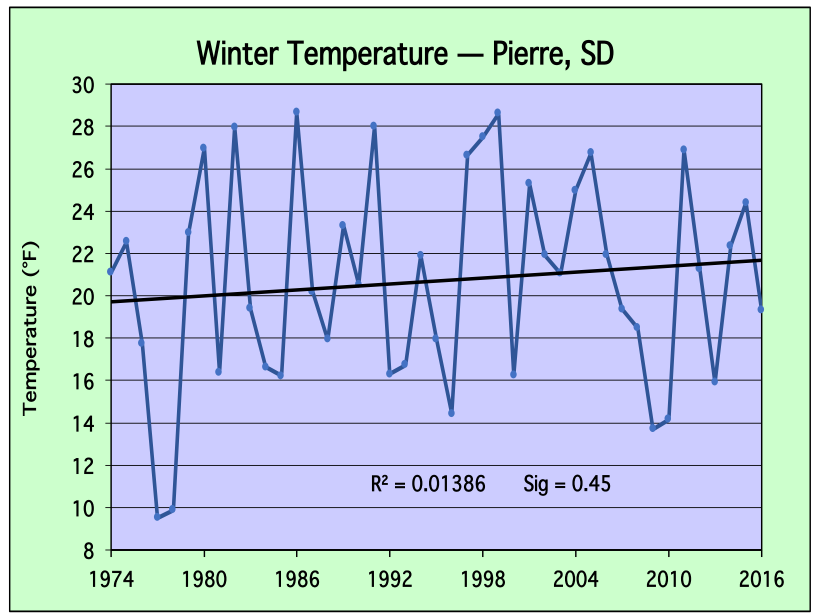

Winter Begin Date — Phoenix, AZ
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.02775
Sig = 0.29

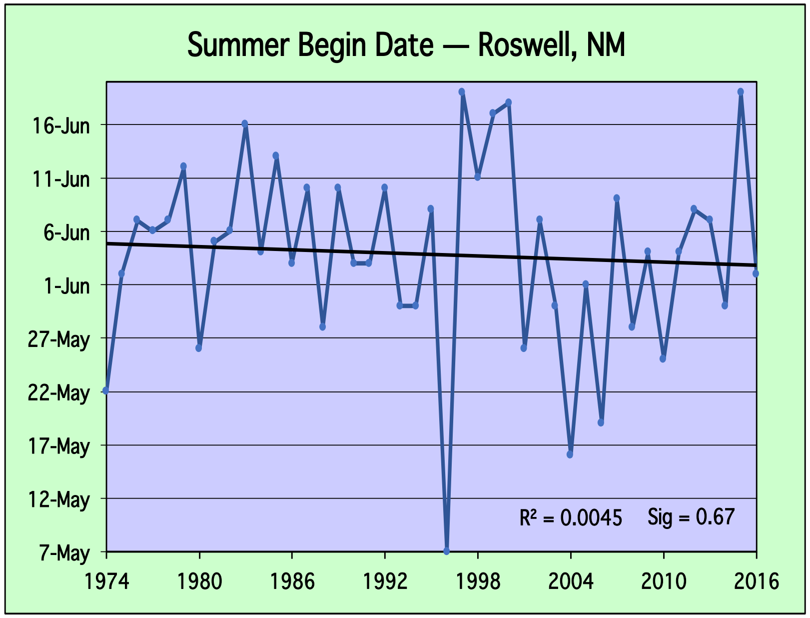

Winter Temperature — Phoenix, AZ
Temperature (°F)
62
60
58
56
54
52
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.11463
Sig = 0.03

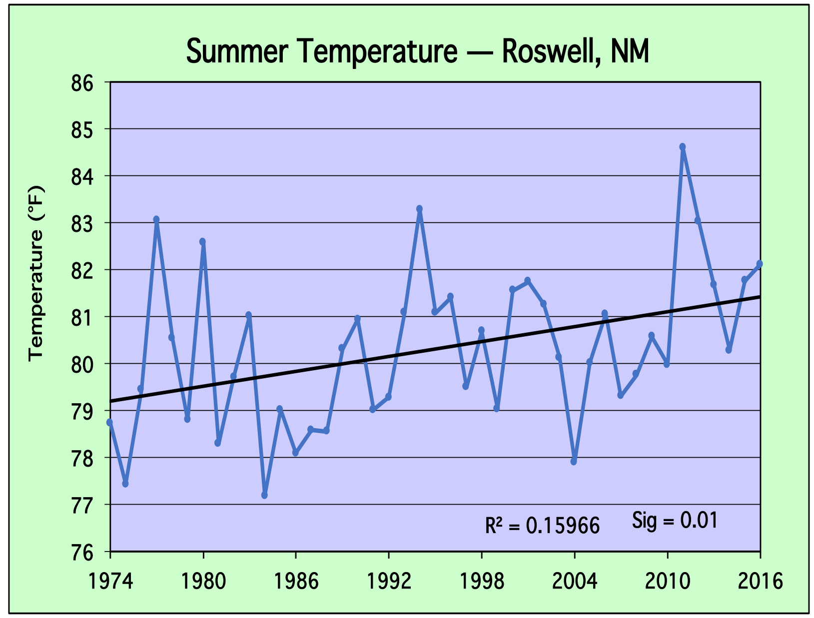

Summer Begin Date — Pierre, SD
22-Jun
17-Jun
12-Jun
7-Jun
2-Jun
28-May
23-May
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.00991
Sig = 0.52

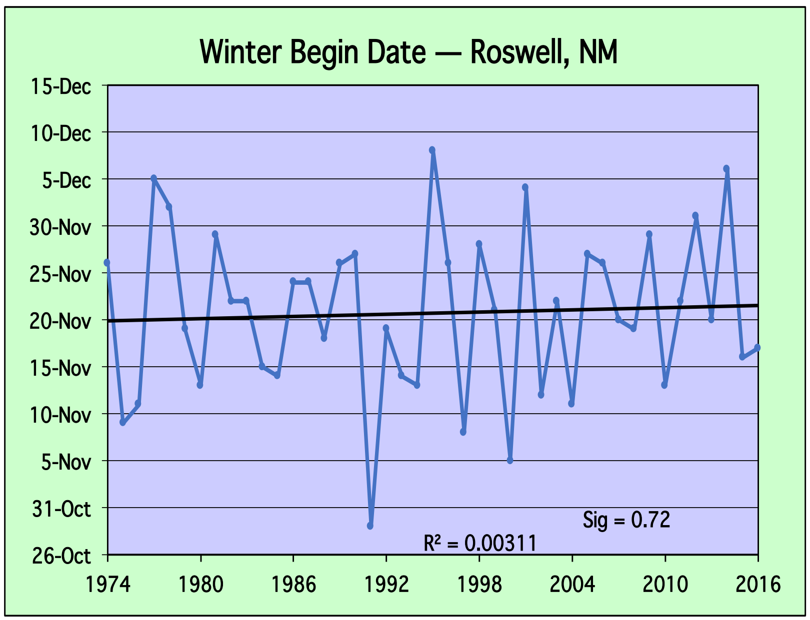

Summer Temperature — Pierre, SD
Temperature (°F)
78 77 76 75 74 73 72 71 70 69 68 67 66
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.01719
Sig = 0.40

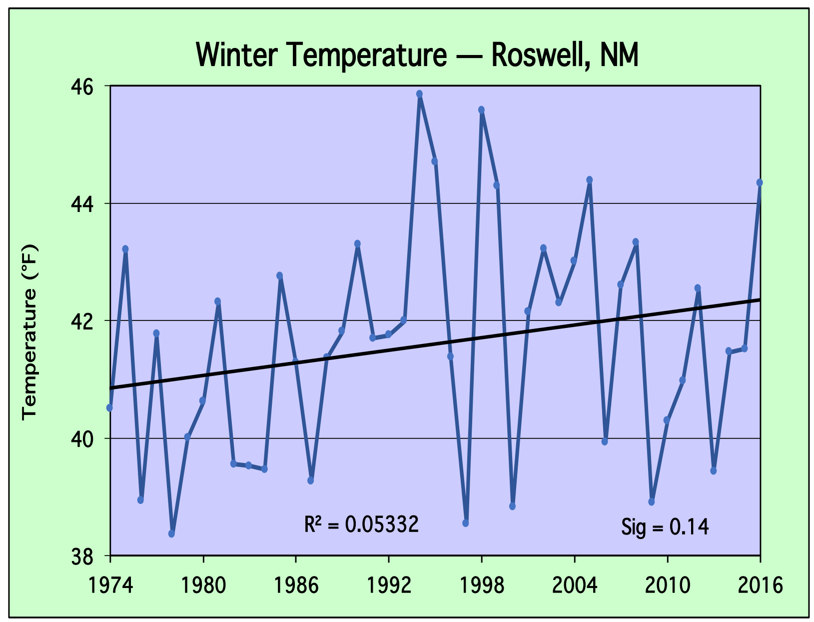

Winter Begin Date — Pierre, SD
30-Dec
25-Dec
20-Dec
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974 1980 1986 1992 1998 2004 2010 2016
Sig = 0.22
R² = 0.03582

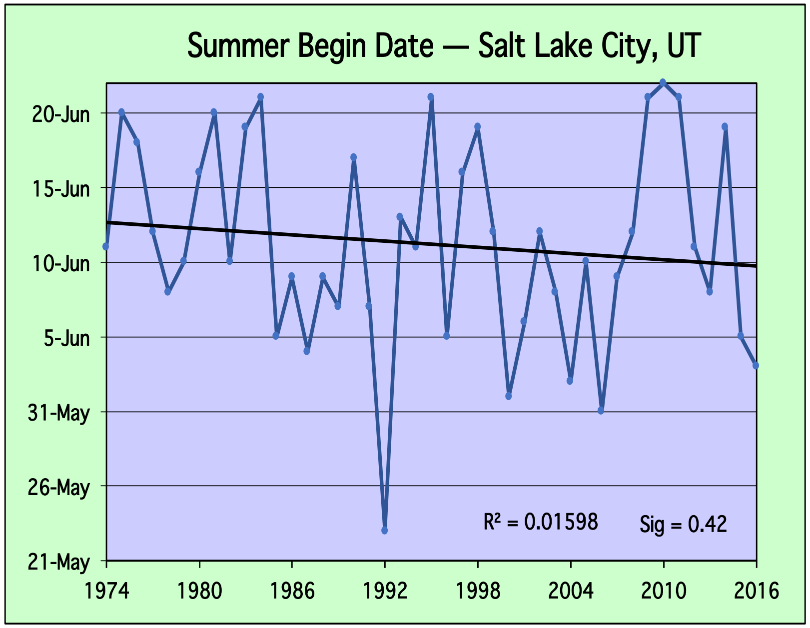

Winter Temperature — Pierre, SD
Temperature (°F)
30 28 26 24 22 20 18 16 14 12 10 8
1974 1980 1986 1992 1998 2004 2010 2016
R² = 0.01386
Sig = 0.45

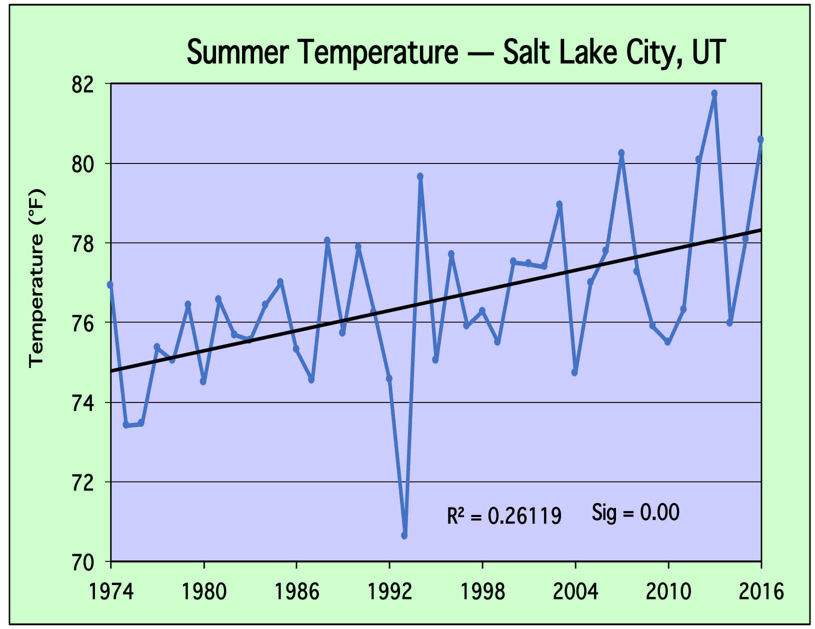

Summer Begin Date — Roswell, NM
16-Jun
11-Jun
6-Jun
1-Jun
27-May
22-May
17-May
12-May
7-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.0045
Sig = 0.67

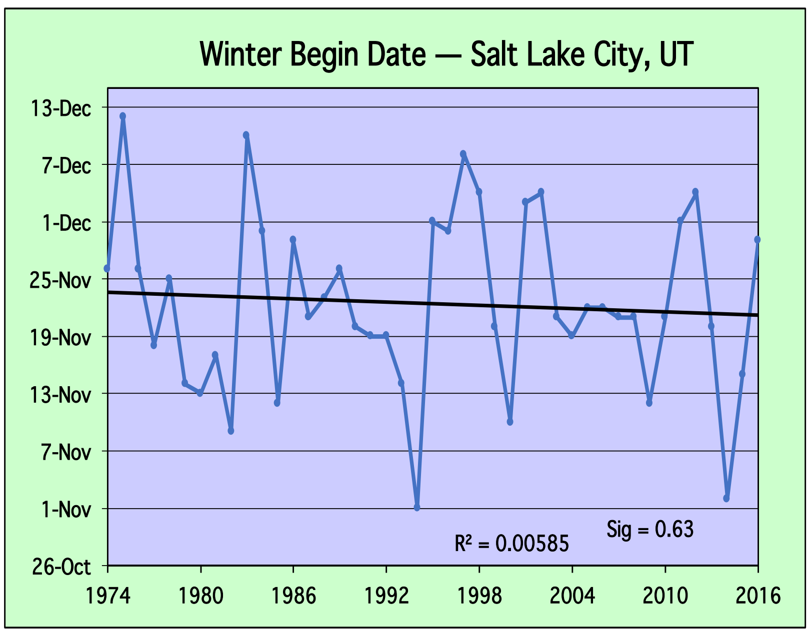

Summer Temperature — Roswell, NM
Temperature (°F)
86
85
84
83
82
81
80
79
78
77
76
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.15966
Sig = 0.01

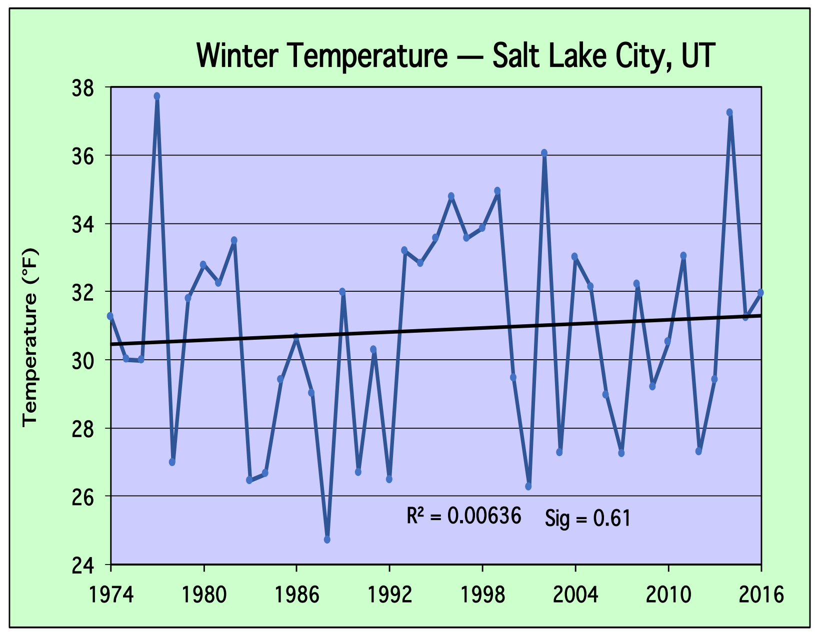

Winter Begin Date — Roswell, NM
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
Sig = 0.72
R² = 0.00311

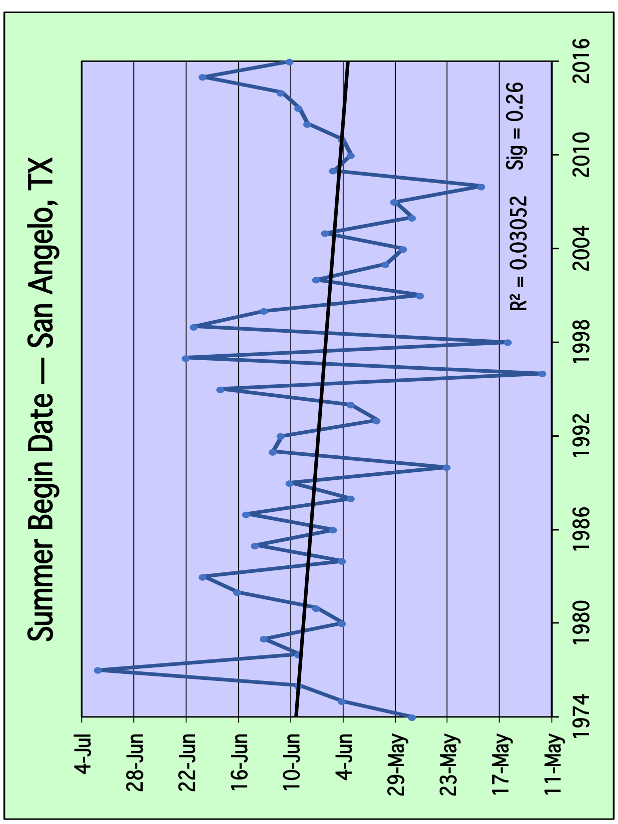

Winter Temperature — Roswell, NM
Temperature (°F)
46
44
42
40
38
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.05332
Sig = 0.14

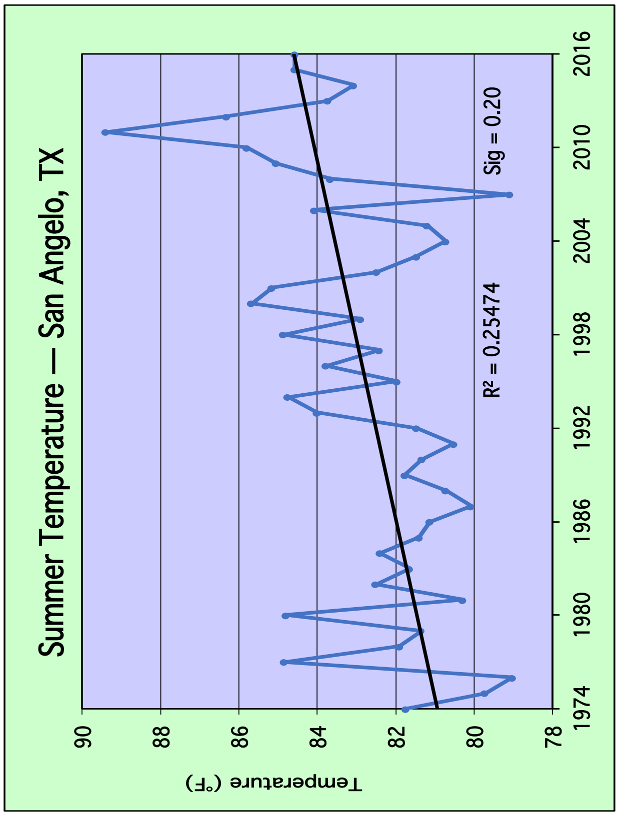

Summer Begin Date — Salt Lake City, UT
20-Jun
15-Jun
10-Jun
5-Jun
31-May
26-May
21-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.01598
Sig = 0.42

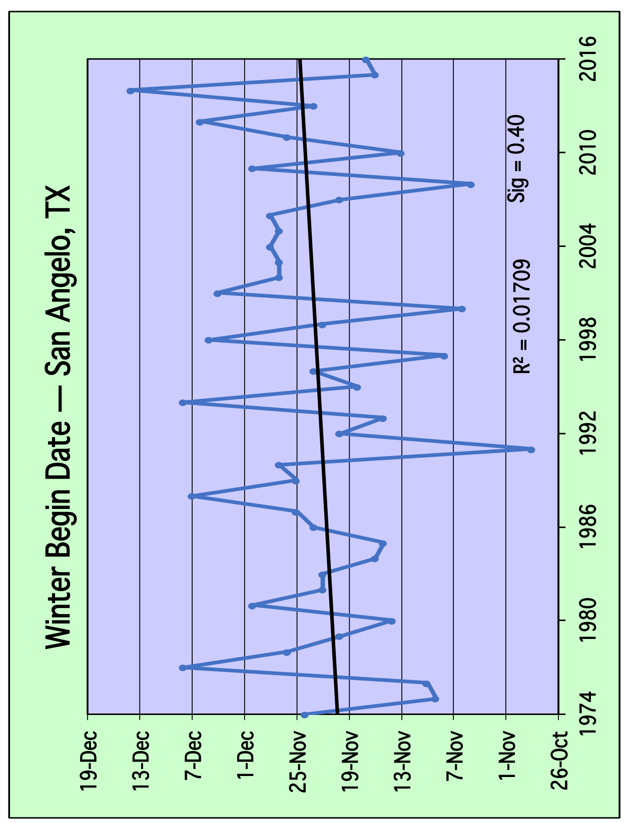

Summer Temperature — Salt Lake City, UT
Temperature (°F)
82
80
78
76
74
72
70
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.26119
Sig = 0.00

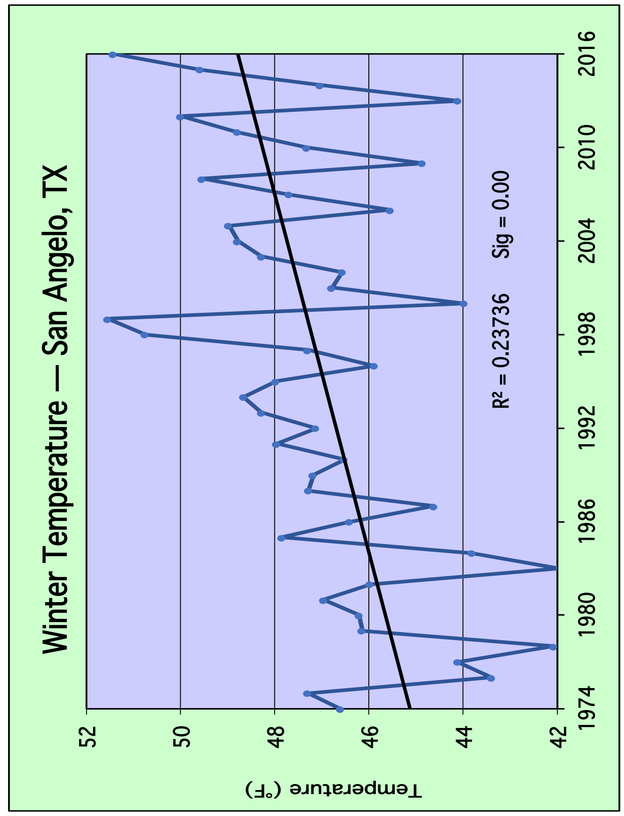

Winter Begin Date — Salt Lake City, UT
13-Dec
7-Dec
1-Dec
25-Nov
19-Nov
13-Nov
7-Nov
1-Nov
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00585
Sig = 0.63

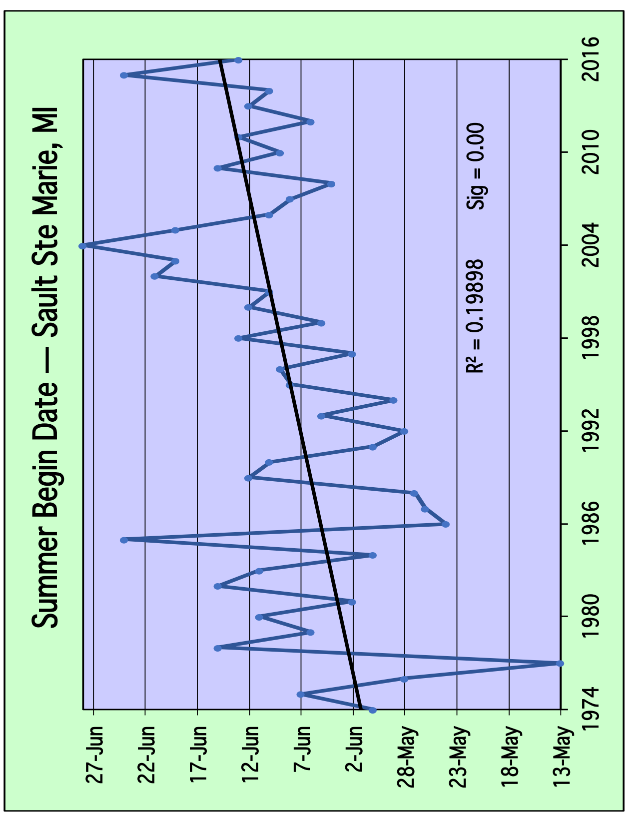

Winter Temperature — Salt Lake City, UT
Temperature (°F)
38
36
34
32
30
28
26
24
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.00636
Sig = 0.61

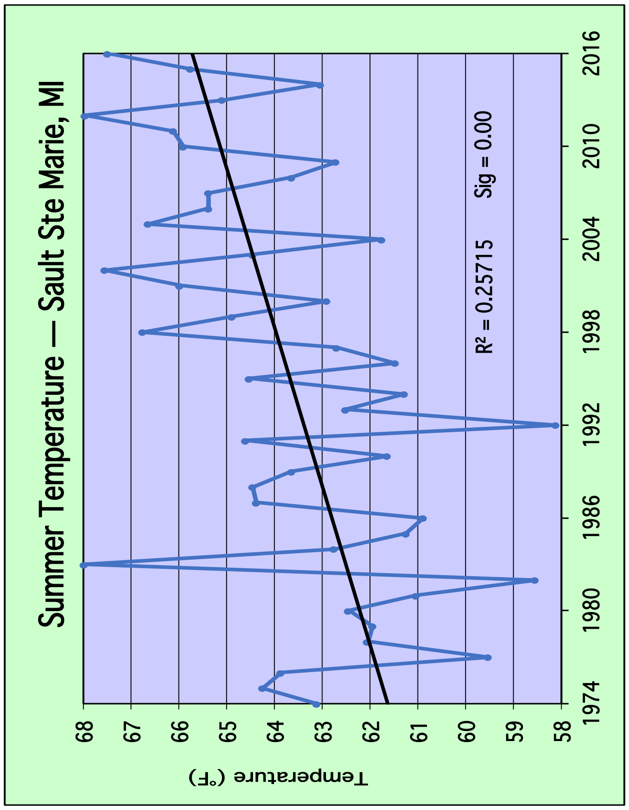

Summer Begin Date — San Angelo, TX
R² = 0.03052
Sig = 0.26
4-Jul
28-Jun
22-Jun
16-Jun
10-Jun
4-Jun
29-May
23-May
17-May
11-May
1974
1980
1986
1992
1998
2004
2010
2016

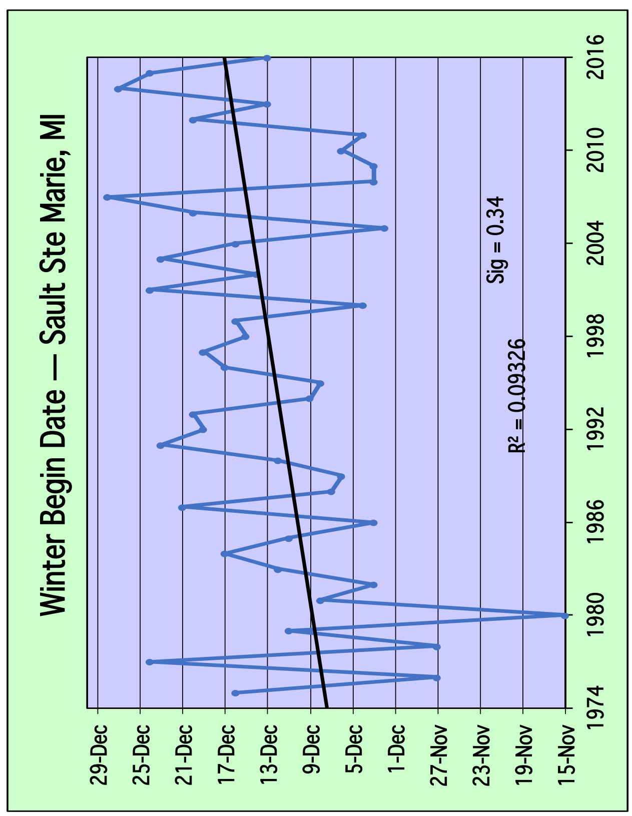

Summer Temperature — San Angelo, TX
R² = 0.25474
Sig = 0.20
Temperature (°F)
90
88
86
84
82
80
78
1974
1980
1986
1992
1998
2004
2010
2016

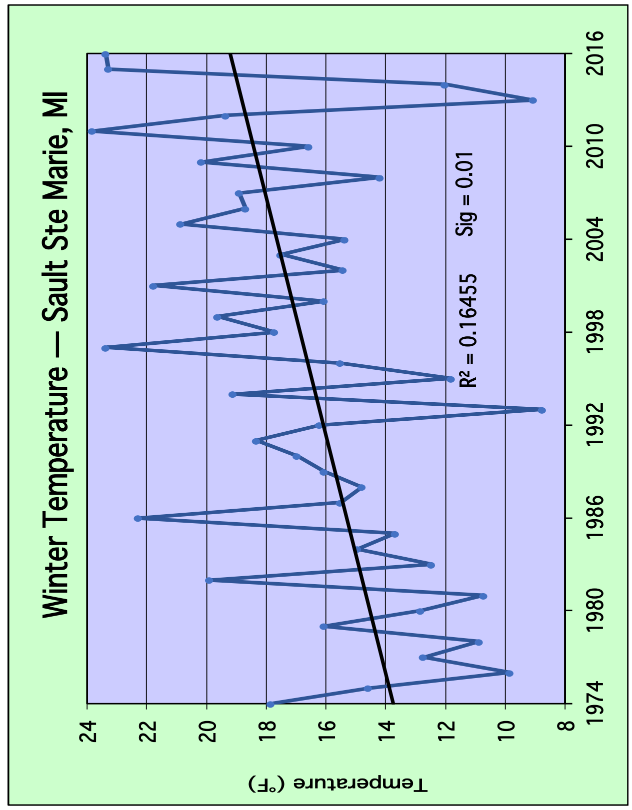

Winter Begin Date — San Angelo, TX
R² = 0.01709
Sig = 0.40
19-Dec
13-Dec
7-Dec
1-Dec
25-Nov
19-Nov
13-Nov
7-Nov
1-Nov
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016

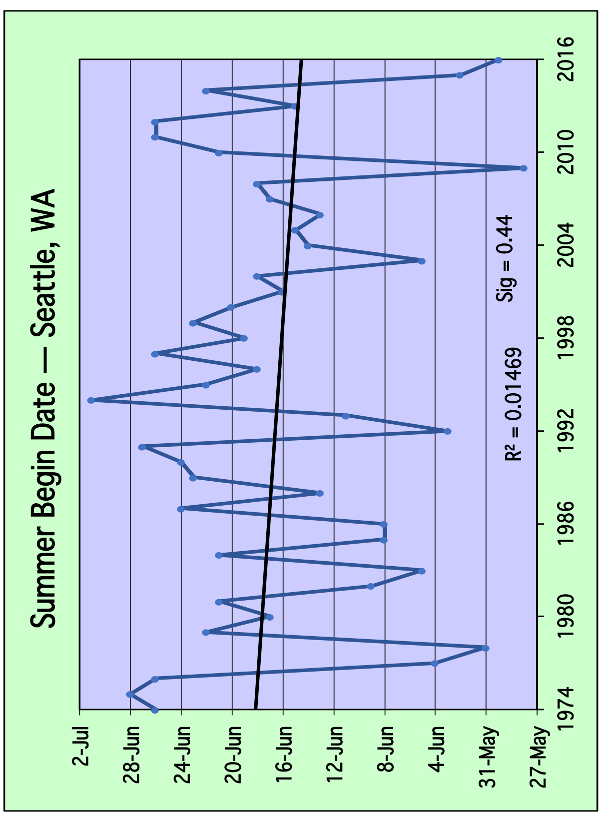

Winter Temperature — San Angelo, TX
R² = 0.23736
Sig = 0.00
Temperature (°F)
52
50
48
46
44
42
1974
1980
1986
1992
1998
2004
2010
2016

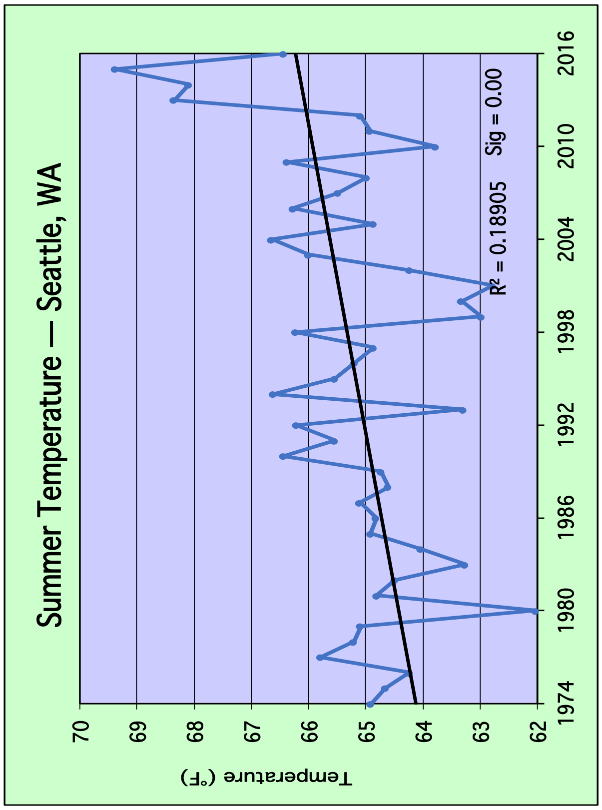

Summer Begin Date — Sault Ste Marie, MI
27-Jun
22-Jun
17-Jun
12-Jun
7-Jun
2-Jun
28-May
23-May
18-May
13-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.19898
Sig = 0.00

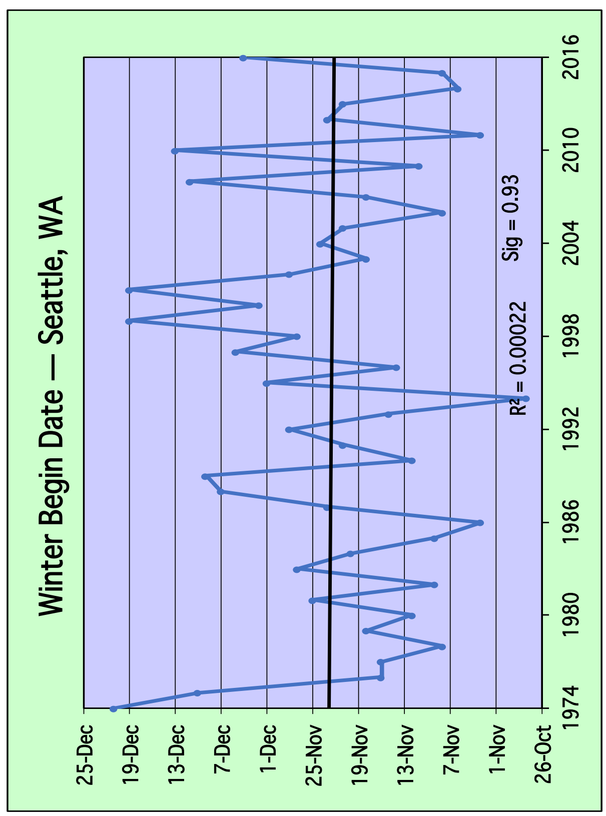

Summer Temperature — Sault Ste Marie, MI
Temperature (°F)
68
67
66
65
64
63
62
61
60
59
58
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.25715
Sig = 0.00

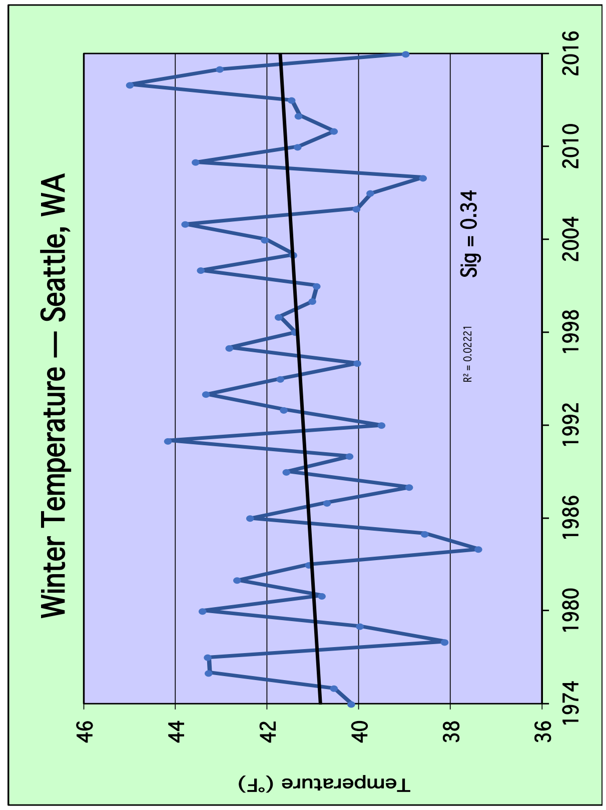

Winter Begin Date — Sault Ste Marie, MI
29-Dec
25-Dec
21-Dec
17-Dec
13-Dec
9-Dec
5-Dec
1-Dec
27-Nov
23-Nov
19-Nov
15-Nov
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.09326
Sig = 0.34

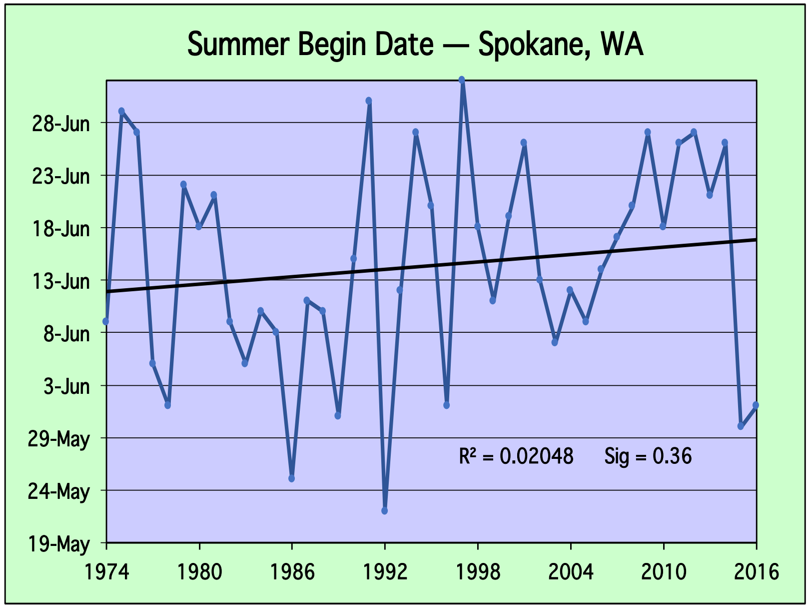

Winter Temperature — Sault Ste Marie, MI
Temperature (°F)
24
22
20
18
16
14
12
10
8
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.16455
Sig = 0.01

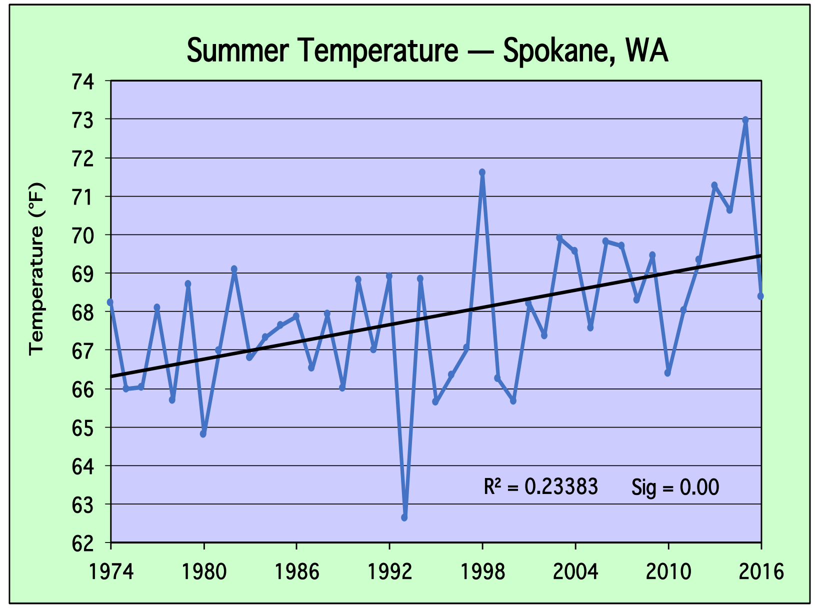

Summer Begin Date — Seattle, WA
R² = 0.01469
Sig = 0.44
2-Jul
28-Jun
24-Jun
20-Jun
16-Jun
12-Jun
8-Jun
4-Jun
31-May
27-May
1974
1980
1986
1992
1998
2004
2010
2016

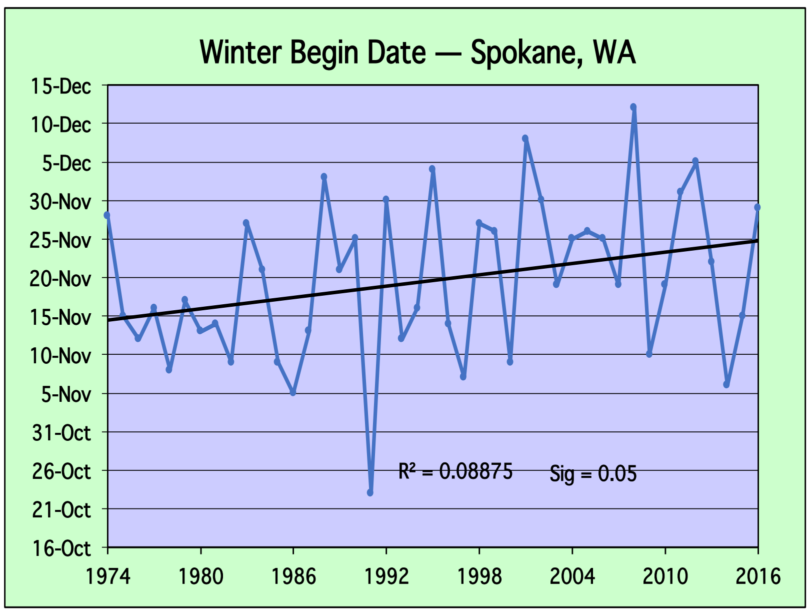

Summer Temperature — Seattle, WA
R² = 0.18905
Sig = 0.00
Temperature (°F)
70
69
68
67
66
65
64
63
62
1974
1980
1986
1992
1998
2004
2010
2016

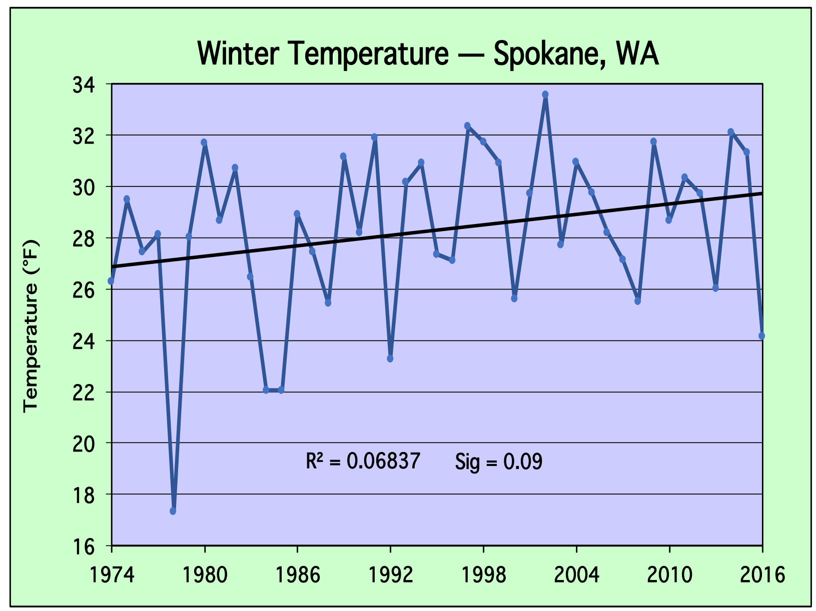

Winter Begin Date — Seattle, WA
R² = 0.00022
Sig = 0.93
25-Dec
19-Dec
13-Dec
7-Dec
1-Dec
25-Nov
19-Nov
13-Nov
7-Nov
1-Nov
26-Oct
1974
1980
1986
1992
1998
2004
2010
2016

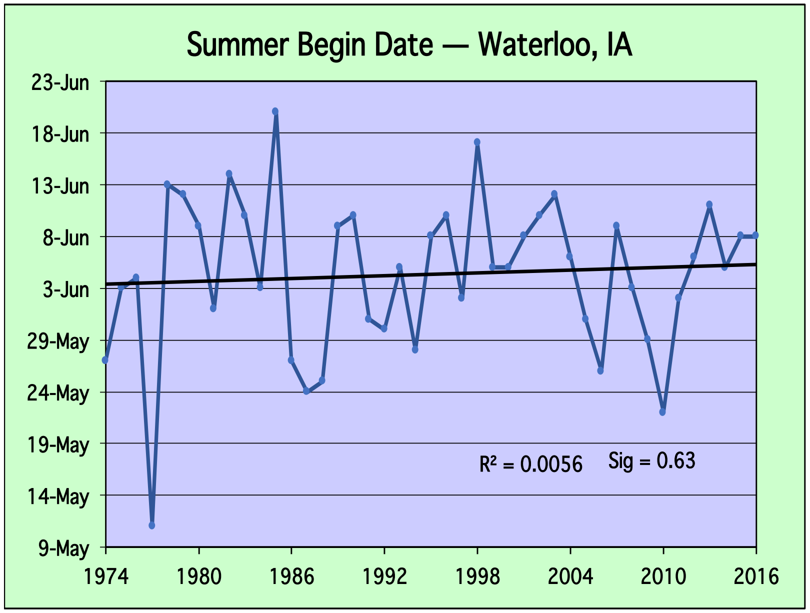

Winter Temperature — Seattle, WA
R² = 0.02221
Sig = 0.34
Temperature (°F)
46
44
42
40
38
36
1974
1980
1986
1992
1998
2004
2010
2016

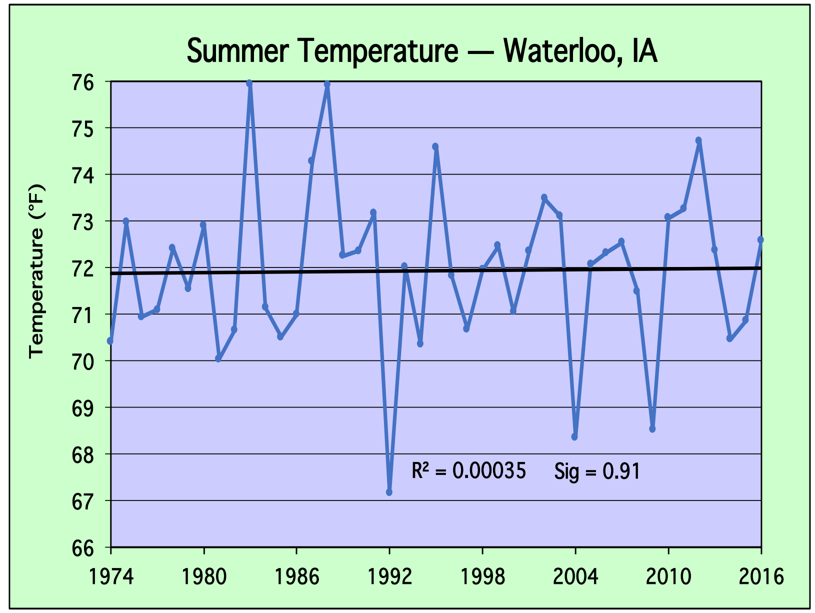

Summer Begin Date — Spokane, WA
28-Jun
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.02048
Sig = 0.36

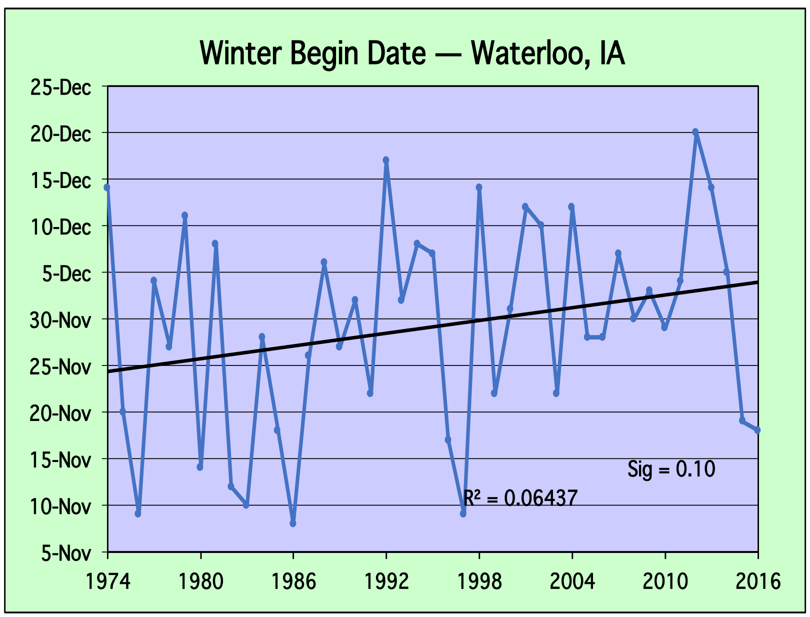

Summer Temperature — Spokane, WA
Temperature (°F)
74
73
72
71
70
69
68
67
66
65
64
63
62
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.23383
Sig = 0.00

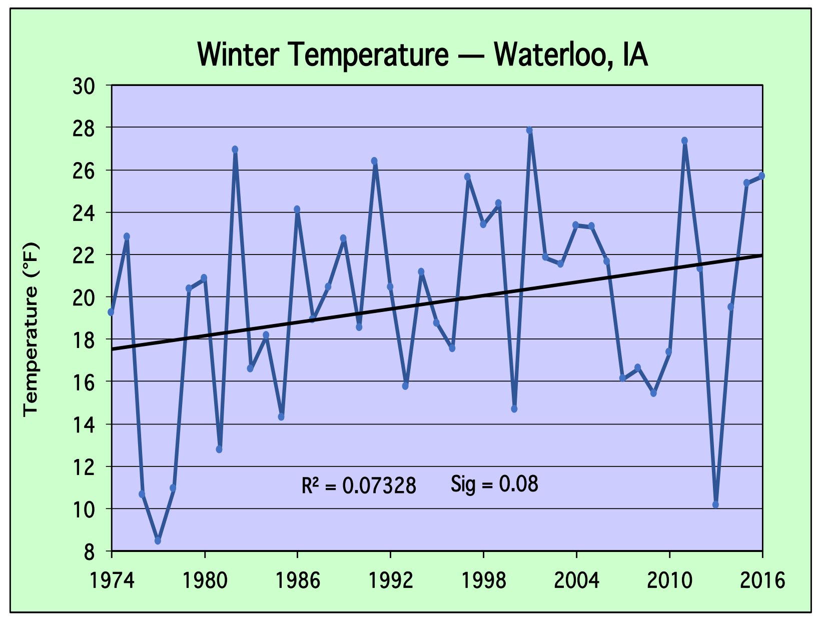

Winter Begin Date — Spokane, WA
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
31-Oct
26-Oct
21-Oct
16-Oct
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.08875
Sig = 0.05


Winter Temperature — Spokane, WA
Temperature (°F)
34
32
30
28
26
24
22
20
18
16
1974
1980
1986
1992
1998
2004
2010
2016
R² = 0.06837
Sig = 0.09


Summer Begin Date — Waterloo, IA
R² = 0.0056 Sig = 0.63
23-Jun
18-Jun
13-Jun
8-Jun
3-Jun
29-May
24-May
19-May
14-May
9-May
1974
1980
1986
1992
1998
2004
2010
2016


Summer Temperature — Waterloo, IA
Temperature (°F)
R² = 0.00035 Sig = 0.91
76
75
74
73
72
71
70
69
68
67
66
1974
1980
1986
1992
1998
2004
2010
2016


Winter Begin Date — Waterloo, IA
Sig = 0.10
R² = 0.06437
25-Dec
20-Dec
15-Dec
10-Dec
5-Dec
30-Nov
25-Nov
20-Nov
15-Nov
10-Nov
5-Nov
1974
1980
1986
1992
1998
2004
2010
2016


Winter Temperature — Waterloo, IA
Temperature (°F)
R² = 0.07328 Sig = 0.08
30
28
26
24
22
20
18
16
14
12
10
8
1974
1980
1986
1992
1998
2004
2010
2016

Appendix A4.
Charts: Objective Season Mean Temperatures by Start Date for Each of the 30 Stations, Analyzed with Linear Regression

Each page in this appendix contains two charts for each station which show the results of a least-squares linear regression as follows:

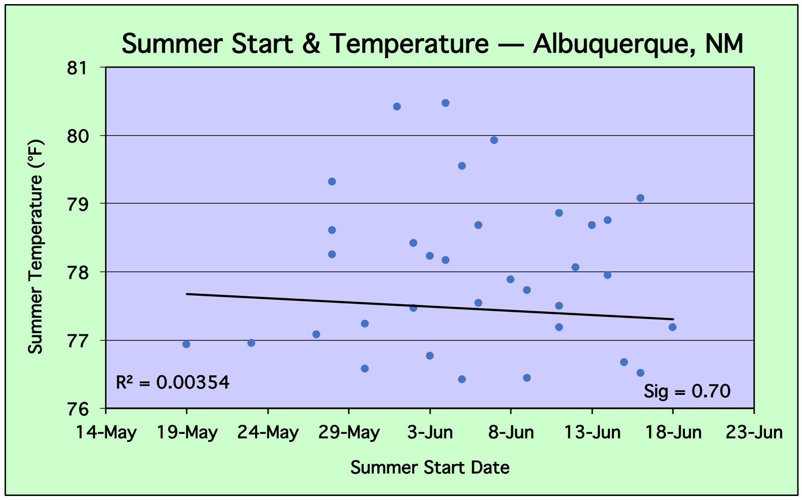
Objectively Defined Summer Season Average Temperature by Start Date

Objectively Defined Winter Season Average Temperature by Start Date

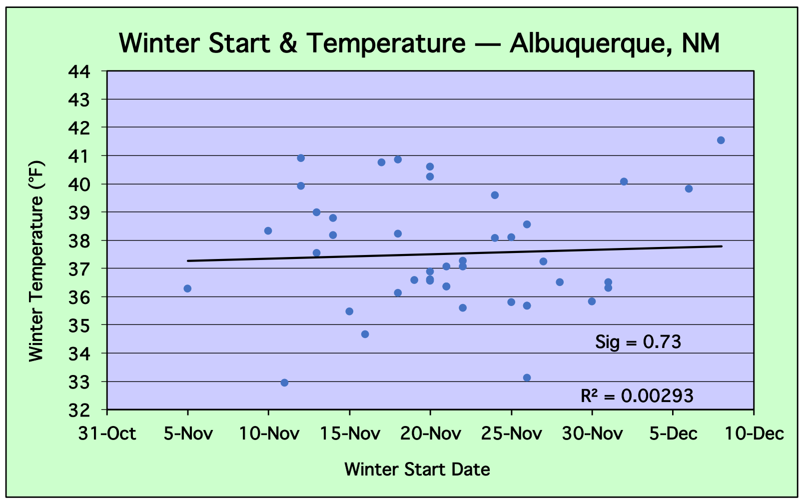
Each chart, displays the r-squared value along with the significence, based on a f-test (a significance of 0.00 indicates <0.005).

The following definitions are used:

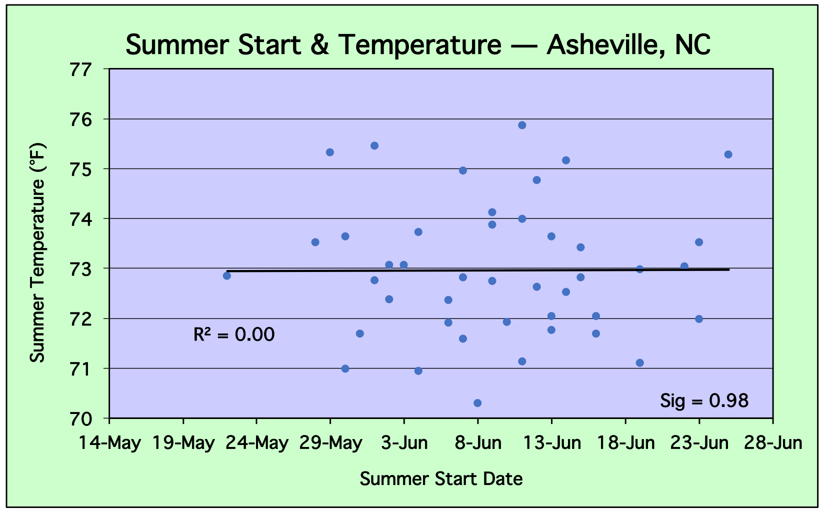
Summer Start	The day on which the objectively defined Summer season started. This is given in Day–Month format.
Winter Start	The day on which the objectively defined Summer season started. This is given in Day–Month format.
Summer Temperature	The average temperature (°F) of the objectively defined Summer season.
Winter Temperature	The average temperature (°F) of the objectively defined Winter season.

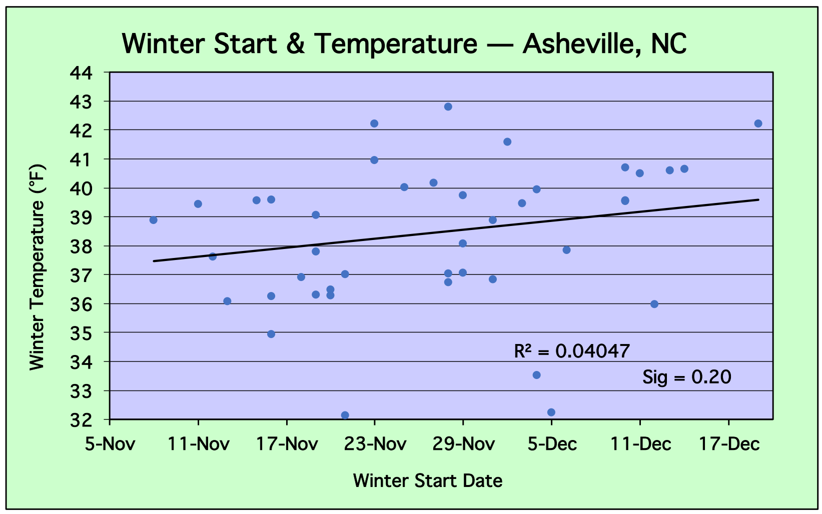


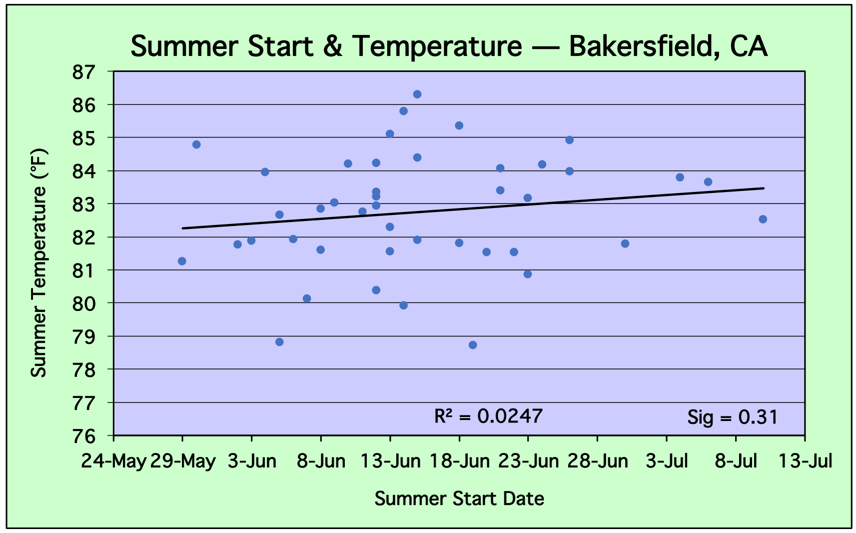
Summer Start & Temperature — Albuquerque, NM
Summer Temperature (°F)
81
80
79
78
77
76
R² = 0.00354
Sig = 0.70
14-May
19-May
24-May
29-May
3-Jun
8-Jun
13-Jun
18-Jun
23-Jun
Summer Start Date

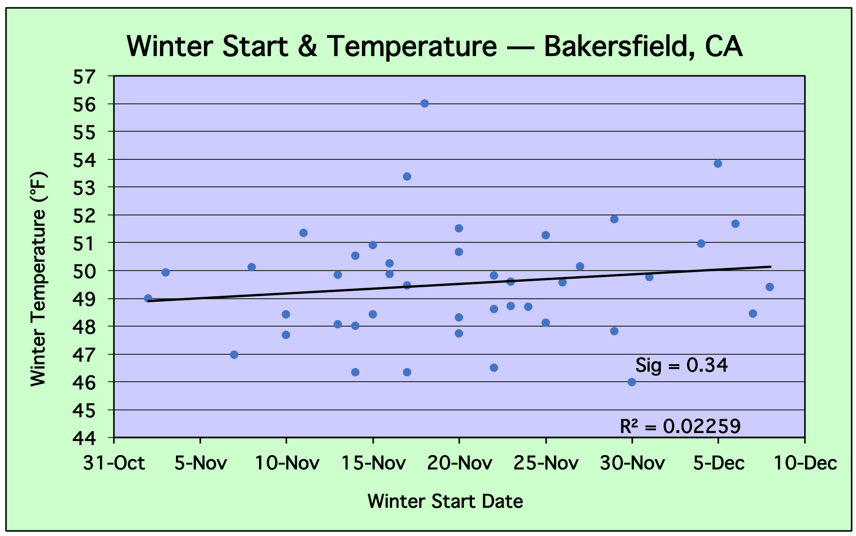


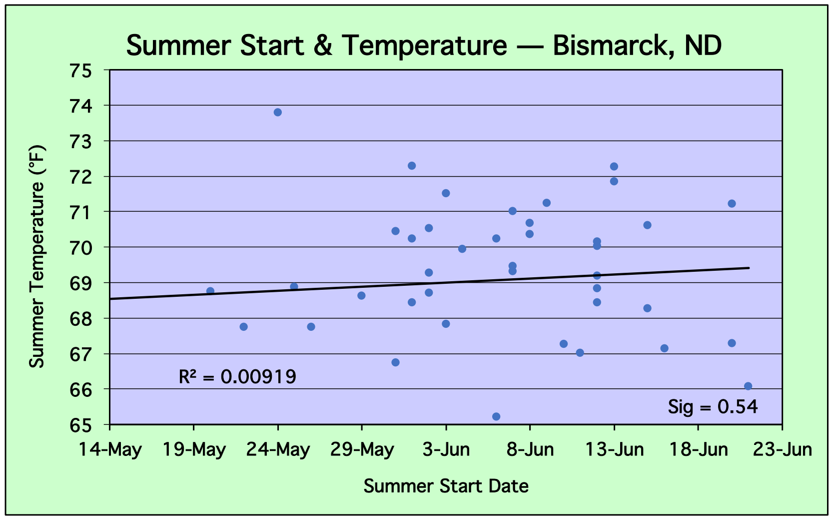
Winter Start & Temperature — Albuquerque, NM
Winter Temperature (°F)
44
43
42
41
40
39
38
37
36
35
34
33
32
Sig = 0.73
R² = 0.00293
31-Oct
5-Nov
10-Nov
15-Nov
20-Nov
25-Nov
30-Nov
5-Dec
10-Dec
Winter Start Date

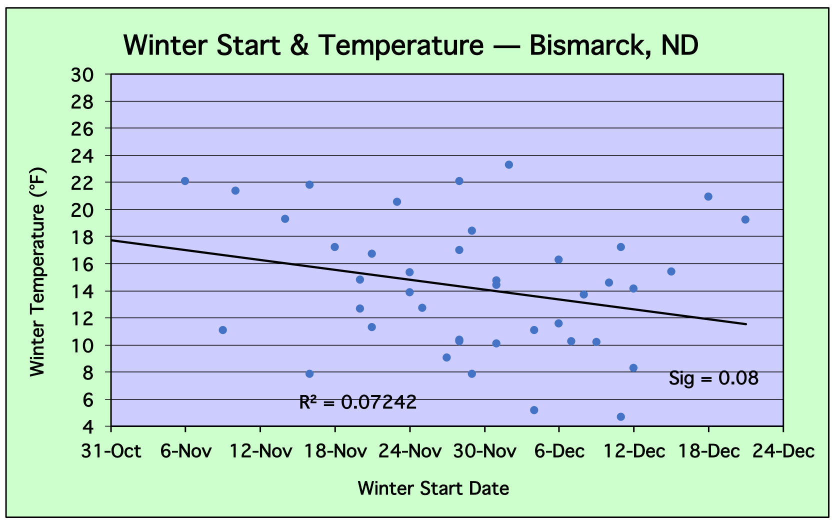

Summer Start & Temperature — Asheville, NC
Summer Temperature (°F)
77
76
75
74
73
72
71
70
R² = 0.00
Sig = 0.98
14-May 19-May 24-May 29-May 3-Jun 8-Jun 13-Jun 18-Jun 23-Jun 28-Jun
Summer Start Date

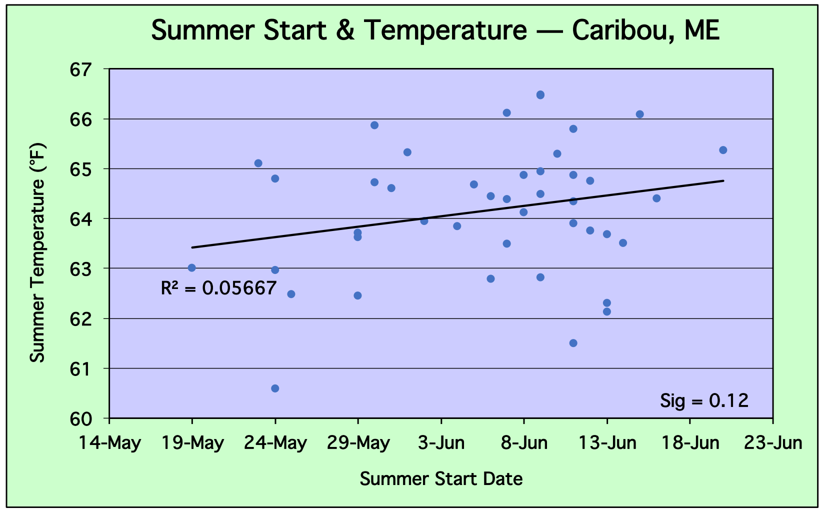

Winter Start & Temperature — Asheville, NC
Winter Temperature (°F)
44
43
42
41
40
39
38
37
36
35
34
33
32
R² = 0.04047
Sig = 0.20
5-Nov 11-Nov 17-Nov 23-Nov 29-Nov 5-Dec 11-Dec 17-Dec
Winter Start Date

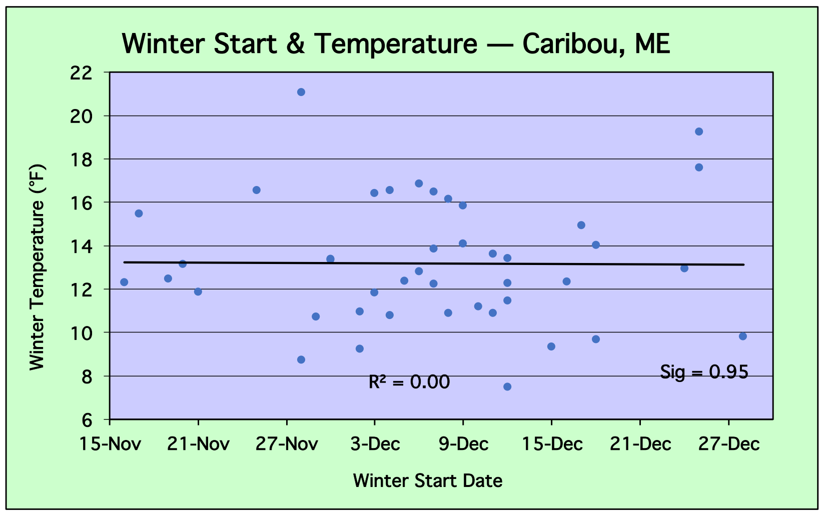

Summer Start & Temperature — Bakersfield, CA
Summer Temperature (°F)
87
86
85
84
83
82
81
80
79
78
77
76
R² = 0.0247
Sig = 0.31
24-May
29-May
3-Jun
8-Jun
13-Jun
18-Jun
23-Jun
28-Jun
3-Jul
8-Jul
13-Jul
Summer Start Date

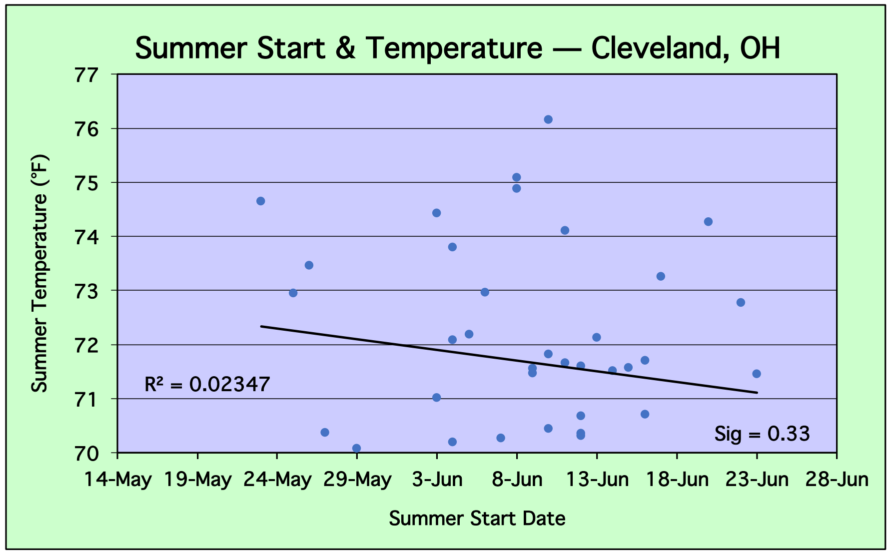

Winter Start & Temperature — Bakersfield, CA
Winter Temperature (°F)
57
56
55
54
53
52
51
50
49
48
47
46
45
44
Sig = 0.34
R² = 0.02259
31-Oct
5-Nov
10-Nov
15-Nov
20-Nov
25-Nov
30-Nov
5-Dec
10-Dec
Winter Start Date

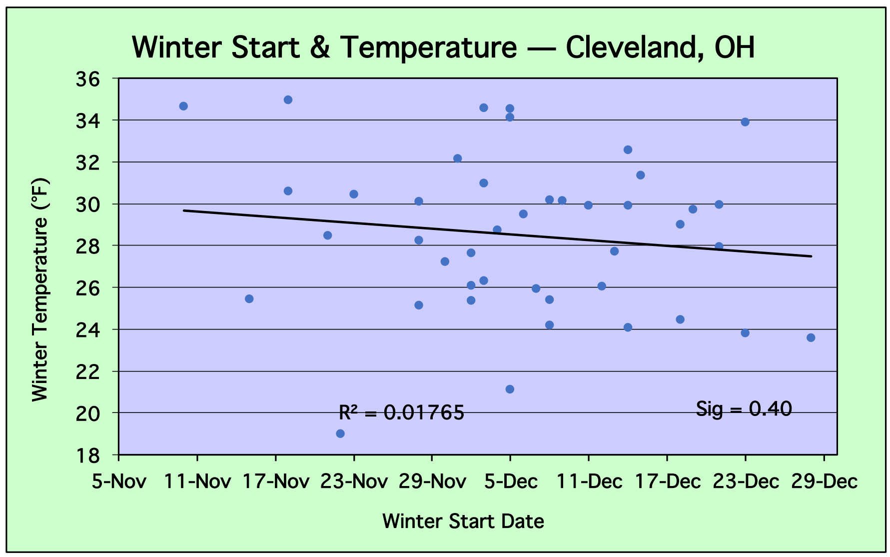

Summer Start & Temperature — Bismarck, ND
Summer Temperature (°F)
75
74
73
72
71
70
69
68
67
66
65
R² = 0.00919
Sig = 0.54
14-May
19-May
24-May
29-May
3-Jun
8-Jun
13-Jun
18-Jun
23-Jun
Summer Start Date

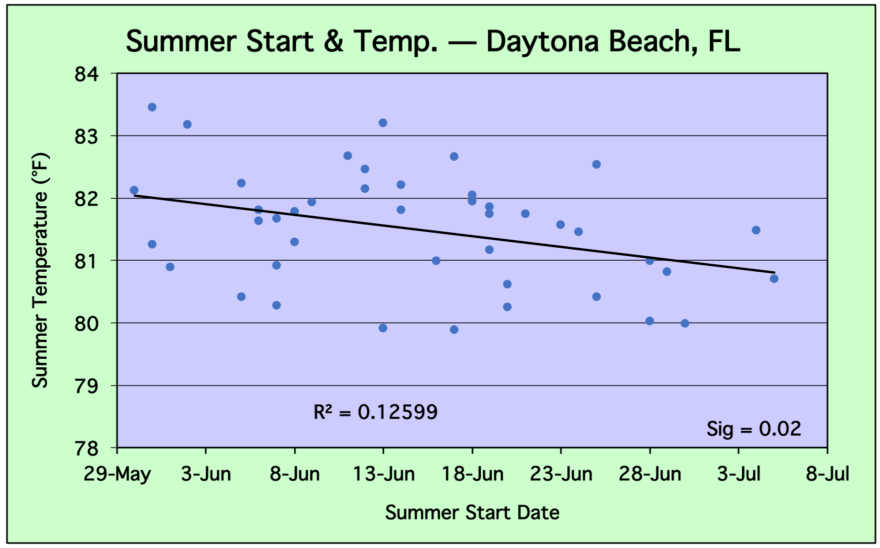

Winter Start & Temperature — Bismarck, ND
Winter Temperature (°F)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
Sig = 0.08
R² = 0.07242
31-Oct
6-Nov
12-Nov
18-Nov
24-Nov
30-Nov
6-Dec
12-Dec
18-Dec
24-Dec
Winter Start Date

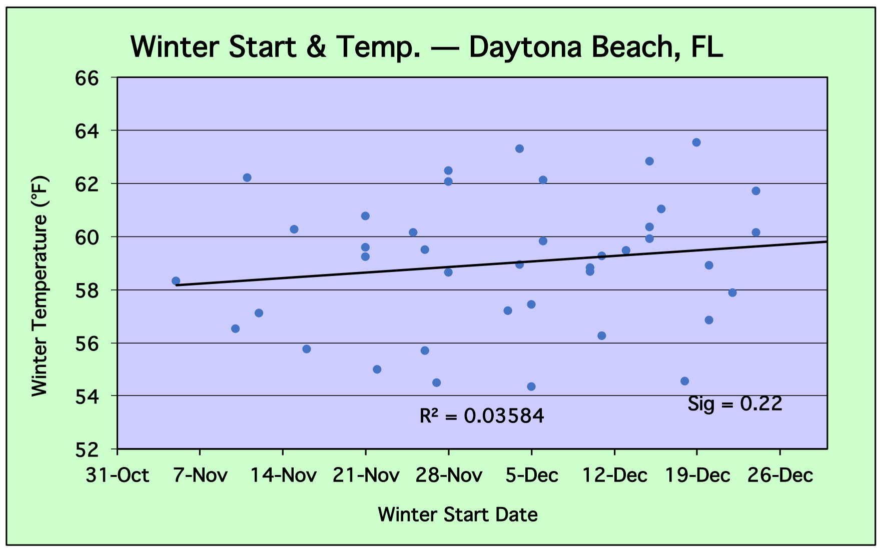

Summer Start & Temperature — Caribou, ME
Summer Temperature (°F)
67
66
65
64
63
62
61
60
R² = 0.05667
Sig = 0.12
14-May
19-May
24-May
29-May
3-Jun
8-Jun
13-Jun
18-Jun
23-Jun
Summer Start Date

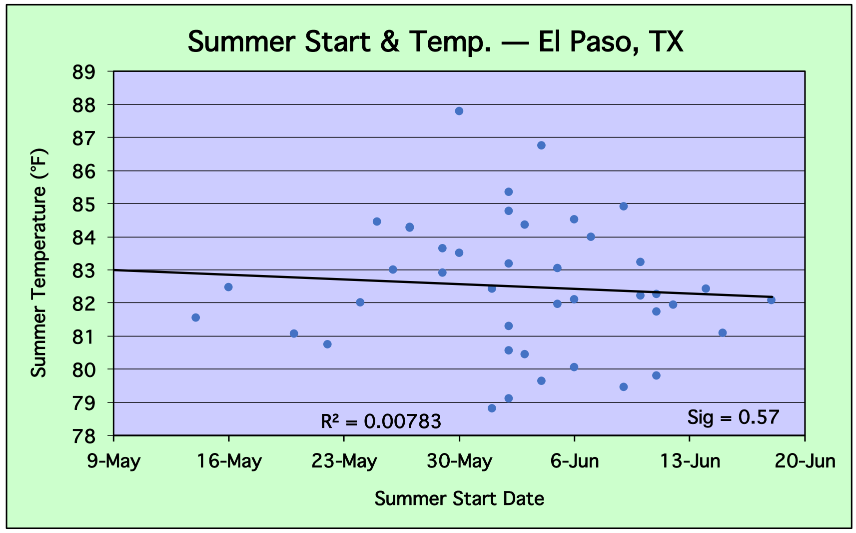

Winter Start & Temperature — Caribou, ME
Winter Temperature (°F)
22
20
18
16
14
12
10
8
6
R² = 0.00
Sig = 0.95
15-Nov
21-Nov
27-Nov
3-Dec
9-Dec
15-Dec
21-Dec
27-Dec
Winter Start Date

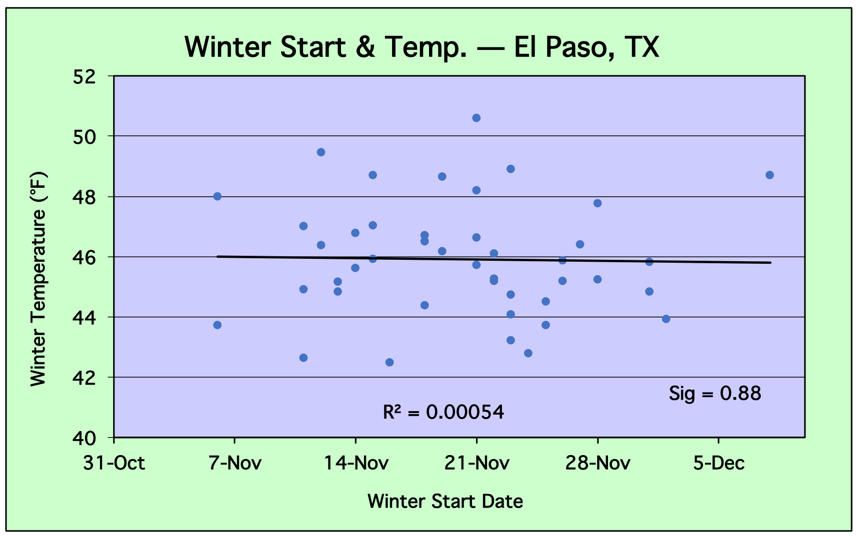

Summary Start & Temperature — Cleveland, OH
Summer Temperature (°F)
77
76
75
74
73
72
71
70
R² = 0.02347
Sig = 0.33
14-May
19-May
24-May
29-May
3-Jun
8-Jun
13-Jun
18-Jun
23-Jun
28-Jun
Summer Start Date

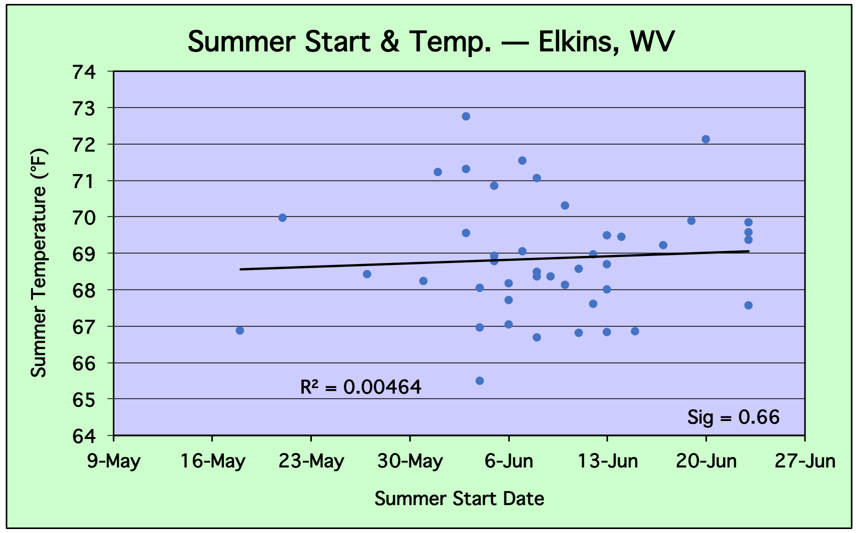

Winter Start & Temperature — Cleveland, OH
Winter Temperature (°F)
36
34
32
30
28
26
24
22
20
18
R² = 0.01765
Sig = 0.40
5-Nov
11-Nov
17-Nov
23-Nov
29-Nov
5-Dec
11-Dec
17-Dec
23-Dec
29-Dec
Winter Start Date

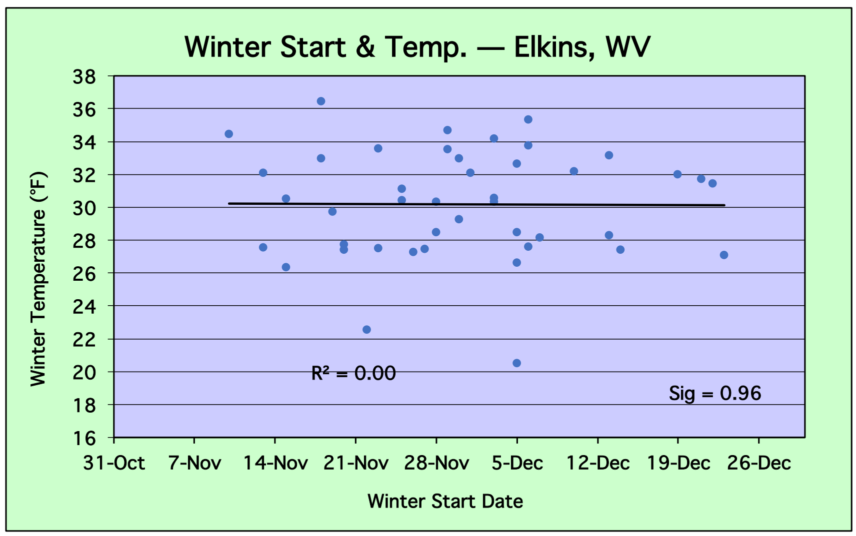

Summer Start & Temp. — Daytona Beach, FL
Summer Temperature (°F)
84
83
82
81
80
79
78
R² = 0.12599
Sig = 0.02
29-May
3-Jun
8-Jun
13-Jun
18-Jun
23-Jun
28-Jun
3-Jul
8-Jul
Summer Start Date

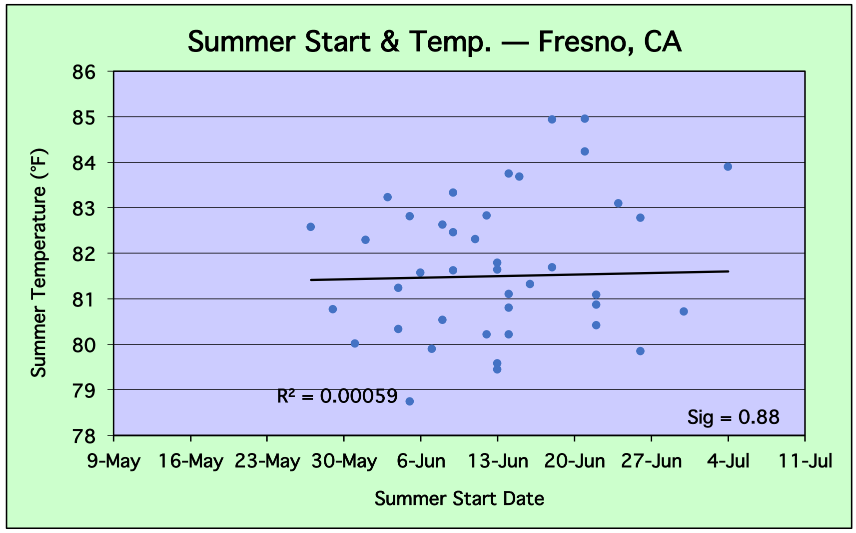

Winter Start & Temp. — Daytona Beach, FL
Winter Temperature (°F)
66
64
62
60
58
56
54
52
R² = 0.03584
Sig = 0.22
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
12-Dec
19-Dec
26-Dec
Winter Start Date


Summer Start & Temp. — El Paso, TX
Summer Temperature (°F)
89
88
87
86
85
84
83
82
81
80
79
78
R² = 0.00783
Sig = 0.57
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
Summer Start Date

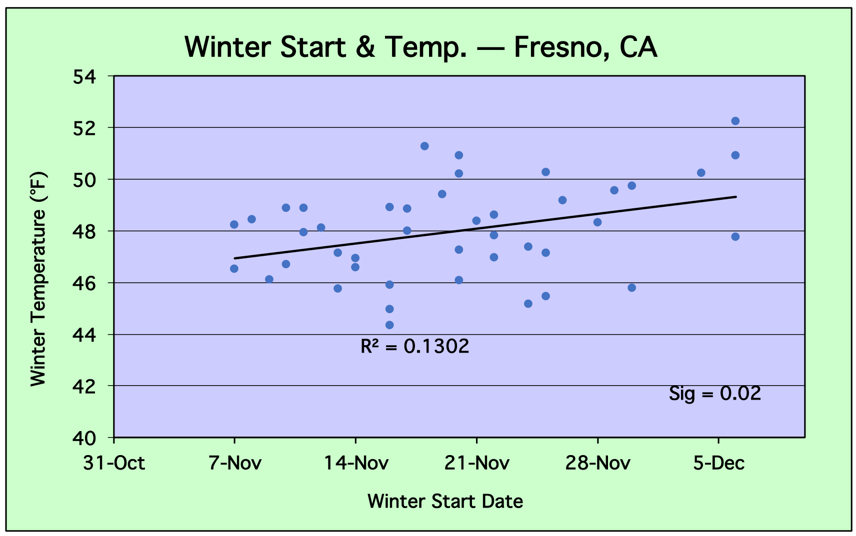

Winter Start & Temp. — El Paso, TX
Winter Temperature (°F)
52
50
48
46
44
42
40
Sig = 0.88
R² = 0.00054
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
Winter Start Date


Summer Start & Temp. — Elkins, WV
Summer Temperature (°F)
74
73
72
71
70
69
68
67
66
65
64
R² = 0.00464
Sig = 0.66
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
Summer Start Date

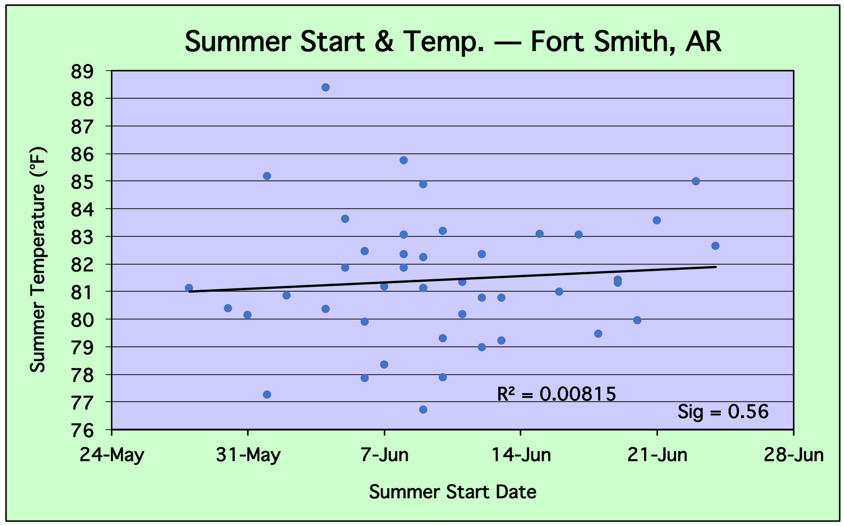

Winter Start & Temp. — Elkins, WV
Winter Temperature (°F)
38
36
34
32
30
28
26
24
22
20
18
16
R² = 0.00
Sig = 0.96
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
12-Dec
19-Dec
26-Dec
Winter Start Date

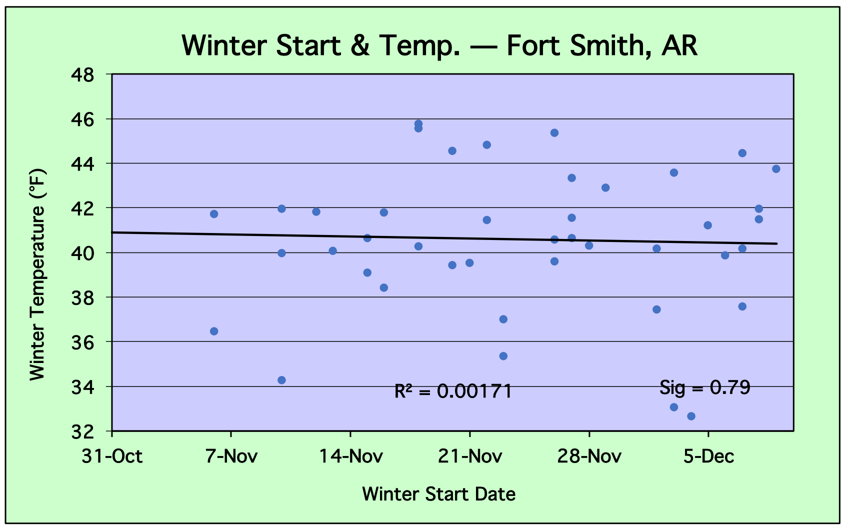


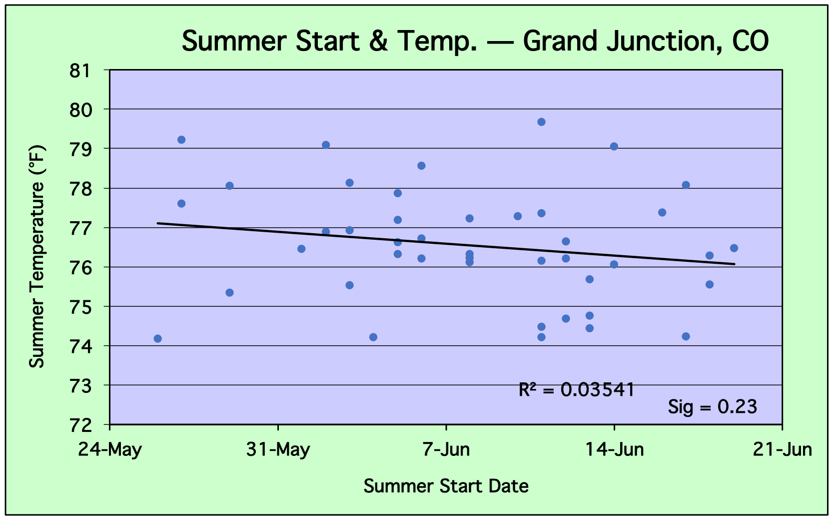
Summer Start & Temp. — Fresno, CA
Summer Temperature (°F)
86
85
84
83
82
81
80
79
78
R² = 0.00059
Sig = 0.88
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
Summer Start Date

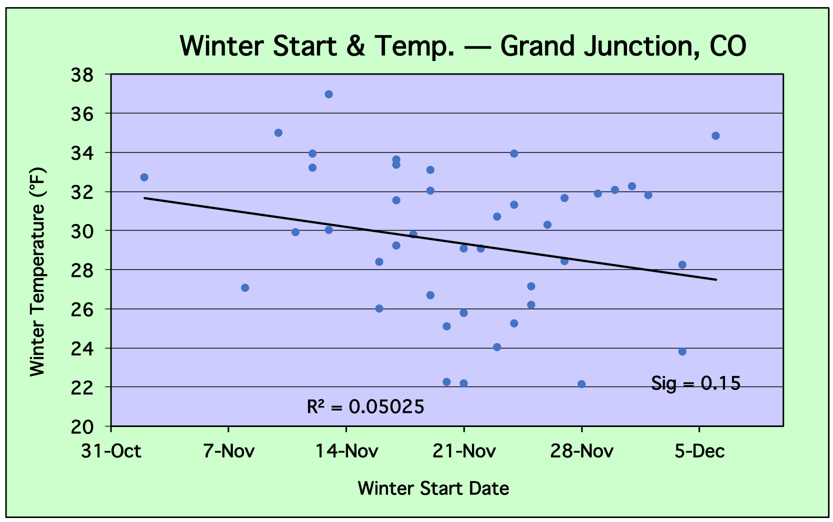


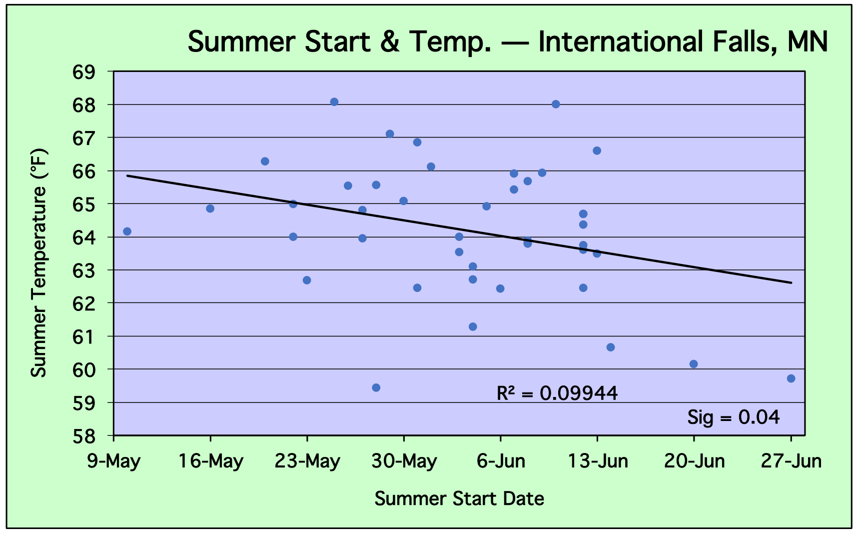
Winter Start & Temp. — Fresno, CA
Winter Temperature (°F)
54
52
50
48
46
44
42
40
R² = 0.1302
Sig = 0.02
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
Winter Start Date

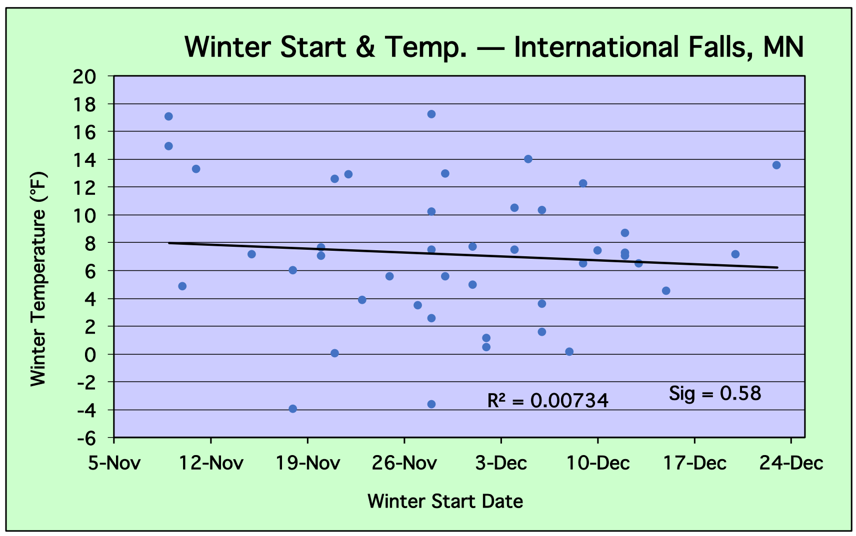

Summer Start & Temp. — Fort Smith, AR
Summer Temperature (°F)
89
88
87
86
85
84
83
82
81
80
79
78
77
76
24-May
31-May
7-Jun
14-Jun
21-Jun
28-Jun
Summer Start Date
R² = 0.00815
Sig = 0.56

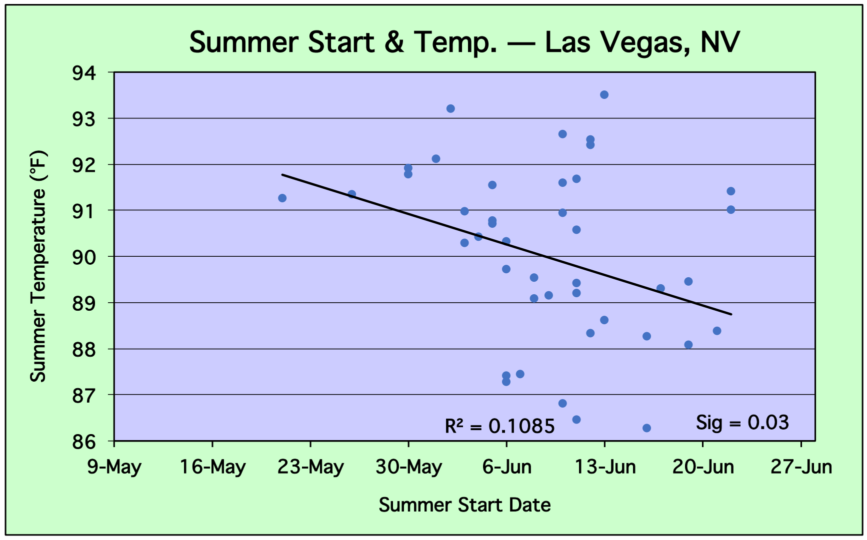

Winter Start & Temp. — Fort Smith, AR
Winter Temperature (°F)
48
46
44
42
40
38
36
34
32
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
Winter Start Date
R² = 0.00171
Sig = 0.79

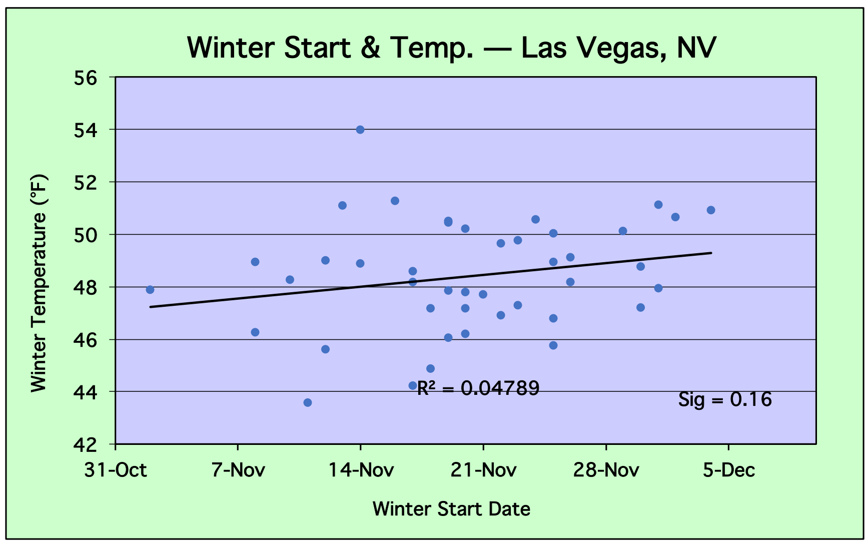

Summer Start & Temp. — Grand Junction, CO
Summer Temperature (°F)
81
80
79
78
77
76
75
74
73
72
R² = 0.03541
Sig = 0.23
24-May
31-May
7-Jun
14-Jun
21-Jun
Summer Start Date

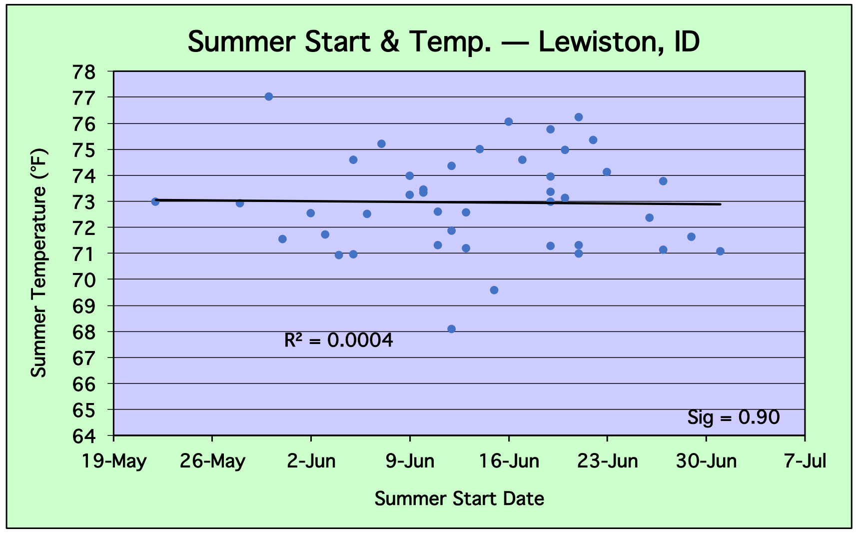

Winter Start & Temp. — Grand Junction, CO
Winter Temperature (°F)
38
36
34
32
30
28
26
24
22
20
Sig = 0.15
R² = 0.05025
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
Winter Start Date

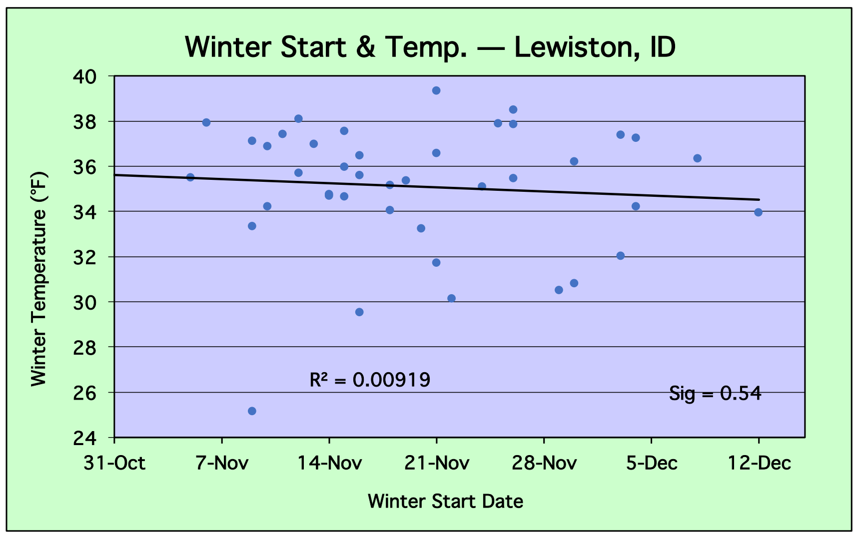

Summer Start & Temp. — International Falls, MN
Summer Temperature (°F)
69
68
67
66
65
64
63
62
61
60
59
58
R² = 0.09944
Sig = 0.04
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
Summer Start Date

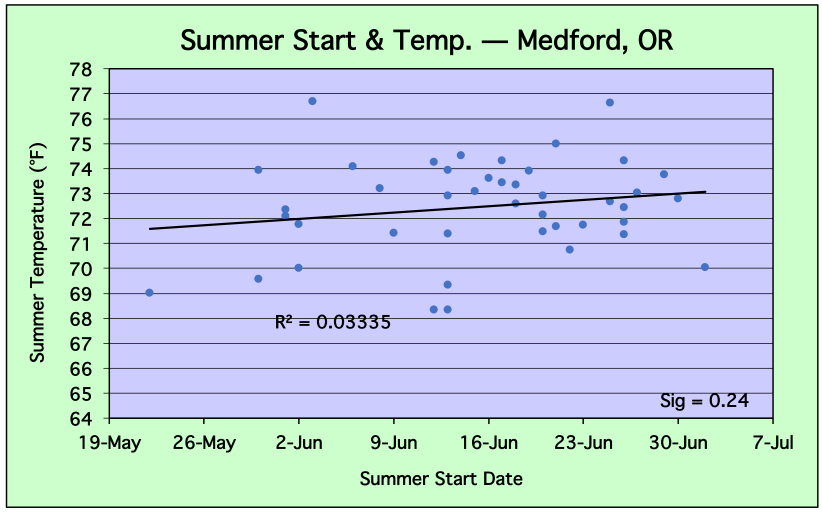

Winter Start & Temp. — International Falls, MN
Winter Temperature (°F)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
R² = 0.00734
Sig = 0.58
5-Nov
12-Nov
19-Nov
26-Nov
3-Dec
10-Dec
17-Dec
24-Dec
Winter Start Date

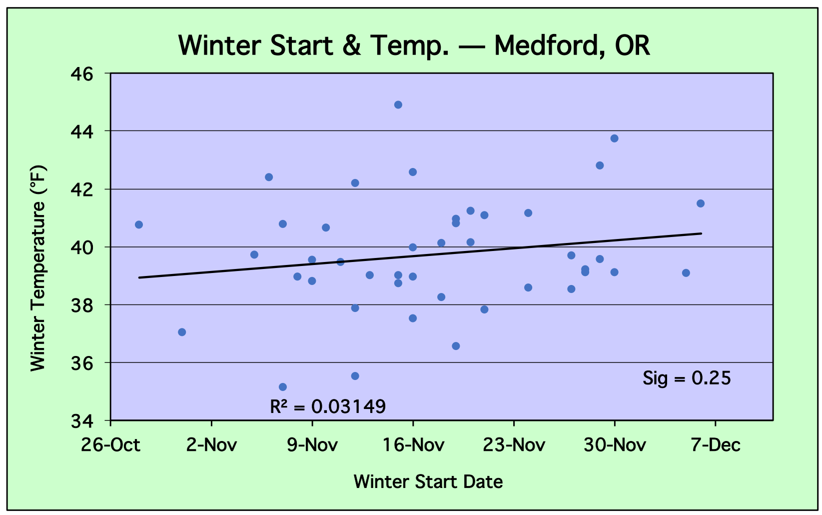

Summer Start & Temp. — Las Vegas, NV
Summer Temperature (°F)
94
93
92
91
90
89
88
87
86
R² = 0.1085
Sig = 0.03
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
Summer Start Date

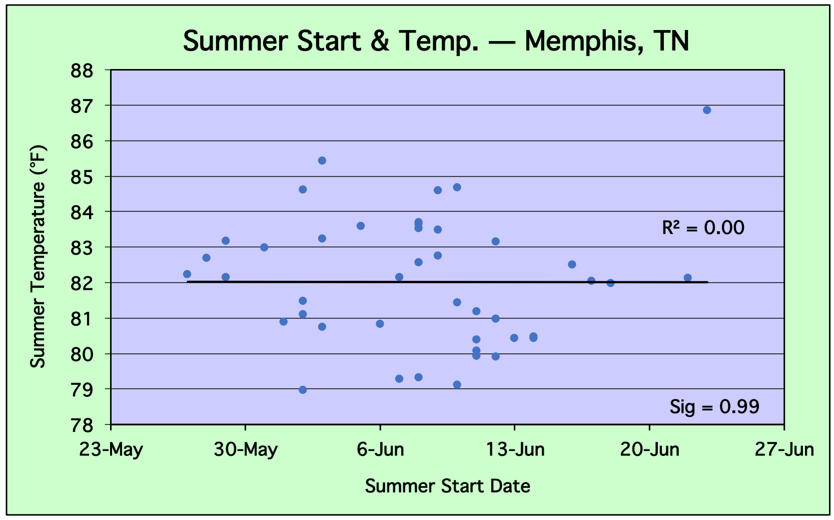

Winter Start & Temp. — Las Vegas, NV
Winter Temperature (°F)
56
54
52
50
48
46
44
42
R² = 0.04789
Sig = 0.16
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
Winter Start Date

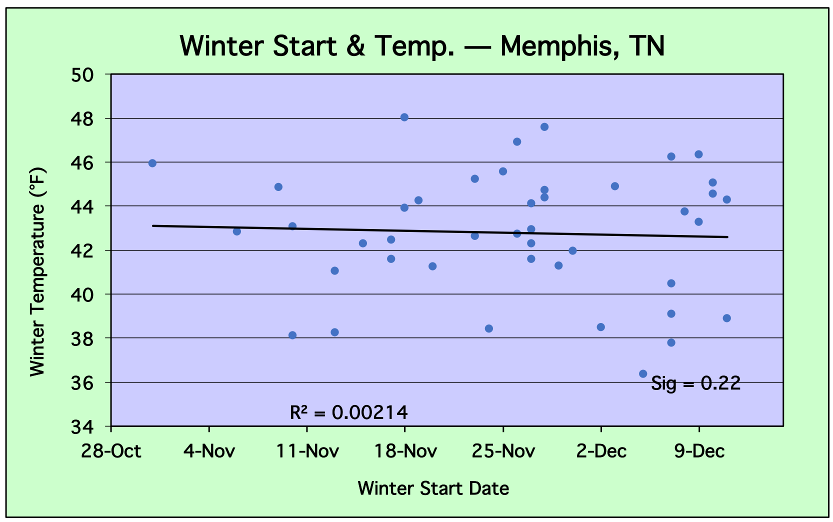

Summer Start & Temp. — Lewiston, ID
Summer Temperature (°F)
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
R² = 0.0004
Sig = 0.90
19-May
26-May
2-Jun
9-Jun
16-Jun
23-Jun
30-Jun
7-Jul
Summer Start Date

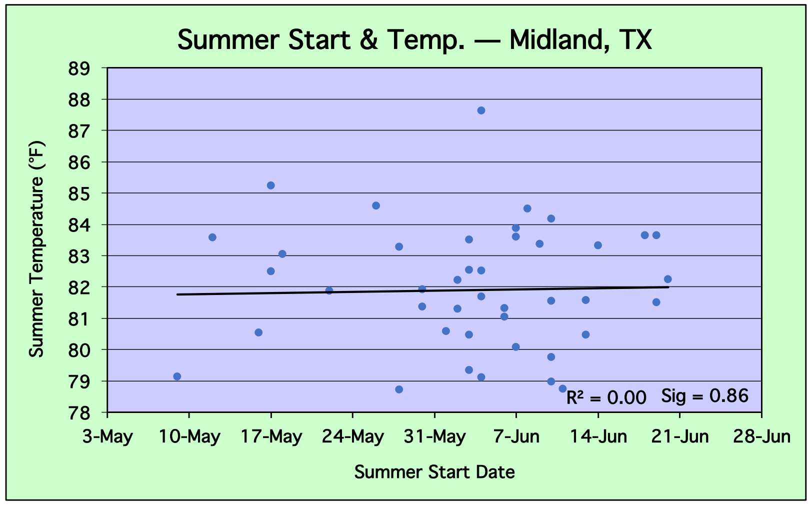

Winter Start & Temp. — Lewiston, ID
Winter Temperature (°F)
40
38
36
34
32
30
28
26
24
R² = 0.00919
Sig = 0.54
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
12-Dec
Winter Start Date

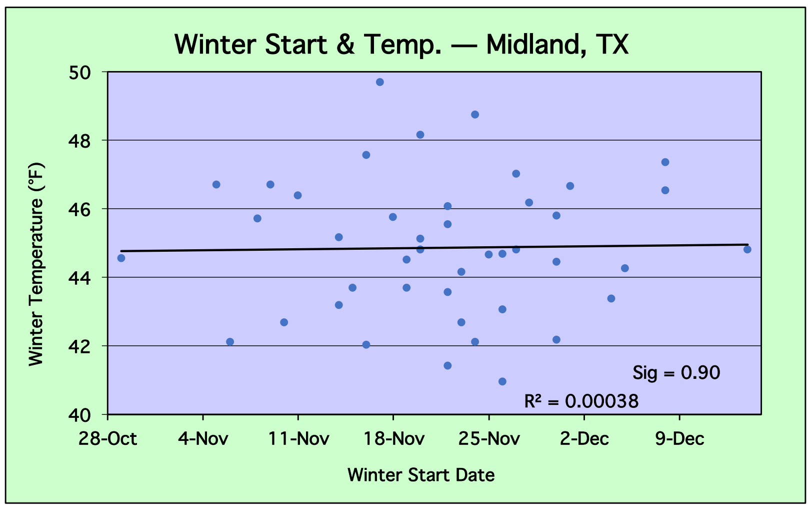

Summer Start & Temp. — Medford, OR
Summer Temperature (°F)
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
R² = 0.03335
Sig = 0.24
19-May
26-May
2-Jun
9-Jun
16-Jun
23-Jun
30-Jun
7-Jul
Summer Start Date

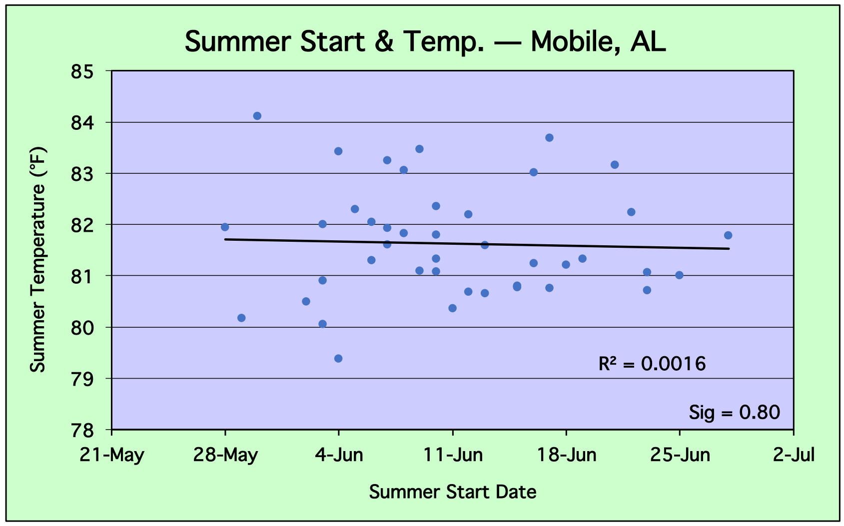

Winter Start & Temp. — Medford, OR
Winter Temperature (°F)
46
44
42
40
38
36
34
Sig = 0.25
R² = 0.03149
26-Oct
2-Nov
9-Nov
16-Nov
23-Nov
30-Nov
7-Dec
Winter Start Date

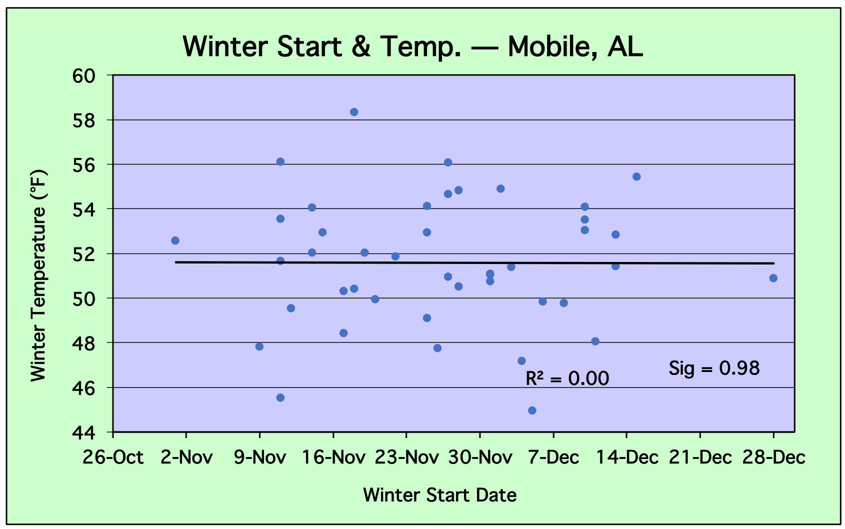

Summer Start & Temp. — Memphis, TN
88
87
86
85
84
83
82
81
80
79
78
Summer Temperature (°F)
R² = 0.00
Sig = 0.99
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
Summer Start Date

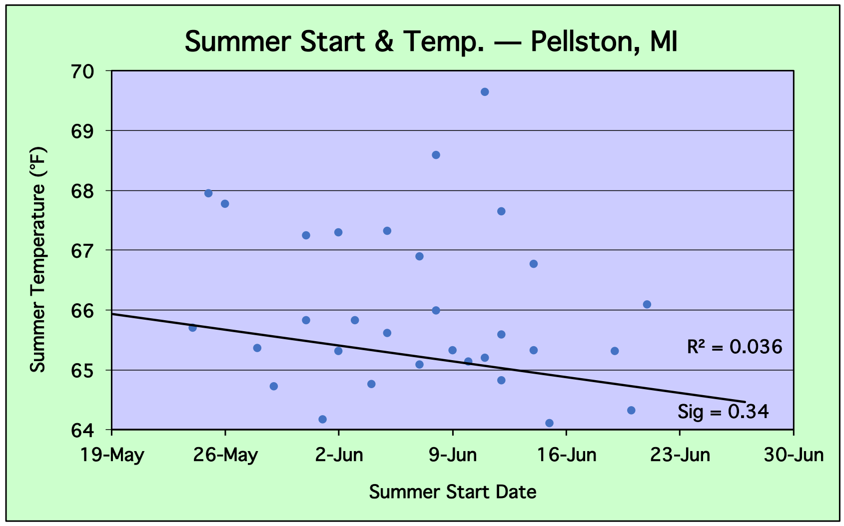

Winter Start & Temp. — Memphis, TN
50
48
46
44
42
40
38
36
34
Winter Temperature (°F)
Sig = 0.22
R² = 0.00214
28-Oct
4-Nov
11-Nov
18-Nov
25-Nov
2-Dec
9-Dec
Winter Start Date

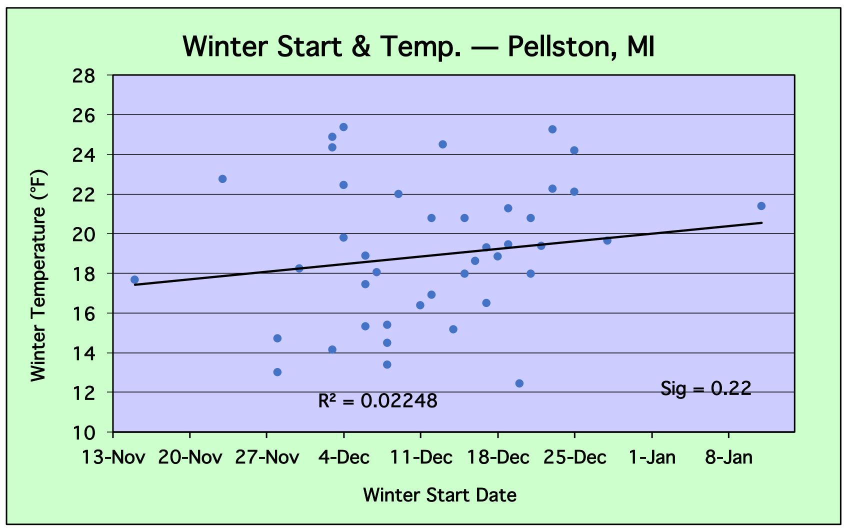

Summer Start & Temp. — Midland, TX
Summer Temperature (°F)
89
88
87
86
85
84
83
82
81
80
79
78
R² = 0.00
Sig = 0.86
3-May
10-May
17-May
24-May
31-May
7-Jun
14-Jun
21-Jun
28-Jun
Summer Start Date

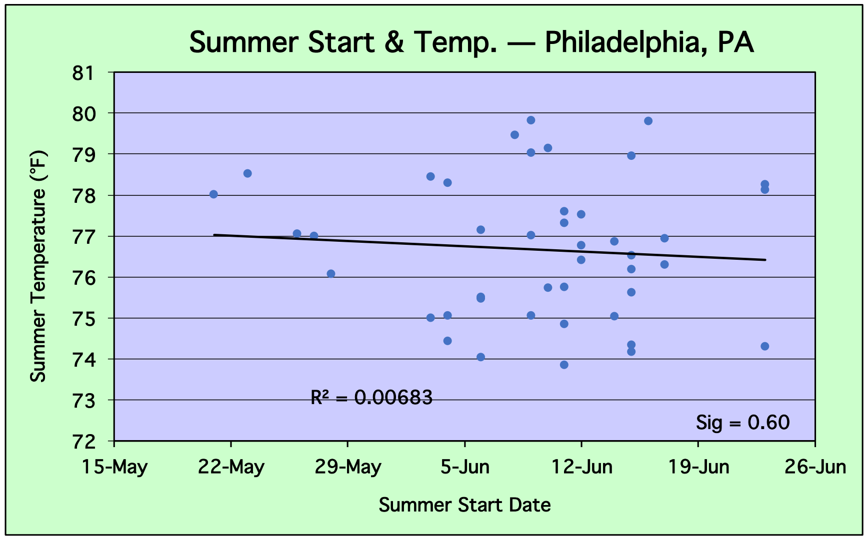

Winter Start & Temp. — Midland, TX
Winter Temperature (°F)
50
48
46
44
42
40
Sig = 0.90
R² = 0.00038
28-Oct
4-Nov
11-Nov
18-Nov
25-Nov
2-Dec
9-Dec
Winter Start Date

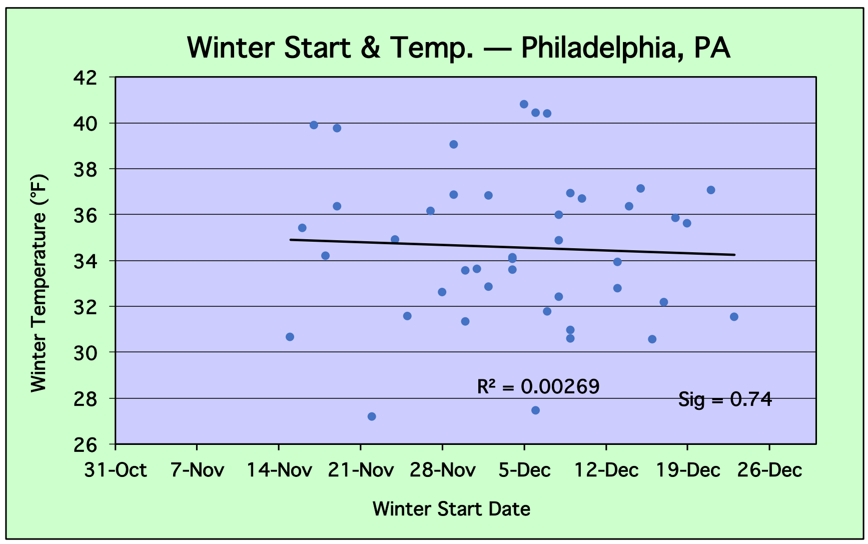

Summer Start & Temp. — Mobile, AL
Summer Temperature (°F)
85
84
83
82
81
80
79
78
R² = 0.0016
Sig = 0.80
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
Summer Start Date

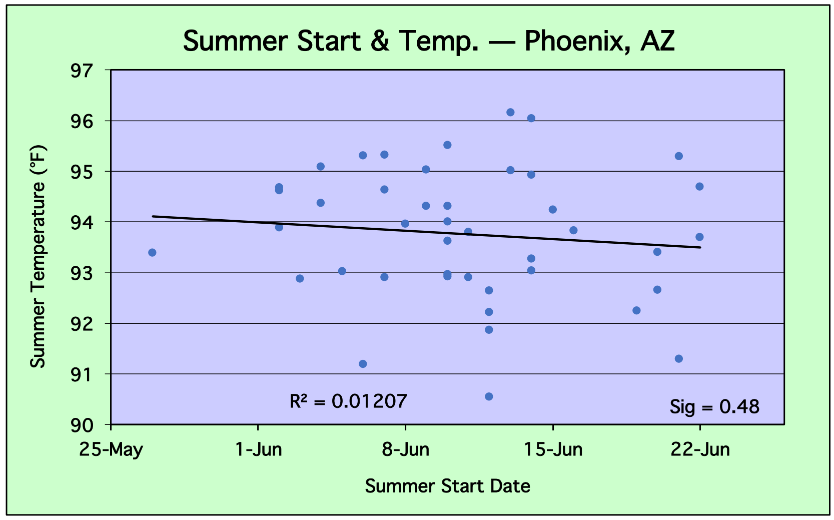

Winter Start & Temp. — Mobile, AL
Winter Temperature (°F)
60
58
56
54
52
50
48
46
44
R² = 0.00
Sig = 0.98
26-Oct
2-Nov
9-Nov
16-Nov
23-Nov
30-Nov
7-Dec
14-Dec
21-Dec
28-Dec
Winter Start Date

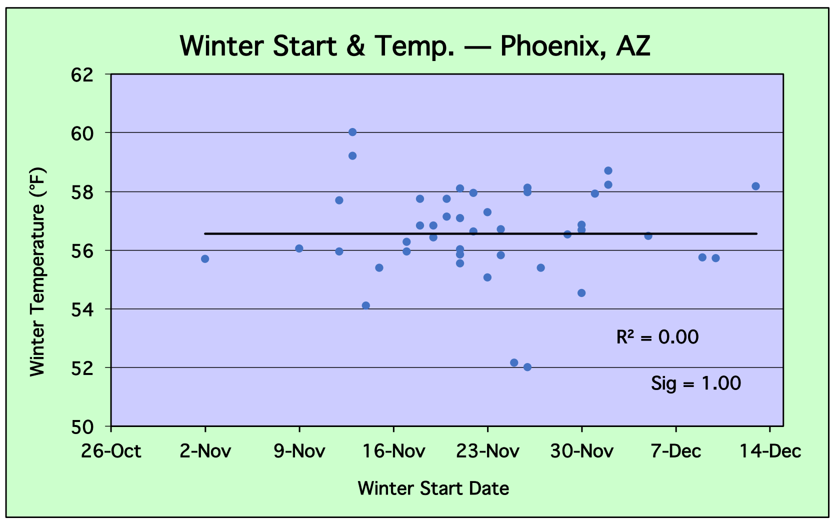

Summer Start & Temp. — Pellston, MI
70
69
68
67
66
65
64
Summer Temperature (°F)
R² = 0.036
Sig = 0.34
19-May
26-May
2-Jun
9-Jun
16-Jun
23-Jun
30-Jun
Summer Start Date

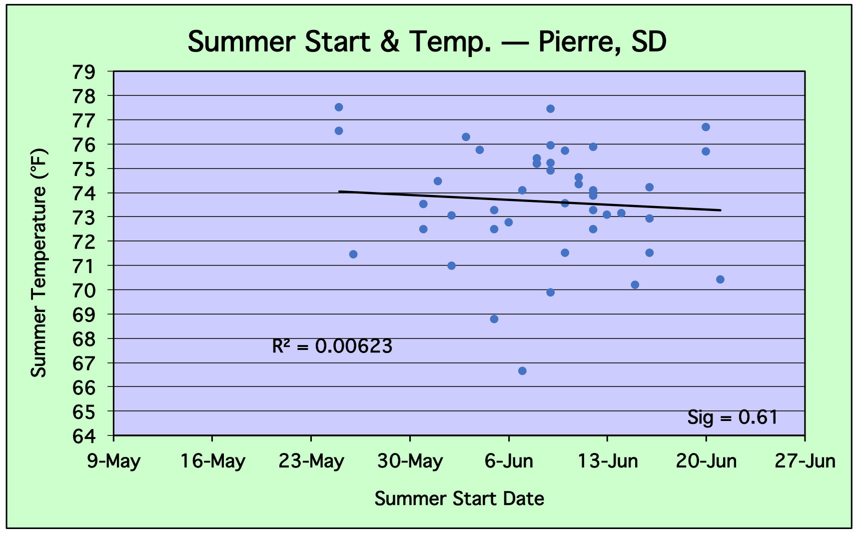

Winter Start & Temp. — Pellston, MI
28
26
24
22
20
18
16
14
12
10
Winter Temperature (°F)
R² = 0.02248
Sig = 0.22
13-Nov
20-Nov
27-Nov
4-Dec
11-Dec
18-Dec
25-Dec
1-Jan
8-Jan
Winter Start Date

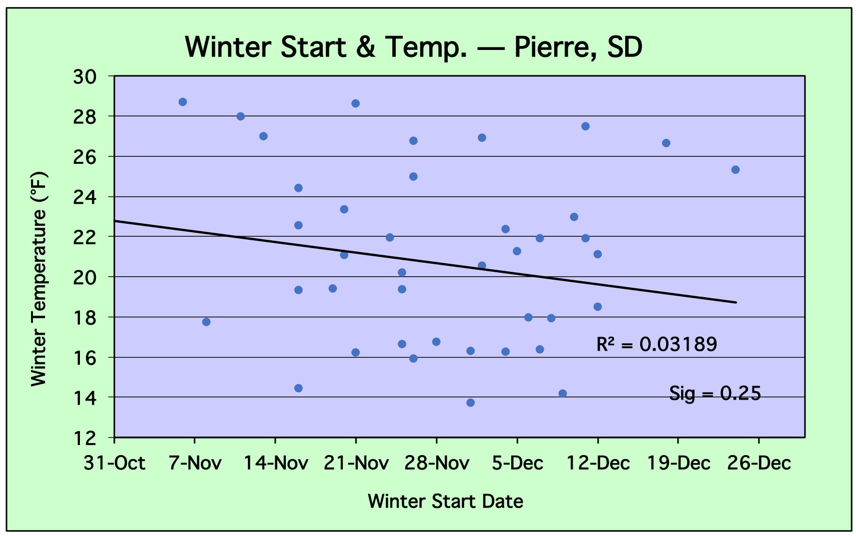

Summer Start & Temp. — Philadelphia, PA
Summer Temperature (°F)
81
80
79
78
77
76
75
74
73
72
R² = 0.00683
Sig = 0.60
15-May
22-May
29-May
5-Jun
12-Jun
19-Jun
26-Jun
Summer Start Date

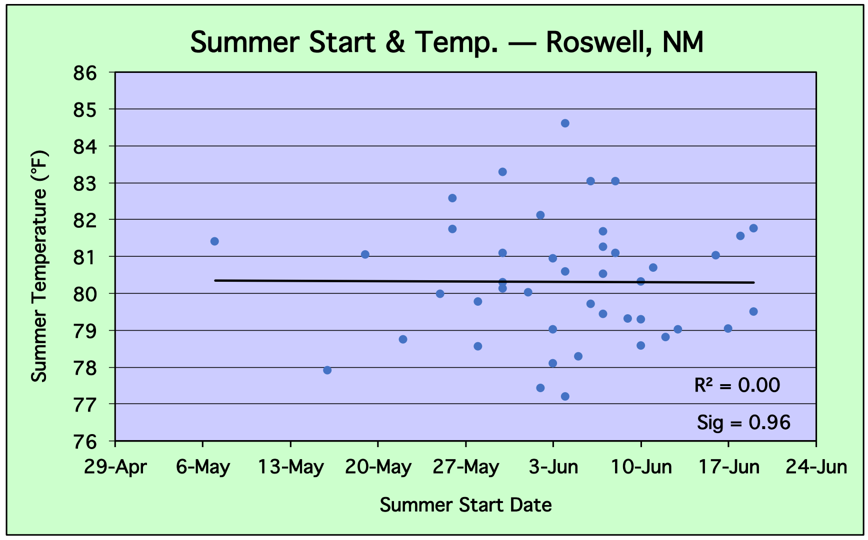

Winter Start & Temp. — Philadelphia, PA
Winter Temperature (°F)
42
40
38
36
34
32
30
28
26
R² = 0.00269
Sig = 0.74
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
12-Dec
19-Dec
26-Dec
Winter Start Date


Summer Start & Temp. — Phoenix, AZ
Summer Temperature (°F)
97
96
95
94
93
92
91
90
25-May
1-Jun
8-Jun
15-Jun
22-Jun
Summer Start Date
R² = 0.01207
Sig = 0.48

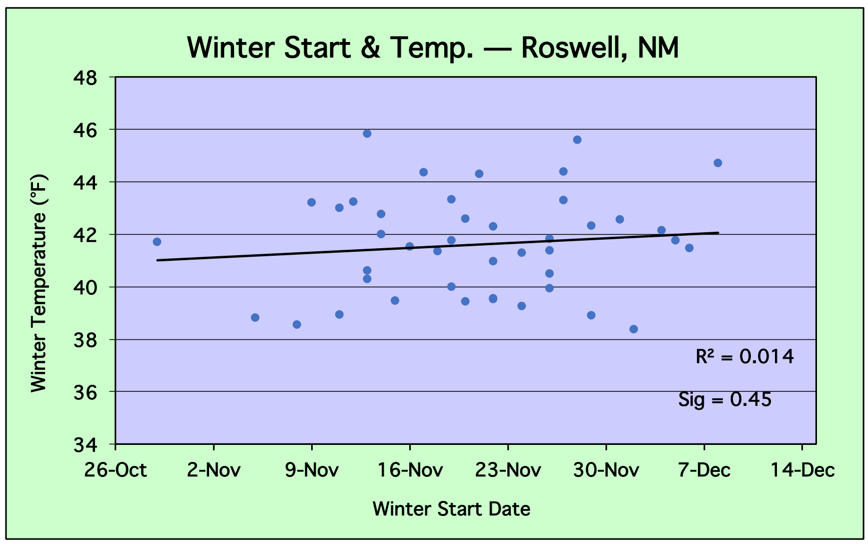

Winter Start & Temp. — Phoenix, AZ
Winter Temperature (°F)
62
60
58
56
54
52
50
26-Oct
2-Nov
9-Nov
16-Nov
23-Nov
30-Nov
7-Dec
14-Dec
Winter Start Date
R² = 0.00
Sig = 1.00


Summer Start & Temp. — Pierre, SD
Summer Temperature (°F)
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
R² = 0.00623
Sig = 0.61
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
Summer Start Date

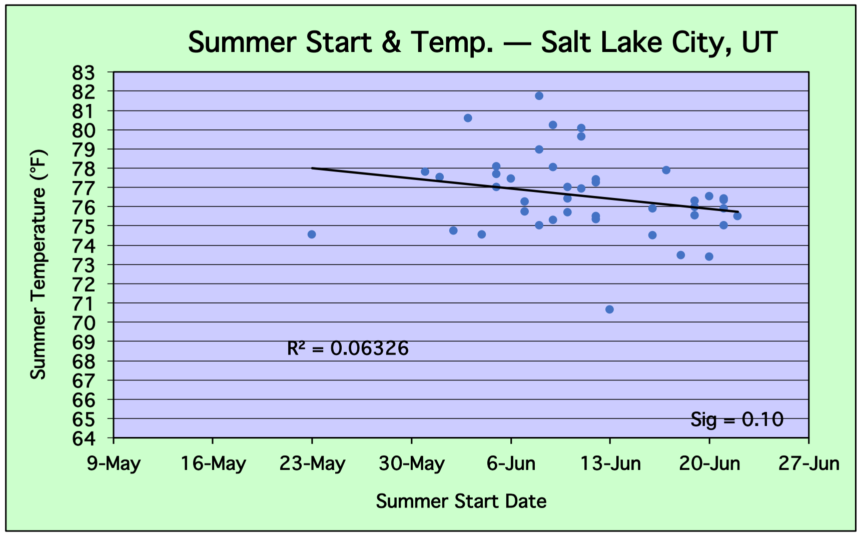

Winter Start & Temp. — Pierre, SD
Winter Temperature (°F)
30
28
26
24
22
20
18
16
14
12
R² = 0.03189
Sig = 0.25
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
12-Dec
19-Dec
26-Dec
Winter Start Date

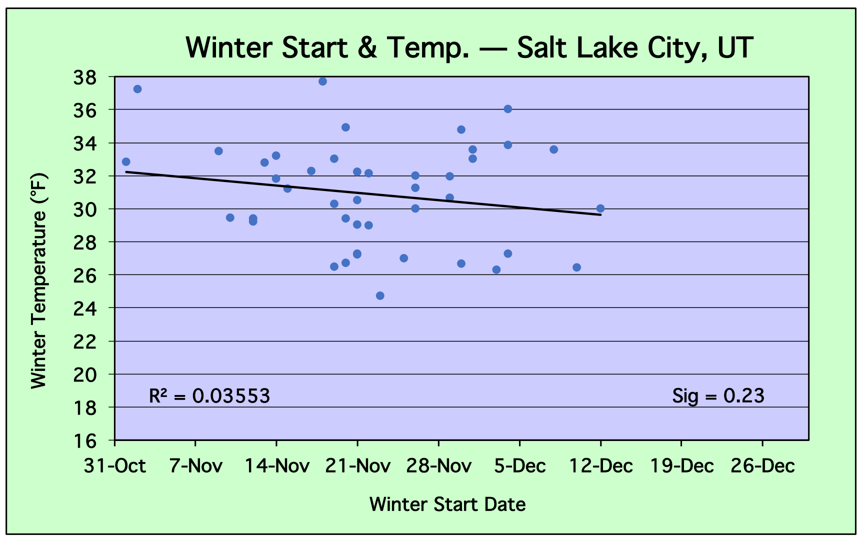


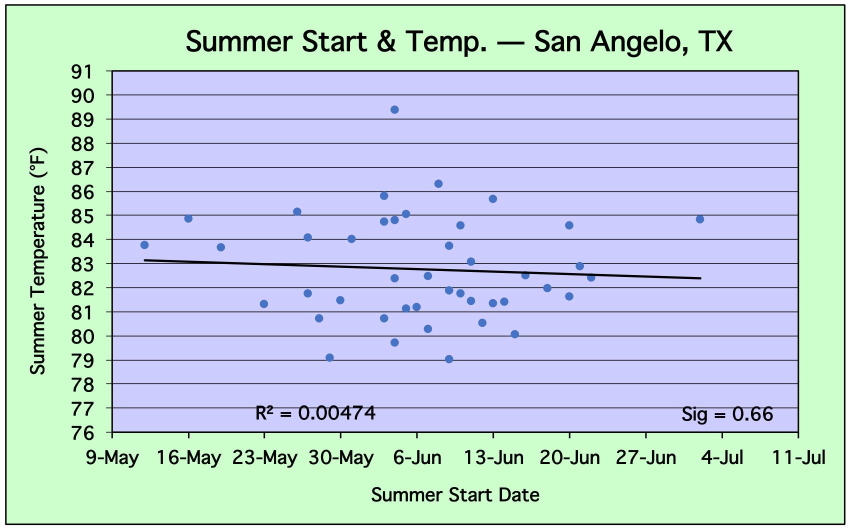
Summer Start & Temp. — Roswell, NM
Summer Temperature (°F)
86
85
84
83
82
81
80
79
78
77
76
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
Summer Start Date
R² = 0.00
Sig = 0.96

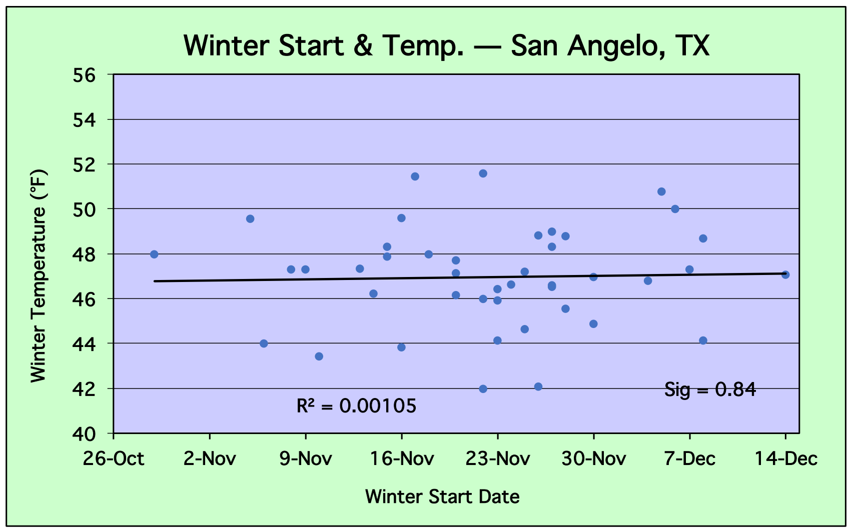


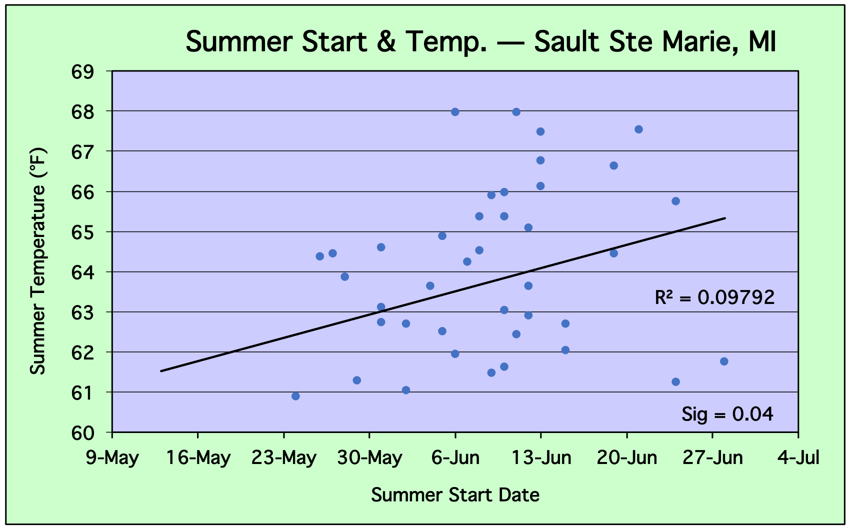
Winter Start & Temp. — Roswell, NM
Winter Temperature (°F)
48
46
44
42
40
38
36
34
26-Oct
2-Nov
9-Nov
16-Nov
23-Nov
30-Nov
7-Dec
14-Dec
Winter Start Date
R² = 0.014
Sig = 0.45

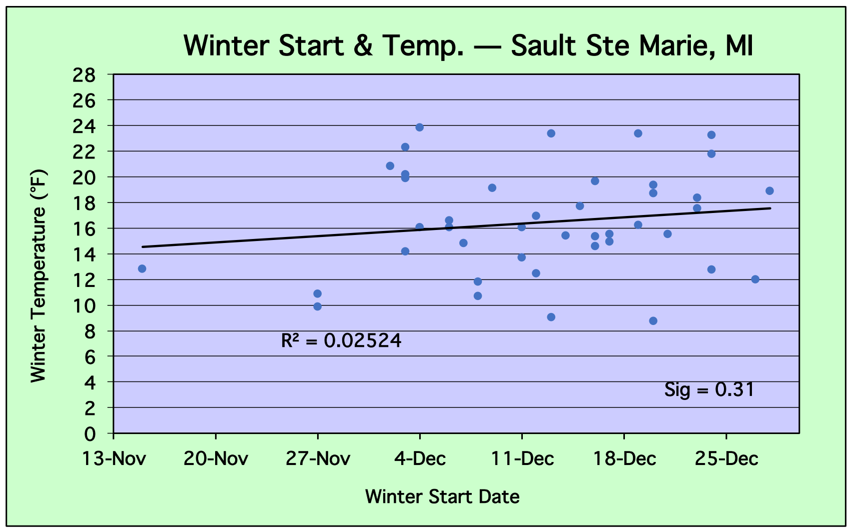

Summer Start & Temp. — Salt Lake City, UT
Summer Temperature (°F)
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
R² = 0.06326
Sig = 0.10
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
Summer Start Date

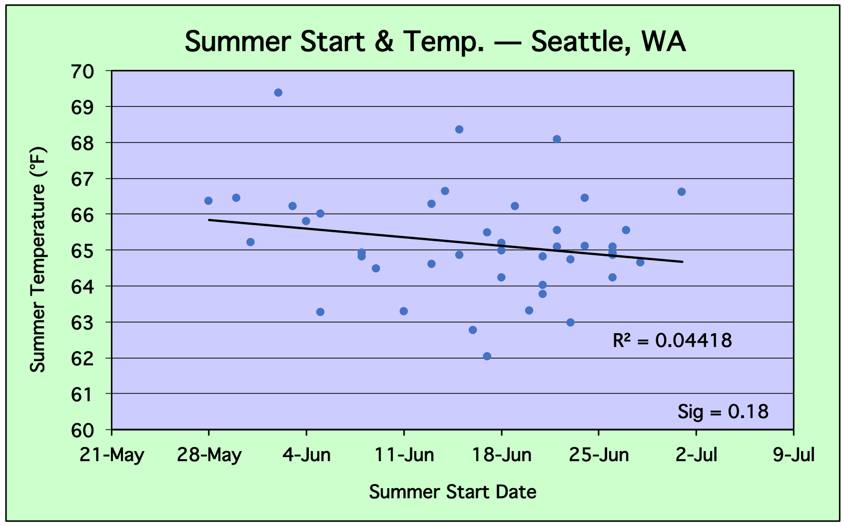

Winter Start & Temp. — Salt Lake City, UT
Winter Temperature (°F)
38
36
34
32
30
28
26
24
22
20
18
16
R² = 0.03553
Sig = 0.23
31-Oct
7-Nov
14-Nov
21-Nov
28-Nov
5-Dec
12-Dec
19-Dec
26-Dec
Winter Start Date


Summer Start & Temp. — San Angelo, TX
Summer Temperature (°F)
91
90
89
88
87
86
85
84
83
82
81
80
79
78
77
76
R² = 0.00474
Sig = 0.66
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
Summer Start Date

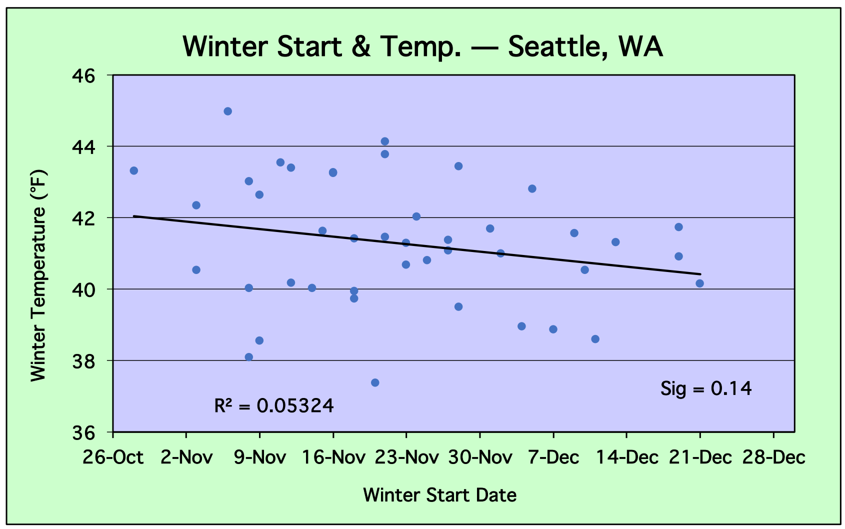

Winter Start & Temp. — San Angelo, TX
Winter Temperature (°F)
56
54
52
50
48
46
44
42
40
Sig = 0.84
R² = 0.00105
26-Oct
2-Nov
9-Nov
16-Nov
23-Nov
30-Nov
7-Dec
14-Dec
Winter Start Date


Summer Start & Temp. — Sault Ste Marie, MI
Summer Temperature (°F)
69
68
67
66
65
64
63
62
61
60
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
Summer Start Date
R² = 0.09792
Sig = 0.04

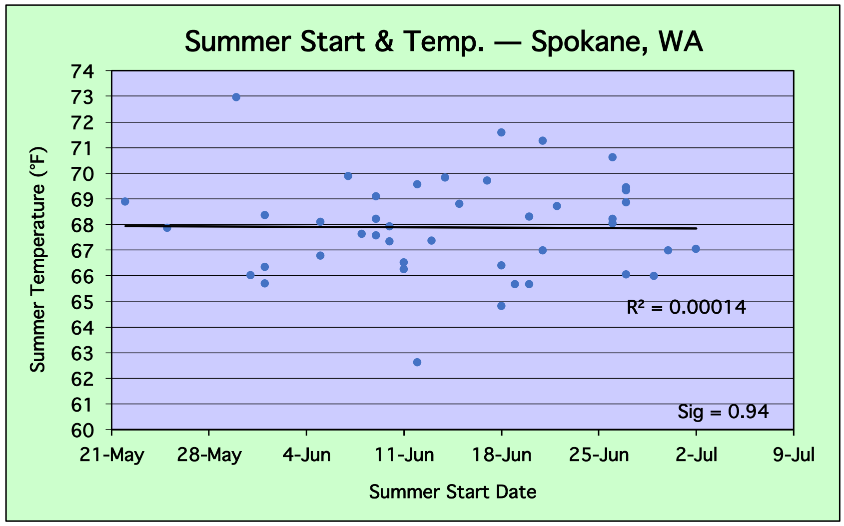

Winter Start & Temp. — Sault Ste Marie, MI
Winter Temperature (°F)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
13-Nov
20-Nov
27-Nov
4-Dec
11-Dec
18-Dec
25-Dec
Winter Start Date
R² = 0.02524
Sig = 0.31

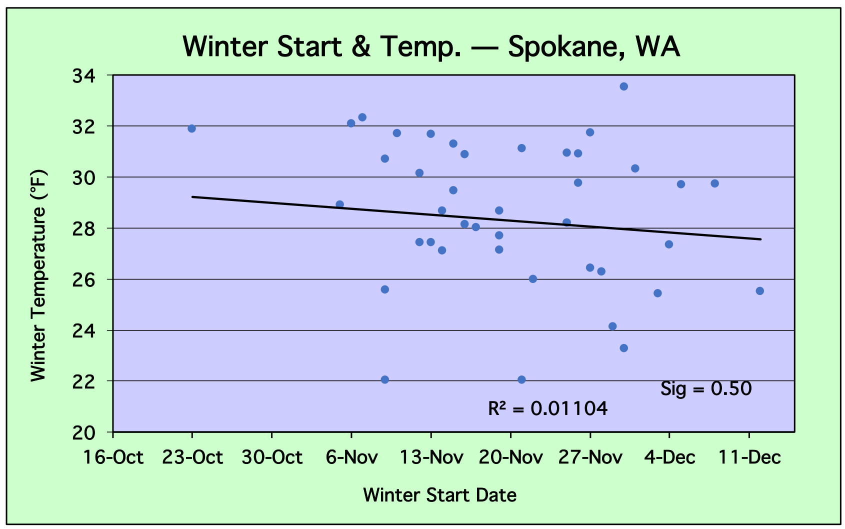


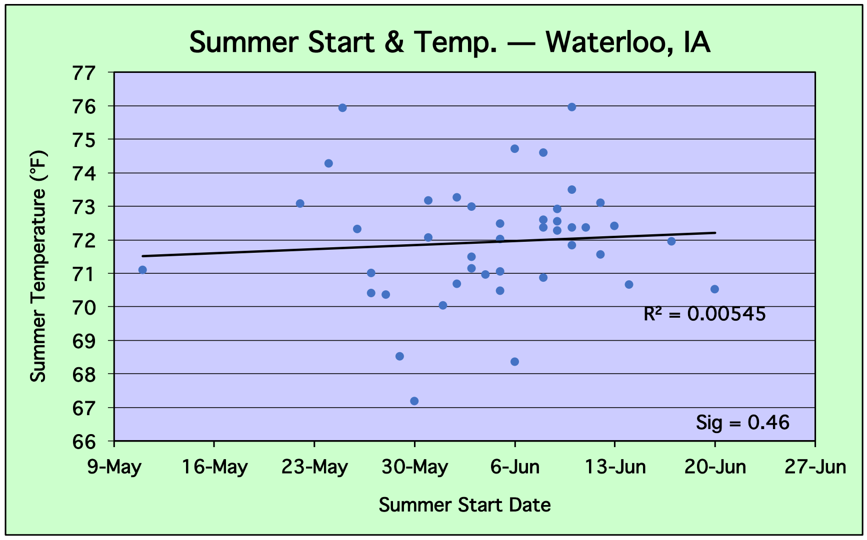
Summer Start & Temp. — Seattle, WA
Summer Temperature (°F)
70
69
68
67
66
65
64
63
62
61
60
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
Summer Start Date
R² = 0.04418
Sig = 0.18

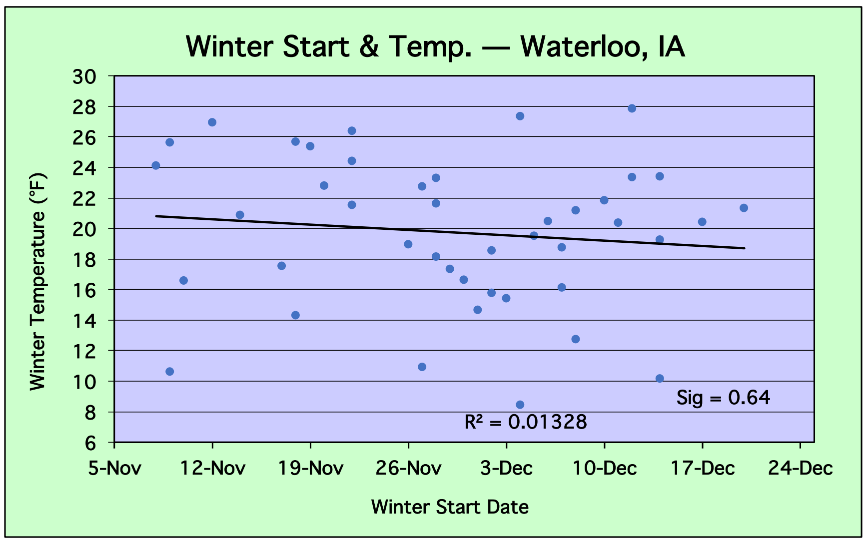


Winter Start & Temp. — Seattle, WA
Winter Temperature (°F)
46
44
42
40
38
36
26-Oct
2-Nov
9-Nov
16-Nov
23-Nov
30-Nov
7-Dec
14-Dec
21-Dec
28-Dec
Winter Start Date
R² = 0.05324
Sig = 0.14


Summer Start & Temp. — Spokane, WA
Summer Temperature (°F)
74
73
72
71
70
69
68
67
66
65
64
63
62
61
60
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
Summer Start Date
R² = 0.00014
Sig = 0.94


Winter Start & Temp. — Spokane, WA
Winter Temperature (°F)
34
32
30
28
26
24
22
20
16-Oct
23-Oct
30-Oct
6-Nov
13-Nov
20-Nov
27-Nov
4-Dec
11-Dec
Winter Start Date
Sig = 0.50
R² = 0.01104


Summer Start & Temp. — Waterloo, IA
Summer Temperature (°F)
77
76
75
74
73
72
71
70
69
68
67
66
9-May
16-May
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
Summer Start Date
R² = 0.00545
Sig = 0.46


Winter Start & Temp. — Waterloo, IA
Winter Temperature (°F)
30
28
26
24
22
20
18
16
14
12
10
8
6
5-Nov
12-Nov
19-Nov
26-Nov
3-Dec
10-Dec
17-Dec
24-Dec
Winter Start Date
R² = 0.01328
Sig = 0.64