A Review of the United States Historical Climatology Network Version 2: Adjusted Temperature Record for Pennsylvania, U.S.A.

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Harrisburg, Pennsylvania. North is to the left. Image Science and Analysis Laboratory, NASA-Johnson Space Center.

ABSTRACT

This report compares the raw with the United States Historical Climatology Network Version 2 (USHCN V2) adjusted temperature records for the twenty-four USHCN listed temperature stations in the state of Pennsylvania. Averaging over the twenty-four stations the raw data yielded a small linear decline with temperatures trending -0.1 ± 0.1 ºC/century, while the U.S. Historical Climatology Network (USCHN) Version 2 adjusted data revealed an increase of 0.7 ± 0.1 ºC/century. Over the twelve year period 1998-2009 a drop in temperature was observed in both data sets with a raw trend of -0.75 ± 0.1 ºC/decade and an adjusted trend of -0.65 ± 0.1 ºC/decade.

INTRODUCTION

The USHCN Version 2 (USHCN V2) temperature record adjustment scheme is designed to "reduce uncertainty in temperature trends for the United States".[1] Raw data are subjected to checks for inconsistencies, such as a daily maximum that is lower than the minimum and errors or a temperature reading that is impossibly high or low.

"Time of observation" corrections are introduced which can change the overall temperature trend over time when compared to the raw record. Menne, et al estimate that this yields an increase in the maximum temperature trend of 0.15ºC per century and an increase in the minimum trend of 0.22ºC per century. Hence, we anticipate an average increase of about 0.185ºC per century to be added to whatever trend is found in the average temperature[2] raw data. This is consistent with the USCHN Version 1 (USHCN V1) adjustment method.

An adjustment for updating from liquid in glass (LiG) to the current electronic thermometers results in a further rise in the temperature trend. Temperature stations were updated beginning in the early 1980s. Most were equipped with the electronic versions in the mid-80s, but 10% of the stations were updated after 1994.

Approximately 0.52ºC is added to the raw maximum reading while 0.37ºC is subtracted from the minimum to account for the electronic readings. Therefore, recent average temperatures are increased by about 0.075ºC to account for the new equipment which is about 0.025ºC higher than USHCN V1. We will consider temperature records from 1895 through 2009 and compute temperature trends over a century. This adjustment is expected to add something in the neighborhood of 0.075ºC per century to whatever trend is seen in the raw data.

Menne, et al combine documented and undocumented changes made after the TOB adjustments in giving their changes to the temperature trends. Their estimate of raising the maximum temperature trend by 0.31ºC per century, while leaving the minimum temperature trend unchanged, includes the LiG to electronic switchover. These combined changes serve to elevate the average temperature trend by about 0.155ºC per century. Thus, roughly 0.08ºC per century is added to the trend due to factors other than switching from LiG to electronic measurement.

Summarizing, we anticipate an upward shift in the average temperature trend of about 0.34ºC per century. This includes the TOB adjustment increase of 0.185ºC per century, an increase of 0.075ºC per century during the LiG to electronic measurement switchover, and a 0.08ºC per century increase for other documented and undocumented changes.

An important feature of this update involves dropping the Version 1 correction for the Urban Heat Island (UHI) effect in favor of an algorithm that detects undocumented change points.[3] This technique should spot sudden shifts such as undocumented station location and equipment changes. It is less clear how it detects the much slower change in the size of a population center.

The checks and adjustments leave the casual observer to wonder how the raw temperature trends compare with those of the final USHCN V2 product where they live. This survey addresses that question for the state of Pennsylvania.[4]

CALCULATIONS

The temperature records are those available through the online USHCN database.[5] Information for the twenty-four temperature stations has been entered into Table I. Their locations within Pennsylvania are shown in Fig. 1. Nine of the twenty-four stations had records that ended prior to February of 2010.

Data were converted from Fahrenheit to Celsius for this review. No changes were made in the data.

Linear least squares was employed to find the best straight line fit through the data. Our interest is not in the precise average temperature for a given year, but in the temperature trend or slope of the line.

Individual results for both the raw and USHCN V2 adjusted temperature records are plotted in Figs. 2-5 for the 24 stations. The temperature trends are labeled on each of the graphs. Color codes were assigned for the raw and adjusted trends to create the comparison maps of Fig. 6.

Averages of the trends were taken over the twenty-four stations. The raw and USHCN V2 adjusted temperature trends are depicted in Fig. 7. The raw temperature records show a decrease with temperatures trending at a rate of -0.1 ± 0.1 ºC/century and the USHCN V2 records reveal an increase of 0.7 ± 0.1 ºC/century.

Adjustments have resulted in an increase of about 0.8 ºC/century. This was higher than the 0.34ºC per century we had initially anticipated. Since the introduction of the electronic temperature stations likely took place prior to 1995, a second round of data analysis was initiated. This should eliminate or nearly eliminate the LiG to electronic thermometer correction in the temperature trend.

Consider the records for the years from 1998 to 2009, a period during which there may have been a temperature drop. We first eliminate the nine stations for which temperature records have ended (see Table I). Since there are a mere 12 years of data, the two stations that reported fewer than 10 annual averages (Eisenhower/Natl Hist Site reported 8 readings and West Chester 2 NW had 9 annual averages) were disregarded. The locations of the remaining temperature stations are shown in Fig. 8.

Linear regression was used to determine the best fit linear trend. The sampling error makes it impossible to detect the LiG to electronic thermometer 0.075ºC uniform shift. However, in this case the temperature trend itself is of interest. During the 1998-2009 time period, a trend toward cooler temperatures was observed for stations in rural, small town, and urban locations as shown in the Fig. 8 plot.

CONCLUSIONS

In the state of Pennsylvania the raw temperature record reveals no significant change in temperature over the period from 1895 to 2009. The USHCN V2 adjusted temperature record shows an increase of less than a degree Celsius over those years. A cooling trend is observed in the raw and USHCN V2 records for the past 12 years.

In both the short and longer term cases the USHCN V2 adjusted data yielded trends that were roughly 1ºC per century higher than those found in the raw temperature records.

[1] M. J. Menne, C. N. Williams Jr., and R. S. Vose, 2009: The U.S. Historical Climatology Network Monthly Temperature Data, Version 2. *BAMS*, **70**, 993-1007. [http://www1.ncdc.noaa.gov/pub/data/ushcn/v2/monthly/menne-etal2009.pdf.]

[2] The average daily temperature is the average of the maximum and minimum temperatures, $T_{ave} = (T_{max}+T_{min})/2$.

[3] M. J. Menne and C. N. Williams Jr., 2009: Homogenization of Temperature Series via Pairwise Comparisons. *J. Climate*, **22**, 1700-1717. [http://www1.ncdc.noaa.gov/pub/data/ushcn/v2/monthly/menne-williams2009.pdf.]

[4] With an area of 46,055 square miles (119,283 km^2) Pennsylvania covers less than a quarter of one-thousandth (2.3×10^{-4}) of the Earth's surface area of about 200,000,000 square miles (5.1×10^8 km^2) .

[5] Data was downloaded from the National Climatic Data Center (NCDC) at the National Oceanic and Atmospheric Administration (NOAA) site. [http://www1.ncdc.noaa.gov/pub/data/ushcn/v2/monthly/].

Label	Station #	Lat. (º)	Long. (º)	Alt (m)	Name	Classification	Raw Record Final Month
A	360106	40.65	-75.45	119	ALLENTOWN LEHIGH VALLEY INTL A	URBAN	Current
B	361354	39.94	-77.64	195	CHAMBERSBURG 1 ESE	SMALL TOWN	10/2009
C	362537	39.81	-77.23	165	EISENHOWER/NATL HIST SITE	RURAL	Current
D	362682	42.08	-80.18	223	ERIE/WSO AP	URBAN	Current
E	363028	41.40	-79.83	302	FRANKLIN	RURAL	Current
F	363526	41.42	-80.37	345	GREENVILLE 2 NE	RURAL	1/1997
G	364385	40.33	-78.92	370	JOHNSTOWN	SMALL TOWN	7/1993
H	364896	40.33	-76.47	137	LEBANON 2 W	SMALL TOWN	Current
I	365915	41.87	-75.85	433	MONTROSE	[RURAL]	5/2009
J	366233	41.02	-80.36	252	NEW CASTLE 1 N	SMALL TOWN	10/2009
K	366689	40.80	-75.62	125	PALMERTON	RURAL	12/1997
L	367029	41.73	-75.45	548	PLEASANT MOUNT 1 W	[RURAL]	Current
M	367322	40.43	-75.93	110	READING 4 NNW	URBAN	3/2008
N	367477	41.42	-78.75	415	RIDGWAY	RURAL	Current
O	367931	40.78	-76.86	133	SELINSGROVE	RURAL	Current
P	368449	40.79	-77.87	357	STATE COLLEGE	SMALL TOWN	Current
Q	368596	41.01	-75.19	140	STROUDSBURG	RURAL	9/2009
R	368905	41.75	-76.44	229	TOWANDA 1 ESE	RURAL	Current
S	369050	39.92	-79.72	291	UNIONTOWN 1 NE	SMALL TOWN	11/2009
T	369298	41.85	-79.15	369	WARREN	SMALL TOWN	Current
U	369408	41.70	-77.39	554	WELLSBORO 4 SW	RURAL	Current
V	369464	39.97	-75.64	114	WEST CHESTER 2 NW	SMALL TOWN	Current
W	369728	41.24	-76.92	159	WILLIAMSPORT/WSO AP	SMALL TOWN	Current
X	369933	39.92	-76.75	119	YORK 3 SSW PUMP STN	SMALL TOWN	Current

Table I. Temperature station identification, location, and surroundings. Classifications in square brackets were determined from satellite images. The letter labels correspond to the map in Fig. 1.

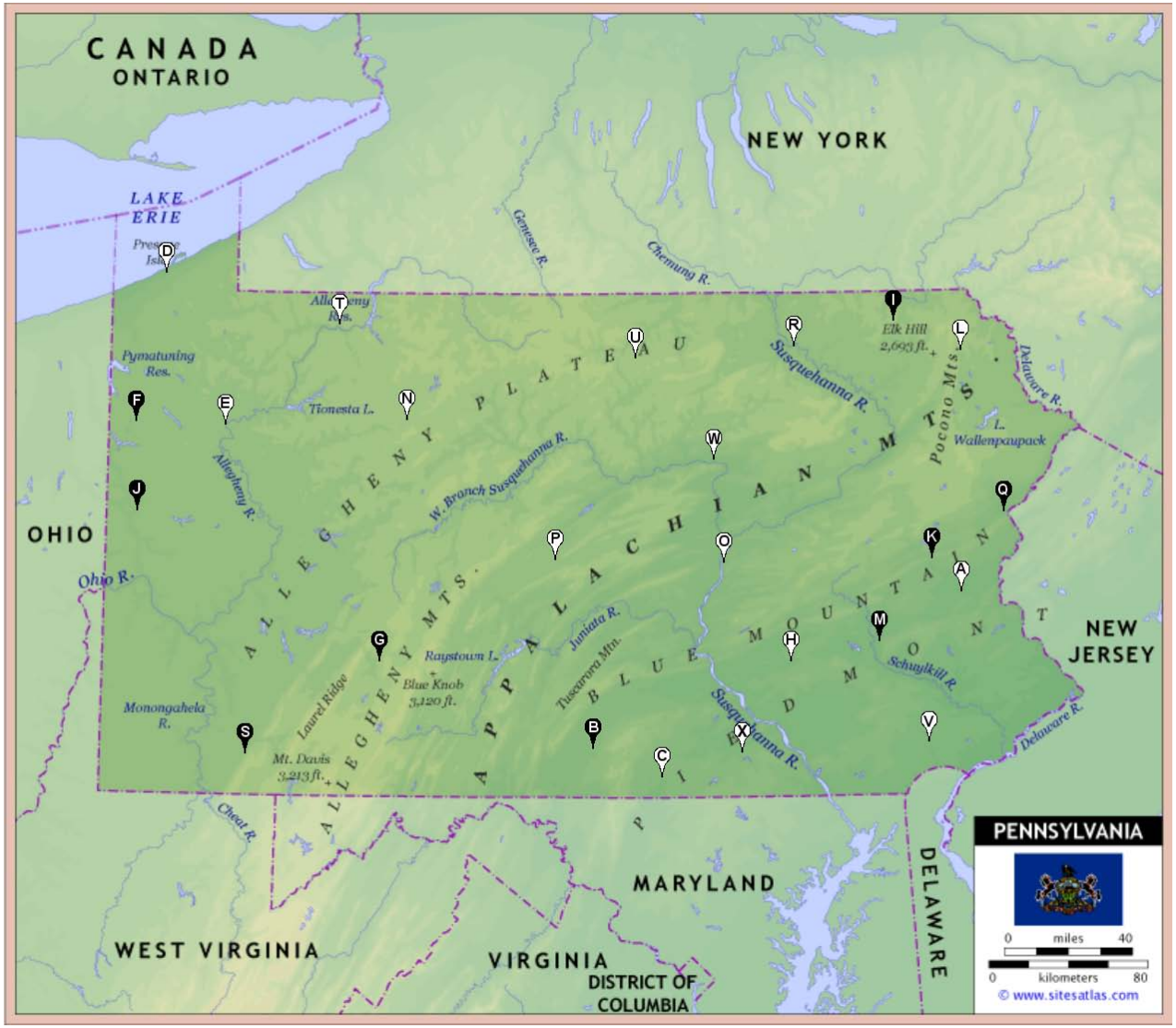


Fig. 1. Locations of the twenty-four temperature stations in Pennsylvania. Those stations that have current records are white with black labels, those whose records have lapsed are black with white labels. Letter labels are defined in Table I.

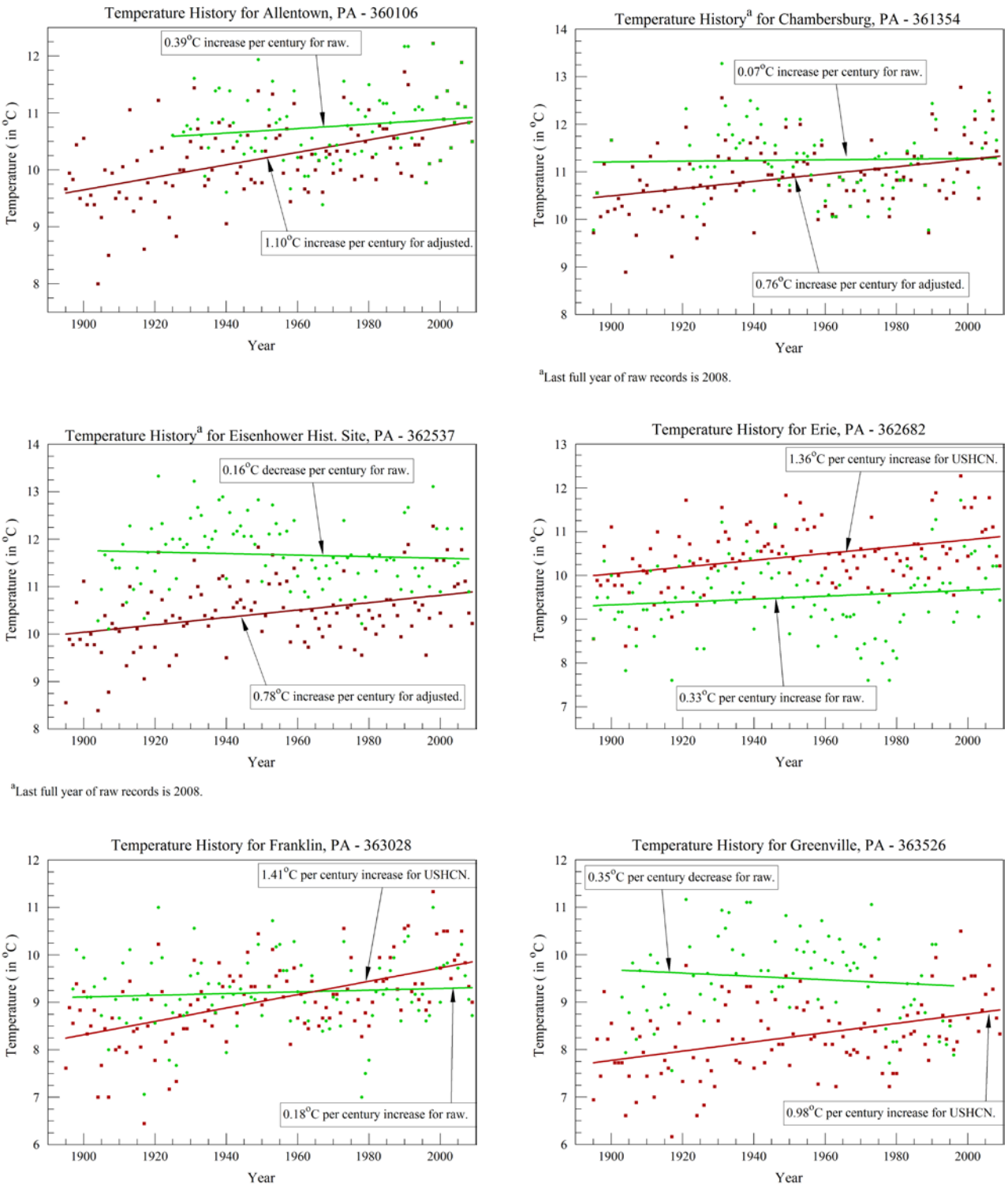
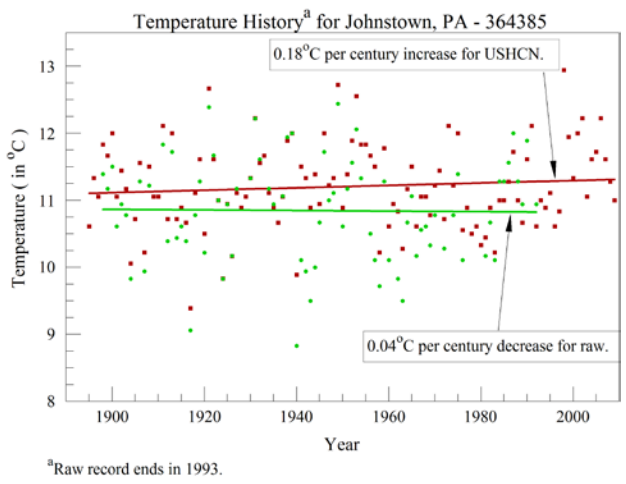
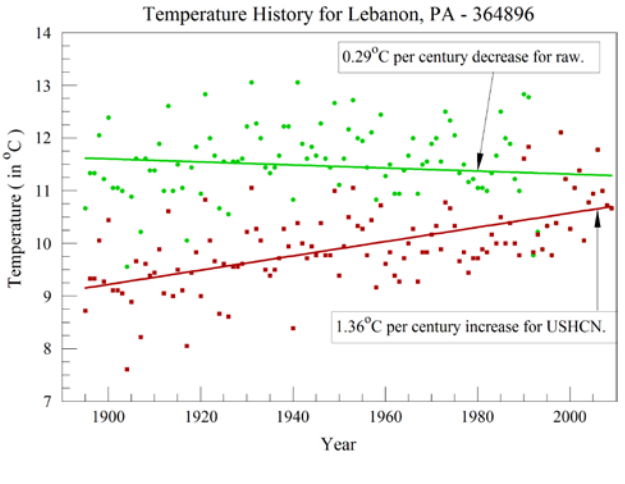
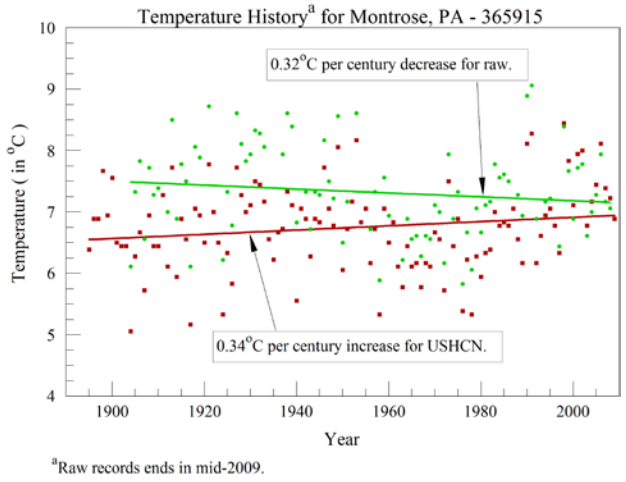
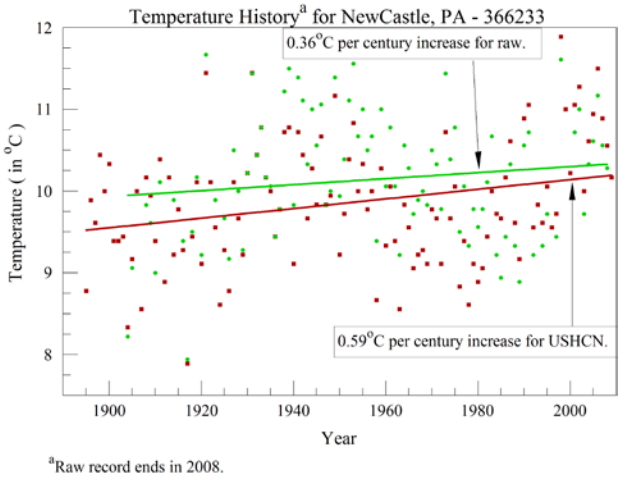


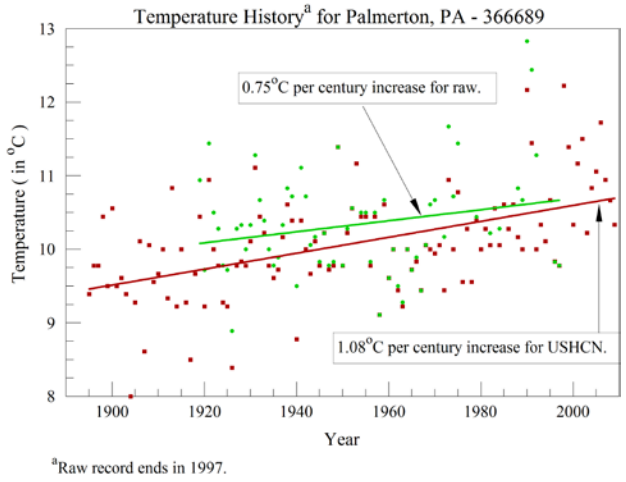
Fig. 2. Average yearly temperature in degrees Celsius versus year for stations A-F. Raw data points appear as green circles, USHCN V2 adjusted data are plotted as red squares. Linear averages for the raw and adjusted data are the green and red lines, respectively.











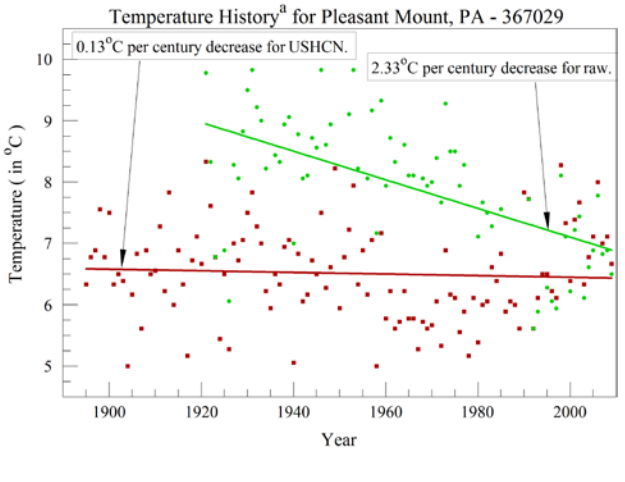


Fig.3. Average yearly temperature in degrees Celsius versus year for stations G-L. Raw data points appear as green circles, USHCN V2 adjusted data are plotted as red squares. Linear averages for the raw and adjusted data are the green and red lines, respectively.

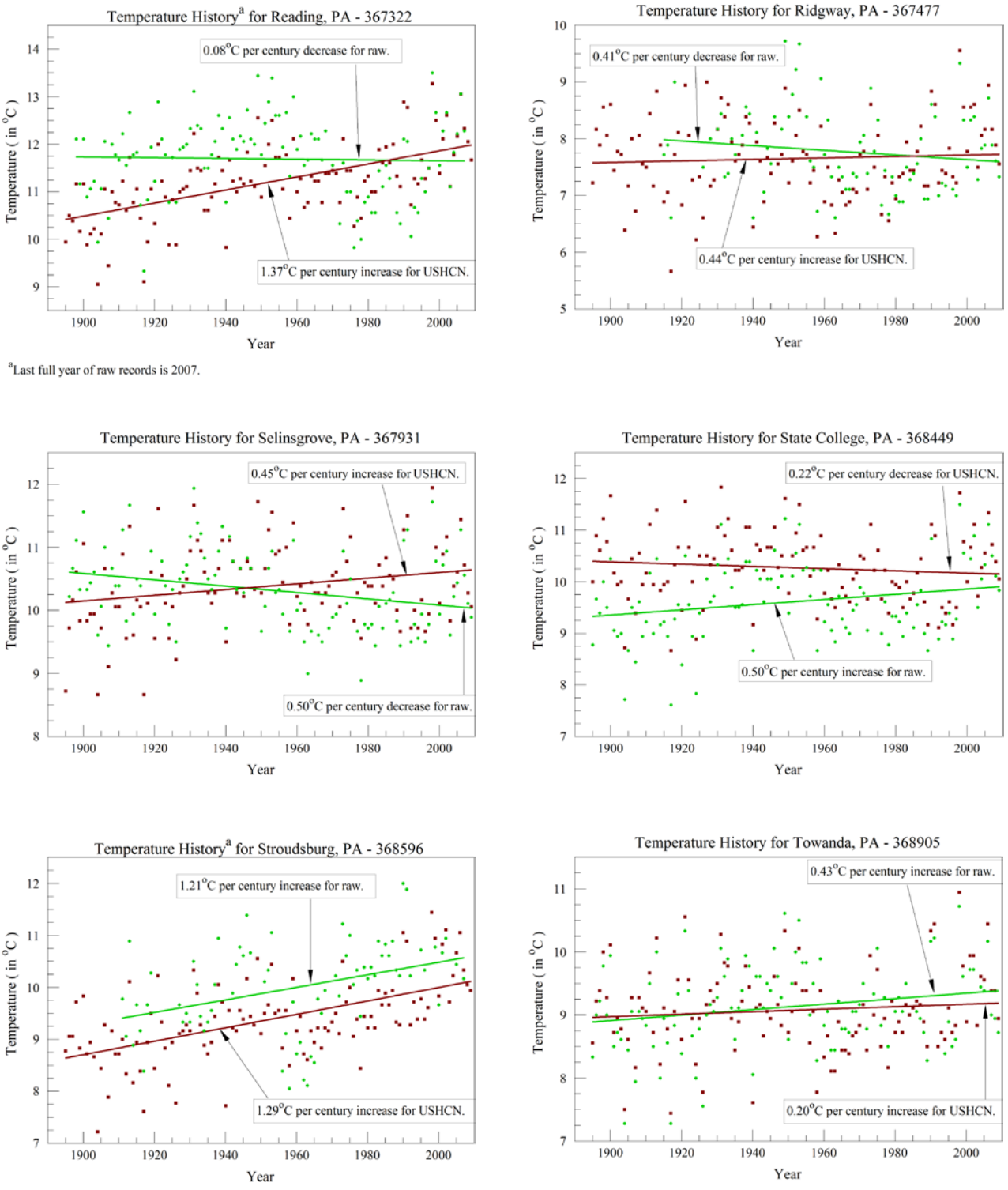
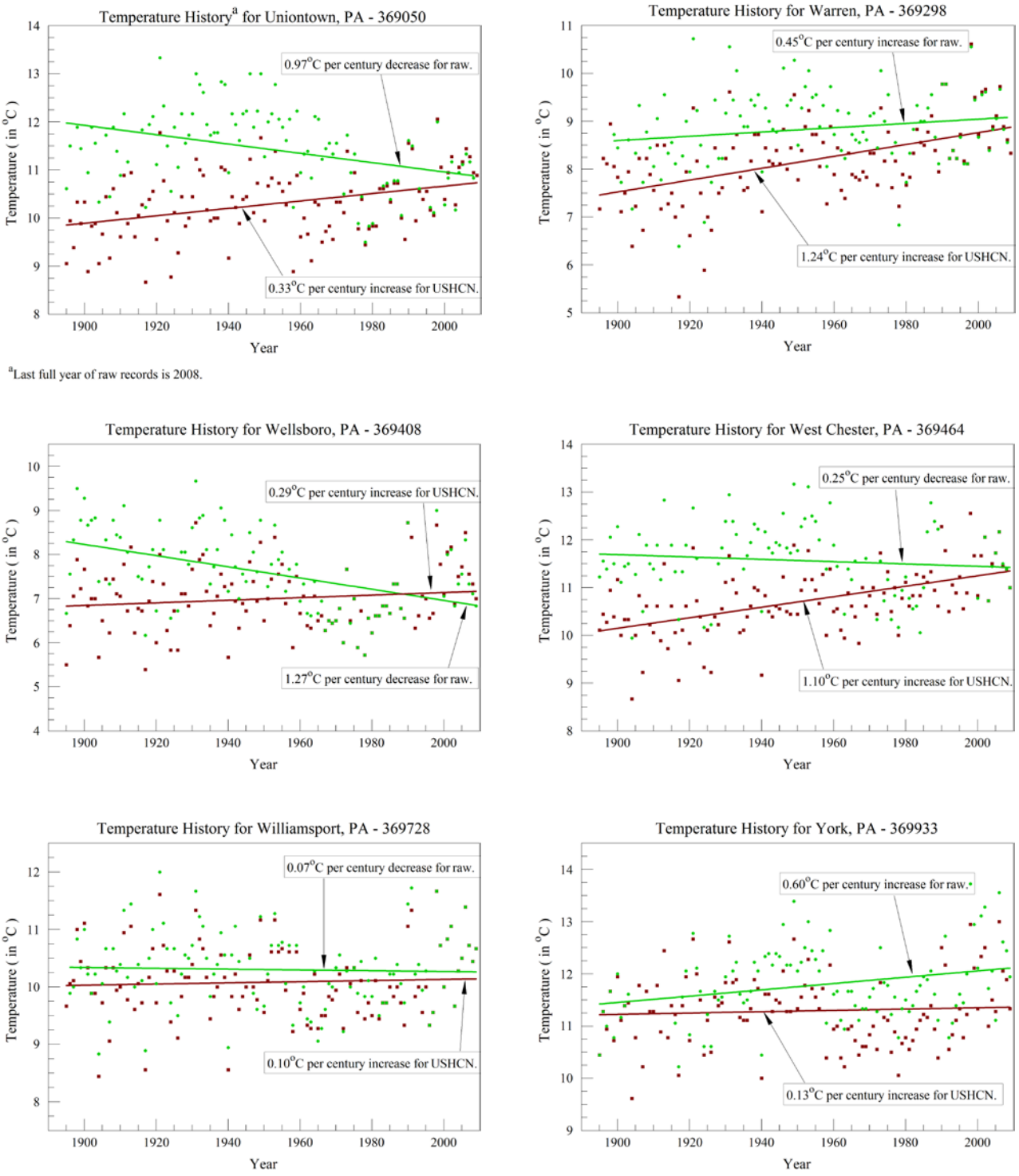


Fig. 4. Average yearly temperature in degrees Celsius versus year for stations M-R. Raw data points appear as green circles, USHCN V2 adjusted data are plotted as red squares. Linear averages for the raw and adjusted data are the green and red lines, respectively.



[a]Last full year of raw records is 2008.

Fig. 5. Average yearly temperature in degrees Celsius versus year for stations S-X. Raw data points appear as green circles, USHCN V2 adjusted data are plotted as red squares. Linear averages for the raw and adjusted data are the green and red lines, respectively.

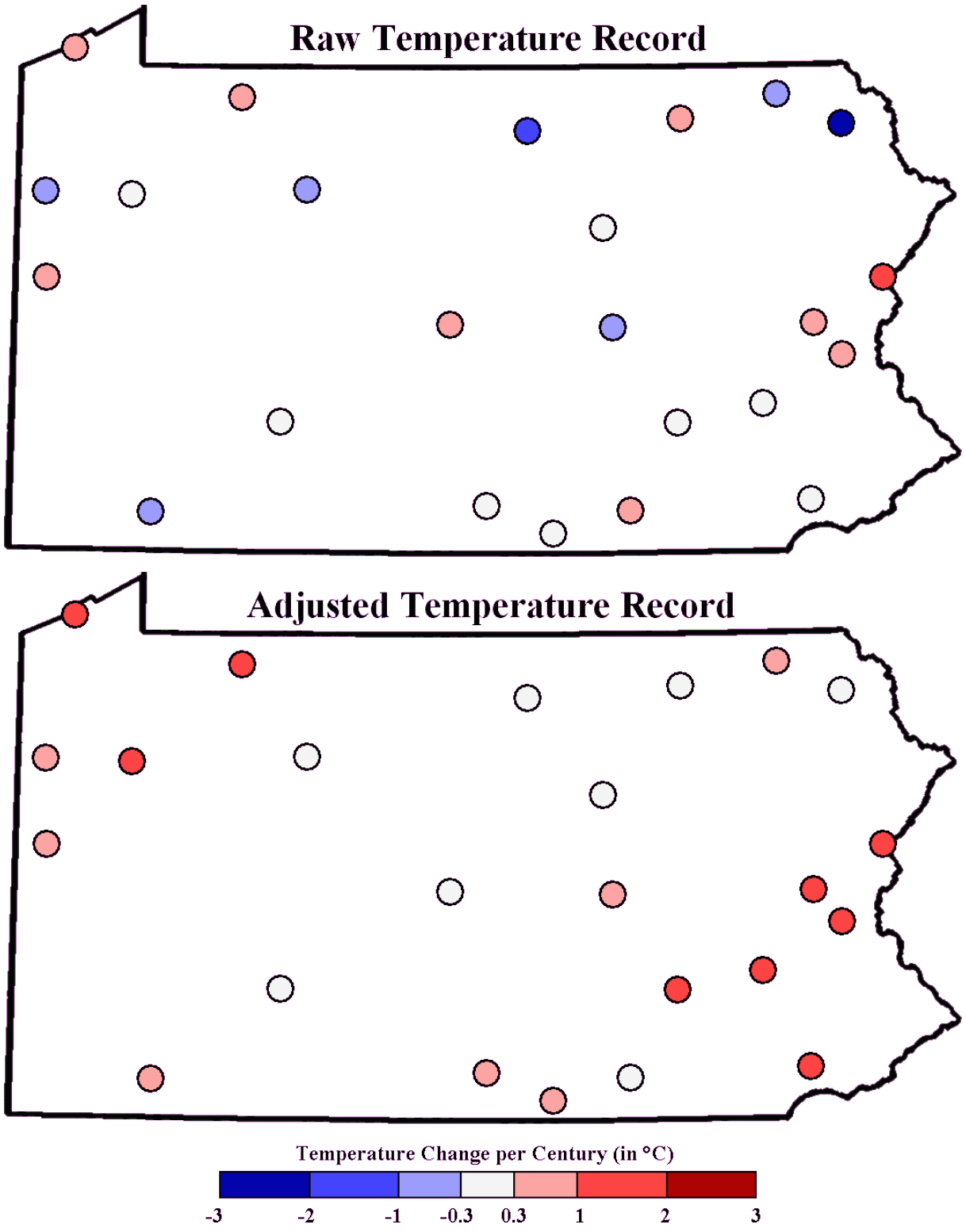


Fig. 6. Temperature trends for the Pennsylvanian temperature stations. Raw data was used for the top map, the USHCN V2 adjusted data for the bottom map.

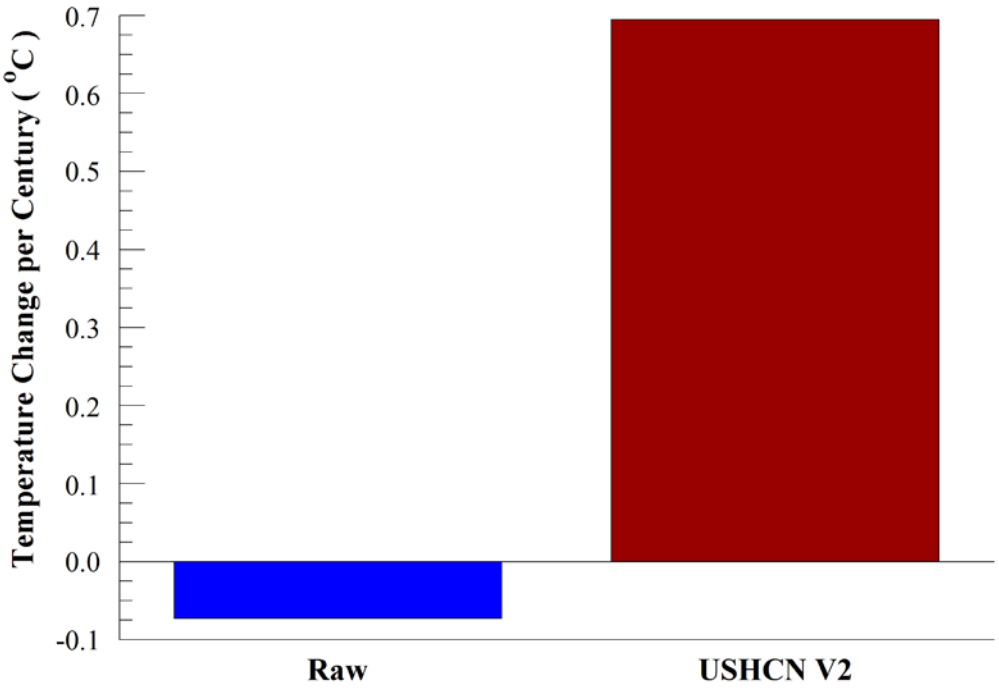


Fig. 7. Overall temperature trend for the twenty-four Pennsylvanian temperature stations calculated using the raw temperature data in blue and the USHCN V2 adjusted record in red.

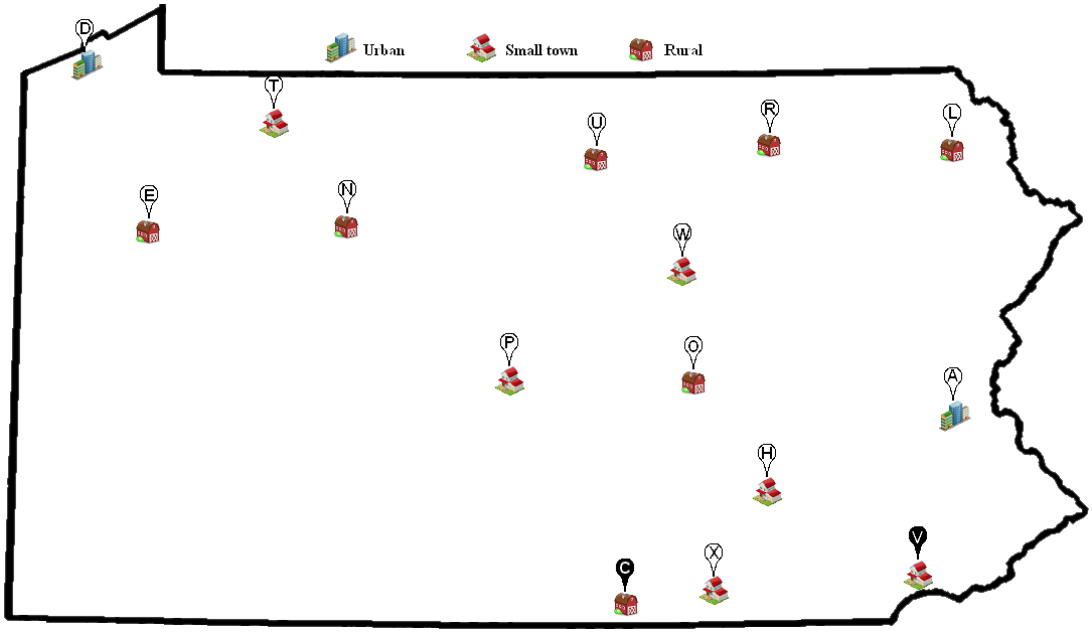


Fig. 8. Stations with current temperature records. The 1998-2009 trends were determined using data from these stations. Eisenhower/Natl Hist Site "C" and West Chester 2 NW "V" were excluded because they had fewer than 10 years of annual average raw temperatures during this period. Additional information on these stations can be found in Table I.

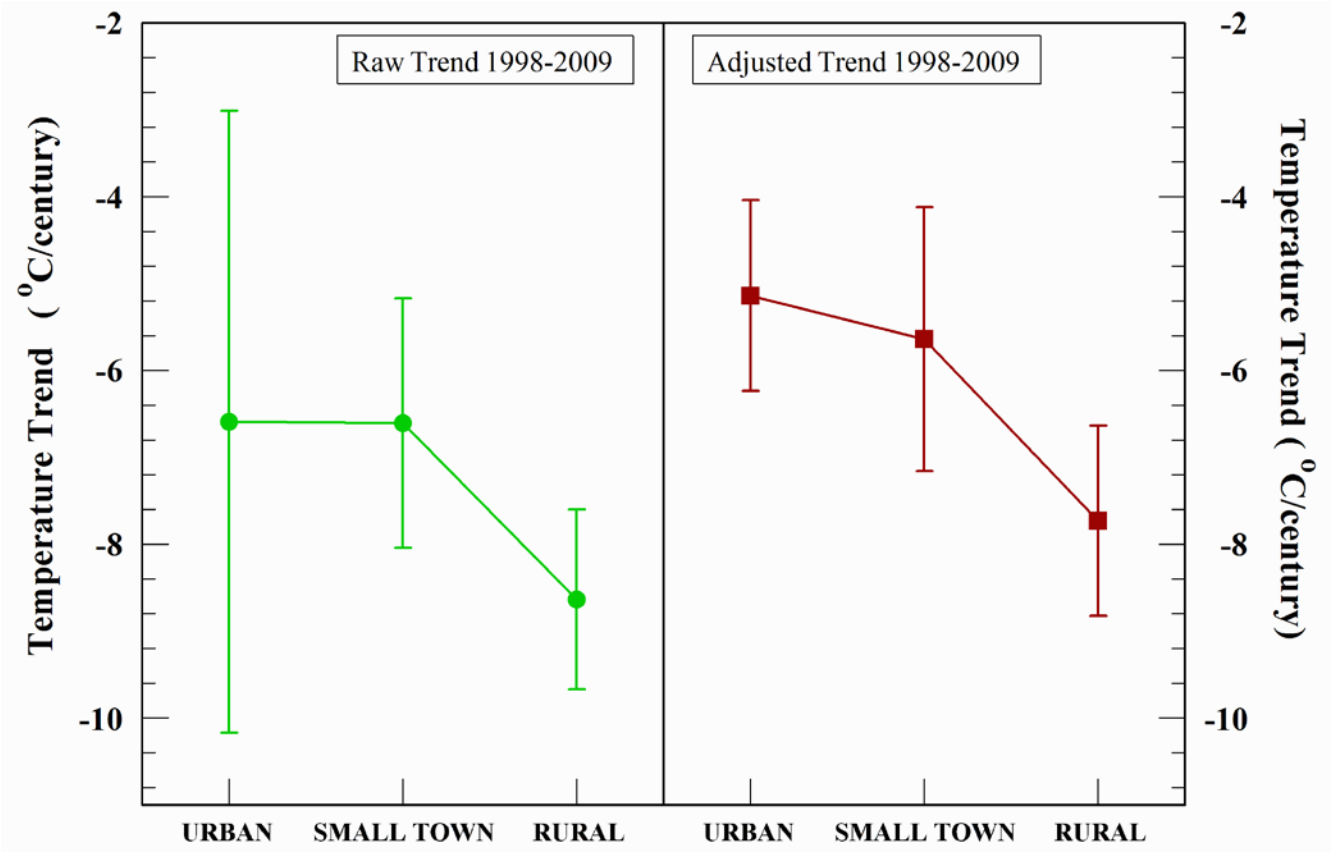


Fig. 9. 1998-2009 temperature trends. Average trends were determined for the urban, small town, and rural locations as shown in Fig. 8 above and identified in Table I.

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