New England's Temperature History and Trends (1911 – 2009)

by Edward R. Long, Ph.D.

SPPI
Science & Public Policy Institute
"science-based policy for a better world"

SPPI Original Paper ♦ August 28, 2010

NEW ENGLAND'S TEMPERATURE HISTORY AND TRENDS (1911 – 2009)

by Edward R. Long, Ph.D. | August 28, 2010

INTRODUCTION

THE PROTOCOL developed by the National Climatic Data Center for massaging raw temperature observations into adjusted values is responsible (Ref 1 – 4) for a significant proportion of the United States temperature increase of +0.6 C° (Ref 5) reported over the past century. NCDC erred (Ref 6 - 10) in adjusting temperature data for 1980-2000 so as to show temperatures higher than those previously reported. The present paper further questions the NCDC's adjustment protocol by way of a study of temperature trends in New England.

CRITERIA FOR SELECTION AND CLASSIFICATION OF METEOROLOGICAL STATIONS

This investigation uses the data (Table I) from all but six (grayed out) of the 44 New England meteorological stations in the NCDC's list. The six stations were excluded because they did not have annual raw data for at least 75 % of the period 1911-2009. A computer-based aerial-view map service was used to classify the stations as rural or urban. The station was classified as urban if located in a town or city or at an industrial, airport, or large-paved site. Of the 44 stations a quarter were classified rural.

No consideration was given to the extent of a station's adherence to NOAA's published data standards. However, the Surface Stations program (Ref 11) has rated many of them, shown in the rightmost column. A blank indicates no rating. Perhaps the most interesting observation of the ratings is those with the highest are in urban surroundings which can lead to Urban Heat Island Effects (UHIE). Thus adherence to NOAA standards may not be the singular standard for excellence.

TABLE I

META DATA FOR NCDC'S NEW ENGLAND METEOROLOGICAL STATIONS

	Station ID	Latitude	Longitude	Elevation (ft)	State	Name	Rural/ Urban	Surface Station Rating
1	62658	41.95	-73.3667	167.6	CT	FALLS VILLAGE	R	4
2	63207	41.3506	-72.0394	12.2	CT	GROTON	U	5
3	67970	41.1247	-73.5475	57.9	CT	STAMFORD 5 N	R	2
4	68138	41.795	-72.2283	198.1	CT	STORRS	U	3
5	370896	41.1667	-71.5833	33.5	RI	BLOCK ISLAND STATE AP	U	
6	374266	41.4906	-71.5414	34.7	RI	KINGSTON	U	
7	376698	41.7219	-71.4325	15.5	RI	PROVIDENCE WSO AP	U	1
8	270706	44.3061	-71.6575	359.7	NH	BETHLEHEM 2	R	
9	272174	43.15	-70.95	24.4	NH	DURHAM	U	4
10	272999	45.0875	-71.2872	506	NH	FIRST CONNECTICUT LAKE	R	3
11	273850	43.7031	-72.2847	183.8	NH	HANOVER	U	4
12	274399	42.9389	-72.3244	158.5	NH	KEENE	U	3
13	431081	44.4681	-73.1503	100.6	VT	BURLINGTON WSO AP	U	4
14	431243	43.3847	-72.5989	256.6	VT	CAVENDISH	R	4
15	431360	43.9833	-72.45	243.8	VT	CHELSEA	U	
16	431580	43.9572	-73.2106	105.2	VT	CORNWALL	U	4
17	432769	44.9094	-72.8083	128	VT	ENOSBURG FALLS	U	4
18	437054	44.42	-72.0194	213.4	VT	SAINT JOHNSBURY	U	4
19	437607	44.6264	-73.3031	33.5	VT	SOUTH HERO	R	
20	437612	44.0725	-72.9736	408.7	VT	SOUTH LINCOLN	R	
21	170100	44.3739	-68.2592	143.3	ME	ACADIA NP	U	4
22	170814	45.6603	-69.812	323.1	ME	BRASSUA DAM	R	
23	171628	44.9197	-69.2417	90.5	ME	CORINNA	R	
24	172426	44.9067	-66.9919	25.9	ME	EASTPORT	U	
25	172765	44.6889	-70.1567	128	ME	FARMINGTON	R	3
26	173046	44.2203	-69.7889	42.7	ME	GARDINER	U	5
27	173944	46.2061	-67.8417	118.9	ME	HOULTON 5N	R	3
28	174566	44.1	-70.2167	54.9	ME	LEWISTON	U	5
29	175304	45.6503	-68.705	109.7	ME	MILLINOCKET	U	5
30	176905	43.6497	-70.3003	13.7	ME	PORTLAND JETPORT	U	2
31	176937	46.6539	-68.0089	182.6	ME	PRESQUE ISLE	U	3
32	179891	45.1572	-67.4044	42.7	ME	WOODLAND	U	4
33	190120	42.3861	-72.5375	45.7	MA	AMHERST	R	4
34	190535	42.4833	-71.2833	48.8	MA	BEDFORD	U	
35	190736	42.2122	-71.1136	192	MA	BLUE HILL	R	3
36	193213	42.145	-73.4172	249	MA	GREAT BARRINGTON 5 SW	R	
37	194105	42.6992	-71.1658	15.2	MA	LAWRENCE	U	3
38	195246	41.6333	-70.9333	21.3	MA	NEW BEDFORD	U	
39	196486	41.9819	-70.6961	13.7	MA	PLYMOUTH-KINGSTON	U	
40	196681	42.05	-70.1833	6.1	MA	PROVINCETOWN	U	
41	196783	42.5242	-71.1264	27.4	MA	READING	U	
42	198367	41.9003	-71.0658	6.1	MA	TAUNTON	U	3
43	198757	42.1608	-71.2458	50.3	MA	WALPOLE 2	U	
44	199316	42.1333	-71.4333	64	MA	WEST MEDWAY	U	

RESULTS AND DISCUSSION

Temperature may be expressed either as an absolute value or as a relative value ("anomaly") with respect to a base value. The anomaly values are preferred, and thus more frequently reported, because averaging absolute temperatures for multiple stations can lead to large errors when any one or more of the stations either has no value or significantly deviates. In contrast, anomaly values provide the trend but not the offset from the base value. Hence the loss or deviation of a station for a particular year only shifts the average by the value of the trend of the missing data.

In main body of this report the absolute temperature data are discussed for New England as a whole and four areas of New England because it provides a clearer comparison of the Rural and Urban locations. The anomaly data, for only the whole of New England, are discussed in an appendix. The anomaly values are the absolute values minus the mean for the period 1961 – 1990, the NCDC's reference period.

DETERMINATION OF ANALYSIS PERIOD

The NCDC station data are posted for the period 1895 - present. Not all stations began operation as early as 1895, hence Raw data does not exist for years prior. Also, many stations have years for which the Raw annual mean is missing during its operation. Finally, stations have years for which the Raw year-to-year profile varies more erratic than others. Thus the averages of the Raw station annual means can have large year-to-year differences. It follows that the more there are missing and erratic years the larger the standard deviation. The Adjusted NCDC data have no missing years because their protocol for deriving Adjusted annual means from the Raw ones includes using interpolations of near-by station values or estimations to fill in the blank years. The protocol also uses a homogenization process which further smoothes the Raw into Adjusted values. Consequently the standard deviations for the averages of the Adjusted station annual means are typically much less than for the Raw data. Standard deviations for the averages of the 11 Rural and for the 27 Urban stations are shown in Figures 1 and 2, for three sets of data: Raw, Adjusted, and a third set "Adjusted (missing years)". The third set is the same as the Adjusted except it is missing values for the same years missing in the Raw.

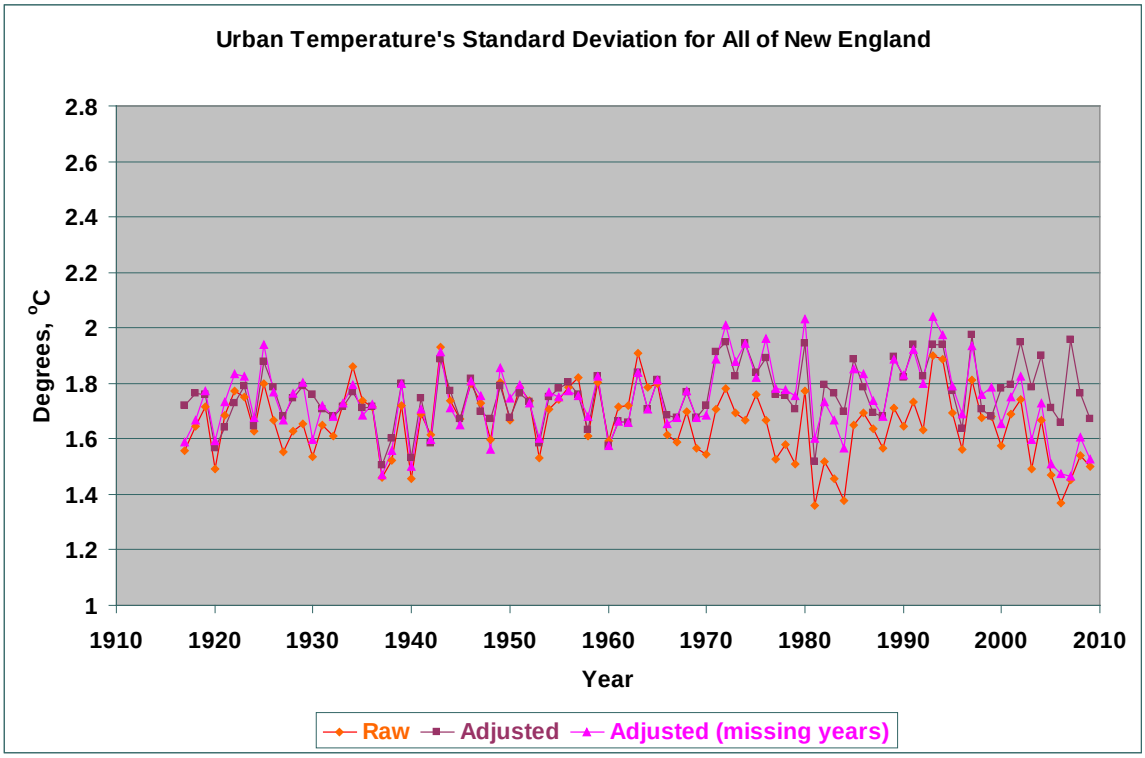

Figure 1 – Standard deviations for Urban locations' Raw, Adjusted, and Adjusted (missing years) data.

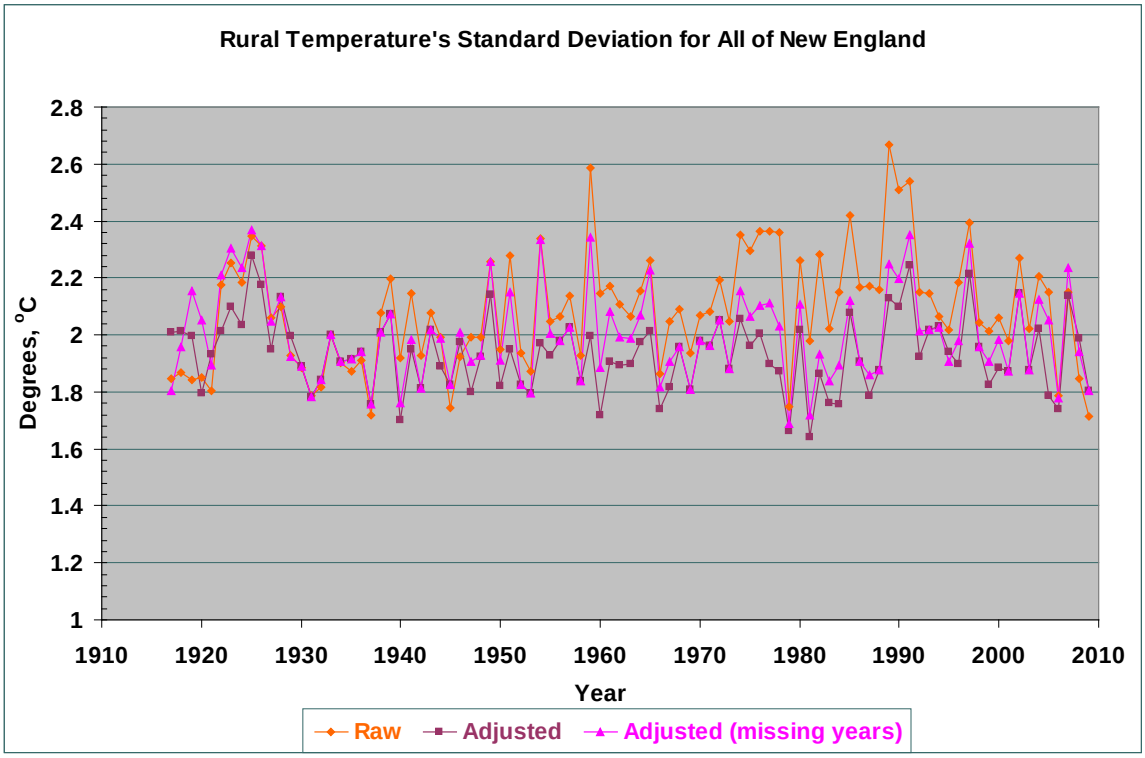

Figure 2 – Standard deviations for Rural locations' Raw, Adjusted, and Adjusted (missing years) data.

Fig. 1 indicates Raw and "Adjusted (missing years)" data for the Urban stations have nearly the same standard deviation values from 1895 to 2009 and thus demonstrate the profile for which data are missing for some years. A comparison of "Adjusted (missing years)" to the Adjusted then indicates the effect of data missing for some years. The two compare well except for the most recent five years. From this an assumption is made this too is the effect of missing data in the Raw set and that remainder of its year-to-year profile is due to the values reported. The 0.31 ^{o}C difference of the Adjusted and "Adjusted (missing years)" for the most recent five years is used as a standard by which the beginning of the period for this study is chosen..

Fig. 2 shows a larger and somewhat more varying statistical deviation for the Rural stations. On the whole, the Raw and Adjusted (missing years) are similar, with some larger values for the Raw from about 1960 to 1990. In this figure the larger difference between the Adjusted and the "Adjusted (missing years)" is from 1895 to the 1910 – 1915 interval. In order to have the differences of these two sets at the beginning of a period have a values no larger than 0.31 ^{o}C, and thus similar trends, 1911 has been chosen as the initial year of this study. For the most part the Rural set's year-to-year profile is similar to that of the "Adjusted (missing years)", except for 1960 – 1990. The Raw's larger standard deviation for the 30-year interval is accepted whether due to nature itself or data collection errors.

NEW ENGLAND AS A WHOLE

Fig. 3 plots average absolute Raw temperatures for the Rural and Urban stations in Table 1, except the six excluded ones, suggesting rural stations are 1.5 -2.5 ^{o}C cooler than urban stations. **The temperature trend for Rural stations is 0.14 C^{o}/century and 0.87 C^{o}/century for the Urban ones, suggesting a significant urban heat-island effect (UHIE).** This evidence of an UHIE is consistent with earlier reports (Ref 1 -4).

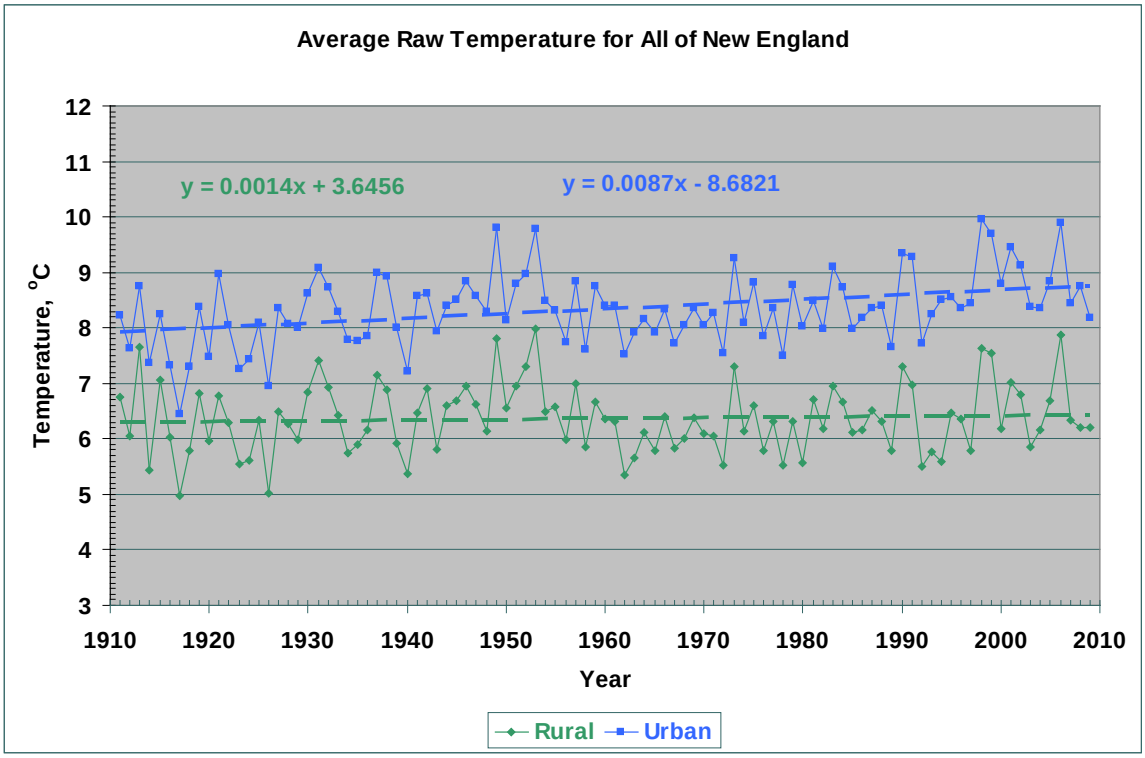

Figure 3 – Annual Raw actual temperature for all of New England, Rural and Urban locations.

If the Rural and Urban trends are combined using a simple average the warming is 0.51 C°/century, but if the Rural and Urban trends are weighted for fractions of land occupied the average is little different from the Rural average. Though the trend of 0.51 C°/century is nearly the same as that of the NCDC's for the contiguous US, the NCDC's trend may or may not be correct (Ref. 1).

Fig. 4 is the same plot, but for adjusted data. These are the data published by NCDC and used by NOAA, EPA, and other US government agencies to guide policy. The Adjusted Rural and Urban trends are near-identical, 1.23 and 1.26 C°/century respectively; that is, the NCDC's data-massaging protocol has artificially increased the century-long warming rate at Rural stations to match the apparent warming rate at Urban stations. Not are just the trends the same but so are the year-to-year profiles.

Thus, policymakers and the public are led to believe that there is no UHIE and that for a little less than a century New England has been warming at a rate some 1.5 - 8.8 times higher than Raw, observed data suggest. This is the same impression the NCDC adjusted data imparts for other areas of and for the whole of the contiguous U. S. (Ref 1 – 4).

The NCDC protocol's massaging effect on the Raw data is more clearly understood from Fig. 5, a plot of adjusted minus raw temperature. A negative value means the Raw value is lower than the Adjusted value, and *vice versa.* The Adjusted temperatures have been systematically adjusted downward, with the shift being larger the further back in time; thus a substantial and artificial warming rate. This is not the impression given by the NCDC's statement that the protocol simply adds an increase of 0.5 C° to each year's Raw value (Ref. 4).

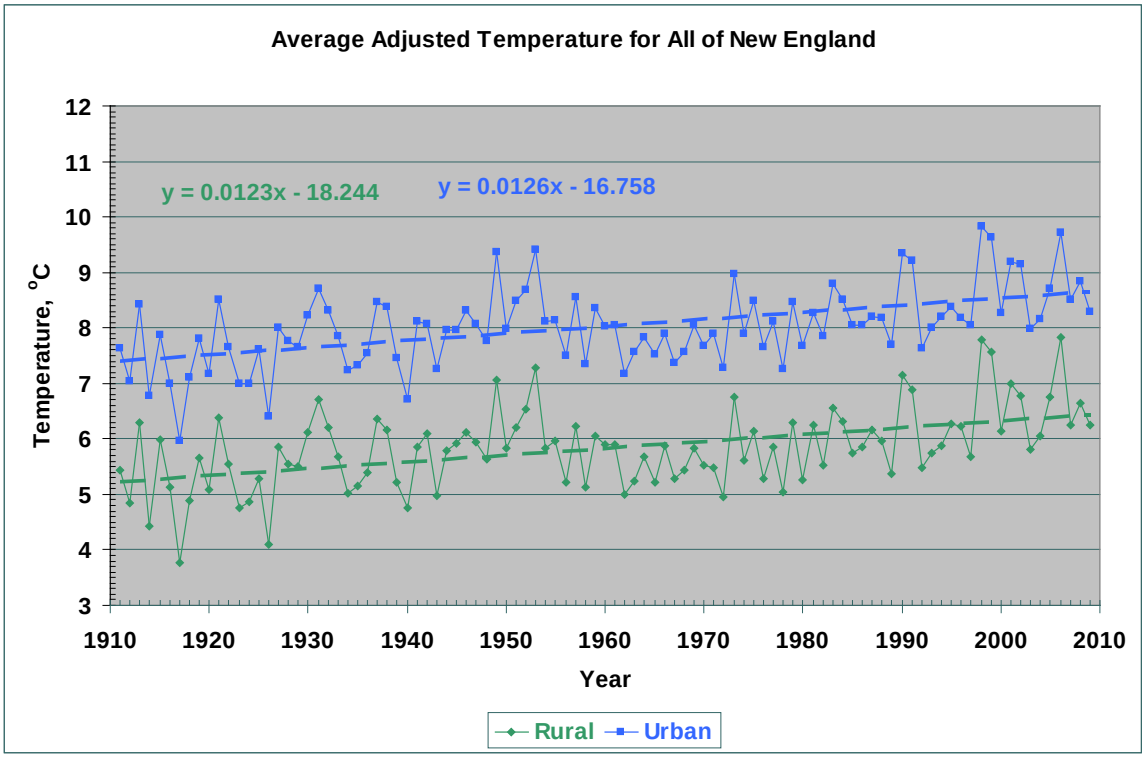

Figure 4 – Annual Adjusted actual temperature for all of New England, Rural and Urban locations.

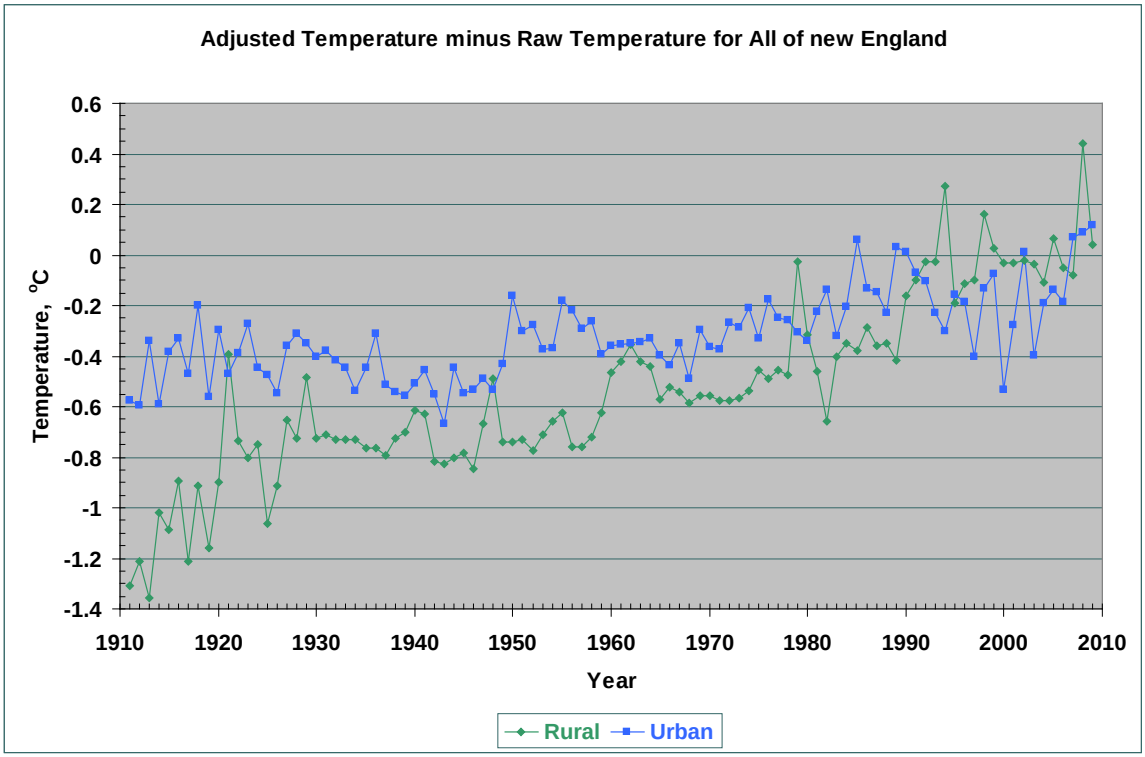

Figure 5 – Adjusted actual temperature minus Raw actual temperature for the whole of New England, the effect of the NCDC data massaging protocol.

FOUR AREAS OF NEW ENGLAND

Connecticut is combined with Rhode Island because Rhode Island has no rural station, while Connecticut has two. The two States have a common boundary and similar water and land surroundings. New Hampshire, with one rural station, and Vermont, with two, are likewise combined, but Maine, with three rural stations, and Massachusetts, with two, are treated as separate areas. Only absolute raw and adjusted absolute temperature plots are provided, because they more clearly show the regional differences. (The temperature anomaly data for the 4 areas are not included in the Appendix.)

Figures 6-9 are the Raw Rural and Urban absolute temperature. Unsurprisingly, the plots show that the higher the latitude the lower is the annual temperature: Connecticut + Rhode Island or Massachusetts followed by New Hampshire + Vermont, and finally Maine. The consistently higher urban value strongly suggests an UHEI. The smaller differences between Rural and Urban values for CT+RI and MA, see Table II, perhaps also suggest an effect of higher population density.

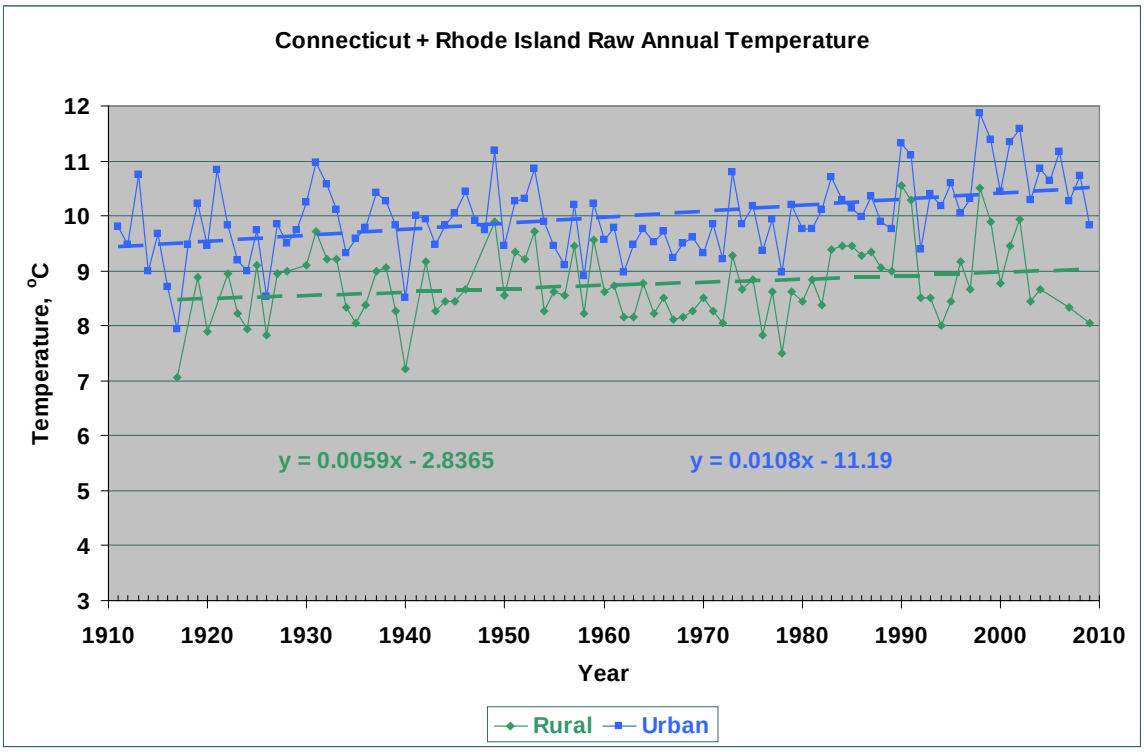

Figure 6 – Raw actual temperature for Connecticut + Rhode Island.

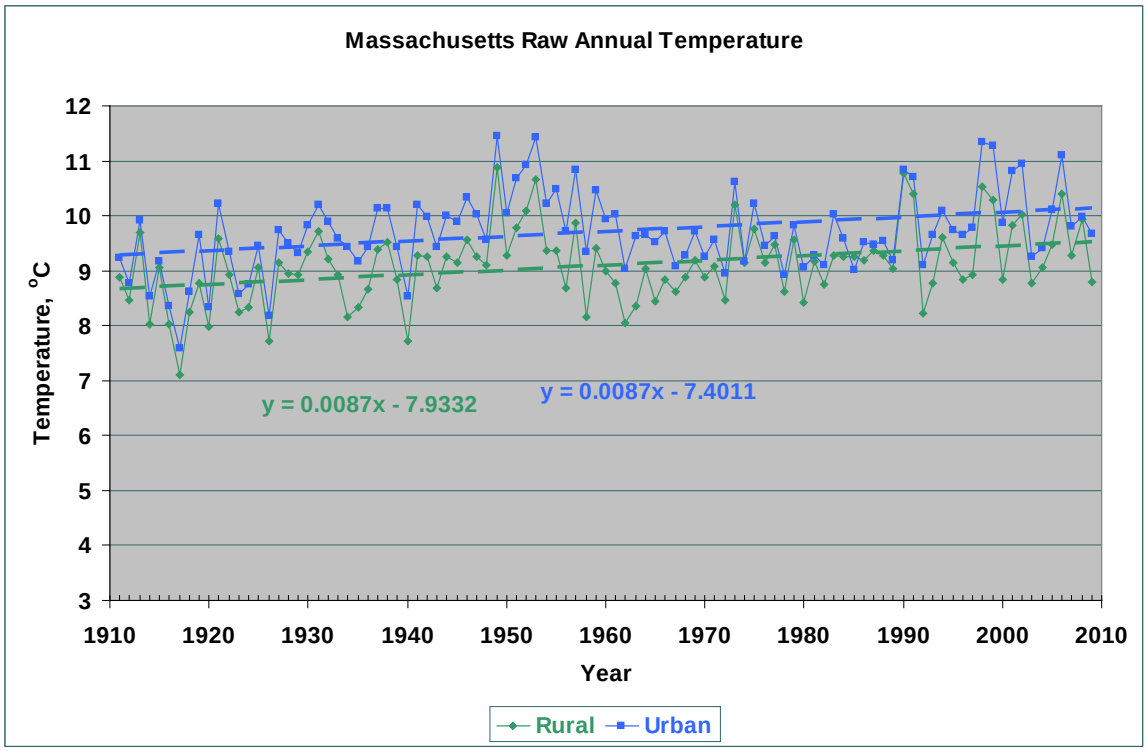

Figure 7 – Raw actual temperature for Massachusetts.

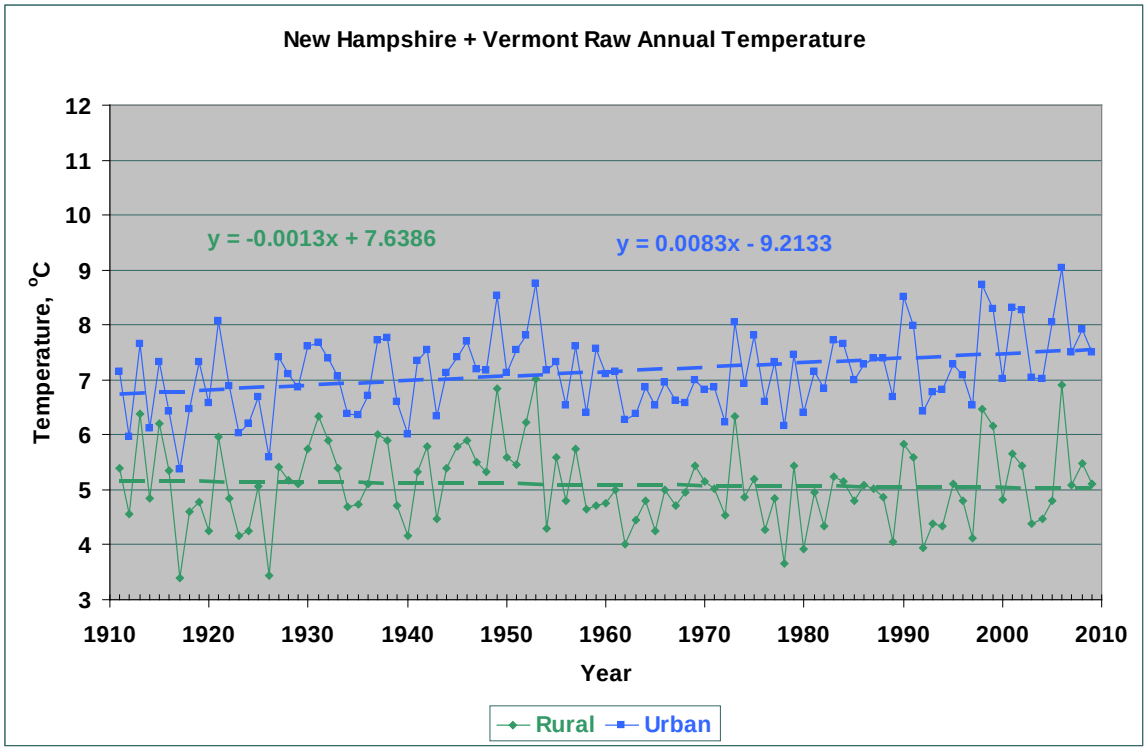

Figure 8 – Raw actual temperature for New Hampshire + Vermont.

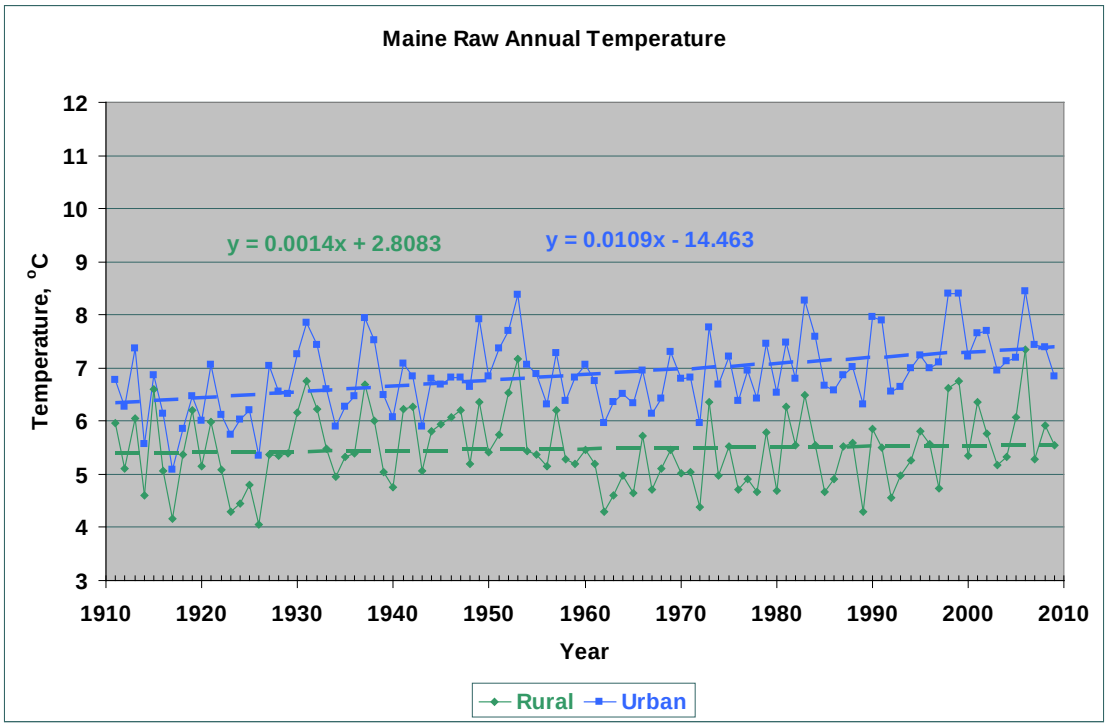

Figure 9 – Raw actual temperature for Maine.

TABLE II
MAX & MIN OF URBAN AND RURAL VALUES IN FIGURES 6-9 AND POPULATION

Area	Max, °C	Min, °C	Max-Min, °C	1900 Pop. Density (People/SqMi)	2009 Pop. Density (People/SqMi)
CT+RI	2.19	0.50	1.69	189	645
MA	1.27	-0.23	1.49	266	625
NH+VT	3.29	1.07	2.17	40	103
ME	2.40	0.26	2.14	20	37

In Figs. 6-9, rural trends for New Hampshire + Vermont (-0.13 °C/century) and Maine (0.14 °C/century) are much less than for Connecticut + Rhode Island (0.59 °C/century) and Massachusetts (0.87 °C/century). Correspondingly, as the values in Table II indicate, Connecticut's, Massachusetts's, and Rhode Island's population density increased more significantly for the period than did Maine's, New Hampshire's and Vermont's. This too indicates UHIE has been a significant contributor to warming in the urban areas.

So it can be said that man may have had an impact on temperature trend but only for the urban environment. It is UHIE that has been the cause and not an increase in atmospheric CO_2, natural or man-made. If CO2 has been the cause then the temperature trend for the Rural and Urban locations would have been the same because the growth trend of CO_2 is the same for all of New England, Rural and Urban, as it is world wide as shown in Fig 10. That is, if we are to follow the prescription advanced by those who advocate anthropological global warming then the

sameness of CO_2 rate of increase in all parts of the world would imply the trends in Rural temperatures would be the same as those for Urban. However, as shown, the trends for the two are not the same.

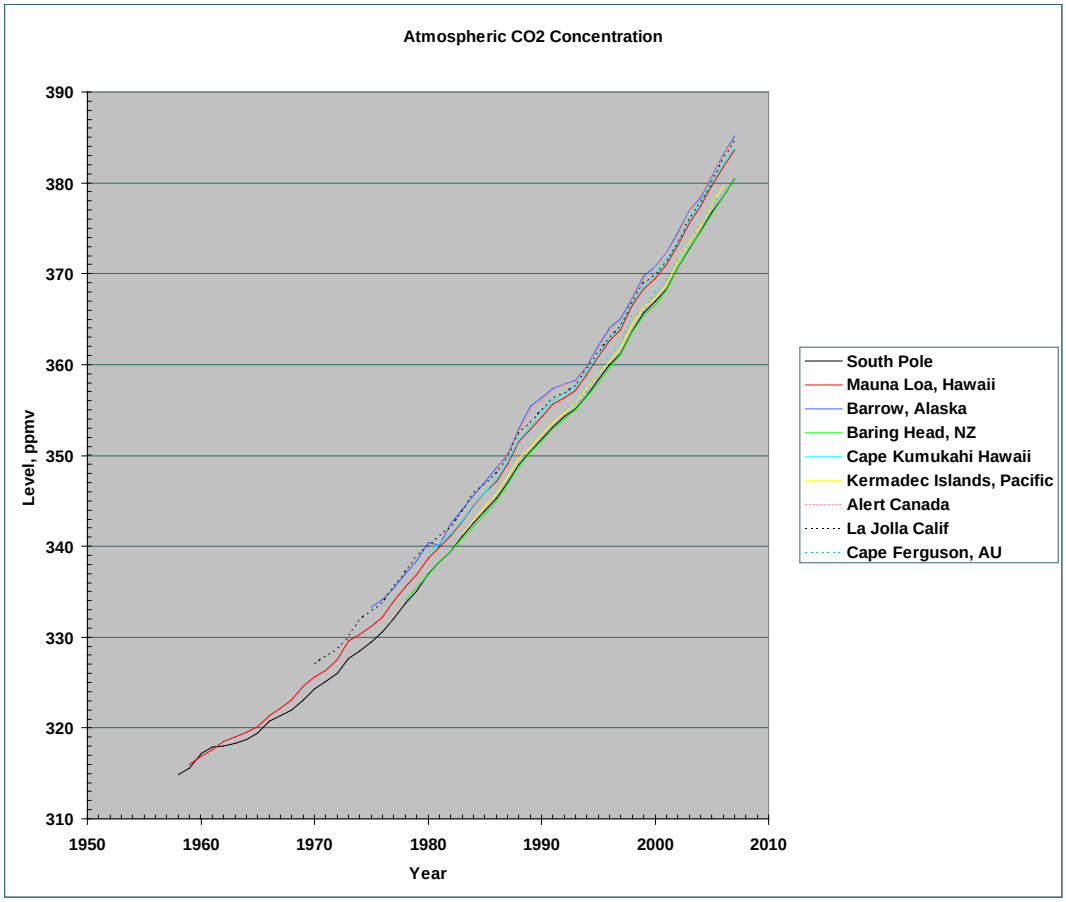

Figure 10 – Atmospheric concentration of CO_2, plotted using data from Ref 12.

Figs. 11-14 show NCDC Adjusted temperatures. While the Rural temperatures are consistently lower at higher latitudes and less than the Urban ones, as they were for the Raw temperatures, other characteristics have been altered by the NCDC adjustment process.

For all of the Adjusted data Figures the patterns of the Rural are almost identical to those of the Urban; i.e. there is no UHIE. Except for the Connecticut+Rhode Island area the magnitudes of the Rural trends are now larger than those of the Urban, see Table III, thus the impression is given that rural areas are heating at a rate faster than urban areas.

As shown in Fig. 5 for all of New England, the Adjusted temperatures for each of the four areas have been increasing lowered with respect to the Raw values the father back into the 20th century and increased for more recently. This is due to the methodologies and assumptions built into the NCDC protocol (Ref 13). So it is that the adjusted data for each area, the data that is reported to the public and the government officials who make policy, artificially report a much larger warming than does the raw observed data.

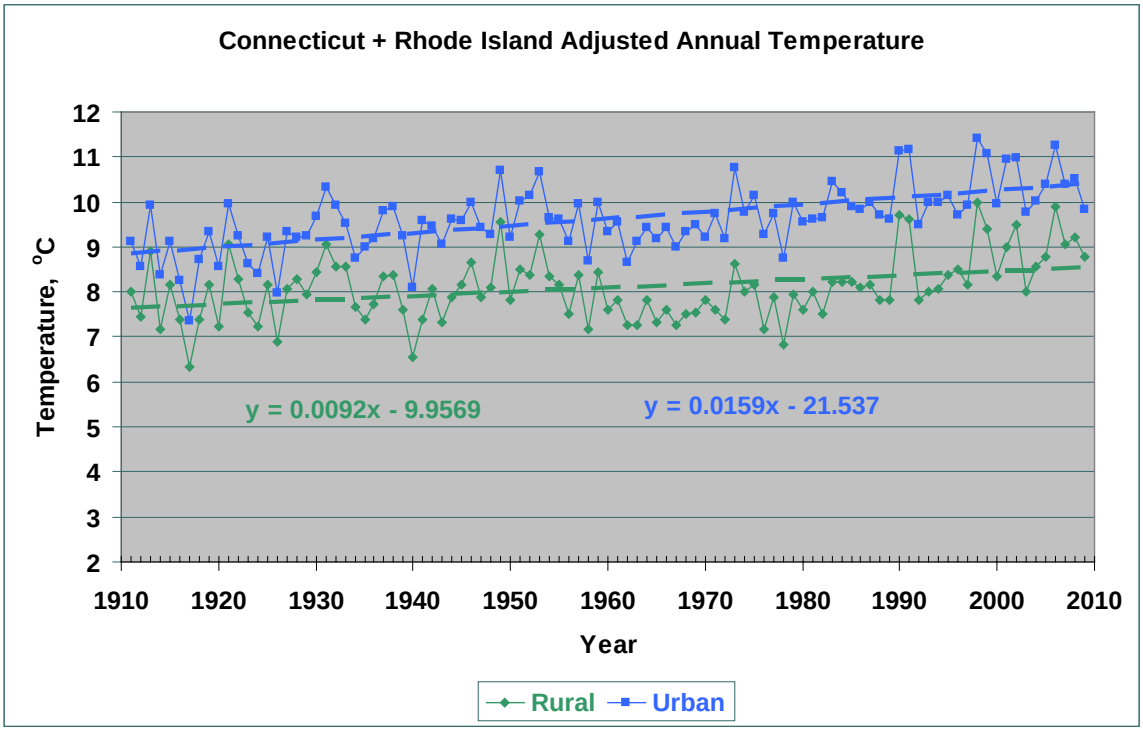

Figure 11 – Adjusted actual temperature for Connecticut + Rhode Island.

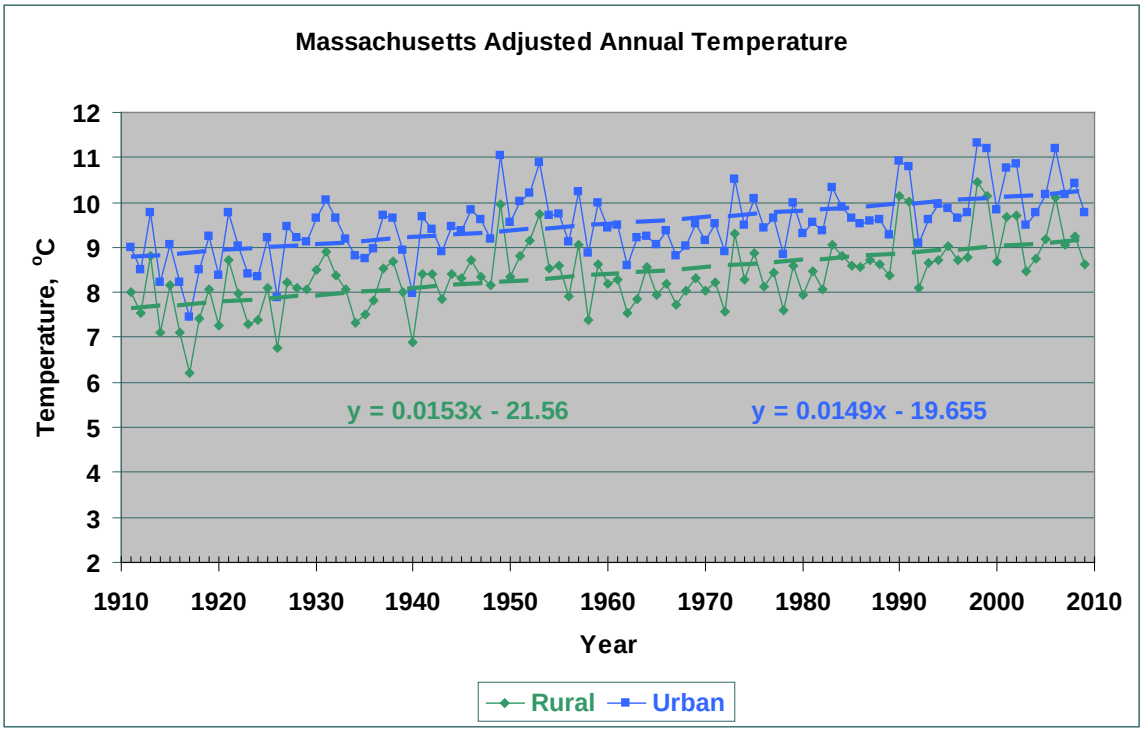

Figure 12 – Adjusted actual temperature for Massachusetts.

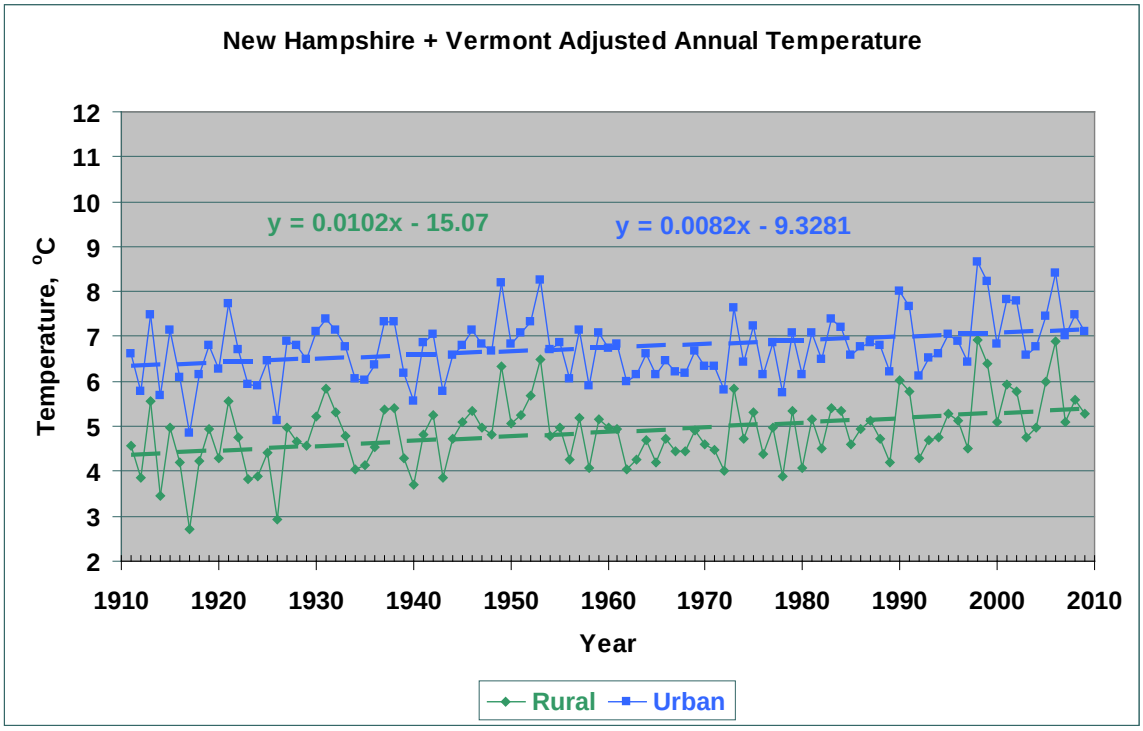

Figure 13 – Adjusted actual temperature for New Hampshire + Vermont.

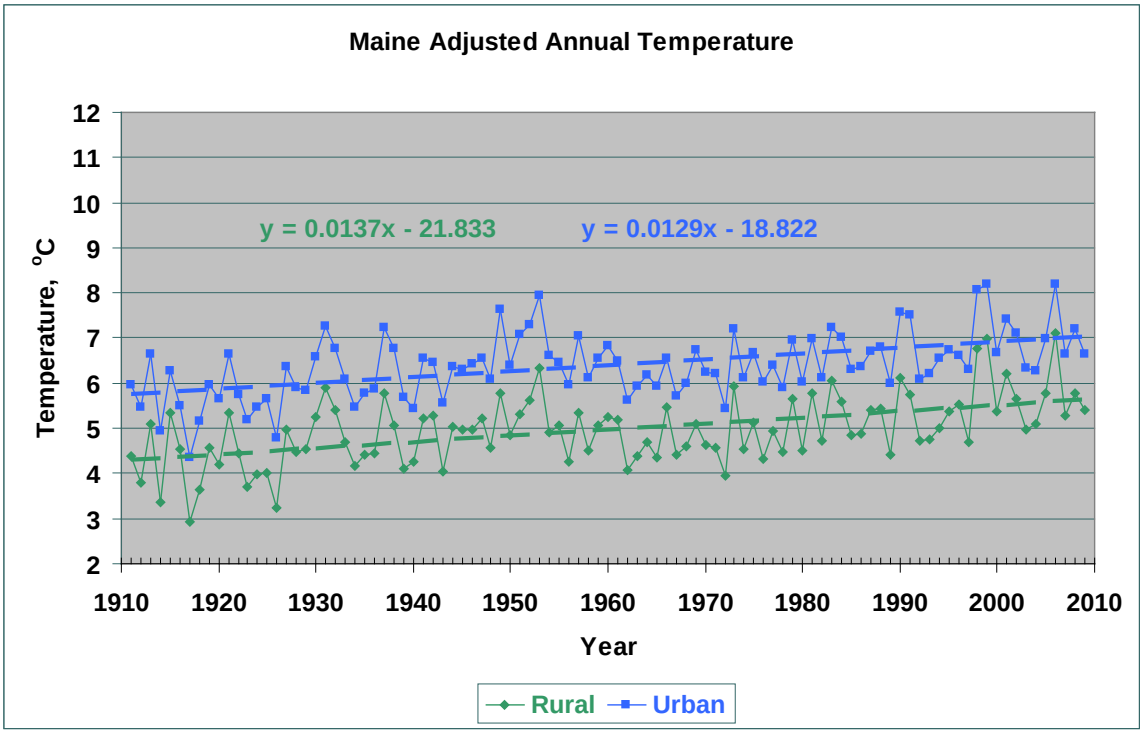

Figure 14 – Adjusted actual temperature for Maine.

TABLE III
ADJUSTED TEMPERATURE TRENDS AND PERIOD MEANS FOR THE AREAS OF NEW ENGLAND

Area	Trend, °C/Century		Period Mean, °C	
	Rural	Urban	Rural	Urban
CT+RI	0.92	1.59	8.08	9.61
MA	1.53	1.49	7.74	9.05
NH+VT	1.02	0.82	4.87	6.75
ME	1.36	1.29	4.64	6.38

CONCLUSION

We have shown that adjusted temperature data is a questionable product of the NCDC data-massaging protocol used to treat the raw temperature data. Though some aspects of the Version2 USHCN algorithm are worthy, such as attempting to correct for changes in equipment and time of observation, the overall effect appears to be a change of observed to adjusted values based on the developers' assumptions or predispositions.

To say this is not the case is to ignore the oddities in the adjusted data, such as forcing rural temperature to behave as though it were urban, with the impossible result that rural warming appears greater than urban. This enhanced warming, purely an artifact of the data-adjustment protocol, is then said to have been caused by rising atmospheric CO_2.

Neither the quantum of warming nor the assertion that CO_2 is the sole cause is correct. The only manmade aspects of the warming are the urban heat-island effect, which is real, and the method of adjusting, combining, and reporting rural and urban temperature values, which is artificial. The NCDC has colored the temperature trends of New England in no less spectacular fashion than Nature colors New England each Fall. We should not be as impressed with the former as we have long been with the latter.

ACKNOWLEDGMENTS: *The author is indebted to all those who reviewed the technical contents of this paper, making critical and helpful comments, particularly Paul Knappenberger, Michael Smith and Joseph D'Aleo. The author also thanks Christopher* Monckton *for the time and toil he made improving the English within this paper. Of course, any inadvertent errors or omissions are solely the responsibility of the author.*

REFERENCES

1. Edward R. Long, Contiguous U. S. Temperature Trends Using Raw and Adjusted Data for One-Per-State Rural and Urban Station Sets, February 27, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/Rate_of_Temp_Change_Raw_and_Adjusted_NCDC_Data.pdf.

2. Edward R. Long, An Inspection of the Urban Heat Island Effect & NCDC's Temperature Adjustments for the State of Utah, March 30, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/urban_heat_island_effect.pdf

3. Jennifer M. Cohen, A Review of the United States Historical Climatology Network Version 2: Adjusted Temperature Record for Pennsylvania, U.S.A., April 20, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/us_historical_climatology.pdf.

4. Edward R. Long and Jennifer M. Cohen, West Virginia The State Global Warming Forgot, SPPI Original Paper, July 21, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/the_state_gw_forgot.pdf.

5. National Climatic Data Center Staff, State of the Climate Global Analysis Annual 2009, February 8, 2005, http://www.ncdc.noaa.gov/sotc/?report=global&year=2009&month=13.

6. Science and Public Policy Institute Staff, Observed Climate Change and the Negligible Global Effect og Greenhouse~gas Emission Limits in the State of Texas, July 26, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/texas.pdf.

7. Science and Public Policy Institute Staff, Observed Climate Change and the Negligible Global Effect of Greenhouse~gas Emission Limits in the State of North Carolina, July 26, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/northcarolina.pdf.

8. Science and Public Policy Institute Staff, Observed Climate Change and the Negligible Global Effect of Greenhouse~gas Emission Limits in the State of Oregon, July 26, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/oregon.pdf.

9. Science and Public Policy Institute Staff, Observed Climate Change and the Negligible Global Effect of Greenhouse~gas Emission Limits in the State of New Mexico, July 26, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/new_mexico.pdf.

10. Science and Public Policy Institute Staff, Observed Climate Change and the Negligible Global Effect of Greenhouse~gas Emission Limits in the United States, July 26, 2010, http://scienceandpublicpolicy.org/images/stories/papers/originals/2010_observed_climate_change.pdf.

11. http://www.surfacestations.org/USHCN_stationlist.htm.

12. Keeling, et. al., Atmospheric CO_2 Records from Sites in the SIO Air Sampling Network, http://cdiac.ornl.gov/trends/co2/sio-keel.html.

13. M..J. Menne, C. N. Williams Jr.,andR.S.Vose,2009:The U.S. Historical Climatology Network Monthly Temperature Data, Version2.BAMS, 70, 993-1007, http://www1.ncdc.noaa.gov/pub/data/ushcn/v2/monthly/menne-etal2009.pdf.

APPENDIX

TEMPERATURE ANOMALY DATA FOR ALL OF NEW ENGLAND

The data in Figs. 3-5 are provided in Figs. 1a-3a, but as temperature anomalies. The ordinate axes in the plots are a more sensitive scale than for Figs. 3-5, so that the familiar time pattern is seen. The annual and 11-year averages show a gradual rise from the early 20th century, a local peak during 1940-1960, followed by a rise into the 21st Century. For comparison the contiguous U. S. Raw temperature anomalies, also using the 1961-1990 reference average, are shown in Figs. 4a and 5a.

The differences between the 11-year averages in Figures 1a and 4a, if scale and plot area are taken into consideration, give rise to the following consideration:

- The two peaks for New England and the Contiguous U. S. are distinct; however, New England's tend to occur about two years earlier. This may or may not have implication for New England being different from the remainder of the country.

- What is important is a comparison of the trends in the New England and Contiguous U. S. 11-year averages for 1911-1950 and 1970-2000. For both the U. S. and New England, the Rural's trend is a larger value for the earlier interval whereas the Urban's is about the same.

  Thus the larger rate of increase in CO_2 concentration in 1950-2000 period, whether or not it was attributable to anthropogenic influences, did not lead to a larger or accelerated warming rate either for New England or for the Contiguous U. S.

- Moreover, the trend of the Raw data for the Urban stations in New England and in the Contiguous U. S. for both periods are strikingly similar, 0.88 and 0.78 ^{o}C/century whereas that for the Raw Rural are not, -0.02 and 0.14 ^{o}C /century. This suggests an urban influence, possibly the heat-island effect due to increasing urbanization around the now-urban stations.

- Why was the scientific community not concerned at the 1905-1935 warming trend when it happened? Certainly the cooling between the earlier and later periods caused concern.

Finally, the identical nature of the Rural and Urban Adjusted data, Fig. 2a is very striking. Not just the trends but the year-to-year profiles are identical. The sameness was observed and discussed for the adjusted absolute temperature data in the main body of the paper. This identical nature suggests something odd has been caused by the NCDC protocol that adjusts the Raw data. Whether accidental or deliberate it does call for questioning of the protocol.

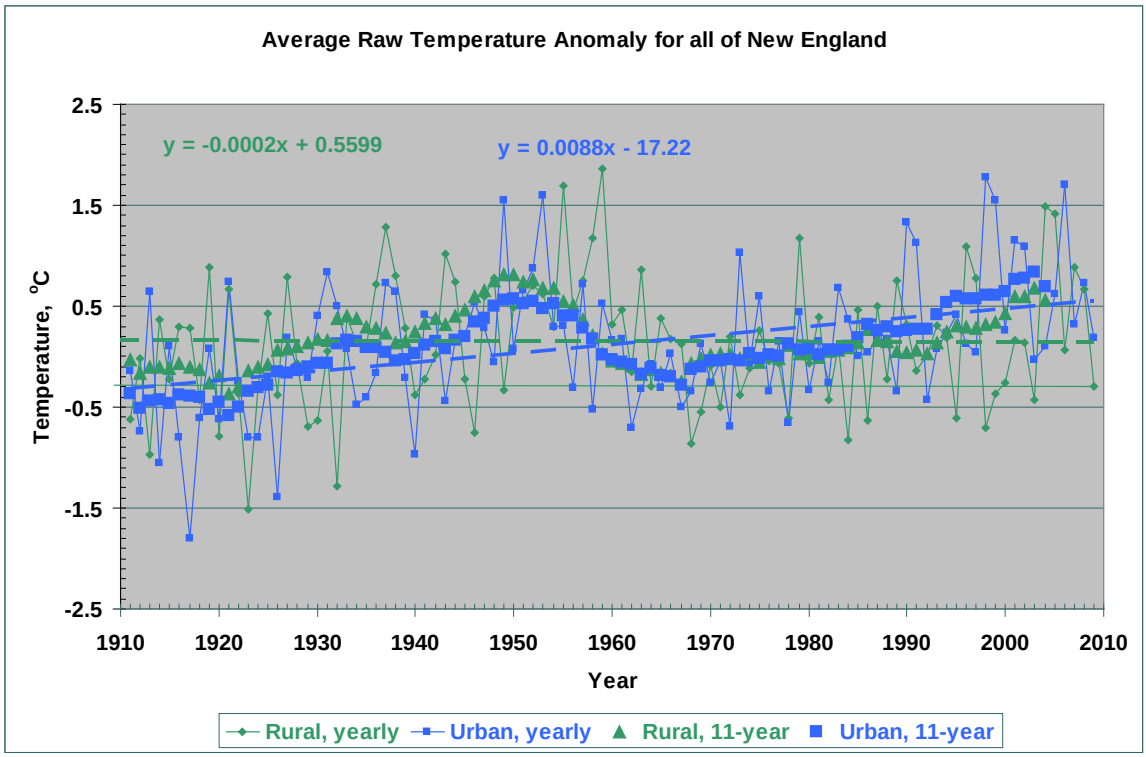

Figure 1a – Annual and 11-year Raw temperature anomalies for all of New England, Rural and Urban locations.

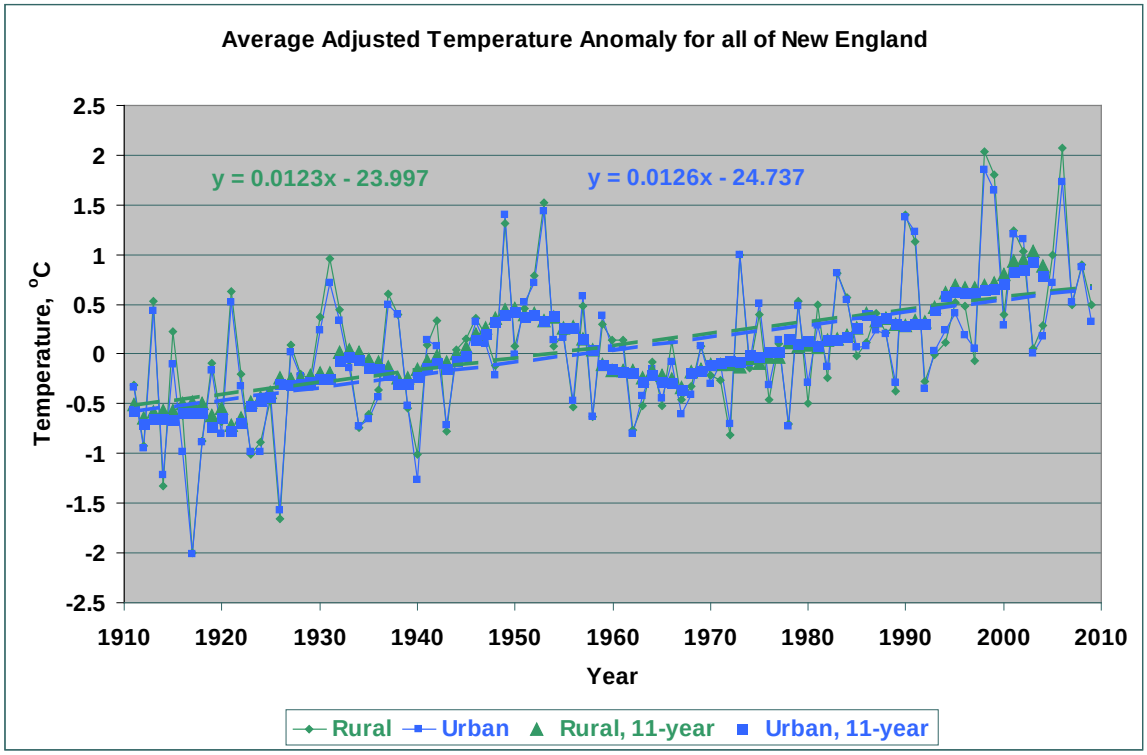

Figure 2a – Annual and 11-year Adjusted temperature anomalies for all of New England, Rural and Urban locations.

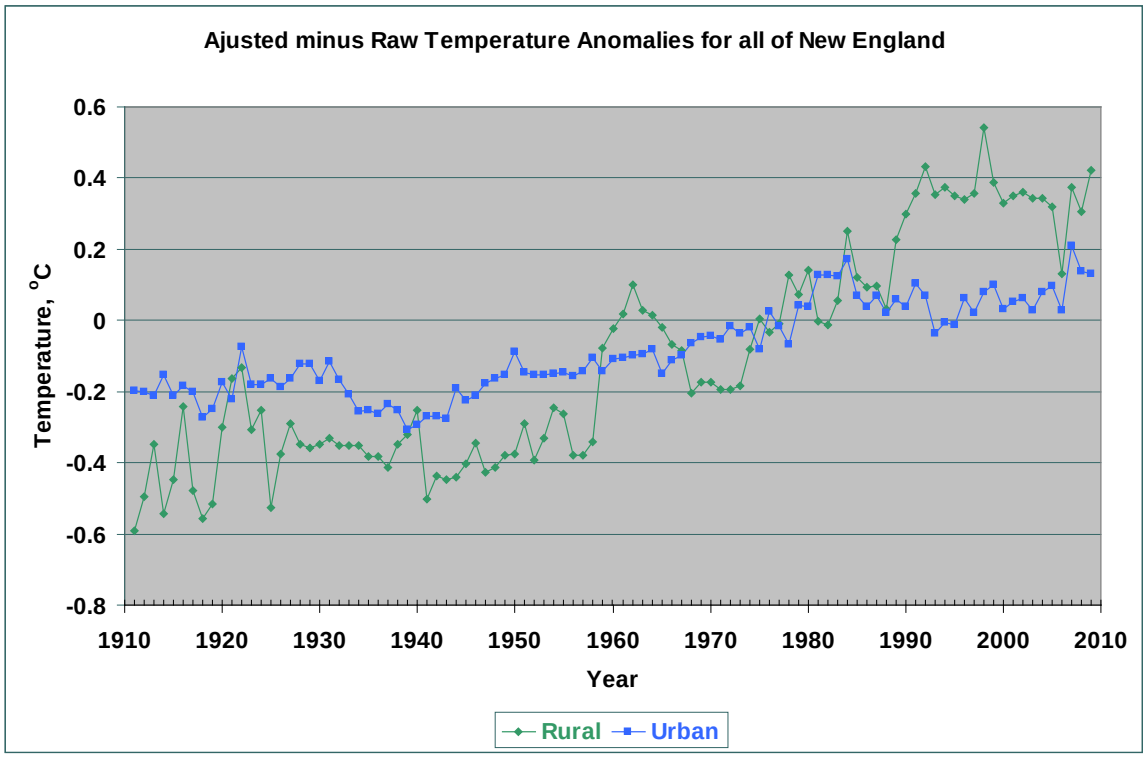

Figure 3a – Adjusted actual temperature minus Raw temperature anomalies for the whole of New England, the effect of the NCDC data massaging protocol.

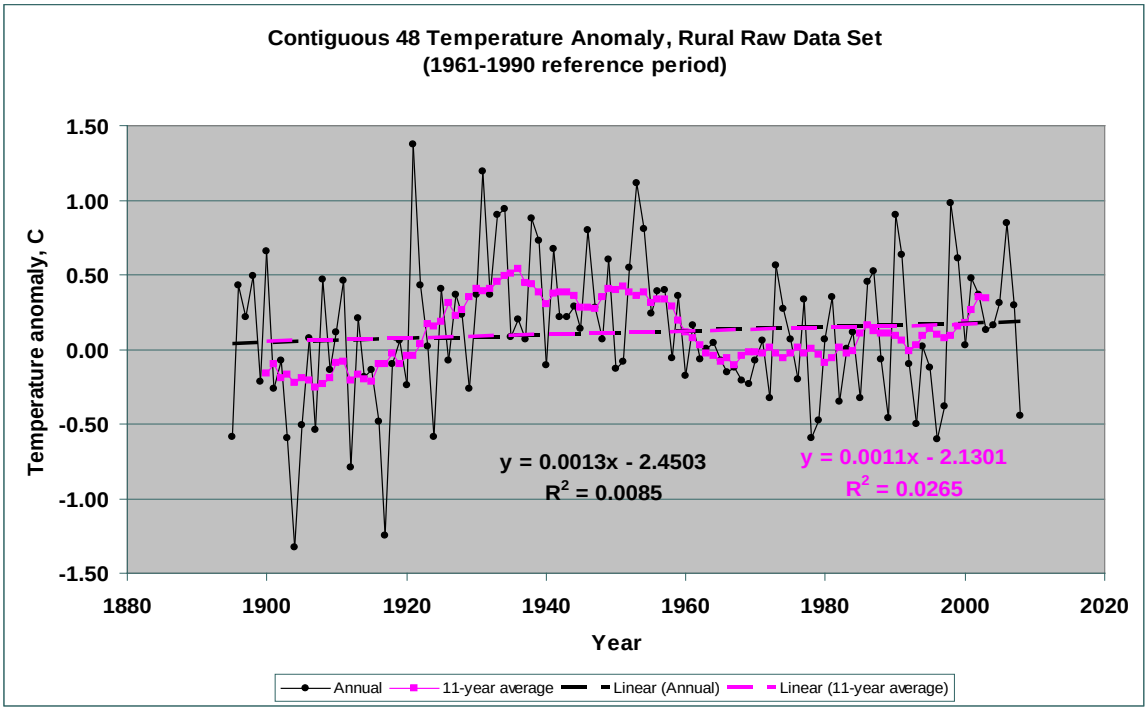

Figure 4a – Contiguous U. S. Raw temperature anomalies, taken from Ref 1.

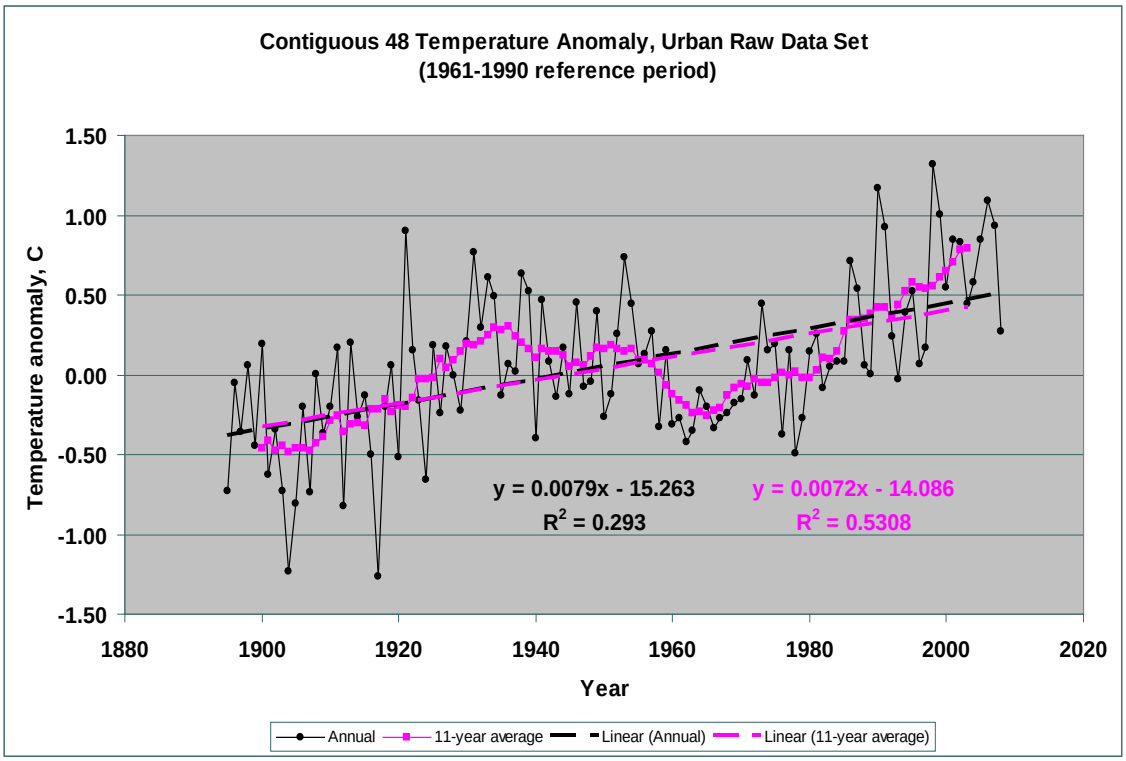

Figure 5a - Contiguous U. S. Raw Urban temperature anomalies, taken from Ref 1.

Cover photo of autumn in New England from backgroundpictures.org.