An Analysis of the National Climatic Data Center Thirty-Year Temperature Normals

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INTRODUCTION

The thirty-year normals, 1971 to 2000 were recently released by the National Climatic Data Center (NCDC) in Asheville, NC. During this thirty-year period, the validity of the data, particularly the temperature data has been affected by changes of varying degree at the climate stations. Ideally, the location of a climate site remains constant; however, stations often move or urbanization in the vicinity of the site can significantly alter the data. Since these factors will be different at every station, it is a difficult task to maintain an accurate, unbiased, homogeneous set of climate normals. Another important change during the 1971 to 2000 period has been the automation of the data collection. At many first order stations beginning in the mid 1990s, the automated surface observing system (ASOS) replaced traditional observation methods. Studies have determined that ASOS may have a slight cold bias with respect to temperature readings. This bias creates a discontinuity (inhomogeneity) during the 1971 to 2000 normals and as a result, much of the temperature adjustment was made due to this factor.

Addressing these inconsistencies, NCDC has developed a set of **"transfer functions"** to make the dataset as homogeneous as possible. NCDC uses a statistical method for detecting discontinuities in the datasets that compares the station in question (candidate station) with neighboring stations (reference stations) selected from the **U.S. Historical Climatology Network (USHCN).** When the relationship between the two sets of data showed a difference that was significant to a particular threshold, the discontinuity was identified and a resulting offset factor was calculated. This method takes the mean value of a twelve-year period prior to and following the discontinuity point (Easterling and Peterson, 1995). NCDC employs this procedure but instead requires a minimum of five years between the discontinuities (NCDC, 2002). Alterations were then performed by applying the offset value to the portion of the record ***before*** the discontinuity, with the ultimate goal being an adjusted dataset that makes the data prior to the discontinuity representative of the current site location.

OFFSET FACTORS APPLIED IN THE MID ATLANTIC

- Nine **1st order climate station sites** in the region are examined **(see Table 1).**

- Offset factors of varying magnitude were employed for **average maximum temperature** at some stations; no changes were made at some stations and no changes were made to **average minimum temperature** at ***any*** of the nine sites **(see Table 2)**. ***The official published set of 1971-2000 temperature normals are represented by data ***with the offset factors applied***.***

- All offset factors were applied to data prior to 1996 (from 1996 through present time actual data was unchanged). **Figure 1** shows offset factor vs. time applied to Richmond, VA on annual basis. This shows that NCDC identified three discontinuity points contained within the 1971 to 2000 period, first in the late 1970s, next in the late 1980s, and lastly with ASOS after 1995. These three discontinuity points create four separate time frames, each with a unique offset factor. These offset factors were created through a comparison of the candidate station, **Richmond (RIC)** with six neighboring co-op stations from the USHCN. The six stations used were:

  1) **Ashland (COOP ID 440327)**
  2) **Crozier (COOP ID 4423142)**
  3) **Hopewell (COOP ID 444101)**
  4) **Walkerton (COOP ID 448829)**
  5) **West Point (COOP ID 449025)**
  6) **Williamsburg (COOP ID 449151)**

  An examination of the data (not shown here) reveals that for the 1971-2000 period, the six-station co-op average high temperature for August was 87.3 F…while for RIC it was 87.1 F. (the normals are 87.3 and 85.7 respectively). The co-op average for August for the 2001-2004 period was 87.8 F…. while for RIC it was 87.3 F. With this data, it appears that the cooling offset factor for RIC was too large since the data after the period is only 0.5 F cooler than the co-op average despite the adjusted normal being 1.6 F cooler.

- In summary, the actual annual average high temperature (no offset factor applied) is 2.1 F warmer at Richmond, VA than at Roanoke, VA (69.1 F vs. 66.9 F) for the 1971-2000 period. After net offset values for the 1971 to 2000 time-frame have been applied (-1.3 F at RIC and +0.3 F at ROA), the official 1971 to 2000 normals are computed, leaving Richmond just 0.6 F warmer than Roanoke for the period (67.8 F vs. 67.2 F). **(see Figure 2).**

PERFORMANCE OF OFFSET FACTORS:

- **Figure 3** shows that **without any offset factors applied**, RIC has a linear best-fit trendline that depicts a net **decrease** in temperature for the 1971-2003 time-frame. This does not agree with the trend for either ROA or the average of the seven other stations, where a net **increase** occurs. The implication of this is that the cooling offset factor that NCDC employed for RIC prior to 1996 is **correct in sign** since it is unlikely that RIC would show a net cooling from 1971 to 2003 while other 1st order stations in the region (except ORF where NCDC also applied a cooling offset value) show net warming. However the ***magnitude*** of the factor appears too large. This is further verified by noting that the period 1996-2003 (since 1996 NCDC determined that no offset values were needed) RIC is still 1.5 F warmer than ROA **(see Figure 4)**. Furthermore, there has not been a single case during the entire 1971-2003 period where RIC has been only 0.6 F warmer than ROA despite this being the official 1971-2000 climate normal **(refer to Figure 2).**

- The data is even more striking when the month of August is considered. With the August offset factors applied (**-1.4 F** for RIC and **+0.5 F** for ROA), Richmond has a **cooler 1971-2000 normal high temperature** than Roanoke **(see Figure 5)**. However, as shown in **Figure 6**, Richmond has actually been cooler than Roanoke in August only three times in the entire 34-year period 1971-2004. Since the time where no offset factors were applied (1996), Richmond has been warmer than Roanoke every time in August. In addition, if the period following the 1971-2000 time-frame (2001-2004) is examined, Richmond has averaged 1.6 F warmer than Roanoke. When RIC is compared to other stations in the region a similar trend is seen, with the values used in the official normals showing that RIC was **cooled too much in comparison to the region**.

OFFSET FACTORS APPLIED IN WESTERN NEVADA: A POSSIBLE MISSED DISCONTINUITY

- The parameter of interest here is average **minimum** temperature. In this case the problem is that **no** offset factor was applied when one should have been. **Figure 7** shows that the Reno Airport climate station (RNO) has seen a dramatic warming of the minimum temperature while at the other stations a much more modest upward trend (or little change) has occurred. A gradual urbanization in the vicinity of the station is a likely contributor to much of the observed minimum temperature warming, but that is beyond the scope of this study. As for the data, the average annual minimum temperature at RNO is 35.2 F for the 1971 to 2000 period. However, the last time the temperature was at or below this normal was 1985. In other words, Reno has been **above normal for 18 years in a row** (1986 through 2003). This trend is unique to RNO as all of the other stations have had several years below normal since the mid 1980s. NCDC adheres to the methodology that "Any discontinuity identified through examination of the difference time series is assumed to be a change at the candidate station." and that "The goal in performing homogeneity adjustments is to produce a time series that is representative of the current observing practices." (NCDC, 2002). The implication here is that the minimum temperature at Reno will continue to be above normal in future years in comparison to the 1971-2000 normals because the data was not adjusted to the more representative recent years. If this were purely a climatic change, then the region as a whole would be seeing the same trend as RNO and an offset factor would not be necessary because the change would not be due to a non-climatic discontinuity point. However, since the warming is far more pronounced at Reno in comparison to the region, a non-climatic discontinuity has occurred, and a warming offset factor should have been added to RNO for the much cooler data prior to mid 1980s.

CONCLUSIONS

- The process of adjusting the thirty-year temperature normals is a necessary one to eliminate discontinuities in the climate record.
- However, as shown in case of Richmond and Roanoke, if the offset factors are too large, more error can be introduced into the climate record than was present without any changes. To avoid this problem in the future, a solution would be to use **other regional 1st order station** trends ***in addition*** to the USHCN neighboring sites when considering an offset factor at a candidate station. This will ensure that broad regional trends are preserved and will keep the relationship between the more visible 1st order climate stations intact.
- Consistency is key to a successful climate record and missed discontinuities must be minimized.
- The 1971-2000 temperature normals alone may not be a good comparison for current observed data in stations such as Richmond, Norfolk and Reno, especially when compared to normals at nearby 1st order sites.

REFERENCES

Easterling, D.R, and T.C. Peterson, 1995: A new method for detecting and adjusting for Undocumented discontinuities in climatological time series. *International Journal of Climatology*, ***15***, *369-377.*

National Climatic Data Center, 2002: United States Climate Normals, 1971-2000 Inhomogeneity Adjustment Methodology., 1-2.

Station	Arpt id	Latitude	Longitude	Elev (ft)
Norfolk, VA	ORF	36*54' N	76*12' W	30
Richmond, VA	RIC	37*31' N	77*19' W	164
Roanoke, VA	ROA	37*19' N	79*58' W	1,149
Lynchburg, VA	LYH	37*20' N	79*12' W	940
Washington, DC	DCA	38*52' N	77*02' W	10
Baltimore, MD	BWI	39*10' N	76*41' W	148
Salisbury, MD	SBY	38*20' N	75*31' W	50
Raleigh, NC	RDU	35*52' N	78*47' W	416
Greensboro, NC	GSO	36*06' N	79*57' W	897

Table 1: Location and elevation of first order stations used in this study.

NCDC 1971-2000 Normal High Temperature Alterations									
	Norfolk, VA	Richmond, VA	Roanoke, VA	Lynchburg, VA	Wash Natl, D.C.	Balt-Wash, MD	Salisbury, MD	Raleigh-Dhm, NC	Greensboro, NC
	ORF	RIC	ROA	LYH	DCA	BWI	SBY	RDU	GSO
Jan	-0.9	-1.4	0.3	0	-0.8	-0.3	0	0	0
Feb	-1.0	-1.4	0.2	0	-0.7	-0.4	0	0	0
Mar	-1.1	-1.4	0.2	0	-0.6	-0.4	0	0	0
Apr	-1.1	-1.3	0.3	0	-0.5	-0.4	0	0	0
May	-1.0	-1.4	0.4	0	-0.4	-0.4	0	0	0
Jun	-0.9	-1.5	0.5	0	-0.3	-0.3	0	0	0
Jul	-1.0	-1.5	0.6	0	-0.2	-0.3	0	0	0
Aug	-1.1	-1.4	0.5	0	-0.4	-0.3	0	0	0
Sep	-1.1	-1.2	0.4	0	-0.4	-0.3	0	0	0
Oct	-1.0	-1.1	0.3	0	-0.7	-0.3	0	0	0
Nov	-0.9	-1.1	0.2	0	-0.7	-0.2	0	0	0
Dec	-0.8	-1.2	0.3	0	-0.8	-0.3	0	0	0
ANNUAL	-1.1	-1.3	+0.3	0	-0.5	-0.3	0	0	0
Average	68.9	69.1	66.9	66.8	66.9	65.4	66.5	70.6	68.5
Normal	67.8	67.8	67.2	66.8	66.4	65.1	66.5	70.6	68.5

Table 2: Offset factor (*F) employed at each station for computation of 1971-2000 climate normals. Blue depicts a cooling offset factor, red represents warming factor.

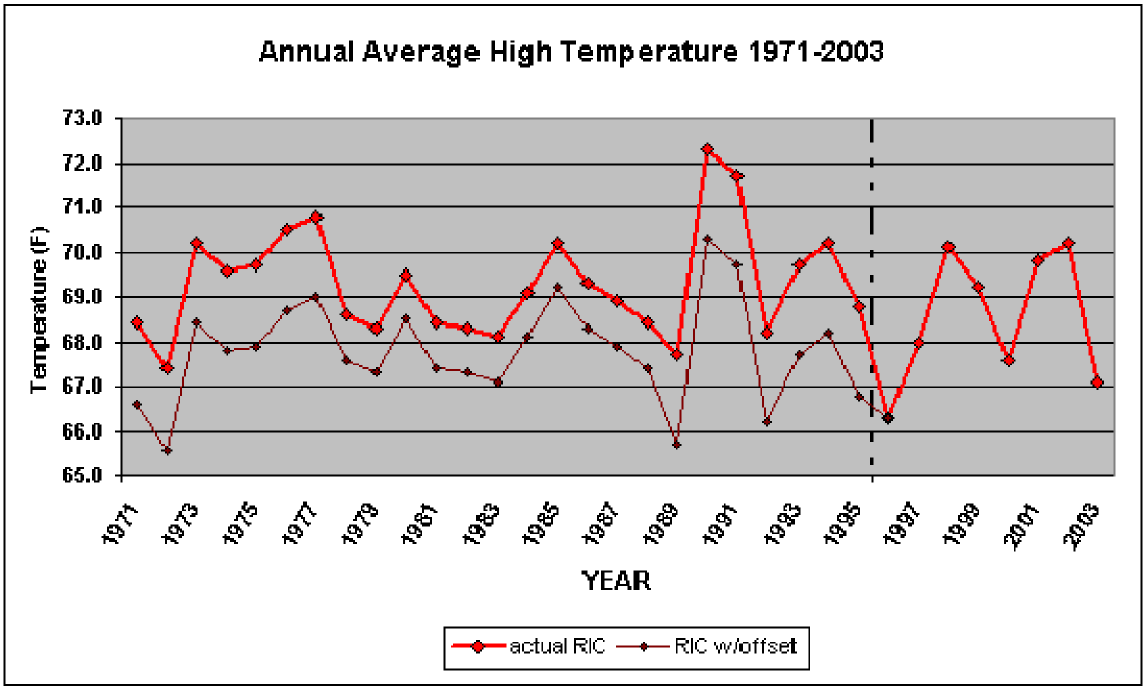

Figure 1: Richmond, VA annual avg high temperature. Dotted line depicts time after which offset factor was no longer applied. Net offset factor for the 1971-2000 climate period is -1.3 F. From 1971 to 1977 offset factor was -1.8 F, 1978-1988 was -1.0 F, 1989-1995 was -2.0 F, and from 1996 onward, no offset was used.

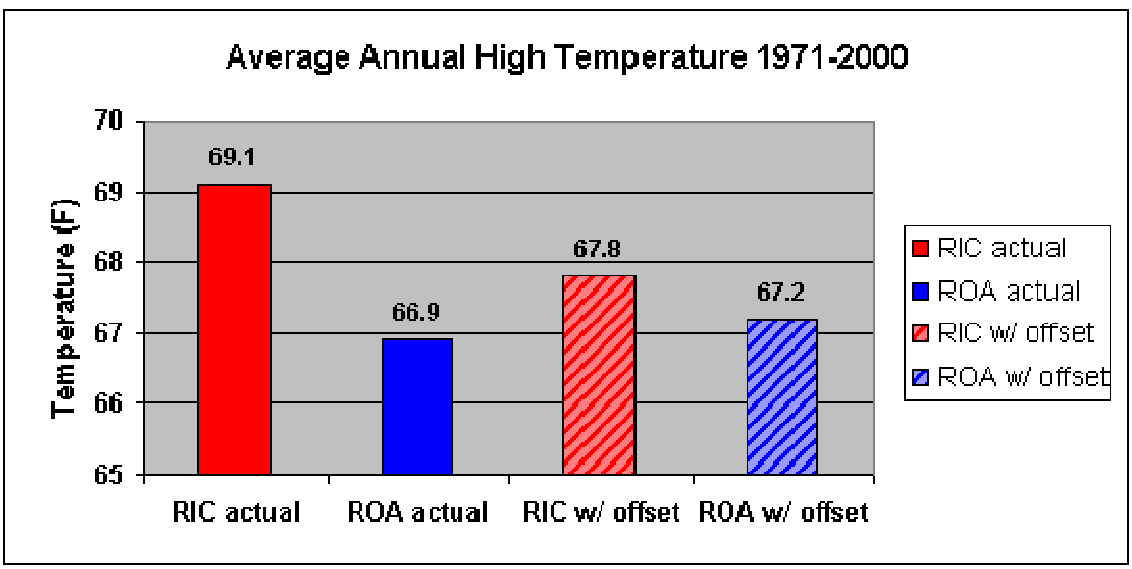

Figure 2: Actual annual avg high temperature for Richmond and Roanoke for 1971-2000 period (solid bars) and avg high temperature with offset factor applied (patterned bars). The patterned bars represent the 1971 to 2000 normals.

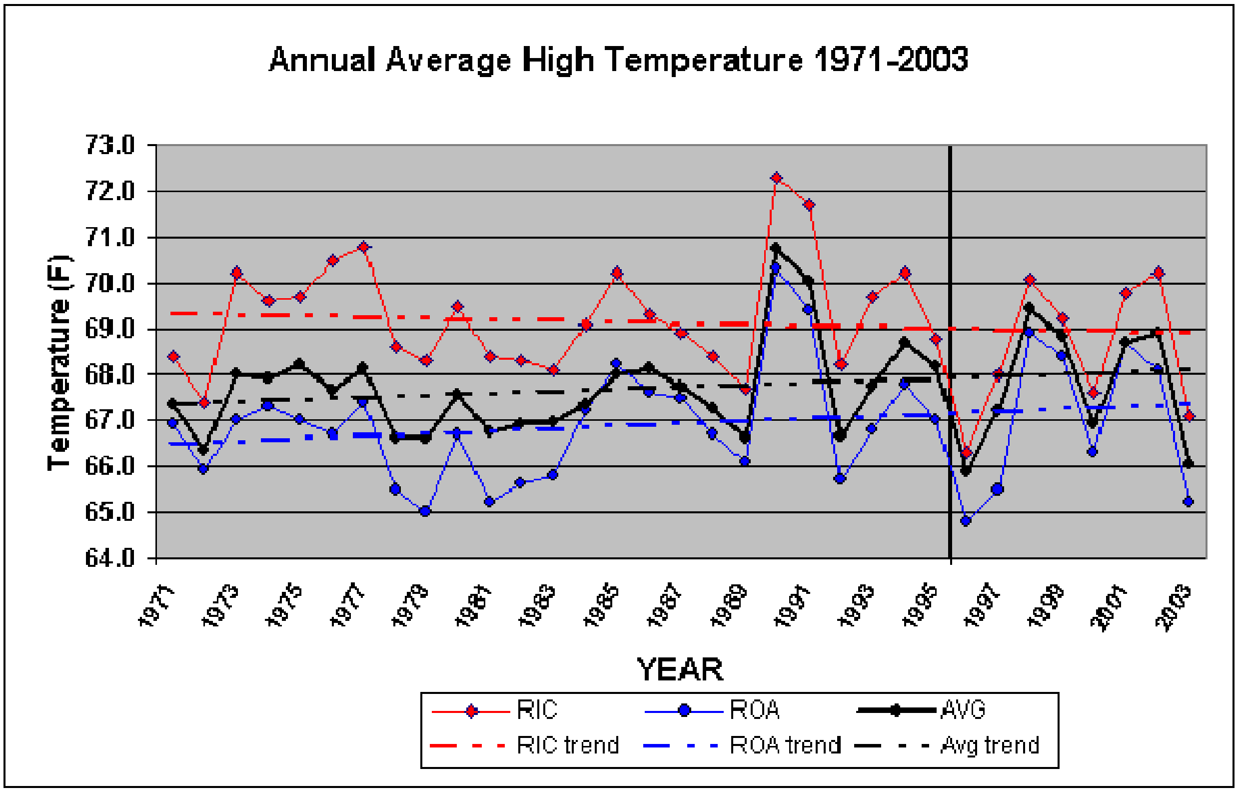

Figure 3: Actual average annual high temperature (no offset factors applied) for RIC, ROA, and an average of the seven remaining stations (black line). Broken lines depict linear best fit trendlines for RIC,ROA, and remaining seven station average for the 1971-2003 period.

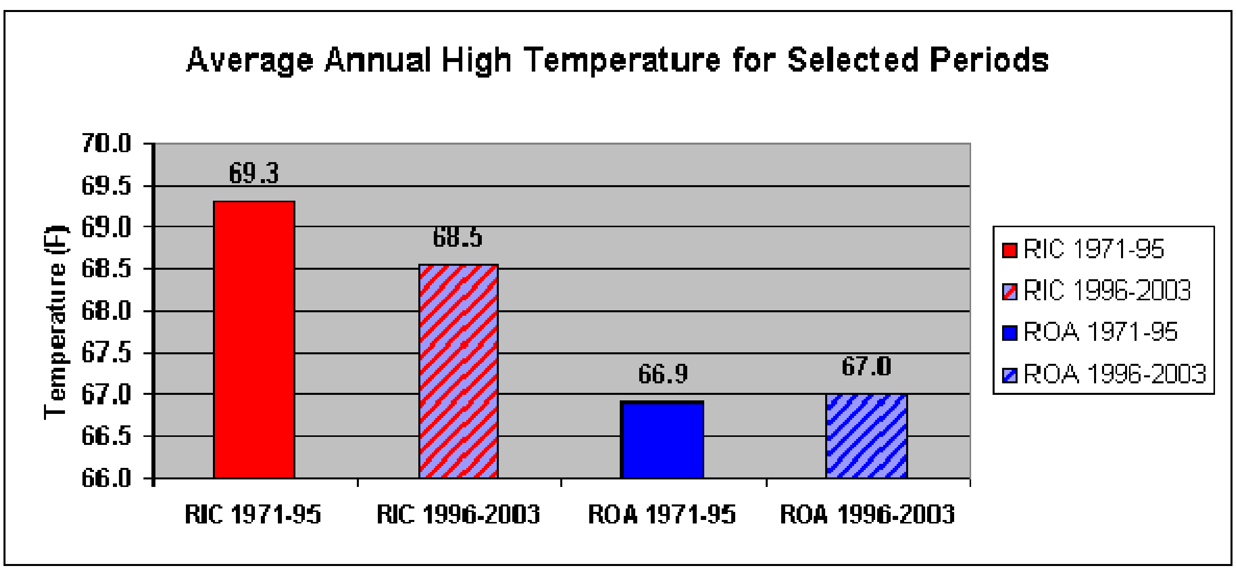

Figure 4: Actual average annual high temperature (no offset factors applied) for RIC and ROA for selected periods.

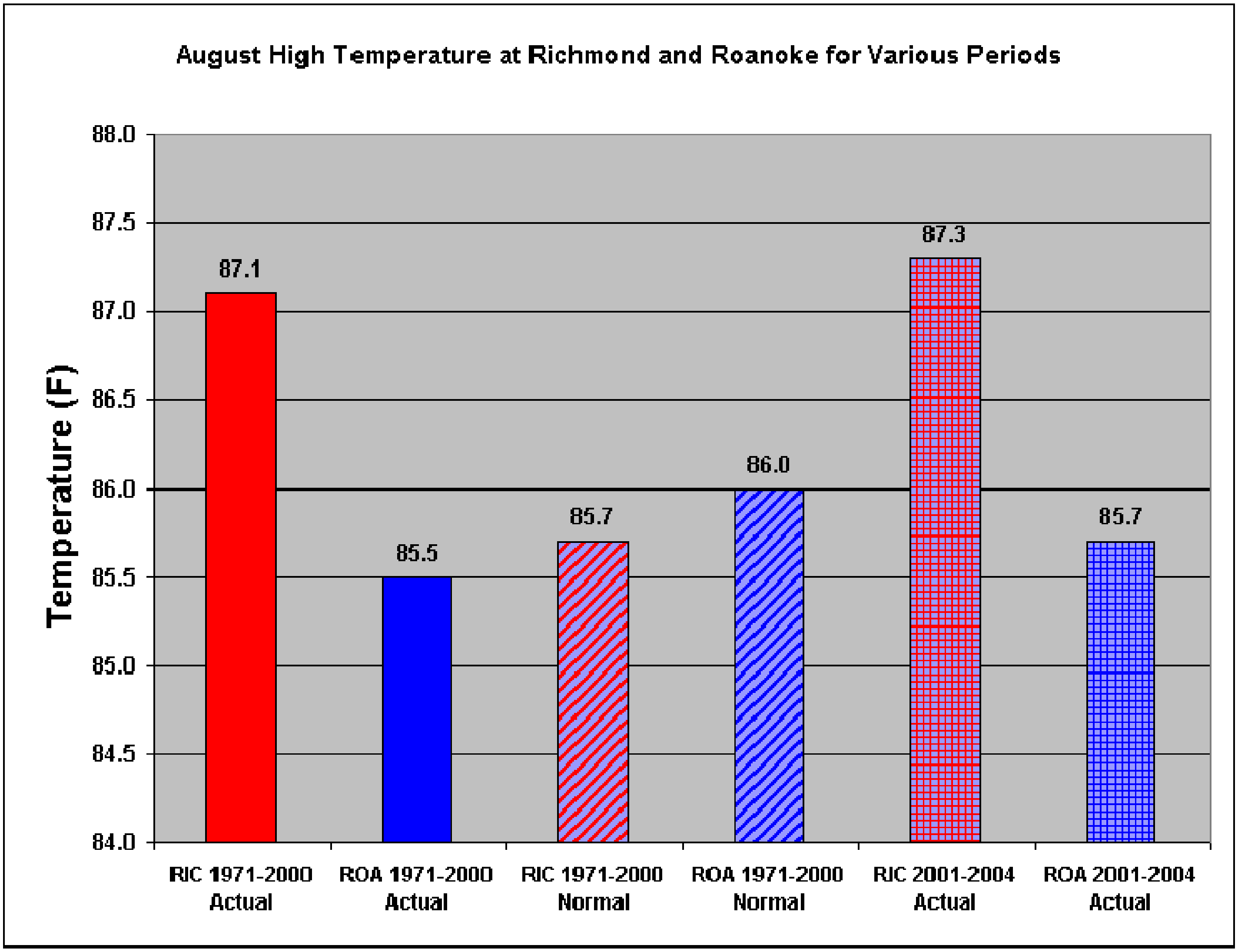

Figure 5: Average August High Temperature at Richmond and Roanoke for Various Periods. The bars labeled "actual" depict data with no offset value while the "normal" bars represent data with the offset applied.

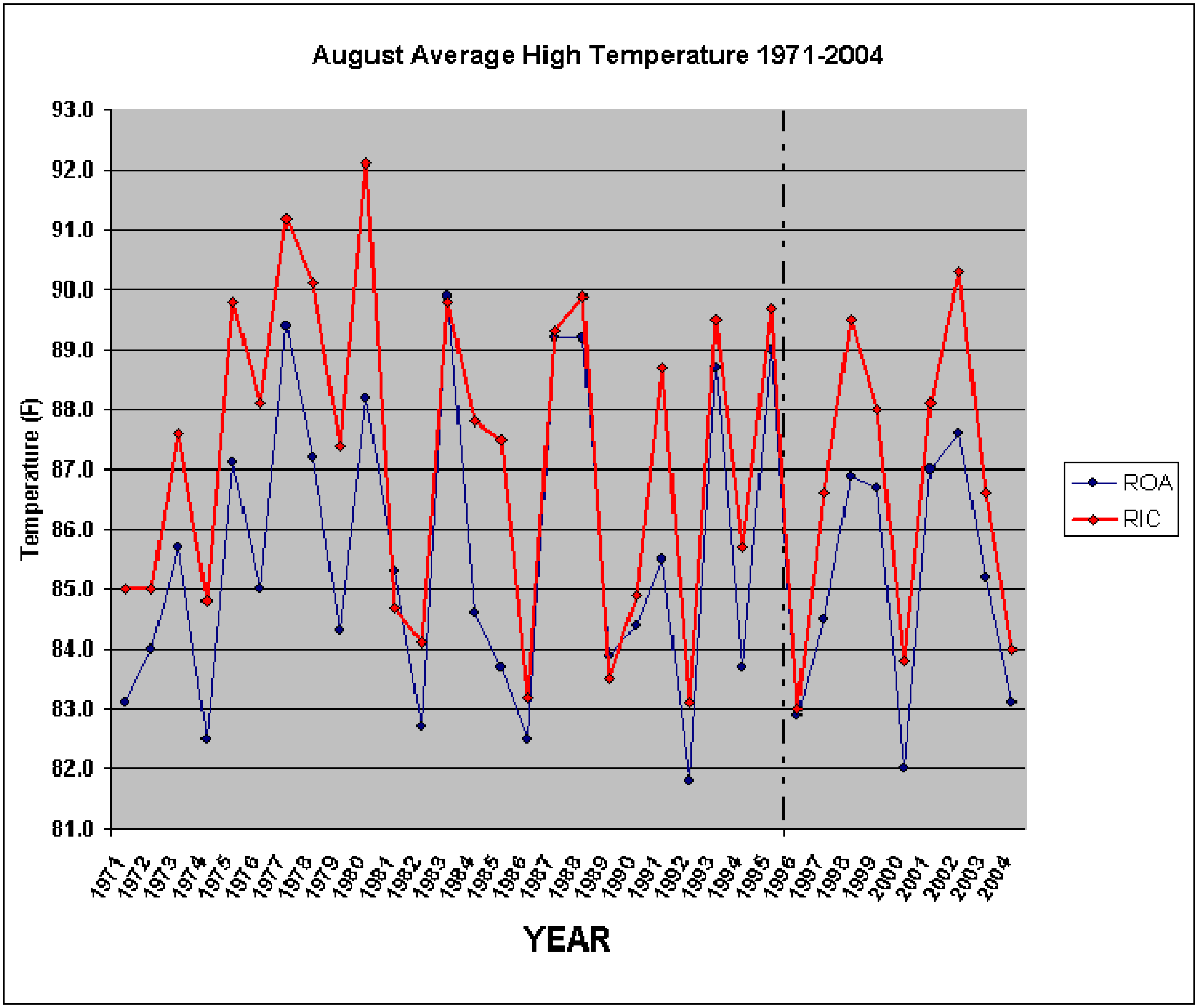

Figure 6: Actual August Average High Temperature (no offset factors applied) at Richmond and Roanoke for the period 1971 to 2004.

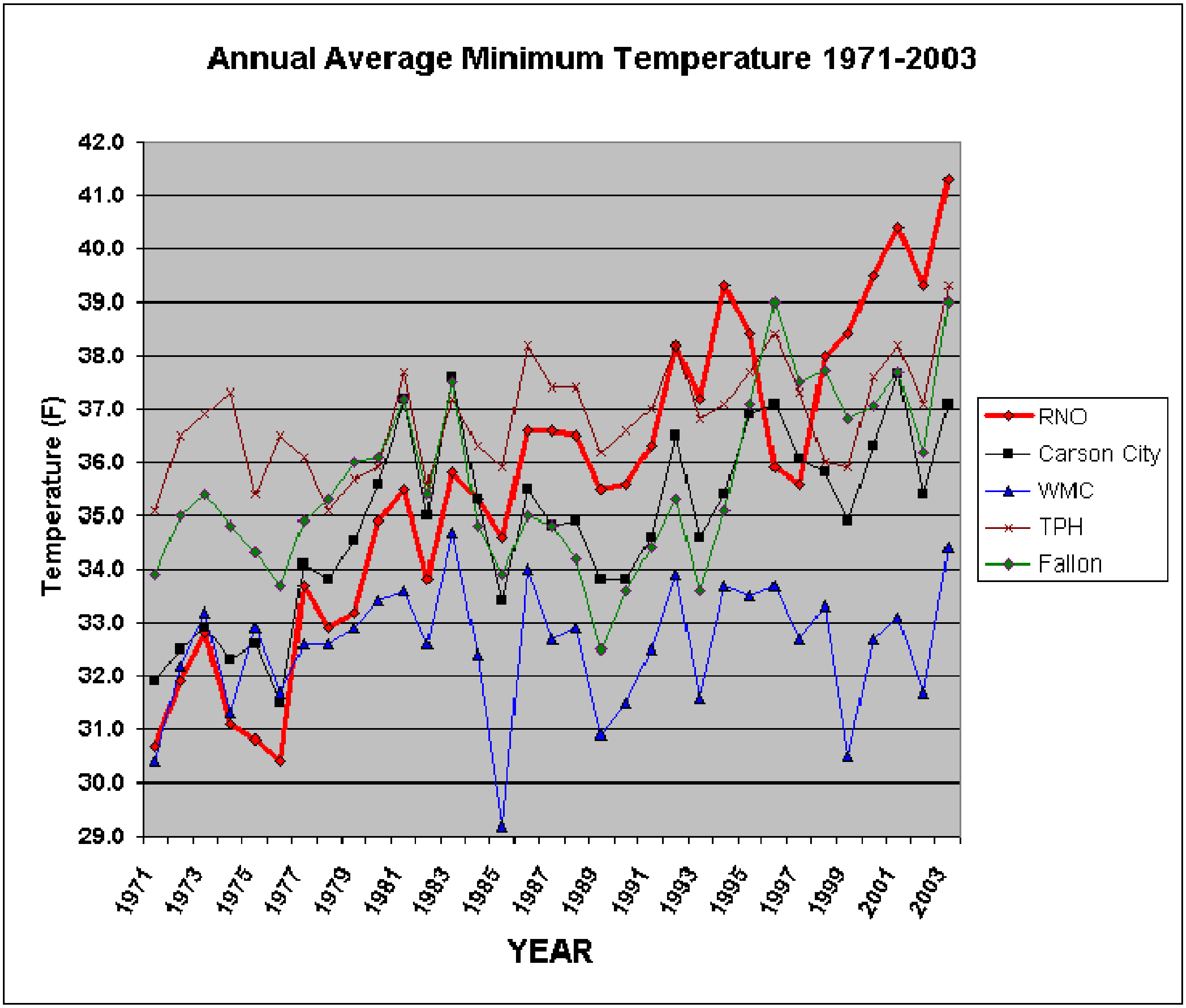

Figure 7: Average Annual Minimum Temperature for Selected stations in western Nevada for the period 1971