

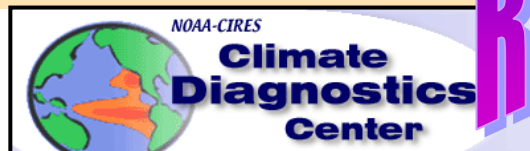
Colorado Temperature Trends

Klaus Wolter

NOAA-ESRL, and University of Colorado, CIRES Boulder

(in collaboration with Nolan Doesken)

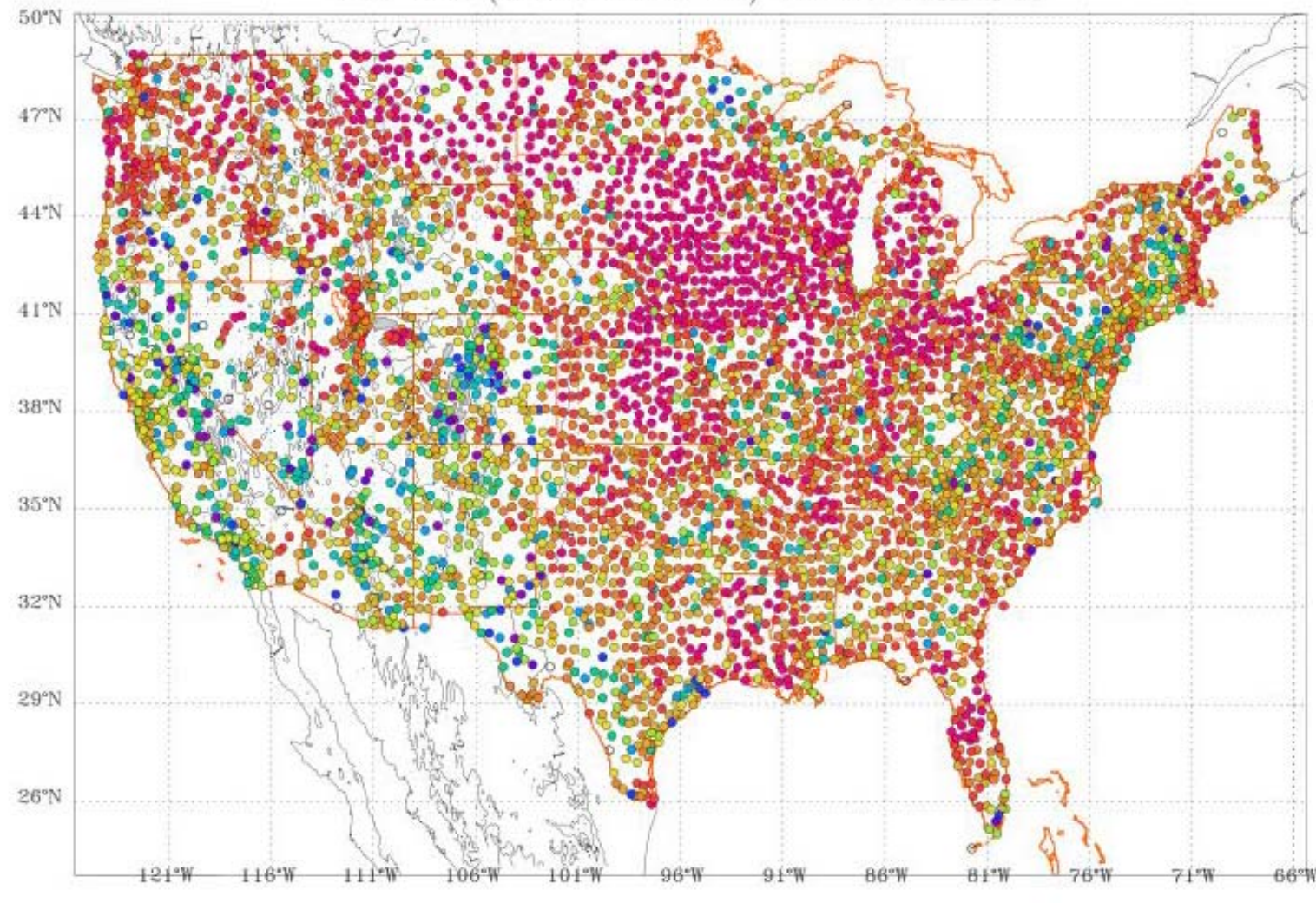
- **Regionalization**
- **Linear Trends: $X^{\circ}\text{F}$ per century is NOT the full story**
- **Significant Regional Trends in Colorado**



R.I.P.



L48 JFM (TAVG SMCU 80) 78-03 03mar06

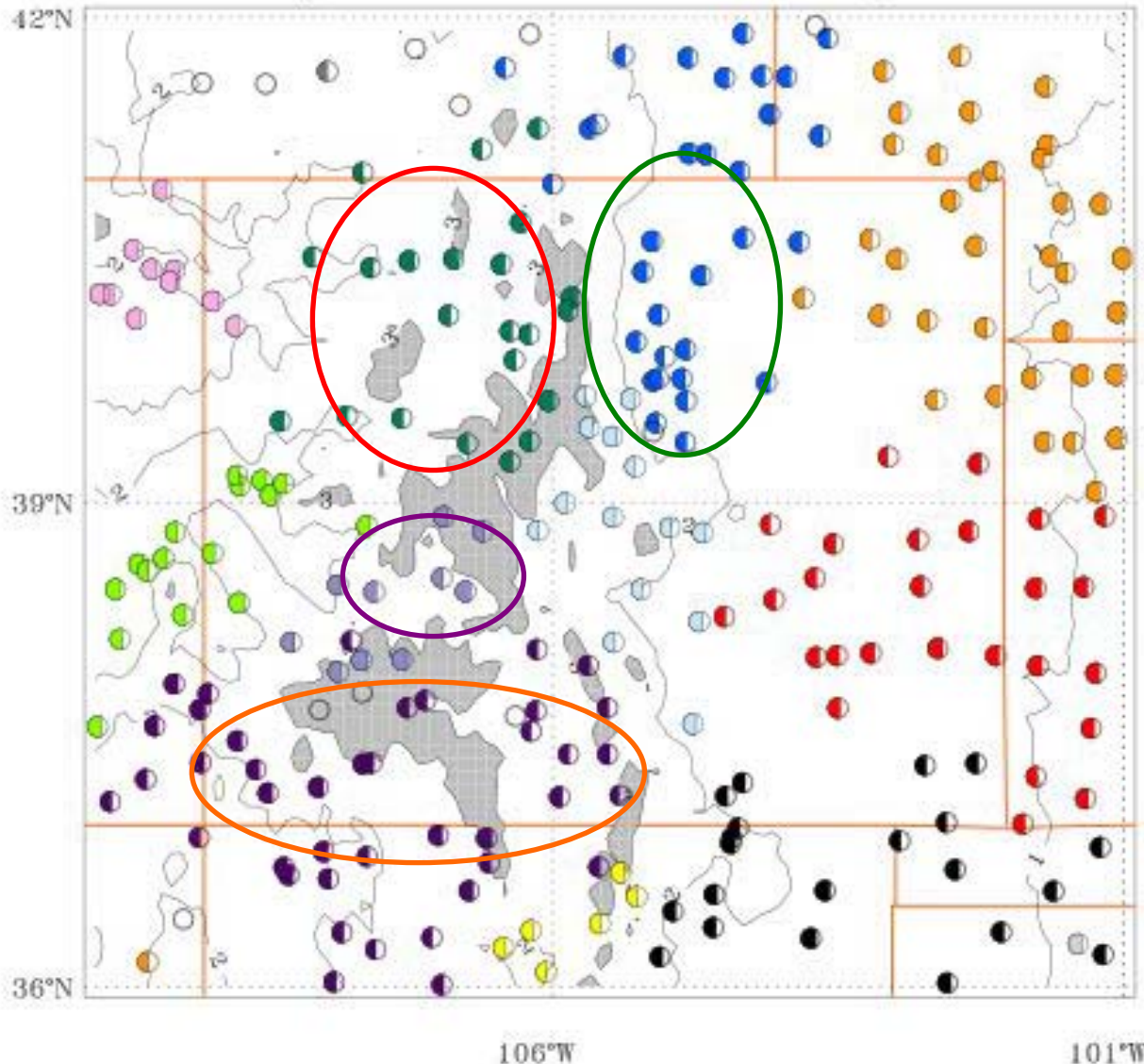


Winters in 1979-03: $\langle r \rangle$ (80km)

Correlativity tends to be highest in the winter. Iowa temperatures could be monitored by just a handful of stations, while Colorado has many more 'local flavors'.

Close-up view of Colorado's new climate divisions

48 OND-SON (P+T CORE SC3D n=120) 78-03 20ma



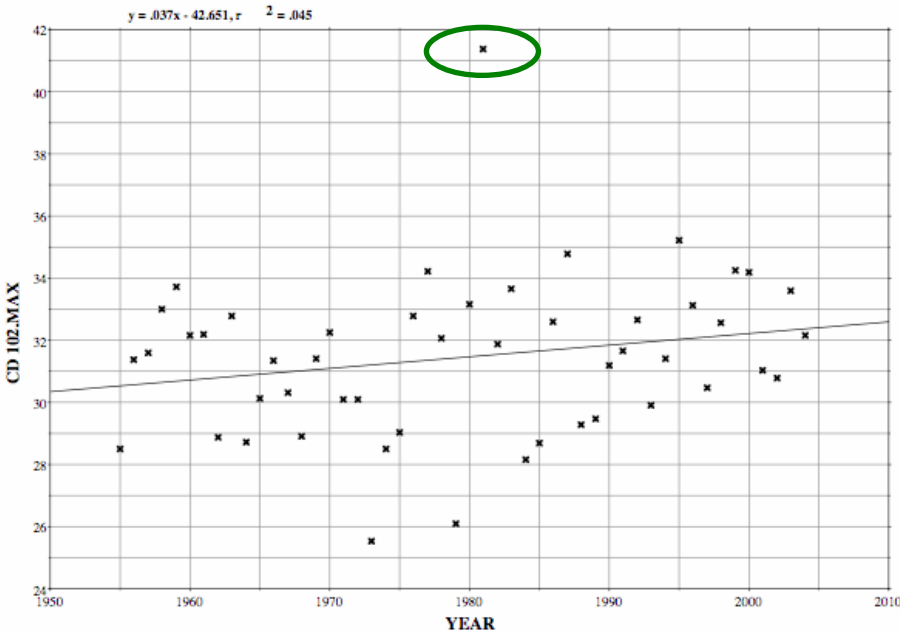
Within each climate division, one can pick stations that are best related to the divisional average to create easily updated climate indices, as well as to extend historical analyses back to near the beginning of instrumental record-keeping.

Here we focus on temperatures from DJF 1954/55 through SON 2004 (50 year trends) for northern mountains, northern Front Range, Gunnison drainage, and southwestern CO.

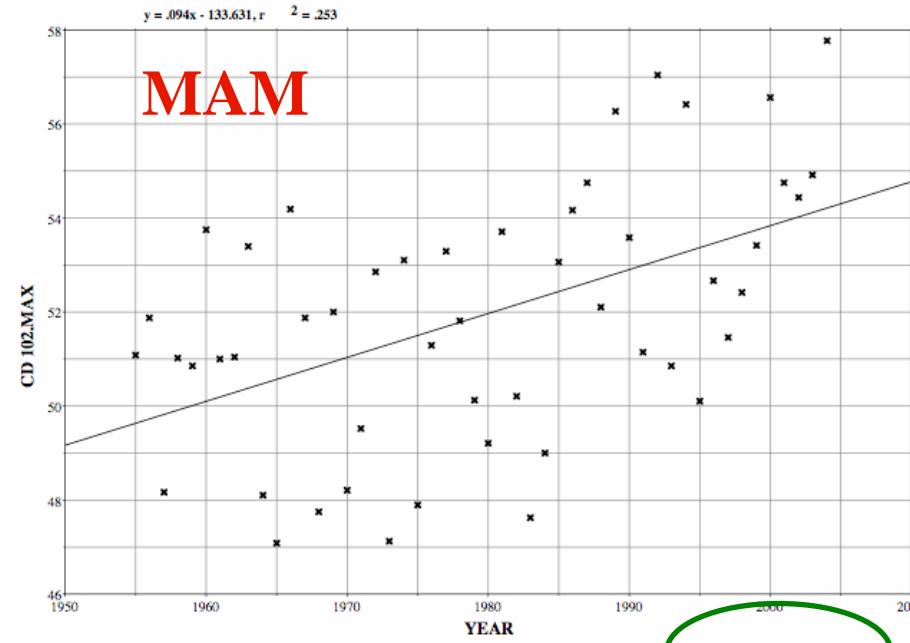
50yr temperature trends in Colorado, or: Caveat emptor!

- Pick 4-5 “best” stations for each new climate division; compute seasonal average Tmax&Tmin; compute linear trend.
- Regression results give both size of trend (°F/50 years) AND statistical significance - noisy data can have large trends without being reliable.
- Trend analyses could be (a) extended back to at least 1931 for all of Colorado, and back to about 1900 for parts of the state; (b) improved by computing regionally averaged *anomalies* rather than computing averages first; (c) made more robust by holding out individual stations/varying the start/end years.

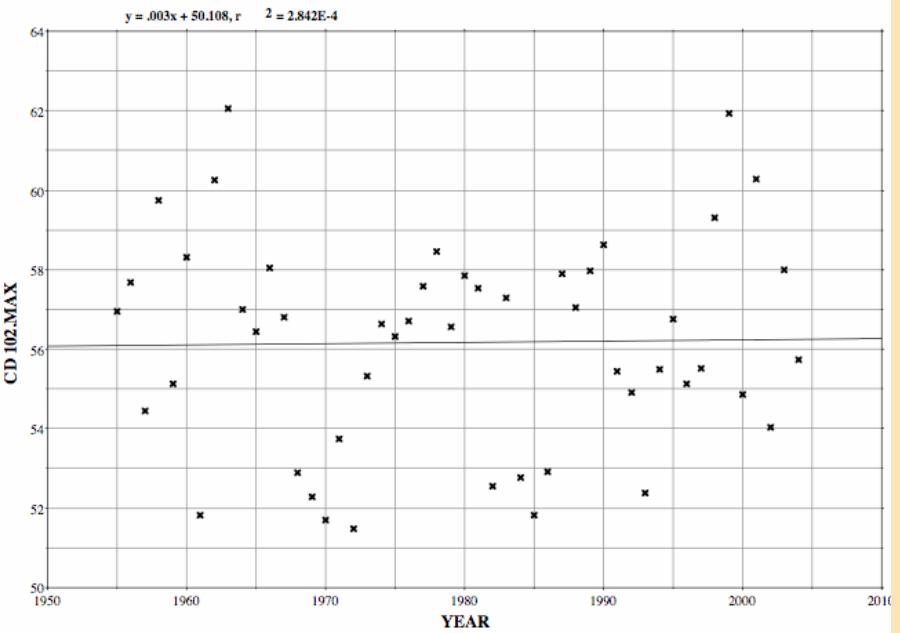
Tmax in CD 102 (NC CO)



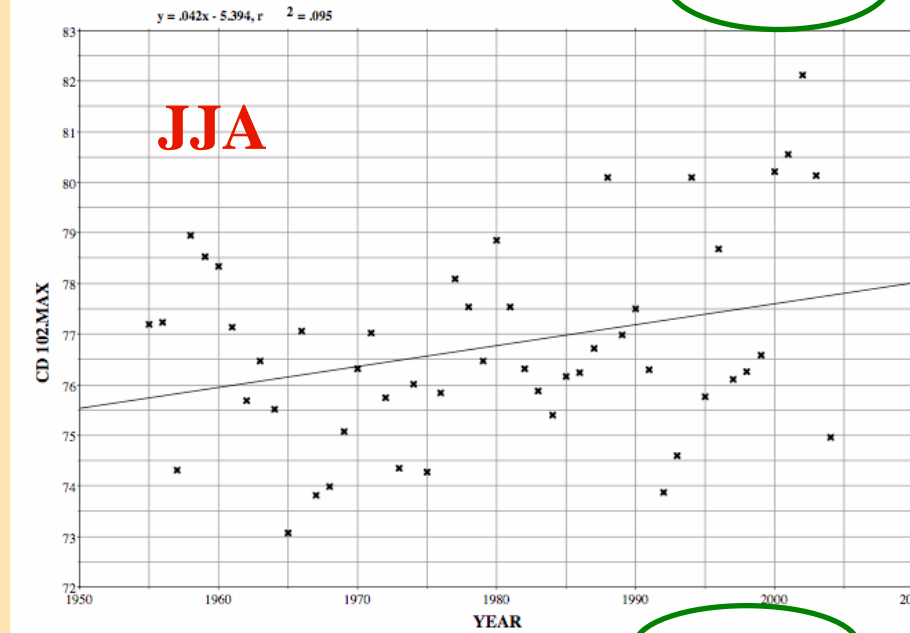
DJF Tmax temperature trend 1954/5-2003/4 for Climate Division 102 (NC Mountains): +1.85F/50yr



MAM Tmax temperature trend 1955-2004 for Climate Division 102 (NC Mountains) +4.7F/50yr & 25% VAR!

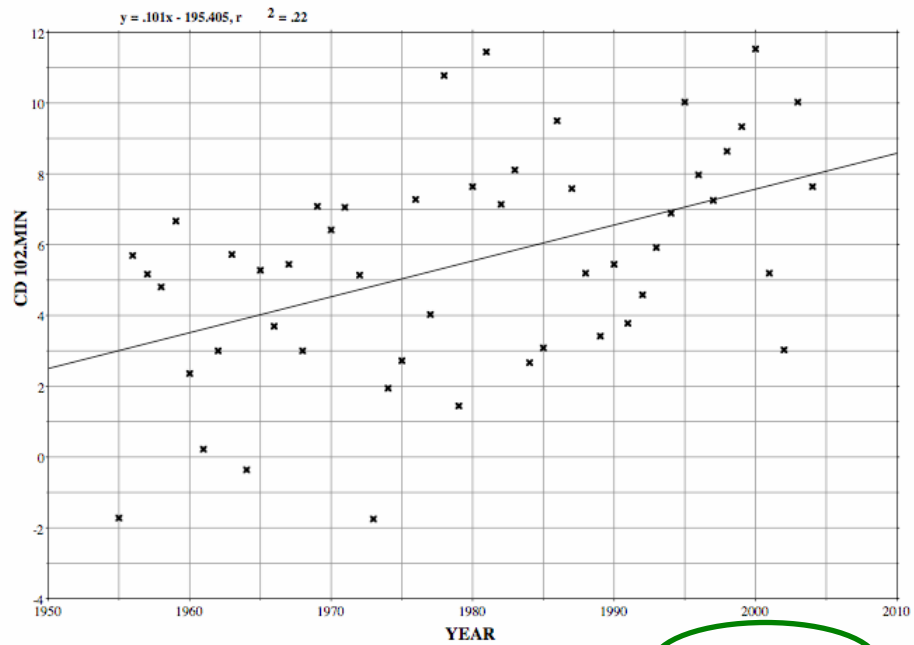


SON Tmax temperature trend 1955-2004 for Climate Division 102 (NC Mountains): +0.15F/50yr

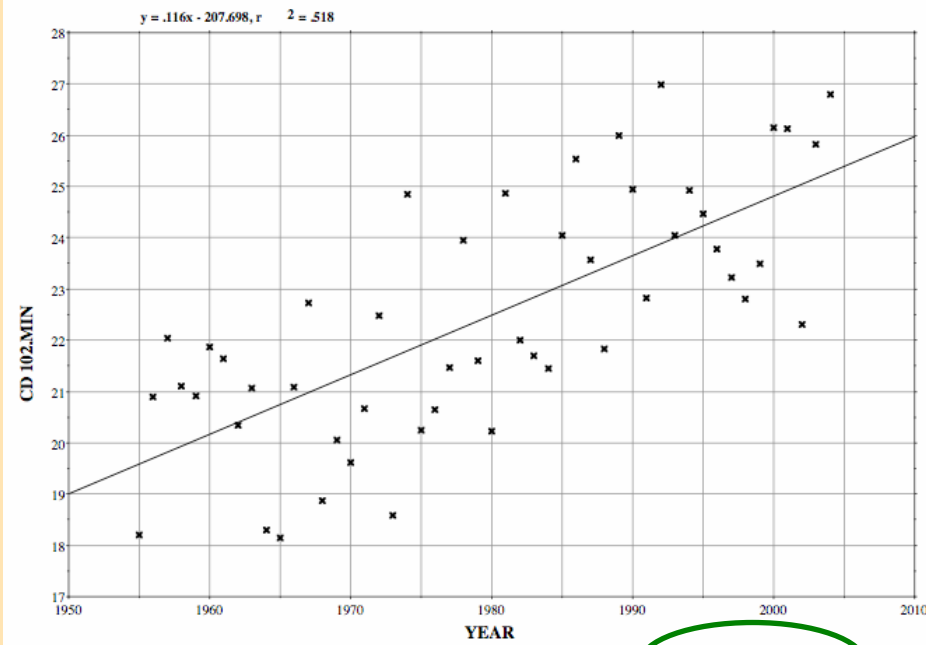


JJA Tmax temperature trend 1955-2004 for Climate Division 102 (NC Mountains): +2.1F/50yr & 9.5% VAR

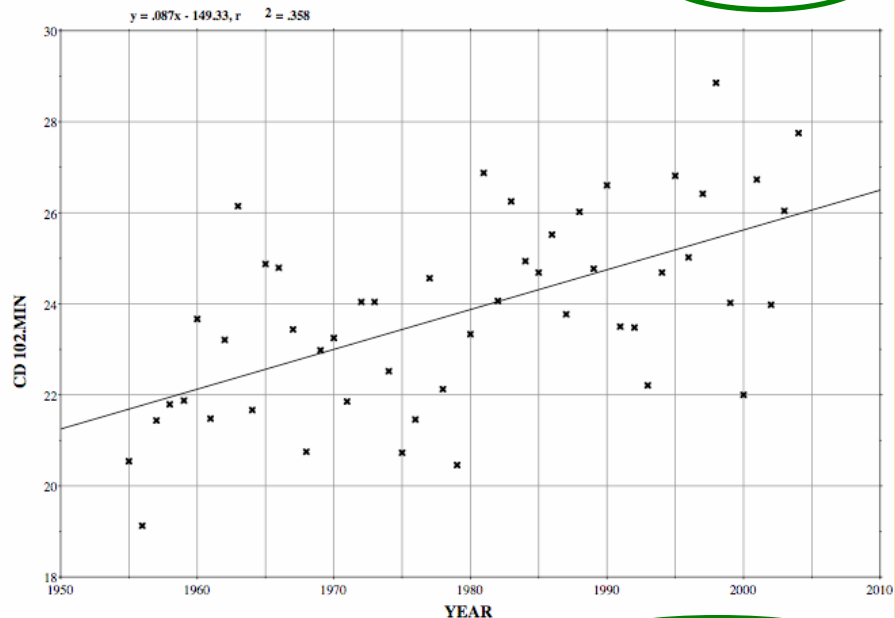
Tmin in CD 102 (NC CO)



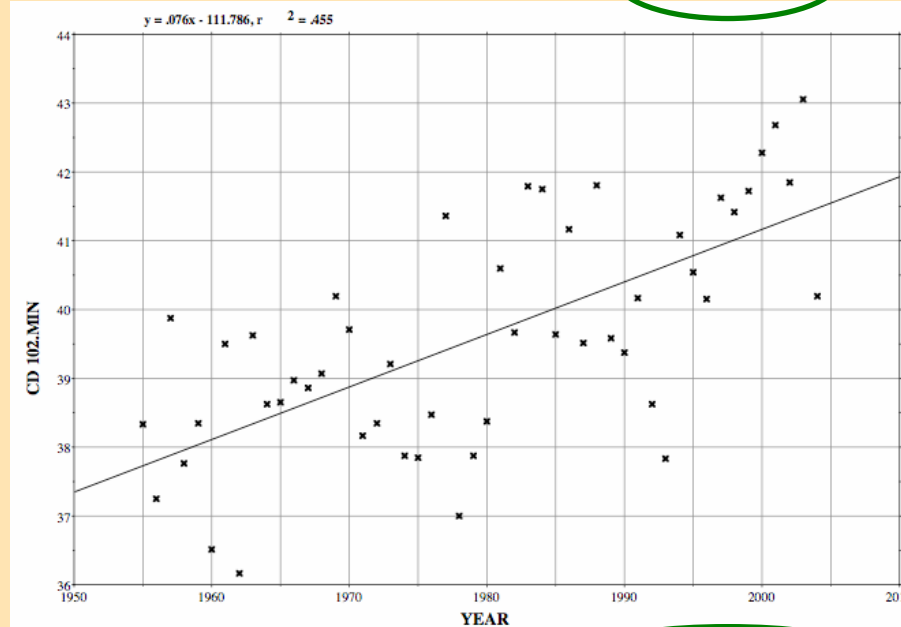
DJF Tmin temperature trend 1954/5-2003/4 for Climate Division 102 (NC Mountains) **+5.0F/50yr & 22% VAR!**



MAM Tmin temperature trend 1955-2004 for Climate Division 102 (NC Mountains) **+5.8F/50yr & 52% VAR!!!**

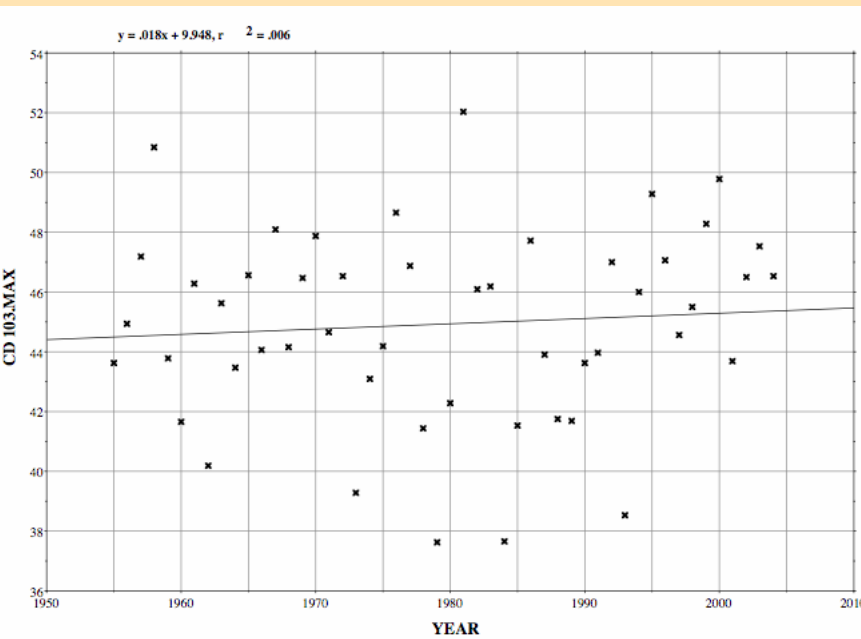


SON Tmin temperature trend 1955-2004 for Climate Division 102 (NC Mountains) **+4.35F/50yr & 35.8% VAR**

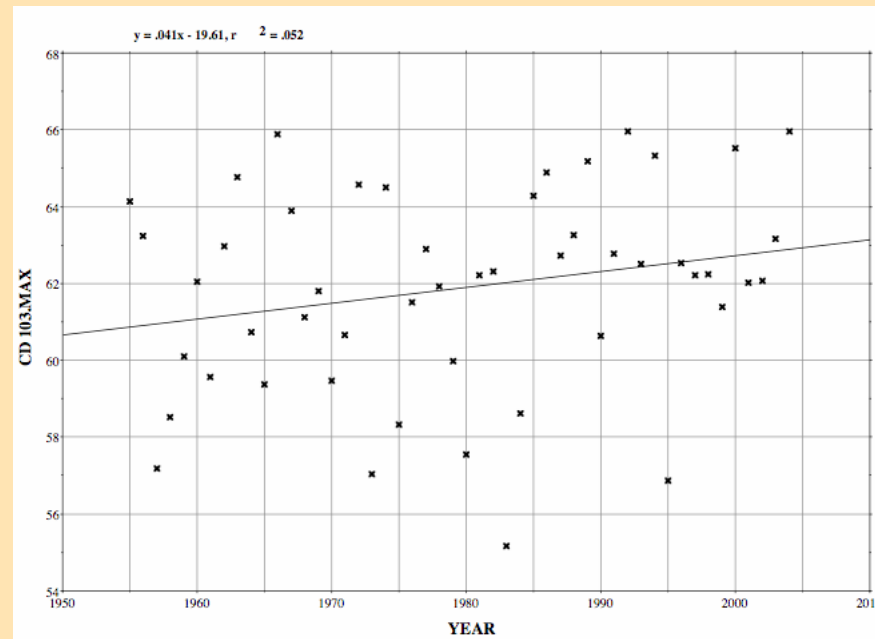


JJA Tmin temperature trend 1955-2004 for Climate Division 102 (NC Mountains) **+3.8F/50yr & 45.5% VAR**

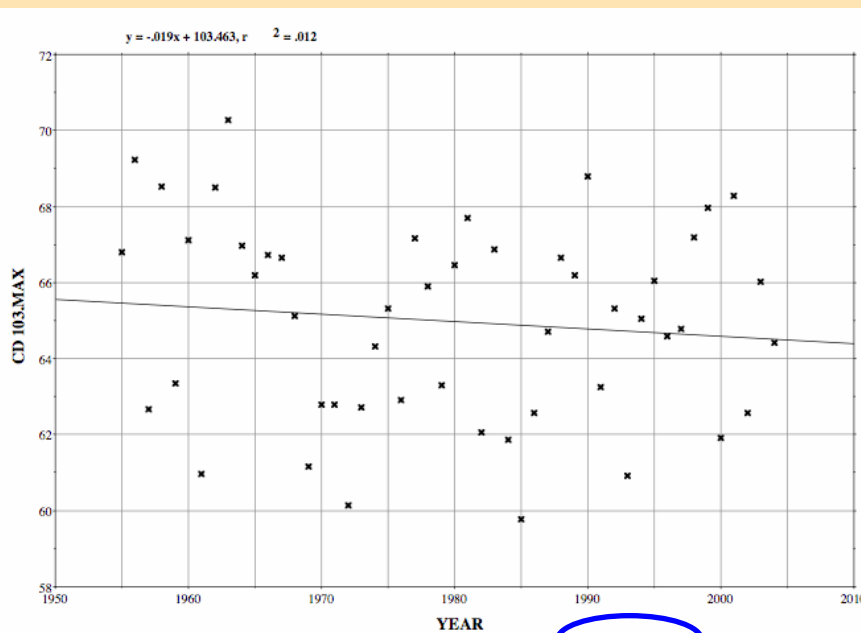
Tmax in CD 103 (Northern Front Range)



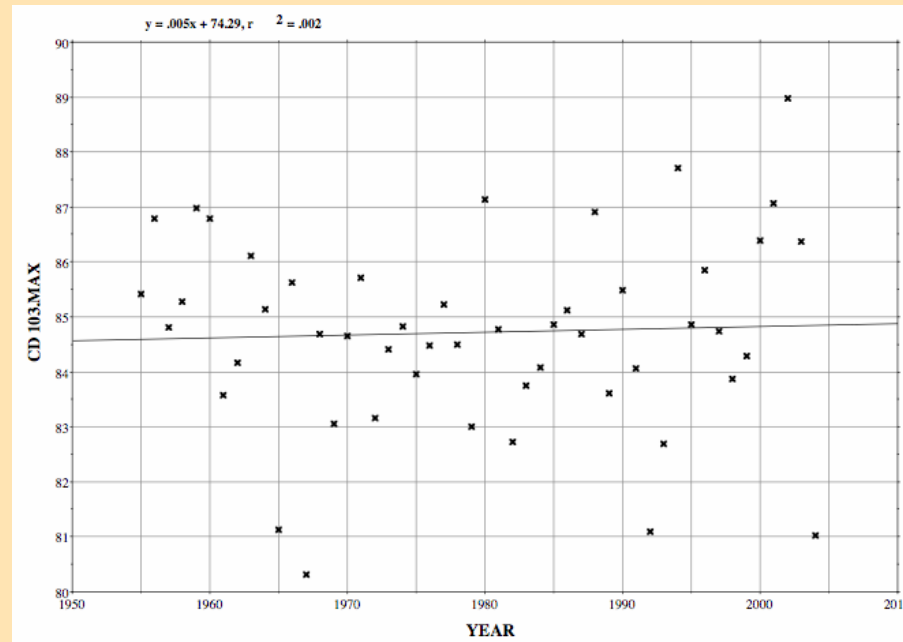
DJF Tmax temperature trend 1954/5-2003/4 for Climate Division 103 (N Front Range): +0.9F/50yr



MAM Tmax temperature trend 1955-2004 for Climate Division 103 (N Front Range): +2.05F/50yr

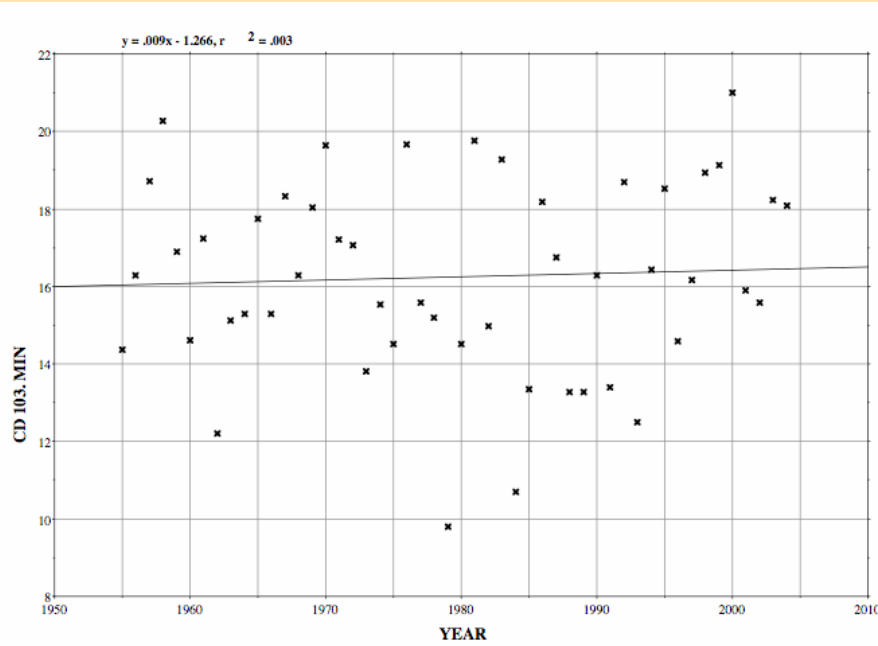


SON Tmax temperature trend 1955-2004 for Climate Division 103 (N Front Range): -.95F/50yr

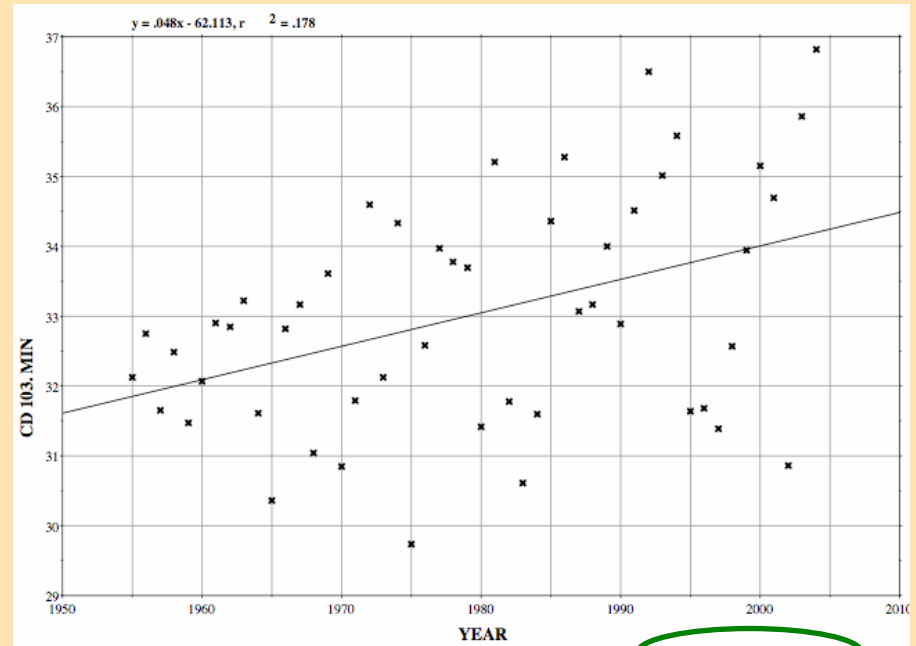


JJA Tmax temperature trend 1955-2004 for Climate Division 103 (N Front Range): +0.25F/50yr

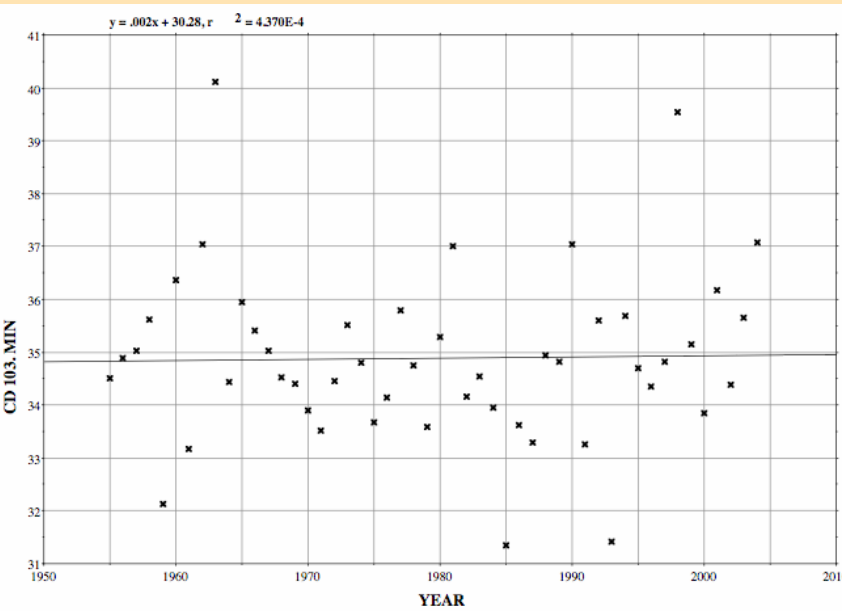
Tmin in CD 103 (Northern Front Range)



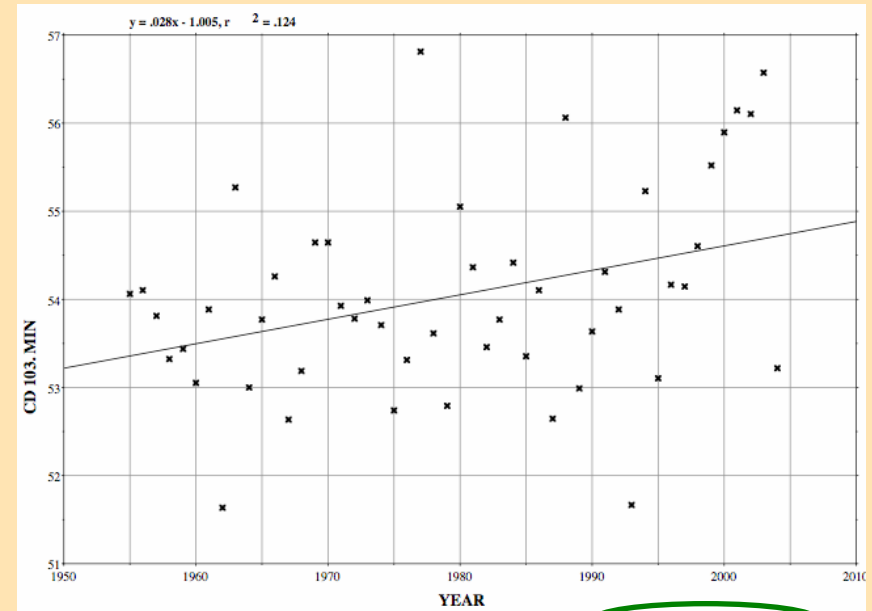
DJF Tmin temperature trend 1954/5-2003/4 for Climate Division 103 (N Front Range): +0.45/50yr



MAM Tmin temperature trend 1955-2004 for Climate Division 103 (N Front Range): **+2.4F/50yr & 18% VAR!**

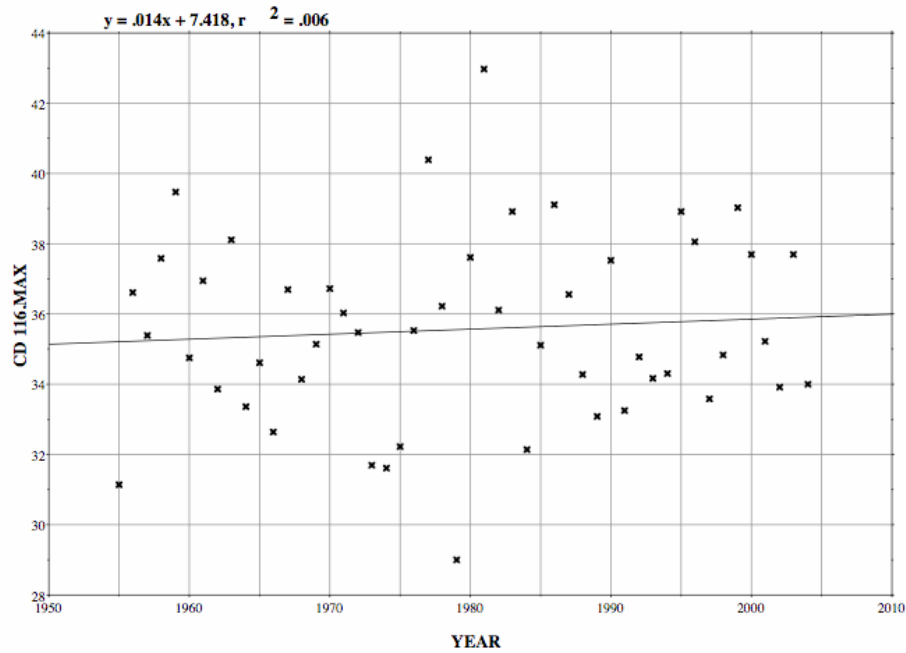


SON Tmin temperature trend 1955-2004 for Climate Division 103 (N Front Range): +0.1F/50yr

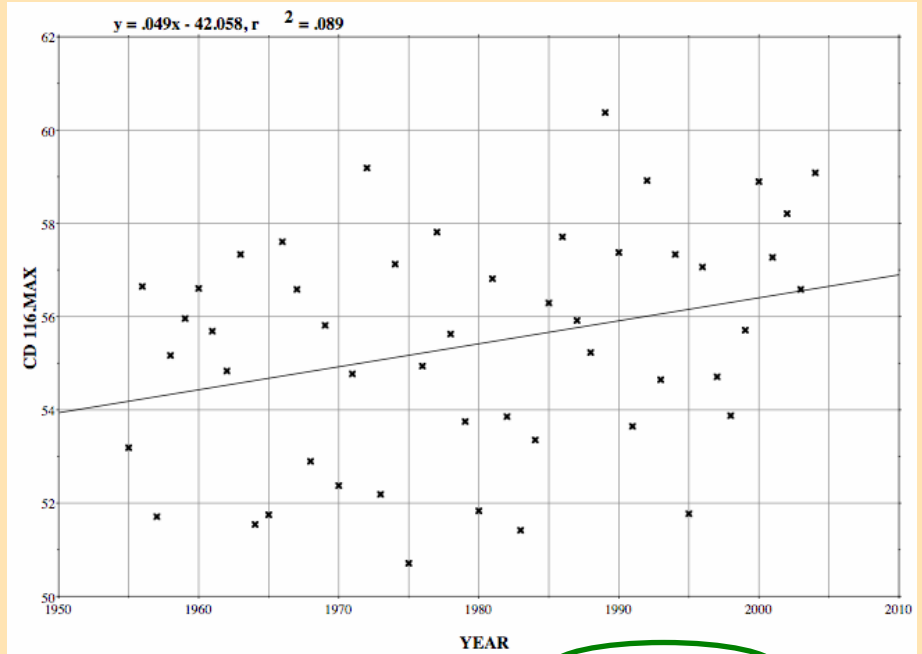


JJA Tmin temperature trend 1955-2004 for Climate Division 103 (N Front Range): **+1.4F/50yr & 12.4% VAR!**

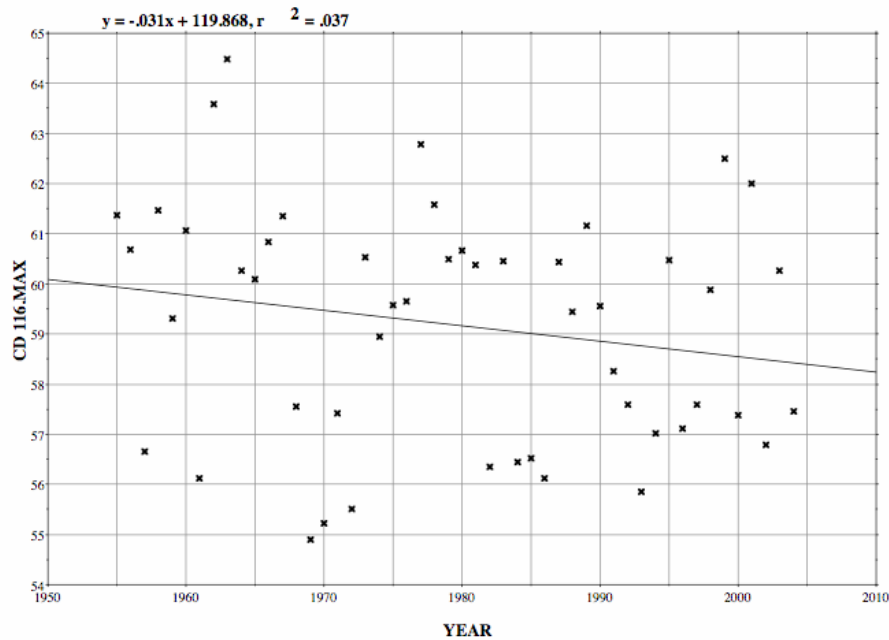
Tmax in CD 116 (Gunnison drainage)



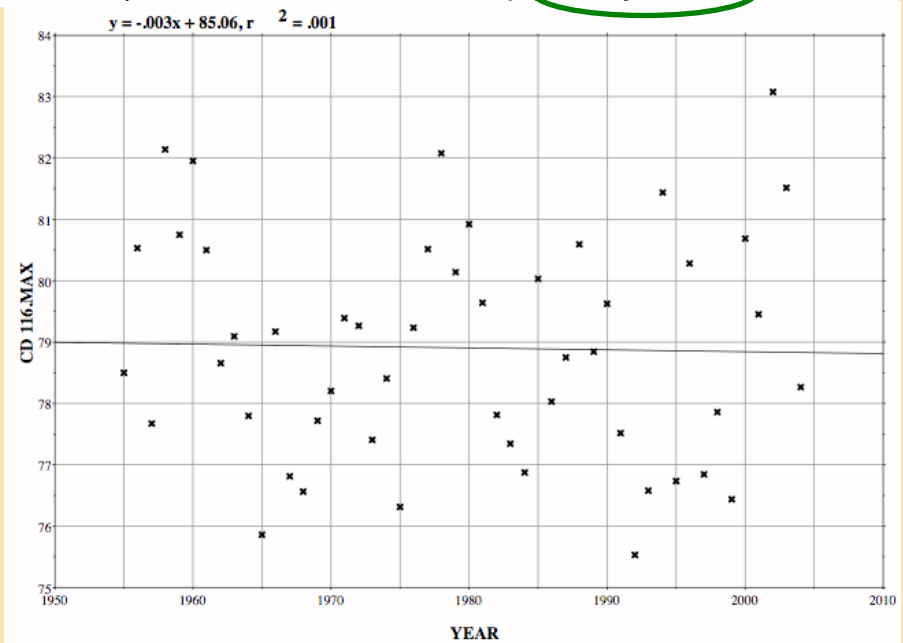
JFJ Tmax temperature trend 1954/5-2003/4 for Climate Division 116 (SC): +0.7F/50yr



MAM Tmax temperature trend 1955-2004 for Climate Division 116 (SC): +2.45F/50yr & 8.9%

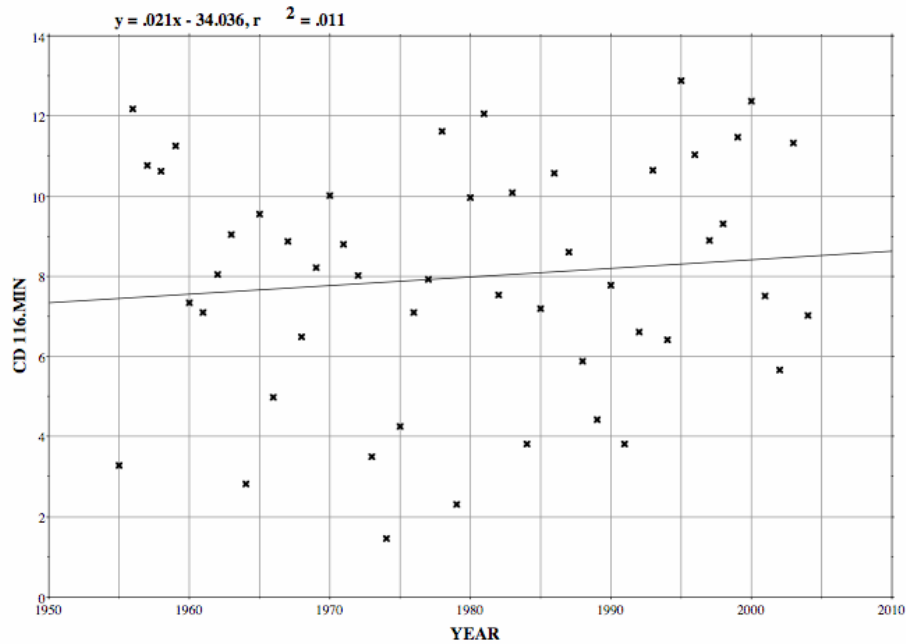


SON Tmax temperature trend 1955-2004 for Climate Division 116 (SC): -1.55F/50yr

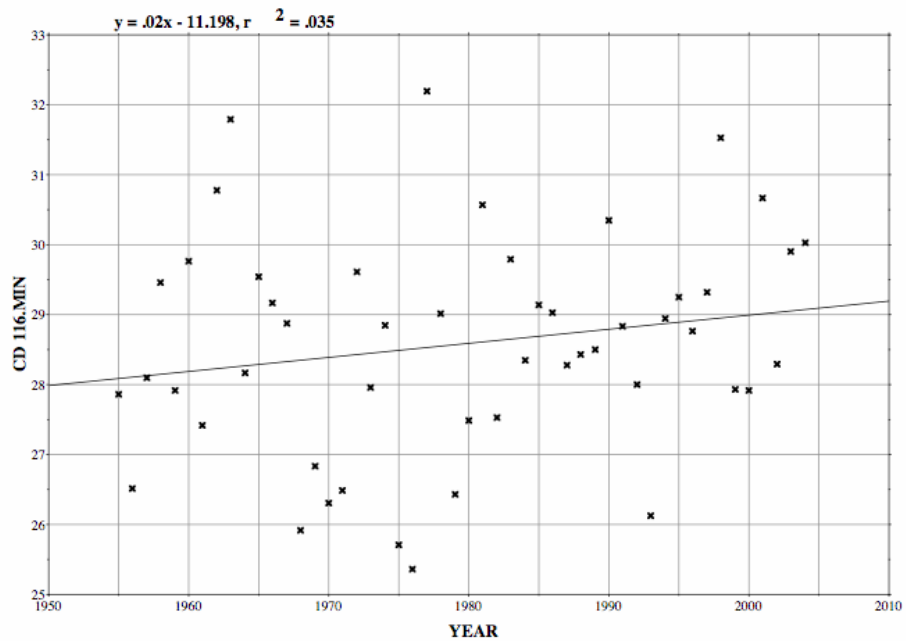


JJA Tmax temperature trend 1955-2004 for Climate Division 116 (SC): -0.15F/50yr

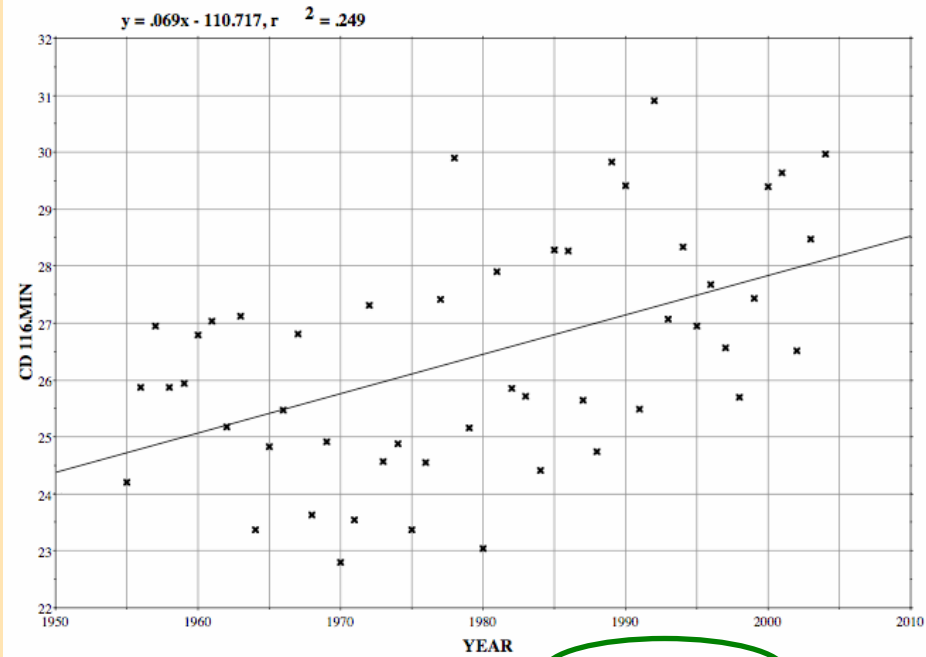
Tmin in CD 116 (Gunnison drainage)



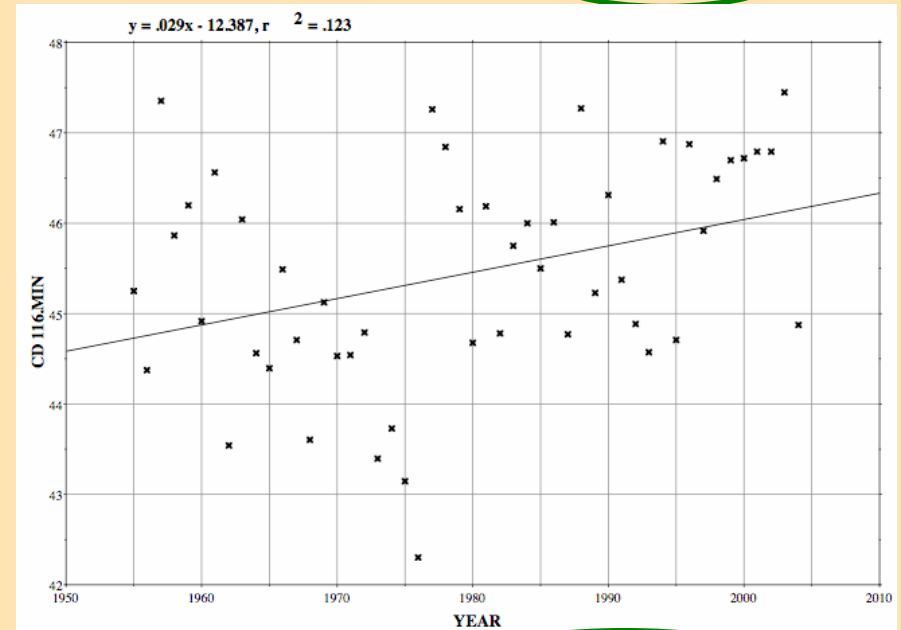
DJF Tmin temperature trend 1954/5-2003/4 for Climate Division 116 (SC): +1.05F/50yr



SON Tmin temperature trend 1955-2004 for Climate Division 116 (SC): +1.0F/50yr

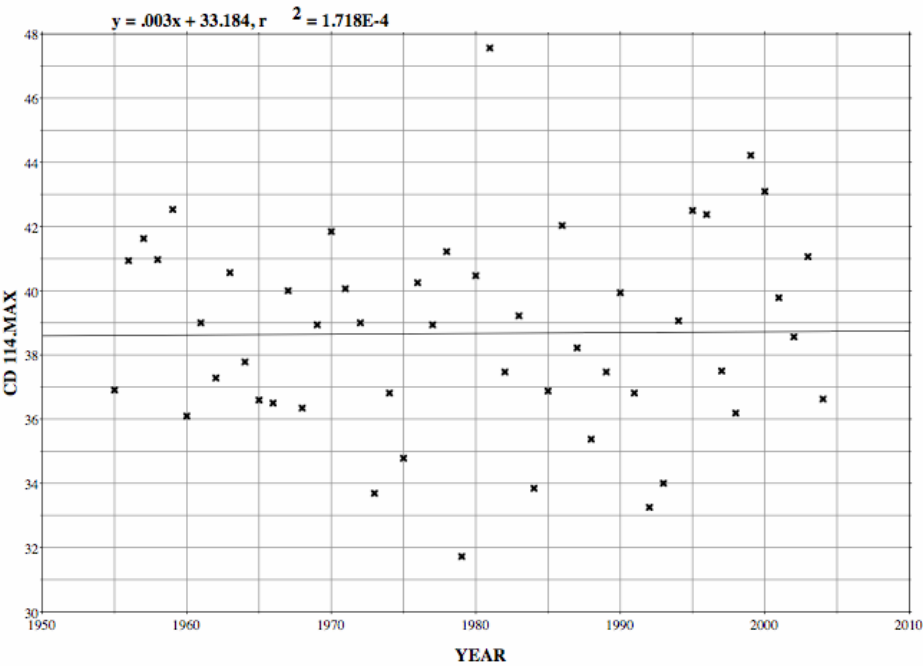


MAM Tmin temperature trend 1955-2004 for Climate Division 116 (SC): +3.45F/50yr & 24.9%!!!

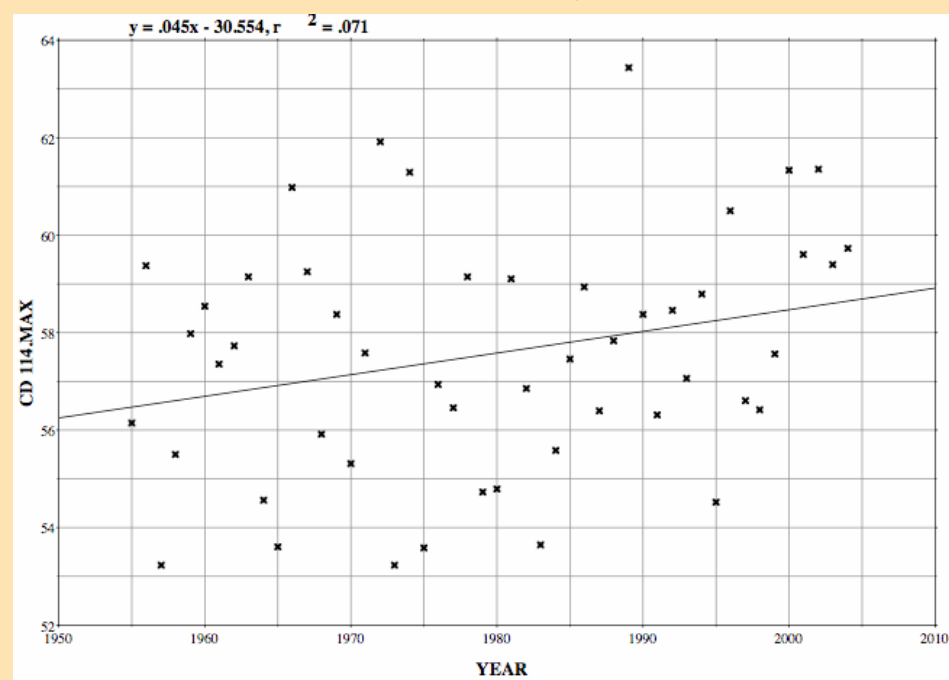


JJA Tmin temperature trend 1955-2004 for Climate Division 116 (SC): +1.45F/50yr & 12.3%!

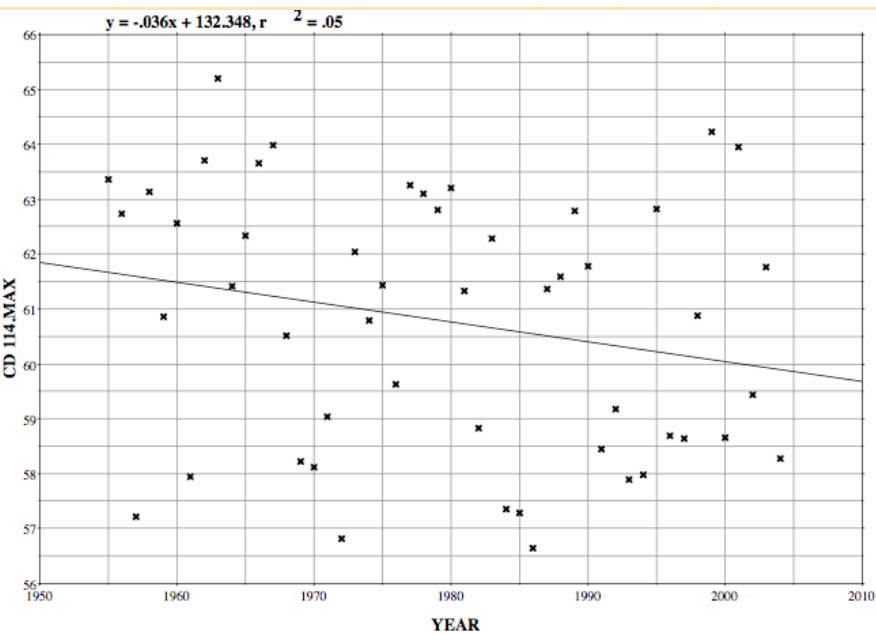
Tmax in CD 114 (Four Corners to San Luis)



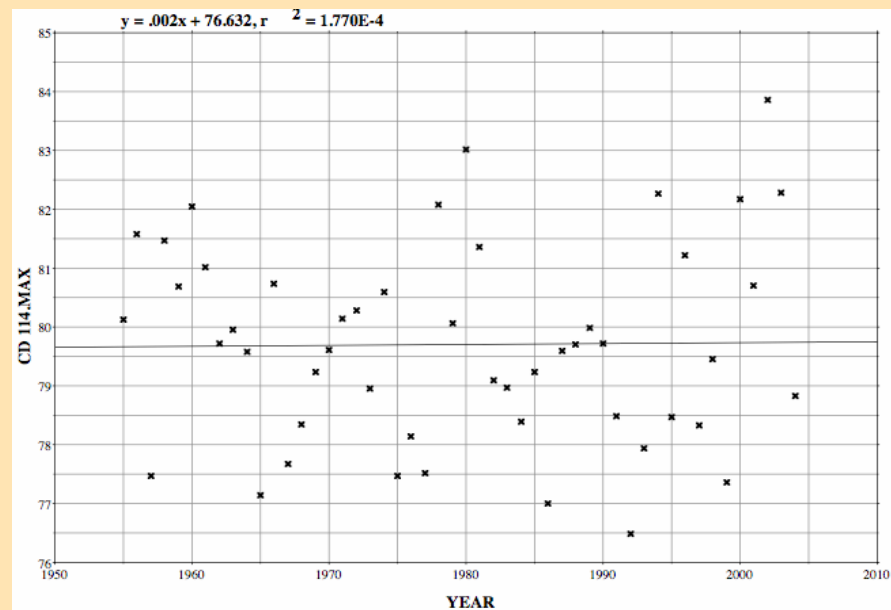
DJF Tmax temperature trend 1954/5-2003/4 for Climate Division 114 (San Luis+): +0.15F/50yr



MAM Tmax temperature trend 1955-2004 for Climate Division 114 (San Luis+): +2.25F/50yr & 7.1%

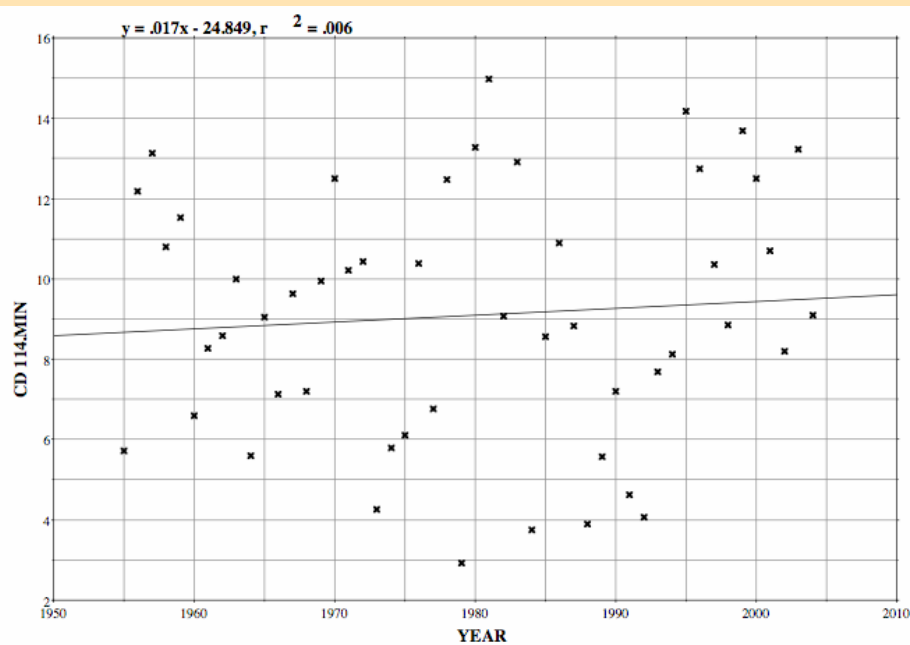


SON Tmax temperature trend 1955-2004 for Climate Division 114 (San Luis+): -1.8F/50yr

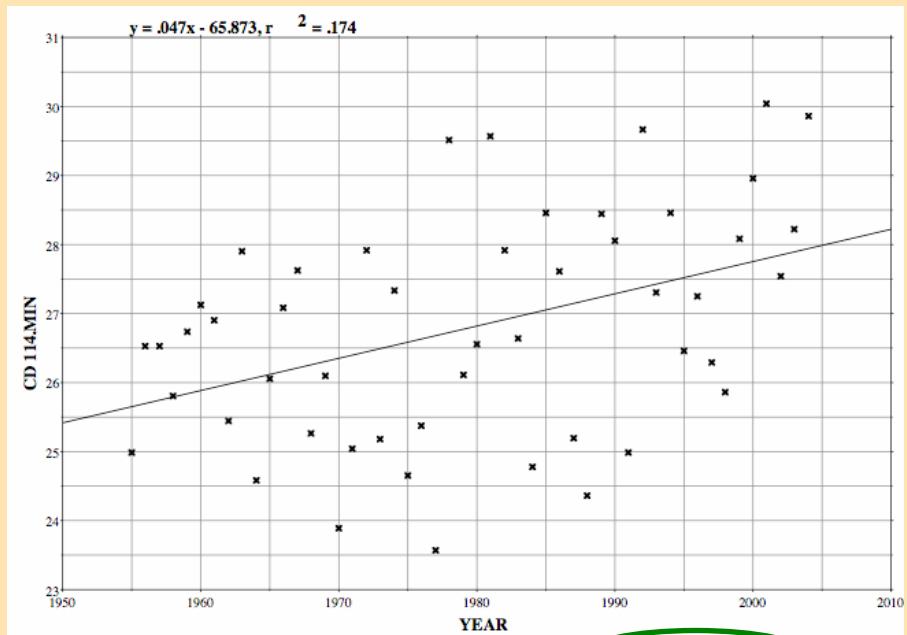


JJA Tmax temperature trend 1955-2004 for Climate Division 114 (San Luis+): +0.1F/50yr

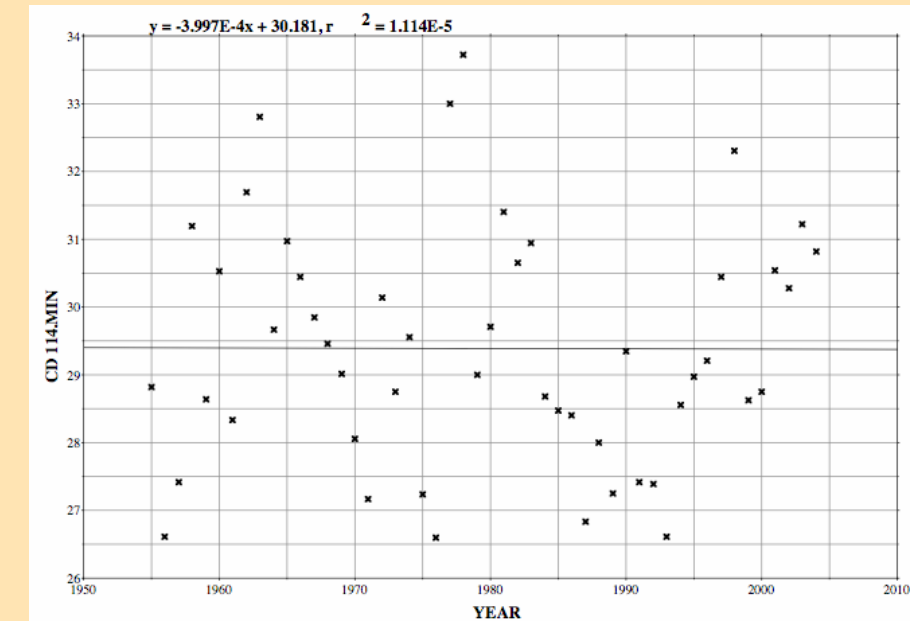
Tmin in CD 114 (Four Corners to San Luis)



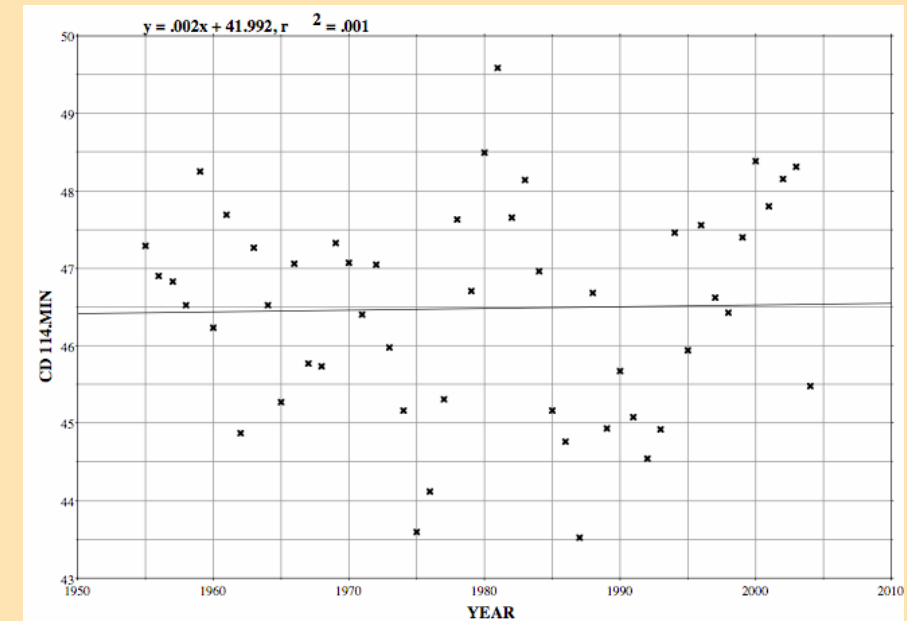
DJF Tmin temperature trend 1954/5-2003/4 for Climate Division 114 (San Luis+): +0.85F/50yr



MAM Tmin temperature trend 1955-2004 for Climate Division 114 (San Luis+): +2.35F/50yr & 17.4%!



SON Tmin temperature trend 1955-2004 for Climate Division 114 (San Luis+): -0.02F/50yr



JJA Tmin temperature trend 1955-2004 for Climate Division 114 (San Luis+): +0.1F/50yr

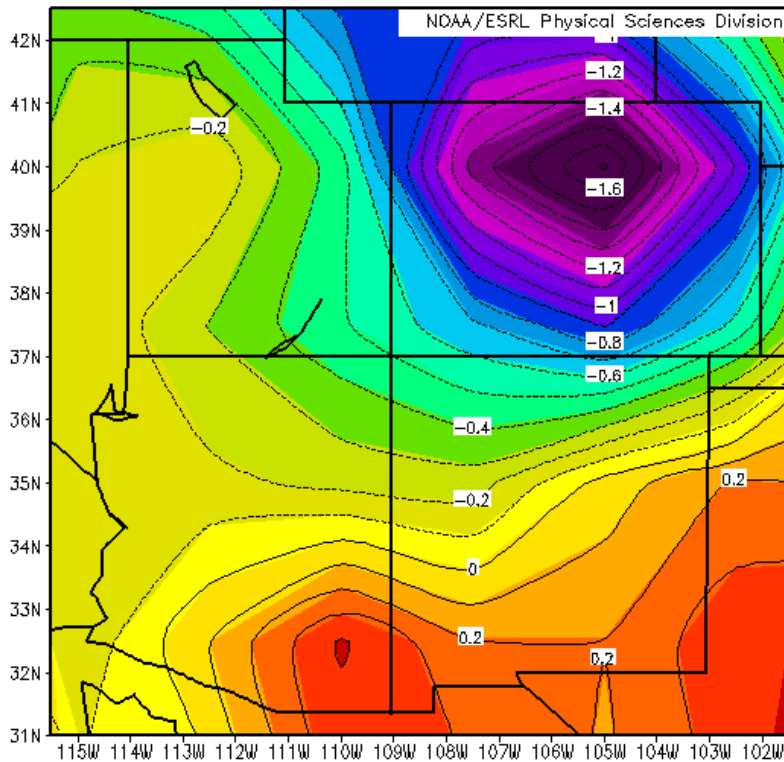
Current summary points, based on carefully selected station data

- **Although there is regional variability in Colorado temperature trends, there are some commonalities that are shared across the state for the last half century:**
 1. **Biggest overall warming trends are for minimum compared to maximum temperatures;**
 2. **Springs are getting significantly warmer, falls cooler, while winters and summers are more split; annual averages have been warming on the order of 1°F (2°F) per 50 years for high (low) temperatures across the state.**
- **Regionally, the north-central part of the state has been warming the fastest, while the eastern plains and southwest have warmed the slowest.**
- **Changing these analyses from the last 50 years to the last 30 years renders more striking warming trends (2-3°F per half century) that are NOT more significant due to year-to-year variability.**
- **This analysis can be extended back to at least 1931 for all parts of the state, while 100-year+ analyses will remain out of reach for most of it until we can patch different station segments together. The Arkansas valley, weakly warming in the last 50 years, shows only a 0.5°F warming trend over the last 100 years, lower than the average for the Globe.**

What else is going on?!

NCEP/NCAR Reanalysis

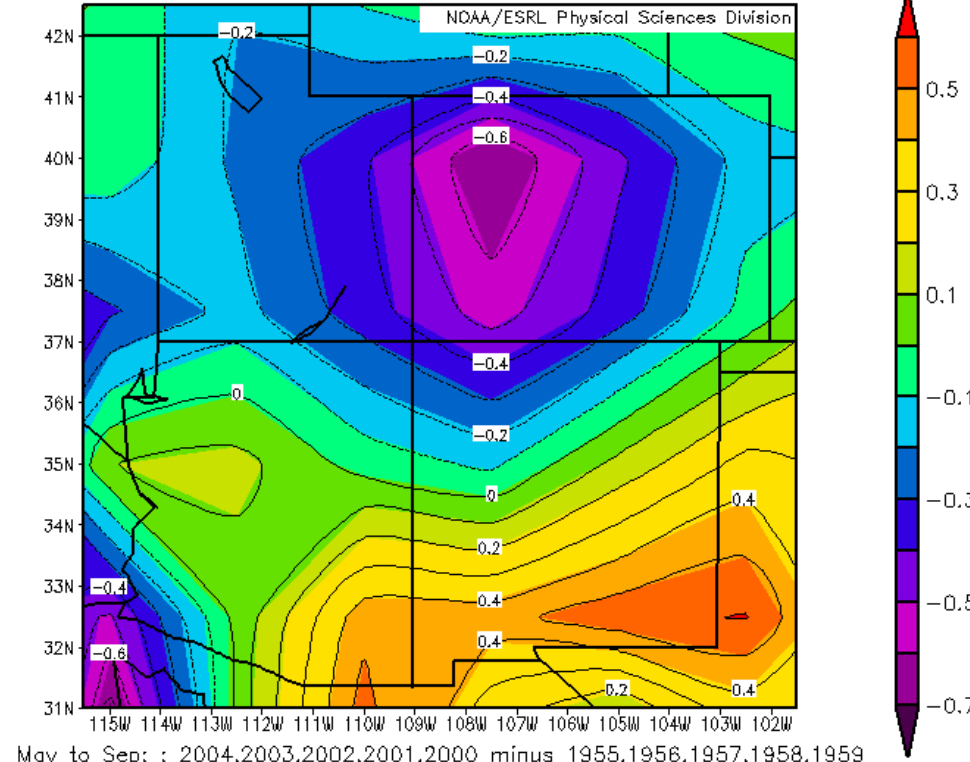
Surface Scalar Wind Speed (m/s) Composite Mean



Oct to Apr : 2004,2003,2002,2001,2000 minus 1955,1956,1957,1958,1959

NCEP/NCAR Reanalysis

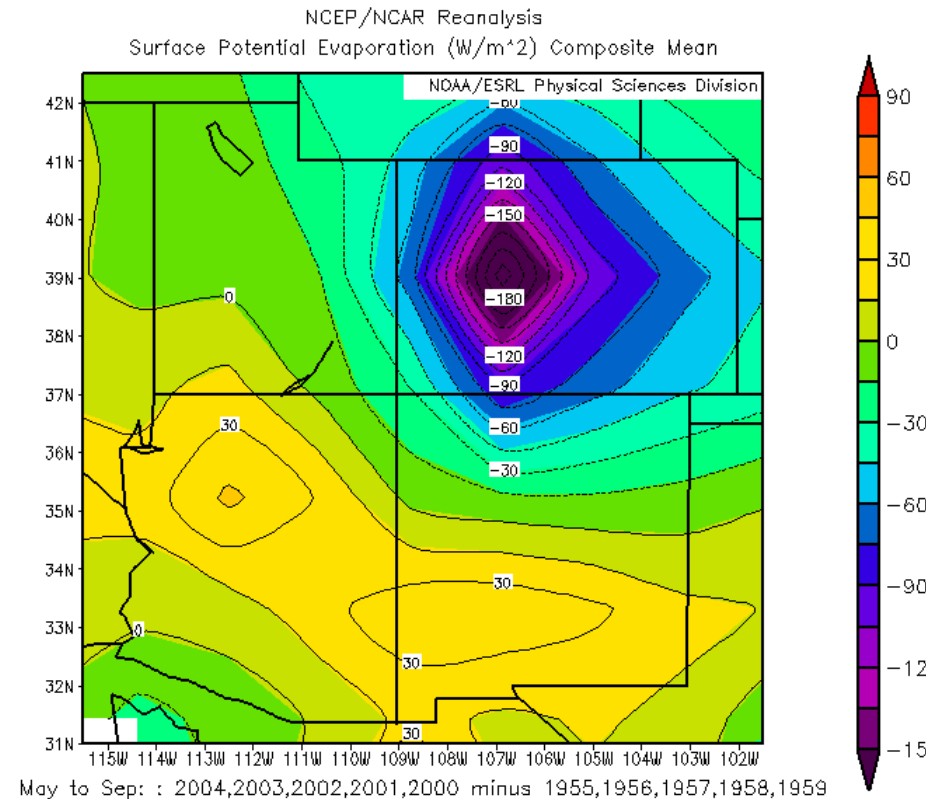
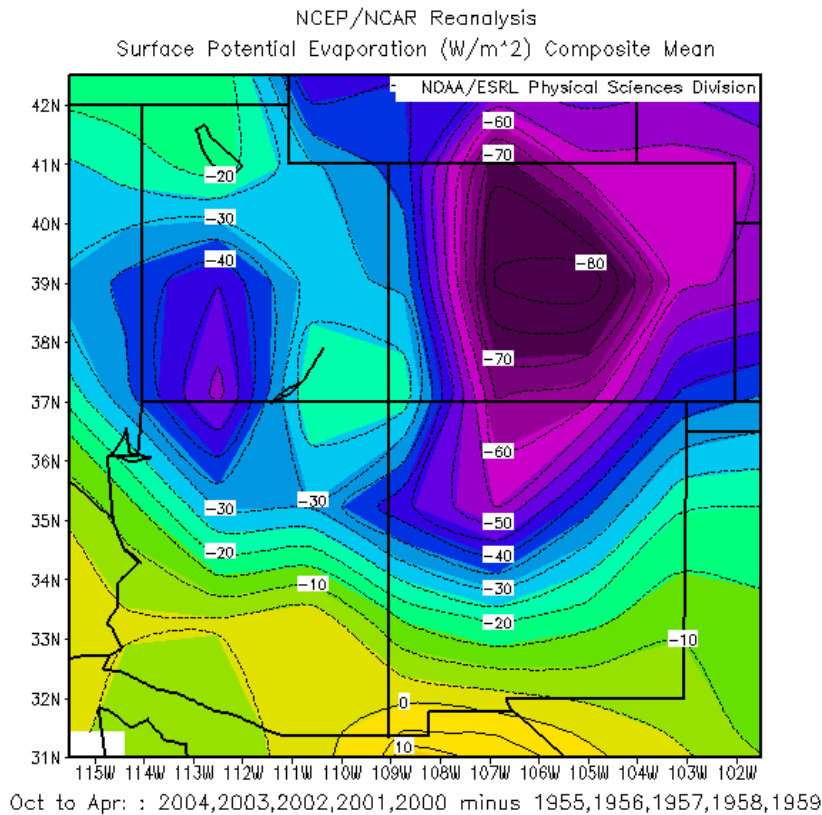
Surface Scalar Wind Speed (m/s) Composite Mean



May to Sep : 2004,2003,2002,2001,2000 minus 1955,1956,1957,1958,1959

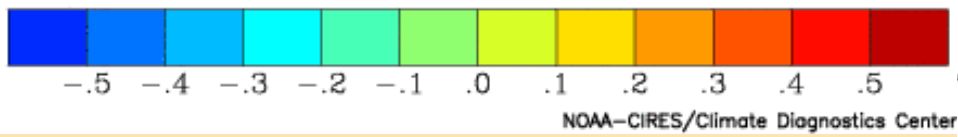
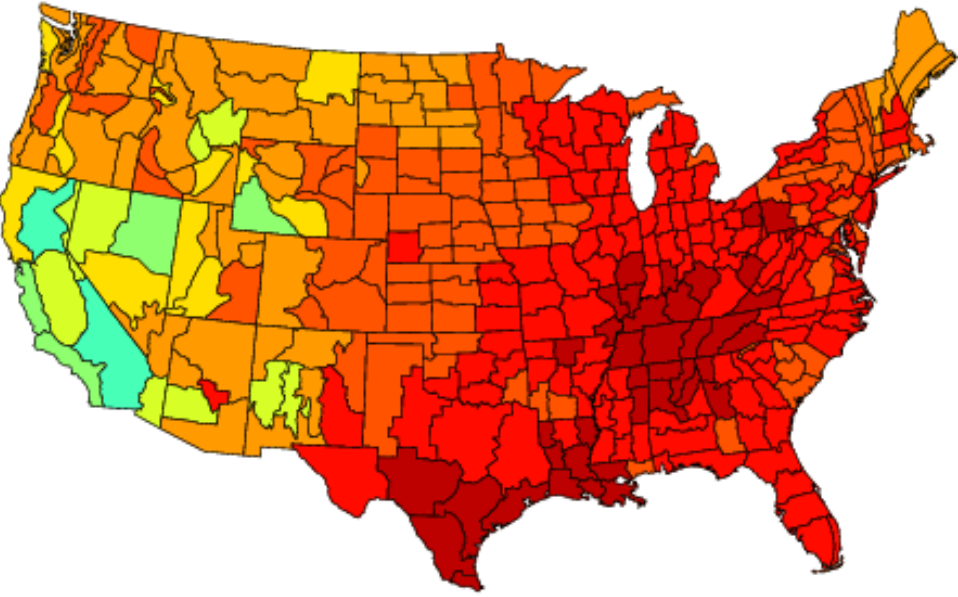
There appears to have been a decline in near-surface wind speed!

What else is going on?!



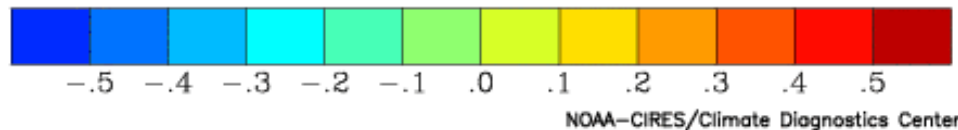
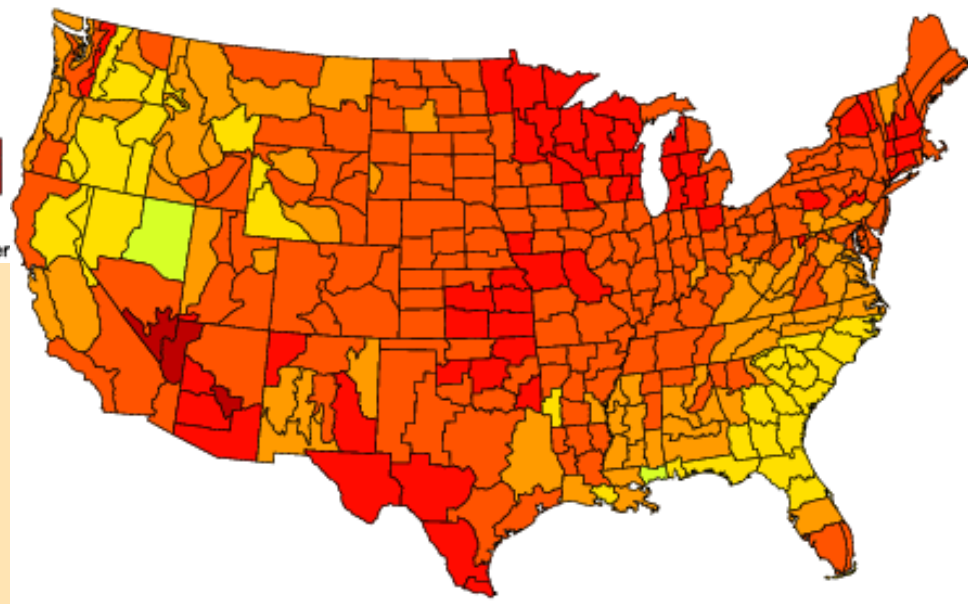
Potential evapotranspiration is down despite higher T_{surf} , if you trust re-analysis data. If true, lower wind speeds and higher RH appear to have been instrumental in this, thus diminishing the impact of recent drought conditions despite higher T_{surf} !

Correlation Temperature Dec to Feb
With Dec to Feb Trend
1976-05



Recent climate trends for the U.S.: (left) winter temperatures for 76-05, (bottom right) same for 71-00. Correlations above 0.3 are considered significant.

Correlation Temperature Dec to Feb
With Dec to Feb Trend
1971-00



Note the recent change in sign in California, and strengthened trend in the eastern U.S.