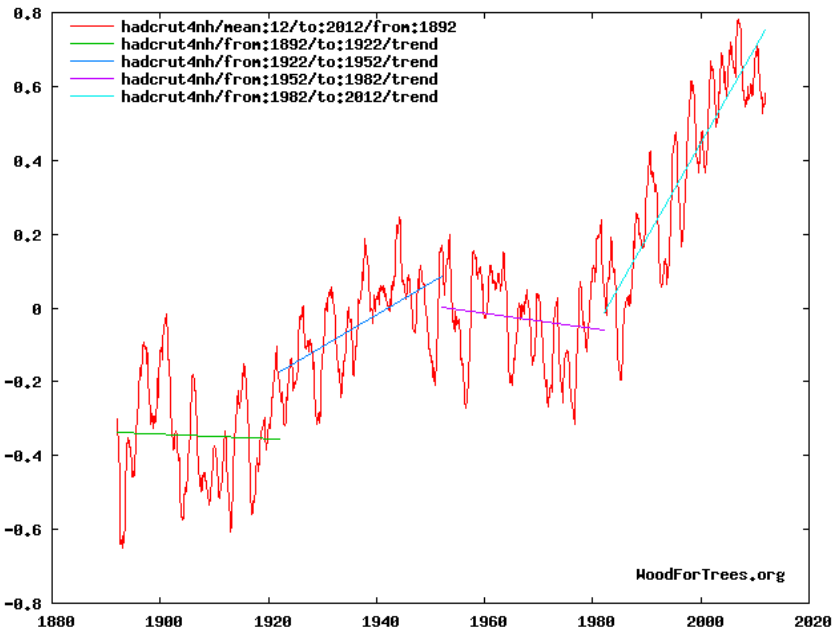
Examining Arctic Amplification and Extrapolating to Unobserved Regions

Positive feedbacks such as decreased albedo due to snow and ice retreat are expected to amplify arctic warming relative to the global trend [Ohring 1978]. Sparse weather station coverage north of 70° and no coverage north of 80° complicates identification of enhanced high-latitude warming. A temperature reconstruction leveraging satellite data to estimate warming in unobserved regions [Cowtan 2013] found that in recent decades "the Arctic is warming at about eight times the pace of the rest of the planet." [http://www.alphagalileo.org/ViewItem.aspx?ItemId=136400&CultureCode=en]. Here I examine the relative temperature trends at latitudes between 0° and 80° for 30 year periods starting in 1892 to determine whether arctic amplification is evident during each of the periods. Further, I attempt to estimate warming north of 80° for the most recent 30 year period using extrapolation of an exponential trend. Arctic amplification is evident only in the most recent 30 year period. Extrapolating from an exponential trend for this period estimates a warming of 4.1 times the global average for the latitudes between 90° and 100°, or about half that found by Cowtan 2013.

Temperature trends were examined using station data available at the University of Chicago climate time series browser. [http://climatemodels.uchicago.edu/timeseries/] At least 800 stations were selected for each latitude band wherever possible. For bands with less than 800 stations, all available stations were selected.

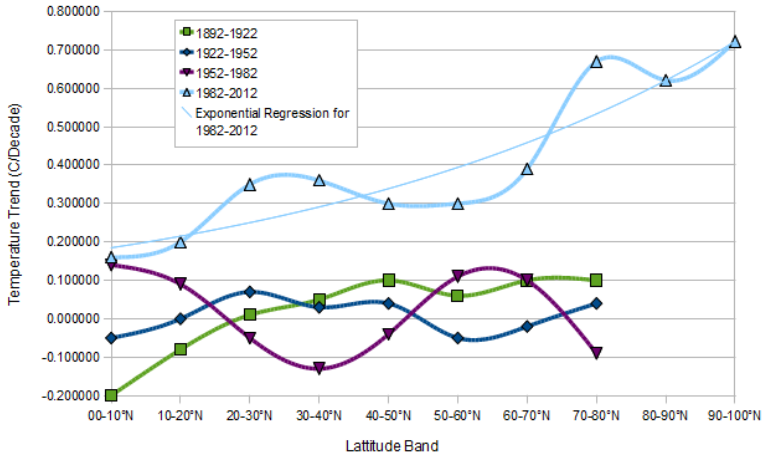
For each band the station data was normalized to a 1900-1950 baseline and the results combined into a single temperature reconstruction. The trend of this composite was recorded for each band over each of the following periods: 1892-1922, 1922-1952, 1952-1982, and 1982-2012.

Figure 1: Northern Hemisphere Temperature Trend by Period



Woodfortrees.org was used to graph the HADCRUT4 northern hemisphere trend for each period studied. The periods between 1892-1922 and 1952-1982 both show a slight cooling trend of -0.0056 and -0.0211 C per decade respectively. The periods between 1922-1952 and 1982-2012 show a warming trend of 0.0866 and 0.2556 C per decade respectively.

Figure 2: Temperature Trend by Latitude Band for Each Period



No clear polar amplification signal is observed in any of the periods prior to 1982-2012.

1892-1922 was a period where the northern hemisphere cooled on average. The cooling appears to have occurred at the equator. Latitudes north of the 20-30°N band observed slight warming.

1922-1952 experienced moderate warming in the northern hemisphere. This warming occurred primarily in the mid-latitudes between 20°N and 40°N.

1982-2012 was a period of rapid warming and shows clear signs of polar amplification. The best fit exponential trend is described by the equation $f(x)=0.16 \cdot 1.16x$. Extrapolating this to the higher latitudes where no direct observations are available gives a warming trend of 0.62 and 0.72 C/Decade for the 80-90°N and 90-100°N bands respectively. This is 3.9 and 4.1 times the HADCRUT4 global average of 0.18 C/Decade over the same period [http://www.woodfortrees.org/data/hadcrut4gl/from:1982/to:2012/trend]. The estimates are sensitive to the trend of the 70-80°N band which is comprised of only 28 stations. Additional data could alter the estimates substantially.

Works Cited:

Kevin Cowtan, Robert G. Way, *Coverage bias in the HadCRUT4 temperature series and its impact on recent temperature trends*, Quarterly Journal of the Royal Meteorological Society, DOI:10.1002/qj.2297, 2013

Georg Ohring, Shoshana Adler, *Some Experiments with a Zonally Averaged Climate Model*. Journal of Atmospheric Sciences, vol. 35, Issue 2, pp.186-205, 1978