A Homogeneous Temperature Record for Southern Siberia

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Abstract

A homogeneous temperature record for Southern Siberia is presented. It shows less warming then the CRU record for this region. The difference could be due to the CRU record containing urban warming.

Introduction

One method to determine climate change is to calculate mean surface temperature anomalies from meteorological stations distributed around the world. One of these calculations is made by the Climate Research Unit (CRU) (Jones and Moberg 2003), which also is the compilation preferred by IPCC (Houghton et al. 2001) in its evaluations of climate change. Another important method is to use oxygen spectral lines from satellite observations to obtain mean troposphere and stratosphere temperatures (Spencer and Christy 1990). It is known that these two methods give different trends when comparing them over different areas and the period for which the satellite record exists (Jones et al. 1997). These discrepancies lead to independent checks of the satellite record (cf Wentz and Schabel 1998), and errors were found and corrected for by Christy et al. (2003), who also note that their satellite record is in good agreement with radiosonde records, a third method of measuring temperatures. The discrepancies also lead to a report by the US National Research Council (2000), which concluded that the differences probably are real. Apart from these two possibilities, there is, of course, a third possibility: That the surface record in some location has deficiencies. This study of a small region in Southern Siberia presents a homogenous temperature record for this region, and shows that there could indeed be problems with the surface record.

Analysis

A interesting technique to homogenise temperature data has been developed by Vincent (1998) for the Canadian network of meteorological stations. Undoubtedly, it is a well tested method, since it has successfully been used to construct the Canadian Historical Temperature Database (Vincent and Gullet 1999). This techniques seems, however, to have been used very little in other regions of the world. I have used this technique to homogenise temperature data in a region with a similar climate and a similarly dispersed network of station as Northern Canada: a region around Lake Baikal in Southern Siberia, Russia. The technique was implemented almost precisely as described by Vincent (1998), including the limitations. Specific values of parameters and the small changes made will be described, below.

For this purpose, stations within a region limited in longitude to 90−130 E and in latitude to 40−75 N were chosen. Only stations with at least 33 years of data were selected. This limit is based on the fact that it is generally believed that data spans should be at least 30 years to be able to detect climate change, and that 33 years is three times the solar cycle, which could have a small influence on surface temperatures. This 33 year limit was also used as the smallest possible period for which it is useful to check for inhomogeneities, in case the data set of a station needs to be subdivided in time. Since my implementation of the technique tests on temporal auto−correlations with lags up to 20 years, the records of course needs be considerably longer than 20 years.

In this region, two smaller regions were also defined. The first is called the reference region (95−125E, 45−70 N). Stations within this region were considered to be chosen as reference stations, while stations outside of the region were only used for filling in gaps in station records. The second one is called the mean region (100−120 E, 50−65 N), and stations within this region were also used for calculating the regional mean. In this innermost region the number of stations increased from 8 in 1901 to 23 in 1951 and then decreased to 12 from 1989 to present. Only four stations, those at Irkutsk, Bratsk, Chita and Kirensk, cover the entire 20th century. For all parts of the analysis, a 99% significance level was used.

Another important definition is what should be called a pair of well−correlated stations.

I consider this to be two stations whose monthly mean temperatures could be stated, with the given significance level, to have a correlation coefficient of at least 0.94 over the period for which both stations have data. This value was chosen as a reasonable value out of a visual inspection of the range of such correlations between pairs of stations. Any gaps in the data for a station are filled from stations which are well−correlated with that station. If that fails, data from the station itself could also be used as a last resort. In this region, the gaps were few and the exact way by which infilling is made turned out be of little importance for the final result.

To make the technique more automatic and hopefully objective in the case of choosing good reference stations, a method was developed based on the following reasoning: Any inhomogeneities in the data set of a station could be of different types. A step caused, for example, by site relocation or a sudden change in the vicinity of the station could go in any direction. A trend caused by slow changes in the environment near the station could also go in any direction. A trend caused by urban warming, warming caused by increasing urbanisation at the site, will be positive. A trend caused by urban cooling would be negative, but this is an essentially unknown phenomena and against the general trend of increasing population and economic activity. If the difference between temperatures of two stations without inhomogeneities is calculated, the resulting record will also be without inhomogeneities, unless there is a true difference in climate change between the two stations, which could show itself as a positive or negative trend. If the difference between a station with inhomogeneities and one with a homogeneous record is calculated, the resulting record will have inhomogeneities. Comparing a station without urban warming to a station with urban warming, will make the temperature of the first appearing to have cooled. If the difference between two stations with inhomogeneities is calculated, the resulting record will probably also have inhomogeneities, since it is unlikely that they will cancel out. In case of inhomogeneities in the difference record, it will not be known from the comparison only from where these inhomogeneities originate. If, however, all possible pairs of station are compared, the best reference stations should be those where the set of difference records have the least number of pairs of inhomogeneities not explained by cooling compared to the other station.

Please note that significant urban cooling in single stations will almost certainly be found and corrected for by this slightly modified Vincent technique. Only if urban cooling should turn out to be a common phenomena will there be problems, as it probably also would for any other technique.

That a station was labelled a reference station by this automatic method does not, however, mean that its temperature record was not checked for inhomogeneities. All reference stations were checked against each other with Vincent's method and homogenised. Thereafter all other stations in the reference region were checked and homogenised and the regional mean was calculated from the stations in the mean region. For every station studied, only well−correlated reference stations were used.

Inhomogeneities were checked for and corrected for in monthly means, as well as in four three−month seasonal averages and in annual means. New annual means were calculated, for calendar years (January−December) from corrected **monthly** means, and for meteorological years (December−November) from corrected **seasonal** means. Please note that the latter thus have corrections calculated from three−month averages. Anomalies were calculated relative to the period 1961−1990.

Annual means could be calculated in several ways, e.g. by using only stations which cover the entire period, by also merging stations to create records which cover the entire period, or by simply averaging over all stations available at any time. The two first methods of course have the same number of records at every single year, while the third have a varying coverage of the region. All three methods gives essentially the same result. Only the result from the third, which have the smallest spread, will be used below.

We may also note that three hypothesis could be tested against the available data:

1) The temperature trend in the chosen period and in the chosen region in the CRU dataset is significantly more positive than that calculated by independent means.

2) The temperature trend in the chosen period and in the chosen region in the CRU dataset is significantly more negative than that calculated by independent means.

3) The temperature trend in the chosen period and in the chosen region in the CRU dataset is not significantly different from that calculated by independent means.

Result and discussion

For this region in Southern Siberia, it turned out that the result is different than the result obtained by CRU, no matter what annual mean that is used. The specific version of temperature record used from CRU is the HadCRUT2 version. The result is shown in Fig. 1 for the calendar year annual means. In Fig 2. it can be seen that there is a significant cooling trend compared to the CRU record, both for the calendar year mean and the meteorological year mean. The cooling trend in the period 1901−2002 is 0.33−0.62 K/century for the calendar year data and 0.45−0.76 K/century for the meteorological year data. The relative cooling trend since 1941 is, −0.03−0.34 K/century and 0.08−0.44 K/century, respectively, for the two means. Thus the data support the first of the three hypothesis mentioned above. Before 1901, the number of stations was considered insufficient to calculate the regional mean.

That the meteorological year mean shows a larger trend difference could be explained by the fact that it is based on corrections for entire seasons. The temperature record for a single month of a station could have considerable year−to−year variability, maybe masking inhomogeneities. When averaging over a three−months period, the inhomogeneities could be easier to detect, provided that they affect more than one month.

The reason for the differences, compared to the CRU calculation, is not known, but probably it is because the CRU compilation contains too little correction for urban warming. It is unlikely that the small modifications made to Vincent's method could have created any non−climate cooling trend. There is at least one further reason to believe that the mean region had a very small warming in this period. There is one "rural" location (< 10,000 inhabitants), Kirensk, that have a record which covers the entire period. This record shows no significant temperature change at all.

This result, however, does not necessarily mean that the CRU surface record for the entire globe is in error. The chosen region is, after all, small, and it is possible that it is an exception and that the CRU record does not, in fact, contain any serious errors on the global scale. The result presented here does, however, suggest that the surface record should be checked in more regions and even globally.

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Figure captions

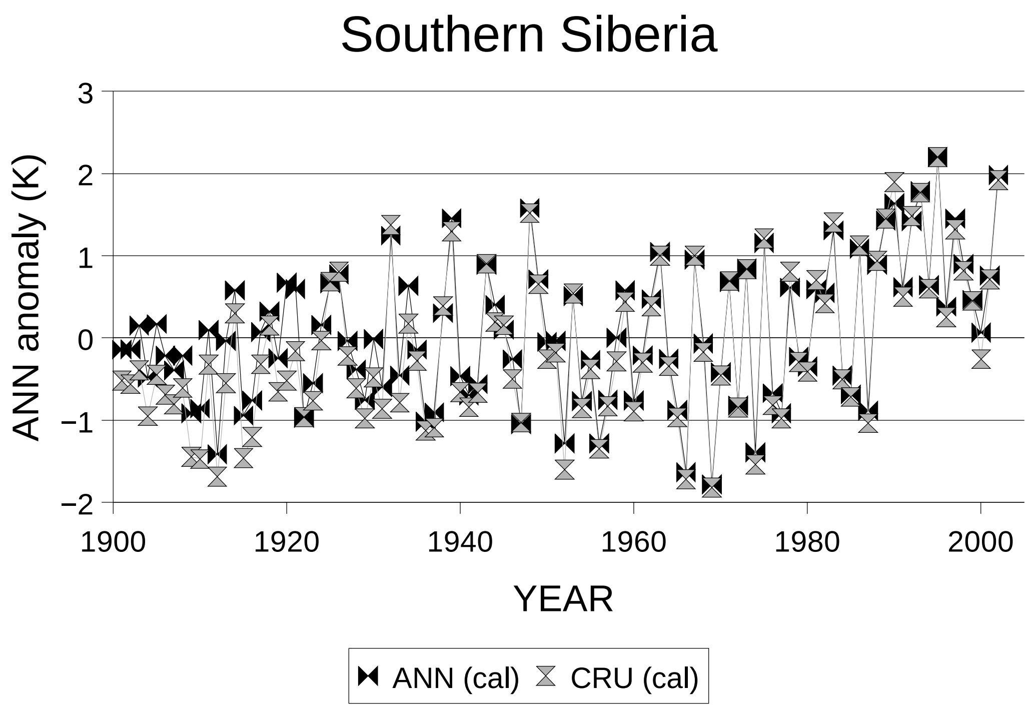
Fig. 1 Temperature history.

The regional annual mean temperature anomaly, compared to the period 1961−1990, in the region 100−120 E/50−65 N as a function of time in this study and from the CRU compilation, for the calendar year mean.

Fig 2. Trend differences.

The difference between annual mean temperature anomalies found for the region 100−120E/50−65 N in this study and from the CRU compilation, for the calendar year mean (cal) and the meteorological year mean (met).

Lars Kamél, Fig. 1



Lars Kamél, Fig. 2.