A Detailed View on Instrumental Temperature Data from Northern Eurasia

Büntgen Ulf[1], David Frank[2], Jan Esper[3]

1 Department of Geography, University of Bonn, Germany ulfbuentgen@gmx.de

2 Tree-Ring Laboratory, LDEO, New York, USA dfrank@ldeo.columbia.edu

3 Swiss Federal Research Institute WSL, Birmensdorf, Switzerland esper@wsl.ch

Motivation

Briffa et al. (1998) describe a reduction in the sensitivity of recent tree growth to temperature at Northern Hemisphere (NH) high latitudes. That paper displays a divergence starting about 1950 between increasing mean summer temperature and decreasing tree-ring density and width for North America and several regions of Northern Eurasia. This phenomenon is significant, because it questions the validity of tree ring width and density records as being a proxy for mid-to-low frequency temperature variability. We believe that a detailed view of the instrumental records of Northern Eurasia will bring more insight to this issue.

Here we analyze the sparse set of meteorological records available for Northern Eurasia by subdividing the area north of 65°N into four study regions: North Europe, West Siberia, Central Siberia, and East Siberia. For these regions, the raw instrumental data and the adjustments made to these measurements by the Global Historical Climatology Network (GHCN) are analyzed. In particular, we searched for urban adjustments that should be made after all other station corrections and adjustments have been completed. Corrections done for urban warming were of particular interest, because increasing temperature trends could additionally be forced by warming effects of urbanized territories. We believe that corrections that do not adequately or fully remove the urban warming effect could account for the discrepancy between the instrumental and tree-ring data.

Introduction

The large number of tree-ring sites in the NH, especially in the boreal zone near the northern timberline, is a valuable network for the reconstruction of paleoclimate (Schweingruber 2002). Tree-ring chronologies can be used as a proxy for past summertime temperature, because the density of wood formed during the late summer and the ring width correlate with local temperatures over the growing season, primarily June, July and August (Briffa et al. 1998). This proxy can provide a detailed history of changing temperatures throughout the last millennium, for local, regional and even hemispheric scales. However, the reconstruction of paleoclimate by using proxy data, such as tree-rings, is closely tied to temperature observations, because the proxy must be calibrated against climate data to estimate the magnitude of past temperature changes.

Briffa et al. (1998) describe a reduced sensitivity of recent tree growth to temperature and show decadally smoothed maximum-latewood density and ring width together with mean summertime temperatures recorded by a sparse instrumental meteorological network. Their paper displays a divergence starting about 1950, between slightly increasing mean summertime air temperature and decreasing tree-ring density and width values. They scaled all data series over the period 1881-1940 to have zero mean and unit variance, except for East Siberia where 1932-1975 was used due to the particular lack of older instrumental records.

Here we analyze the corrections that were made between the raw and the adjusted instrumental data from Northern Eurasia, especially to understand urbanization effects in these time series (Jones et al. 1990). Raw measurements must be individually adjusted because of problems such as shifts in station locations, changes in instrumentation and urban heating influencing the station's environment. Such corrections are made by the GHCN (Peterson et al. 1998, 1999).

One hypothesis is that if effects of urban warming are not properly or fully removed from the instrumental measurements some of the divergence in the low frequency response between the tree-ring and meteorological records as seen in Briffa et al. (1998) can be explained.

Material and Methods

In order to get a detailed view on instrumental meteorological stations in the large region of Northern Eurasia between 65°-75°N, we downloaded both raw and adjusted version 2 GHCN monthly weather station temperature data from the IRI/LDEO Climate Data Library website. Version 2 of the Global Historical Climatology Network is a data set of 7300 monthly mean temperature stations and 5100 monthly mean maximum and minimum temperature stations, which are gathered from 30 data sources (Peterson et al. 1998). To be consistent and clear, we only used the homogeneous raw and adjusted data series that were marked with „ver.0" and did not mix different sources.

After downloading the data from all 23 stations in our study area that had data for at least the period 1950-1980, we classified them by the length of their records and by their surrounding population (**Figure 1**). Seven stations had records that started before 1900, five of which are located in Northern Europe and West Siberia, and only two in the vast expanse of Central and East Siberia. Following GISS (Goddard Institute for Space Studies) conventions, the 23 instrumental meteorological stations were classified as urban (pop. > 50,000), suburban (pop. > 10,000) and rural (pop. < 10,000) (Hansen et al. 1999, 2001).

The large size of the study area near the northern timberline prevents us from handling it as a single region. Based on station correlation matrices for the raw and adjusted data series, the 23 stations were subdivided into 4 geographical regions (Northern Europe; West Siberia; Central Siberia and East Siberia). These four regions are similar to the division of Eurasia as done by Briffa et al. (1998). For Northern Europe, in addition to the Russian meteorological stations, we also obtained records from Sweden – Haparanda, the longest record measuring since 1875 – Norway, Karasjok – and Finland, Sodankyla.

For each of these 4 regions, the raw and adjusted normalized June, July and August temperature trends of the individual stations as well as the regional average trend curves are shown (**Figure 2**). All data are normalized over the period 1951 – 1980, because every station is represented in this 30-year window. The normalization was done to avoid the dominance of a single month when averaging together and comparing June, July and August monthly temperature records. To make sure that no bias is introduced when normalizing over only 30 years, we also normalized different stations over their entire individual length, but received similar temperature trends and relationships between raw and adjusted series.

To reach a more precise understanding of the way the GHCN adjusts raw data, the difference of adjusted minus raw summer temperature for each station records were calculated. We did not use the normalized data to show real adjustments in C°. **Figure 3** shows the adjusted minus raw data for the four stations classified as urban in our study area.

Discussion

Figure 1 shows that both lengths and spatial distribution of meteorological stations decrease from west to east in the high northern latitudes of Eurasia. This fact influences the meaningfulness of average meteorological station records out of sparsely covered regions such as Northern Eurasia. Only three meteorological stations in the region of 65° - 75°N reach back to 1881. Especially when doing analysis with gridded temperature data, a single station can have a huge impact on a large area in data sparse regions such as Northern Eurasia, because they generally represent weighted averages of only few station records.

Plots of the normalized individual raw and adjusted series, and their means (**Figure 2**) for the four regions, do not reveal a consistent or clear relationship between raw and adjusted series. The means of the adjusted and raw series are fairly similar, except towards the earlier parts of the instrumental record, where significant differences occur. Here, there are fewer data series making the mean sensitive to adjustments made to individual stations. This early portion of the record is critical to understand the lower frequency trends in the instrumental records during the late 19^{th} and 20^{th} centuries and further illustrates the limited nature of the instrumental data available.

Similarly, differences between raw and adjusted series for the four urban stations do not reveal consistent results (**Figure 3**). If adjustments to correct for urban warming were carried out, we would expect to see a negative slope for the adjusted minus raw data. However, trend lines for the Haparanda and Kandalaksa stations yield positive slopes. No adjustments were made to the Dudinka station summer temperatures. Only the Murmansk station indicates a general downward correction. These results suggest either a dominance of other corrections that mask those done for urban warming or might simply indicate the absence of adequate corrections to account for urban warming. Similar graphs for all stations (not shown) do also not reflect corrections for urban warming, independent of their surrounding population. We could not detect any uniform adjustment-pattern based on the three population classifications (Urban, Suburban and Rural), that relates to the individual size of the settlement where the meteorological station is located.

In summary, when focusing on the way the GHCN adjusts raw instrumental data, no intuitive adjustments were found that might relate to eliminate effects of urban warming. We believe the sparse distribution of meteorological stations between 65°N and 75°N in Eurasia, the general and rigid classification (urban, suburban, and rural) and the way adjustments are done or even not, provide some uncertainty to the 'true' climate of Northern Eurasia. Potentially, some of the low frequency divergence between tree ring and instrumental data can be explained by inadequate or missing corrections. We plan to further analyze the discrepancy between tree ring and instrumental records in the Northern Eurasian sector.

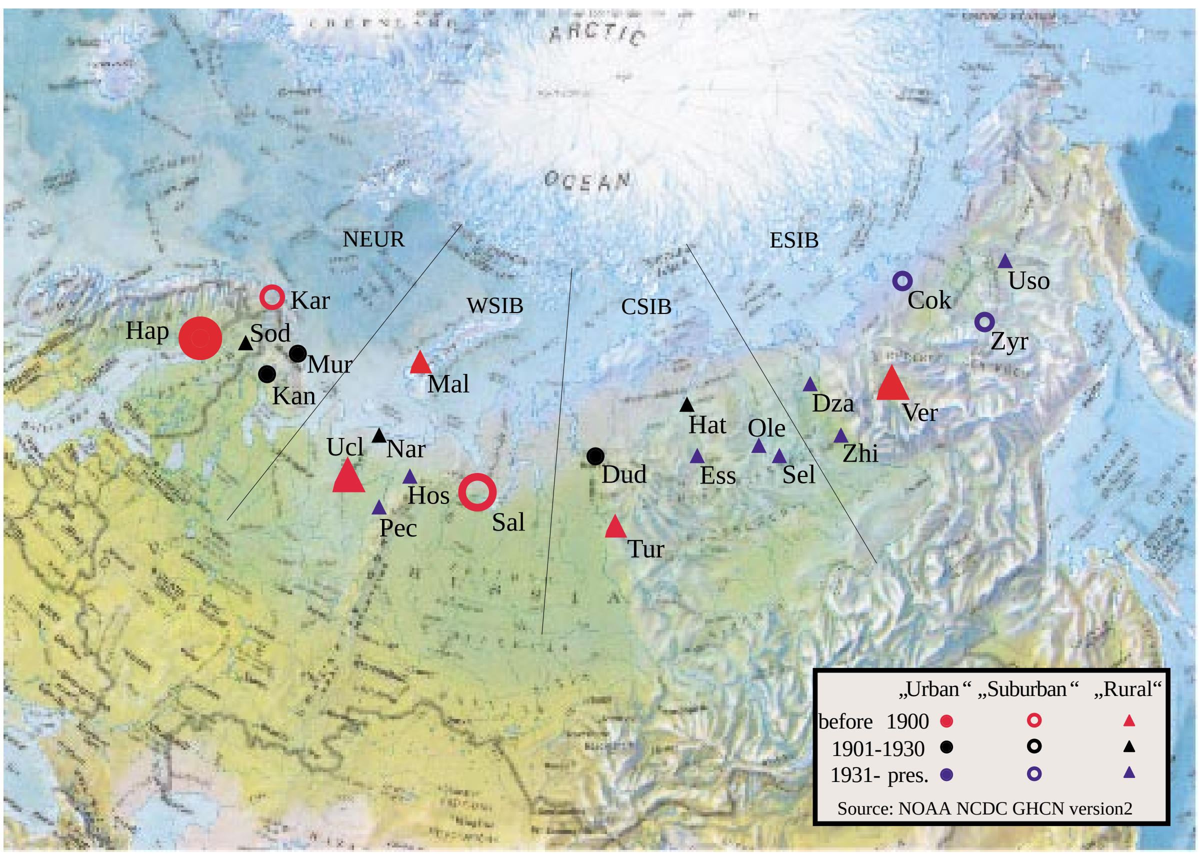
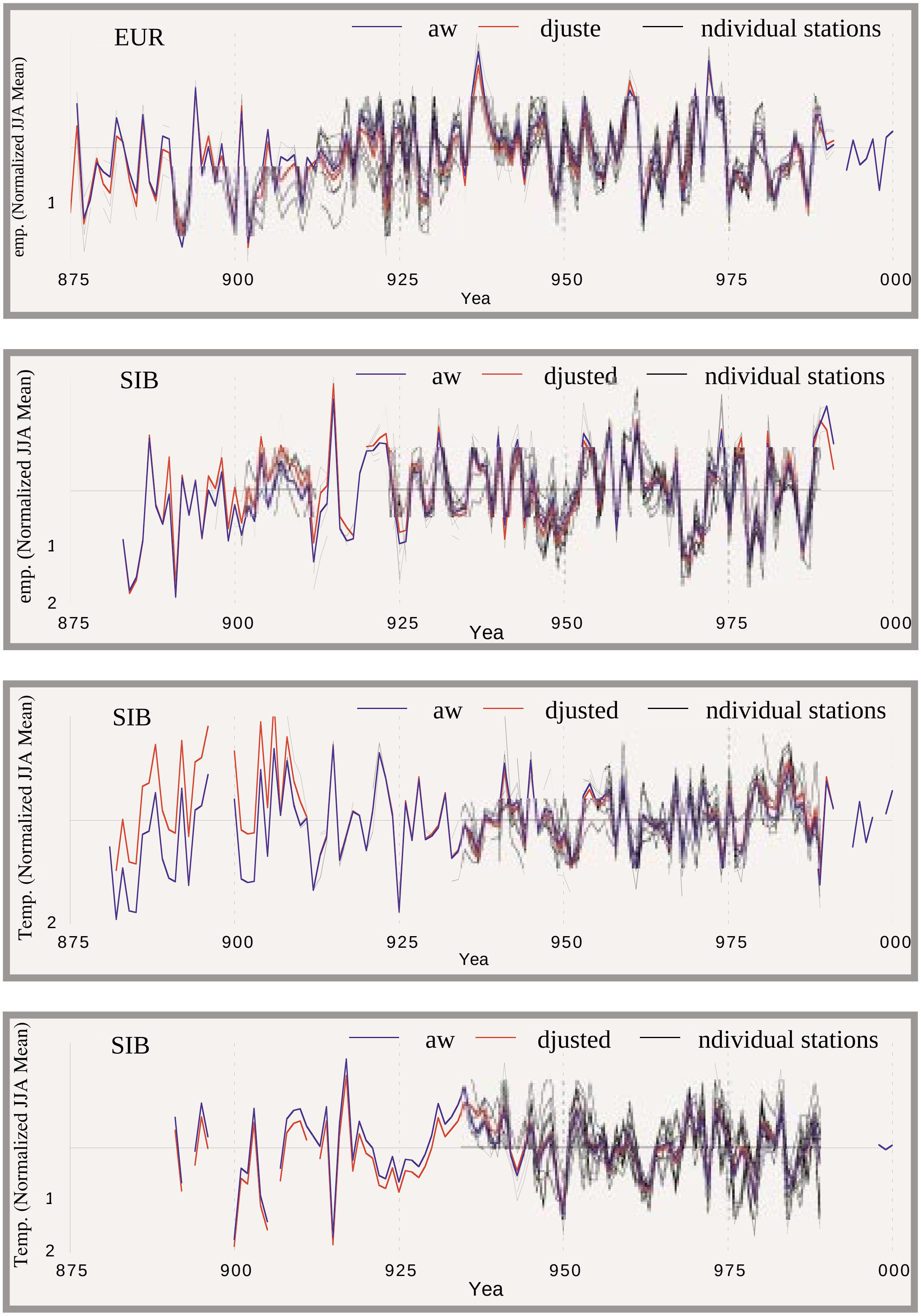
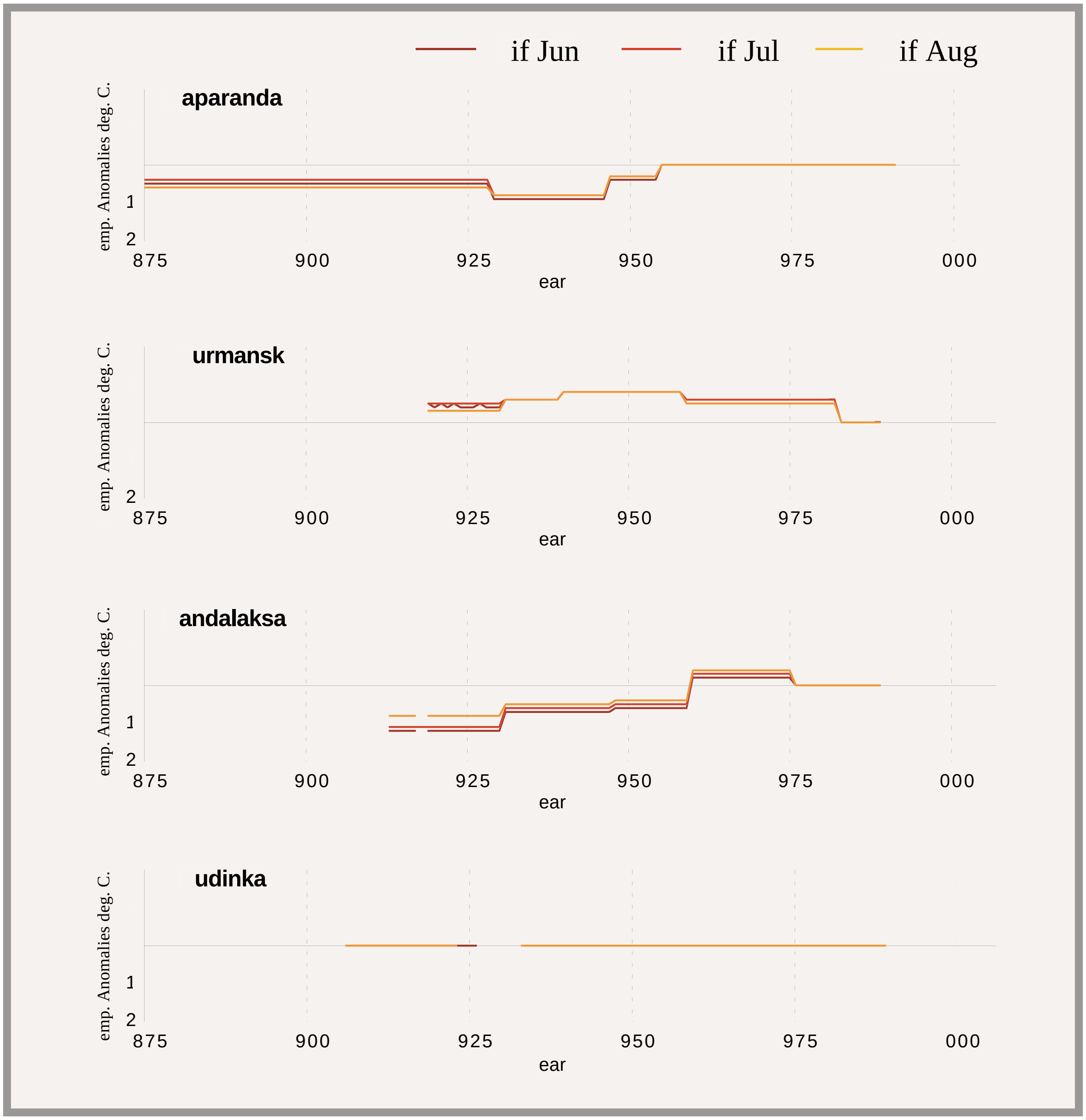


Figure 1. Locations of the 23 meteorological stations used in our study. These stations were classified according to the length of record and population setting. The four sub-regions are also shown: NEUR=Northern Europe; WSIB=Western Siberia; CSIB=Central Siberia; ESIB=Eastern Siberia.



igure 2 Plots of raw and adjusted normalized JJA mean temperatures for the four sub-regions. NEUR=Northern Europe; WSIB=Western Siberia; CSIB=Central Siberia; ESIB=Eastern Siberia. Individual station records (thin black lines), and regional means for both the raw (thick blue lines) and adjusted (thick red lines) are shown.



igure 3 Adjusted minus raw values for the months of June, July and August for each of the four urban stations in the study area. In the absence of other factors, adjustments for urban warming would result in lines of negative slope when differences are calculated in this way. No adjustments were made to the summer Dudinka record.

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