

Temperature trends in Baltic Sea region between 1901-2010

The goal of this paper is to find out how temperature near Baltic Sea has changed since the beginning of 20th century. To accomplish this we analyze historical temperature records from several stations around Baltic Sea. All the data is taken from Climate Time Series Browser (CTSB) [1]. Stations had to match 3 conditions:

1. less than 300 km from the Baltic Sea,
2. data coverage of at least 80% during goal period,
3. having at least some data for each decade.

Haparanda, Helsinki/Seutula, KobenHavn, Potsdam, St.Peterburg¹, Tallinn and Vilnius are matching these criteria (figure 1). The only acceptable station in Sweden is Haparanda leaving west coast uncovered. Most of the gaps in chosen data are less than four straight years with one exception: 1913-1918 in Tallinn.

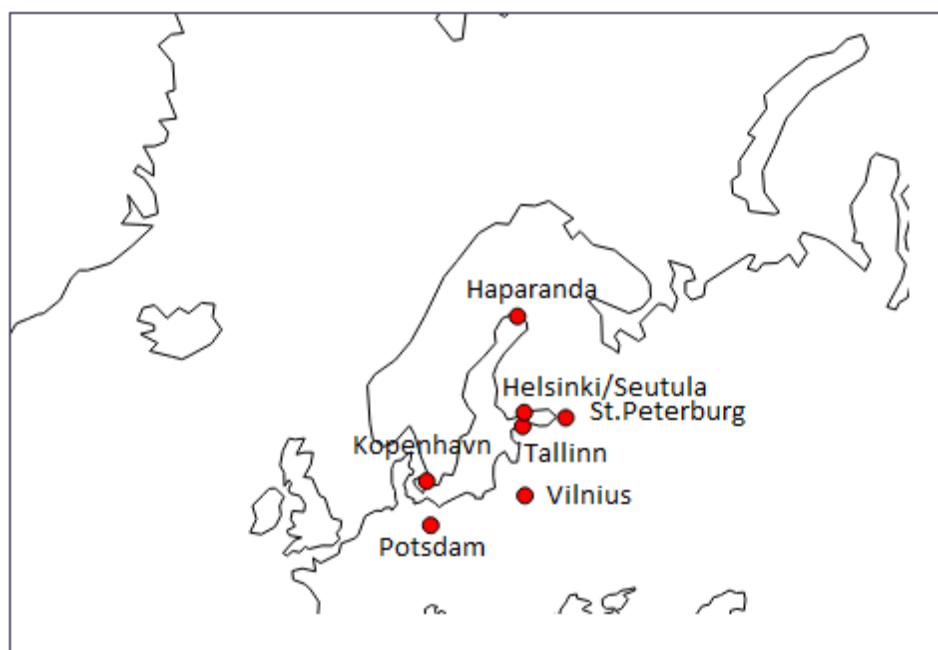


Figure 1. Stations selected for analysis.

¹ Spelling "mistake" is deliberate. The name of the city is St. Petersburg, but in the time series browser the name of the station is St.Peterburg.

Station	1900-1950 avg
Haparanda	1.08
Helsinki/Seutula	4.39
Kobenhavn	7.95
Potsdam	8.52
St.Peterburg	4.46
Tallinn	5.01
Vilnius	5.50

Table 1. Average (mean) temperature for each station between 1900-1950.

Since we have several missing values over the years in our dataset we have to normalize each station to its 1900-1950 average and we analyze temperature anomalies instead of actual temperature values [2]. Seasonal temperatures are normalized to yearly averages (instead of seasonal averages) as well. Actual measured temperatures can be several degrees higher depending on station. See 1900-1950 averages for each station in table 1.

I used meteorological definition of seasons meaning summer is during whole months June, July and August and winter is during whole months December, January and February [3]. Average temperature for season is calculated using monthly averages weighted by days. Exact formulas are as follows:

- $T_{spring} = \frac{(31T_{Mar} + 30T_{Apr} + 31T_{May})}{92}$,
- $T_{summer} = \frac{(30T_{Jun} + 31T_{Jul} + 31T_{Aug})}{92}$,
- $T_{autumn} = \frac{(30T_{Sep} + 31T_{Oct} + 30T_{Nov})}{91}$,
- $T_{winter} = \frac{(31T_{Jan} + 28T_{Feb} + 31T_{Dec})}{90}$ or $T_{winter} = \frac{(31T_{Jan} + 29T_{Feb} + 31T_{Dec})}{91}$ for leap years.

Winter months are taken from the same year.

Next I calculated average annual temperature and average season temperature for each decade. The results displayed in Table 2 show relatively stable normalized annual average temperature during first three decades in 20th century rising from -0.30°C to -0.16°C . Following decades (1931-1960) are warmer (0.47°C , 0.10°C , 0.01°C) with 1930s being the warmest decade before 1980s and highest summer average (10.97°C) before 1990s. During 1960s we see warmest autumns (3.90°C) and coldest winters (-10.92°C) of the century. Average annual temperature dropped to 1920s level (-0.16°C).

Starting with 1970s we see steady increase in annual averages (between $0.24^{\circ}\text{C}/\text{decade}$ and $0.59^{\circ}\text{C}/\text{decade}$). During the decade average spring (-0.85°C) and winter (-9.17°C) temperatures are higher than ever before. Summers were also warm being only second to 1930s (10.8°C compared to 10.97°C). A decade later average spring temperature rose even further reaching -0.09°C with annual average reaching 0.57°C .

1990s show average summer temperature exceeding 11°C for the first time (11.04°C). The winters are even more remarkable averaging at -7.63°C . Annual average rose to 1.10°C . Warming continued during 2000s. Although average winter temperature dropped to -8.32°C , spring, summer

and autumn averages are record breaking: 0.41°C, 11.51°C and 4.82°C respectively. Annual average reaches 1.41°C being almost 1°C higher than any decade before 1980s.

	Year	Spring	Summer	Autumn	Winter
1901-1910	-0.30	-1.68	9.65	0.61	-9.48
1911-1920	-0.19	-1.39	9.77	-0.34	-9.64
1921-1930	-0.16	-1.31	9.98	1.57	-9.80
1931-1940	0.47	-1.27	10.97	3.54	-9.30
1941-1950	0.10	-1.44	10.50	2.51	-10.03
1951-1960	0.01	-1.80	10.64	2.51	-9.57
1961-1970	-0.16	-1.34	10.53	3.90	-10.92
1971-1980	0.33	-0.85	10.80	1.62	-9.17
1981-1990	0.57	-0.09	10.54	3.56	-9.41
1991-2000	1.10	0.02	11.04	2.93	-7.63
2001-2010	1.41	0.41	11.51	4.82	-8.32
Average	0.29	-0.97	10.54	2.47	-9.39

Table 2. Average annual and seasonal temperatures normalized with 1900-1950 average for decades between years 1901-2010.

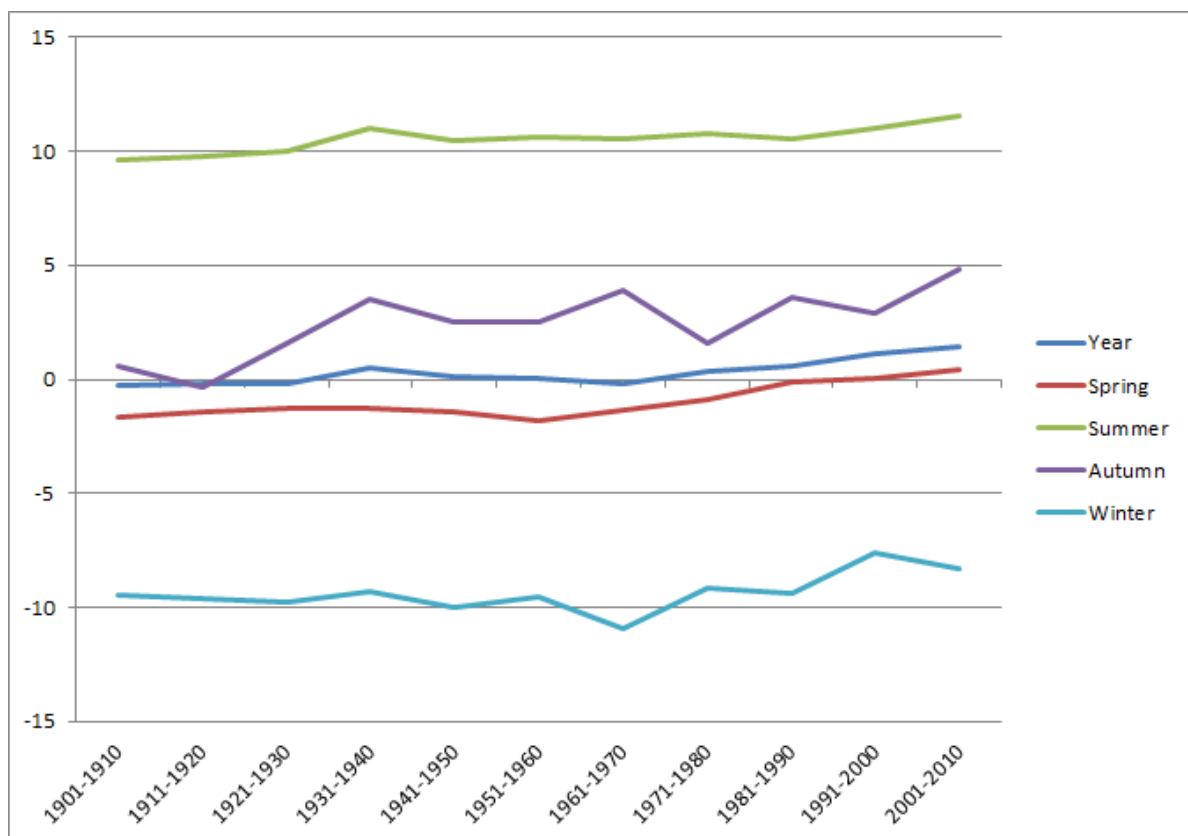


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References

1. Climate Time Series Browser with selected stations:
<http://climatemodels.uchicago.edu/timeseries/#JgeEWCrIvGdEs>
2. Question 7. Why use temperature anomalies?
<http://www.ncdc.noaa.gov/cmb-faq/anomalies.php>
3. Meteorological Versus Astronomical Summer—What's the Difference?
<http://www.ncdc.noaa.gov/news/meteorological-versus-astronomical-summer%E2%80%94what%E2%80%99s-difference>