Temperature Variations in Europe and North America since the Beginning of Instrumental Observations

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With the intention of an analysis, *19* climatological stations have been selected which are in possession of an annual mean temperature series longer than two hundred years (*Table I*). The running 9-year mean temperatures have been used in order to determine the coincidences of the warmings and coolings at different stations in central, western and northern Europe, as well as in the eastern USA. Several short periods were found with simultaneous maxima or minima in many different locations. Comparing these periods with volcanic activity, it is pointed out that the temperature minima are close to high volcanic activities, and temperature maxima to calm volcanic episodes. It has been also found that in *8* stations out of *18* temperature maxima before *1880* were higher than those after *1880*. It is likely that the global mean temperature had relatively low value around *1880*.

Hőmérséklet-változások Európában és Észak-Amerikában a műszeres észlelések kezdete óta. 19 klímaállomást választottunk ki elemzés céljára, amelyek kétszáz évnél hosszabb évi középhőmérsékleti sorozattal rendelkeznek (*I. táblázat*). A hőmérsékleti adatok *9*-éves simított értékeit használtuk, hogy meghatározzuk a melegedések és lehűlések egybeesését különböző állomásokon Közép-, Nyugat- és Észak-Európában, továbbá az USA keleti részén. Több olyan rövid időszakot találtunk, amelyeket a különböző helyek egyidejű maximum vagy minimum hőmérséklete jellemez. Összehasonlítva ezen időszakokat a vulkáni tevékenységgel, kimutatható, hogy a hőmérsékleti minimumok erős vulkánossághoz, a maximumok csendes vulkánossághoz közeli években fordultak elő. Megállapítottuk azt is, hogy *18* állomásból *8*-ban *1880* előtt a hőmérsékleti maximumok magasabbak voltak, mint *1880* után. Valószínű, hogy a globális középhőmérséklet *1880* körül viszonylag alacsony volt.

Introduction

It is widespread known, that the global mean temperature of the Earth has increased by cca *0·5* K since *1880*-s (**Lockwood, 1986**; **Götz, 1983**; **Brazdil, 1987**). The warming has been as much as *0·8* K in the northern hemisphere, and reached its peak in years *1938—40*. Hence many authors concluded, that this warming is the response of the atmosphere to increasing CO_2 after beginning of industrialisation and technical development from late *19*-th century (**Energy and Climate, 1977**; **Budyko, 1982**). Moreover according to numerical climate model experiments the global warming may reach *2—5* K by *21*-st century, if the increase of atmospheric CO_2 will continue with present rate (**Bach, 1991**). This warming may result in shifts of climatic zones.

However the question is, whether the temperature variations could be explained by means of a single factor, namely the change of atmospheric CO_2 and other greenhose-gases (CH_4, N_2O, etc.). It is also well known, that the energy flux density of anthropogeneous sources in area as large as *100—1000* km^2 (megapolises, industrial centers) approaches the net solar radiation density, which is about *100* W/m^2 (**Lockwood, 1986**; **Koppány, 1989**). On the other hand many climatic stations are located in area with dense population. Thus at least a fraction of the global warming is apparent, and is consequence of urbanization.

It is also noteworthy, that the global mean temperature decreased by cca *0·3* K from *1940* to *1979*, while the cooling in this period in northern hemisphere was as much as *0·5* K. This fact suggests, that the atmospheric temperature is influenced by other factors besides the greenhouse affect, since the atmospheric carbondioxide has grown after *1940* continuously.

Therefore it is reasonable to investigate temperature series of length more than *100* year in order to deside: whether significant warmings took place before *1880*, too, and if yes, then these preindustrial warmings were higher or lower, than those in *20*-th century. *19* climatic stations were selected possessing more or less continuous temperature series started early *19*-th century or further back. The records available from these stations are insufficient for calculation mean global or hemispheric temperature variations. Still the early instrumental measurements might provide some information on regional temperature changes occured in last *2* or *3* centuries, mainly from great part of Europe, and from eastern United States.

Data sources

The temperature records have been taken mostly from Bracknell data basis up to *1960* in form of magnetic tapes. Some additional series were obtained from **C. D. Schönwiese**, Goethe University of Frankfurt am Main, among others the records of Central England (**Schönwiese, 1988**), and the data of period *1961—70* from **World Weather Records**. The series of Budapest since *1780* are available in **A. Réthly**'s work (**Climate of Budapest, 1947**), and in file of the Hungarian Meteorological Service. The list of climatic stations is presented in *Table I*.

The majority of stations (*14*) is located between 46—56°N latitudes, i.e. in moderate zone, three stations are in subtropical zone, and two stations in subpolar zone, respectively. *16* stations have continuous temperature series, two stations have interrupted series (Charleston and Copenhagen), in these cases either only the continuous part was used or the short interruptions were completed by interpolation. The records of Prague from *1939* to *1950* were added to those obtained from Bracknell.

Table I Geographical positions and observation periods of climatic stations

Central England	52·8°N	2·5°W	1659—1987
De Bilt	52·6°N	5·1°E	1706—1970
Charleston (USA)	32·9°N	80·0°W	1741—1759 1823—1965
Edinburgh	55·9°N	3·2°W	1764—1970
Basel	47·6°N	7·6°E	1755—1970
Genf	46·2°N	6·2°E	1753—1970
Trondheim	63·4°N	10·4°E	1761—1969
Stockholm	59·4°N	18·0°E	1757—1970
Koppenhága	55·6°N	12·5°E	1768—1776 1782—1788 1798—1970
Greenwich	51·5°N	0·0°	1763—1970
Berlin	52·6°N	13·4°E	1769—1970
Párizs	48·8°N	2·5°E	1764—1970
Prága	50·1°N	14·4°E	1771—1989
New Haven (USA)	41·3°N	72·9°W	1781—1970
Hohenpeissenberg	47·8°N	11·0°E	1781—1970
Bécs	48·3°N	16·4°E	1775—1970
Budapest	47·5°N	19·0°E	1780—1970
Kremsmünster	48·1°N	14·1°E	1796—1985
Genova	44·5°N	3·5°E	1833—1986

Method and results

As a first step decadal mean temperatures were calculated for all available climatic stations. By analyzing such rough materials sinchronous warmings or coolings appeard in some stations, e.g. the decade of **1731—40** proved warm both in Central England and De Bilt with positive decadal temperature anomaly (*+0·4*°C). Similar relative **warming** occured in **1791—1800** at twelf stations, in **1861—70** at eleven stations etc. On the other hand relatively great **negative anomalies** were found in **1811—20** at eight stations, in **1881—90** at 13 climatic stations etc.

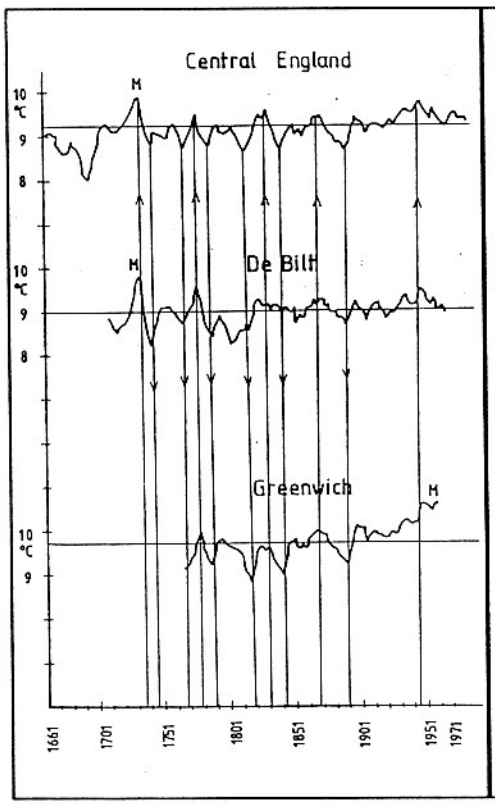

Figure 1 *Running 9-year mean temperature since the beginning of instrumental observations at Central England, De Bilt, Greenwich*

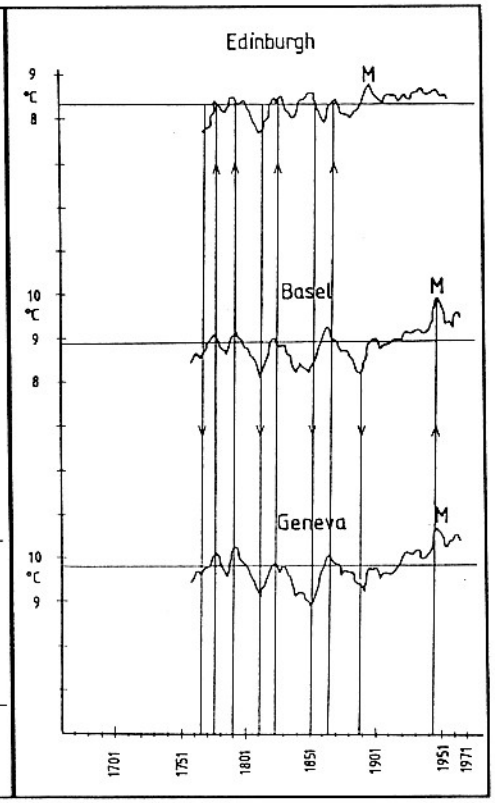

Figure 2 *The same for Edinburgh, Basel, Geneva*

In order to get more exact dates of local warming and cooling at various stations running *9*-year averages were determined. Further on the standard devitions of *9*-year mean temperatures and the mean values of the whole series were also calculated for each station. The secular temperature variations are presented in *Fig. 1—6*. The arrows directing upwards denote warming, „M" marks the maximum

value in whole series of a given station, the arrows directing downwards denote cooling. One can recognize **sinchronous maxima** in some stations in periods of *1772—79*, of *1790—94*, of *1822—30*, of *1859—65*, of *1893—97*, of *1930-s* and *1940-s*. On the other hand **minima** can be found in some stations in periods of *1767—70*, of *1812—16*, of *1836—41*, of *1888—91*, of *1903—05* and of *1960-s*.

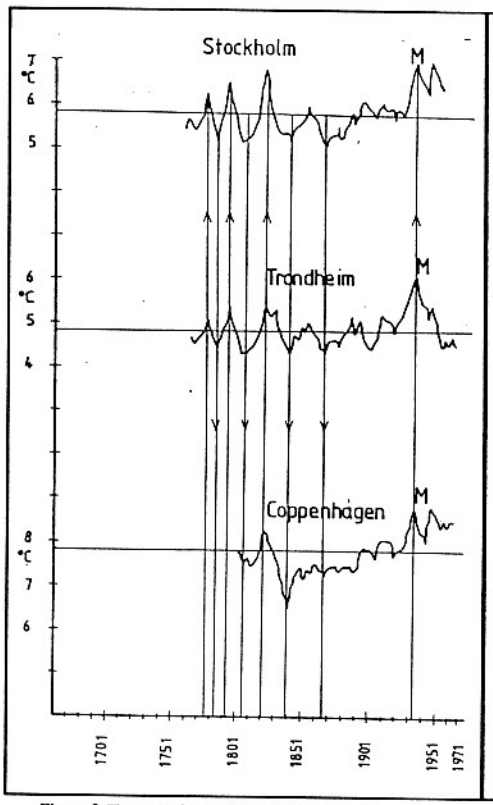

Figure 3 *The same for Stockholm, Trondheim, Copenhagen*

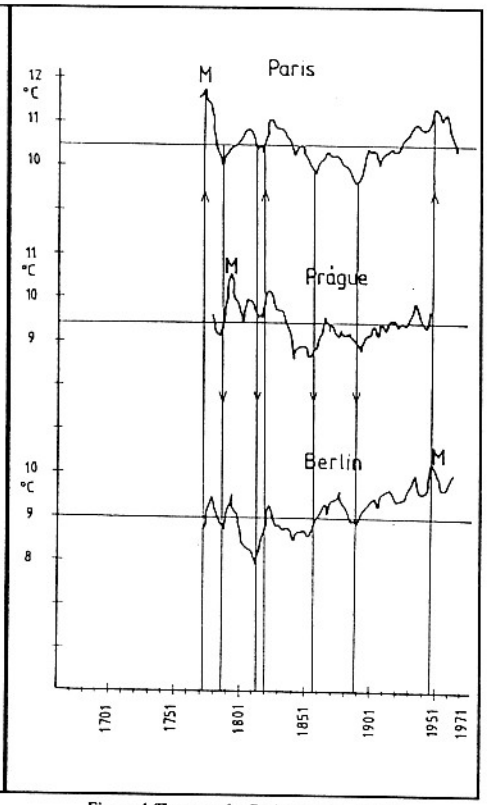

Figure 4 *The same for Paris, Prague, Berlin*

Schönwiese (1988) has found significant negative correlations between the mean temperature of northern hemisphere and several kinds of volcanic indices. In *Fig. 7* the spells of sinchronous warmings and coolings are presented during the period of *1731—1970* (above), while the dust vail index (DVI) is shown below since *1750*, with the names of greater volcanic eruptions. According to DVI there were calm volcanic periods in 1. *1770—80*, 2. *1790—1810*, 3. *1820—31*, 4. *1845—1880*, 5. *1913—1962*. These calm periods coincided with the years of temperature maxima mentioned above. Uncommonly long **volcanic silence** appeard between *1912* and *1963*, wich coincided with the significant warming in *20*-th century. **Strong volcanic activities** were registrated in the northern hemisphere: 1. around

1756 and **1785** (Laki, Iceland), respectively, 2. between **1815** and **1822** (Tambora), 3. in years **1875—83** (Krakatau), 4. around **1902** and **1912**, respectively (Sta Maria, Katmai), 5. and after **1963** (Agung). The coincidences of active volcanic spells with coolings in majority of climatic stations are evident in *Fig. 7.*

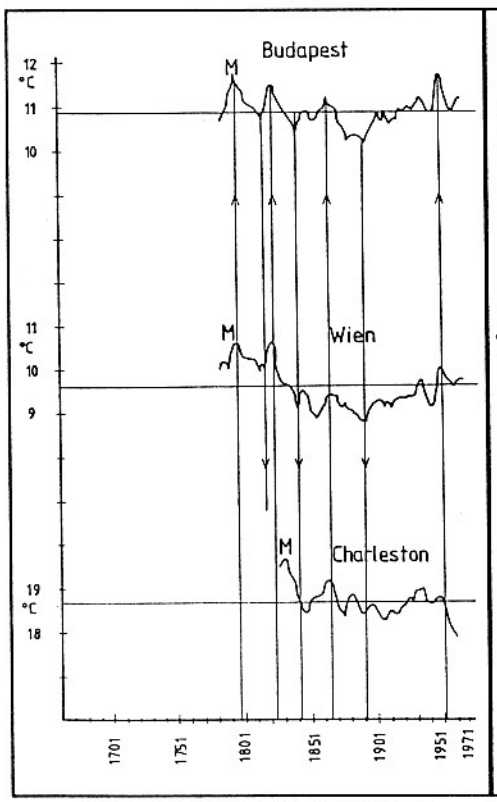

Figure 5 *The same for Budapest, Wien, Charleston*

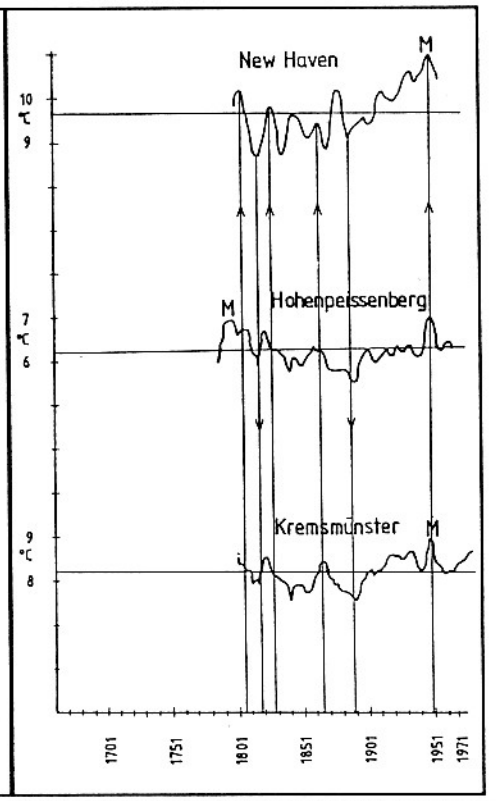

Figure 6 *The same for New Haven, Hohenpeissenberg, Kremsmünster*

One of the main purpose of this study is to investigate the temperature maxima before *1880* and to decide the evidence of warmer periods comparing with those in the *20*-th century. *Table II* contains the highest running *9*-year mean temperature anomalies at each stations, before and after *1880*. In the first column one can find the mean annual temperature for the whole series and the standard deviation of running *9*-year averages (s), respectively. In the second column the maxima years are shown with the annual temperature anomalies in form of ratio k = anomaly/standard deviation i.e. signal/noice, both concernd the warmings before *1880*.

Table II The warmest running 9-year mean temperature

Station	t°C	s°C	before	1880 (k)	after	1880 (k)	Δt°C
Basel	8·9	0·38	1794 1865	+0·87 +1·18	1947	+2·95	+0·67
Berlin	8·9	0·36	1794 1876	+1·44 +1·69	1947	+1·28	-0·5!
Budapest	10·9	0·33	1794	+2·52	1949	+2·45	-0·2!
Charleston	18·7	0·35	1831	+2·86	1935	+0.94	-0·7!
New Haven	9·7	0·59	1790	+1·57	1949	+2·19	+0·73
Central England	9·25	0·33	1734 1830	+2·36 +1·33	1947	+2·0	-0·12!
Coppenhagen	7·8	0·49	1822	+1·04	1947	+2·2	+0·57
De Bilt	9·0	0·30	1733 1777	+2·87 +2·03	1947	+2·1	-0·23!
Edinburgh	8·3	0·26	1794 1854	+0·65 +1·19	1936	+1·65	+0·12
Geneva	9·8	0·38	1794	+1·32	1947	+2·53	+0·46
Genova	15.7	0·36	1865	+2·50	1946	+1·67	-0·30!
Greenwich	9·7	0·39	1779	+0·69	1897 1947	+1·05 +2·38	+0·66
Hohenpeissenberg	6·2	0·33	1793—94	+2·39	1949	+2·45	+0.02
Kremsmünster	8·2	0·31	1800 1822 1863	+1·13	1947	+2·45	+0·41
Paris	10·5	0·46	1771—72	+2·67	1949	+1·76	-0·42!
Prague	9·5	0·52	1793	+2·11	1949	+1·35	-0·40!
Stockholm	5·8	0·48	1794 1822	+1·48 +2·08	1947	+2·67	+0·28
Trondheim	4·8	0·37	1794 1822	+1·43 +1·49	1934	+3·38	+0·7
Wien	9.6	0·50	1798	+2·18	1949	+1·04	-0·57!

The third column contains the same characteristics but after *1880*, while in fourth column Δt denotes the difference: maximum annual temperature in *20*-th century — maximum annual temperature before *1880*. If this difference is positive that means relative warming in the *20*-th century, if it is negative, then stronger warming took place in period before *1880*. The latter cases are marked with „!". Nine stations out of *19* have proved relative greater warming before *1880*, among others Charleston and Prague (*-0·67*°C), Paris (*-0·42*), Wien (*-0·57*), De Bilt (*-0·23*), Genoa (*-0·25*) etc.

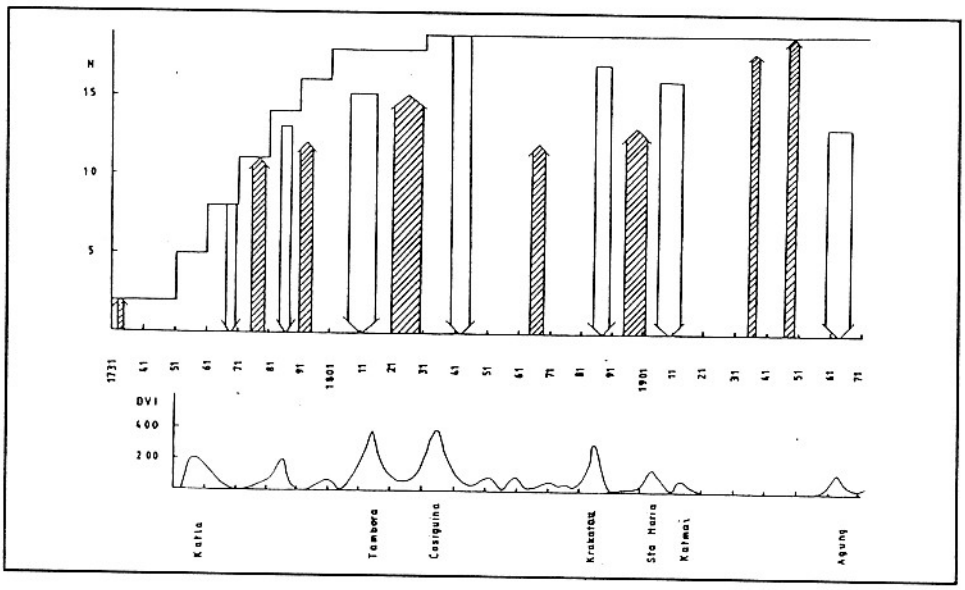

Figure 7. Above: Number of climatic stations (N) possessing temperature data after 1731; arrows upwards denote the number of stations with simultanous maxima, downwards denotes the number of stations with sinchronous minima. Below: Dust veil index with the names of significant volcanic eruptions

Hence it seems, that there took place significant warmings in *18*-th and *19*-th century, too, before increase of atmospheric carbon-dioxide due to industrialization. **(Keil, 1961)** analyzing long temperature series of Basel, Hohenpeissenburg, Jena and Prague, has got similar consequences even by using *30—40—50—60* year smoothed temperature data.

After maxima in *1930-s* or *1940-s* universal cooling was observed by *1950-s* or *1960-s* in all stations (*Table III*). The ratio k = (change from maximum to minimum)/standard deviation exceeds unit at *16*, exceeds *2* at *7*, exceeds *3* at *2* stations.

Table III

	Highest running 9-year temp. in the 20-th century		The following minimum		Cooling after 1930-s or 1940-s	
Station	Year	°C	Year	°C	°C	k
Central England	1947	9·8	1966	9·2	-0·6	-1·91
De Bilt	1947	9·6	1966	8·9	-0·7	-2·37
Greenwich	1947	10·7	1954	10·5	-0·2	-0·51
Edinburgh	1936	8·8	1954	8·4	-0·4	-1·23
Basel	1947	10·0	1959	9·3	-0·7	-1·79
Genf	1947	10·7	1954	10·2	-0·5	-1·26
Stockholm	1947	7·1	1954	6·3	-0·8	-1·56
Trondheim	1934	6·1	1954	4·4	-1·7	-4·49
Coppenhagen	1947	8·9	1966	8·3	-0·6	-1·14
Paris	1949	11·3	1966	10·2	-1·1	-2·37
Prague	1949	10·2	1959	9·5	-0·7	-1·35
Berlin	1947	9·4	1958	8·7	-0·7	-1·89
Budapest	1949	11·7	1958	10·9	-0·8	-2·45
Wien	1949	10·1	1959	9·6	-0·5	-1·0
Charleston	1935	19·0	1959	17·9	-1·1	-3·26
New Haven	1949	11·0	1956	10·4	-0·6	-1·03
Hohenpeissenberg	1949	7·0	1966	6·1	-0·9	-2·82
Kremsmünster	1947	9·0	1959	8·1	-0·9	-2·74
Genova (1833—1982)	1946	16·3	1958	15·4	-0·9	-2·50

Conclusions

1. The temperature series longer than *100* year exhibit minima in period *1886—1891* in majority of climatic stations (see *Fig. 7*).

2. Numerous temperature maxima found before *1880*, and in *45%* of stations these maxima are higher, than those in *1930-s* or *1940-s*.

3. The warming in *1930-s* or *1940-s* coincides with longest calm volcanic period since *1750*.

4. A uniform cooling took place by *1950-s* or *1960-s*.

5. In light of these facts the global temperature variations may not be explained exclusively with greenhouse effect.

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