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3. AIR TEMPERATURE IN WROCŁAW (BRESLAU) IN THE PERIOD 1710-1721 BASED ON MEASUREMENTS MADE BY DAVID VON GREBNER

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INTRODUCTION

The history of early-instrumental meteorological observations in Poland is quite rich and is among the longest in the world. The first observations were made in Warsaw in late 1654 or early 1655, while the temperature series described and analysed here is the second oldest instrumental series in Poland. Temperature and atmospheric pressure observations were made in Wrocław (Breslau, nowadays south-west Poland) from April 1710 to December 1721 by the physician David von Grebner and both series are now the longest surviving Polish series of their kind (Grebner 1723, for more details see also Przybylak 2010).

David von Grebner used the Florentine thermometer (Thermometrum Academiae Florentinae), which had a brass scale with a star in the middle, above which were 80 degrees and below which were 100 degrees (Landsberg 1983). The results of his observations are available in unpublished form in the Library of Wrocław University. For purposes of comparison, another Wrocław physician – Johann Kanold (1679-1729) – began meteorological measurements in Silesia (e.g. Wrocław, Oława, and Legnica) and in other European countries in 1717. He recorded measurements in Wrocław up to 1726, and then from 1727 to 1730 they were continued by Andreas Elias Büchner (1701-1769), a professor of medicine at Wrocław University (Brázdil and Valášek 2002, Munzar 2003, Brázdil *et al*. 2008). These included measurements of air temperature, air pressure, wind direction and general descriptions of weather. Measurements were taken three times a day and the results were published in an encyclopaedic series *Sammlung Von Natur- und Medicin-, Wie auch hierzu gehörigen Kunst- und Literatur-Geschichten* (the so-called *Breslauer Sammlung* – Wrocław Collection).

In the early-instrumental measurement period observers used thermometers with unknown individualised scales which are difficult to convert to the scales used in present-day instruments. That is why comparison of temperature changes between historical times and the present-day is rather difficult. At the first half of

the 18th century all over Europe, thermometers based on the Florentine thermometer (Magnum Thermometrum Academiae Florentinae) have often been used. However, these instruments were different from those originally constructed in Italy. For example, in Europe (including Italy) Florentine thermometers with 180-degree, 200-degree or even with 360-degree scales were used (Middleton 1966, Quinn and Compton 1975). Moreover, the two fixed points used in the construction of today's thermometers (freezing and boiling points) were not used in these thermometers. That is why, even comparison of temperature measurements made by different thermometers of the same type can be impossible, if the instruments were not identical and more research is still needed to solve the problem of converting the old scales to new ones. Some work has already been done on this issue (e.g. Camuffo 2002a, 2002b, Cocheo and Camuffo 2002), however, similar investigations are needed for other copies of thermometers. At present the only way we can compare the historical and present climate is by using the index method for available temperature measurements (for more details about this method see, e.g. Pfister 1992 or Przybylak *et al.* 2005).

For the purposes of describing the present temperature characteristics in Wrocław the following studies have been used: Kosiba (1948), Pyka (1991, 1998), Dubicka (1996), Dubicka and Pyka (2001).

DATA AND METHODS

Temperature data for Wrocław (Fig. 1) used in the present paper generally cover the period from 18th April 1710 to 31st December 1721. The series, however, contains two big gaps: i) from 3rd September 1712 to 26th October 1713 and ii) from 25th July to 31st August 1717. As a result, years with incomplete data have been excluded from this analysis. In the source documents there is no information about the precise location of these measurements, the exposition of the thermometer or its height above ground level (Landsberg 1983, Pyka 2003). However, it is quite possible that the thermometer was installed in a window.

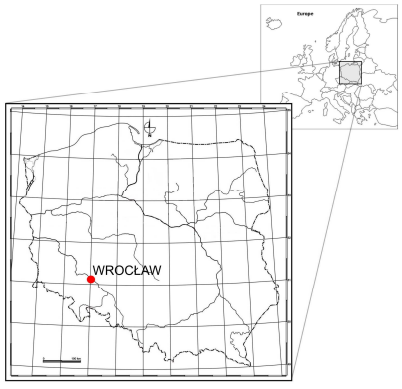
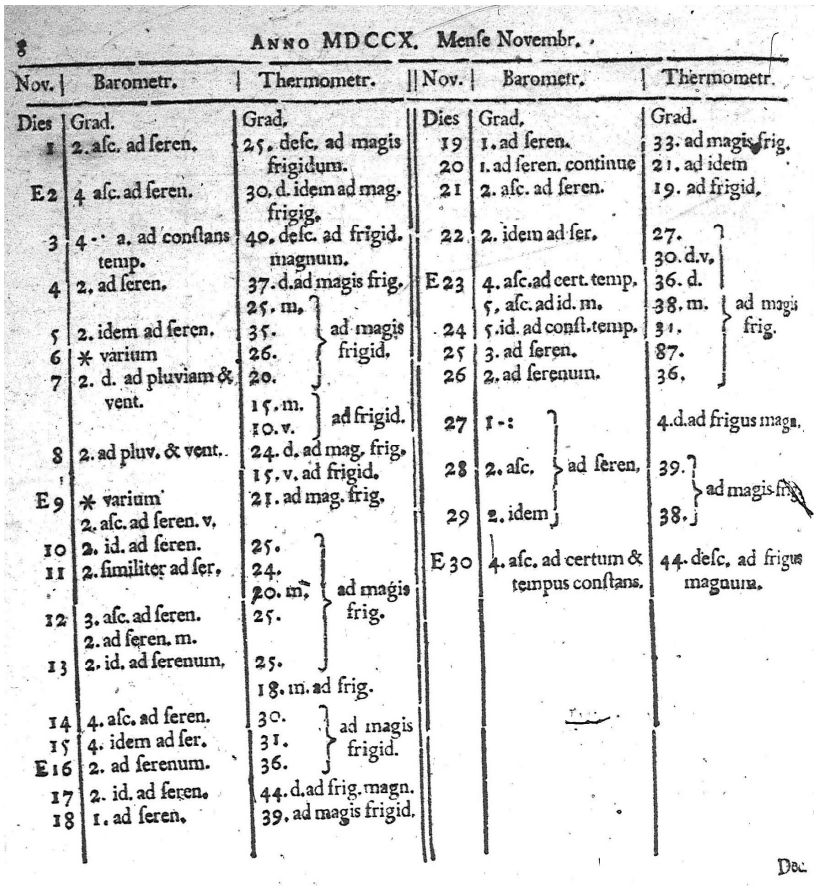


Fig. 1. Location of Wrocław in Poland and Europe

Air temperature measurements were made once a day (usually in the morning), but during periods when there were extreme weather changes measurements were made more frequently, i.e. two to three times a day or more (Fig. 2). Complete data, however, only exist for the morning hours, and therefore it is only these which have been used for the analysis.



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Nov. Dies	Barometr. Grad.	Thermometr. Grad.	Nov. Dies	Barometr. Grad.	Thermometr. Grad.
1	2. aſc. ad ſeren.	25. deſc. ad magis frigidum.	19	1. ad ſeren.	33. ad magis frig.
			20	1. ad ſeren. continue	21. ad idem
E2	4 aſc. ad ſeren.	30. d. idem ad mag. frigig.	21	2. aſc. ad ſeren.	19. ad frigid.
3	4 · · a. ad conſtans temp.	40. deſc. ad frigid. magnum.	22	2. idem ad ſer.	27. 30. d.v.
4	2. ad ſeren.	37. d. ad magis frig.	E23	4. aſc. ad cert. temp.	36. d.
		25. m.		5. aſc. ad id. m.	38. m.
5	2. idem ad ſeren.	35.	24	5. id. ad conſt. temp.	31.
6	* varium	26.	25	3. ad ſeren.	87.
7	2. d. ad pluviam & vent.	20.	26	2. ad ſerenum.	36.
		15. m.			
		10. v.	27	1 · :	4. d. ad frigus magn.
8	2. ad pluv. & vent.	24. d. ad mag. frig.			
		15. v. ad frigid.	28	2. aſc.	39.
E9	* varium	21. ad mag. frig.			
	2. aſc. ad ſeren. v.		29	2. idem	38.
10	2. id. ad ſeren.	25.	E30	4. aſc. ad certum & tempus conſtans.	44. deſc. ad frigus magnum.
11	2. ſimiliter ad ſer.	24.			
		20. m.			
12	3. aſc. ad ſeren.	25.			
	2. ad ſeren. m.				
13	2. id. ad ſerenum.	25.			
		18. m. ad frig.			
14	4. aſc. ad ſeren.	30.			
15	4. idem ad ſer.	31.			
E16	2. ad ſerenum.	36.			
17	2. id. ad ſeren.	44. d. ad frig. magn.			
18	1. ad ſeren.	39. ad magis frigid.			

Dec.

Fig. 2. Example of source data document for Wrocław (1710-1721) (Grebner 1723)

The Florentine thermometer had a brass scale divided into 180 sections with a star in the middle (Fig. 3). In addition, the scale had descriptions of different categories of thermal sensations (Tab. 1). Data were digitised and their quality was checked. All standard statistical calculations were conducted and the results were shown in Florentine degrees (hereafter deg.).

Table 1. Thermal sensation descriptions on the scale of the Florentine thermometer used in Wrocław, 1710-1721

Thermal sensation	Range in F.S. deg.
Hot and dry (“*ad calidissimus*”)	>60
Very warm (“*ad magis calidum*”)	40- 60
Warm (“*ad calidum*”)	20-40
Moderation (“*temperatum*”)	0-20
Cold (“*ad frigidum*”)	–20-0
Very cold (“*ad magis frigidum*”)	–40-–20
Frost (“*ad frigidus Magnum*”)	–60-–40
Sharp frost (“*ad frigidissimus*”)	<–60

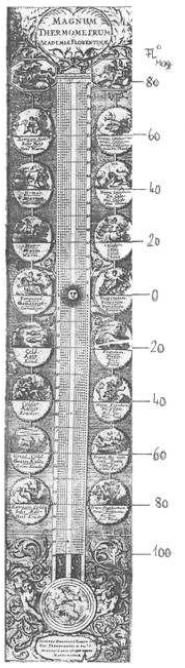

Fig. 3. Magnum Thermometrum Academiae Florentine (www.freunde-alteretterinstrumente.de; 06.2010)

RESULTS AND DISCUSSION

The absolute range of air temperatures in the study period oscillated from –91.0 (31st Dec. 1711) to 55.0 (23rd Jul. 1712) Florentine scale degrees. Annual mean air temperature in the period 1710-1721 (excluding the incomplete years 1712, 1713 and 1717) reached –12.6 deg. On average, the warmest month was July (20.1 deg.) while the coldest was January (–46.4 deg.) (Fig. 4). In these months air temperatures of above +20.0 deg. (July) and below –20.0 deg. (January) were recorded with the greatest frequency of occurrence.

The coolest year in the study period was 1711 (–17.8 deg.) and the warmest was 1719 (–7.8 deg.). In the warmest year both winter and summer were also the warmest with mean temperatures of –36.0 deg. and 26.4 deg., respectively. On the other hand, the very cold averages of 1711 were the result of very low winter and autumn temperatures, the lowest of the whole study period. On average, autumn (–11.6 deg.) was warmer than spring (–14.4 deg.) (Tab. 2). Only for summer was the mean air temperature above 0.0 deg (Fig. 5).

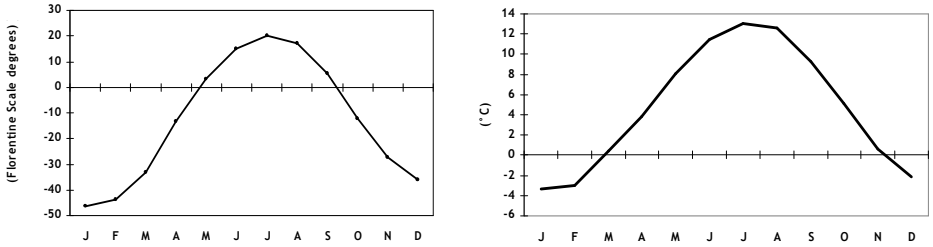

Fig. 4. Annual courses of air temperature in Wrocław, 1710-1721 (upper graph) and 1970-1981 (lower graph). (Explanations: J, F, M, … – January, February, March,

Table 2. Mean seasonal values of air temperature in Wrocław in the period 1710-1721 in Florentine Thermometer Scale degrees

Month	deg	Month	deg	Month	deg	Season	deg
Jan.	–46.4	May	3.3	Sep.	5.3	Winter	–41.9
Feb.	–43.7	Jun.	14.9	Oct.	–12.1	Spring	–14.4
Mar.	–33.0	Jul.	20.1	Nov.	–27.1	Summer	17.3
Apr.	–13.4	Aug.	17.1	Dec.	–36.0	Autumn	–11.6

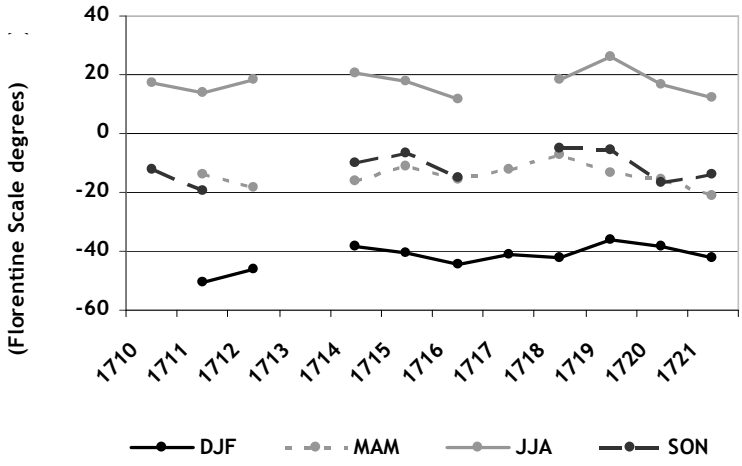

Fig. 5. Year-to-year courses of mean seasonal values of air temperature in Wrocław, 1710-1721. (Explanations: DJF, MAM, … – winter, spring, …)

Anomalies of annual mean air temperatures (with reference to the whole period) show two periods with positive values, and probably three periods with negative values (Fig. 6). The patterns of occurrence of temperature anomalies in

autumn are similar to those of annual anomalies. On the other hand, winter anomalies increased gradually from the beginning to the end of the study period. A similar increase (though not quite as clear) can be observed for the summer air temperature anomalies. The spring was clearly warmer in the second part of the study period.

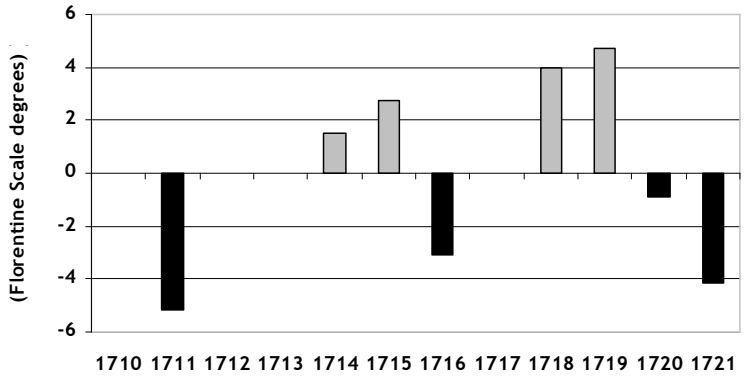

Fig. 6. Year-to-year course of mean annual air temperature anomalies in Wrocław in the period 1710-1721

The thermometer scale had descriptions of thermal sensation which are set every 20 deg. Based on these descriptions the frequency of occurrence of each category was calculated (Fig. 7). In winter, temperatures of below -20.0 deg. dominated with a frequency of 99%. The highest frequency of "sharp frost" was noted in January and February. In summer temperatures above +20.0 deg. occurred with a frequency of 97%. The extreme warm thermal sensations "hot and dry" occurred only in July and August.

Due to the difficulties in scale conversion, a detailed comparison of the temperatures in Wrocław in the study period with contemporary temperature conditions is still not possible. However, it is possible to compare some features of the annual courses. The comparison of such data from the historical period with contemporary data from the 20th century (1970-1981) shows similar annual runs of air temperature; in both cases the highest and lowest mean monthly temperatures occurred in July and January, respectively (Fig. 4).

From the literature we know that the beginning of the 18th century is colder than the second half of the 20th century (Przybylak 2007, 2008). This period is considered as the close of the Little Ice Age (Lamb 1977, after Brázdil et al. 2005). The first twenty years of the 18th century are about 0.5°C cooler throughout

Europe than the 20th century (Brázdil *et al*. 2005). This is confirmed by the high frequency of occurrence of categories of thermal sensations described as "very cold", "frost" and "sharp frost", during winter in the period 1710-1721. However, we should remember, that the analysed data are from morning measurements, and therefore should be compared to minimum temperature rather than to the daily mean. The comparison of the data measured with minimum temperature from Wrocław is being tested and results of this work will be published in a separate paper.

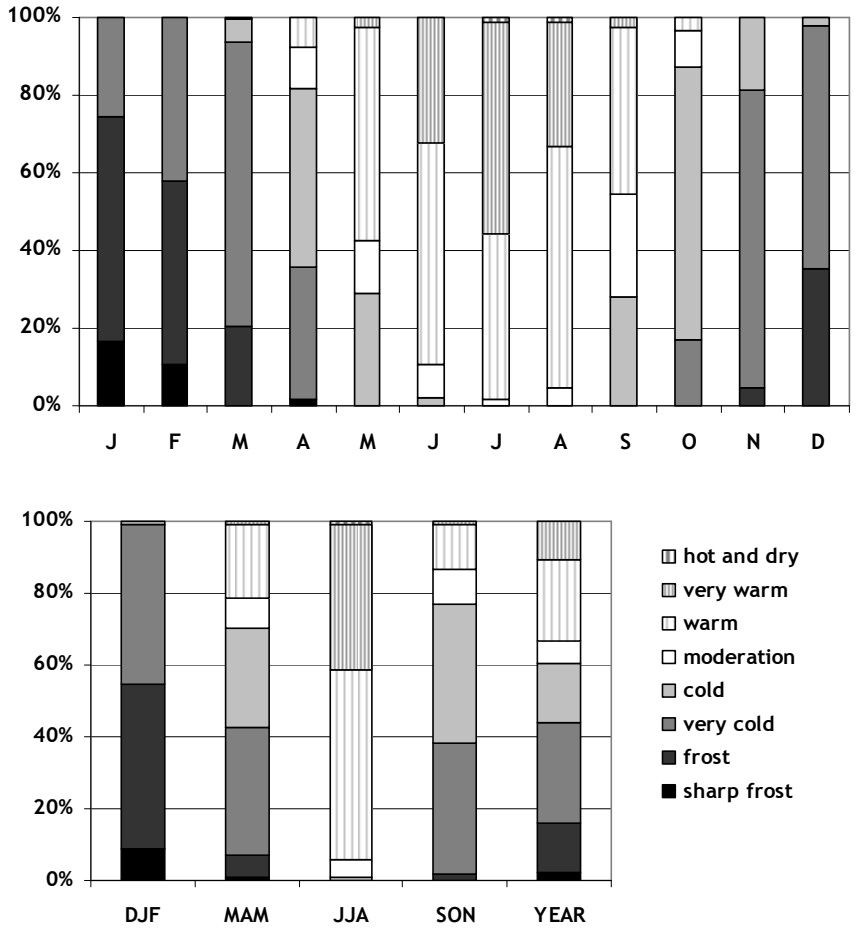

Fig. 7. Frequency of occurrence of specific categories of thermal sensations based on the scale used on the Florentine Thermometer (Wrocław, 1710-1721). (Explanations as in Fig. 4 and 5, respectively)

CONCLUSIONS

1. The thermal conditions in Wrocław in the period 1710-1721 were cool, with a high frequency of temperatures lower than –20.0 deg. In the study period mean annual temperature values show an increasing tendency.

2. Winter air temperature had the strongest influence on annual mean air temperature in Wrocław, which was coldest in the coldest year and warmest in the warmest year in the period 1710-1721. Winter air temperature maintains this influence in the present climate.

3. There is a great need to convert the scale of the Florentine thermometer used in Wrocław (1710-1721) into Celsius. Attempts to do this up to now have not met with any success.

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