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THE TRANSFORMATION OF THERMAL DESCRIPTIVE CHARACTERISTICS IN CRACOW FROM 16TH CENTURY INTO THE QUANTITATIVE EVALUATION

Abstract: The discovered records document the first systematic weather observations on the territory of today's Poland, in Cracow. The meteorological observations from the period of 1502-1540 are the most precious information in the file as they were made by the one observer - Marcin Biem of Olkusz. The notes were made regularly and they concerned a long historical period.

Key words: daily weather observations, transformation, the 16th century, the visual weather observations.

1. Introduction

Weather notes found in astronomical calendars (ephemerides) constitute the rich source of information of the hydro-meteorological conditions allowing determining the type of climate in the past, as the regular instrumental meteorological observations were not made.

The studies on climate conditions and meteorological data should be based on the reliable and validated observation material. The investigation of the history of the climate and meteorology phenomena up to the end of the 17th century is very challenging and causes the multiple difficulties. Information comes mainly from the narrative written sources. One has to allow for many discrepancies and inaccuracies in climate phenomena evaluation made by different authors.

The reconstruction of climate conditions of the chosen area does not only mean the qualitative climate description (warm, cold, dry, humid, oceanic, continental, etc.) but also requires the knowledge of the quantitative values (Hess 1968). The reviewed literature suggests the lack of existence of any references in Poland that would base on the written sources from the 16th century.

2. Methods and Data

The present investigation utilises the contemporary research methods that are applicable to historical climatology and chosen according to the type of source material. The special emphasis in climate investigations has been put on verifying the homogeneity of the measurement series. It has been decided that fairly strong criteria need to be applied while choosing the basic material for the investigation of the climate in Cracow in the 16th century. The sufficient length of the observation series is necessary to assume that the inferred climate changes objective.

The analysis of the hand-written data for Cracow was started with the data verification. It was important to establish that the data was recorded only by the eyewitness and were homogenous in the sense that the same person recorded the data. In the climate relations reconstruction task when using the various sources material from the same region one has to take into account that the data are different in degree of detail and vary in evaluation of the climate changes. This is why, only the notes of Marcin Biem were chosen for the investigation. It should be mentioned that the initial processing of this kind of data is much more difficult than the some indirect data (e.g. tree-rings) that has the qualitative character from the start.

The proposed method of data retrieval and storage has only been applied to the original historical sources (hand-written manuscript). The data have been collected for the months in the periods 1502-1507, 1527-1531 and 1535-1540. The thermal conditions were reconstructed using the method introduced by J. Michalczewski (1981) amended with the author's modifications based on the numerical evaluation of the air temperature worked out from the narrative description for the Vitebsk area for the years 1656-1664. The supposed values of temperature would refer to the narrative description in the 16th century in Cracow, that are the average values from distributive series calculated for the arbitrary chosen intervals in the years 1826-1960. For the winter months the 6-level scale describing the sensed air temperature has been adopted

Tab. 1. The thermal conditions criteria for the winter months.

Descriptive characteristics of air temperature in 17 th c. (from Chrapowicki's Diary)	Class limits (°C) according to Michalczewski	Descriptive characteristics of air temperature in 16 th c. (from Diary of Marcin Biem – in Latin)	Mean temperature of the class (°C)		
			From period 1826-1960		
			Dec.	Jan.	Feb.
Extremely frosty day	> -20.0°C	Gelu intensus vis magna geli	-21.9	-21.8	-22.6
Very frosty day	-19.9; -12.0	Gelu intensus vel magnus	-14.5	-14.8	-14.5
Frosty day	-11.9; -5.0	Remissivus frigorie	-7.8	-8.0	-7.8
Cold day	-4.9; -3.0	Gelu satis magnus vel satis rigidus. dies gelativa	-3.8	-3.9	-3.9
Normal day	-2.9; +1.0	Dies temperantia. dies satis calide	-0.7	-0.8	-0.8
Thaw	>0	Resolutio	2.8	2.8	2.9

with the class minimum and maximum temperatures numerically estimated as proposed by Michalczewski. The temperature intervals and daily narrative descriptions proposed by J. Michalczewski, and equivalent 16th century descriptions are presented in Table 1. However, for summer months the average daily air temperature has been adopted as thermal condition criteria. In this case the thermal sensing scale by Boksa and Boguckij (1966) has been used (after Kozłowska-Szczęśna et al. 1997) (Tab. 2).

Tab. 2. The thermal conditions criteria for the summer months.

Sensible temperature	Class limits (°C)	Descriptive characteristics of air temperature in 16 th c. (from Diary of Marcin Biem – in Latin)	Mean temperature of the class (°C)		
			From period 1826-1960		
			Jun.	Jul.	Aug.
Very cold	<= 10.0	Dies regide vel rigiditas.	9.1	9.7	9.6
Cold	10.1; 15.0	Dies frigide	13.2	13.9	13.6
Ideal	15.1; 20.0	Dies calide	17.5	17.8	17.6
Warm	20.1; 25.0	Dies multum calide	21.6	21.8	21.6
Hot	25.1; 30.0	Dies calidus. aestus. aestus magnus. aestus mximus	26.4	26.0	26.4

Tab. 3. Number of days with air temperature from write records in Cracow – January.

Years 16 th c	Number of days with observ.	Daily descriptive characteristics of air temperature						
		Extremely frosty	Very frosty	Frosty	Cold	Cool warm	Thaw	Normal mean
		Mean temperature of the class (°C)						
		-21.8	-14.8	-8.0	-3.9	-0.8	2.8	-3.1
1502								
1503	31	0	2	0	12	1	6	10
1504	22	0	1	1	6	0	0	14
1505	31	0	2	0	10	5	0	14
1506	31	0	12	2	8	1	4	5
1507	31	0	1	1	10	0	9	10
1527	25	0	7	2	7	3	4	3
1528	31	0	3	1	7	1	4	2
1529	31	0	8	0	20	0	0	15
1530	31	0	1	0	9	17	2	3
1531	17	0	2	1	7	4	0	2
1535	30	0	4	1	17	0	1	7
1536	31	0	2	0	12	1	5	11
1537	31	0	4	0	21	0	2	4
1538	31	0	0	0	20	6	0	5
1539	31	0	2	0	14	11	0	4
1540	31	0	4	0	14	0	6	7

Tab. 4. Number of days with air temperature from written records in Cracow – July.

Years 16 th c.	Number of days with observ.	Daily descriptive characteristics of air temperature					
		Very cold	Cold	Ideal and dry	Very warm	Hot	Normal mean
		Mean temperature of the class (°C)					
		9.7	13.9	17.8	21.8	26.0	18.8
1502	24	0	0	10	0	0	14
1503	31	2	0	11	3	2	13
1504	31	0	0	17	0	0	14
1505	31	2	0	10	0	0	19
1506	31	1	0	9	0	0	21
1507	31	0	0	4	0	0	27
1527	31	0	0	3	0	8	20
1528	31	0	0	0	0	3	28
1529	21	0	0	1	0	0	20
1530	31	0	0	3	6	7	15
1531	31	2	0	8	0	0	21
1535	31	0	0	3	0	8	30
1536	31	0	0	0	0	3	26
1537	21	0	0	1	0	0	18
1538	31	0	0	3	6	7	17
1539	31	2	0	8	0	0	28
1540	31	0	0	0	0	18	13

The average temperature refers to each of the interval, calculated from the distributive series for the winter months (December-February; Table 1) and summer months (June-August; Table 2) for years 1826-1960. The source materials come from the research station of the Department of Climatology, Institute of Geography, Jagiellonian University in Cracow.

The data list coming from Marcin Biem diaries and listed by months and years (Tab. 3 and 4) allows to calculate the number of cases in individual intervals. After multiplying the number of cases by the average temperature of the interval and their summation the final monthly average temperatures are obtained. They will be used for the winter and summer average temperature estimation. The distance between the present observation site and the one in the 16th century (Collegium Maius and Wawel Hill) is not exceeding 3 km in straight line and therefore it can be assumed that the observations come from the same place. This is why the temperatures of the classes were not corrected for location change. There are no criteria for description differentiation applied to the transition seasons (spring, autumn) so it is difficult to relate temperature to the narrative descriptions characterising the thermal conditions and this is why this paper contains the reconstructed thermal data for Cracow only for January and July (Tab. 5).

3. Conclusion

In Cracow the largest temperature differences in comparison with the period 1826-1960 occurred in winter and the smallest in summer. The coldest month was January 1529 when mean monthly temperature was -8°C . The warmest month was July 1540 with the temperature exceeding 23°C . Mean monthly temperature for January was characterised with greatest variability in the periods 1527-1531 and 1502-1527, while for July it was 1535-1540. The obtained data is reliable and should be used in the future to investigate the climate changes in the past.

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Tab. 5. Mean value of temperature for January and July in Cracow in the first half of the sixteenth century.

Years	Temperature ($^{\circ}\text{C}$)	
	January	July
1502		18
1503	-3	19
1504	-4	18
1505	-4	18
1506	-7	18
1507	-2	19
1527	-6	21
1528	-2	20
1529	-8	19
1530	-2	21
1531	-4	18
1535	-5	19
1536	-3	19
1537	-5	19
1538	-3	18
1539	-3	19
1540	-4	23
1826-1995	-3.0	18.7
1901-1960	-2.5	18.8