JOURNAL OF ENVIRONMENTAL GEOGRAPHY
Journal of Environmental Geography 7 (1–2),1–9.
DOI: 10.2478/jengeo-2014-0001
ISSN: 2060-467X

18TH-CENTURY DAILY MEASUREMENTS AND WEATHER OBSERVATIONS IN THE SE-CARPATHIAN BASIN: A PRELIMINARY ANALYSIS OF THE TIMIŞOARA SERIES (1780-1803)

Ildikó Csernus-Molnár[1], Andrea Kiss[2], Edit Pócsik[3]

[1]Department of History, Central European University, Nádor u. 9, H-1051 Budapest, Hungary
[2]Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Karsplatz 13, 1040 Vienna, Austria
[3]Institute of Communication in Foreign Languages, University of Szeged, Honvéd tér 6, H-6722 Szeged, Hungary
*Corresponding author, e-mail:kiss@hydro.tuwien.ac.at

Research article, received 26 January 2014, accepted 15 March 2014

Abstract

Covering a period of 23 years, the Timişoara (in historical Banat region; today SW-Romania) series is the earliest known long-term 18th-century daily measurement (temperature, pressure) and weather observation series (precipitation, sky coverage, meteorological extremes), preserved in the south-eastern lowlands of the Carpathian Basin. Based on data derived from the original weather diary of the royal pharmacist Karl Joseph Klapka, in this paper the early instrumental measurement and daily observation series is presented referring to the temperature, pressure, precipitation conditions, cloudiness, wind, types of precipitation and extreme weather events that occurred in Timişoara in the period of 1780-1803. The two daily temperature measurement series show very high (over r=0.95) correlations, while pressure series are also in good agreement with other known late 18th-century measurement series of the same period in the Carpathian Basin (Buda, Miskolc and Kežmarok). The Timişoara-series also contains important information concerning such weather extremes as the severe winter of 1784 or the unusual number of summer fog events in 1783 (presumably related to the Icelandic Lakagígar eruption), which are also reported in the present paper.

Keywords: historical climatology, early instrumental measurements, daily weather observations extreme weather events, 18th century

EARLY INSTRUMENTAL MEASUREMENTS AND METEOROLOGICAL OBSERVATIONS IN HISTORICAL HUNGARY

The 18th century is of basic importance from the viewpoints of the implementation of a uniform European measurement network and also from the development of meteorology and climatology in historical Hungary that covered the majority of the Carpathian Basin. The instrumental measurements and daily visual weather observations, carried out at the end of the 18th century, already provide much more accurate information on the weather conditions of the period – mainly on the temperature, pressure and precipitation events – than the earlier ones (e.g. Szőkefalvi-Nagy and Zétényi, 1965; Réthly, 1970). Both inside and outside of the *Societas Meteorologica Palatina* network, these records were usually made by (highly) educated people; in most cases by physicians, pharmacists, astronomers or members of the clergy (Brázdil et al., 2002, 2005; Demarée et al., 2002). Measurements and observations were initiated mainly on the basis of uniform methods, and thus, clear similarities in practices can be traced, for instance, in the Spanish, Swedish, Belgian, Italian and Czech analyses. These previous investigations can help in the methodology to process manuscripts, and correct as well as analyze data gained from the manuscripts (Barriendos et al., 2002; Brázdil et al., 2002, 2003; Camuffo, 2002a etc.).

Mainly due to the assembling work of Antal Réthly (1970), there are four known instrumental measurement series, combined with daily weather records, extending over several years from this time-period in the area of historical Hungary (*Fig. 1*). Firstly, the series of Buda station (Buda observatory) should be mentioned, which operated as a member of the *Societas Meteorologica Palatina* European measurement network, and its measurements were systematically documented in the Societas yearbooks until 1792. The temperature data and the daily visual observations from Miskolc (Hungary) between 1780 and 1801 (together with pressure series in 1780 and in the period 1794 - 1800), appeared in published form in 1794 and 1802 (by Benkö, 1794, 1802), and were partly analyzed (see Szőkefalvi-Nagy and Zétényi, 1965). Additionally, observations and measurements carried out in Kežmarok (in Slovakia; historical Késmárk) between 1789 and 1800 by János Genersich, remained in handwritten form (National Széchényi Library, Budapest, Fol. Germ. 114), similar to the data of Timişoara (in Romania; Temesvár in historical Hungary).

Fig. 1 Location of places mentioned in the paper (thick black line: 18th century borderlines of countries that belonged to the Hungarian crown; thin black line: present day country borders)

Recently, a complex processing of the Miskolc and Kežmarok originals has been carried out. These additional data can help us to provide an even more detailed picture of the weather patterns characterizing the Carpathian Basin in the late 18th century. This paper presents the measurements and daily records carried out in Timişoara: the digitalization of Klapka's written records – extending over 23 years – made it possible for us to perform the statistical analyses of the temperature and pressure data, as well as that of the daily meteorological observations. The importance of this work arises from the fact that, except for one publication concerning the Miskolc temperature series (Szőkefalvi-Nagy and Zétényi, 1965), the in-depth, detailed analysis of the Hungarian instrumental measurements and daily observations from the late 18th century, apart from the Buda(pest) series (the only late 18th century series included in the Societas Meteorologica Palatina network), have not been provided in published form.

THE KLAPKA-MANUSCRIPT AND DATA PROCESSING

The original manuscript can be found in its entirety in the Manuscript and Rare Book Collection of the Eötvös Loránd University Library in Budapest (catalogue No. E 40). The observer, Karl Joseph Klapka, was a royal pharmacist, coming from Znojmo (South-Moravia), who moved to Timişoara around the year 1780 (Szinnyei, 1900; Klapka, 1886). Although no information is currently available on the exact location of his measurements in Timişoara, it is quite probable that the measurements took place at the building (yard?) of the Pharmacy located in the city centre. Except for one or two missing days, an essentially continuous data series is available concerning the years between 1780 and 1803. The diary consists of data measured three times every day. The temperature measurements were carried out simultaneously by two thermometers (in Réaumur and Fahrenheit). In case of pressure measurements, the scale was divided according to the Paris measure in inches ('Grad') with values of 26, 27 and 28, every inch with 12 lines ('Dig') and every line with 10 units. In addition, Klapka regularly (three times a day) added information about the state of sky, cloudiness, wind variety and precipitation events (with types mentioned).

As the first step of digitalization, the numerical and textual information, available in the Klapka manuscript, was converted (i.e. typed in) to an excel file: in case of pressure the inch values had to be completed, while negative temperature values (with the sign "under zero") were converted to negative values. Due to the very uniform use of ink and the homogeneity of handwriting, we presume that the available manuscript was the copied, finalized version of the measurements. In a few cases, when a copying mistake of values was obvious (e.g. missing sign of negative value), we have corrected the actual number. Concerning the description of daily weather conditions, the precipitation-related narrative information was interpreted and transformed into numerical values (see details later). After digitalization and interpretation of the manuscript, the temperature and pressure series, and the daily records (written in Latin) were suitable for statistical analysis.

One of the great advantages of the Klapka-manuscript is that it provides continuous information for the period between 1780 and 1803, thus a data series characterized by unique continuity is available for this region, and for the south-eastern region of the Carpathian Basin in particular. It is an essentially important fact, since regular daily reports of the *Societas Meteorologica Palatina* were put aside for a few years after 1792. As a consequence, the daily observations carried out at the end of the century in Buda are not available; only monthly averages are known. The other advantage of this measurement series is that it originates from the last decades of the 18th century thus coincides with the so-called 'Maldá-anomaly', a period famous for its extreme weather conditions (Barriendos et al., 2003; Brázdil et al., 2003).

TEMPERATURE MEASUREMENTS

The early liquid-in-gas thermometers were very different from each other in many respects, namely deformation of the glass tube and bulb, polymerization of organic thermometer liquids, slipping of the scale or the capillary etc. which can cause measuring errors (Camuffo, 2002b). In this way, in order to be able to carry out statistical analysis of the data the two types of temperature measurement series provided by Klapka, had to be converted into one common unit of measure – in our case the Celsius degree scale. Furthermore, the comparison of the data recorded in the manuscript with the contemporary measurements of Buda, Kežmarok and Miskolc allows us to carry out a comprehensive analysis. In case of the Timişoara series, using the Celsius values derived from the measurements in Fahrenheit and Réaumur, morning, noon, evening and daily averages could be calculated. For the calculation of daily averages the Kämtz method was applied: (1* morning+1* noon+2* evening)/4 (see e.g. Dall'Amico and Hornsteiner, 2006; see also Kern, 2009).

The values measured by two different types of thermometers were practically identical to each other (r=1), correlated well both with the contemporary monthly temperature data series of Buda (r=0.98) (*Fig. 2*) and with the temperature data series of the period 1961-1990 measured in Timişoara (r=0.99) as well. Moreover, monthly values show strong correlation with the available contemporary measurement series of Miskolc (r=0.94) and Kežmarok (r=0.97). The second figure (*Fig.* 2) shows the monthly averages of temperature values in Timişoara and in Buda regarding the studied 23 years (1780-1803). It is conspicuous that, after 1783, there is a difference of approximately 3 degrees on average between the two observation sites: the monthly temperature values in Timişoara are all-time higher than those of Buda (which fits the general differences in climate), which is particularly visible in case of mild winters such as 1786, 1792, 1796, 1798 or 1800. It has to be emphasized, however, that difference between the Buda and Timişoara temperature series is much less significant in case of summer, and even less detectable in case of autumn and spring values (see *Fig.* 2). Moreover, the daily course of mean temperatures referring to the entire study period, in general, reflects values comparable to the 20th-century differences in climate (*Fig. 3*). Nevertheless, the generally high winter values and relatively small differences in the course of daily temperature might allow the possibility of some influence of heating (it was a common practice /especially in towns/ to put the thermometers on the wall, or place them in courtyards etc.).

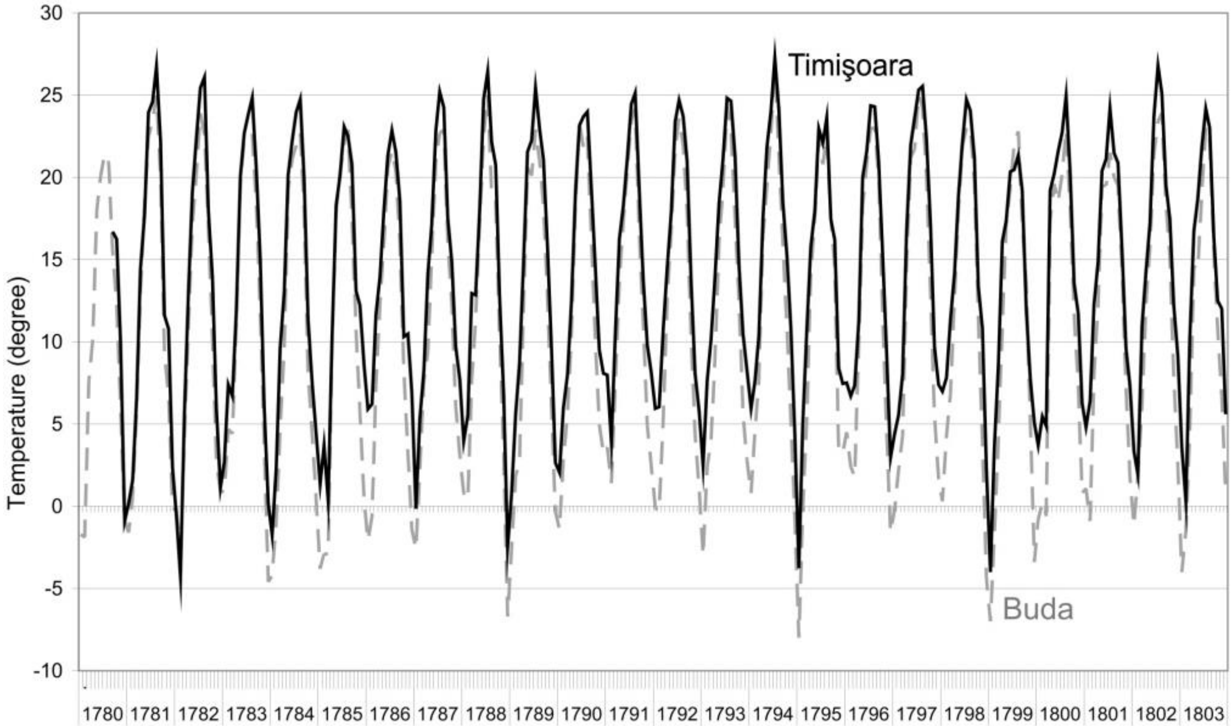

Fig. 2 Monthly averages of temperature values measured in Timişoara and Buda in 1780-1803 (ºC)

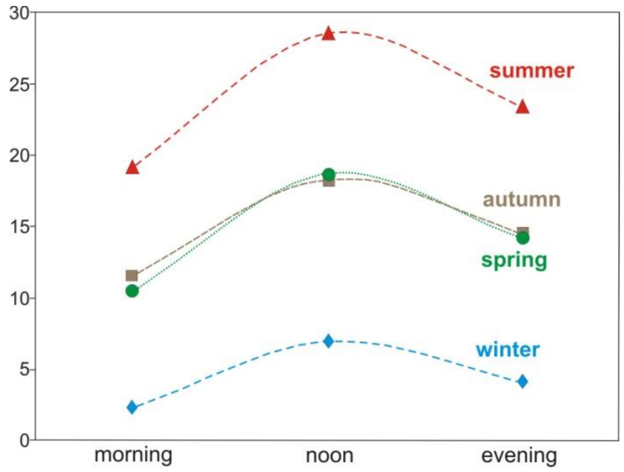

Fig.3 Daily course of temperature measured in 1780-1803, in Timişoara (ºC)

The values transformed are still raw data series, and it follows from that, that a deeper and more accurate analysis should be carried out in future. Comparing the annual courses of temperature series in 1780-1803 and 1961-1990 (*Fig. 4*), it comes clear that monthly temperatures measured in 1780-1803 are generally 2-3 ºC higher than those measured in 1961-1990 in Timişoara; this difference can reach 5 ºC in winter months. Thus, higher degrees can be systematically detected not only compared to the contemporary Buda measurements (located ca. 250 km northwest to Timişoara with the Great Hungarian Plain in between), but also to the present-day (1961-1990) Timişoara data series. What could be the reason of this difference, especially in winter time? The clear reasons are unknown; nevertheless, the urban location of the pharmacy, and the contemporary practices of settling the instruments (maybe an inner yard location, thermometer placed on the wall) or some technical reasons (installation) can also be responsible for the differences. Since positive temperature anomalies can primarily be detected during mild winters and they are less visible during summers, the effect of insolation seems to be a less likely reason for the higher temperature values.

Based on the Klapka-measurements, in Timişoara especially the summers of 1781, 1788, 1794 and 1802 turned out to be outstanding warm. The extraordinary hot summer of 1783, which was reported in large parts of Central Europe (Brázdil et al., 2003), was not an unusually hot summer in Timişoara concerning monthly averages (see *Fig. 2*). On the basis of monthly average temperatures, the hardest winters in Timişoara occurred in 1782, 1789, 1795 and 1799, which were otherwise accompanied by ice jam floods along the Danube in the Carpathian Basin, similarly to some other areas in Central Europe (see e.g. Strömmer, 2003; Kiss, 2007; Glaser, 2008; Brázdil et al., 2010).

Due to its severe conditions and the great and extraordinary winter- and spring-flood events, the winter of 1784 (after the great Lakagígar eruption in Iceland) is considered as one of the most famous European extremes in the last decades of the 18th century (for a European overview of flood waves, background and consequences, see Brázdil et al., 2008). Although the winter of 1784 was clearly colder than usual in Timişoara, if we merely take the temperature averages into consideration, it was not one of the coldest winters of the study period. It is rather due to the great temperature variations (very cold periods were interrupted by rather mild ones), reflected in the course of daily temperatures as well as the values of daily maximum and minimum temperatures (*Fig. 5*), that this winter was reported as a notably cold one in the Carpathian Basin, when both ice jam flood (e.g. in December on the Maros river) as well as floods due to snow-melt (from January) occurred around Timişoara and in the Banat area (see e.g. Kiss et al., 2006; Kiss and Csernus-Molnár, 2008; Kiss et al., 2008).

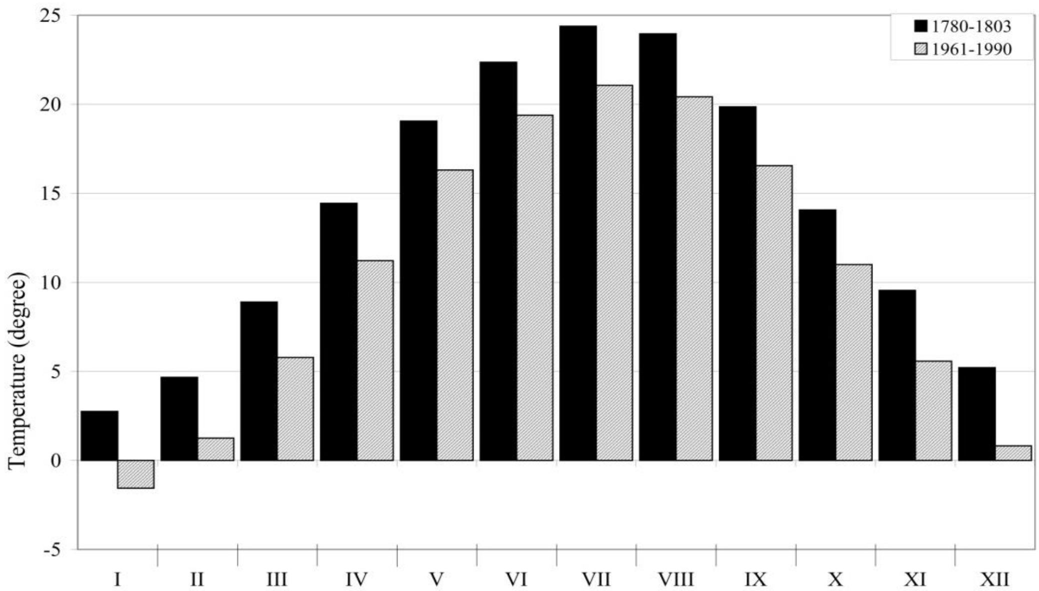

Fig.4 Annual course of measured temperature values in Timişoara: 1780-1803, 1961-1990 (in ºC)

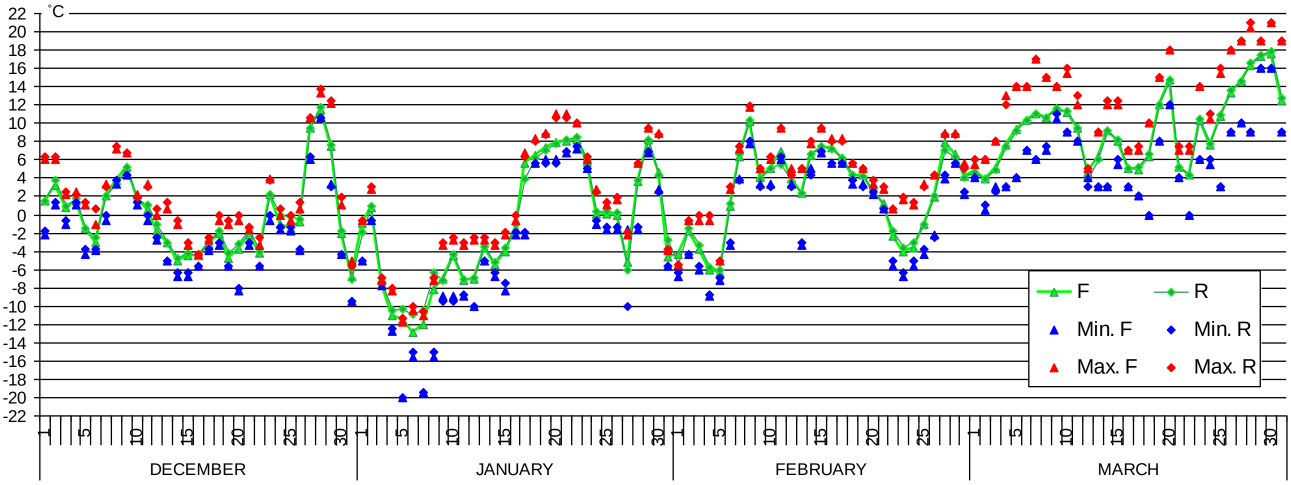

Fig. 5 Daily measured temperature (provided in ºC; thermometers: F=Fahrenheit; R=Réaumur): average (green lines), maximum (red) and minimum (blue) values in Timişoara between 1 Dec. 1783 and 31 March 1784

The late 18th century was also rather rich in individual temperature extremes in Central Europe, and also in Timişoara and the Carpathian Basin. In Timişoara, the coldest December occurred in 1788 (-2.6 ºC measured by Klapka; in 1961-1990: 0.8 ºC), the coldest March (0.3 ºC; 1961-1990: 5.8 ºC) and spring were measured in 1785 (1.7 ºC; 1961-1990: 11.1 ºC), whereas the warmest April occurred in 1800 (19.2 ºC; 1961-1990: 11.2 ºC).

AIR PRESSURE MEASUREMENTS

Similar to temperature, pressure measurements were provided three times per day in a rather systematic way. Even if Klapka provided no evidence on the measurement unit of his pressure data series, based on the values included in the manuscript, the pressure data presumably were recorded in Paris inches, which was widely applied in this period in Europe. From the original daily values, transformed to hPa form, daily and monthly averages were calculated (*Fig. 6*): although the annual pressure averages show some parallels to those measured in Timişoara between 1961 and 1990, the non-corrected values are significantly lower than the ones measured in the 20th century. Apart from the fact that these are still raw values (not corrected to temperature or reduced to sea elevation), the values will change after corrections, the problem of low values clearly needs further elaboration.

Similarly to the analysis of the temperature data, for further quality assessment of the pressure measurements carried out in Timişoara, the daily data series of Buda were applied, the raw data of which were obtained from the Mannheim series of the *Societas Meteorologica Palatina* (*Ephemerides… 1781-1792*), and transformed to hPa using the aforementioned formula. As, similarly to the

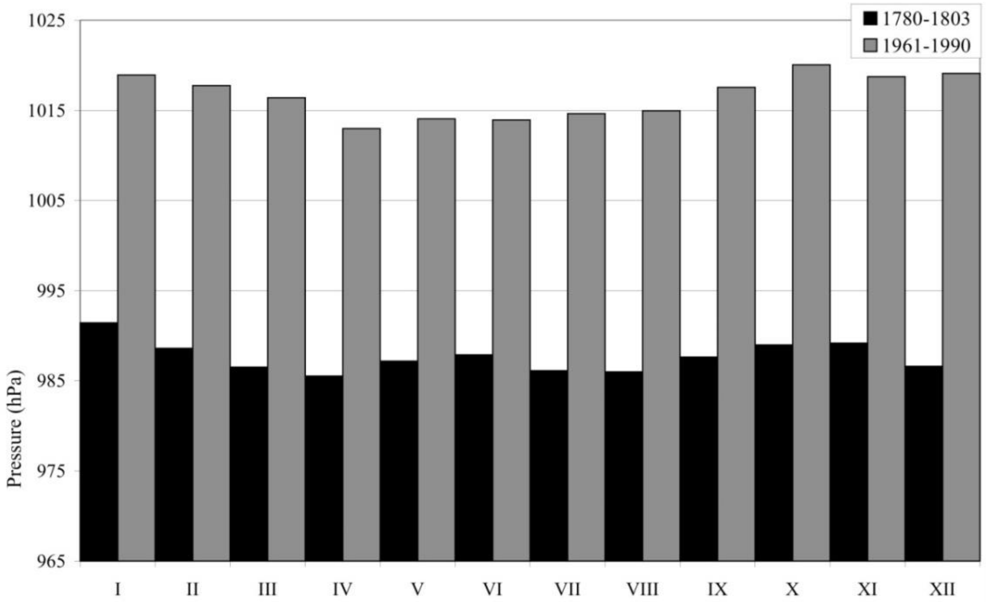

Fig. 6 Comparison of monthly averages of pressure values (without corrections), measured in the periods 1780-1803 and 1961-1990 in Timişoara

temperature series, the pressure series from Buda also contains values measured three times every day, it could be compared with the pressure values measured in Timişoara. The correlation between these monthly averages is also strong (r=0.58; <0.01 significance level): the strongest correlation can be detected in winters (e.g. in January of 1784: r=0.98), while the lowest were in summers (e.g. in July of 1783: r=0.37). The daily values are also comparable with measurements of Miskolc (r=0.24; 0.01 significance level) and Kežmarok (r=0.87; <0.01 significance level; with rel. short overlapping period). Low correlations with the Miskolc pressure measurement series can also be caused by the fact that the Miskolc series are rather problematic as (when provided) only one value is available for each day without any information on the time of measurement (see also Szőkefalvi-Nagy and Zétényi, 1965). Comparing the Timişoara (raw) pressure series (1780-1803) to the measured (corrected) values of 1961-1990, similarly strong connection can be detected (r=0.65; <0.01 significance level). This fact also highlights the considerable potentials of this early and almost uninterruptedly recorded 23-year long series.

DAILY OBSERVATIONS, WITH SPECIAL EMPHASIS ON PRECIPITATION PATTERNS

Beyond recording the measured temperature and pressure values, Klapka also provided a systematic description of weather events (e.g. precipitation, atmospheric phenomena) three times every day in Latin. Since the application of contemporary terminology, the use of specific words have special importance in proper understanding of weather conditions, it is necessary to provide the precise, present-day interpretation of the more important terms. Terms appearing most often in the manuscript refer to transparency, cloudiness, type of precipitation (e.g. snow, fog), motion of air (e.g. windy) or to temperature (e.g. cold, hot). However, some individual phenomena (e.g. rainbow) also appear in the manuscript (see *Table 1*).

In addition to the measured temperature and pressure values, the aforementioned observations provide us more information for instance about the number of days with precipitation, the physical condition of precipitation, the number of cloudy or of foggy days. From all these information the systematically recorded daily evidence on precipitation might be the most important.

PRECIPITATION OBSERVATIONS

A significant further section of the daily observation records refers to precipitation. Although no precipitation measurements were carried out, Klapka recorded the information on precipitation every day. From this evidence, it is possible to calculate days with precipitation, dividing the information according to precipitation types. After aggregating the number of days with precipitation summed up for each month, the numbers of rainy, snowy and mixed days were separately grouped (*Fig. 7*). At the same time the manuscript also provides some information on trace precipitation (mostly about the number of foggy days - see later), which were treated separately from normal precipitation information. We have to note that even if some comparisons were carried out with precipitation measurement data series, the number of days with precipitation is not equivalent to the amount of precipitation measured in other places. Moreover, it is possible that precipitation events during the night were sometimes not recorded in the manuscript.

Precipitation results (quantity) were compared with the daily precipitation data of Buda, published in the volumes of the *Societas Meteorologica Palatina* (*Ephemerides… 1781-1803*). The correlation between the Buda and Timişoara datasets shows connection on 5% significance level (r=0.27). Thus, despite the great distance (over 250 km) and the differences in precipitation patterns, some connections could be detected with the contemporary measured precipitation datasets of Buda, which supports the further potentials of the late 18th-century daily precipitation information recorded in Timişoara.

At the same time, the manuscript also reflects on some of the dry (such as 1794, 1797, 1800, 1802 etc.) and rainy years (such as 1786, 1795, 1801). In the latter case,

Table 1 Basic terminology applied in the descriptions of daily visual observations

Latin term	English meaning	Latin term	English meaning
1. Sky coverage, transparency		3. Motion of air	
nubilum, nubiles	cloudy, clouds	*ventus, ventosus*	wind, windy
(*semi-*) *serenum* (*sereno*)	(half-) clear sky (air)		
Obscurum	unclear, grey/dark weather (sky)	4. Temperature-related terms	
2. Types of precipitation, physical condition		*frigidus, frigeo* (*frigefacto*)	cold, cooling down
pluvia (*pluvius, pluviosus*)	rain (rainy)	*calidus* (*caleo*)	Warm
nives, ningo/*ninxi*, (*nivosus*)	snow, snowing (snowy)	5. Atmospheric phenomenon	
Nebula	fog	*arcus pluvius*	Rainbow

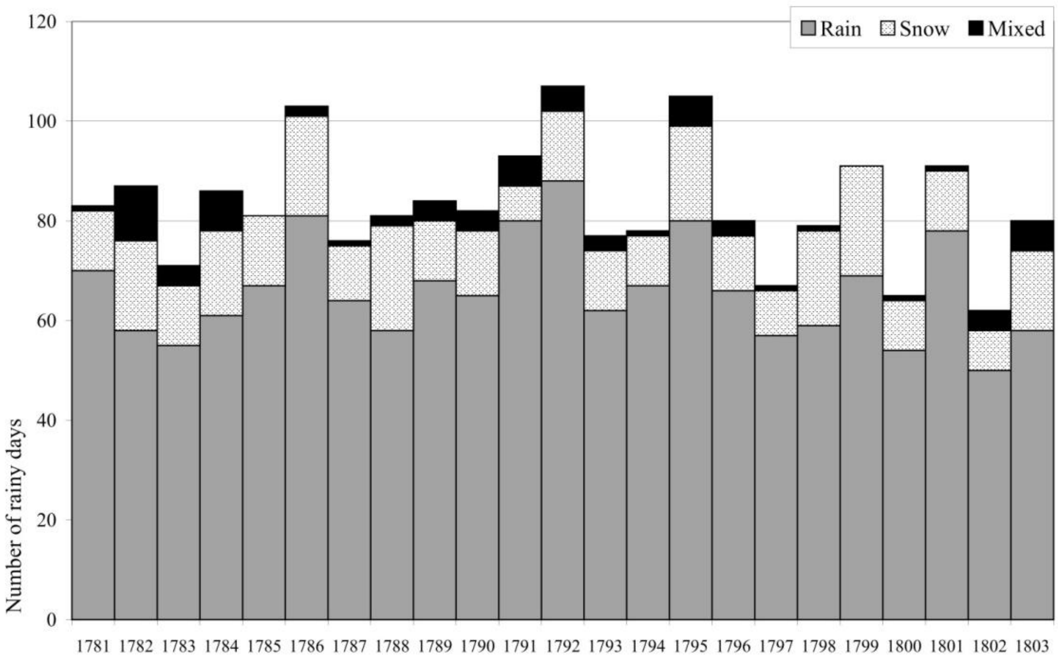

Fig.7 Number of days with precipitation per year in Timişoara (trace precipitation excluded): 1781-1803

the number of days with more significant precipitation events exceeds 100 (e.g. 1786, 1792, 1795; see *Fig. 7*). Concerning anomalous and extreme months, the springs of 1794, 1801 and 1802, the summers of 1784, 1788, 1793, 1800, 1802 and 1803, the autumns of 1783, 1793, 1797 and 1802, the winters of 1790, 1794, 1796 and 1801 appeared to be particularly dry. Nevertheless, the summer of 1801, the autumns of 1791, 1794 and 1801, the winters of 1781, 1792 and 1795 seem to be particularly rainy. On an annual scale 1790, 1793, 1802 (where not only the spring but also the autumn) and 1803 were dry - at least based on the number of days with precipitation.

As we pointed out earlier, it is an important fact that the number of days with precipitation events is not always closely related to the amount of precipitation: that is why, for example, the otherwise famous drought year of 1794, does not appear as a great singularity in the record. Moreover, the (inter)annual distribution of days with precipitation is also an important, further question to be discussed, greatly influencing drought patterns (especially in case of agricultural drought). The distribution of days with precipitation, presented annually, still provides some rather interesting information, even concerning the drought year of 1794. For instance, 77 days with precipitation events were recorded in the manuscript concerning that year, but only 12 days were noted to be rainy in the entire spring, and no precipitation at all was recorded in March. Moreover, there were no more than 4 rainy days in August. Reports from other documentary evidence, such as contemporary newspapers (e.g. in *Magyar Hírmondó* 19 August 1794), are also available about the great drought (‘beyond any record’) of spring and summer on the Great Hungarian Plain which - among other evidence - provide a rather detailed and clear picture about the severe lack of precipitation mainly in spring and summer, but practically also in winter and in the preceding years (for a short overview of scientific literature about this drought event see Kiss, 2009).

Another interesting example can be raised from 1781: the annual distribution of days with precipitation events was rather extreme during the year. Whereas the winter (1781) was remarkably rainy, the spring and the summer were rather dry. The year of 1792 was similar. Despite the fact that Klapka observed more than 100 days with notable precipitation, the highest number of days with precipitation events was observed during winter, while spring and summer were dry.

TRACE PRECIPITATION

Although similarly to precipitation evidence, trace precipitation was probably not always recorded in time, some conclusions can be drawn, especially concerning the number of foggy days provided in the manuscript. Probably the most interesting example is the extraordinary event which reflects from the written records occurred in this period: an unusually large number of days (14) with fog was recorded in Timişoara during the summer of 1783. This is rather extreme in this season and shows an unambiguous anomaly compared with the other summers of the studied period (1781-1803); the number of foggy days in summer was usually between 2 or 3, but never (apart from 1783 summer) exceeded 7 (*Fig. 8*). The unusually large number of foggy days is in good agreement with the great number of dry fogs recorded all over Europe in this summer (also in the actual *Societas Meteorologica Palatina* volume), which was one of the 'side-effects', impacts of the Lakagígar eruption in Iceland during the summer of 1783.

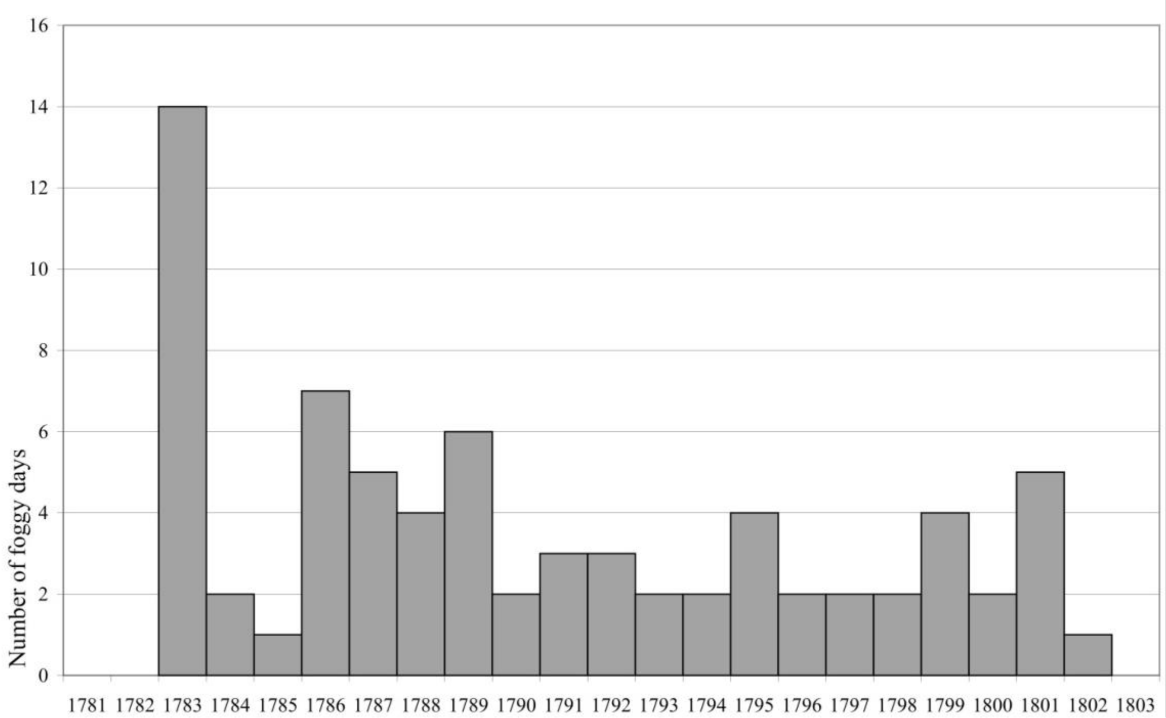

Fig. 8 Number of foggy days in summer (1781-1803), recorded in the Klapka-manuscript

The consequences of this major volcanic eruption (lasted for 6 months) have been extensively presented in many studies, including atmospheric and weather impacts, the extreme precipitation and temperature conditions (hot summer with numerous thunderstorms, extreme winter etc.) together with related flood waves and ice jam floods during the hard winter of 1784 in Europe (see e.g. Stothers, 1996; Self and Rampino, 1998; for Hungary: Kiss et al., 2006; latest European overview: Brázdil et al., 2010). Apart from other consequences, a large number of contemporary reports can also be found concerning the dry fog phenomenon in the Carpathian Basin: newspapers, such as the *Magyar Hírmondó* (12. July 1783.) or the *Pressburger Zeitung* (30. July 1783.) published reports about this unusual but rather interesting phenomenon.

CONCLUSIONS AND OUTLOOK

The Timişoara weather diary written between 1780 and 1803 by K. J. Klapka (pharmacist) represents the south-easternmost meteorological instrumental measurements in the Carpathian Basin from the late 18th century. The importance of the Timişoara measurements and daily observations lies in their continuity (for 23 years, with only some days missing), construction and accuracy, and in the fact that they date back to an important period of historical climatology, namely the second part of the 18th century (the so-called 'Maldá-anomaly') which was famous for its temperature and precipitation extremes. Due to the fact that the *Societas Meteorologica Palatina* volumes were not published after 1792 and the daily measurements at Buda are not available for several years after 1792 (only monthly sums are known), the measurement series of Timişoara represents the single, continuous daily temperature and pressure data series from this region known at present (the series of Miskolc and Kežmarok are incomplete, and with some further quality problems; see Csernus-Molnár and Kiss, 2011).

After the digitalization of the measurement series of Timişoara, the measured data could be compared to the results of the contemporary measurements carried out in Buda, Miskolc and Kežmarok: strong correlations were detected between both the temperature and pressure series, which prove the further elaboration potentials of the datasets included in the manuscript. Concerning the daily weather records the information on precipitation play an important role as the analysis of the number of days with precipitation provided some further parallels to the contemporary Buda measurement series. Moreover, the data on trace precipitation could provide some interesting information concerning the large number of foggy days observed in the summer of 1783, which might be in relation with the consequences of a major Icelandic (Lakagígar) volcanic eruption in 1783.

References

Barriendos, M., Martin-Vide, J., Pena, J. C., Rodriguez, R. 2002. Daily Meteorological Observation in Cádiz – San Fernando. Analysis of the Documentary Sources and the Instrumental Data Contect (1786-1996). *Climatic Change* 53, 151–170. DOI: 10.1007/978-94-010-0371-1_6

Barriendos, M. – Llasat, M. C. 2003. The Case of the 'Maldá' anomaly in the Western Mediterranean Basin (AD 1760-1800): An Example of a Strong Climatic Variability. *Climatic Change* 61, 191–216. DOI: 10.1023/a:1026327613698

Benkö, S. 1794. Ephemerides Meteorologico-Medicae annorum 1780…..1793. Vindobonae: Typis Alb. Ant. Patzowsky. Tom. I-V. 258, 330, 283, 323, 164 p.

Benkö, S. 1802. Novae Ephemerides astronomico-medicae annorum 1794…..1801. Vindobonae: Typis Alb. Ant. Patzowsky. 204 p.

Brázdil, R., Valášek, H., Sviták, Z., Macková, J. 2002. History of weather and climate in the Czech Lands. Vol. V: Instrumental Meteorological Measurements in Moravia up to the End of the Eighteenth Century. Brno: Masaryk University. 250 p.

Brázdil, R., Valášek, H. , Macková, J. 2003. Climate in the Czeh Lands the 1780s in Light of the Daily Weather Records of Parson Karel Bernard Hein of Hodonice (Southwestern Moravia): Comparison of Documentary and Instrumental Data. *Climatic Change* 60, 297–327. DOI: 10.1023/a:1026045902062

Brázdil, R., Pfister, C., Wanner, H., van Storch, H., Luterbacher, J. 2005. Historical Climatology in Europe , The State of the Art. *Climatic Change* 70, 363-430. DOI: 10.1007/s10584-005-5924-1

Brázdil, R. , Kiss, A. , Luterbacher, J. , Valášek, H. 2008. Weather Patterns in Eastern Slovakia 1717-1730, Based on Records from the Bresslau Meteorological Network. *International Journal of Climatology* 28/12, 1639–1651. DOI: 10.1002/joc.1667

Brázdil, R., Demarée, D.R., Deutsch, M., Garnier, E., Kiss, A., Luterbacher, J., Macdonald, N., Rohr, Ch., Dobrovolný, P., Kolář, P., Chromá, K. 2010. European floods during the winter 1783/84: scenarios of an extreme event during the 'Little Ice Age'. *Theoretical applied Climatology* 100, 163–189. DOI: 10.1007/s00704-009-0170-5

Camuffo, D. 2002a. History of the long series of daily air temperature in Padova (1725-1998). *Climatic Change* 53, 7–75. DOI: 10.1007/978-94-010-0371-1_2

Camuffo, D. 2002b. Calibration and Instrumental Errors in early Measurements of Air Temperature. *Climatic Change* 53, 279–329. DOI: 10.1007/978-94-010-0371-1_11

Csernus-Molnár, I. , Kiss, A. 2011. A XVIII. század végi magyarországi műszeres mérések feldolgozási és vizsgálati lehetőségei (Research and study possibilities of late 18th-century instrumental weather measurement series in Hungary). In: Kázmér, M. (ed.). *Környezettörténet 2* (Environmental history 2). Budapest: Hantken Kiadó. 203–214.

Dall'Amico, M., Hornsteiner, M. 2006. A simple method for estimating daily and monthly mean temperatures from daily minima and maxima. *International Journal of Climatology* 26, 1929–1936. DOI: 10.1002/joc.1363

Demarée, G. R., Lachaert, P. J., Verhoeve, T., Thoen, E. 2002. The Long-Term Daily Central Belgium Temperature (CBT) Series (1767-1998) and Early Instrumental Meteorological Observations in Belgium. *Climatic Change* 53, 269–293. DOI: 10.1007/978-94-010-0371-1_10

Ephemerides Societatis Meteorologicae Palatinae Observationes. Mannheim: Ex Officina Novae Societatis Typographicae. Tom. I-XII, 1781-1792.

Genersich, J. 1789-1800. Meteorologische Beobachtungen in dem Jahr 1789. Országos Széchényi Könyvtár, Kézirattár, Fol. Germ. 114.

Glaser, R. 2008. Klimageschichte Mitteleuropas. 1200 Jahre Wetter, Klima, Katastrophen. Darmstadt: Primus Verlag. 264 p.

Kern, Z., Popa, I. 2009. Assessing temperature signal in X-ray densitometric data of Norway spruce and the earliest instrumental record from the Southern Carpathians. *Journal of Environmental Geography* 2(3-4), 15–22.

Kiss, A., Sümeghy, Z., Danku, Gy. 2006. Az 1783-1784. évi szélsőséges tél és a Maros jeges árvize (Severe winter of 1783-1784 and the ice flood on the Maros river). In: Kiss, A., Mezősi, G., Sümeghy, Z. (eds.). Táj, környezet és társadalom / Landscape, Environment and Society. Szeged: SZTE. 353–362.

Kiss, A., Sümeghy, A., Fehér, Z. Zs. 2008. A Maros 18. századi áradásai és egy jellemző téli árvizének területi hatásai (18th-century floods of the Maros river and the areal consequences of a winter flood). In Füleky, Gy. (ed.) A táj változásai a Kárpát-medencében. Az erdélyi táj változásai(Landscape changes in the Carpathian Basin. Changes of the Transylvanian landscape). Gödöllő: Szent István Egyetem. 94–100.

Kiss, A. 2007. „Suburbia autem maxima sui in parte videntur prorsus esse deleta" , Danube icefloods and the pitfalls of urban planning: Pest and its suburbs in 1768-1799. In: Kovács, Cs. (ed.) *From Villages to Cyberspace.* Szeged: University Press. 271–282.

Kiss, A. 2009. Historical climatology in Hungary: Role of documentary evidence in the study of past climates and hydrometeorological extremes. *Időjárás* 113(4), 315–339.

Kiss, A. , Csernus-Molnár, I. 2008. Időjárási viszonyokhoz kapcsolható szélsőségek területi vonatkozásai a Temesi Bánságban: 1780-1800 (Areal consequences of weather-related extremes in the Temesi Bánság/Banat area: 1780-1800). In Füleky, Gy. (ed.) A táj változásai a Kárpát-medencében. Az *erdélyi táj változásai* (Landscape changes in the Carpathian Basin. Changes of the Transylvanian landscape). Gödöllő: Környezetkímélő Agrokémiáért Alapítvány-Szent István Egyetem. 101–106.

Kiss, A., Sümeghy, Z., Danku, Gy. 2006. Az 1783-1784. évi szélsőséges tél és a Maros jeges árvize (The severe winter of 1783-1784 and the ice-flood of the Maros river). In Kiss, A., Mezősi, G., Sümeghy, Z. (eds.) Táj, környezet és társadalom / Landscape, Environment and Society. Szeged: University Press. 353–362.

Klapka, C.J. 1803. Observationes Thermometricae et Barometricae a 1a Septembris 1780. usque ultimam Decembris 1803. Temesvarini factae per C. J. Klapka. Eötvös Loránd University Library, Manuscript and Rare Book Collection, Cat. number E 40.

Klapka, Gy. 1886. Emlékeimből (From my memories). Budapest: Franklin Társulat. 4–5.

Réthly, A. 1970. Időjárási események és elemi csapások Magyarországon 1701-1800-ig (Weather events and natural disasters in Hungary in 1701-1800). Budapest: Akadémiai Kiadó. 519-565.

Self, S., Rampino, M.R. 1998. The Relationship between Volcanic Eruptions and Climatic Change: Still a Conundrum. *EOS* 69/6, 74–86.

Stothers, R.B. 1996. The great dry fog of 1783. *Climatic Change* 32, 79–89. DOI: 10.1007/bf00141279

Strömmer, E. 2003. Klima-Geschichte. Methoden der Rekonstruktion undhistorische Perspektive. Ostösterreich 1700 bis 1830. Forschungen und Beiträge zur Wiener Stadtgeschichte 39. Vienna: Deuticke. p. 325.

Szinnyei, J. 1900. Magyar írók élete és munkái (Life and works of Hungarian writers). Budapest: Hornyánszky Viktor. Vol. 6. 466.

Szőkefalvi-Nagy, Z., Zétényi, E. 1965. Egy XVIII. századi magyar meteorológus: Benkő Sámuel miskolci orvos (An 18th-century Hungarian meteorologist: Sámuel Benkő, the doctor of Miskolc). *Borsodi Szemle* 9, 51–56.