EARLY INSTRUMENTAL METEOROLOGICAL OBSERVATIONS IN THE CZECH LANDS III: FRANTIŠEK JINDŘICH JAKUB KREYBICH, ŽITENICE, 1787–1829

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František Jakub Jindřich Kreybich (1759–1833) worked as parish priest in Žitenice, where he carried out meteorological observations in 1787–1829. Kreybich's handwritten daily records are preserved in the Archives of the Academy of Sciences, Prague, the Czech Republic; they are fragmentary before 1800, then form a continuous series from November 1800 to December 1818. Data from Žitenice at the level of monthly values exist for 1790–1793, published by Strnadt (1795) then, starting with 1817, they appeared regularly in the publications of the I. R. Patriotic-Economic Society. For the period November 1800–December 1818, the analysis of air pressure and temperature, wind direction and the frequency of selected meteorological phenomena is carried out on the basis of daily values. Monthly series of air pressure and temperature at Žitenice have been homogenised for the period November 1800–December 1829 through reference to measurements recorded at the Prague-Klementinum and Vienna-Hohe Warte stations.

František Jakub Jindřich Kreybich (1759–1833) působil jako farář v Žitenicích, kde prováděl svá meteorologická pozorování v letech 1787–1829. Kreybichovy rukopisné denní záznamy jsou dochovány v Archivu AV ČR v Praze ve fragmentech před rokem 1800 a v souvislé řadě z období listopad 1800–prosinec 1818. Na úrovni měsíčních hodnot z let 1790–1793 jsou uvedeny údaje z Žitenic v publikaci Strnada (1795) a od roku 1817 byly pravidelně publikovány ve spisech c. k. Vlastenecko-hospodářské společnosti. Pro období listopad 1800–prosinec 1818 je na základě denních hodnot provedena statistická analýza tlaku a teploty vzduchu, směru větru a četností výskytu vybraných meteorologických jevů. Měsíční řady tlaku a teploty vzduchu v Žitenicích byly pro období listopad 1800–prosinec 1829 homogenizovány podle měření stanic Praha-Klementinum a Vídeň-Hohe Warte.

Key words: instrumental meteorological measurements – air temperature – air pressure – wind – meteorological phenomena – meteorological singularities – hydrometeorological extremes – František J. J. Kreybich – Žitenice

INTRODUCTION

Although the first instrumental meteorological measurements for the region were taken at Zákupy (northern Bohemia) for 21 December 1719–31 March 1720 (Brázdil, Valášek, 2002), the development of meteorological observations in Bohemia was most closely associated with the existence of the Klementinum astronomical observatory in Prague. The measurement of precipitation, air pressure and temperature began there in 1752, under Josef Stepling, its first director (Observationes, 1753; Kreil, 1865). Whereas observations for the subsequent period 1753–1768 have not been found, those for the following years survived, largely thanks to the work of the third observatory director, Antonín Strnad, who published the monthly means of air pressure for the years 1752 and 1769–1793 and the monthly means of air temperature for the years 1770–1793 (Strnadt, 1794a, 1794b). As well as this, Strnad also published summary monthly overviews of visual daily observations in Prague for 1769–1771 (Strnadt, 1788, 1789, 1790) and a part of the measurements for 1774 (Strnadt, 1775). On 1 January 1775, Strnad began regular daily observations (Meteorologická pozorování, 1976), through which, after 1 August 1781, Klementinum came to be included in the network of 39 meteorological stations that make up the Societas Meteorologica Palatina (Seydl, 1954; Pejml, 1975).

Antonín Strnad was aware of the importance of meteorological observations from the very beginning and made an appeal that they be more widespread in Bohemia (Strnadt, 1776): "Many thanks would be due to anyone who, without great daily exertion, records changes in the air, the rise and fall of warmth, changes in the winds, dry or rainy weather; anyone who can procure the necessary instruments for the country and prepare suitable people for the task will later be remembered with glory. Eventually this may also have useful consequences over the course of the years, something that could lead us to a better knowledge of the state of the country. I herewith invite all Czech patriots to lend their hands, together with me, to realise this useful enterprise in the future." Probably thanks to Strnad's

activities, further meteorological observations appeared in Bohemia in the 1780s and 1790s for (Prague aside), Žitenice (Pejml, 1985), Choceň, Planá, Teplá and Boleboř (Strnadt, 1791, 1795).

The meteorological observations for Žitenice made by František J. J. Kreybich are among the best-known and of the longest duration for their era. Stöhr (1920) characterised them as second-oldest only to the measurements at Klementinum. The analysis of Kreybich's observations, which is the subject of the present paper, is a thematic continuation of the analysis of the earliest instrumental measurements in the Czech Lands, made by Ferdinand Knittelmayer in Brno (Brázdil et al., 2006) and Andreas Sterly at Jihlava (Brázdil et al., 2007).

FRANTIŠEK J. J. KREYBICH

František Jindřich Jakub Kreybich (also spelt Kreibich) (Fig. 1) was born on 25 July 1759 at Kamenický Šenov, into the family of a linen merchant (for Kreybich's further biographical data see Hackel, 1842; Grunert, 1888; A. H., 1925, 1933; Mucha, 1959; Pejml, 1970; Bechyně, 1972; Pejml, 1985). He spent his school days with relatives at Hoštka and went on to study in the choir of a Jesuit grammar school in Chomutov. It was here that his interests in the exact sciences, natural history and technical drawing were kindled and nurtured by the rector of the establishment. He completed college education with success at the public examinations in mathematics and physics in Prague in 1779–1780; he was also interested in astronomy.

Kreybich was then admitted to the Prague general seminary and subsequently spent a year at the Litoměřice seminary, where he was ordained in 1786. His first post was curate to Žitenice (Fig. 2). In 1795 he was appointed parish priest and in the same year qualified as Doctor of Philosophy. He also taught catechism at the agricultural school in Žitenice (1791–1801). In 1794 Kreybich completed, after three years of work, a detailed map of the Litoměřice diocese, required by the bishop as a template for dividing his administrative area into parishes. He then participated in the creation of a further series of maps and became known as a cartographer (Mucha, 1959, 1986; Pejml, 1985). However, his career was interrupted when, on 31 May 1806, he was struck by lightning in a thunderstorm during a trip to Poustevna near Skalice. His life was saved only by the prompt intervention of the regional physician, one Dr. Kottenauer. To convalesce, he spent considerable time at a spa in Teplice (Grunert, 1888; A. H., 1925).

In the course of Kreybich's residence at the Žitenice rectory, the establishment became an important cultural and scientific centre. Guests at the rectory included such notables as Alois David, director of the Klementinum observatory and Kassian Halaschka, a professor at Prague University. Kreybich also kept up a correspondence with Strnad and David (see e.g. Ankert, 1902), to whom he sent the results of his meteorological observations.

Kreybich received a number of acknowledgements for his productive work. In 1806 he was appointed honorary canon of the chapter, then dean in 1817. In 1810–1811 he was invited as a consultant expert to a frontier committee negotiating claims made by Saxony to certain enclaves in the Rumburk region (Mucha, 1959). In 1820 he was appointed a corresponding member of the I. R. Patriotic-Economic Society and in 1827 an honorary member of the Society of the Patriotic Museum.

Kreybich's work in Žitenčice ended in 1829, after some 43 year. The reason for his retirement and his move

Figure 1. František Jindřich Jakub Kreybich (1759–1833) (O. Kotyza archives).

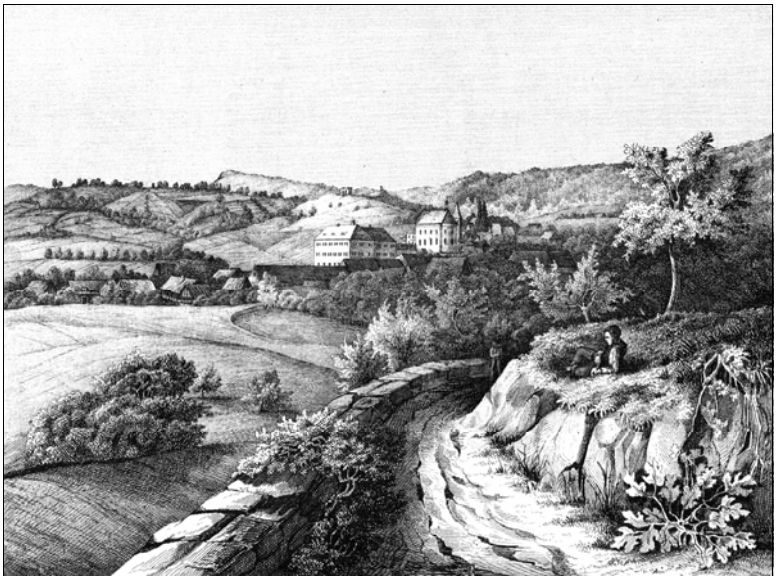


Figure 2. A view of Žitenice before 1850 (Regional Museum, Litoměřice).

to Litoměřice may perhaps be found in social unpleasantness arising out of a sermon in which he publicly reproached the dissolute life of a certain official (Riegrův slovník naučný, 1864). In Litoměřice, he lived on Michalská Street in what is known as the "Budův dům" at No. 38. He died of double pneumonia there on 17 December 1833, at the age of 74.

METEOROLOGICAL OBSERVATIONS MADE BY FRANTIŠEK J. J. KREYBICH

According to Katzerowsky (1887), Kreybich's meteorological observations were available at the State Secondary Technical School at Litoměřice. However, all trace of them ends in the late 19th century. At the latest, the observations started in the year 1787 (Fig. 3), for the first ten months of which there exist summaries of Kreybich's data in the Archives of the Academy of Sciences, Prague, Czech Republic (Wetterbeobachtung, catalogue no. 766). Meteorological observations for 1788, 1790 and 1794 are also deposited in the same place (Meteorologische Beobachtungen, catalogue no. 767) together with brief comparative barometric measurements for 1793, 1797 and 1798 (Observationes, catalogue nos. 712, 717, 721, 747). Kreybich even complemented his observations between November 1787 and June 1788 (Fig. 4) by graphical expression. Strnad used Kreybich's observations on the meteorological character of the autumn and December of 1788 and January of 1789 in Žitenice in his relatively detailed compilation analysis of an extremely cold December in 1788 (Strnadt, 1791, 1793a). As well as this, Strnadt (1795) published the results of Kreybich's observations of air pressure and temperature for the individual months of the period 1790–1793 (for 1791 see also Strnadt, 1793b).

Figure 3. Summary of the meteorological observations of František J. J. Kreybich for 1787, title page (Wetterbeobachtung, catalogue no. 766).

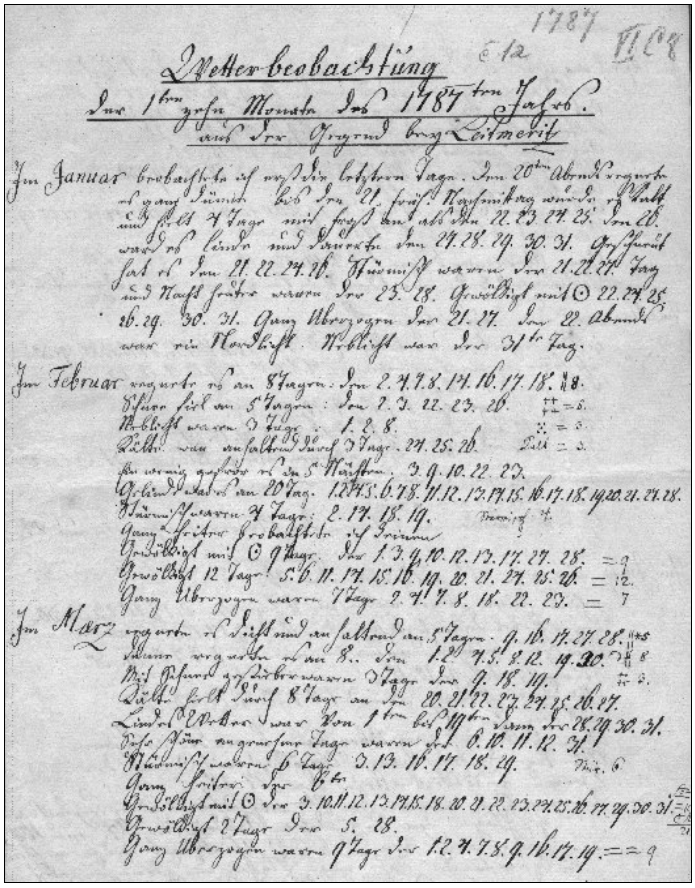
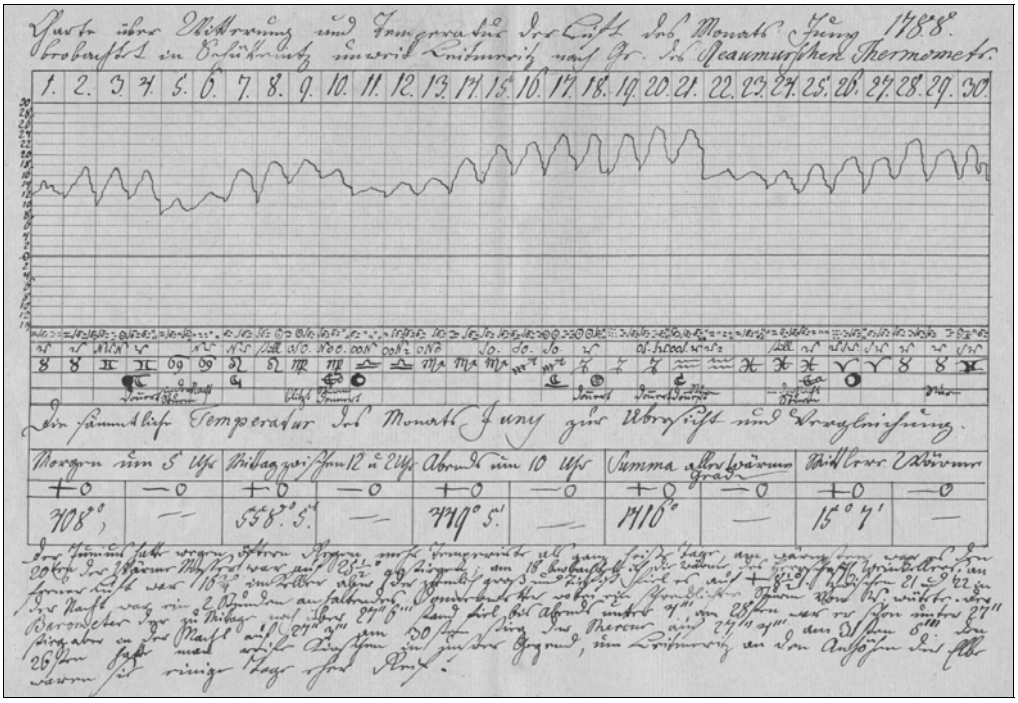


Figure 4. Overview of 150 meteorological observations for June 1788 processed by Kreybich (Meteorologische Beobachtungen, catalogue no. 767).



Kreybich's handwritten daily records of meteorological observations from November 1800 until December 1818 inclusive, sent to David of the I. R. Patriotic-Economic Society in the Bohemian Kingdom (Meteorologische Beobachtungen 1800–1818, catalogue nos. 768–785) remain preserved in the Archives of the Academy of Sciences, Prague, Czech Republic (Šlechtová, 1981). Kreybich's monthly overviews consist of three parts corresponding to three daily readings, in addition to columns for the day and the phases of the moon (Fig. 5). Each of these parts includes the measurement of air temperature in Réaumur degrees (with a separate column for positive and negative temperatures), air pressure in Paris measures, temperature at the barometer and symbols expressing the character of the weather. Below the table for any given month appears a word characteristic of his evaluation of the values measured. Every year is then completed with a summary of the values measured for the individual months. Starting with 1802, the observations are further complemented by an agrometeorological overview of the year with mention of any impacts on the harvest.

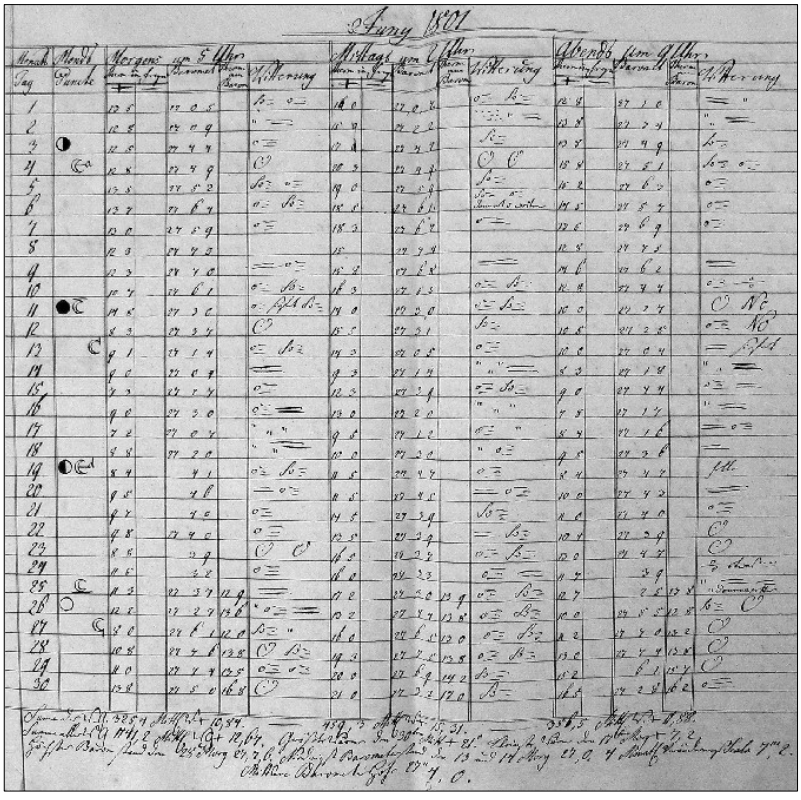
Starting in 1817, Kreybich's Žitenice observations were regularly published in the writings of the above-mentioned society (Nachricht, 1825, 1826), continuing in a new series until the end of his observations (Neue Schriften, 1828–1832; Resultate, 1828). The writings give the monthly and the annual means of air pressure, calculated from the highest and the lowest values reduced to temperatures in 0°R. Monthly and annual means of air temperature are calculated as the means of the sums of all positive and all negative air temperatures. The means of the two characteristics were also completed with the absolute annual maxima and minima and their dates of occurrence. Žitenice also appears in the table of prevailing monthly wind directions. As well as contributing to this, Kreybich's work also proved useful to the general economic overviews of Bohemia for the given year, always published after the meteorological overview proper.

No detailed information about the installation of the thermometer and barometer at the Žitenice rectory is available from Kreybich's records. In 1796, the I. R. Patriotic-Economic Society had thermometers and siphon barometers produced for its observers, but it is not clear whether or not Kreybich used instruments already in his possession. It is noteworthy that, in reports from 1801 (Meteorologische Beobachtungen, catalogue no. 768), he states that the society thermometer agrees with his, but that society barometer shows values 1.2 Parish lines lower. New instruments were later available from the Society in 1817 and 1827 but it is not clear whether Kreybich was involved.

The times of day at which Kreybich made his observations in the period 1800–1818 are not all perfectly defined. There were stable readings at 1400 and 2100 hours, but the exact timing of the morning observations is problematical. In simplified form one might say that Kreybich measured at 0700 hours in November–February, at 0600 hours in March–April and September–October and at 0500 hours from May to August. In a number of cases, however, this scheme is impaired by observation at the time of the sunrise, which appears for the first time in 1805 (thus, in the whole of 1816, with the exception of September), or further deviations from the above time (thus, in May 1802 at 0600 hours, in December 1813 at 0800 hours). Thus the recent standard observation times, at 0700, 1400 and 2100 hours, were observed in the period 1800–1818 in only a quarter of all months (of which only 1803 completely). With respect to the daily air temperature variation, measurement at an earlier time than 0700 hours leads to underestimation, and a later term overestimation, of the temperature from the morning reading. From 1819 onwards, detailed information on Kreybich's measurements has not survived.

Despite all these problems with the morning observations, there is no doubt that the measurements at Žitenice were carried out by Kreybich three times a day, not leaving out any evening readings, as maintained by Stöhr (1930) or Gattermann (1935 – quotation in Pejml, 1985). With respect to the quality of judgement, Pejml (1985) posed another question, namely that of who stood in to measure for Kreybich when he was away on his frequent journeys, since there is not a single omission in the time observations for the above period.

Figure 5. A specimen of the daily meteorological records made by František J. J. Kreybich: June 1801 (Meteorologische Beobachtungen, catalogue no. 768).

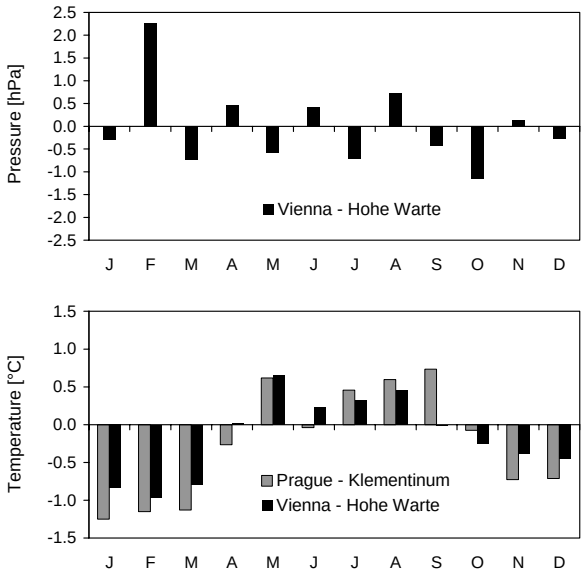


ANALYSIS OF THE METEOROLOGICAL OBSERVATIONS MADE BY FRANTIŠEK J. J. KREYBICH AT ŽITENICE

Kreybich's measurements at Žitenice (50º33´12´´N, 14º09´44´´ E, 223 m.a.s.l.) have been used in a number of papers to date, particularly in the analysis of temperature patterns, since this place was once considered to be the warmest in Bohemia (e.g. Fritsch, 1851; Kreil, 1865; Katzerowsky, 1887, 1890, 1895; Stöhr, 1920; Gattermann, 1924, 1926).

The period 1801–1829, for which with Kreybich's observations survive was, according to measurements at the secular Prague-Klementinum and Vienna-Hohe Warte stations, colder from October to April and warmer from May to September in comparison with the years 1961–1990. In the case of air pressure, according to the Vienna measurements, an almost regular alternation of positive (highest in February) and negative (highest in October) events occurs in the difference between the two periods (Fig. 6).

Figure 6. Differences in mean air pressure and temperature for the years 1801–1829 and the normal period 1961–1990 for Prague-Klementinum and Vienna-Hohe Warte stations.



Air pressure

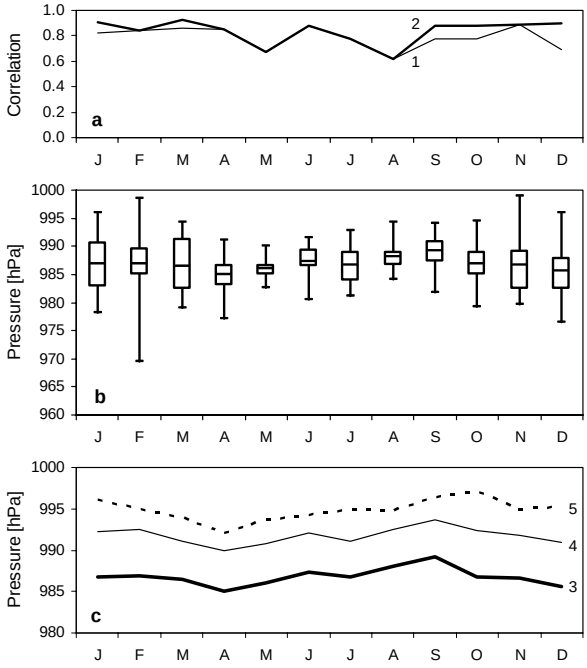
The values of air pressure were measured at Žitenice in Paris inches and lines (1 inch = 27.07 mm, 1 line = 2.256 mm), from which they were converted to mm Hg and subsequently to hPa. Two different pressure series for Kreybich's Žitenice measurements are available:

- series of monthly means calculated as the average of three daily readings for the period 1800–1818 (Meteorologische Beobachtungen 1800–1818, catalogue nos. 768–785) which is difficult to convert to 0 ºC because knowledge of Kreybich's barometer is limited,
- series of monthly means calculated from maximum and minimum daily values converted to 0 ºR for the period 1816–1829 (Nachricht, 1825, 1826; Neue Schriften, 1828–1832).

A further common monthly pressure series from Žitenice, consisting of both the series mentioned, has been created and the Standard Normal Homogeneity Test (SNHT – Alexandersson, 1986) used for homogeneity testing of it. In the first step, based on differences in monthly pressure means between Žitenice, Prague-Klementinum and Vienna-Hohe Warte, erroneous values were identified and then corrected by linear regression (Prague – October 1807; Vienna – January 1816, September 1812, December 1817). Erroneous values from March 1820–1822, September 1821–1822, October 1825 and December 1821–1822 in Žitenice were filled in after application of SNHT which did not exhibit any inhomogeneity in the Žitenice monthly data (Vienna-Hohe Warte as reference station). But correlation coefficients between both series are rather weak, mainly in May (0.67) and August (0.62), while in the other months they fluctuated between 0.78 (July) and 0.92 (March) (Fig. 7a).

The homogenised monthly series for air pressure in November 1800–December 1829 were further used to express annual variation by means of a box plot (Fig. 7b), which also yields information on the variability of individual monthly means. The annual variation demonstrates a main maximum in September (with secondary maxima in February and June) and a main minimum in April. The highest

Figure 7.
a) Correlation coefficients of monthly means of air pressure between the Žitenice and Vienna-Hohe Warte stations in the period November 1800–December 1829 before (1) and after (2) homogenisation;
b) box plot of mean monthly air pressure at Žitenice in the period November 1800–December 1829;
c) mean annual variation of air pressure in Žitenice (3) in comparison with the Prague-Klementinum station (4) (data for Prague in Fritsch, 1850) in the period November 1800–December 1829 and with the Brandýs nad Labem-Stará Boleslav station (5) in the period 1961–1990 (data in Míková, Coufal, 1999).

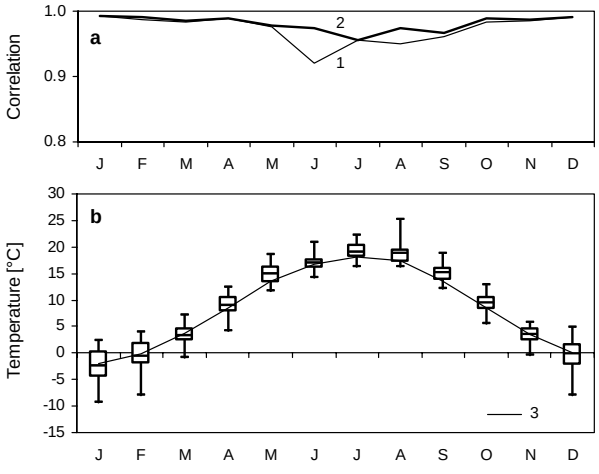


mean monthly value occurred in November 1805 (998.9 hPa), the lowest in February 1823 (969.6 hPa). The variation range of monthly extremes is highest between November and February, and lowest in May. A comparison of Žitenice data with the annual variation of air pressure at the Brandýs nad Labem-Stará Boleslav station (50°11´17´´ N, 14º39´57´´ E, 180 m.a.s.l.) in the period 1961–1990 shows a movement of maxima from September to October while the minimum conforms in April (Fig. 7c). On the other hand, the Žitenice observations are closely comparable to those of the Prague-Klementinum station for 1801–1829 (Fritsch, 1850).

Air temperature

In similar fashion to that applied to air pressure, testing of the homogeneity of series of mean monthly air temperatures was also carried out, in this case with respect to the Prague-Klementinum station. With very high correlation coefficients between the two series, homogenisation was done for measurements taken in June, September and October from 1823, and were corrected in the November data from 1800–1802. As well as this, disputable means in February 1808, March 1801 and August 1823 were corrected with respect to Prague-Klementinum (Fig. 8a). The annual variation in mean air temperatures expressed by the box plot indicates a simple annual wave with a minimum in January and a maximum in July, from which the temperature for August differs very little (Fig. 8b). The highest monthly mean occurred in August 1807 (25.3ºC), the lowest in January 1823 (–9.3ºC). For comparison, the annual variation of temperatures at the Doksany station (50º27´16´´ N, 14º09´42´´ E, 158 m.a.s.l.) in the period 1961–1990 is also shown in Fig. 8b. With respect to this station, temperatures in Žitenice were higher between April and October.

Figure 8.
a) Correlation coefficients of the monthly means of air temperature between the Žitenice and Prague-Klementinum stations in the period November 1800–December 1829 before (1) and after (2) homogenisation;
b) mean annual temperature variation at Žitenice in the period November 1800–December 1829 expressed by box plot in comparison with the station Doksany (3) in the period 1961–1990 (data for Doksany see Květoň, 2001).



Wind

In 1806–1818 Kreybich included the frequency of wind directions in his overview of monthly observations, on the basis of which it has been possible to compile wind roses for the individual seasons and for the year (Fig. 9a). The prevalence of a western flow is recognizable for winter, autumn and the year, while in summer this direction was overtaken by the frequencies for the north-westerly wind. In spring the two wind directions are almost equal, with only the frequency of the occurrence of the south-easterly wind approaching them. For the period 1819–1827, each month at Žitenice is characterised only by the prevailing wind direction (in 1828–1829 only for the whole year). This information was collated for the whole period 1806–1827, showing the frequencies of prevailing seasonal winds (Fig. 9b); south-westerly winds prevailed in winter and autumn, north-westerly in spring and summer.

Figure 9.
a) Relative frequencies (%) of wind direction for the seasons and the year at Žitenice in the period 1806–1818;
b) seasonal relative frequencies (%) of prevailing wind direction at Žitenice in the period 1806–1827: 1 – winter, 2 – spring, 3 – summer, 4 – autumn.

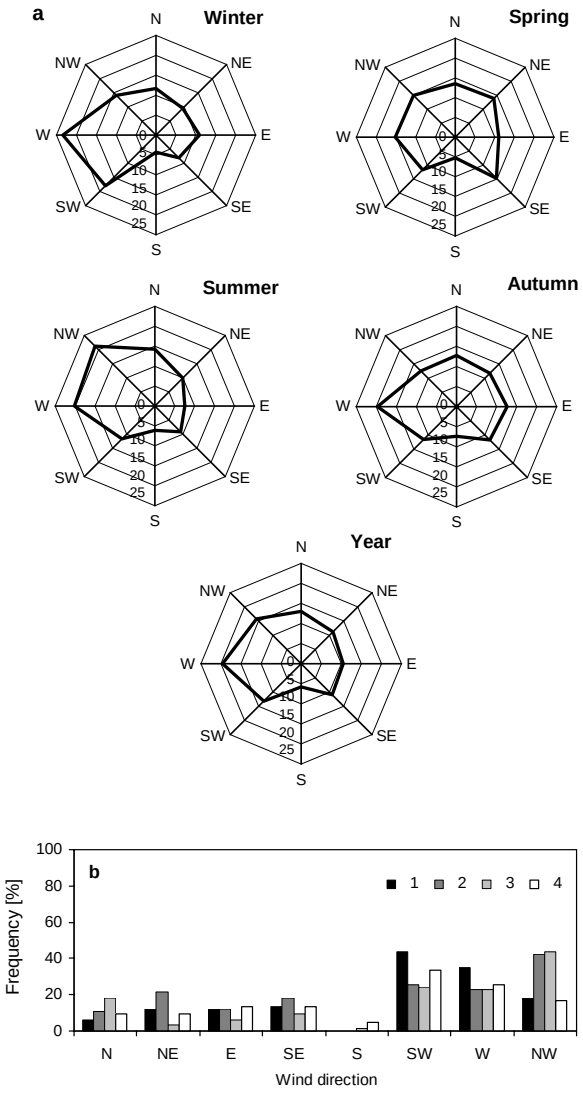
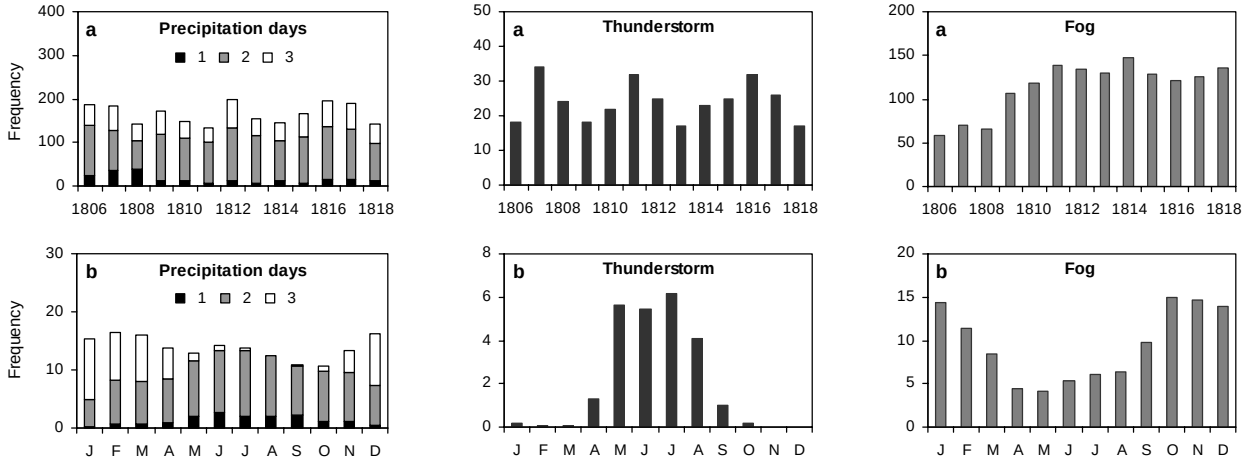


Figure 10. Fluctuation (a) and the mean annual variation (b) of the frequency of occurrence of precipitation days (1 – heavy rain, 2 – light rain, 3 – snow or hail), thunderstorms and fogs at Žitenice over the period 1806 to 1818.



Kreybich also recorded the number of days with *stürmisch*, "stormy wind" between 1806 and 1818. The storminess frequency in Žitenice showed a smoothed annual variation with a maximum in February (secondary peak in August) and a minimum in July. A total of 63 days with stormy wind occurred in 1813, but in 1816 this total was only 17 days.

Meteorological phenomena

Kreybich's monthly overviews for 1806–1818 also include the frequency of precipitation, fog, thunderstorms, stormy wind and variable weather, frosts and the state of the sky.

In the case of precipitation days (Fig. 10), Kreybich distinguished between heavy and light rains and solid precipitation (snow, hail). In the period processed he recorded the most precipitation days in 1812 (199), the least in the year before (132). In the annual variation, frequencies for December to March dominate, with minima falling to October and September.

Kreybich observed thunderstorms (Fig. 10) at Žitenice for every month of the year except November and December. The maximum occurred in July, followed by May and June. Their annual number fluctuated between 34 days (1807) and 17 days (1813 and 1818).

The number of fogs (Fig. 10) was evidently underestimated in 1806–1808 (maximum in 1814). In terms of annual variation, the maximum occurred in October, followed by the frequencies of fogs in November–January; with minima recorded in April–May.

Meteorological singularities

Kreybich's daily records from November 1800 to December 1818 have also made it possible to address the study of meteorological singularities as calendar-bound deviations in a given meteorological element from its mean long-term variation. Singularities were studied for air pressure and temperature employing the methodology established by Řezníčková et al. (2007), which makes it possible to evaluate statistically significant deviations in the annual variation of those elements.

In the case of air pressure in the period November 1800–December 1818, altogether 23 singularities were found with a mean duration of 3.0 days; the longest singularities extended to the 7 days of 1–7 January and 13–19 September (Table 1, Fig. 11). For air temperature, altogether 29 singularities were found with a mean duration of 2.8 days (Table 1, Fig. 12). In 9 cases a statistically significant deviation from the mean was only recorded for a period of one day. The longest temperature singularity, with duration of 8 days, fell to 2–9 May.

Examination of Table 1 demonstrates close agreement between these events and the singularities revealed by analysis of Knittelmayer's observations in Brno in 1799–1812 (Brázdil et al., 2006), pointing to a certain temporal stability and spatial extent. In terms of the best-known meteorological singularities traditionally mentioned for the Czech Republic (Řezníčková et al., 2007), the situation in Žitenice in the period November 1800–December 1818 was as follows:

- "deep winter" – expressed only on days 11–14 January, bound to a negative singularity of air pressure (12–14 January), not to the prevalence of an anticyclonic weather regime
- "May cooling" – usually associated with the so-called "Ice-men" did not appear at all; on the contrary, the longest warm anomaly occurred on 2–9 May (further 21–22 May and, surprisingly, the onset of "Médard Weather" on 8–12 June) as well
- "high summer" – there was a perceptible singularity in the case of air temperature, with positive anomalies on 22–25 July, 27 July and 29 July–1 August
- "Indian summer" – this was well expressed by two episodes of high air pressure on 13–19 September and 3–6 October, which were not reflected in the air temperature singularities (positive deviation only for 7–8 October)
- "Christmas thaw" – this positive temperature singularity appears with a delay only on 29–30 December, the more significant preceding cooling falling to 19–21 December.

Table 1.
Singularities in air pressure and temperature in the period November 1800–December 1818 in Žitenice after Kreybich's observations and in comparison with singularities in Brno for the period 1799–1812 (Brázdil et al., 2006).

Key:
MD – mean deviation
H – higher pressure
L – lower pressure
C – cold
W – warm

Pressure					Temperature				
No	**Type**	**Period**	**MD** [hPa]	**Brno**	**No**	**Type**	**Period**	**MD** [°C]	**Brno**
1	H	1-7 Jan	3.2	2, 4-8 Jan	1	C	11-14 Jan	-1.3	12-13 Jan
2	L	12-14 Jan	-2.7	12-14 Jan	2	W	21 Jan	1.1	21-22 Jan
3	L	20-22 Jan	-2.5	20-22 Jan	3	C	26-27 Jan	-0.8	27 Jan
4	H	19-21 Feb	4.0	19-21 Feb	4	C	20 Feb	-0.9	-
5	L	8-10 Mar	-3.0	-	5	W	3-5 Mar	0.9	3-4 Mar
6	H	25-27 Mar	2.2	23-27 Mar	6	C	23-27 Mar	-0.8	23-26 Mar
7	H	5 Apr	1.6	4-6 Apr	7	W	7-9 Apr	1.0	-
8	L	15-17 Apr	-3.8	-	8	C	20-23 Apr	-1.4	-
9	H	2-3 June	0.9	-	9	W	2-9 May	1.2	2-4, 9-10 May
10	H	11-13 June	1.2	-	10	W	21-22 May	0.9	22-23 May
11	L	2-4 July	-2.5	2-5 July	11	W	8-12 June	0.8	6-8 June
12	H	9 July	0.8	-	12	C	18-20 June	-0.7	18-20 June
13	L	17-20 July	-1.2	-	13	C	23-25 June	-0.9	23-25 June
14	H	17-18 Aug	1.0	-	14	W	1 July	0.6	-
15	L	11 Sep	-1.4	-	15	C	5-6 July	-0.7	-
16	H	13-19 Sep	2.2	14-19 Sep	16	W	9-11 July	1.1	9-10 July
17	L	22-24 Sep	-2.0	23-24 Sep	17	C	17 July	-0.8	17-19 July
18	H	3-6 Oct	3.0	2-6 Oct	18	W	22-25 July	0.6	24 July
19	L	8-12 Oct	-1.9	8-11 Oct	19	W	27 July	0.6	-
20	L	29 Oct	-2.0	-	20	W	29 July-1 Aug	1.0	28 July-3 Aug
21	H	28-29 Nov	2.0	-	21	C	17 Aug	-0.8	16-18 Aug
22	L	6 Dec	-2.0	2-6 Dec	22	W	29 Aug-1 Sep	1.0	28 Aug-1 Sep
23	L	8-10 Dec	-2.8	8-9 Dec	23	W	7-8 Oct	0.5	6-9 Oct
					24	C	11-15 Oct	-0.8	11-15 Oct
					25	W	23 Oct	0.6	-
					26	C	3 Nov	-0.6	2-3 Nov
					27	C	11 Dec	-0.8	-
					28	C	19-21 Dec	-1.1	17-22 Dec
					29	W	29-30 Dec	1.1	24-29 Dec

Figure 11. Annual variation of mean daily air pressure in Žitenice for the period November 1800–December 1818:
a) three-day running means smoothed by 60-day low-pass filter,
b) three-day running deviations with intervals of reliability (80%) and marking of singularities with a duration of ≥ 2 days (for numbers, see Table 1).

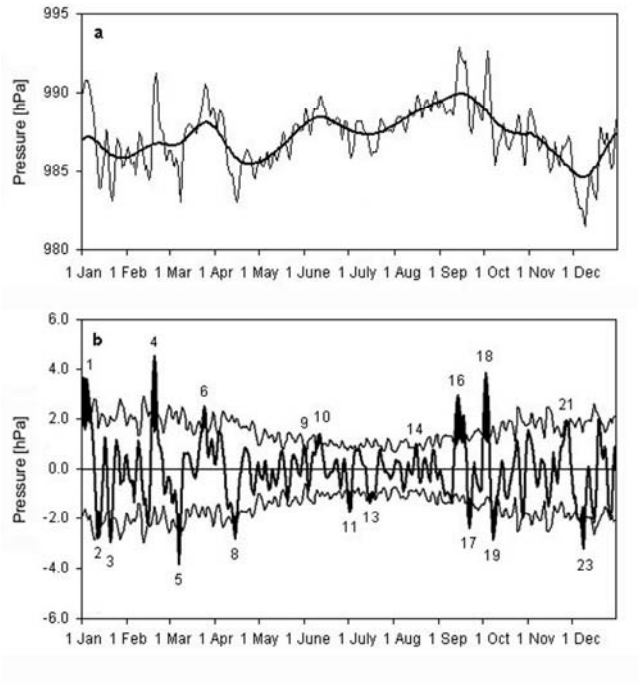
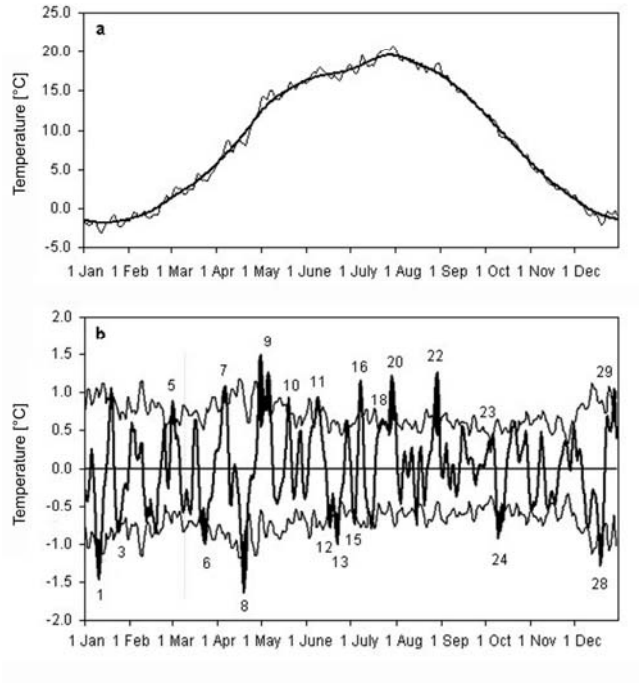


Figure 12. Annual variation of mean daily air temperature in Žitenice for the period November 1800–December 1818:
a) three-day running means smoothed by 60-day low-pass filter,
b) three-day running deviations with intervals of reliability (80%) and marking of singularities with a duration of ≥ 2 days (for numbers, see Table 1).



EXTREME HYDROMETEOROLOGICAL PHENOMENA IN THE OBSERVATIONS OF FRANTIŠEK J. J. KREYBICH

As a sensitive observer, František J. J. Kreybich also included in his records information on the occurrence of extreme hydrometeorological phenomena. Thus, in 1787 he drew attention to thunderstorms during which lightning started fires, namely on 13 April near Lovosice, 12 June in Terezín, 14 June and 7 July in Roudnice nad Labem, and on 16 June and 31 July in several places. From 1802 onwards, information about extremes appears in the economic overviews for given years with which he rounded off his own meteorological observations. These dealt particularly with the evaluation of impacts of the weather on agricultural production of grains, vegetables, fruit and grapevines.

Kreybich recorded a certain amount of information on floods, often with reference to the movement of ice and the formation of ice barriers (for floods on the Elbe and the Ohře see Brázdil et al., 2005). Thus, on the night of 13/14 February 1805, the ice started moving on the Elbe at Litoměřice and stopped at Lovosice, when water with ice spread over fields. Substantially worse was, however, a sudden rise of water when the course of the river near Děčín was blocked on 26 February. In 1810, the ice on the Elbe started moving on 28 February and on the following day the water rose in both the Ohře and the Elbe, to such an extent that the roads and surroundings of Brozany, Doksany, Brňany, České Kopisty, Terezín and further communities were under water. During this long-lasting flood, the water culminated on 4 March and particularly after rain on 15 March. The water also left the course of the river in 1811 during movement of ice around Litoměřice. In 1812 the waters of the Ohře flooded the territory from Doksany up to its confluence with the Elbe, which also rose above its banks later (on 3 and 6 April). Kreybich devoted a particularly detailed description to the long and hard winter of 1813/14, when thick ice formed on the rivers and there was a flood associated with the movement of ice during which a bridge at Litoměřice was destroyed on 24 March (Fig. 13) and five people drowned. From 10 to 15 May 1815, the Elbe in flood damaged cereals, potatoes and further field crops. Another movement of thick ice was recorded at the beginning of January 1816. Kreybich mentioned damage to hay as the Elbe flooded meadows near Mělník at the beginning of June 1817.

Kreybich also recorded cases of drought. For example, in autumn 1810, great heat and more than two months of drought dried out brooks and streams, while the Elbe at Litoměřice fell to the lowest levels in living memory. Mills could not operate, leading to high prices for flour. Frequent rains in November rectified the situation.

Kreybich also noticed frosts. Thus, for 1 June 1810 he mentioned great frost damage to young trees in higher positions, also speaking in a similar way of frosts around 15 November. On 29 June 1813, potatoes, beans and cucumbers froze in a strong frost and on 4–5 July snow fell in the mountains. Frosts on 16–22 April 1815 caused damage to walnut trees and grapevines. Repeated frosts towards the end of May of the same year again harmed grapevines and emerging grains. Grapevines suffered from the first frosts at the beginning of October 1817 and particularly in strong frosts on 16–18 October.

For 15 May 1811, Kreybich recorded considerable hail damage to field crops around Žatec. Further thunderstorms with hail on the evening of 2 July did less damage, but a strong west by south-west wind across Třebenice, Lovosice, Litoměřice and Žitenice did great damage to roofs and windows, and uprooted fruit trees. The specification of the trajectory in Kreybich's report indicates that it might have been a tornado.

Kreybich's information on the summer months of 1816 is particularly interesting. This season was characterised by unusually thick fogs and dangerous thunderstorms, during which lightning often struck and started fires. These thunderstorms were accompanied by heavy downpours and hailstorms, particularly on 5 August (Podbořany, Minice, Břvany in the Žatec region and the area between Libčeves and Libochovice in the Litoměřice region), and again on 14 August (the surroundings of Libčeves). Cold and rainy weather from May throughout the summer led Kreybich to rank this year as far from productive and, in a number of places, to place it among years with very bad crops. The year 1816, in the wake of the mighty volcanic eruption of Tambora (Lesser Sunda Islands, Indonesia; VEI = 7) in April 1815 (Sigurdsson, Carey, 1992), is marked as "the year without a summer" (see e.g. Stommel, Stommel, 1983; Harington, ed., 1992; Písek, Brázdil, 2006).

Figure 13.
The Litoměřice bridge, destroyed during the Elbe flood of 24 March 1814 (Regional Museum, Litoměřice, catalogue no. SV H 3820).

CONCLUSIONS

The meteorological and cartographic activities of František J. J. Kreybich lent him a status that significantly extended beyond the region in which he lived and worked. Kreybich's observations stand out for their precision, comparability to the standards of modern climatological measurements, and their duration, even though they are not complete for the whole period of 1787–1829 in terms of daily and monthly values. Despite this shortcoming, they make it possible to obtain a considerable amount of valuable climatological information from a period in which analysis for the territory of the Czech Lands is otherwise based almost exclusively on the work of Prague-Klementinum. No less important are Kreybich's reports of hydrometeorological extremes and their impacts, including the agrometeorological characteristics he assigned to individual years. He thus made a significant contribution to the completion of the mosaic of early instrumental meteorological measurements in the Czech Republic.

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Wetterbeobachtung der 1ten zehn Monate des 1787ten Jahrs aus der Gegend bey Leitmeritz. Catalogue no. 766 (VI C 8, No. 1).