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Meteorological Observations in Bern and Vicinity, 1777-1834

Chantal Hari, Yuri Brugnara, Christian Rohr, and Stefan Brönnimann*

Oeschger Centre for Climate Change Research and Institute of Geography, University of Bern, Switzerland

Abstract

This paper describes several meteorological records from Bern and vicinity, together covering the period 1777-1834. They comprise measurements in Bern by Karl Lombach, 1777-1789, Samuel Studer, 1779-1789 and 1797-1827, and Emanuel Fueter, 1803-1834. Studer was pastor and later professor of theology in Bern, but during the period 1789-1797 was appointed to Büren an der Aare, where he also continued his measurements before returning back to Bern and continuing measurements. As no other measurements were performed in Bern during these years, the Büren measurements could help to fill the gap, together with the series by Johann Jakob Sprüngli in Sutz, 1785-1802. In this paper, we describe the sources and metadata pertaining to these series. Then we analyse the data, their processing and quality control and we compare the series during their overlapping periods. These series, together with others already digitised and published in this volume, will contribute to a 250-yr meteorological series for Bern.

1. Introduction

Meteorological measurements started in Bern in 1760 by Franz Jakob von Tavel, covering however only ten years, of which only seven have daily data (Wyer et al., 2021). Although there are data from nearby locations (Neuchâtel, Gurzelen), measurements in the city of Bern continued only in 1777, when Karl Lombach started observations. In 1779, pastor Samuel Studer began making measurements. The latter diligently observed for a period of almost 50 years, thus providing a very long segment, although during eight years he made his measurements in Büren an der Aare, some 22 km away from Bern. During ten years, Lombach and Studer observed in parallel, providing an opportunity for comparison and quality assessment. During Studer's observing period, records are also available from Johann Jakob Sprüngli in Sutz (24 km from

* Corresponding author: Stefan Brönnimann, University of Bern, Institute of Geography, Hallerstr. 12, CH-3012 Bern, Switzerland. E-mail: stefan.broennimann@giub.unibe.ch.

Bern) and Samuel Emanuel Fueter in Bern. In this paper, we discuss these series. They might form important parts of a new long Bern record. In 1826, Friedrich Trechsel began measurements and continued until 1848, partly overlapping with a series by Daniel Gottlieb Benoit from 1837 to 1853. These series have been described by Flückiger et al. (2020) in this volume.

In this paper, we present the data from the four observers, for an overview of all early Swiss series see Pfister et al. (2019). These series will complement the already published Swiss series (Brugnara et al., 2020b). Images of this project will also be published in a repository; the digitised data will be available from various sources, including MeteoSwiss, EUROCLIMHIST and the Copernicus Climate Change Service (C3S) Global Land and Marine Observations Database (Noone et al., 2021).

The paper is organised as follows. Section 2 provides a historical overview of the measurements made by all observers. Section 3 describes the results of the quality assessment and presents the data. In Section 4, we then compare the Lombach, Studer, and Fueter series. Conclusions are drawn in Section 5.

2. Data

2.1. Karl Lombach

Karl Lombach (1740-1811) was the son of Niklaus Lombach, military officer and bailiff, and Maria Anna Margaretha Dachselhofer. He worked as an administrator of the salt depot ("Salzmagazinverwalter") in Bern. We can assume that he had a strong interest in science. He was a member of the Bernese Economic Society (but in 1768 refused payment and was excluded; see Salzmann, 2009).

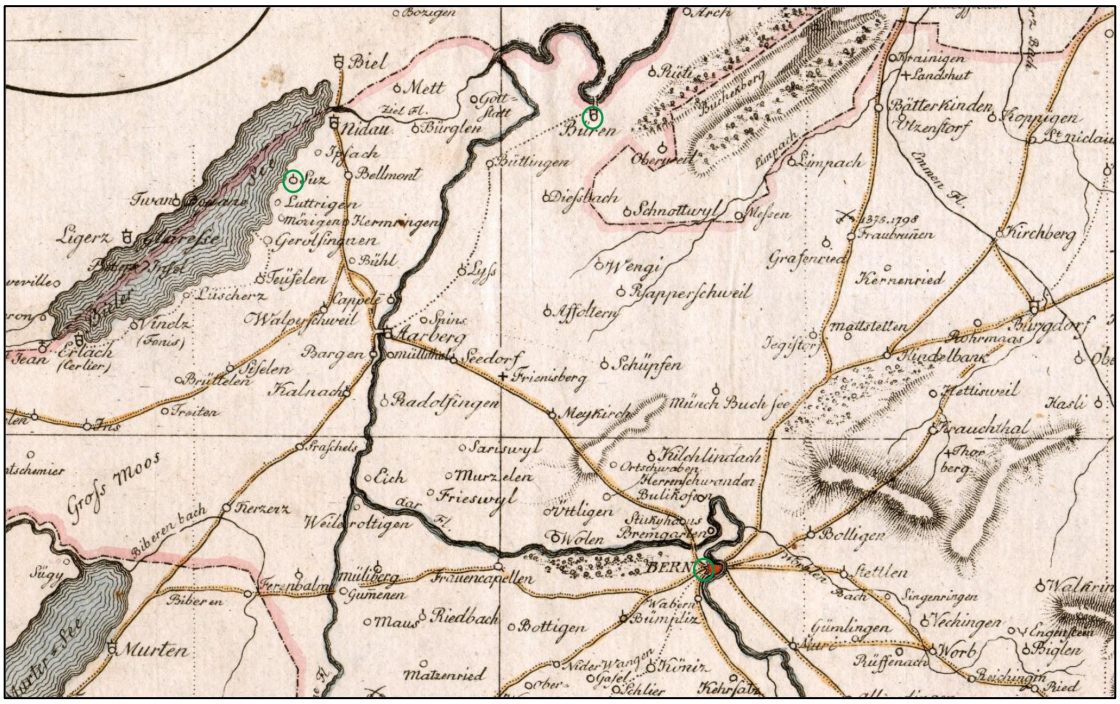


Figure 1. Map of the Canton of Bern showing Bern, Sutz, and Büren an der Aare (Helvetischer Almanach für das Jahr 1801 (1801)).

Figure 2. Map of Bern (excerpt) in the 1790s with the location of the Burgerspital (B), the Cathedral "Münster" (M) and the Villette (V) (from: Mülleratlas, Geodata: City of Bern).

Lombach performed the measurements at the Burgerspital ("im grossen Spital"), near today's railway station (Fig. 1, B in Fig. 2), and from June 1785 at the nearby salt depot. His measurements cover the period 1777-1789. Lombach measured temperature and pressure (typically in the morning and at 13:30 to 14:30) and observed precipitation and wind. According to Pfister (1975), Lombach used a mercury thermometer. Although the second observer, Samuel Studer, also measured at the Burgerspital during the same years as Lombach, there is no evidence for correspondence between the two men concerning their measurements.

Lombach's data can today be found at Burgerbibliothek Bern (GA Oek.Ges. 98, 13-25, OeGB 1782/3). An example sheet is shown in Figure 3. Some monthly means were published in the journal of the Bernese Economic Society, which provided the instruments to Lombach.

2.2. Samuel Studer

Samuel Emanuel Studer was born on 18 November 1757 in Bern (see Hari, 2021, for the following). He was the son of a wealthy butcher, also named Samuel, and his wife, Magdalena Hartmann. The Studer family was naturalized from Grafenried as early as 1593 (Braun, 2016). They never had an active part in the government. Studer lost his father when he was only eight years old. From then on, his upbringing was directed by one of his uncles, Daniel Ludwig Studer, who was interested in mathematical sciences and later a professor of theology in Bern. Due to health problems, Studer did not follow his ambition to become a medical doctor. Instead, he opted for a spiritual career, which offered the opportunity to pursue scientific interests. It was through this interest that he met Jakob Samuel Wyttenbach, then preacher at the Burgerspital and a famous scientist. After Wyttenbach's promotion to another position in 1781, Studer took over the position at the Burgerspital. In 1789, Studer became pastor in Büren an der Aare (Fig. 1) for seven years. In 1797, Studer returned to Bern and occupied the chair for practical theology. From 1827 to 1831, he was the highest dean of the Bernese church (Braun, 2016).

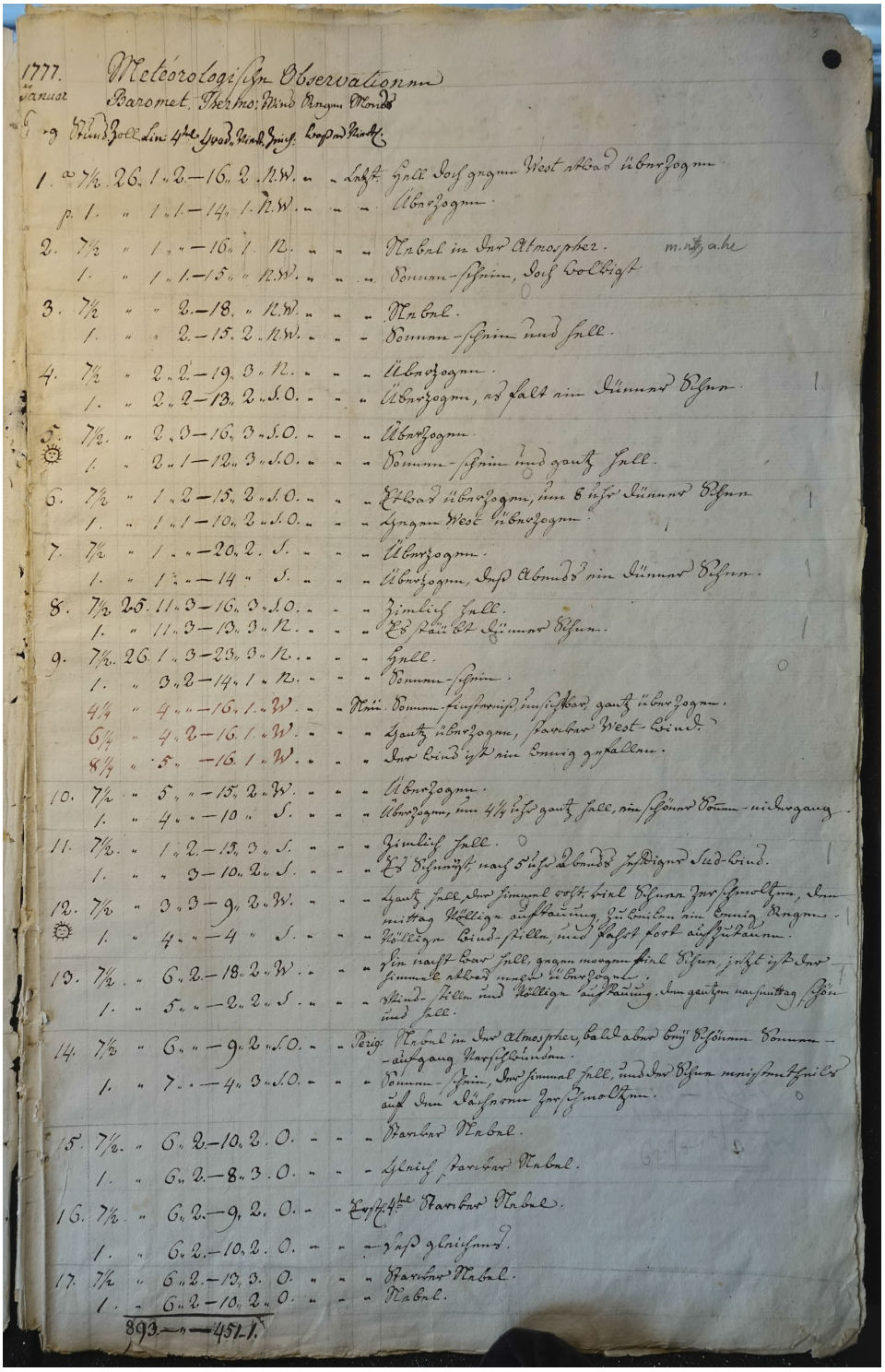


Figure 3. Observation sheet from Karl Lombach with measurements and observations for January 1777 (Burgerbibliothek Bern, GA Oek.Ges. 98, 13-25).

Studer had broad scientific interests that also encompassed geology, entomology and conchyliology. In 1786, he became a member of the Bernese Economic Society and in 1815 was a founding member of the Swiss Natural Sciences Society. His meteorological record begins on 20 December 1779 with measurements of temperature and air pressure and observations of wind at the Burgerspital in Bern (Figs. 1 and 2). They fall into the peak phase of the Enlightenment, a period when the number of meteorological measurements increased very rapidly (Brönnimann et al., 2019).

He made his measurements three times daily until 1827, when his weak eyes no longer allowed him to read and write down the measured values correctly. These observations meant a lot to Studer. It was reported that even on 16 November 1789, the day of his wedding, he stopped at the Burgerspital on the way from Köniz to read and to write down instrumental measurements, which truly shows the significance of this activity to him.

After his return to Bern in 1797, Studer occupied at least three apartments: until October 1803 he lived in two different houses next to the Cathedral (M in Fig. 2), while it is not clear where he lived after 1803 (almost certainly somewhere in the Old City). Therefore, it is to be assumed that his measurements suffer from inhomogeneities caused by the relocations.

Except for the time when he measured at the Burgerspital, Studer had installed two or even three thermometers, each facing a different direction, to compensate for the lack of a suitable location with northern exposure in his apartments. He was well aware of the direct solar insolation as a possible source of error and had thus marked the values affected by direct sunlight with a symbol to show their invalidity. Additional valuable information stems from his notes that describes the surfaces to which the thermometers were attached and the implications this had on the temperature readings. He also read two different barometers in parallel to check on instrumental biases or drifts.

Studer's measurement ended in 1827. They cover almost 50 years and thus constitute one of the longest one-man series. His observation sheets are kept in the Burgerbibliothek Bern (Mss.h.h.XX.5.1-5). An example is shown in Figure 4.

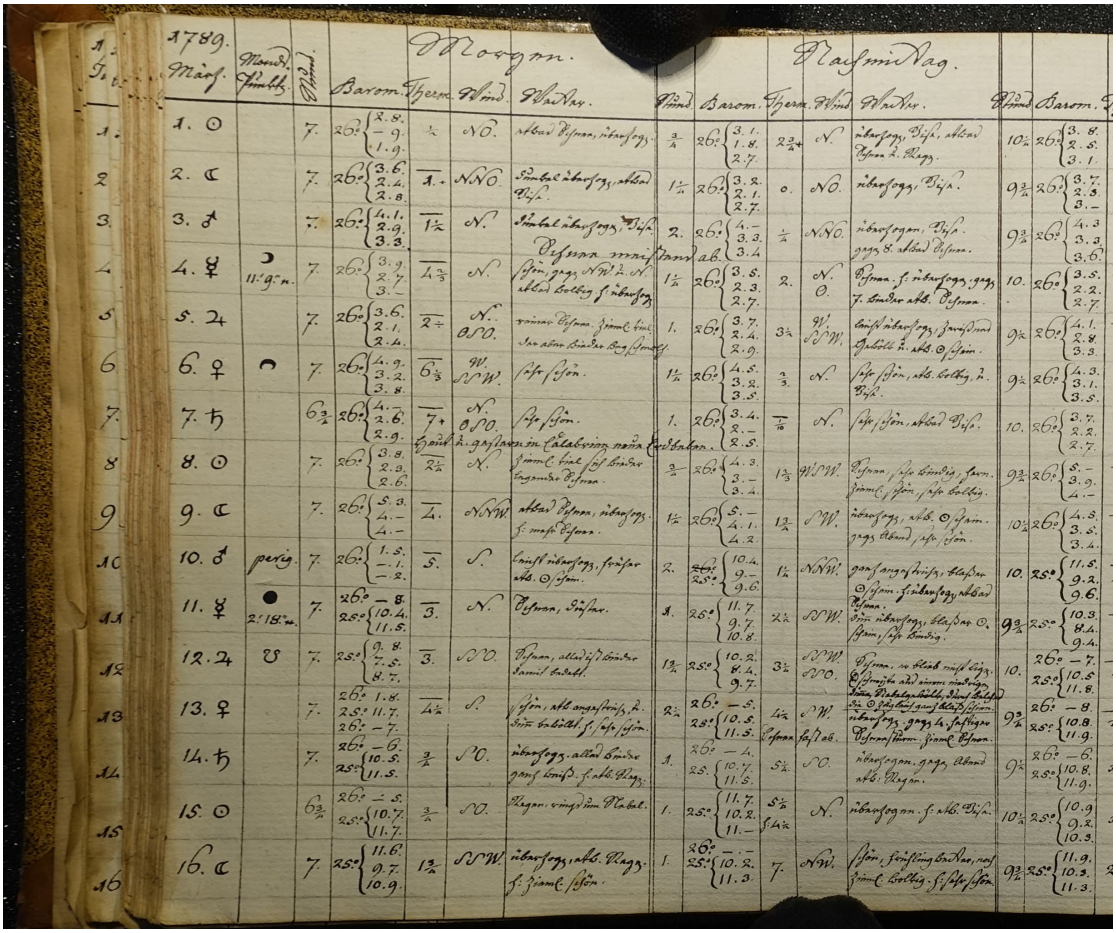


Figure 4. Sheet of Studer's data for 1789 (Burgerbibliothek Bern, Mss.h.h.XX.5.1).

2.3. Johann Jakob Sprüngli

The observer of the third series discussed was the parson Johann Jakob Sprüngli (1717-1803). He was also the observer in Gurzelen, a series that is discussed in Wyer et al. (2021) in this volume. Only a brief summary is therefore given here. His career as a parson started in Zweisimmen in 1757, from where he moved to Gurzelen in 1765 and to Sutz in 1784 (Wolf, 1855, 1872). He observed the weather in all three places, from 1767 with meteorological instruments. In Sutz he performed observations from 1785 to 1802.

As Studer, Sprüngli was in contact with priest Jakob Samuel Wyttenbach and had a close relation with the Bernese Economic Society, which provided him with instruments. His observations and measurements are of a high quality (Pfister, 1975; Burri and Zenhäusern, 2009). The handwritten observations can be found in the Burgerbibliothek Bern (GA Oek.Ges. 111, 114, 115, 116). An example sheet is shown in Figure 5.

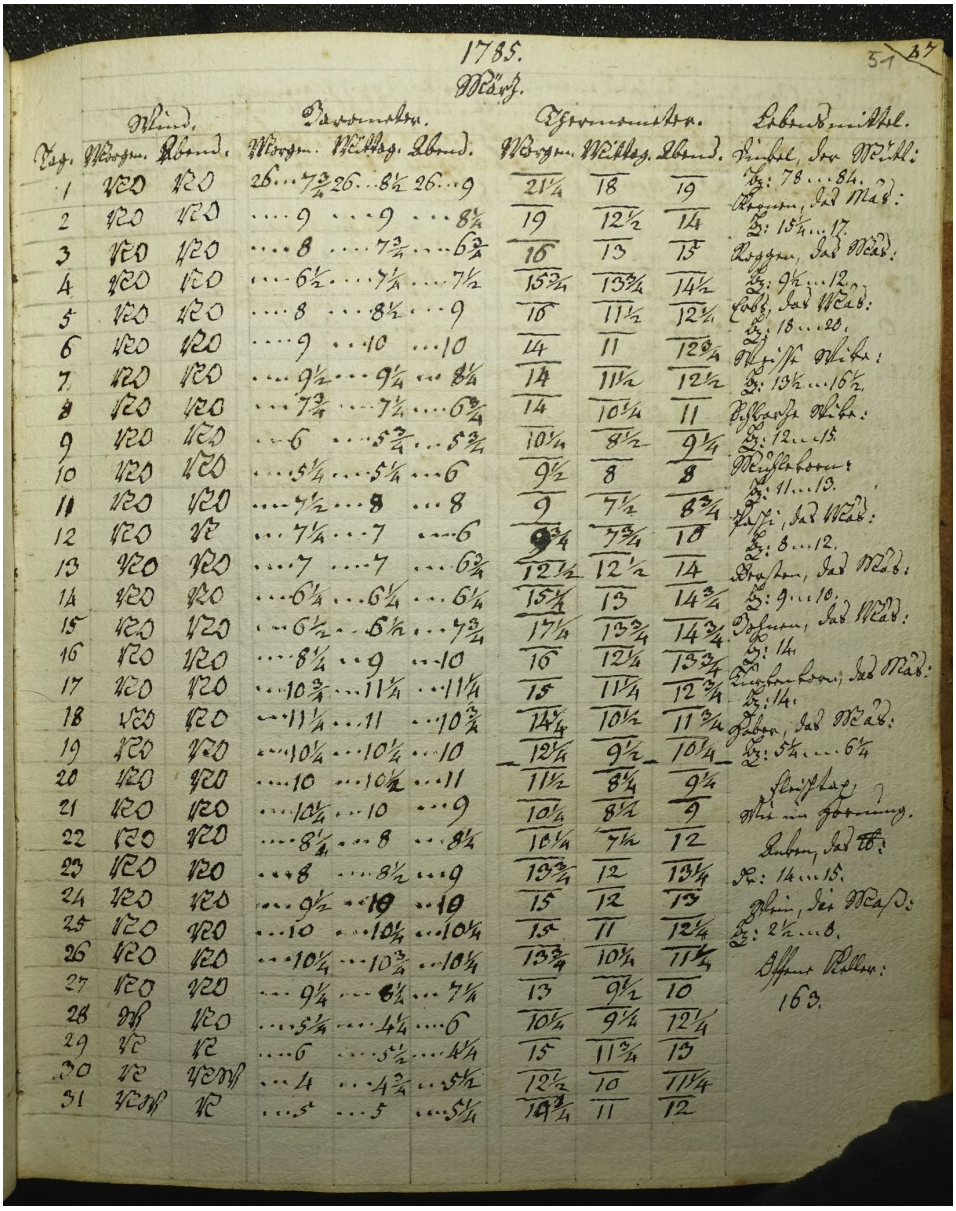


Figure 5. Example sheet of Sprüngli's data for 1785 (Burgerbibliothek Bern, GA Oek.Ges. 111).

2.4. Samuel Emanuel Fueter

Samuel Emanuel Fueter was a merchant and owner of a grocery store (see Gorgé, 2005). He was a member of the Swiss Natural Sciences Society almost from its start in 1815 and from 1817 to 1828 also member of the Bernese Natural Sciences Society.

Fueter's observations cover the period 1803 to 1834. Initially these are daily temperature ad twice daily pressure data (morning, evening), but from 1819 onward there are typically two temperature measurements (at sunrise and 14 local time) and four pressure measurements per day (8, 11, 14, and 20 local time). The data are today stored at the Burgerbibliothek Bern (Mss.h.h.XXIII.95.1-95.3). An example sheet is shown in Figure 6. It is not known where Fueter made his measurements, but an educated guess is that he measured at his family's estate at the "Villette", about 500 m west of the Burgerspital (V in Fig. 2).

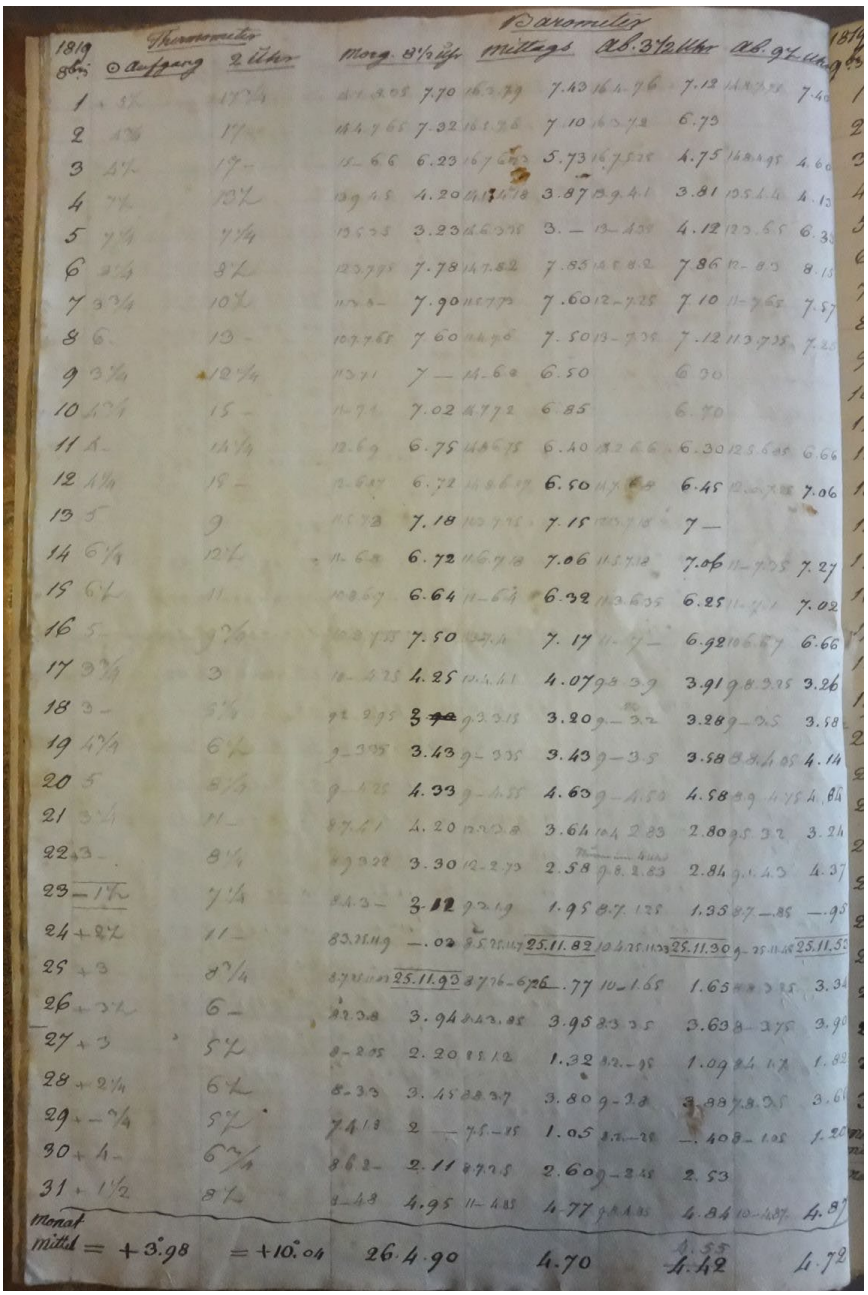


Figure 6. Example sheet of the series by Fueter for 1819 (Burgerbibliothek Bern, Mss.h.h.XXIII.95.1-95.3).

3. Processing and quality control

All series were processed as detailed in Brugnara et al. (2020a). In this Section, we analyse the results of the quality control for the individual series, before analysing the overlaps between the segments in the next Section. For Studer, both thermometers and barometers are analysed.

The Lombach series (Fig. 7) exhibits similar correlations between morning and noon series as most of the other series discussed in this book. The corresponding plots for the Studer series are shown in Figure 8, divided into two periods and analysing two instruments for each parameter. Correlations are again similar as for Lombach, with no peculiarities. However, comparing the two barometers, the plots for the early period and, even more clearly, those for the later period show two distinct relations. Obviously one or both of the barometers underwent a change (e.g., in measuring height, corrections, or in the instrument). Without analysing further series, it is difficult to assess which of the two is incorrect. The analysis of the two thermometers in the second period shows differences between them in the morning, but a very good agreement in the afternoon. Unlike for pressure, we find no systematic change over time in the relation between the two instruments. Therefore, in the following, we use the primary thermometer (usually with eastern exposure, except for 1801-1803 when it had northern exposure).

The first segment of the Fueter series (termed Fueter I hereafter) has only once daily temperature. Its twice daily pressure data (morning, evening) show a relatively low correlation, while the second part of the series (Fueter II, Fig. 7 bottom) shows excellent correlations between morning and noon and lower between morning and evening (note that evening here encompasses both the 14 and 20 measurement). Temperature was not analysed due to differences in the time of day.

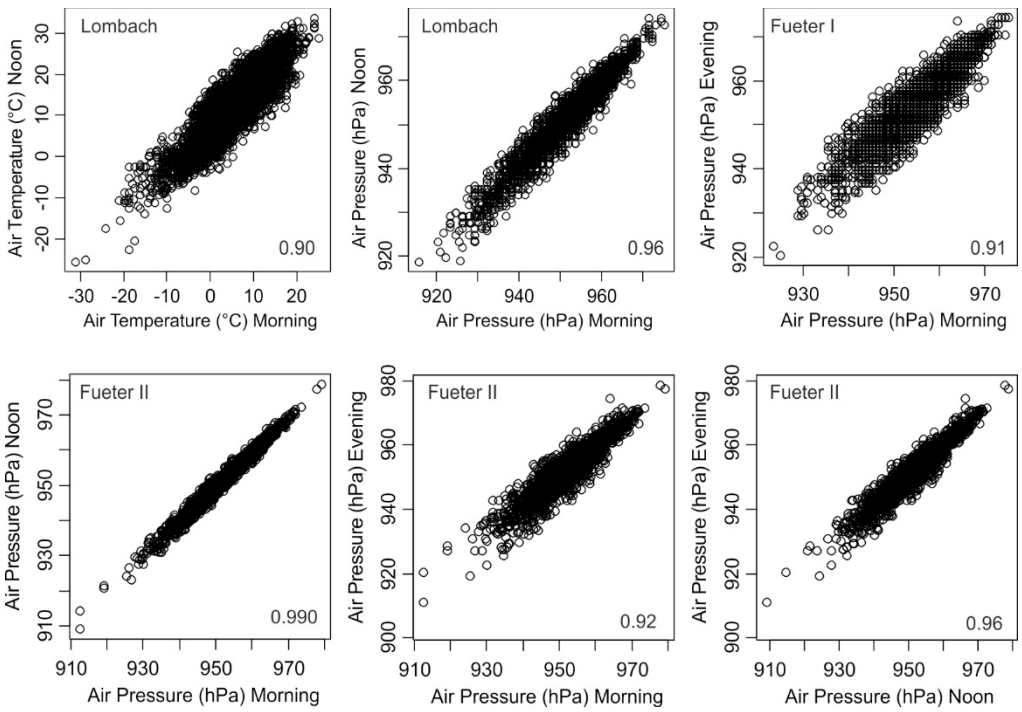


Figure 7. Mutual comparisons of morning, noon, and evening series of pressure and temperature in Bern in the series of Lombach and Fueter I (top) and Fueter II. Numbers indicate the Pearson correlation coefficient.

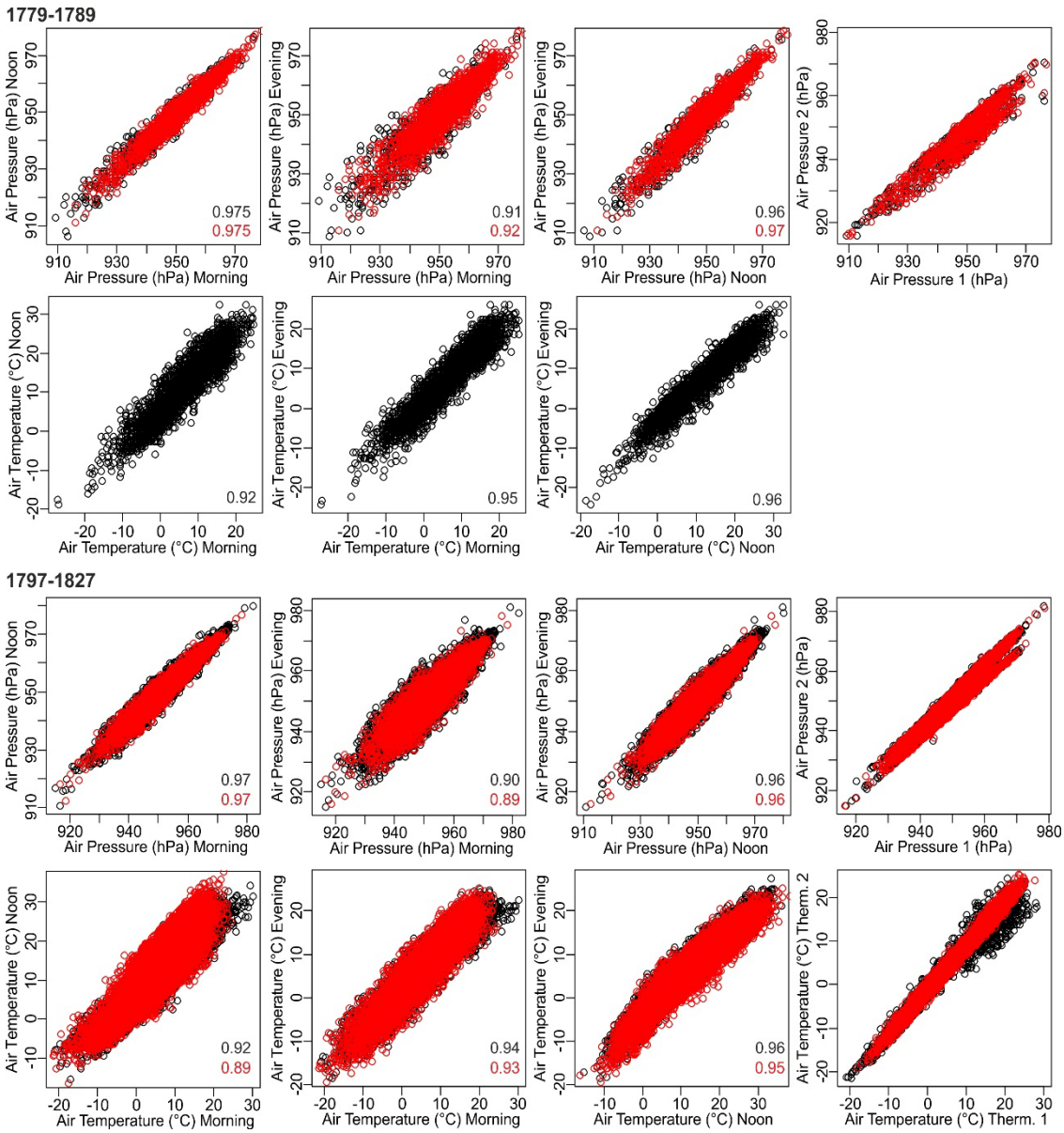
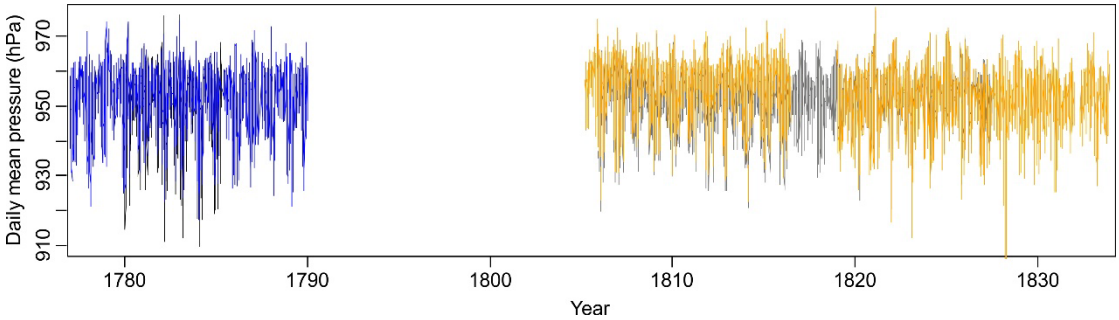


Figure 8. Mutual comparisons of morning, noon, and evening series of pressure and temperature in Bern in the Studer series, divided into the first part (top) and the second part (bottom). Numbers indicate the Pearson correlation coefficient. Black circles indicate thermometer or barometer 1, red circles indicate thermometer or barometer 2. In the right column, black circles indicate morning and red circles noon measurements.

4. Comparison of the Lombach, Studer and Fueter series

The Bern series has the advantage that many overlapping segments are available. One of the longest segments is that of Studer. In its early years, this series overlaps with that of Lombach (and the series from Neuchâtel, see Wyer et al., 2021), and the last part of the Studer segments overlaps with the series of Fueter (and even that of Trechsel; see Flückiger et al., 2020). In this Section, we analyse the overlaps between Lombach and Studer, Fueter I and Studer, and Fueter II and Studer.



A first impression can be obtained by plotting daily means of air pressure as a time series (Fig. 9). It becomes clear that the early Bern period in Studer's record (before the move to Büren) has slightly lower minimum pressures than those measured by Karl Lombach at the same location, although the maxima are similar. The absolute level depends on the altitude where the barometer is mounted, which might have been different for the two series. Since the pressure readings before 1797 are not corrected for the temperature of the mercury, the variability could depend on the temperature of the room where the barometer was mounted. In the period after 1800, we find a slight difference in absolute values between Studer and the first segment of Fueter, but not between Studer and the second segment of Fueter.

A direct comparison between air pressure from Lombach and Studer clearly shows that the point cloud represents an overlap of two distinct relations, both in the morning and at noon, when using Studer's second barometer. Plotting the ratio (not shown) reveals two step changes of ca. 5 hPa. When using the first barometer (Fig. 10, top), a very good agreement is found. This indicates that Studer's second barometer underwent two changes (therefore, in Fig. 9, we have plotted only the first barometer). The temperature records show a good agreement both in the early morning and in the evening.

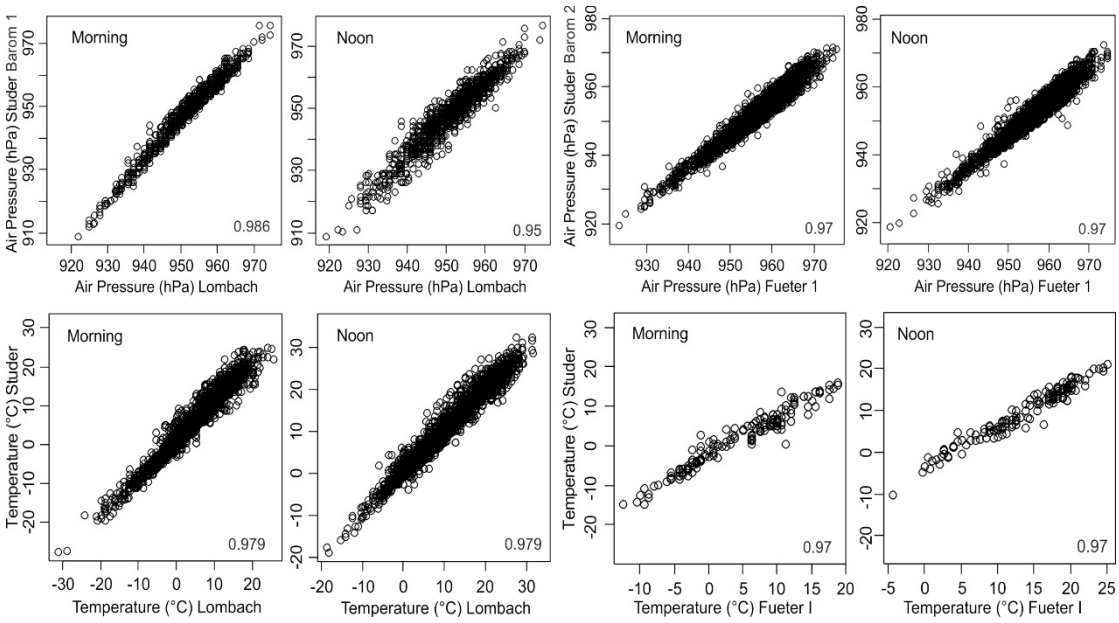


Figure 10. Comparison of the records of Lombach/Studer and Fueter I/Studer for morning and noon (here including data up to 15 local time) for air pressure and temperature. Numbers indicate the Pearson correlation coefficient.

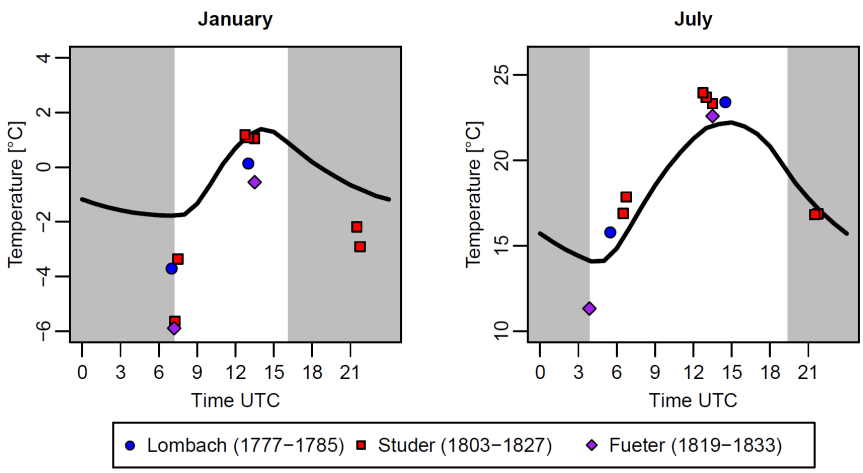


Figure 11. Average temperature values for different observation times in January, April, July and October in the Bern series compared with the mean diurnal cycle at Bern (Zollikofen) during 1981-2010 (2°C has been subtracted). Grey areas indicate nighttime.

The overlap between Studer and the first segment of the Fueter series (Fig. 10, bottom) reveals again good agreement for temperature (though based on very few data points only), but distinct, overlapping relation for pressure measured with the first barometer. A plot of pressure differences versus time (not shown) shows a clear change in 1807, amounting to around 5 hPa. No such change is found in the second barometer. Therefore, in this case we assume that the first barometer, and not the second, is affected by a step change. In Fig. 9, we therefore used the second barometer.

Finally, the comparison between the second segment of the Fueter series and Studer (not shown) exhibits almost perfect agreement for pressure, with correlations of 0.99 or higher. This is suspicious and indicates that parts of the records might be copies of each other (*e.g.*, one with and one without temperature correction). For temperature, in turn, a correlation analysis is not meaningful due to too strong changes in observation times.

When comparing the temperature measurements with a modern climatological diurnal cycle (Fig. 11), a few interesting features can be noted. In January, the early instrumental temperatures are lower than expected, in part because the periods include several intense cold outbreaks (e.g., 1779, 1812, 1826, and 1830) that have no match in modern climate. In July, one can guess that the morning and early afternoon measurements by Studer are affected by radiative biases, which are to be expected given the eastern exposure of his thermometer. Moreover, the morning measurements by Fueter are very low, which suggests a rural environment outside the Old City.

5. Conclusions

A number of observers made meteorological measurements in Bern, together covering the period 1760 to present with only few gaps. This paper describes several records covering the 1779-1834 period. These records include the almost 50-yr series of Samuel Studer, in addition to series by Karl Lombach, Johann Jakob Sprüngli, and Samuel Emanuel Fueter. The overlap between the series allows comparisons to be made. These comparisons show that the records are not without problems. Several step changes are found in the pressure data and others can be

assumed from metadata (relocations). They will have to be addressed in the homogenisation of the records.

Nevertheless, the series are particularly interesting as they cover a climatically relevant time period with several extreme events. The period includes the Laki eruption (1783/4) and its aftermath and the warm late 18th/early 19th century including the record heat year 1807 (Casty et al., 2005). Temperature then dropped, reaching a low point in the "Year without a Summer" of 1816, after the Tambora eruption, and temperature remained low for the subsequent years (Brönnimann, 2015). The records presented here can therefore shed new light on these climatic anomalies.

The paper also describes scientific efforts in the late 18th and early 19th century. The observers comprise a city administrator, two pastors, and a merchant (see Brönnimann and Wintzer, 2019, for the value of context information). All four were deeply inclined to sciences, and all were members of one or several scientific societies.

The data are made publicly available by MeteoSwiss. They will also be available from the C3S data Global Land and Marine Observations Database (Noone et al., 2021) and from EURO-CLIMHIST (Pfister et al., 2017).

Acknowledgements

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