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Daniel Huber's Meteorological Record from Basel, 1789-1829

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Abstract

The long meteorological series from Basel, arguably the most prominent Swiss series, in its current form is based on data from Delémont and Mulhouse in the period 1805-1825. These data were used to fill the gap between the two very long records of Johann Jakob D'Annone (covering 1755 to 1804) and Peter Merian (1826 until the start of the Swiss Network in 1863). However, a series measured in Basel by Daniel Huber, covering 1789-1829 (and thus overlapping with both segments) could fill this gap. Here we describe this series, including information on the location, observer, and instruments as well as the processing and quality control procedures. This is important as Daniel Huber did not stick to fixed observation hours. Correcting for this however, yields a high-quality record that can be used to generate a new Basel record. We also briefly discuss the records of Delémont and Mulhouse and compare Huber's data with these records as well as with the data form D'Annone and Merian. All data are available from MeteoSwiss.

1. Introduction

The Basel temperature and pressure record reaches back to 1755. Together with Geneva, this is the longest Swiss meteorological series and widely used in research. The current version of the series dates back to Bider et al. (1958) and Bider and Schüepp (1961), who focused on two main, very long segments: that of Johann Jakob D'Annone (covering 1755 to 1804) and that of Peter Merian (who measured from 1826 onward and from 1863 onward for the new Swiss network). The gap between the two series (1805-1825) was filled with data from Delémont and Mulhouse. While this may be appropriate for analyses of monthly means, it

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might not be for daily-level analyses. This is particularly unfortunate as this period comprises the "Year Without a Summer" of 1816 (Brönnimann and Krämer, 2016) as well as the drop of central European climate from relative warmth to a cold period that was accompanied by the last glacier advance of the Little Ice Age and that was part of a global climate excursion (Brönnimann et al., 2019).

This period, called "interregnum" by Bider et al. (1958) could however be covered by measurements made in Basel. Among many other series that were inventoried, compiled and digitized in the context of the Swiss National Science Foundation project CHIMES (Pfister et al., 2019) and the GCOS Switzerland project "Long Meteorological Series" is a record by Daniel Huber that covers 1789 to 1829. It thus overlaps with other segments and could potentially help to fill the gap. The series is described in old literature (Riggenbach, 1892) and judged to be of high quality. However, it was not used due to its irregular observation times. Bider et al (1958) do not mention the series. Given the current interest not only in past climate, but also past weather, a complete sub-daily or daily series from Basel is desirable. It is against this background that we revisited the Huber series.

This paper describes the metadata on these series. On the one hand, observers, locations, and instruments are described (Section 2), on the other hand, processing and quality control of the data series as well as some analyses (Section 3). Conclusions are drawn in Section 4. Metadata on the stations are incorporated in the inventory of Pfister et al. (2019); the data can be obtained from the MeteoSwiss website.

2. Observers and observations

2.1. The series by Daniel Huber

Daniel Huber (1768-1829, Fig. 1) grew up in an academic environment. He was the son of an astronomer, his brother was professor in history and pastor. Huber studied classical philology and medicine in Basel. In 1792 he became professor of mathematics at the Basel University. From 1802 onward he was director of the University Library. His scientific work dealt with comets as well as with problems of optics. He also was involved in the trigonometric measurements of Basel from 1815 on, which had a large influence on establishing a meteorological network in Switzerland (Riggenbach, 1892). He was founder, in 1817, of the Natural Sciences Society of Basel (Marti-Weissenbach, 2008).

Huber observed at different locations. From 1789 to April 1802 he performed the measurement at "Haus zur Eich (Nr. 1327)", in the city district of St. Alban (H1, in Fig. 2). From May 1802 onward he measured near the Cathedral (H2 in Fig. 2). Two different addresses can be found ("Haus Nr. 1373" and "in dem Laub Nr. 1455") but they may refer to the same place. From 1804 to 1829 he measured "in his official residence behind the Cathedral" (which refers to the house Nr. 1373). The digitization of the Huber data was a tremendous effort. Huber made numerous measurements. We have digitized far over 100,000 instrumental measurements (in addition to thousands of wind observations) from over a thousand of pages of material. The measurements were made at 30,888 measurement times during 11,518 days. Huber measured up to 13 times per day, at very irregular times. This was the reason why the data have not been used in science (Riggenbach, 1892). Bider et al. (1958) as well as all later work did not use the Huber series.

Figure 1. Daniel Huber. Portrait in a medaillon in private possession, between 1790 and 1820 (University Library Basel, Portrait collection UBH Portr BS Huber D 1768, 1a).

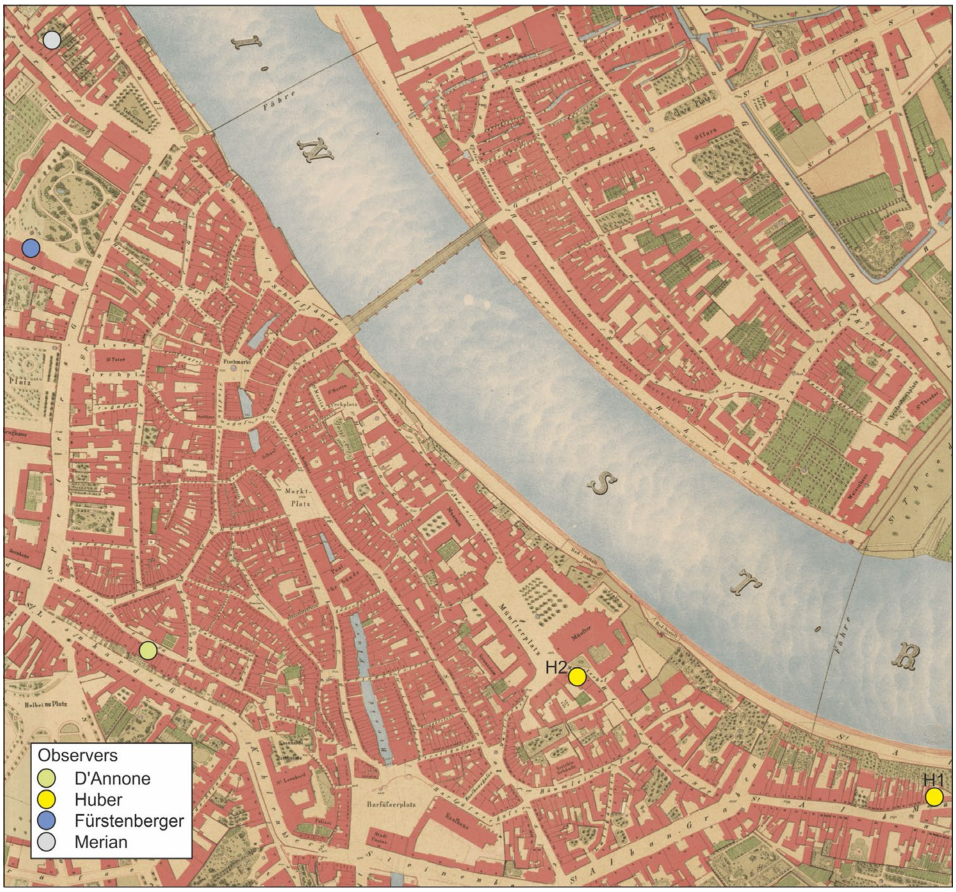

Figure 2. Locations of meteorological observations in Basel by D'Annone, Huber (H1: 1789-1802, H2: 1802-1829), Fürstenberger, and Merian (see also Brönnimann and Brugnara, 2020a) Map: Löffelplan, produced 1857-1859, published 1862 (source: Geoportal Kanton Basel Stadt). The location of Burckhardt's observations (which also overlap with Huber's) is unknown.

In addition to the sheer amount of observations, the situation is further complicated as Huber used numerous different barometers and thermometers, often in parallel. Some instruments, perhaps loans of his peers, were read only for a few days, but most were employed for months or years.

For this work we produced merged pressure and temperature series. In the case of pressure, we gave highest priority to the oldest barometer (where the age is defined by the first appearance in the data), while for temperature a separate priority list was generated based on our experience with the data. In Table 1 we give an overview of the 10 thermometers that contribute to the merged series. The positions "vorne" (i.e., front) and "hinten" (i.e., back) refer to, respectively, the window of Huber's office and the window on the 3rd floor (handwriting difficult to decipher) on the back of the house. The positions "unten" and "oben" refer probably to the lower and upper floor in the house in St. Alban. Note that Huber was, to our knowledge, the first person in Switzerland to use a centigrade (Celsius) thermometer for regular meteorological observations.

There are frequent gaps in the data (Fig. 3). Some of the data might have been simply lost. Another likely explanation is that Huber might have been often away from Basel. Before her premature death in 1805, Huber's younger sister Valeria was occasionally in charge of the measurements.

The worst problem in the digitization of the Huber data was the extremely chaotic nature of his notes, which is probably another reason why the data have never been used before. Some data sheets are relatively ordered and clean (see excerpt in Fig. 4). Other data sheets are extremely chaotic, as is shown in the excerpts in Figure 5. Huber used every piece of paper he could get to write down his observations, even playing cards; sometimes the data occupy every possible space of a page and are written in every direction; moreover, the date is not always written explicitly and some pages require puzzle-solving skills to be correctly interpreted. Probably Huber copied the measurements in his "clean" register only when he had some spare time, or he copied only those that he considered of particular value. It is therefore to be expected that the digitization error is far larger than with other sources (we expect an error rate of the order of 3-5%). Date errors are also more likely.

In Section 3 of this paper, the Huber data are compared with the data from D'Annone, which overlap between 1789 and 1804 and which were described by Brönnimann and Brugnara (2020), as well as with the series from Burckhardt and Fürstenberger from the 1820s that were described in Brönnimann and Brugnara (2021). We also compare the series with two further records that we also digitized in this and previous projects, namely from Mulhouse and Delémont and which are briefly described in the following.

Table 1. Composition of the merged temperature series created from Huber's measurements

Priority	Scale	Position	Period	Contribution [%]
1	Micheli du Crest	*unten*	1789-1802	37.7
2	Micheli du Crest	*oben*	1789-1800	3.0
3	Réaumur	*oben*	1796-1798	0.5
4	Micheli du Crest	*vorne*	1802-1803	0.2
5	Réaumur	*vorne*	1803-1829	35.9
6	Réaumur	*vorne (Laub?)*	1823-1827	2.2
7	Celsius	*vorne*	1823-1825	0.03
8	Réaumur	*hinten*	1802-1814	2.2
9	Micheli du Crest	*hinten*	1802-1829	18.1
10	Celsius	*hinten*	1818-1827	0.07

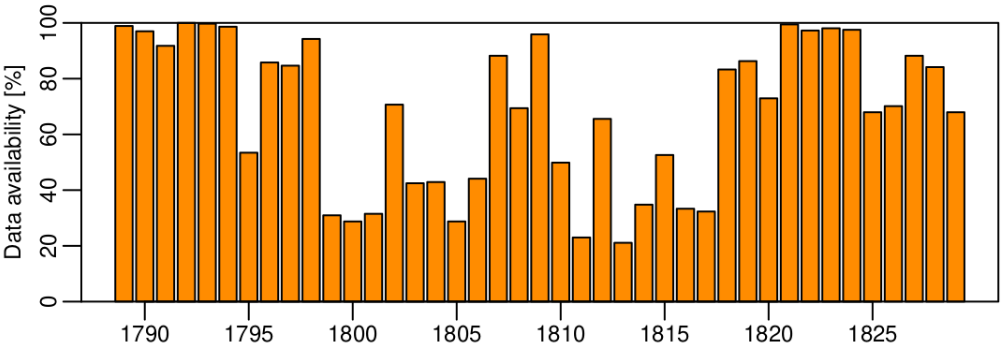

Figure 3. Percentage of days per year with temperature measurements in the Huber series.

2.2. The series from Mulhouse and Delémont

Several observers made measurements in Mulhouse during the 18th century, but only for short times. The first to make long-term measurements was the town's prefect Daniel Meyer, who measured between 1777-1824 with instruments provided by the Societé Royale de Médecine in Paris (Riggenbach, 1892; Metzger and Pfister, 2017) We had the data in two formats: raw data spanning 1794 to 1812, from three thermometers (here we only use the first), three times daily; and daily means published by the Swiss Meteorological Service (SMZ, 1885) spanning 1800-1824, which arguably became the starting point for later efforts.

The record of Delémont was measured by F. J. Helg, a physician, and covers the period 1802-1832, with a few gaps. It consists of three times daily measurements of temperature and pressure. As for the Mulhouse record, it was reduced to daily means in the late 19th century (SMZ, 1870) and then arguably used in that form by Bider et al. (1958) and Bider and Schüepp (1961).

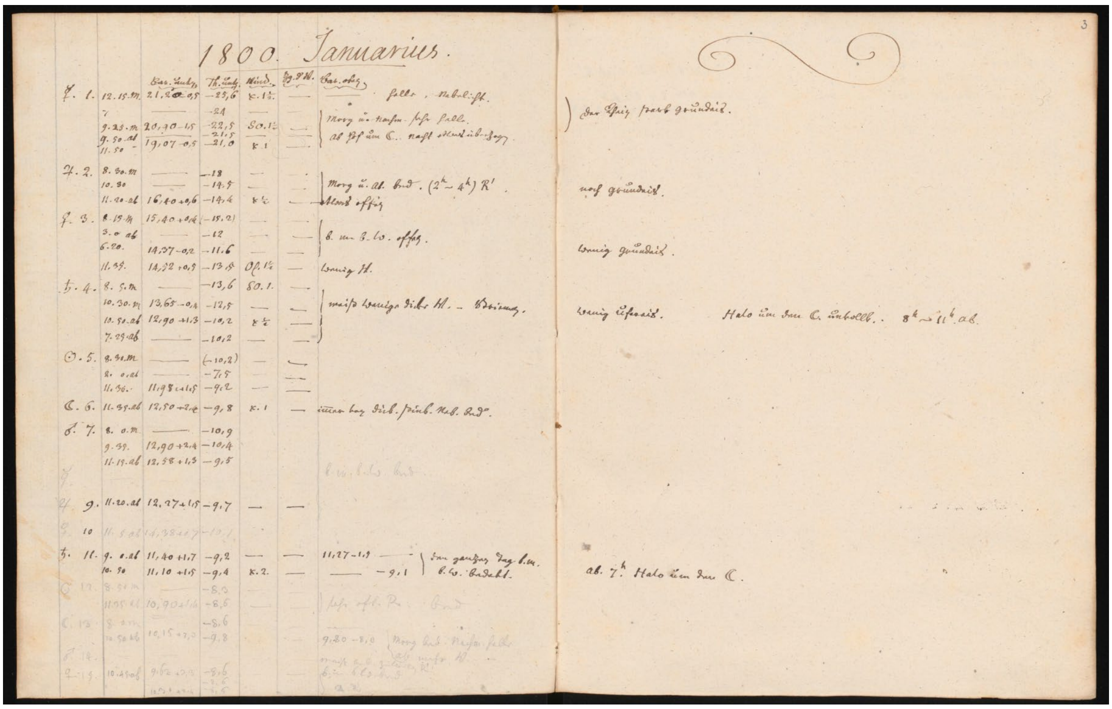

Figure 4. Data sheet from Huber's series, showing measurements for January 1800 (University Library, Basel).

Figure 5. Excerpts from rather chaotic data sheets from the Huber series (University Library, Basel).

3. Processing and Quality Assessment

Here we present the results from the quality control procedure (see Brugnara et al., 2020) and then compare the data with the contemporary records of d'Annone, Burckhardt, Fürstenberger, Mulhouse, and Delémont, For the analysis we subdivided the Huber data into 1789-1802 and 1802-1829, corresponding to the two measurement locations. The internal consistency of the measurements is generally good in both periods (Fig. 6). However, in the second period the cross correlations for temperature are a bit lower. This is probably related to the fact that in those years Huber did not always stick to one primary thermometer. Instead, during the warm season he used the thermometer in the back for the morning and the one outside his office for the rest of the day. We know that the back window was exposed to sunlight in the afternoon, because Huber sometime flagged the measurements with a Sun symbol (we did not use those values).

We find mostly good agreement with d'Annone's data (Fig. 7). We actually expect Huber's pressure measurements to be of better quality, given that they are corrected for temperature while d'Annone's measurements are not. Moreover, the temperature measured by d'Annone is sometime much higher than that by Huber, hinting at some bias in the former.

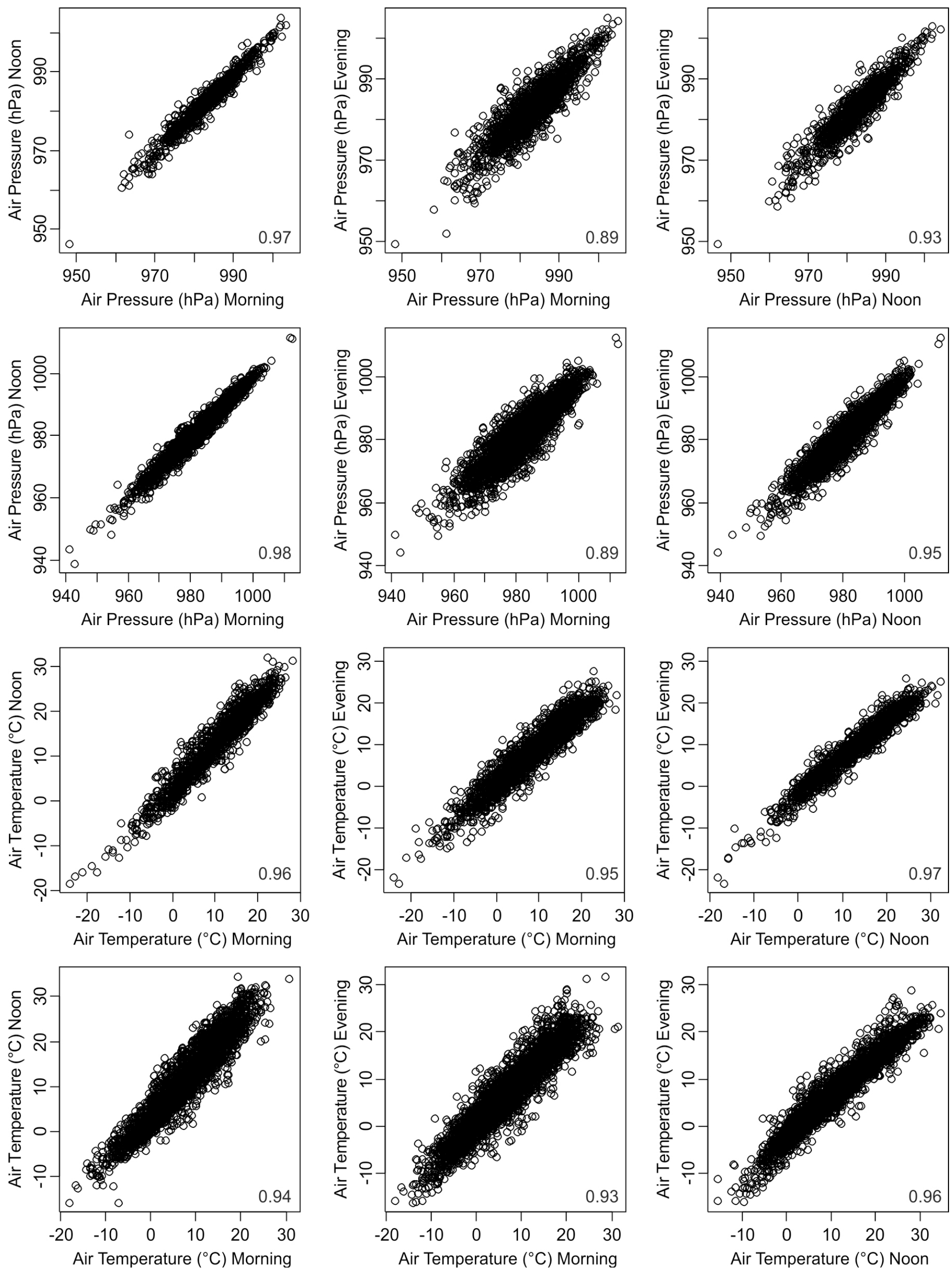

Figure 6. Mutual comparisons of morning, noon, and evening measurements in the series of Huber. Top: pressure, period 1, second row: pressure, period 2, third row: temperature, period 1, fourth row: temperature, period 2. Numbers indicate the Pearson correlation coefficient.

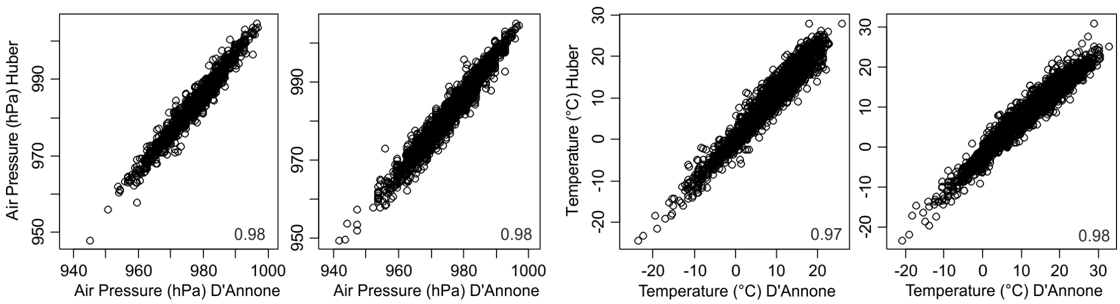

Figure 7. Comparisons of morning and evening measurements of pressure (left) and temperature (right) in the Huber series (first period) against the series of D'Annone. Numbers indicate the Pearson correlation coefficient.

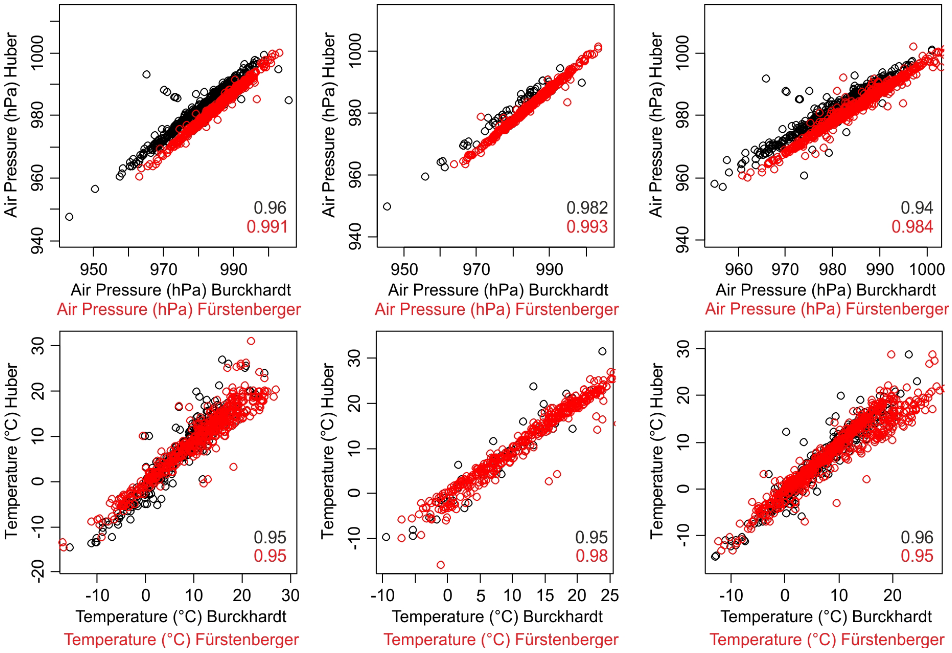

Figure 8. Comparisons of morning (left), noon (middle) and evening (right) measurements of pressure (top) and temperature (bottom) in the Huber series (first period) against the series of Burckhardt (black) and Fürstenberger (red). Numbers indicate the Pearson correlation coefficient.

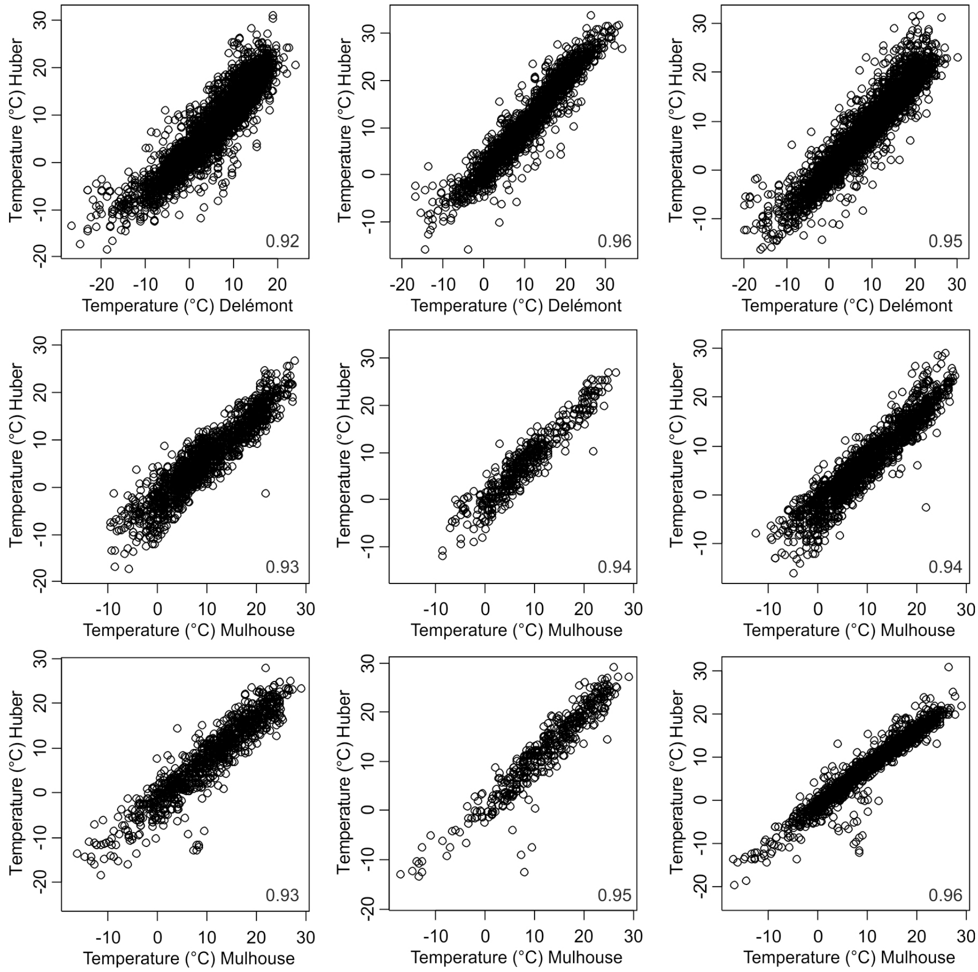

Figure 9. Comparisons of morning (left), noon (middle) and evening (right) measurements of temperature in the Huber series against Delémont (top row: period 2) and against Mulhouse (middle row: period 1, bottom row: period 2). Numbers indicate the Pearson correlation coefficient.

The pressure measurements by Burckhardt also suffer from a missing temperature correction, and their lower quality is evident when comparing them with Fürstenberger's and Huber's measurements. (Fig. 8). On the other hand, the temperature measurements by Fürstenberger appear to suffer from an inhomogeneity, particularly evident in the evening. A few digitization errors (missing negative sign) are evident in the Mulhouse series (Fig. 9).

When comparing the temperature measurements with the modern-day diurnal cycle (Fig. 10), it is clear that Huber had trouble with radiation biases in his second apartment, as already suggested by the fact that he used a different thermometer in the morning. His office in the city centre had probably an eastern orientation, which allowed the sunlight to affect the thermometer until about noon. The biases are comparable to those affecting the measurements of d'Annone. On the other hand, judging from the data, he probably had a near to optimal north-facing installation in the house in St. Alban (i.e., before May 1802).

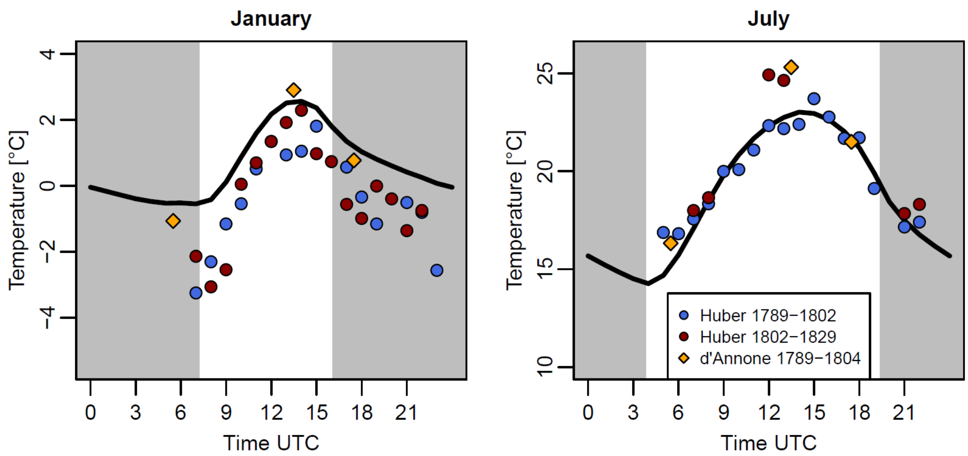

Figure 10. Diurnal temperature cycle in January (left) and July (right) in present-day (1981–2010, -1 °C to account for climate change) MeteoSwiss data from Basel-Binningen (thick black line) and in the series by Huber and d'Annone. For Huber, observation times were rounded to the nearest hour. Grey shading indicates nighttime.

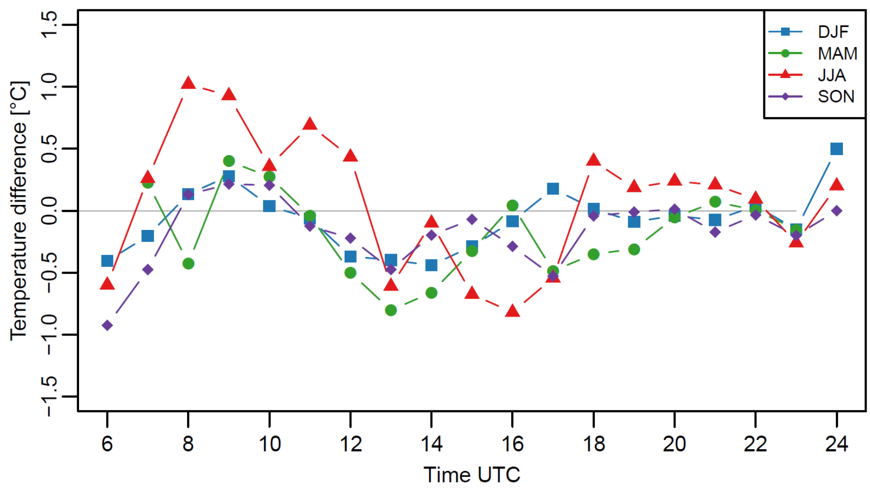

Figure 11. Mean differences between parallel measurements at the front (*vorne*) and back window (*hinten*), aggregated by time and season. Only the thermometers with Réaumur scale at the front and Micheli du Crest scale at the back are considered. Times were rounded to the nearest hour.

To further explore the radiation bias, we analyse the parallel measurements between the front and the back window in Figure 11. We see that the maximum bias at the front window is between 8:00-9:00 UTC in summer, while it is much smaller in the other seasons. The bias at the back window has the maximum in the early afternoon, except for summer when the maximum is reached at 16:00 UTC. These results suggest that the front window was close to a northeast orientation. The back window, as the name suggests, was exposed to the opposite direction, i.e. southwest.

4. Conclusions

The meteorological series from Basel is currently the longest evaluated meteorological series from Switzerland (together with that from Geneva). In this paper we analyse one particularly important segment covering the period 1789 to 1829. It covers the gap from 1805-1825, which previously was infilled with data from Delémont and Mulhouse.

Overall the quality of the Huber record is probably superior to other contemporary records, in particular to the d'Annone record. Unfortunately, it is rather incomplete, especially during the most relevant period when no other series for Basel exist, which includes the "Year Without a Summer". In addition, the difficulties encountered in the digitization process might to some extent affect its quality.

Huber was particularly interested in comparing different instruments and different exposures. His data provide a huge amount of parallel measurements that might be used to estimate and correct errors in his and other records.

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). Together, the different series from Basel may allow the construction of a new "Basel series", which, unlike its precedent, is not filled in with data from Mulhouse and Delémont. However, this paper also shows that inconsistencies still need to be resolved.

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