Wyer, V., Y. Brugnara, and S. Brönnimann (2021) Meteorological Series from Neuchâtel, Bern and Gurzelen. In: Brönnimann, S. (Ed.) *Swiss Early Instrumental Meteorological Series.* Geographica Bernensia G96, p. 169-182, DOI: 10.4480/GB2020.G96.16.

Meteorological Series from Neuchâtel, Bern, and Gurzelen from the 18th Century

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Abstract

Three meteorological series from the Greater Bern region are presented, which overlap and together span a 32-year period in the 18th century. The series include Neuchâtel (1753-1782), Bern (1760-1770) and Gurzelen (1766-1784). Since meteorological series from Bern are then continuous from 1779 onward, these three series allow a backward extension and allow generating a long Bern series that spans 270 years. This paper, which accompanies the publication of the data and describes the three series.

1. Introduction

The compilation of Swiss early instrumental meteorological series in the framework of the CHIMES project of the Swiss National Science Foundation revealed that, in Bern, observations have been recorded from 1760 until the start of the MeteoSwiss network in December 1863, albeit with some gaps (Pfister et al., 2019). The series are typically 10–30 years long and exhibit overlaps with each other, but they also contain long gaps. Although not all data have been found, a close-to-continuous record could possibly be obtained when supplementing with data from nearby locations. Within the Swiss GCOS project "Long meteorological series" we could digitise remaining segments in order to generate a long series. Here we focus on three overlapping series: the earliest series from Bern, measured by Franz Jakob von Tavel and covering 1760-1770, a long series from Neuchâtel by Frédéric Moula covering 1753-1782 (with gaps), and a series from priest Johann Jakob Sprüngli from Gurzelen, 1766-1784. These series connect those of Lombach (1777-1789), Samuel Studer (1779-1827) and Samuel Emmanuel Fueter (1803-1833), which will be described in an upcoming paper (Hari et al., this volume) and later series by Benoît and Trechsel (Flückiger et al., 2020). Together, these

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series might form an instrumental climate record for Bern that reaches back to the mid-18th century. This would not only constitute a new long Swiss series, but would also be a long record in a European context (see Brönnimann et al., 2019).

This paper describes the three series and provides detailed information on observers and locations. It accompanies the inventory of the Swiss early instrumental series (Pfister et al., 2019) and the publication of imaged data sheets (https://zenodo.org/record/3066836#.XVv-fGRS8-U) as well as of the data series (Brugnara et al., 2020a, https://doi.pangaea.de/10.1594/PANGAEA.909141) which are also available from EURO-CLIMHIST (Pfister et al., 2017) and MeteoSwiss and were submitted to the Global Land and Marine Observations Database (GLAMOD) of the Copernicus Climate Change Service (C3S) (Thorne et al., 2017).

The paper is organised as follows. In Section 2 we introduce the three series, including information on observers and instruments, where available. In Section 3 the individual series are presented and compared in their overlapping parts. The paper ends with brief conclusions.

2. Measurements and instruments

The locations of the three series discussed in this paper are shown in Figure 1, the most important characteristics are summarized in Table 1. The main series and reference is Bern. Neuchâtel is ca. 40 km from Bern, Gurzelen ca. 20 km, which is a relatively short distance. Note, however, that Gurzelen is located in the pre-Alps, Neuchâtel at the shore of a lake, which represents a somewhat different climate despite the spatial proximity. Fortunately, the overlap of the three series is very long which allows assessing the effect of different climates. The Neuchâtel series has previously been used to extend the Geneva series back to 1753, which is at a distance of 106 km and in a different basin. We think that it would be more suitable to use the Neuchâtel series as an extension of the Bern series. In the following we discuss the three series individually.

Figure 1. Map of the region Neuchâtel-Bern including the locations of the three series. Amt für Geoinformation des Kantons Bern, Meyer-Weiss-Atlas (1796-1802), 1:120'000 © AGIS Koordination Aarau.

Table 1. Summary of the three meteorological series discussed in this paper. BPU = Bibliothèque publique et universitaire, BBB = Burgerbibliothek Bern, Sammlungen = Sammlungen von landwirthschaftlichen Dingen der Schweitzerischen Gesellschaft in Bern/Abhandlungen und Beobachtungen durch die Ökonomische Gesellschaft zu Bern gesammelt

Period	Observer	Location	Variables	*n*	Source
1753-1782	Frédéric Moula	Neuchâtel	p, T, wdir, Wn	3	BPU Neuchatel: MsA 164, Bull. soc. sci. nat. Neuchatel VI (1861-1864, IX (1871)
1760-1770	Franz Jakob von Tavel	Monbijou	p, T, Pr, wdir, Wn	2-3	1760-1762: Sammlungen 1763-1766: BBB: GA Oek. Ges. 100, GA Oek. Ges. 101, GA Oek. Ges. 102, GA Oek. Ges. 103, 1763-1770: Sammlungen (monthly)
1766-1784	Jakob Sprüngli	Gurzelen	p, T, Wn, wdir	1-3	BBB: GA Oek. Ges. 109 (17,18,22) (1771-1776); GA Oek. Ges. 111/112/113/114 (1766-1784)

2.1. Bernese Economic Society and the von Tavel series

Meteorological measurements in Bern began in the context of the Bernese Economic Society (OeGB), representing a prominent example of "learned society" typical of the enlightenment period (Pfister, 1975; Lüdecke, 2010). Under the leadership of Gabriel Herbort, Franz Jakob "Monbjiou" von Tavel, and Niklaus Emanuel Tscharner, the OeGB founded the Commission for Meteorological Observations. The OeGB placed a strong focus on meteorological observations and installed a measurement and observation network, which was mainly used to optimise agriculture in order to increase yields and societal resilience to supply crises (Pfister, 1975). Another objective was to assess relations between meteorology and the development of vegetation (Carrard, 1763), which should also be observed, and outbreak and course of diseases should be studied. The OeGB was further interested in raising the scientific awareness of the population and reduce superstitious traditional farming techniques (Pfister, 1975).

A key element of their plan was a standardisation of the instruments and procedures to allow comparisons, which can be seen as a pioneering achievement and as a precursor to the Swiss-wide measurement network of the Swiss Natural Sciences Society in the 19th century (Pfister, 2008). The OeGB chose the French measurement system as the standard, which was common at that time in Central Europe. Carrard (1763) provided details about the installation, use and control of the barometers. The instruments were used cistern barometers. However, no information exists on the exact description of the barometers actually used by von Tavel (Pfister, 1975). To measure the air temperature, the OeGB used a mercury thermometer with a Réaumur scale. In 1762, the Society switched to the Micheli du Crest spirit of wine thermometer (see Brugnara et al., 2020a). It was recommended that the thermometer should be exposed to the open air and protected from any solar radiation, ideally a north-facing window or wall (Carrard, 1763). To best capture daily maxima and minima, the observation times were set to sunrise and 3 p.m. (Pfister, 1975).

The OeGB had rain gauges constructed according to the model from the Paris Academy. Figure 2 visualises a pluviometer in use, which consists of a collecting funnel and a cylindrical storage body. The radius and height of the cone-shaped funnel measures 32.48 cm and is connected to the cylinder, whose radius and height are 9.43 cm and 54 cm, respectively. The collecting area is about 3300 cm^2 and the surface area of the storage body is about 275 cm^2. Observers can read the values of the ruler in the cylinder and relate them to estimate the actual amount of precipitation that fell. Previous studies suggest the precipitation measurements of the OeGB are comparable to those of today (Pfister, 1975).

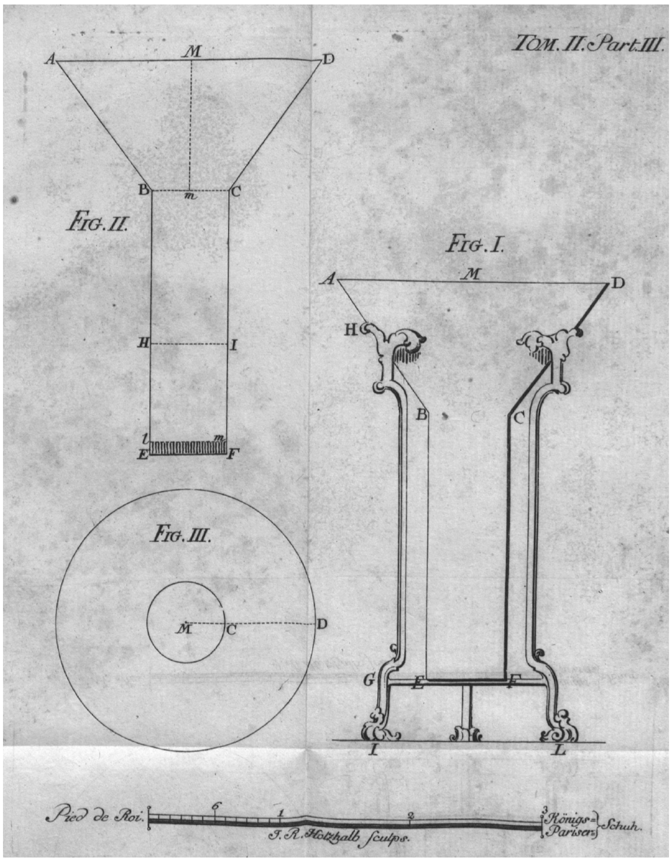


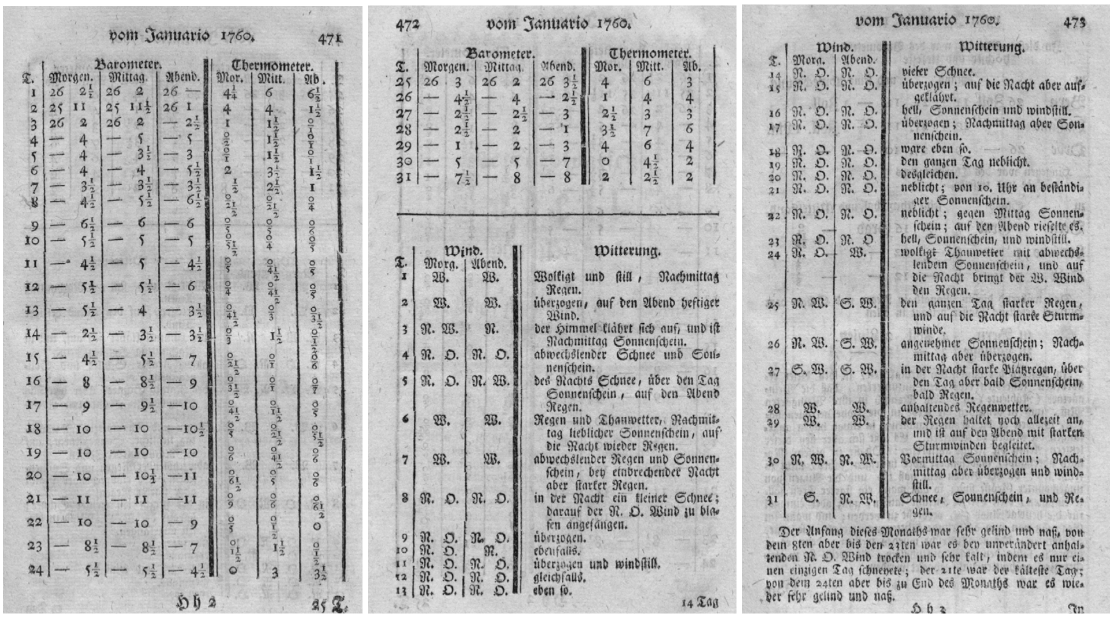
Figure 2. Sketch of the rain gauge to be used, from "Sammlungen von landwirthschaftlichen Dingen der Schweitzerischen Gesellschaft von Bern" (Vol. 2, 1761).

In the beginning, the selection of measurement sites depended on voluntary observers who made themselves available. The commission ensured that the sites were equipped with thermometers, barometers, rain gauges and wind vanes. The network covered the area of the old Canton of Bern over a period of ten years. However, in some cases it shows large gaps. In 1761, the OeGB founded so-called secondary societies in rural areas in order to ensure the exchange of information and measured values. One compulsory field was the recording of meteorological observations. At the beginning, the members responsible for this were committed and continuously recorded and made their data available to the OeGB. The resignation of Secretary Tscharner in 1767 had the consequence that the publications of the meteorological papers were shortened and delayed. All these factors led to the dissolution of these secondary societies from 1767 onwards. The lack of will on the part of the observers and the lack of recognition of their work led to the end of meteorological recording in 1770 (Pfister, 1975).

The "Auszüge einiger Berathschlagungen der ökonomischen Gesellschaft" (OeGB, 1762) show that in 1759 the Society appointed persons responsible for recording and sending in meteorological observations in the various regions. Franz Jakob von Tavel was responsible for recording the meteorological observations of the Bern station from 1760. His estate "Monbijou" was located about 1.3 km southwest of the city centre (Fig. 3; see Gimmi et al., 2006). Due to family disputes, measurements for February 1766 are missing (Pfister, 1975). In the summer of the same year, he stopped his measurements because the authorities expressed criticism of the OeGB (Gimmi et al., 2006). In addition to meteorological observations, he carried out other tasks for the OeGB until financial speculation ruined him in 1775. He left the OeGB and spent the rest of his life in poor circumstances in Paris (Pfister, 1975).

Von Tavel's data were published in the journal of the OeGB (Fig. 4). From 1760 to 1766 the individual measurements were published and can be found in the archive of the Burgerbibliothek Bern. These data were later included in the "Schweizerische Meteorologische Beobachtungen" (Wolf, 1871). From 1763 to 1769, monthly mean temperature data per time of day were published in the Society's journal together with monthly extremes. For 1770, only the monthly extremes were provided. Unfortunately, we could not find daily data after 1766.

Figure 3. Map of Bern in the 1790s with the location of Monbijou (from: Mülleratlas, Geodata: City of Bern).



vom Januario 1760. 471

T.	Barometer. Morgen.		Mittag.		Abend.		Thermometer. Mor.	Mitt.	Ab.
1	26	2½	26	2	26	—	4¼	6	6½
2	25	11	25	11½	26	1	4	4	1½
3	26	2	26	2	—	2½	1	1½	0/1
4	—	4	—	5	—	5	0/2	1½	0/1
5	—	4	—	3½	—	3	0/1	1½	0/1
6	—	4	—	4	—	5½	2	3½	1½
7	—	3½	—	3½	—	3½	½	2½	1
8	—	4½	—	5½	—	6½	0/2½	0/2½	0/4
9	—	6½	—	6	—	6	0/5	0/5	0/7
10	—	5½	—	5	—	5	0/5½	0/4	0/5
11	—	4½	—	5	—	4½	0/5	0/4½	0/5
12	—	5½	—	5½	—	6	0/4	0/4½	0/5
13	—	5½	—	4	—	3½	0/4½	0/3	0/3½
14	—	2½	—	3½	—	3½	0/3	1½	0/1
15	—	4½	—	5½	—	7	0/2½	0/1	0/6
16	—	8	—	8½	—	9	0/3½	0/1	0/7
17	—	9	—	9½	—	10	0/4½	0/1½	0/5
18	—	10	—	10	—	10½	0/5	0/2½	0/5½
19	—	10	—	10	—	10	0/6	0/4½	0/6
20	—	10	—	10½	—	11	0/6½	0/5	0/6
21	—	11	—	11	—	11	0/9	0/6	0/6½
22	—	10	—	10	—	9	0/5	0/1½	0
23	—	8½	—	8½	—	7	0/1½	1½	0/1½
24	—	5½	—	5½	—	4½	0	3	3½

Hh 2 25 T.

472 vom Januario 1760.

T.	Barometer. Morgen.		Mittag.		Abend.		Thermometer. Mor.	Mitt.	Ab.
25	26	3	26	2	26	3½	4	6	3
26	—	4½	—	4	—	2½	1	4	4
27	—	2½	—	2½	—	3	2½	3	3
28	—	2½	—	2	—	1	3½	7	6
29	—	1	—	2	—	3	4	6	4
30	—	5	—	5	—	7	0	4½	2
31	—	7½	—	8	—	8	2	2½	2

T.	Wind. Morg.	Abend.	Witterung.
1	W.	W.	Wolkigt und ſtill, Nachmittag Regen.
2	W.	W.	überzogen, auf den Abend heftiger Wind.
3	N. W.	N.	der Himmel kläbrt ſich auf, und iſt Nachmittag Sonnenſchein.
4	N. O.	N. O.	abwechslender Schnee und Sonnenſchein.
5	N. O.	N. W.	des Nachts Schnee, über den Tag Sonnenſchein, auf den Abend Regen.
6	W.	W.	Regen und Thauwetter, Nachmittag lieblicher Sonnenſchein, auf die Nacht wieder Regen.
7	W.	W.	abwechslender Regen und Sonnenſchein, bey einbrechender Nacht aber ſtarker Regen.
8	N. O.	N. O.	in der Nacht ein kleiner Schnee; darauf der N. O. Wind zu blaſen angefangen.
9	N. O.	N. O.	überzogen.
10	N. O.	N.	ebenfalls.
11	N. O.	N. O.	überzogen und windſtill.
12	N. O.	N. O.	gleichfalls.
13	N. O.	N. O.	eben ſo.

14 Tag

vom Januario 1760. 473

T.	Wind. Morg.	Abend.	Witterung.
14	N. O.	N. O.	vieler Schnee.
15	N. O.	N. O.	überzogen; auf die Nacht aber aufgeklährt.
16	N. O.	N. O.	hell, Sonnenſchein und windſtill.
17	N. O.	N. O.	überzogen; Nachmittag aber Sonnenſchein.
18	N. O.	N. O.	ware eben ſo.
19	N. O.	N. O.	den ganzen Tag neblicht.
20	N. O.	N. O.	desgleichen.
21	N. O.	N. O.	neblicht; von 10. Uhr an beſtändiger Sonnenſchein.
22	N. O.	N. O.	neblicht; gegen Mittag Sonnenſchein; auf den Abend rieſelte es.
23	N. O.	N. O	hell, Sonnenſchein, und windſtill.
24	N. O.	W.	wolkigt Thauwetter mit abwechslendem Sonnenſchein, und auf die Nacht bringt der W. Wind den Regen.
25	N. W.	S. W.	den ganzen Tag ſtarker Regen, und auf die Nacht ſtarke Sturmwinde.
26	N. W.	S. W.	angenehmer Sonnenſchein; Nachmittag aber überzogen.
27	S. W.	S. W.	in der Nacht ſtarke Platzregen, über den Tag aber bald Sonnenſchein, bald Regen.
28	W.	W.	anhaltendes Regenwetter.
29	W.	W.	der Regen haltet noch allezeit an, und iſt auf den Abend mit ſtarken Sturmwinden begleitet.
30	N. W.	N. W.	Vormittag Sonnenſchein; Nachmittag aber überzogen und windſtill.
31	S.	N. W.	Schnee, Sonnenſchein, und Regen.

Der Anfang dieſes Monaths war ſehr gelind und naß, von dem 8ten aber bis den 23ten war es bey unverändert anhaltenden N. O. Wind trocken und ſehr kalt, indem es nur einen einzigen Tag ſchneyete; der 21te war der kälteſte Tag; von dem 24ten aber bis zu End des Monaths war es wieder ſehr gelind und naß.

Hh 3 In

Figure 4. Data for Bern, January 1760, published in the Society's journal "Sammlungen von landwirthschaftlichen Dingen der Schweitzerischen Gesellschaft von Bern" (Vol. 1, 1760). Negative values are denoted with "0/".

2.2. The Neuchâtel series

The Neuchâtel series was measured by Frédéric Moula (1703-1782) and is one of the oldest Swiss series. Frédéric Moula was the son of Hugoenot refugees. He studied in Geneva and Basel as a scholar of Johann Bernoulli. After working as a teacher he became professor of mathematics in St. Peterburg in 1733 and in 1736 member of the Academy of St. Petersburg. From 1758 on he held the post of a “Royal Translator”. He published articles on mathematics (Marti-Weissenbach, 2009).

Moula performed regular meteorological measurements from 1753 to 1782 in Neuchâtel. During the 1760s, the measurements were part of the network of the OeGB. Together with his own observations, Moula also sent observations from La Brévine in the Jura Mountains to the OeGB. He had given instruments to the pastor in La Brévine (we only have temperature data and only for 1759). The Neuchâtel data from Frédéric Moula can be found today in the Bibliothèque publique et universitaire (BPU) Neuchâtel (MsA 164). The data have also been published in the *Bull. soc. sci. nat. Neuchatel* VI (1861-1864) and IX (1871). An example sheet is shown in Figure 5.

Moyenne du jour à Neuchâtel.

JANVIER.

	1753.	1754.	1755.	1756.	1757.	1758.	1759.
1	— 4.4	— 2.0	0.6	1.2	— 4.2	— 2.6	0.7
2	— 5.6	— 1.2	0.4	3.2	— 4.3	0.2	3.7
3	— 6.1	— 0.8	— 0.3	1.8	— 4.6	1.0	4.1
4	— 2.6	0.4	— 3.3	2.5	— 7.5	1.5	5.8
5	0.1	— 1.4	— 8.0	2.9	— 10.6	1.3	7.2
6	— 0.3	0.2	— 11.2	1.2	— 9.5	0.1	3.7
7	— 2.7	1.7	— 12.6	2.9	— 5.2	— 0.2	2.0
8	— 4.4	2.3	— 11.6	3.2	— 8.0	— 1.7	2.8
9	— 4.2	1.6	— 9.9	2.9	— 7.7	— 2.4	3.2
10	— 3.4	— 3.9	— 5.5	1.9	— 6.4	— 1.0	5.1
11	— 4.0	— 3.1	— 3.4	1.0	— 5.5	— 0.2	4.9
12	0.6	0.7	— 3.4	0.0	— 4.7	3.7	3.3
13	1.7	0.7	— 2.1	4.5	— 2.9	4.6	1.7
14	2.8	— 0.1	— 0.6	7.0	2.0	2.9	2.6
15	2.6	3.1	— 0.1	6.3	1.4	4.7	— 0.4
16	2.8	4.3	— 1.4	2.3	0.6	0.4	— 1.5
17	— 3.1	4.2	1.1	2.1	0.0	— 2.7	— 1.3
18	— 2.7	3.6	0.9	2.9	— 0.7	— 7.7	— 1.6
19	— 2,4	5.1	1.8	5.6	1.4	— 7.1	— 1.3
20	— 2.7	2.3	2.1	4.9	2.2	— 7.2	0.4
21	— 3.7	1.6	— 0.4	3.8	2.0	— 8.8	— 1.7
22	— 2,3	0 9	— 5.0	1·2	2.9	— 7.7	— 1.5
23	— 3.0	2.7	— 7.0	0.7	— 1.4	— 6.7	— 1.7
24	— 7.4	2.8	— 7.1	3.3	— 1.3	— 6.8	— 1.5
25	— ·7.8	6.5	— 8.2	3.1	4.5	— 6.8	— 0.9
26	— 7.0	5.6	— 8.3	2.9	2.5	— 8.0	— 1.5
27	— 5,8	0.2	— 9.6	2.8	2.0	— 6.1	— 3.0
28	— 4.5	— 2.1	— 5.7	0.7	3.8	— 6.1	— 3.3
29	— 2.8	— 3,3	— 5.9	— 0.9	2.3	— 8.2	— 3.4
30	— 3.1	— 5.6	— 3.8	— 1.2	2.1	— 3.9	— 2.6
31	— 1.2	— 6.0	— 5.8	— 0.4	1.0	— 2.6	— 1.7

Figure 5. Daily mean temperatures from Moula were published in Bull. soc. sci. nat. Neuchatel VI (1861-1864): Rapport du comité météorologique de la Société des Sciences naturelles de Neuchâtel pour l'année 1861.

Table 2. Station or thermometer relocations of the Neuchâtel series

Date	Event	Details
19.01.1754	Station relocation	From Rue des Moulins (2nd floor, NE exposure) to Rue de St. Maurice (SE exposure, but afternoon observations with NW exposure using an alcohol thermometer?)
18.06.1754	Station relocation	To Rue de l'Hopital (thermometer on the wall of a small gallery)
01.12.1754	Thermom. relocation	N exposure behind a window on Rue de l'Hopital
15.06.1758	Station relocation	Faubourg (NW window)
12.01.1766	Station relocation	Maison de Mad. la Ministre Petitpierre neé Montandon
26.04.1770	Station relocation	Maison de Ms. Bovet (2nd floor, N exposure)
17.10.–24.11.1770	Temporary relocation	Rue des Moulins (N exposure) – Observer Daniel Sandoz
09.12.1775	Station relocation	Maison de M. le Maitre ? Pon???
11.06.–31.07.1781	Temporary relocation	Maison de M. Sandoz – Observer Ministre Meuron Petispierre
01.08.–11.09.1781	Temporary relocation	Maison de charité – Observer M. Cartier

The metadata on the series indicate that Moula, working as a teacher for various families, changed the observation location frequently. At least 7 different locations are mentioned (Table 2). Moreover, he left the thermometer to others during travels, leading to temporary relocations. Generating a homogeneous time series in this situation is difficult. It should be noted, however, that this series has been widely used in the past as part of the Geneva series.

An even earlier series exists for Neuchâtel, recorded by Laurent Garcin (1683-1752). Data for the years 1734 and 1735 were published in the Journal "Mercure Suisse". An article from 1736 indicates that the series continued, but only these two years could be found.

2.3. The Gurzelen series

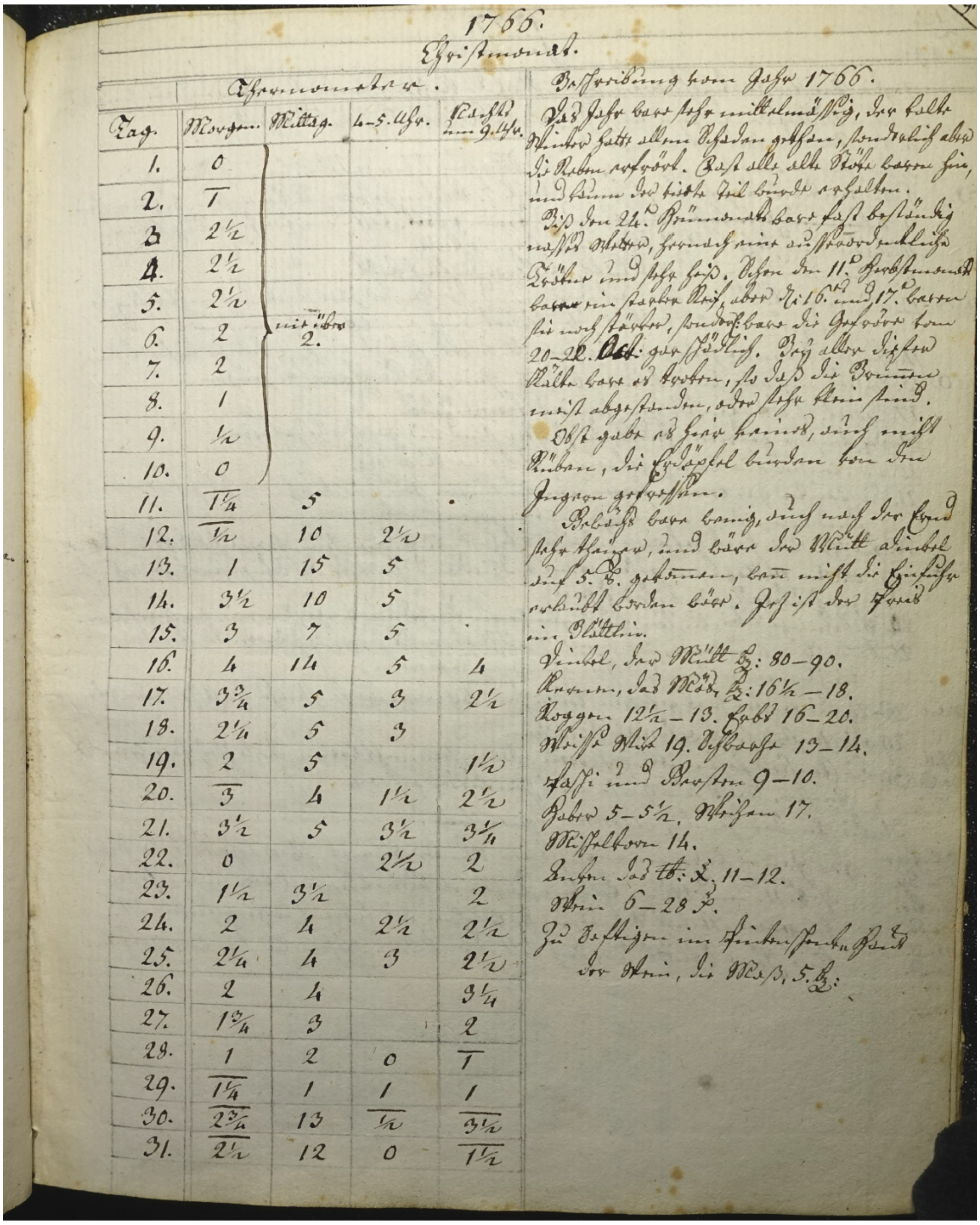
Johann Jakob Sprüngli (1717-1803) was the son of a priest from Leutwil. He was educated as priest in Bern, had various positions before becoming priest in Zweisimmen (Bernese Oberland) in 1757, then in Gurzelen in 1765 and eventually in Sutz (Lake Biel) in 1784 (Wolf, 1855). He began daily weather observations in 1759, while priest in Zweisimmen, and also observed plant and animal phenology, earthquakes, Aurorae Borealis and other phenomena. In Gurzelen he continued his observations, now also with meteorological instruments. After being reassigned to Sutz, he continued the observations there until the year 1802.

Sprüngli observed two to four times per day. He had a barometer and a thermometer, however we know little about the instruments used in the first years of observations. Sprüngli was not among selected observes for the network of the OeGB, but obviously did have close relations to the Society. In 1765 he figures among the founding members of the Zweisimmen branch of the OeGB (Burri and Zenhäusern, 2009), although he moved to Gurzelen in the same year. His observations for 1770 were published in the journal of the OeGB and in 1772 the Society decided to provide him with meteorological instruments (Burri and Zenhäusern, 2009). He was in contact with priest Jakob Samuel Wyttenbach, member of the Society and later co-founder of the Bernese and Swiss Natural Sciences Societies.

Sprüngli's observations are of excellent quality and were widely used in historical climatology (Pfister, 1975; Burri and Zenhäusern, 2009). Daily data for Gurzelen, 1767-1770, were included in the "Schweizerische Meteorologische Beobachtungen" 8 (1871), p. 97-100, but the individual observations have never been published and processed. Sprüngli's handwritten observations are today part of the OeGB collection of the Burgerbibliothek Bern (GA Oek. Ges. 109 (17, 18, 22) (1771-1776); GA Oek. Ges. 111/112/113/114 (1766-1784)). An example sheet is shown in Figure 6.

3. Data processing and quality assurance

The data were processed as described in Brugnara et al. (2020a). The thermometer readings in Réaumur were converted assuming a Deluc-type thermometer. An uncertainty remains on how the zero point was determined during the calibration, which can lead to a systematic error of about 1 °C. By 1760, however, the practice of using the melting point of ice – advocated in Switzerland by Deluc and Micheli du Crest – rather than freezing water was already well established among instrument-makers (see Camuffo, 2020).



1766.

1.	0			
2.	$\overline{1}$			
3.	2½			
4.	2½			
5.	2½			
6.	2			
7.	2			
8.	1			
9.	½			
10.	0			
11.	$\overline{1\frac{1}{4}}$	5		
12.	$\overline{\frac{1}{2}}$	10	2½	
13.	1	15	5	
14.	3½	10	5	
15.	3	7	5	
16.	4	14	5	4
17.	3¾	5	3	2½
18.	2¼	5	3	
19.	2	5		1½
20.	$\overline{3}$	4	1½	2½
21.	3½	5	3½	3¾
22.	0		2½	2
23.	1½	3½		2
24.	2	4	2½	2½
25.	2¼	4	3	2½
26.	2	4		3¼
27.	1¾	3		2
28.	1	2	0	$\overline{1}$
29.	$\overline{1\frac{1}{4}}$	1	1	1
30.	$\overline{2\frac{3}{4}}$	13	$\overline{\frac{1}{2}}$	$\overline{3\frac{1}{2}}$
31.	$\overline{2\frac{1}{2}}$	12	0	$\overline{1\frac{1}{2}}$

Figure 6. Sprüngli's observations for December 1766. Negative values are denoted with an overbar.

3.1. Individual series

Moula's series from Neuchâtel has twice daily observations. Plotting morning versus evening values of pressure and temperature (Fig. 7) yields correlations of 0.90 and 0.96, respectively. These numbers are in the same range as for most other stations. No particular indications for lower quality are found. Whether segments of this series can be used to backward extend the series of Bern still remains open. Fortunately, there are also overlaps (albeit short) with the series in Gurzelen and the next Bern series from Lombach and Studer, which will be discussed in an upcoming paper (Hari et al., 2021).

The Bern segment by von Tavel is the shortest segment of the series discussed here. Scatter plots of observations at different times of the day (Fig. 8) show a good agreement. No clear problems are detected. The relatively coarse reporting resolution for pressure is apparent. The corresponding plots for the Gurzelen series are almost identical with those of Bern, with very similar correlation coefficients. The scatter plots exhibit the same shapes. Again, no evidence for systematic problems is found in this way.

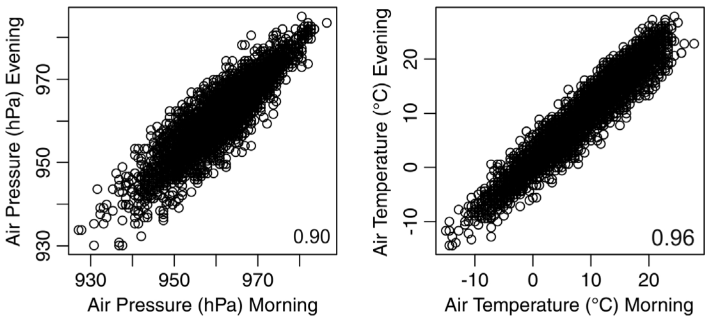


Figure 7. Mutual comparisons of morning and evening series (the number indicates the Pearson correlation coefficient) of (left) pressure and (right) temperature in Neuchâtel.

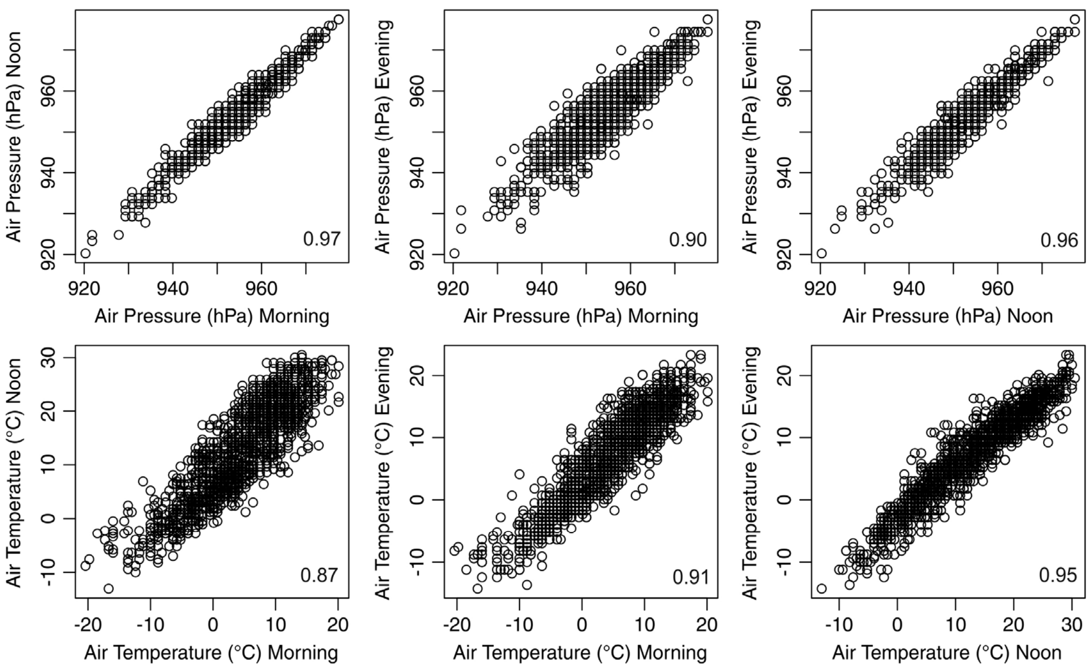


Figure 8. Mutual comparisons of morning, noon, and evening series of pressure and temperature in Bern. Numbers indicate the Pearson correlation coefficient.

Finally, we compared the diurnal cycle of the historical segments with that of corresponding MeteoSwiss stations in recent years (Fig. 10), shifted by 1-2 °C to account for climate change. For Neuchâtel an excellent agreement is found both in winter and in summer. The Bern series fits well in summer, but in winter the morning and evening readings seem rather low. Gurzelen has high values in winter for all times of the days and low values in summer, particularly at noon. This is an indication that Sprüngli measured temperature indoors. The value of these temperatures for current climate research is therefore very limited.

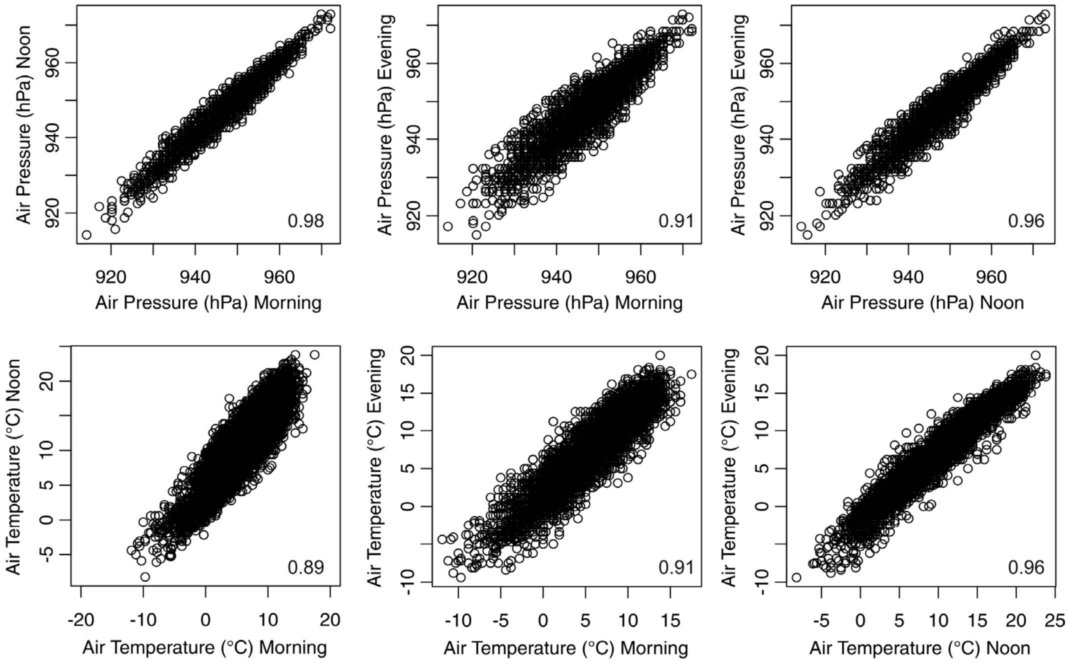


Figure 9. Mutual comparisons of morning, noon, and evening series of pressure and temperature in Gurzelen. Numbers indicate the Pearson correlation coefficient.

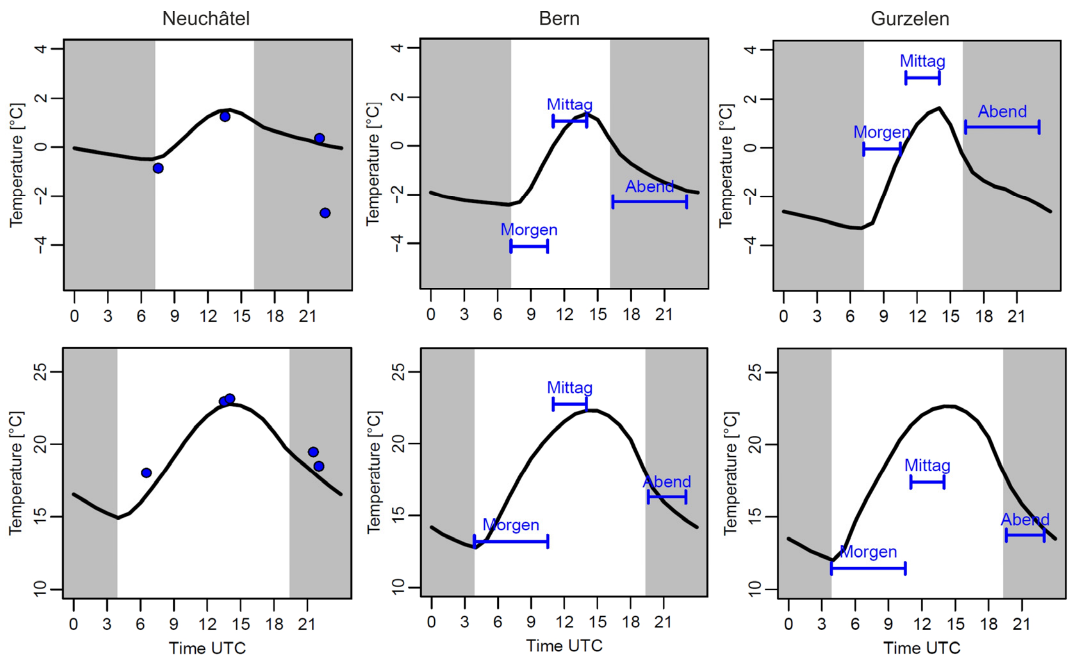


Figure 10. Diurnal cycle of temperature in (top) January and (bottom) July in MeteoSwiss data (thick black line) as well as in the historical series (grey shading indicates nighttime). Note that for Bern and Gurzelen the exact time is not known, but only “Morgen” (morning), “Mittag” (noon) and “Abend” (evening). Reference series used are Neuchatel, 1981-2010, 1 °C subtracted, Bern Zollikofen (2006-2018, 2 °C) and Thun (2011-2020, 2 °C)

3.2. Comparison of overlapping segments and monthly mean series

Since the aim is eventually to combine all Bern records (including those from Neuchâtel and Gurzelen) into one long record, it is essential to analyse the overlaps between the series carefully. While there is only a short overlap between Gurzelen and Bern, overlaps are longer for Neuchâtel/Bern and Neuchâtel/Gurzelen. Figure 11 shows all overlaps as scatter plots.

Overall the correlations are very high, mostly higher than those between different times of day at one site. However, the visual inspection of the comparison of pressure between Neuchâtel and Bern shows a separated point clouds, which concerns the values of January to June 1766 (when the Bern series ends). From this plot it is not possible to conclude which of the two series is wrong. However, the start of the offset period coincides with a station relocation (Table 2).

The scatter plots for temperature indicate a very good agreement between Neuchâtel and Gurzelen, despite the relatively large distance (the red points were excluded for the correlation). The Bern series shows cooler winter mornings than the other two sites, as already noted in Figure 10, leading to a curved, non-linear relation between temperatures in Neuchâtel and Bern. This might indicate cold air pooling at von Tavel's measuring location or effects of radiation cooling. During the short direct overlap, temperatures in Bern and Gurzelen correlate well, but Bern is cooler despite the lower altitude, which could be explained by indoor temperatures in Gurzelen.

Finally, we analyse the monthly series from all segments for pressure and temperature (Fig. 12). Pressure shows an excellent agreement between the series. The individual segments appear to have positive trends that could be due to instrument drifts. They are reproduced in neighbouring series, but not in the pressure extracted for the closest grid point to Bern from

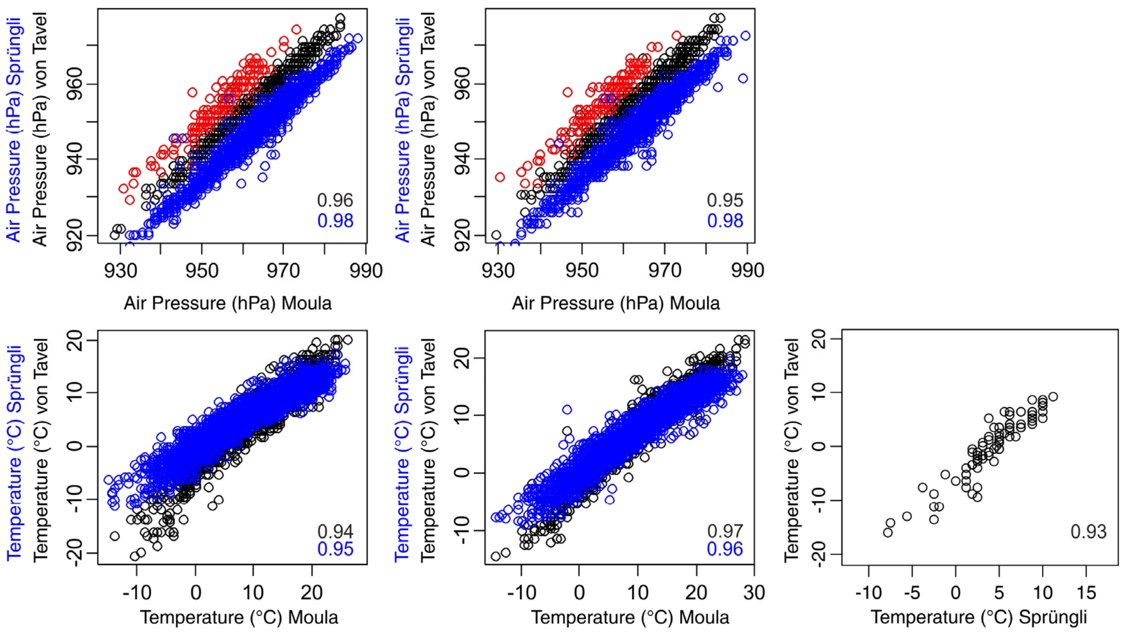


Figure 11. Mutual comparisons between the series from Neuchâtel, Bern and Gurzelen for (top) pressure and (bottom) temperature for (left) morning and (right) evening. The right panel compares data from Bern and Gurzelen at noon. Red dots denote the time period of January to July 1766, which produces an obviously shifted point cloud. Numbers in the bottom right corners indicate Pearson correlation coefficients (red points were excluded).

the global monthly reconstruction EKF400 version 2 (Valler et al., 2021), which is shown for comparison. The period Jan-Jun 1766 (red point cloud in Fig. 11) seems to be more likely due to low values in Neuchâtel than high values in Bern, which is also supported by EKF400v2.

With respect to temperature, the low amplitude of the annual cycle in Gurzelen is striking and points to indoor temperatures. Apart from an obvious outlier in the noon series in Bern in 1769, the agreement with Neuchâtel is good. Nevertheless, while the pressure series demonstrate that a long, continuous pressure series for Bern can be obtained, this will be far more difficult for temperature. The Neuchâtel series has many location changes, and the Gurzelen indoor temperatures can hardly be used to generate a long series.

4. Conclusions

Meteorological measurements in Bern started in 1760, and since then measurements have been taken most of the time, though with some gaps. Many of the series are however only 10–20 years long. The CHIMES project has revealed that – regarding coverage alone - a close-to-continuous record could potentially be generated, and some of the gaps could be filled with data from neighbouring stations (Pfister et al., 2019). However, the individual segments now need to be assessed. This paper describes three series that could form the start of the Bern record. The series discussed cover Neuchâtel (1753-1782), Bern (1760-1770) and Gurzelen (1766-1784).

The data processing and analysis shows that temperatures in Gurzelen were most likely indoor temperatures, they cannot be used to generate a long Bern series. Further, the metadata also indicate that the Neuchâtel series was measured at different locations. Because compari-

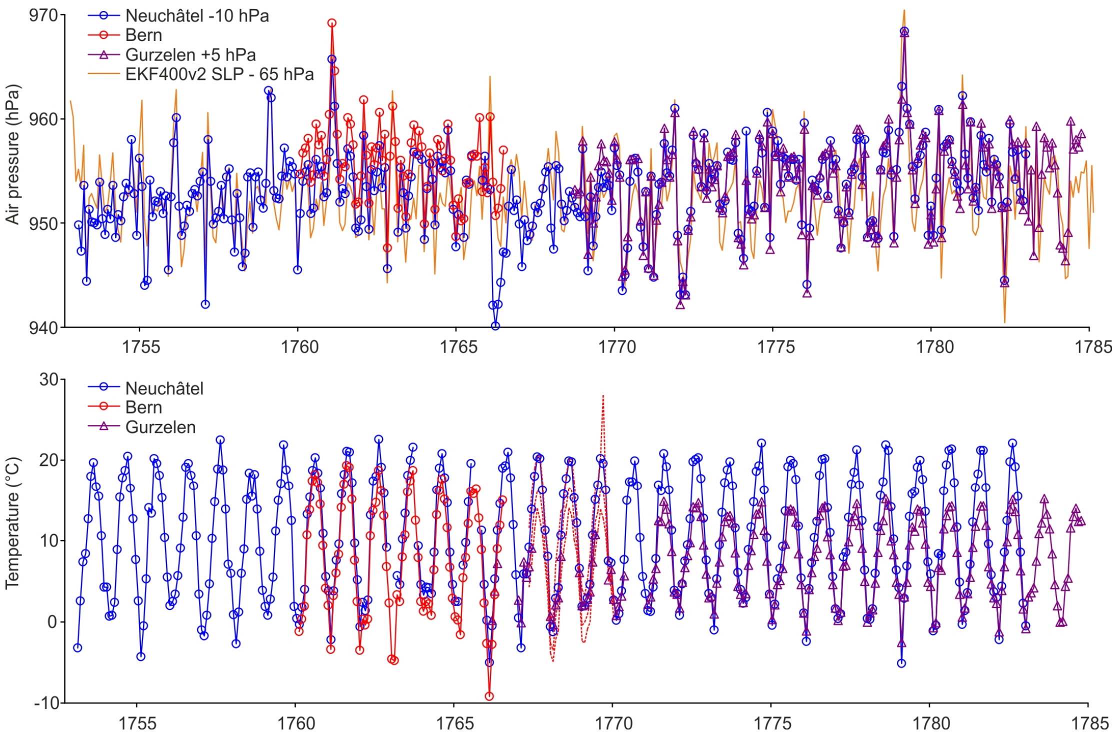


Figure 12. Monthly series of (top) pressure and (bottom) temperature for Neuchâtel, Bern and Gurzelen. For Bern, 1767-1770, only monthly values for the three observation times are available (dashed).

sons with Bern can only be performed from 1760 onward, breaks in the early part may not be visible in our analysis. Furthermore, a six-month period in 1766 in pressure data from Neuchâtel is offset. Nevertheless, apart from the latter, the quality seems better for pressure than temperature. The data from Neuchatel, Bern, and Gurzelen compare well with each other and with data from a reconstruction. A continuous series without gaps could possibly be generated for pressure.

The data are further described in Brugnara et al. (2020a) and made publicly available at https://doi.pangaea.de/10.1594/PANGAEA.909141, via MeteoSwiss and via the C3S Global Land and Marine Observations Database (Thorne et al., 2017) as well as EURO-CLIMHIST (Pfister et al., 2017). The images can be downloaded from https://zenodo.org/ record/3066836#.XVv-fGRS8-U.

Acknowledgements

The work was supported by the Swiss National Science Foundation (project WeaR, 188701), by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme grant agreement No 787574 (PALAEO-RA), by Copernicus Climate Change Service (C3S) 311a Lot 1, by GCOS Switzerland (project "Long Swiss Meteorological Series"), and by EURO-CLIMHIST.

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