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Two Meteorological Series from Geneva, 1782–1791

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Abstract

From 1782 to 1791, two observers performed instrumental meteorological measurements in Geneva. Jean Senebier observed at the Musée de l'Académie from 1782 to 1789 for the Meteorological Society of Mannheim, Fréderic-Guillaume Maurice observed at the Observatoire de Mallet from 1787 to 1791. Here we discuss the recovery and processing of the data and compare the two series in their overlapping year, *i.e.,* 1789. This paper accompanies the online publication of the data sheets and of the re-evaluated data.

1. Introduction

Geneva hosts one of the three prominent long-term series of Switzerland, reaching back to the 1750s (Bider and Schüepp, 1961; Schüepp, 1961). A monthly series back to 1753 was compiled by Schüepp (1961) and homogenised by MeteoSwiss, which in its early years however uses data from Neuchâtel. Daily data from Geneva starting in 1796 were published 1873 in a Supplement to the Annals of MeteoSwiss. Within the project Digihom (Füllemann et al., 2011), all subdaily data were digitsed back to 1796 (see Brönnimann et al., 2020). Subsequently, within the CHIMES project, we complement these series backwards into the 18th century. An overview of all series project is given in the Brugnara et al. (2019).

During the early decades, the Geneva series is composed of many individual series (Tab. 1). Regular meteorological observations in Geneva reach back to 1760 (Pfister et al., 2019). Until 1800, observations were performed at least at seven locations. Here we describe the two

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Table 1. Overview table of historical meteorological measurements in Geneva, 1760-1863. # indicates the number of the location in Fig. 1, Alt = altitude in m asl (data from Pfister et al., 2019)

Location	#	Lat	Lon	Alt	Observer	Start	End
Petit-Saconnex (summer) Rue Beauregard (winter)	1	46.21666 46.19861	6.13083 6.14833	411 394	Charles Benjamin de Lubières	1760	1789
Rue Basse des Allemands-Dessus	2	46.20388	6.14416	376	Guillaume-Antoine Deluc	1768	1800
Observatoire de Mallet	3	46.19916	6.15111	399	Jacques-André Mallet, Abraham? Trembley, Marc-Auguste Pictet	1773	1777
Observatoire de Mallet	3	46.19916	6.15111	399	Marc-Auguste Pictet	1778	1788
Observatoire de Mallet	3	46.19916	6.15111	399	Frédéric-Guillaume Maurice	1787	1791
Pictets appartment and Cartigny	4	46.20156	6.14879	396	Marc-Auguste Pictet	1774	1787
Musée de l'Académie (Promenade des Bastions 1)	5	46.19861	6.14527	380	Jean Senebier	1782	1789
Jardin Botanique	3	46.199	6.151	395.6	Marc-Auguste Pictet, Vaucher	1798	1821
Nouveau Jardin Botanique	6	46.20011	6.14523	380	not known	1822	1825
Pont des Tranchées (Passerelle de Saint-Antoine)	7	46.19797	6.15238	394	not known	1826	1835
Observatoire de Genève	8	46.19961	6.15211	401	not known	1836	1863
Genève-Genthod		46.264	6.158	406	Frédéric-Guillaume Maurice	1789	1800

series of Jean Senebier (for details see Grenon, 2010) at the Musée de l'Académie, 1782-1789, and of Fréderic-Guillaume Maurice at the Observatoire de Mallet, from 1787–1791.

The paper is organised as follows. Section 2 describes the series from Maurice, Section 3 the series from Senebier. Section 4 describes the processing and shows the data, a comparison of the two series for the overlapping year 1789 is presented in Section 5. Conclusions are drawn in Section 6. The station metadata are part of an inventory published in Pfister et al. (2019), the images (https://zenodo.org/record/3066836#.XVv-fGRS8-U) and digitised data (https://doi.pangaea.de/10.1594/PANGAEA.909141) can be downloaded from public repositories and are available from EURO-CLIMHIST (Pfister et al., 2017) and MeteoSwiss.

Figure 1. Locations of historical meteorological measurements in Geneva, 1760–1863 (numbers refer to Table 1, source of aerial photo: Bundesamt für Landestopografie).

2. Description of the Maurice series

2.1. Location and observer

The meteorological data from the Maurice series were published in the *Journal de Genève.* The measurements took place at the old observatory (Observatoire de Mallet) in the city of Geneva (Gautier, 1843; Fig. 1; see Brönnimann et al., 2020, for a historical map), today "Rue Charles Galland" (the park nearby is still called "Parc de L'Observatoire"). The observatory was located ca. 399 m asl and around 700 metres from Lake Geneva.

The measurements were made by Frédéric-Guillaume Maurice. He was an agronomist (Journal de Genève, 1794), advocate, auditor, castellan and caretaker of a hospital (Bollinger, 2008). Additionally, he was also a member of the "Conseil des Deux-Cents".

Maurice made measurements with different meteorological instruments: thermometer, barometer, hygrometer and an electrometer. He read all the instruments three times a day. He also observed the wind direction and noted the coverage of the sky. The standard measuring times were set at sunrise, 2 pm and sunset. The reason of choice for the measuring times is described in an article in the *Journal de Genève* called "Explications rélatives aux Observations météorologiques" as follows:

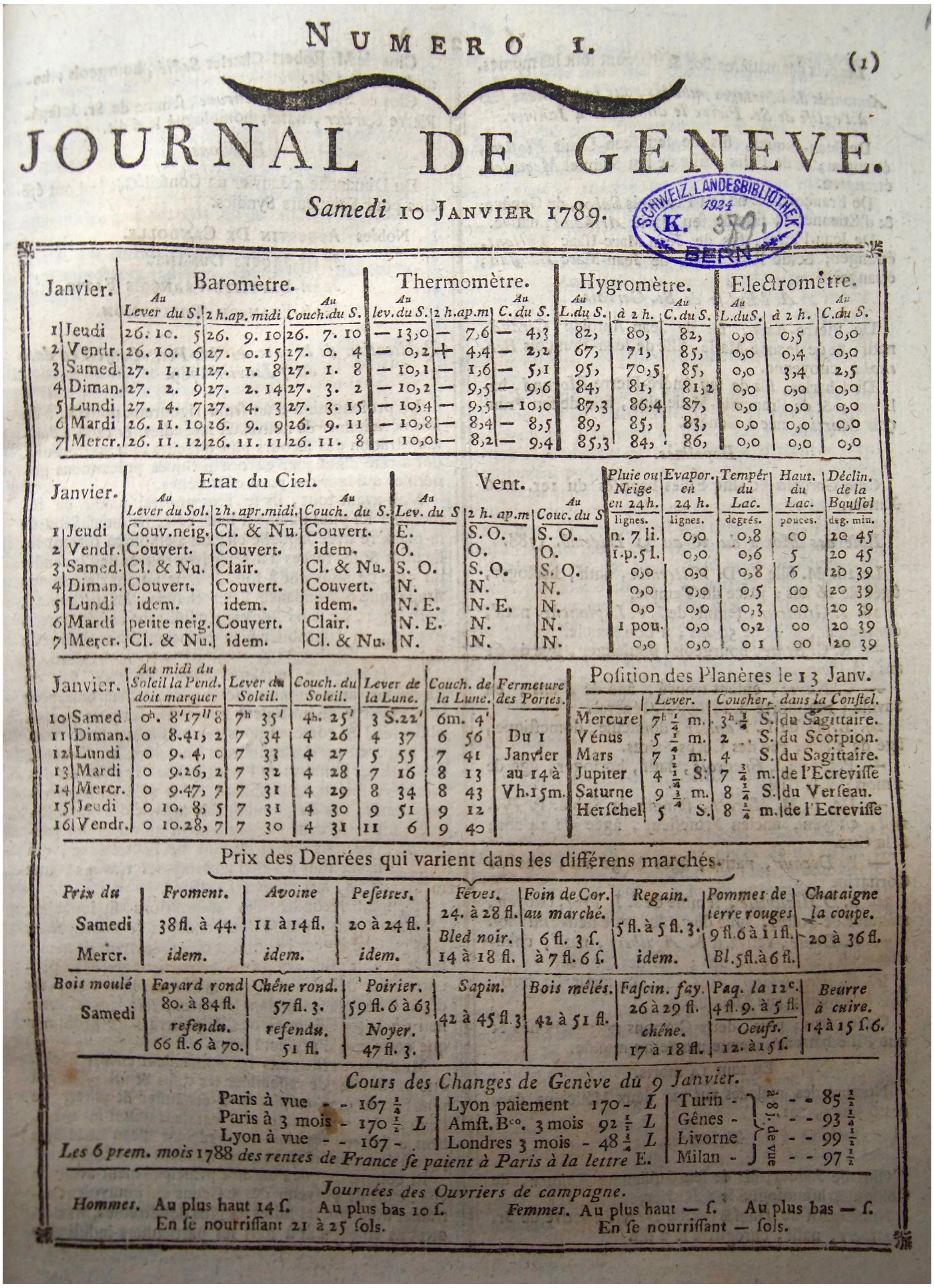
"On a donc cru rendre les observations qui se feront à Genève plus intéressantes, en choisissant trois époques dans la journée qui fussent les mêmes dans toutes les saisons, rélativement à l'influence du Soleil. On observe, 1. Le matin au lever du Soleil; 2. à 2 h. après-midi; 3. Au coucher du Soleil. La première de ces époques a l'avantage d'indiquer le moment le plus froid dans les 24 heures, qui a lieu constamment vers le lever du Soleil. La seconde est placée dans le moment de la plus grande chaleur du jour: en forte que ces deux observations indiquent pour l'ordinaire les deux extrêmes de température qui auroient pu être observés dans les 24 heures. Enfin, la troisième époque, qui répond au coucher du Soleil, offre un moment, météorologiquement, plus intéressant qu'aucun autre dans la soirée." (Journal de Genève, 1787, p. 8).

(It was therefore thought to make the observations in Geneva more interesting, by choosing three times of the day that were the same in all seasons, with regard to the influence of the Sun. We observe: 1. in the morning at sunrise; 2. at 2 p. m.; 3. at sunset. The first of these times has the advantage of indicating the coldest instance within 24 hours, which is always around sunrise. The second is placed in the moment of the greatest heat of the day. These two observations usually indicate the two extremes of temperature that could have been observed within 24 hours. Finally, the third time, which corresponds to sunset, is a moment that is, meteorologically, more interesting than any other in the evening.)

Maurice also measured once a day the precipitation, the evaporation, the temperature and water level of Lake Geneva and the times of the sun- and the moonrise as well as the sunset and moonset. In general, no detailed information is available on the instruments used by Maurice. Nevertheless, it is known that Marc-Auguste Pictet bought and modified instruments when the Observatory de Mallet was opened in the year 1773 (Grenon, 2010). Therefore, the assumption is made that for the period of time between 1787 and 1791, Maurice used the same instruments that Pictet had acquired in 1773.

2.2. Instruments

There is not much information available about the thermometer used by Maurice, except that its scale was in °R (degrees Réaumur). We can assume, that a mercury thermometer was used, as it was standard for this time. Furthermore, no specifications about the exact position of the thermometer were found in the metadata. In the middle of the 18th century, a northern setup of the instruments was often practiced and the influence of radiation errors was well known (Pfister, 1988).



NUMERO I. (1)

JOURNAL DE GENEVE.

Samedi 10 JANVIER 1789.

Janvier.	Baromètre. Au Lever du S.	2 h. ap. midi	Au Couch. du S.	Thermomètre. Au lev. du S.	2 h. ap. m	Au C. du S.	Hygromètre. Au L. du S.	à 2 h.	Au C. du S.	Electromètre. Au L. du S.	à 2 h.	Au C. du S.
1 Jeudi	26. 10. 5	26. 9. 10	26. 7. 10	— 13,0	— 7,6	— 4,3	82,	80,	82,	0,0	0,5	0,0
2 Vendr.	26. 10. 6	27. 0. 15	27. 0. 4	— 0,2	+ 4,4	— 2,2	67,	71,	85,	0,0	0,4	0,0
3 Samed.	27. 1. 11	27. 1. 8	27. 1. 8	— 10,1	— 1,6	— 5,1	95,	70,5	85,	0,0	3,4	2,5
4 Diman.	27. 2. 9	27. 2. 14	27. 3. 2	— 10,2	— 9,5	— 9,6	84,	81,	81,2	0,0	0,0	0,0
5 Lundi	27. 4. 7	27. 4. 3	27. 3. 15	— 10,4	— 9,5	— 10,0	87,3	86,4	87,	0,0	0,0	0,0
6 Mardi	26. 11. 10	26. 9. 9	26. 9. 11	— 10,8	— 8,4	— 8,5	89,	85,	83,	0,0	0,0	0,0
7 Mercr.	26. 11. 12	26. 11. 11	26. 11. 8	— 10,0	— 8,2	— 9,4	85,3	84,	86,	0,0	0,0	0,0

Janvier.	Etat du Ciel. Au Lever du Sol.	2h. apr. midi.	Au Couch. du S.	Vent. Au Lev. du S	2 h. ap. m	Au Couc. du S	Pluie ou Neige en 24 h. lignes.	Evapor. en 24 h. lignes.	Tempér du Lac. degrés.	Haut. du Lac. pouces.	Déclin. de la Bouſſol deg. min.
1 Jeudi	Couv. neig.	Cl. & Nu.	Couvert.	E.	S. O.	S. O.	n. 7 li.	0,0	0,8	00	20 45
2 Vendr.	Couvert.	Couvert.	idem.	O.	O.	O.	1. p. 5 l.	0,0	0,6	5	20 45
3 Samed.	Cl. & Nu.	Clair.	Cl. & Nu.	S. O.	S. O.	S. O.	0,0	0,0	0,8	6	20 39
4 Diman.	Couvert.	Couvert.	Couvert.	N.	N.	N.	0,0	0,0	0,5	00	20 39
5 Lundi	idem.	idem.	idem.	N. E.	N. E.	N.	0,0	0,0	0,3	00	20 39
6 Mardi	petite neig.	Couvert.	Clair.	N. E.	N.	N.	1 pou.	0,0	0,2	00	20 39
7 Mercr.	Cl. & Nu.	idem.	Cl. & Nu.	N.	N.	N.	0,0	0,0	0 1	00	20 39

Janvier.	Au midi du Soleil la Pend. doit marquer	Lever du Soleil.	Couch. du Soleil.	Lever de la Lune.	Couch. de la Lune.	Fermeture des Portes.
10 Samed.	0h. 8′17″ 8	7h 35′	4h. 25′	3 S. 22′	6m. 4′	
11 Diman.	0 8. 41, 2	7 34	4 26	4 37	6 56	Du 1
12 Lundi	0 9. 4, 0	7 33	4 27	5 55	7 41	Janvier
13 Mardi	0 9. 26, 2	7 32	4 28	7 16	8 13	au 14 à
14 Mercr.	0 9. 47, 7	7 31	4 29	8 34	8 43	Vh. 15m.
15 Jeudi	0 10. 8, 5	7 31	4 30	9 51	9 12	
16 Vendr.	0 10. 28, 7	7 30	4 31	11 6	9 40	

Poſition des Planètes le 13 Janv.

	Lever.	Coucher.	dans la Conſtel.
Mercure	7h $\frac{1}{4}$ m.	3h. $\frac{3}{4}$ S.	du Sagittaire.
Vénus	5 $\frac{1}{4}$ m.	2 . . S.	du Scorpion.
Mars	7 $\frac{1}{2}$ m.	4 S.	du Sagittaire.
Jupiter	4 $\frac{1}{4}$ S.	7 $\frac{3}{4}$ m.	de l'Ecreviſſe
Saturne	9 $\frac{3}{4}$ m.	8 $\frac{1}{4}$ S.	du Verſeau.
Herſchel	5 S.	8 $\frac{3}{4}$ m.	de l'Ecreviſſe

Prix des Denrées qui varient dans les différens marchés.

Prix du	*Froment.*	*Avoine*	*Peſettes.*	*Fèves.*	*Foin de Cor. au marché.*	*Regain.*	*Pommes de terre rouges*	*Chataigne la coupe.*
Samedi	38 fl. à 44.	11 à 14 fl.	20 à 24 fl.	24. à 28 fl.	6 fl. 3 ſ. à 7 fl. 6 ſ.	5 fl. à 5 fl. 3.	9 fl. 6 à 11 fl.	20 à 36 fl.
Mercr.	*idem.*	*idem.*	*idem.*	*Bled noir.* 14 à 18 fl.		*idem.*	*Bl.* 5 fl. à 6 fl.	

Bois moulé	*Fayard rond*	*Chêne rond.*	*Poirier.*	*Sapin.*	*Bois mêlés.*	*Faſcin. fay.*	*Paq. la 12e.*	*Beurre à cuire.*
Samedi	80. à 84 fl. *refendu.* 66 fl. 6 à 70.	57 fl. 3. *refendu.* 51 fl.	59 fl. 6 à 63 *Noyer.* 47 fl. 3.	42 à 45 fl. 3	42 à 51 fl.	26 à 29 fl. *chêne.* 17 à 18 fl.	4 fl. 9. à 5 fl. *Oeufs.* 12. à 15 ſ.	14 à 15 ſ. 6.

Cours des Changes de Genève du 9 Janvier.

Paris à vue - - 167 $\frac{1}{4}$
Paris à 3 mois - 170 $\frac{1}{2}$ *L*
Lyon à vue - - 167 -
Lyon paiement 170 - *L*
Amſt. Bco. 3 mois 92 $\frac{1}{2}$ *L*
Londres 3 mois - 48 $\frac{3}{4}$ *L*
Turin - - - 85 $\frac{1}{2}$
Gênes - - - 93 $\frac{1}{4}$
Livorne - - 99 $\frac{1}{2}$
Milan - - - 97 $\frac{1}{2}$
à 8 j. de vue

Les 6 prem. mois 1788 *des rentes de France ſe paient à Paris à la lettre* E.

Journées des Ouvriers de campagne.

Hommes. Au plus haut 14 ſ. Au plus bas 10 ſ. En ſe nourriſſant 21 à 25 ſols.
Femmes. Au plus haut — ſ. Au plus bas — ſ. En ſe nourriſſant — ſols.

Figure 2. Photograph of a data sheet published on Saturday 10 January 1789 in the Journal de Genève (Journal de Genève, 1789).

Unfortunately, there is also not much information available on the barometer and its accompanying thermometer. We assume that a mercury barometer and a mercury thermometer were used.

2.3. Source

All meteorological data used for this time series refer to the *Journal de Genève*. The first edition of the *Journal de Genève* was published on 12 March 1787. From 4 August 1787, the *Journal de Genève* was published as weekly newspaper, always on Saturday. On the first page of the paper, a data sheet containing all the measured meteorological data from the past week was printed. Beside temperature and atmospheric pressure data, humidity, wind direction, precipitation, cloudiness and other data were printed in the paper (Journal de Genève, 1794). A photograph of a data sheet is shown in Figure 2. Although the newspaper appeared until 1794, the meteorological data sheets were only printed until July 1791. Beside the meteorological data, the newspaper also contained different reports about the meteorological measurements, reports about the first ascent of the Mont Blanc, the amount of newborn and deceased, new marriages as well as letters from and to the editors of the journal (Bollinger, 2008; Journal de Genève, 1794).

The *Journal de Genève* was consulted at the Swiss National Library in Bern. Furthermore, a second important source of information about the measurements published in the *Journal de Genève* and of information on historical meteorological measurements in Geneva for the 18th century was a thin book entitled “Notice historique sur les observations Météorologique faites à Genève” (Gautier, 1843). The book was consulted in the Bibliothèque de Genève in Geneva.

3. Description of the Senebier series

3.1. Location and observer

The meteorological data published in the Annals of the Meteorological Society of Mannheim (Societas Meteorologica Palatina) were measured at the “Musée de l’Académie” in the old city of Geneva. Nowadays, the building is still used as a university library, the “Bibliothèque de Genève”. The library is located at the Promenade des Bastions 1, 380 metres above sea level and around 700 metres away from Lake Geneva.

The observer of the data published by the Meteorological Society of Mannheim for the station Geneva was Jean Senebier. He was born in 1742 in Geneva and also died there in 1809. From 1770 until 1773 he was a priest in Chancy. Between 1773 and 1795 and again from 1799 until 1809 he was the city librarian of Geneva. From 1787 until 1791 he also was an employee of the *Journal de Genève* (Cetta, 2014). It is unknown whether Senebier and Maurice knew each other and what relationship they had. Between 1782 and 1789 Senebier made measurements for the Meteorological Society of Mannheim (Gautier, 1843).

3.2. Instruments and measuring times

The measuring instruments used by Jean Senebier at the "Musée de l'Académie " were all provided for free by the Meteorological Society of Mannheim (Kreutz, 2010). The measuring instruments were built in Mannheim by Carlo Artaria. All measuring sites associated with the Meteorological Society of Mannheim received two mercury thermometers, a mercury barometer and a hygrometer (Grenon, 2010). The Meteorological Society of Mannheim recommended standard measurement times for all participating measuring sites. Thus, the measured data could be compared with all the other measuring sites. Measurement times in Geneva were 7 am, 1 pm and 9 pm, which does not correspond to the standard "Mannheim hours" (7 am, 2 pm, 9 pm). In addition to temperature and atmospheric pressure, humidity, wind direction and precipitation were measured as well (Gautier, 1843; Societas Meteorologica Palatina, 1792). Construction manuals for all provided instruments are described in detail in Latin language in the first edition of the annals of the Meteorological Society of Mannheim from the year 1783 (Societas Meteorologica Palatina, 1783).

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OBSERVATIONES GENEVENSES

Autore SENEBIER.

Horae obſervationis ordinariae 7 mat. 1 pom. 9 veſp.

Januarius.

Dies.	Barom.	Therm. intern.	Therm. extern.	Hygr.	Declin.	Ventus.	Pluvia.	Evap.	Flum.	Luna.	Coeli facies.	Meteora.
	dig. lin. dec	gr. dec.	gr. dec.	gr. dec	gr. min.	direct. vires	lin. ſcrupulae	lin. dec	ped. dig.			
1	26, 10, 0	0. 1/2	—12, 0	27, 0		S					[illegible]	
	9, 4	2, 5	— 8, 6	25, 3		S W	guttulae				==	‡‡ 1 poll. 1/4.
	8, 5	4, 3	— 2, 0	20, 4		W	1, 10				==	‡‡ 10 lin.
2	26, 10, 2	1, 4	—1, 0	23, 0		W	guttulae				==	
	11, 3	4, 6	—0, 2	24, 7		N W					==	
	27, 1, 0	5, 4	—5, 0	22, 1		O					⊙	
3	27, 1, 3	1, 4	—8, 4	22, 3		W					⊙	
	1, 3	4, 4	—5, 0	24, 4		W					⊙	
	1, 6	4, 3	—6, 7	25, 2		O vehem.					⊙	
4	27, 2, 4	1, 2	—10, 4	24, 1		O vehem.					==	
	2, 7	4, 0	— 9, 3	24, 6		O vehem.					==	
	3, 7	4, 5	—10, 2	24, 7		O vehem.					==	
5	27, 4, 4	0. 1/2	—10, 5	23, 4		O					==	
	4, 3	2, 2	— 9, 2	24, 4		O					==	
	3, 3	2, 7	— 9, 7	23, 7		O					⊙	
6	26, 11, 2	0, 0	—10, 0	23, 7		W	1, 1				==	‡‡ 1 poll.
	9, 4	1, 3	— 8, 0	23, 0		O	0, 2				==	
	10, 3	4, 1	— 8, 4	23, 2		O vehem.					[illegible]	
7	26, 11, 4	—0, 1	—10, 5	23, 4		O					[illegible]	
	11, 6	1, 4	— 9, 0	25, 0		O					==	
	11, 7	2, 2	— 8, 7	25, 0		O					==	
8	26, 10, 4	—0, 2	—8, 6	23, 2		W					==	
	9, 3	2, 3	—4, 6	26, 7		W					==	
	8, 3	2, 7	—6, 0	24, 7		W					==	
9	26, 8, 7	0, 7	—2, 4	21, 0		W	0, 7				[illegible]	⁙ ‡‡ 7 lin.
	8, 3	3, 4	—2, 3	25, 1		W					=	
	7, 4	4, 6	—4, 2	23, 2		W					[illegible]	
10	26, 6, 0	2, 2	—2, 3	22, 3		W					==	‡‡ 3 poll. 6 lin.
	4, 5	4, 6	—0, 2	23, 7		S W	3, 6				==	
	4, 2	6, 4	—0, 1	21, 0		N W	2, 6				==	
11	26, 6, 5	3, 6	1, 7	20, 0		S W					=	⁙
	6, 5	6, 3	4, 0	25, 0		N W					[illegible]	
	6, 6	7, 4	1, 7	21, 0		O					[illegible]	
12	26, 7, 3	4, 7	0, 3	20, 3		W					==	⁙
	8, 4	7, 6	1, 0	23, 2		W					==	⁙
	9, 5	8, 6	—0, 6	21, 0		W					[illegible]	⁙
13	26, 8, 3	5, 4	—0, 5	22, 0		N W	2, 5				==	
	7, 7	7, 2	1, 0	23, 4		N W	3, 10				==	
	7, 2	8, 0	0, 5	22, 3		S W	1, 10				==	
14	26, 7, 0	6, 4	0, 3	21, 3		S W					==	
	6, 6	7, 4	1, 7	22, 1		N W					==	
	6, 4	8, 5	1, 3	23, 0		N W					==	
15	26, 7, 2	6, 4	2, 3	22, 3		W vehem.	13, 2				==	
	8, 5	7, 4	4, 0	25, 2		W					==	
	10, 0	9, 1	3, 0	23, 0		W					==	

Figure 3. Data sheet from the annals of the Meteorological Society of Mannheim for the station Geneva, January 1789 (Societas Meteorologica Palatina, 1789, p.172).

To measure the outside temperature, a mercury thermometer was used. The thermometer was sited out-of-doors at the "Musée de l'Académie". The scale of the thermometer was in °R (Grenon, 2010). The Meteorological Society of Mannheim advised that the thermometer must be placed on the northern side of a building. Furthermore, the thermometer should be protected from the reflected radiation of surrounding buildings and the ground (Traumüller, 1885).

The air pressure was measured with a mercury barometer. A thermometer was installed next to the barometer. Both were situated in a room with as little sun as possible. The measurements were noted in three columns with "pouce", "ligne" and "seizième de lignes du pied de roi" as units of length (see Brugnara et al., 2019). There are references in the text which lead to the assumption that the air pressure measurements got reduced to 10 °R (Traumüller, 1885), although it seems that this was not always the case.

3.3. Source

For every year in which the Meteorological Society of Mannheim collected data, a year book with all the data from every measuring station was published. These yearbooks are now online available as pdf documents on the website of the Ludwig Maximilian University of Munich (http://epub.ub.uni-muenchen.de/). The Meteorological Society of Mannheim collected data from measuring stations all over Europe between 1781 and 1792. For Geneva, there are data available for a period of time between 1782 and 1789. However, for the years 1787 and 1788, only monthly and daily averages are available, respectively. These data are not used for the following analyses.

The data sheets published in the year books of the Meteorological Society of Mannheim are the same for every participating measuring station. An example is shown in Figure 3. The printed tables contain a row for every day and a column for every type of measurement (Societas Meteorologica Palatina, 1792).

4. Data processing

After the digitisation of the datasheets of the meteorological measurement series recorded by Fréderic-Guillaume Maurice and Jean Senebier, the temperature and atmospheric pressure raw data had to be converted into contemporary units. In addition, instrumental and measuring errors were corrected and the quality of the data was checked. In the following, the preparation of temperature and atmospheric pressure data will be described in detail.

4.1. Temperature data

In a first step, the temperature data were converted from °R to °C by multiplication with a factor 1.25 (see Brugnara et al., 2019, for details). In a second step, measuring errors caused by the deformation of the glass over time had to be corrected, which affected the zero-point over the first years after production. As in Winkler (2009), we corrected the temperature by subtracting 0.1 °C during the first year, 0.2 °C during the second until 0.6 °C was reached (see also Auchmann et al., 2012).

For the temperature data measured by Maurice, no information about the time of acquisition of the thermometer was found. Therefore (as already mentioned in Sect. 2), the assumption was made, that the same thermometer still was in use, which Marc-August Pictet acquired for the Observatoire de Mallet in 1773 (Grenon, 2010). This means that for all temperature data entries from the Journal de Genève, 0.6 °C were subtracted to correct for the deformation of the glass.

For the correction of the temperature data measured by Senebier, the following assumption was made: The thermometer was built by Mr. Artaria in 1781 and sent to Geneva straight after it was finished. There, it was used from 1782 onward. Thus, for the temperature data from 1782, 0.1 °C was subtracted and so on. From 1787 on, 0.6 °C was subtracted.

4.2 Atmospheric pressure

Measurements were reported in three colums “pouce”, “ligne” and “seizième de lignes du pied de roi”. One “pouce” is 27.07 mm and one “ligne” is 2.2558 mm (one “seizième de lignes du pied de roi”, is a sixteenth of a “ligne”, *i.e.,* 0.141 mm. The third column of the Senebier data is in eighth of a “ligne” (0.282 mm). With this information, the air pressure measurements could be converted first in millimetres and then further into hectopascals as described in Brugnara et al. (2015, 2019). There is no gap in the air pressure measurements.

To make the datasets comparable to each other and to other data sets they had to be corrected respectively reduced. Since both measuring series were already reduced to 10 °R (12.5 °C) (Societas Meteorologica Palatina, 1792; Journal de Genève, 1794) no further reduction to 0 °C is necessary to be able to compare them among themselves. However, to achieve comparability with other data sets, this would be necessary. Moreover, at times Senebier did not reduce pressure to 10 °R but provided the attached temperature instead. For the correction for local gravity the latitude 46.2° N and the elevation above sea level were needed. The location of the Senebier measurements is 378 m asl, whereas the one of the Maurice measuring series is at 394 m asl. The height above sea level was also needed for the reduction to mean sea level. In addition, the outside temperature values were required. Where the instrument description allowed, a cistern level correction for fixed-cistern barometers was carried out.

Due to the lack of information on the measuring instrument, no cistern level correction could be carried out for the Maurice series. For the Senebier series, thanks to the detailed description of the instruments, a cistern level correction could be made. This required the internal diameter of the barometer tube (4.5 mm) and the zero level. Since there is no reference in the description to another zero level, we used 760 mm. The correction took place before the original unit was converted in mm and hPa. The correction caused an average reduction of the measured values of 0.59 hPa.

4.3. Analysis of the series

In the following, the data from the Senebier series are plotted. The quality control of the temperature data led to the flagging of 30 values (out of 6467), corresponding to 0.5% of the values. Plotting the values for different times of day against each other (Fig. 4) shows high correlations exceeding 0.95 for all comparisons.

The quality control for pressure data fagged 113 of 6573 values, corresponding to 1.7% of all data points. This is a relatively high fraction, which is most likely due to typos in the ephemerides. The non-flagged data from the three measurement times (Fig. 5) for pressure also show high correlations, particularly between morning and noon, which is typical for all sites. Correlation between morning and evening is smaller due to the larger time difference.

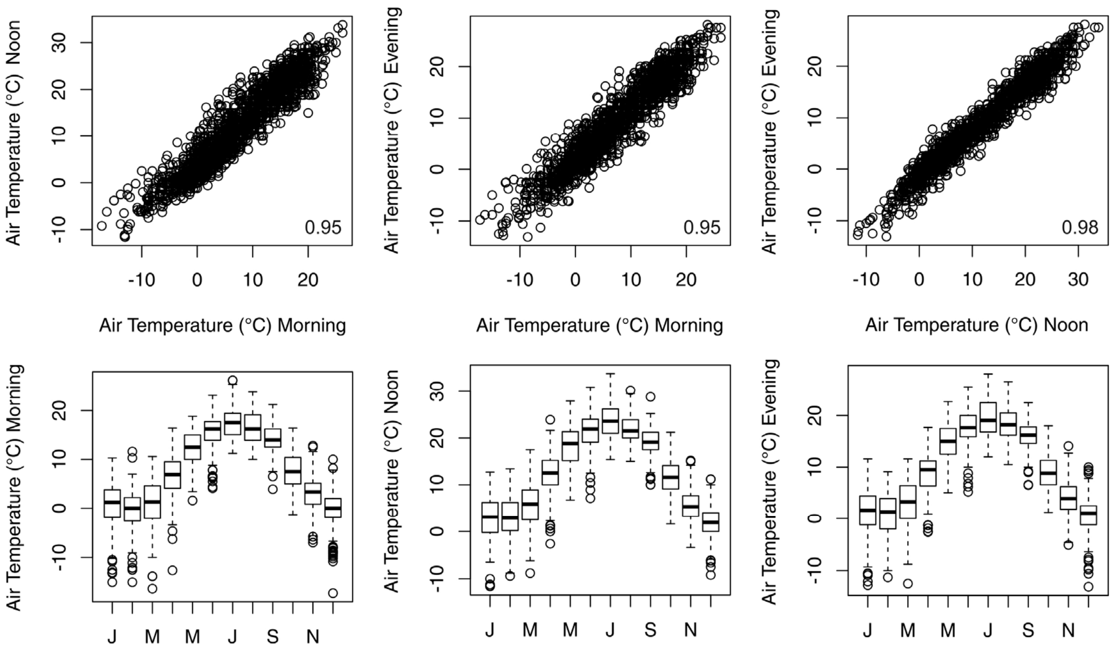

Figure 4. Analysis of temperature data from the Senebier series. The top row shows mutual comparisons of morning, noon, and evening series (the number indicates the Pearson correlation coefficient), the bottom row shows box plots for each of the three times of day as a function of calendar month (box indicates quartiles and median, whiskers extend to at most 1.5x the interquartile range from the box).

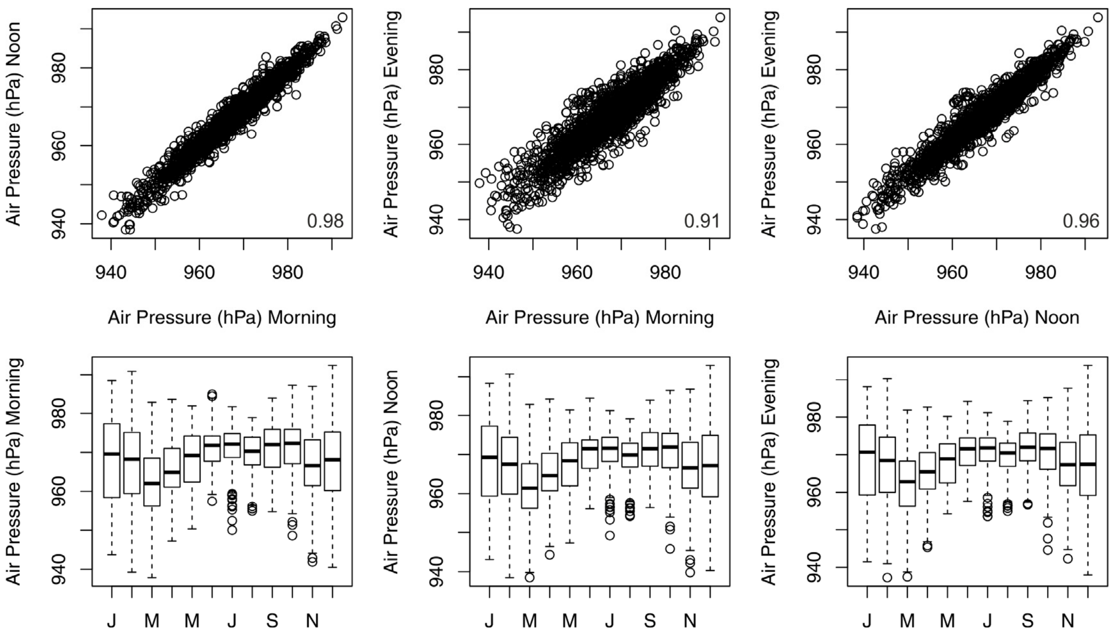

Figure 5. Analysis of pressure data from the Senebier series. The top row shows mutual comparisons of morning, noon, and evening series (the number indicates the Pearson correlation coefficient), the bottom row shows box plots for each of the three times of day as a function of calendar month (box indicates quartiles and median, whiskers extend to at most 1.5x the interquartile range from the box).

The annual cycle shows a clear minimum in March as well as the expected higher variability from December to February. In summer, negative outliers (extending more than 1.5x the interquartile range from the lower quartile) are common, while positive outliers do not occur.

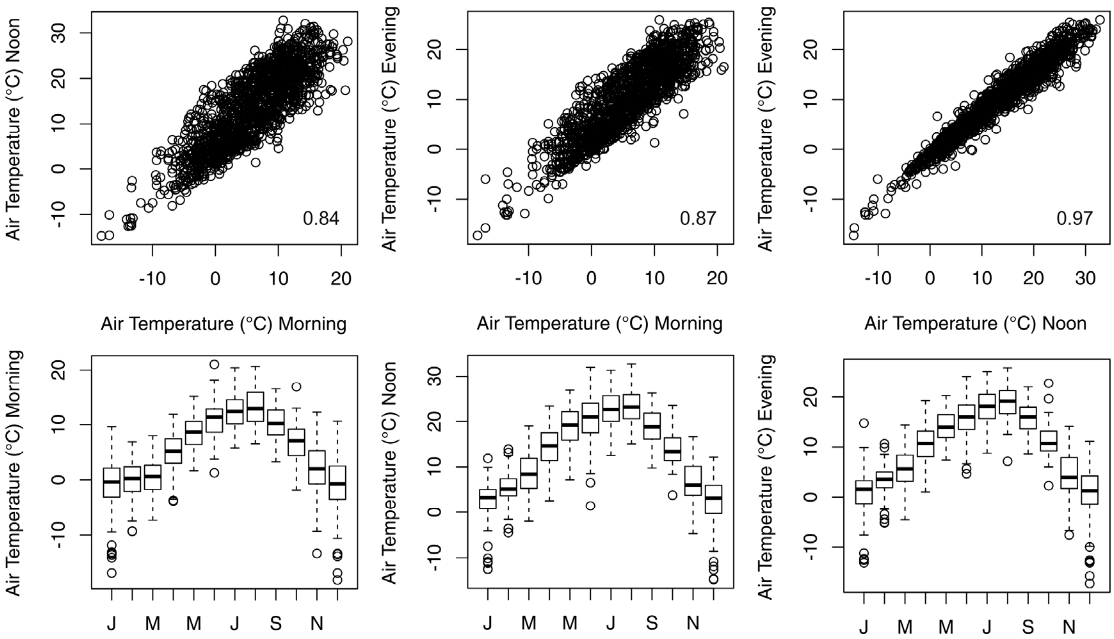

Figure 6. Analysis of temperature data from the Maurice series. The top row shows mutual comparisons of morning, noon, and evening series (the number indicates the Pearson correlation coefficient), the bottom row shows box plots for each of the three times of day as a function of calendar month (box indicates quartiles and median, whiskers extend to at most 1.5x the interquartile range from the box).

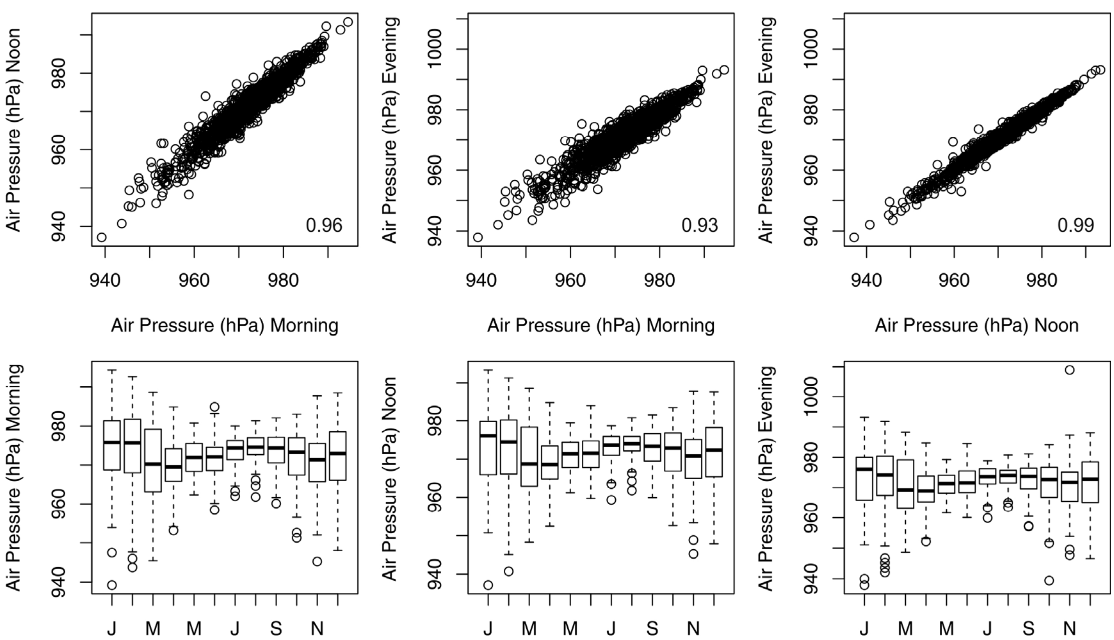

Figure 7. Analysis of pressure data from the Maurice series. The top row shows mutual comparisons of morning, noon, and evening series (the number indicates the Pearson correlation coefficient), the bottom row shows box plots for each of the three times of day as a function of calendar month (box indicates quartiles and median, whiskers extend to at most 1.5x the interquartile range from the box).

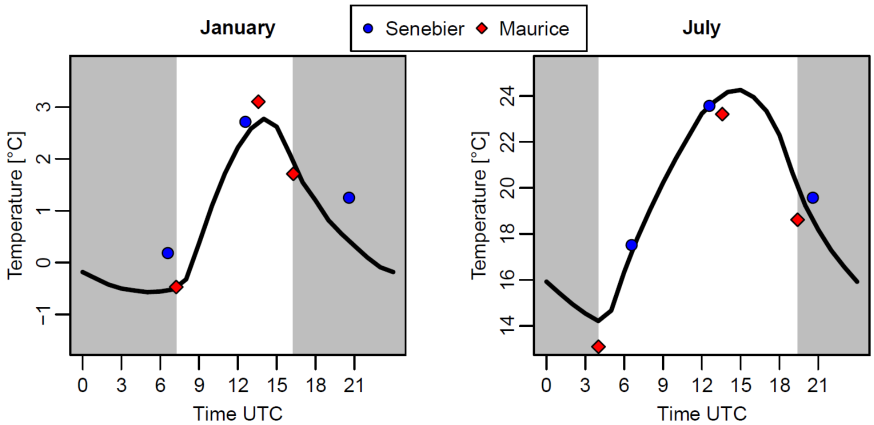

Figure 8. Diurnal cycle of temperature in January (left) and July (right) in present-day MeteoSwiss data (thick black line) as well as in the series from Senebier and Maurice (grey shading indicates nighttime).

The corresponding results for the Maurice series are shown in Figures 6 and 7. Correlations for temperature are clearly worse for the Maurice data than for the Senebier data, particularly due to the morning measurement. Good agreement is found between noon and evening temperatures. For pressure, the corresponding plots (Fig. 7) reveal a good agreement, again particularly for the noon and evening measurements.

Figure 8 shows the comparison of the mean temperature values at the different observation times with the diurnal cycle of the modern MeteoSwiss station at Geneva-Cointrin (1 °C was subtracted to take global warming into account). The data from both records match the modern climatology very well, with deviations smaller than 1 °C.

5. Comparison of the two series in the overlapping year 1789

After having analysed the two series individually, they are now compared for the overlapping year 1789 (Fig. 9). The agreement for pressure is excellent for all times of the day. Also for temperature, a good agreement is found. The morning temperatures were higher in the Senebier series than in the Maurice series during warm days, which is arguably due to the fact that Maurice measured at sunrise and Senebier at a fixed hour. Correlations for the noon and evening series are excellent. This points to a high quality of both series.

Finally, Figure 10 shows the time series of monthly mean pressure from both series. They agree very well in the (short) overlapping year and demonstrated that long series can be generated from concatenating the different segments.

6. Conclusions

From 1782 to 1791, two observers performed instrumental meteorological measurements in Geneva. Jean Senebier observed at the Musée de l'Académie from 1782 to 1789 for the Meteorological Society of Mannheim, Fréderic-Guillaume Maurice observed at the Observatoire de Mallet from 1787 to 1791. Here we discuss the recovery and processing of the data and compare the two series in their overlapping year, *i.e.,* 1789. This paper accompanies the online publication of the data sheets and of the re-evaluated data.

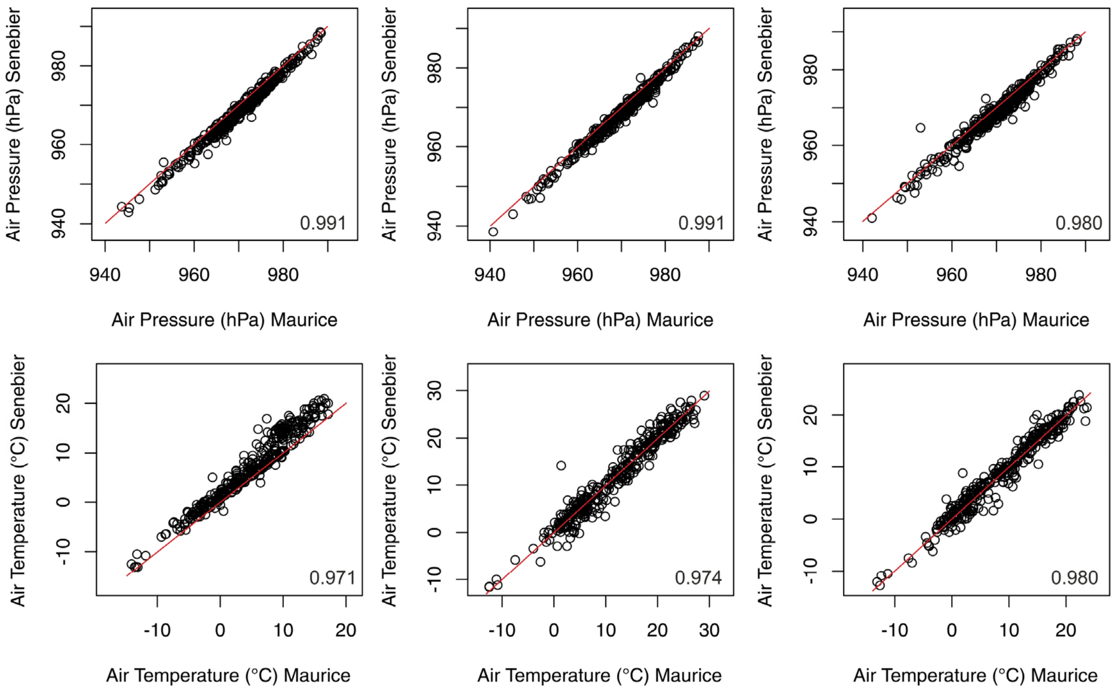

Figure 9. Comparison of temperature and pressure data from the Maurice and Senebier series. Shown are scatter plots of pressure (top) and temperature (bottom) for morning (left), noon (middle), and evening (right) series (the number indicates the Pearson correlation coefficient).

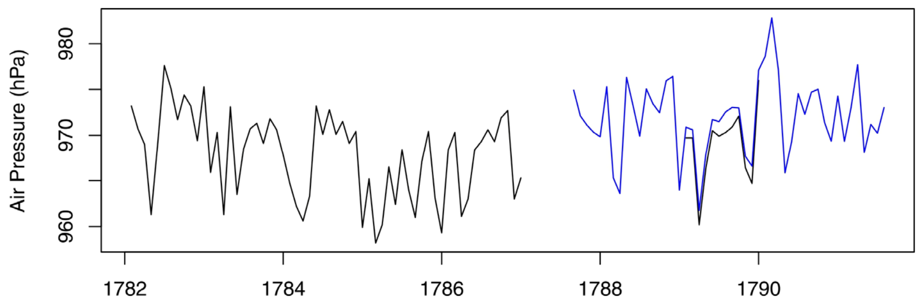

Figure 10. Time series of monthly mean air pressure from the Senebier series (black) and the Maurice series (blue).

The quality control and analysis reveals a good quality of the series in terms of internal consistency (between the series for different times of the day) as well as in the overlapping period. The Maurice series seems to be somewhat worse than the Senebier series as to what concerns the internal (time-of-day) correlations of temperature, but better than the Senebier series for pressure. Their mutual agreement in the overlapping year is excellent. The Geneva series is one of the longest of Switzerland and previous re-evaluations of this series found wide applications. However, the series is composed of many short bits. This analysis suggests that a good quality can be achieved nevertheless as many of these segments overlap and thus allow a quality assessment.

The digitisation of the Geneva series contributes to GCOS Switzerland and to Copernicus Climate Change Service (C3S) data compilations (Thorne et al., 2017). At a global level, the efforts form part of the "Atmospheric Circulation Reconstructions over the Earth" (ACRE) initiative (Allan et al., 2011). All metadata are incorporated in a registry (Pfister et al., 2019), the images can be downloaded from https://zenodo.org/record/3066836#.XVv-fGRS8-U and the Senebier data are downloadable from the repository https://doi.pangaea.de/10.1594/PANGAEA.909141. All data will also be available form MeteoSwiss and from EURO-CLIMHIST (Pfister et al., 2017) and they will be incorporated into the C3S data repository.

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