Article

The difficulty of interpreting early hygrometric measurements performed by Louis Morin in Paris, 1701–1711 CE

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Abstract: This paper discusses what is, to our knowledge, the oldest subdaily measurement series of humidity taken over several years. In detail, Louis Morin performed the measurements in Paris, three times a day, and between May 1701 and June 1711. A correlation analysis of Morin's humidity measurements with various meteorological variables yields comparable results with respect to relative humidity measurements of the E-OBS-data. Thus, the Spearson correlation coefficient of the humidity measurements reveals with daily minimal temperature -0.37 , mean temperature -0.55, maximum temperature -0.54, diurnal temperature range -0.62, and total cloud cover 0.31. However, with a spearson correlation coefficient of 0.10 no correlation was found with precipitation data. Further evidence for the plausibility of the measurements is shown by a day-to-day analysis of the first half-year of 1709. Here abrupt changes in the humidity measurements of Morin can be explained by the other measurements/observations of Morin. According to the correlation analysis, indirect notes in his journal, and others, we argue that Morin used the hygrometer developed by Francesco Folli. However, the conversion of the data to common units is not done and is subject to further research.

Keywords: Climate of the past, Hygrometer, Early instrumental measurements, Climate, Historical climatology

1. Introduction

Early measurements series of meteorological variables, among others, serve to reconstruct the climate of the last centuries. Gravity, temperature and humidity of the atmosphere were among the first features of the natural world to be quantified using new scientific instruments [1]. In the literature more attention was paid to early temperature measurements, early pressure measurements as well as early precipitation measurements in order to achieve long-term measurement series, which allow conclusions on climate variability [e.g. 2–13]. In comparison, there is little work in the literature on hygrometer measurements. The reason for this probably lies in the difficulty of interpreting the humidity data. Hygrometers have varied and still vary in their construction, in the exact element they are designed to measure, and in the materials used as humidity indicators, which can range from human hair or hemp strings to strips of two metals that react differently to the amount of water in the atmosphere [1]. Thus, since the humidity measurements were based on different physical principles, comparability was difficult [14]. Moreover, in the early period from the 15th to 18th century, most instruments had only a qualitative response and/or a strong dependence on both temperature and relative humidity [14]. However, Camuffo et al. [14] have been able to calibrate as well as homogenize goose quill hygrometer measurements by Chiminello ranging from 1794 to 1826. Other measurements such as those of Galand [1] are still being researched, as they cannot be analyzed in isolation and metadata are largely unknown. Thus, to the authors' knowledge, this sub-daily ten-year

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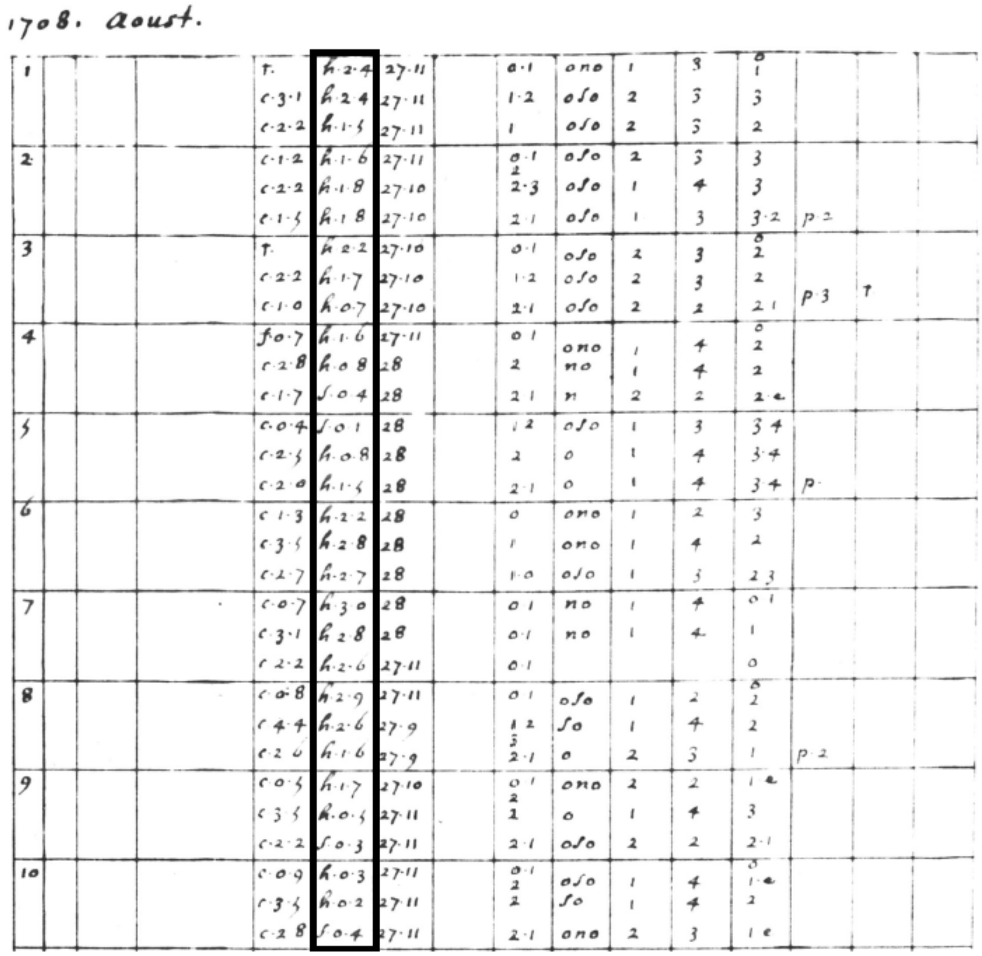
time series of humidity measurements made by Louis Morin is exceptional for the early 18th century. Other measurements/observations of Morin have already been analyzed. Previously, we analyzed temperature, direction of the movement of the clouds and cloud cover in one publication [18] and precipitation data in another[19]. Overall, temperature [15–18], atmospheric pressure [10], precipitation [17,19], direction of the movement of the clouds [16–18] and cloud cover [16,18] have been analyzed. Because of the lack of publications concerning early hygrometer measurements, the aim of this publication is to provide data from a 10-year series of measurements without gaps, to highlight the problems caused by the lack of metadata, and to asses the measurements in terms of plausibility. Section 2 introduces the humidity measurements and shows all known metadata as well as derived metadata. Section 3 section briefly presents the quality control and the methods used, such as correlation analysis. Section 4 shows the plausibility of the measurement using correlation analysis and day to day analysis. The paper closes with Section 5, a comprehensive discussion.

2. Data

2.1. The observer Louis Morin and his meteorological journal

Louis Morin lived from 11 July 1635 to 1 March 1715 in Paris. The majority of Morin's measurements and observations (e.g., temperature, pressure, direction of the movement of the clouds, humidity, etc.) were performed three times a day. A detailed explanation of his measurements and observations, and his biography have been presented in previous studies [15,17,18]. A consequence of his fixed daily routine is that his measurements/observations show almost no gaps. This leads to a consistent record of his meteorological journal, which shows at least one entry for 98.7 % of all days [18].

Figure 1 reveals an Example of Morin's notes (source: Institute of History/Oeschger Centre for Climate Change Research, University of Bern). Column 1 shows the day of the month; column 2 the day of the lunar cycle; column 3 the conjunction, opposition, and other aspects of the moon and the sun; column 4 the conjunction, opposition, and other aspects of the planets; column 5 the thermometer measurements; column 6 the hygrometer measurements; column 7 the barometer measurements; column 8 the wind direction; column 9 the wind strength; column 10 the direction of the movement of the clouds; column 11 the regional origin of air; column 12 the speed of the clouds; column 13 the cloud cover; column 14 intensity and duration of rainfall; column 15 fog, snow, small hailstones, thunder, parhelia, and the color of the sky; column 16 gives miscellaneous observations, such as earthquakes, comets, and halos. For more details, see other publications [15–19]. The hygrometer measurements are higlighted in column 6 of Fig. 1. These consist of a letter, where "h" stands for humide (wet) and "s" for sec (dry), and two numbers, which usually range from 0.0 to 8.0, where the higher the number the drier/wetter. I.e. it can be reed as a scale with decimal numbers. Morin's measurements series ends with consecutive days of dry values with numbers exceeding 8.0 (for instance 11.0). The reason for this trend toward drier values is not known to us, but speaks for a measuring device whose scale can be easily expanded. This is possible for a circular scale.



1708. aoust.

1	T.	h.2.4	27.11	a.1	ono	1	3	o 1		
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	c.2.2	h.1.5	27.11	1	oso	2	3	2		
2	c.1.2	h.1.6	27.11	o.1	oso	2	3	3		
	c.2.2	h.1.8	27.10	2 2.3	oso	1	4	3		
	c.1.5	h.1.8	27.10	2.1	oso	1	3	3.2	p.2	
3	T.	h.2.2	27.10	o.1	oso	2	3	o 2		
	c.2.2	h.1.7	27.10	1.2	oso	2	3	2	p.3	T
	c.1.0	h.0.7	27.10	2.1	oso	2	2	2 1		
4	f.o.7	h.1.6	27.11	o 1	ono	1	4	o 2		
	c.2.8	h.o.8	28	2	no	1	4	2		
	c.1.7	s.o.4	28	2 1	n	2	2	2.e		
5	c.o.4	s.o.1	28	1 2	oso	1	3	3 4		
	c.2.5	h.o.8	28	2	o	1	4	3.4		
	c.2.o	h.1.5	28	2.1	o	1	4	3 4	p.	
6	c.1.3	h.2.2	28	o	ono	1	2	3		
	c.3.5	h.2.8	28	1	ono	1	4	2		
	c.2.7	h.2.7	28	1.o	oso	1	3	2 3		
7	c.o.7	h.3.o	28	o 1	no	1	4	o 1		
	c.3.1	h.2.8	28	o.1	no	1	4.	1		
	c.2.2	h.2.6	27.11	o.1				o		
8	c.o.8	h.2.9	27.11	o 1	oso	1	2	o 2		
	c.4.4	h.2.6	27.9	1 2	so	1	4	2		
	c.2.6	h.1.6	27.9	3 2.1	o	2	3	1	p.2	
9	c.o.5	h.1.7	27.10	o 1	ono	2	2	1 e		
	c.3.5	h.o.5	27.11	2 1	o	1	4	3		
	c.2.2	s.o.3	27.11	2.1	oso	2	2	2.1		
10	c.o.9	h.o.3	27.11	o.1 2	oso	1	4	o 1.e		
	c.3.5	h.o.2	27.11	2	so	1	4	2		
	c.2.8	s.o.4	27.11	2.1	ono	2	3	1 e		

Figure 1. Example of Morin's notes from August 1708 (Source: Institute of History / Oeschger Centre for Climate Change Research, University of Bern). The hygrometer measurements are higlighted in column 6. These consist of a letter, where "h" stands for humide (wet) and "s" for sec (dry), and two numbers, which usually range from 0.0 to 8.0. The other columns are shortly explained in the text.

2.2. *The daytime and time span of the measurements*

Most of the time, Morin made three measurements per day, but there are a few days on which he noted observations (for instance precipitation) four, five, or six times. According to Morin's fixed daily routine, it is suggested that these measurements and observations were done at around 6 am, between 11 am and 2 pm, and between 6 and 7 pm [17]. Cornes et al. [9] estimated the observation times at 6 am, 3 pm, and 7 pm. Further evidence of the times of the measurements was provided by Pliemon et al. [18] using a statistical analysis, which suggested measurement times at 6 am to 8 am, 3 pm to 5 pm, and 6 pm to 8 pm.

2.3. *The location of the measurements*

In the map of Paris [20], the marked locations show where Morin lived (see Fig. 2). Until October 1685, Morin lived on Quinquempoix Street, then until June 1688 in the Hotel Rohan-Soubisse, where the National Archives are located today. Until his death in 1715, he lived in the abbey Saint-Victor, which is located at the city border next to the Seine [15,17]. This means that the entire humidity measurements from 1701 to 1711 were performed at the same location.

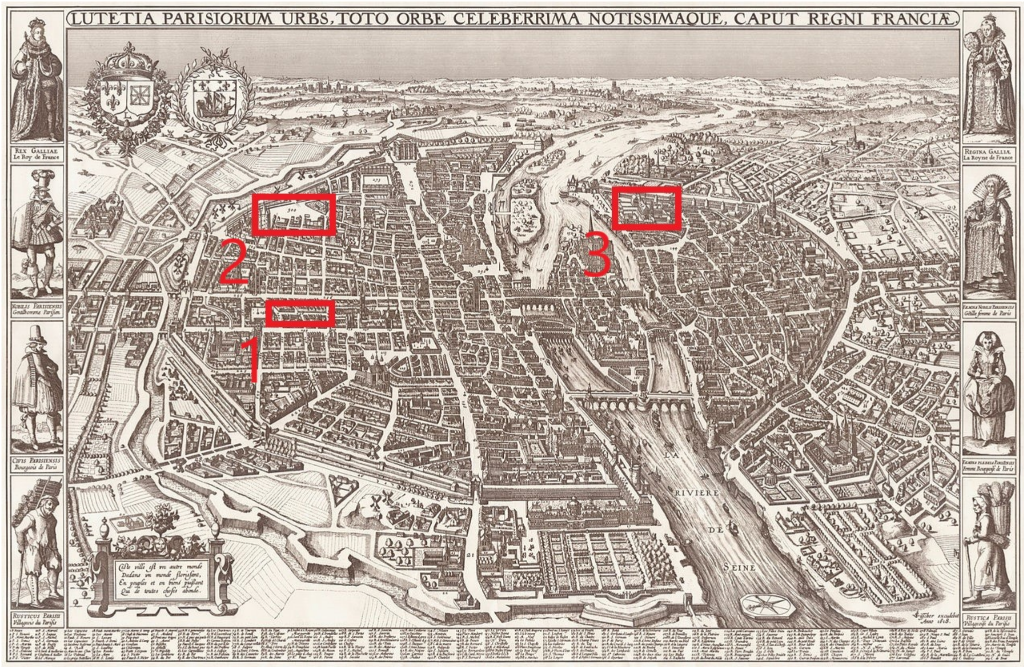

Figure 2. A map of Paris [20], the marked locations show where Morin lived. Until October 1685, he lived in the Quinquempoix Street (1); then until June 1688 in the Hotel Rohan-Soubisse (2), where the National Archives are located today; and until his death in 1715 he lived in the abbey Saint-Victor (3), which is located at the city border next to the Seine.

2.4. The measuring device

The measuring instrument of Morin is not known. At the beginning of the 18th century, there was a variety of different methods of measuring humidity, even though, for example, the definition of relative humidity was not yet known. Already in the 15th century Nicolaus de Cusanus (1401–1464) and Leon Battista Alberti (1404–1472) used hygrometric fabrics, the former wool and the latter a sponge, to measure the change in weight [21**? ?**]. Leonardo Da Vinci (1452–1519) is also known to have used cotton to measure humidity [21]. Characteristic for hygrometric measurements, which measure the difference in weight, is that these measurements measure the mass ratio r:

$$r = \frac{m_w}{m_g}, \tag{1}$$

where m_w is the mass of water vapor in the air and m_g is the mass of the dry air. So these instruments describe the absolute amount of water vapor in gaseous environments. Furthermore, condensation hygrometers were already known in the early 18th century. The invention of a condensation hygrometer in 1655 is attributed to of Ferdinand II, Grand Duke of Tuscany. The majority of hygrometers measure the relative humidity (RH):

$$RH = \frac{e}{e_s} \cdot 100[\%], \tag{2}$$

where e is the actual water vapor pressure and e_s is the saturation vapour pressure. I.e., they measure the ratio of moisture in the air to the highest amount of moisture at a particular air temperature. The invention of the first mechanical hygrometer using a human hair is credited to Horace Benedict de Saussure (de Saussure 1783) [21]. However, similar methodologies using different materials have been used before. For instance, Santorio Santorre invented in 1626 a hygrometer based on the change in length of a ballasted cord or a string. This hygrometer was further developed by Francesco Folli (see Fig. 3) and Vincenzo Viviani in the 1660s [21]. In 1687, Guillaume Amontons showed at the Academie Royale des Sciences a hygroscopic hygrometer, which depends on the change in volume of a vessel/reservoir made of some hygroscopic substance (a leather bag) [21]. Another sort of hygrometer grew out of the observation that the awns or "beards" of various seeds twist or untwist as they become dry or moist (for instance wild oat) [21] . This short list does not claim to be exhaustive, but lists the most relevant humidity measurement methods of the early 18th century.

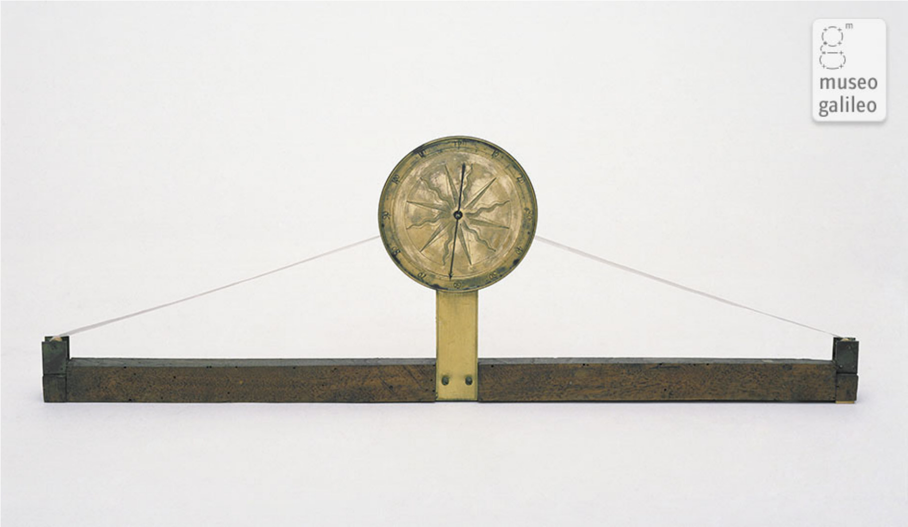

Figure 3. The so called paper ribbon hygrometer invented by Francesco Folli (Museo Galilei Florence).

A hint which measuring instrument Morin could have used is given only implicitly, namely he noted on the 11 February 1702, the 6 January 1709, and the 8 November 1709 "papier baisse", which should mean something like fallen paper. These notes appear after a longer period of exceptionaly wet conditions, which leads to a higher probability of ripping. Furthermore, on 1 August 1704 he noted after a longer period of exceptional dry values the word “change”. This knowledge closes the circle on the following measuring principles/instruments, after Folli, after Viviani and after Adams. The instrument according to Adam’s measuring principle, however, was invented only in the middle of the 18th century, but it would be conceivable that Morin used a similar gravimetric measuring instrument with paper. The measurement principle of Folli’s and Viviani’s instrument is similar, and the following speaks for the measuring instrument of Folli: "*In 1665, having settled in Florence, he (Folli) presented the instrument to Grand Duke Ferdinand II de’ Medici (1610-1670) who - as Folli himself reported - "seemed to appreciate it, and had some copies made, which he promptly sent to various Princes of Europe*" (Museo Galilei Florence). It is known that the Medici, who founded the first meteorological network, sent measuring instruments to some cities in Europe. This is how this measuring instrument could have found its way to Paris.

The measuring principle worked as follows: *A square-sectioned wooden rod carries a small roll at each end. One of the rolls holds the end of a paper ribbon, while the other end passes over the second roller. It originally supported a small (missing) weight that kept the ribbon in tension. The center of the rod holds a vertical support for a decorated brass dial fitted with a circular graduated scale. On the dial a pointer is pivoted with a pulley: the ribbon passes over the pulley and its length variations, in response to change in atmospheric humidity, are indicated by the pointer* (Museo Galilei Florence). It is also stated that the paper tore from time to time and was later replaced by something else. This fact is consistent with Morin’s notes and we hypothesize that Morin used this measuring instrument. The task now is to show whether Morin obtained plausible measurement results and whether these correspond to the characteristics of a relative humidity measurement.

2.5. Reference data

We adopted quality-assured daily data from ERA5 (1979–present) to compare the total cloud cover (TCC) to contemporary conditions [22]. As a reference period for the daily mean temperature, daily minimum temperature, daily maximum temperature, daily precipitation sum, daily mean sea level pressure, and daily mean relative humidity we used the observations of E-OBS version 25.0e [23]. As reference time period we used the climate normal from 1991–2020.

3. Methods

3.1. Quality analysis

A great effort has been put to check the plausibility/correctness of the transliterated data. By means of the guide of Brönnimann et al. [24], a double key entry, followed by post-processing was chosen for the digitization process.

3.2. Validation

To validate Morin's measurements, we calculated Pearson and Spearman correlations with other measurements/observations. Furthermore, we analyse a time period of half a year to see if the measurements make sense.

4. Results

4.1. Characteristics of the measurements

Striking characteristics of the time series can be seen in Fig. 4: an unusually strong annual cycle with dry values in summer and wet values in winter as well as a non existing daily cycle. Note that positive values in Fig. 4 mean wet conditions and negative values mean dry conditions. One would expect, when measuring relative humidity, a weak to disappearing annual cycle for the morning measurement and a recognisable annual cycle for the afternoon and evening measurement. To the best of the authors' knowledge, there are no longer humidity measurements from the 18th century for comparison. Except of Domínguez-Castro et al. [25], who discovered humidity measurements performed with a modified measuring instrument after Folli from Valencia. These were carried out by Francisco Antonio Espinos and published in the newspaper 'Diario de Valencia' between 1790 and 1835. Although the daily humidity cycle of Valencia differs from Paris due to the sea breeze circulation (two opposing flows; one at the surface (called the sea breeze) and one aloft (which is a return flow)), we were able to show similarities in the characteristics of the raw data using the data made available to us from Dominguez-Castro. Namely, the daily cycle is also weakly pronounced and an annual cycle is also recognizable for all measurement periods. The measuring instrument seems to be not sensitive to abrupt changes in humidity.

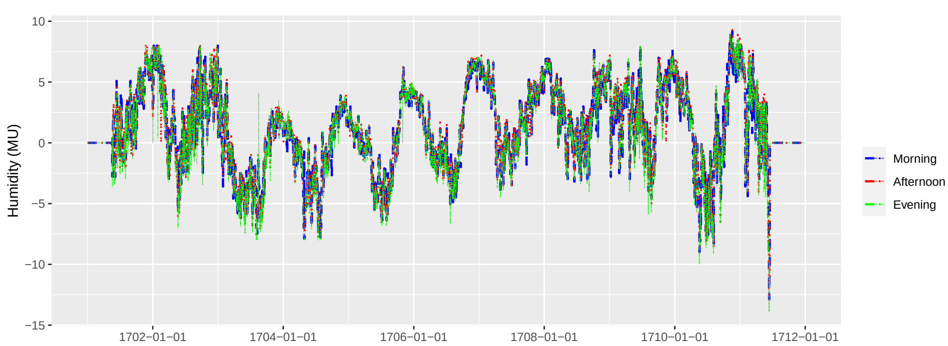

Figure 4. A time series plot of the raw data from the morning, afternoon, and evening measurements given in Louis Morin's humidity unit (positive values mean wet conditons and negative values mean dry conditions).

4.2. Correlation with other meteorological variables

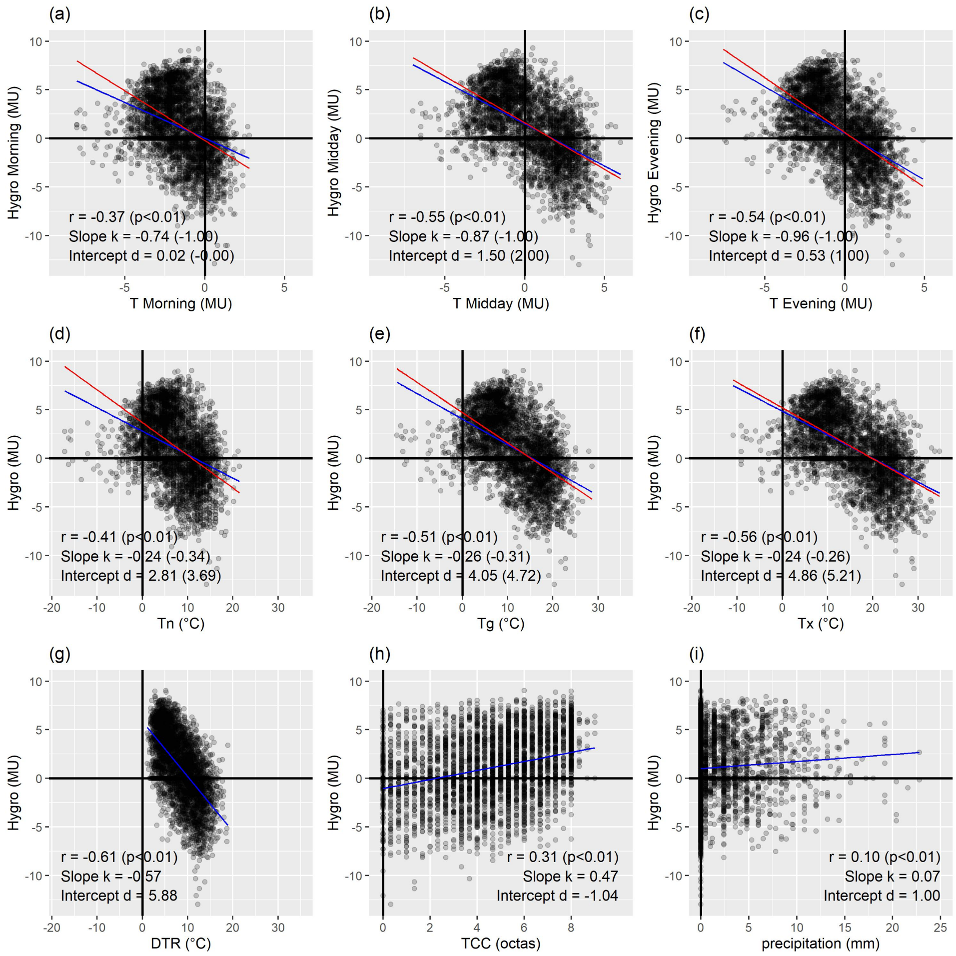

Figure 5. Panels show the correlation of humidity (daily mean) with (a) morning temperature, (b) afternoon temperature, (c) evening temperature, (d) minimum temperature (Tn), (e) mean temperature (Tg), (f) maximum temperature (Tx), (g) diurnal temperature range (DTR), (h) total cloud cover (TCC), (i) precipitation. Each case reveals a scatterplot of the correlated variables, the Pearson correlation coefficient, a linear regression (blue line), slope and interception of the regression line, and for (a) to (f) additionally a linear regression for positive degrees Celsius temperature values (red line) as well as slope and interception of these in parentheses.

The correlation-anaylsis of the humidity measurements with the different measurments/observations of Morin reveals plausible results. The results are summarized in Fig. 5, where (a) to (c) show the correlation with the morning, afternoon and evening temperature; (d) to (f) show the correlation with minimum (Tn), mean (Tg), and maximum (Tx) temperature; (g) shows the correlation with the diurnal temperature range (DTR); (h) shows the correlation with the total cloud cover (TCC); (i) shows the correlation with precipitation. Fig. 5 shows in each case a scatterplot of the correlated variables, the Spearson correlation coefficient, a linear regression (blue line), slope and interception of the regression line, and for (a) to (f) additionally a linear regression for positive degrees Celsius temperature values (red line) as well as slope and interception of these in parentheses.

In general, drier humidity measurement values can be expected for higher temperatures. This is expressed in a negative slope in (a) to (f) and is fulfilled for all graphs. Furthermore, the Pearson correlation coefficients between humidity and Tn, Tg, and Tx show similar results compared to the E-OBS-data. For the Morin measurements the coefficients result in $r_{Tn} = -0.37$, $r_{Tg} = -0.55$ and $r_{Tn} = -0.54$. The correlation with the diurnal temperature range results in -0.62 for the Morin data. The regression line for the hygrometer data as a function of total cloud cover gives a slope of 0.47 and thus a plausible result. The Spearman correlation coefficient gives 0.31. Unreasonable is the Spearman correlation coefficient with precipitation of only 0.10.

As a comparison, the correlation coefficients for the Eobs data result in $r_{Tn} = -0.23$, $r_{Tg} = -0.38$ and $r_{Tn} = -0.47$, $r_{DTR} = -0.61$, $r_{TCC} = -0.53$ and $r_{Pr} = -0.39$. In each case, the correlation with the maximum and mean temperature is the highest and the correlation with the minimum temperature is the lowest. However, the hygrometer data are more strongly temperature-dependent in Morin's measurements. The most significant difference shows the correlation with precipitation. The lower correlation with cloud cover and precipitation can be explained by the inertia of the measuring instrument. I.e. abrupt changes in humidity (e.g. thunderstorms) cannot be displayed.

One question that is still open is how the measuring instrument was positioned, i.e. whether Morin performed an indoor or outdoor measurement. And if outdoor, whether it was protected from the wind or not. In Fig. 6 we show box plots of the standardized humidity measurements as a function of the wind strengths (0 means no wind and 4 strong wind). We could not find any dependence and conclude that Morin, also due to the well matching correlations with the other variables, that Morin carried out his measurements in the outdoors, but shielded.

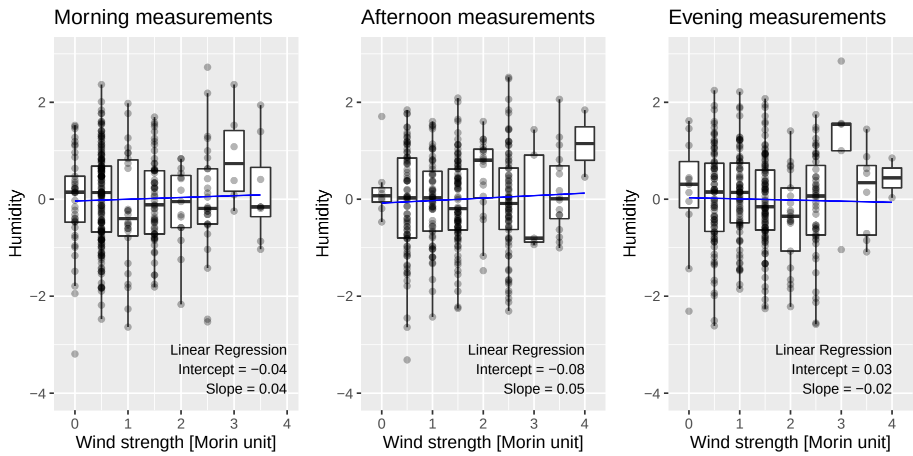

Figure 6. Box plots of standardized humidity measurements as a function of wind strength for the year 1707. The blue line shows the linear regression.

4.3. Day-by-day analysis

The variety, as well as the temporal resolution of Morin's recorded climate variables, allow us to assess the hygrometer measurements using a day-by-day analysis. For this purpose, Fig. 7 shows the humidity measurements in Morin's unit, the temperature in degrees Celsius, the cloud cover in octas, the air pressure in hPa, the direction of the movement of the clouds, and the precipitation in mm in the period from January 1709 to June 1709. We chose the first half of 1709 because it includes the cold winter of 1708/09. In the following lines we analyze in more detail the time periods in which the hygrometer measurements undergoe strong changes. These are shaded dark gray in Fig. 7. In all selected time periods, the respective change in the values of the hygrometer measurement can be explained on the basis of the other measurements/observations.

The first period marks the beginning of what is considered in the literature to be an extremely cold winter. On 6 January 1709, the wind direction on the ground changes from west to east (not shown in the graph), with winds of maximum strength according to Morin's scale being recorded until the 7th in the evening. The direction of cloud movement changes on the 7th from west the east. Temperatures drop drastically with a minimum of -18 degree celsius first on the 13th and on further following days. The mean air pressure is 1010 hPa on the 5th and 1029 hPa on the 7th. Light precipitation occurs on the 5th and on the 8th. The hygrometer measurement experiences a sudden drop towards dry values. These individual measurements/observations describe a cold air movement from the east, and thus, due to the sudden drop of the dew point temperature, the hygrometer measurements are plausible in this time period. It should be noted, however, that Morin noted "papier baisse" on the 6th between morning and afternoon measurements (see Sect. 2).

The period from 21st February 1709 to 05th March 1709 suggests a cold air flow at the beginning of this period (between the 21st and 23rd): Direction of cloud movement from the northeast, temperature drop, heavy cloudiness followed by clearing, pressure increase and light rain. From 24th February 1709, the temperature rises, the cloudiness increases and the cloud movement direction changes to the east in the following days. This causes a drop in the values of the humidity measurement at the beginning of the period and an increase later.

The third time period extends from 15th April 1709 to 23rd April 1709. In this period the humidity measurement shows a strong decrease to dry values. The other measurements/observations indicate an area of high pressure: Consistently high temperatures, low cloud cover, high pressure, and almost no precipitation.

The fourth period extends from 19th June 1709 to 25th June 1709. Characteristic in this period is the unimodal peak of humid conditions. The explanation for this is a persistent cloud cover between 20th and 22nd, which leads to a low diurnal range in temperature (low maximum temperature), rain and consequently wetter conditions. However, an expected low pressure is only slightly pronounced in the records.

5. Discussion

The analysis reveals that Louis Morin recorded meaningful values and it is likely that he used a paper ribbon measuring instrument, which is based on the measuring principle of Francesco Folli. This is supported by the fact that Morin's instrument measures relative humidity, the note "papier baisse" which indicates an instrument that used paper, and the fact that this instrument was sent to several cities in Europe by the Florentine Meteorological Network. Even though there is nothing in the analyses that speaks against this hypothesis, it should be noted that the evidence is weak. We cannot show if and when how strongly temperature-dependent the measurement is. A temperature dependence would create spurious correlations and make the analyzed correlations probably invalid. Nonetheless, correlation analysis of Morin's humidity measurements with various meteorological variables yields comparable results with respect to relative humidity measurements of the E-OBS-data.

Thus, the Spearson correlation coefficient of the humidity measurements reveals with the minimum temperature -0.37, with mean temperature -0.55, and with maximum temperature -0.54. The Pearson correlation coefficient with the diurnal temperature range results in -0.62 for the Morin data and -0.61 for the E-OBS-data. Furthermore, the Spearman correlation coefficient gives 0.31 for the Morin data and 0.53 for the E-OBS data. The most significant difference can be seen by the correlation with precipitation. Here the Spearman correlation coefficient gives only 0.10 for the Morin data and 0.39 for the E-OBS data. Further evidence for the plausibility of the measurements is shown by the day-to-day analysis. Here we analyzed strong changes in the humidity measurements in the first half of 1709, each of which can be explained by the other meteorological variables.

One problem is that we do not explicitly know how the measurement device was placed and performed. Indoor and outdoor measurements give significantly different results. An indication for this is the analysis of the wind strength, where no correlation could be found. Thus we conclude, also due to the comparable correlation results with the other meteorological variables, that Morin used his instrument shielded outdoors.

Although Morin's measurements make it possible to compare humidity measurements with other meteorological variables, calibration and conversion to a common unit seems difficult. More measurement series as well as empirical measurements of the early hygrometer measurement devices are needed, to find a calibration and to receive values in common units. Therefore, we did not transform Morin's measurements into common units and kept his unit for analysis.

Kommentar Thomas: Wolkenbewegung (Pfeile) wird noch bearbeitet

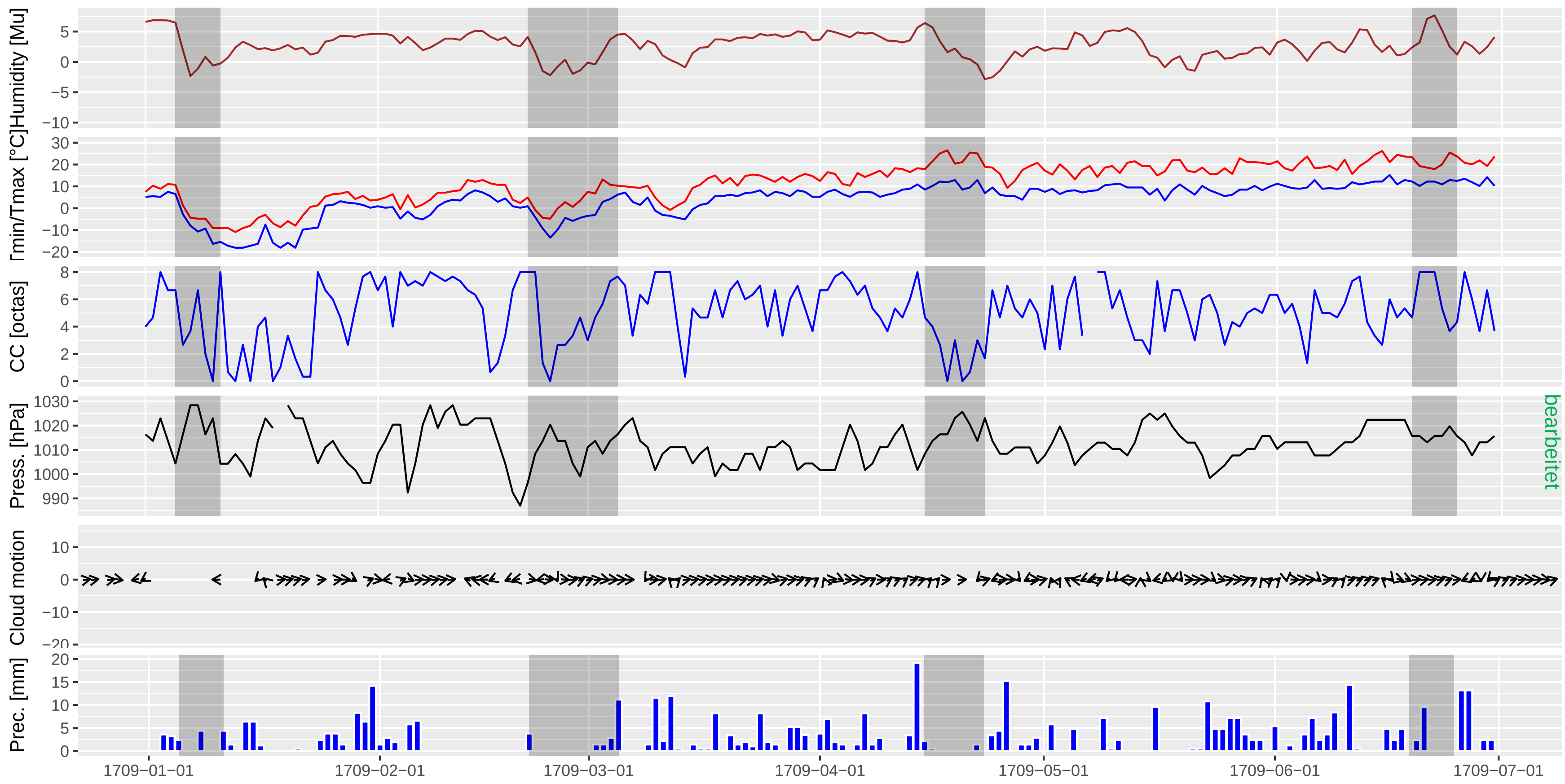

Figure 7. From top to bottom humidity measurements in Morin's unit, temperature in degrees Celsius, cloud cover in octas, air pressure in hPa, direction of the movement of the clouds, and precipitation in mm in the period from January 1709 to June 1709. Dark gray areas mark time periods, in which hygrometer measurements undergoe strong changes.

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Data Availability Statement: We encourage all authors of articles published in MDPI journals to share their research data. In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Where no new data were created, or where data is unavailable due to privacy or ethical re-strictions, a statement is still required. Suggested Data Availability Statements are available in section "MDPI Research Data Policies" at https://www.mdpi.com/ethics.

Acknowledgments:

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results'.

Sample Availability: Samples of the compounds ... are available from the authors.

Abbreviations

The following abbreviations are used in this manuscript:

Tn	minimum temperature
Tg	mean temperature
Tn	maximum temperature
DTR	diurnal temperature range
TCC	total cloud cover

References

1. Slonosky, V.C.; Bauden, F.; Waller, R. LES OBSERVATIONS DU TEMPS AU XVIII SIÈCLE.: GALLAND, MORIN, DE LA HIRE ET LE CLIMAT DU « PETIT DU GLÂCIAIRE ». In *Antoine Galland (1646-1715) et son Journal: Actes du colloque international organise a l'Universite de Liege (16-18 fevrier 2015) a l'occasion du tricentenaire de sa mort*; Bauden, F.; Waller, R., Eds.; Peeters Publishers, 2020; Vol. 12, *Actes du colloque international organise a l'Universite de Liege (16-18 fevrier 2015) a l'occasion du tricentenaire de sa mort*, pp. 497–518. https://doi.org/10.2307/j.ctv1q26m6v.26.
2. Manley, G. Central England temperatures:monthly means, 1659 to 1973. *Quarterly Journal of the Royal Meteorological Society* **1974**, *100*, 389–405, [https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1002/qj.49710042511]. https://doi.org/https://doi.org/10.1002/qj.49710042511.
3. Auer, I.; Böhm, R.; Schöner, W. *Austrian Long-term Climate 1767–2000: Multiple Instrumental Climate Time Series from Central Europe.*; Vol. 25, Zentralanstalt für Meteorologie und Geodynamik: Wien, 2001.
4. Bergström, H.; Moberg, A. Daily air temperature and pressure series for Uppsala. *Climatic Change* **2002**, *53*, 213–252.
5. Moberg, A.; Bergström, H.; Krigsman, J.R.; Svanered, O. Daily air temperature and pressure series of Stockholm (1756-1998). *Climatic Change* **2002**, *53*, 171–212.
6. Können, G.P.; Brandsma, T. Instrumental pressure observations from the end of the 17th Century: Leiden (The Netherlands). *International Journal of Climatology* **2005**, *25*, 1139–1145.
7. Auer, I.; Böhm, R.; Jurkovic, A.; Lipa, W.; Orlik, A.; Potzmann, R.; Schöner, W.; Ungersböck, M.; Matulla, C.; Briffa, K.; et al. HISTALP—historical instrumental climatological surface time series of the Greater Alpine Region. *International Journal of Climatology* **2007**, *27*, 17–46. https://doi.org/https://doi.org/10.1002/joc.1377.
8. Rousseau, D. Les températures mensuelles en région parisienne de 1676 à 2008. *La Météorologie* **2009**, *67*, 43–55. https://doi.org/10.4267/2042/30038.
9. Cornes, R.C.; Jones, P.D.; Briffa, K.R.; Osborn, T.J. A daily series of mean sea-level pressure for London, 1692–2007. *International Journal of Climatology* **2012**, *32*, 641–656, [https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1002/joc.2301]. https://doi.org/https://doi.org/10.1002/joc.2301.

10. Cornes, R.C.; Jones, P.D.; Briffa, K.R.; Osborn, T.J. A daily series of mean sea-level pressure for Paris, 1670–2007. *International Journal of Climatology* **2012**, *32*, 1135–1150, [https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1002/joc.2349]. https://doi.org/https://doi.org/10.1002/joc.2349.
11. Brönnimann, S.; Allan, R.; Ashcroft, L.; Baer, S.; Barriendos, M.; Brázdil, R.; Brugnara, Y.; Brunet, M.; Brunetti, M.; Chimani, B.; et al. Unlocking pre-1850 instrumental meterologoical records: a global inventory. *Bulletin of the American Meteorological Society* **2019**, *100*, ES389–ES413.
12. Camuffo, D.; della Valle, A.; Becherini, F.; Zanini, V. Three centuries of daily precipitation in Padua, Italy, 1713–2018: history, relocations, gaps, homogeneity and raw data. *Climatic Change* **2020**, *162*, 923–942.
13. Lundstad, E.; Brugnara, Y.; Pappert, D.; Kopp, J.; Samakinwa, E.; Hürzeler, A.; Andersson, A.; Chimani, B.; Cornes, R.; Demarée, G.; et al. The global historical climate database HCLIM. *Scientific Data* **2023**, *10*, 44.
14. Camuffo, D.; Bertolin, C.; Bergonzini, A.; Amore, C.; Cocheo, C. Early hygrometric observations in Padua, Italy, from 1794 to 1826: the Chiminello goose quill hygrometer versus the de Saussure hair hygrometer. *Climatic Change* **2014**, *122*, 217–227.
15. Legrand, J.P.; Le Goff, M. Louis Morin et les observations météorologiques sous Louis XIV. *La Vie des Sciences* **1987**, *4*, 251–281.
16. Legrand, J.P.; Le Goff, M.; Mazaudier, C.; Schröder, W. Solar and auroral activities during the Seventeenth Century. *Acta. Geod. Geoph. Mont. Hung.* **1992**, *27*, 251–282.
17. Pfister, C.; Bareiss, W. The climate in Paris between 1675 and 1715 according to the Meteorological Journal of Louis Morin. In *Climatic Trends and Anomalies in Europe 1675–1715: High Resolution Spatio-temporal Reconstructions from Direct Meteorological Observations and Proxy Data: Methods and Results*; Frenzel, B.; Pfister, C.; Gläser, B., Eds.; Gustav Fischer Verlag: Stuttgart, Jena, New York, 1994; pp. 151–171.
18. Pliemon, T.; Foelsche, U.; Rohr, C.; Pfister, C. Subdaily meteorological measurements of temperature, direction of the movement of the clouds, and cloud cover in the Late Maunder Minimum by Louis Morin in Paris. *Climate of the Past* **2022**, *18*, 1685–1707. https://doi.org/10.5194/cp-18-1685-2022.
19. Pliemon, T.; Foelsche, U.; Rohr, C.; Pfister, C. Precipitation reconstructions for Paris based on the observations of Louis Morin, 1665–1713 CE. *EGUsphere* **2023**, *2023*, 1–32. https://doi.org/10.5194/egusphere-2022-1445.
20. Visscher, J.C. *Lutetia Parisiorum urbs, toto orbe celeberrima notissimaque, caput Regni Franciae. Bibliotheque Nationale de France, Paris*, 1618. Source: gallica.bnf.fr / Bibliothèque nationale de France, online access: 04.01.2022.
21. Middleton, W. E. Knowles (William Edgar Knowles), . *Invention of the meteorological instruments, by W. E. Knowles Middleton*; Number Accessed from https://nla.gov.au/nla.cat-vn2475304, Johns Hopkins Press: Baltimore, 1969.
22. Hersbach, H.; Bell, B.; Berrisford, P.; Biavati, G.; Horányi, A.; Muñoz Sabater, J.; Nicolas, J.; Peubey, C.; Radu, R.; Rozum, I.; et al. ERA5 hourly data on single levels from 1940 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS) **2023**. (Accessed on 16-05-2023), https://doi.org/10.24381/cds.adbb2d47.
23. Cornes, R.C.; van der Schrier, G.; van den Besselaar, E.J.M.; Jones, P. An ensemble version of the E-OBS temperature and precipitation datasets. *J. Geophy. Res. Atmos.* **2018**. https://doi.org/10.1029/2017JD028200.
24. Brönnimann, S.; Annis, J.; Dann, W.; Ewen, T.; Grant, A.N.; Griesser, T.; Krähenmann, S.; Mohr, C.; Scherer, M.; Vogler, C. A guide for digitising manuscript climate data. *Climate of the Past* **2006**, *2*, 137–144. https://doi.org/10.5194/cp-2-137-2006.
25. Domínguez-Castro, F.; Vaquero, J.M.; Rodrigo, F.S.; Farrona, A.M.M.; Gallego, M.C.; García-Herrera, R.; Barriendos, M.; Sanchez-Lorenzo, A. Early Spanish meteorological records (1780–1850). *International Journal of Climatology* **2014**, *34*, 593–603, [https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1002/joc.3709]. https://doi.org/https://doi.org/10.1002/joc.3709.