



# 1 Synthetic Weather Diaries: Concept and Application to Swiss 2 Weather in 1816

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8 **Abstract.** Climate science is about to produce numerical daily weather reconstructions based on meteorological  
9 measurements for Central Europe 250 years back. Using a pilot reconstruction covering Switzerland at 2x2 km2  
10 resolution for 1816, this paper presents methods to translate numerical reconstructions and derived indices into  
11 text describing daily weather and the state of vegetation. This facilitates comparison with historical sources and  
12 analyses of effects of weather on different aspects of life. The translation, termed “synthetic weather diary” could  
13 possibly be used to train machine learning approaches to do the reverse: reconstruct past weather from categorized  
14 text entries in diaries.

## 15 1 Introduction

16 The past decade has seen tremendous advances in numerical weather reconstructions. They were enabled by new  
17 numerical techniques such as data assimilation (Compo et al. 2011), combined with a new demand arising from  
18 new scientific questions (better understanding variability), new societal needs (prepare for extreme weather events  
19 in the future), and the more widespread use of numerical modelling in climate impact research. In this situation,  
20 historical instrumental data – but also documentary weather data - become once again valuable for science (Allan  
21 et al., 2011). Based on digitised historical instrumental data, model chains can be built (e.g., numerically simulating  
22 the damage of past storm or flood events, see Stucki et al., 2015, 2018) and analysed together with historical  
23 sources (e.g., Allan et al., 2016; Veale et al., 2017).

24 In addition to data assimilation, providing global weather data at coarse resolution back to the early 19th century  
25 (Slivinski et al. 2019), also other techniques such as analog resampling of regional weather fields (Caillouet et al.,  
26 2019; Devers et al., 2020; Pfister et al., 2020) have been used to reconstruct local daily weather 150-200 years  
27 back in time, with the potential to go even further back. These reconstructions provide a resource not just for  
28 climate science, but also for historians. Depending on the application, a translation between numerical weather  
29 data and the descriptive text format in which historical observations and weather diaries are typically written would  
30 be beneficial. In this paper I present a first step in this direction, termed “synthetic weather diary”.

31 Turned into categorized text, numerical weather reconstructions could supplement historical sources with weather  
32 descriptions, much like weather reports today. They could provide, for instance, information on the day-to-day  
33 weather for a specific journey or during a military operation. In addition to the individual measurements, useful  
34 information for historians could be gained from specific indices based on these daily data. Such indices could  
35 provide information on the freezing of water bodies, the state of vegetation, or drought conditions.

36 The translation makes numerical reconstructions and observations directly comparable, which is not only useful  
37 for historians, but also for climate sciences. For instance, generating synthetic weather diaries from numerical data



38 in recent decades could be used to train machine learning algorithms to provide the weather pattern (e.g., the  
39 weather type or even a full spatial field). A trained algorithm could then be used to classify daily weather in the  
40 past based on categorized information from historical weather diaries.

41 Codification of descriptive weather information is a core work of historians of climate (Riemann et al., 2015). A  
42 next step then is to establish an ordinal scale, which has been attempted mostly at the monthly or seasonal scale.  
43 So-called “Pfister indices” (Pfister et al., 2018) are often used and categorize weather in three-point (-1, 0, 1) or  
44 seven-point (-3, -2, -1, 0, 1, 2, 3) indices, with corresponding designations such as “extremely cold”, “cold”, etc.  
45 (Pfister, 1999). Calibrating such indices with measurement-based time series in order to calibrate climate  
46 reconstructions implies a similar translation from numerical data to text, though on the monthly or seasonal scale.  
47 In this paper I describe a pilot study to generate synthetic weather diaries based on daily weather reconstructions  
48 for Switzerland for the year 1816, known as a „Year Without a Summer“. Weather and climate during this year  
49 were affected by the eruption of Tambora in Indonesia in 1815 (Raible et al., 2016; Brönnimann and Krämer,  
50 2016). The summer was very cold and rainy, particularly in Central Europe (Auchmann et al., 2012; Luterbacher  
51 and Pfister, 2015; Veale and Endfield, 2016), although the adverse weather conditions were only partly due to  
52 direct effects of the eruption. The “Year Without a Summer” of 1816 is arguably among the most prominent  
53 climate events of the past 350 years. Concurring with increased vulnerability after the Napoleonic wars (due to  
54 political instability, economic shifts after the end of the continental system, high unemployment rates, and  
55 inadequate governance), the societal consequences of this weather event were severe, particularly in Switzerland  
56 (Krämer, 2015; Behringer, 2016). Further weather-related effects were related to snow accumulation, such as  
57 avalanches in the following winter (Rohr, 2015) and a flood event in early summer 1817, although the snowmelt  
58 contribution was large only close to the Alps (Rössler and Brönnimann, 2018). The Tambora eruption was one of  
59 at least five large eruptions within a relatively short period, which together had profound effects on the global  
60 climate system, including monsoons, and on Alpine glaciers (Brönnimann et al., 2019).

61 In the following I describe the weather reconstruction, the translation into text as well as the generation of impact-  
62 related indices. Then I evaluate the synthetic diaries by comparison with daily observations (which are already in  
63 categorized form) and monthly weather summaries as well as brief daily weather notes written down on Lord  
64 Byron’s famous journey through Switzerland (Byron, 1839) in September 1816. A discussion then follows on the  
65 use of “synthetic weather diaries” in history and science. The paper ends with brief conclusions.

## 66 **2 Data**

### 67 **2.1 Numerical reconstructions**

68 The daily weather reconstructions for 1816 used in this paper are taken from Flückiger et al. (2017) and cover  
69 Switzerland. They were produced with the specific aim of numerically modelling potential harvest yields during  
70 the “Year Without a Summer” of 1816 in Switzerland. Furthermore, they were subsequently used to numerically  
71 model the flood events of 1817 (Rössler and Brönnimann, 2018). In the following, I give a brief summary of the  
72 reconstruction technique. Note that the reconstruction was not designed for day-to-day accuracy. Nevertheless, it  
73 best serves the purpose of presenting the concept of synthetic weather diaries as it is the earliest, high-resolution  
74 spatial weather reconstruction available at the moment of writing and also because the “Year Without a Summer”  
75 of 1816 is well documented and of particular interest.



76 The reconstruction is based on an analog resampling. The analog pool consists of 59 years of daily 2 x 2 km<sup>2</sup>  
77 resolved fields of minimum and maximum temperature ( $T_{\min}$  and  $T_{\max}$ , which we averaged to daily mean  
78 temperature,  $T_{\text{mean}}$ , for this study) and precipitation from the data sets TminD, TmaxD, and RhiresD (Frei, 2014),  
79 reaching back to 1961. Solar irradiance fields were produced using a k-nearest neighbour interpolation. From this  
80 pool, the day that is closest to a historical target day, according to all measurements available at that historical day,  
81 was chosen, as is detailed in the following. The process was repeated for each day, and the sequence of closest  
82 analogs constitutes the reconstruction.

83 Three stations were used to define a measure of distance between analog pool and historical target day: Geneva,  
84 Delémont (both in Switzerland), and Hohenpeissenberg (Bavaria). These were the only three stations within or in  
85 the vicinity of Switzerland with daily or subdaily data at the time the reconstruction was produced. We used  $T_{\min}$   
86 and  $T_{\max}$  for Geneva and Hohenpeissenberg,  $T_{\text{mean}}$  for Delémont and precipitation for Geneva. The Euclidian  
87 distance was chosen as the distance measure. We accounted for a change in temperature between the historical  
88 period and the pool-of-analog period, as detailed in Flückiger et al. (2017).

89 The analog selection then proceeded in several steps: The chosen analog must be in the same season as the target  
90 day (calendar day  $\pm 30$  days) and must be of the same weather type (according to Auchmann et al., 2012). Then,  
91 the closest day in the analog pool according to Euclidian distance between the station measurements of the  
92 historical target day and every day in the pool of analogs was chosen. Finally, the temperature change was  
93 subtracted from the analog temperature to obtain the reconstruction for the past (precipitation and irradiance were  
94 not changed).

95 Note that a much improved reconstruction (relying on much more data and using a post-processing step that  
96 additionally corrects the best analog towards the observations) is available from 1864 onward (Pfister et al., 2020).  
97 It is used in this paper only briefly to assess the effect of the reconstruction quality on the agreement between the  
98 synthetic weather diary and independent weather notes.

99 In addition to the reconstructed fields, I also use Swiss weather types, which are available for every day back to  
100 1763 (Schwander et al. 2017). The data set provides for each day the most likely of seven weather types, along  
101 with its probability. Each weather type can be equated to a short meteorological description of the weather. The  
102 seven weather types (termed CAP7, where CAP stands for Cluster Analysis of Principal Components) are based  
103 on the so-called CAP9 weather types of MeteoSwiss (Weusthoff, 2011) which encompass nine types. The  
104 reduction to seven types (by combining existing types) was necessary as in the early decades, some types could  
105 not be well discriminated, Table 1 shows an overview.

## 106 2.2. Data for comparison: Non-instrumental observations

107 The gridded reconstruction is based only on instrumental measurements from three stations. In a recent project we  
108 have uncovered (Pfister et al., 2019) and digitized (Brugnara et al., 2020) many more instrumental series for  
109 Switzerland back to the early 18th century, such that we now have ten series for 1816. This effort was part of a  
110 global effort to uncover more historical instrumental data (Brönnimann et al., 2019b), a lot of which is currently  
111 being digitized. With these data, more accurate reconstructions will be produced in the future. The Swiss data  
112 could be used to independently evaluate the reconstruction used here, but I touch on this only briefly as it is not  
113 the goal of this paper. Rather, most of these additional series also have categorized daily weather observations,  
114 and some have descriptive monthly summaries. In this paper I focus on these entries for three series: Geneva,



115 Aarau, and St. Gall. These three series are described in the following; they can be downloaded from EURO-  
116 CLIMHIST (Pfister et al., 2017).

117 The Aarau weather data, published in the journal *Archiv der Medizin Chirurgie und Pharmazie* (Zschokke, 1817)  
118 contain twice or three times daily instrumental (pressure, temperature) and non-instrumental (precipitation, sky  
119 cover) information (Faden et al., 2020). An example for September 1816, is given in Figure 1. The weather data  
120 were recorded by Heinrich Zschokke (1771-1848), a German-born teacher and politician. The record was  
121 continued by his son and overall covers almost 60 years.

122 Likewise, the St. Gall record contains instrumental (temperature, pressure) and non-instrumental (precipitation,  
123 sky cover) information, recorded twice daily. The observations were made by pharmacist Daniel Meyer (1778-  
124 1864) from 1812 to 1832 and continued by other, unknown observers (Hürzeler et al., 2020). The data were  
125 published in the journal *Der Erzähler* (Meyer, 1816, 1817).

126 The series from Geneva (Auchmann et al., 2012) was observed by Marc-Auguste Pictet (1752-1825), a scientist  
127 and publisher from Geneva. He was director of the Geneva Observatory; in fact, he may rightly be called a  
128 meteorologist. His observations, published monthly in the journal “Bibliothèque universelle” (Pictet, 1816), also  
129 include monthly summaries with notes on the state of vegetation. Note that the instrumental measurements from  
130 Geneva were used to produce the daily numerical reconstruction, so they are not independent. Therefore, I do not  
131 compare the daily entries here, but rather the monthly summaries.

132 Finally, I also briefly use weather observations made by a person named Furrer in Winterthur from 1849-1867  
133 (Pfister et al., 2019). The data were taken from the Zurich State Archive (Furrer, n. y.). They are used to test my  
134 approach in a later period, when better reconstructions are available.

### 135 **2.3 Data for comparison: Weather diary**

136 Synthetic weather diaries can also be generated for journeys. To test this, I used the travel diary of Lord Byron  
137 during his famous voyage from Lake Geneva through the Bernese Oberland in September 1816. I extracted several  
138 weather related statements from his travel journal (Byron, 1839) and extracted the same information, in space and  
139 time, in the numerical reconstruction.

## 140 **3 Method**

### 141 **3.1 General concept and reference period**

142 In order to make the weather reconstructions as useful as possible to non-climatologists, while allowing to better  
143 compare them to weather observation notes, I structured the data in a similar way as found in many observation  
144 books. Daily values and descriptors are listed, and for each month a summary is given:

- 145 • For each day, the absolute number is given for  $T_{\text{mean}}$  and precipitation, accompanied by additional  
146 information (relating to a reference period, see below) and a set of descriptive qualifiers concerning each  
147 variable and the weather type.
- 148 • For each month, monthly statistics are given for  $T_{\text{mean}}$  and precipitation in numerical form. Additionally,  
149 monthly indices are calculated and given numerically. Again, this section is accompanied by descriptive  
150 qualifiers for both, the monthly weather and the indices.

151 Observers might sometimes report on temperature in an “absolute” manner (e.g., referring to freezing), but often  
152 also in a relative way (e.g., “very cold day”) based on their own experience and perhaps in some cases alluding to



153 societal memory. This requires information on the observers and observation context. For this study this implies  
154 putting absolute numbers in the context of a reference period. For consistency, I use the same reference period as  
155 in Flückiger et al. (2017): the period 1800-1820 without the volcanically perturbed years 1809-1911 and 1815-  
156 1817. Fields of reference period mean temperature for every calendar day are available from Flückiger et al.  
157 (2017), so results presented here can be compared with that study. However, obviously a historical observer would  
158 not have a memory of the future.

159 Note that Flückiger et al. (2017) did not reconstruct every day in the historical reference period. Rather, they  
160 defined a present-day reference period, 1982-2009, from which they subtracted the difference (in terms of a  
161 seasonal cycle) between the periods 1800-1820 and 1982-2009 based on instrumental observations from the three  
162 mentioned stations for the historical reference period. For precipitation and solar irradiance, no change was added  
163 and thus 1982-2009 is considered as a reference period for these two variables. In this paper, for consistency, I  
164 follow the same approach.

165 Historical observers, in their reporting, might account for the changing variability in the course of the seasons. For  
166 instance, variability is larger in winter than in summer. Temperature on a “cold” summer day might be less below  
167 average (in degrees Celsius) than on a “cold” winter day. I therefore standardized the anomalies, again using the  
168 1982-2009 standard deviation (calculated for each calendar day and then smoothed by fitting the first two  
169 harmonics of the seasonal cycle). Likewise, monthly averages or monthly statistics were expressed as standardized  
170 anomalies by using the reference period annual cycle and standard deviations calculated per calendar month.

### 171 **3.2 Obtaining daily weather descriptions**

172 The first step to obtain daily weather descriptions is to establish a taxonomy that eventually allows a comparison  
173 between observations and numerical reconstructions. The target taxonomy must be reducible to the observed  
174 taxonomy, but ideally contains additional information. The observations by both Zschokke and Meyer were  
175 already extremely standardised. With respect to precipitation, the main categories are rain, snow, or an empty field  
176 (standing for dry). In the case of Zschokke, we also (rarely) find the terms “Schneeregen” (mix of snow and rain)  
177 and “Staubregen” (most likely: drizzle<sup>1</sup>). In the case of Winterthur, which was used for testing the method in 1865,  
178 we also find “Nebelregen”, “Nebel” and “neblig” (fog rain, fog, foggy; for the comparison we assume that  
179 precipitation amounts are below the detection threshold chosen in the next Section.).

180 In short, Zschokke and Mayer both provide basically three categories (rain, snow, or dry), two or three times per  
181 day. The synthetic weather diary has only daily resolution (so the observations need to be aggregated for  
182 comparison), but information can be categorized into more classes which can then be aggregated. The definitions  
183 of the classes are indicated in Table 2 and described in more detail in the following.

184 For all standardized anomalies (daily or monthly) we use a seven-point scale defined in Table 3. Note that this  
185 scale deviates from similar seven-point scales as defined, e.g., by Pfister et al. (2018) which is also included in  
186 Table 3. This is because on the daily scale, a non-linear (in terms of the underlying variable; the scale is almost  
187 linear in terms of probabilities) categorization as implied by the “Pfister indices” seems hard to achieve; it would  
188 require detecting rather subtle changes close to the average. Therefore a linear scale is preferred. The basic  
189 categories  $-x$  or  $x$  (e.g., “cold” or “warm”) are similar in the two classifications, with thresholds roughly near the

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<sup>1</sup> „Staubregen“ is described as drizzle in many contemporary dictionaries (e.g., Adelung 1811). However, the term was also used for dust fall (e.g., Saharan dust events). For the comparison we assume that the amount in any case would be below the detection threshold that is later chosen.



190 quartiles, but there is a large discrepancy in the use of the term “extreme”. There is approximate agreement of my  
191 scale with the likelihood scale in the IPCC calibrated language (IPCC, 2013) where “likely” and “very likely”  
192 refer to 66% and 90% cumulative probability (in my scale “x” and “very x” refer to 69.1% and 93.3%,  
193 respectively). However, the scale can easily be adapted, and indeed should be adapted, for other applications.

194 For the daily values, the following information is given:

- 195 • For  $T_{\text{mean}}$  the synthetic weather diary contains the absolute values, the anomaly from a contemporary  
196 reference period, and the standardized anomaly. The taxonomy is based on the latter, using the seven-  
197 point scale (Table 3): values  $< -2.5$  are termed “extremely cold”,  $-2.5$  to  $-1.5$  “very cold”,  $-1.5$  to  $-0.5$   
198 “cold”,  $-0.5$  to  $0.5$  “average”,  $0.5$  to  $1.5$  “warm”,  $1.5$  to  $2.5$  “very warm”, and  $>2.5$  “extremely warm”.
- 199 • For precipitation the synthetic diary gives the absolute value as well as the qualifier “dry” ( $<1$  mm),  
200 “slight rain” (1 to 5 mm), “rain” (5 to 15 mm) and “heavy rain” ( $>15$  mm). The thresholds are chosen  
201 arbitrarily. For the case of Geneva, 69% of the days in the reference period are “dry”. Of the remaining  
202 days, half have “slight rain”, 36% have “rain” and 14% “heavy rain”. The sensitivity to the choice of the  
203 thresholds is analysed later. If daily mean temperature was below  $2$  °C (following Zubler et al., 2014) the  
204 qualifiers “slight snowfall”, “snowfall”, “heavy snowfall” are used instead.
- 205 • Sky conditions are given as text. For this, irradiance was first expressed as fraction of the maximum  
206 possible value for the corresponding calendar day. The latter was approximated here by the simple  
207 function  $100 * (1.4 \text{ W/m}^2 - \cos(w))$ , where  $w$  is the angle corresponding to the calendar day centred around  
208 the solstices. If the fraction is higher than 0.66 and no precipitation is reconstructed, the sky is described  
209 as “clear”; if it is below 0.66, or if there is precipitation, “partly cloudy”, if it is below 0.33, “cloudy”.
- 210 • Finally, I provide the most likely weather type for that day from the Swiss CAP7 weather statistics  
211 (Schwander et al., 2017), along with the probability of that weather type on that day and a text description  
212 of the type. Note that the weather type cannot directly be compared with the (often observed) wind  
213 direction unless the local situation is very well understood. However, for future applications, wind would  
214 be an important component of a synthetic weather diary.

215 Note that irradiance was calculated from an interpolation of few station data and should only be analysed closed  
216 to current weather stations, which is the case for the four extracted weather diaries. However, spatial field cannot  
217 be analysed, and I do not provide numerical values in the synthetic weather diaries.

### 218 3.3 Monthly weather summaries

219 For each month, the following information is given:

- 220 • Mean  $T_{\text{mean}}$  of the month, again along with the deviation from the reference and a qualifier (7-point scale,  
221 Table 3), number of freezing days ( $T_{\text{mean}} < 0$  °C)
- 222 • Precipitation sum (also expressed as percentage of the reference for that calendar month) and number of  
223 rain or snow days,
- 224 • Monthly counts of the 7 weather types (also expressed as percentage of the corresponding relative  
225 frequency for that calendar month in the reference period), and
- 226 • Three derived indices described below: Growing Degree Days, maximum 10-day value of Freezing  
227 Degree Days, and water balance, each given as absolute value and qualifiers

228 This information can further be condensed, if necessary. The following monthly indices are used:



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- Growing Degree Days (GDD): The cumulative sum of  $T_{\text{mean}}$  above 4 °C (starting on 1 January) is a measure for suitability for crop growth. Each month I give the value for that month (with reference) as well as the delay at the end of the month with respect to the median in the reference period, and a qualitative description (“extremely early” to “extremely late”, according to standardised anomalies using the 7-pt scale). While leaf unfolding or flowering quite generally depends on GDD, crop maturity (and thus harvest dates) or leaf colouring are more species dependent and depend on other factors. Therefore, GDD delays and qualifiers are only given for the months of March to July.
  - Freezing Degree Days (FDD): The cumulative sum of  $T_{\text{mean}}$  below 0 °C (with a positive sign), accumulated over the 10 previous days. For the months January to April and October to December, the maximum of this 10-day index per month ( $\max_{10}\text{FDD}$ ) is given. If maximum FDD exceeds 50 °C, then a note “small lakes frozen” is indicated, if it exceeds 90 °C, “large lakes frozen” is indicated. These thresholds are in approximate agreement with Franssen and Scherrer (2008), but, again, would have to be adapted for each application.
  - A monthly index of the water balance (precipitation minus potential evapotranspiration, P-E) is calculated by making use of the precipitation amount and  $T_{\text{mean}}$ , from which potential evapotranspiration is calculated using the Thornthwaite (1948) formula. The monthly balance is standardized and then described in each month with the 7-pt scale (“extremely wet” to “extremely dry”).

## 246 4 Results

### 247 4.1 Non-instrumental observations for Aarau and St. Gall

248 The synthetic weather diaries for Aarau and St. Gall are given in the electronic supplement. Their performance in  
249 terms of temperature can be measured by comparing the numerical values with the instrumental temperature series  
250 from the two stations, which were not used in the reconstruction process and are thus independent. After  
251 subtracting the mean annual cycle in the reference period from both series (by fitting the first two harmonics of  
252 the seasonal cycle), I find a correlation of 0.81 and 0.72, respectively. Note that the measurements themselves  
253 have errors. In view of that, the correlations indicate that even though the reconstruction is only based on three  
254 stations, the temperature fields are quite reliable.

255 For rainfall and sky cover, I compare our synthetic diaries with the actual observations from the two stations. As  
256 an example, the Aarau observations for July 1816 are shown in Fig. 1, the corresponding synthetic diary in Table  
257 4. Both the observations and the synthetic diary indicate a particularly rainy month, but on a day-to-day scale there  
258 are also clear differences. In the observation, there are only three days without any precipitation (20, 21 and 23  
259 July), of which two are also dry in the synthetic diary. The latter gives eight “dry” days (of which four have zero  
260 precipitation, four have less than 1 mm).

261 A plot comparing observations and synthetic weather diary for both stations for both precipitation and sky  
262 conditions is shown in Fig. 2 (middle and bottom). While the agreement at the level of seasonal characteristics is  
263 quite favourable – both synthetic weather diaries and observations confirm the high number of rainy days in  
264 summer and also agree on less rainy periods – there are also important differences. For instance, the first half of  
265 September is rather dry in the synthetic diaries (both Aarau and St. Gall), but many rainy days are reported at both  
266 stations.



267 The agreement can be quantified with Spearman correlations by coding rain/no rain in the observations as 0 and 1  
268 (“Nebelregen”, “Nebel”, “neblig” and “Staubregen” were set to 0) and in the synthetic diary as 0 to 3 for “dry”,  
269 “slight rain/snowfall”, “rain/snowfall”, and “heavy rain/snowfall”). In this way I find correlations of around 0.25  
270 for Aarau and St. Gall. Coding snow with a negative sign in both sources, correlations increase to slightly above  
271 0.4 at both sites. Although highly significant, this agreement may not be good enough yet to be useful on a day-  
272 to-day scale.

273 There are several causes for discrepancies: Errors in the reconstruction, errors in the observations, lack of  
274 representativity of observations for a grid cell, and inadequate translation. The error in the reconstructions can be  
275 partly assessed by comparison with similar analyses in a period after 1864, when better reconstructions are  
276 available (Pfister et al., 2020). In these reconstructions, the error of precipitation was assessed by subsampling in  
277 the 1961-2010 period. Correlations of 0.75-0.90 were found for most parts of Switzerland, which however  
278 constitutes an upper-limit estimate as this analysis has no representativity error and a good quality of the underlying  
279 measurements. A more realistic case is to analyse these reconstructions in the very early years of the Swiss  
280 Meteorological network. Non-instrumental observations are available, for instance, for Winterthur. Comparing  
281 rainfall in the first three years (1864-1866) in the same way (coding snow with a negative sign), I find a correlation  
282 of 0.5. This analysis accounts for the same errors as in the case of 1816, the only difference being better  
283 reconstructions. This estimate is an upper-limit of the quality that can possibly be reached 250 years back using  
284 additionally digitised data (Brugnara et al., 2020). For the year 1865, the comparison is also shown in Fig. 2.  
285 Clearly the agreement is better in this case. Most importantly, the difference between this relatively dry year and  
286 the wet year 1816 is extremely clear.

287 The error of the translation could be assessed by changing the chosen thresholds. In the case of Aarau, the threshold  
288 for precipitation could have been set too high in the synthetic diary. I tested all combinations of threshold of 0.5  
289 or 1 mm, 5 or 8 mm, and 15 or 20 mm for the separation between the four classes for both Aarau and St. Gallen.  
290 In fact, most other combinations gave slightly better results (e.g., 0.5/8/20 mm), but differences were small. In any  
291 case, for other applications the thresholds would have to be reconsidered.

292 Finally, the agreement between observed and synthetic sky conditions is very low. Correlations, defined similarly  
293 as above, yield coefficients of 0.06 and 0.12 for St. Gall and Aarau, respectively, which is too low to be useful.  
294 Visually, large differences become apparent between the observations at Aarau and St. Gall. Specifically, the  
295 category “cloudy” (“bewölkt” in Zschokke, “trüb” or “neb. trüb” in Mayer) differs a lot between the sites at the  
296 expense of “partly cloudy”. More work and more care is required to obtain a good classification.

297 The weather type information can give additional information. For instance, every day but one (27 July) in the  
298 example of July 1816 is attributed to a cyclonic weather type. This agrees well with the rainy character of the  
299 month. Note also the frequent westerly winds noted in the observations, which is in accordance with westerly or  
300 west-southwesterly weather types, although in that case knowledge of the local wind situation and the channelling  
301 of winds is required.

#### 302 **4.2 Monthly summaries for Geneva**

303 For testing the monthly summaries in the synthetic weather diaries, I compare them with the observations from  
304 Geneva. Marc-Auguste Pictet, in his observations published in the “Bibliothèque universelle” also gives a monthly  
305 summary. This sort of information is typical in historical weather sources. Here I compare the entries for the  
306 months of March to September, which are most relevant for crops, in a qualitative way (Table 5). Note that for



307 this Table, for brevity's sake, the synthetic monthly summaries have been further simplified (e.g., not all weather  
308 types are indicated, but only those that were anomalously frequent or infrequent).

309 The comparison (highlighted in italics) shows a relatively good agreement. Almost in all months, Pictet points to  
310 the delay of vegetation, which is also seen in the synthetic diary based on growing degree days. The calculated  
311 delay reaches 22 days in July (relative to the historical reference period). This is less than indicated by Pictet (one  
312 month), which however refers to one comparison year. Agreement is also found with respect to most mentions of  
313 temperature and rainfall. For instance, the reported "harsh temperatures" in March correspond to a cold month in  
314 the synthetic diary, the "cold and rainy weather" in July compares well with the characterisation "very cold" and  
315 "extremely wet" in the synthetic diary. Worse agreement is found for October, which according to Pictet was of  
316 "remarkable beauty", but in the synthetic weather diary is characterised as "cold", though with below normal  
317 rainfall.

#### 318 **4.3. Comparison with Lord Byron's journey**

319 A possible example of use of synthetic weather diary is to track the weather experienced during an expedition or  
320 journey. As an example, I use the famous journey of Lord Byron through the Swiss Alps in September 1816. After  
321 a dreadful summer with almost constant rain, the weather was improving and Lord Byron found the weather to be  
322 quite nice during the trip.

323 Figure 3 shows the reconstructed fields for five days in September 1816, along with a dot that marks the location  
324 of Byron as well as the weather descriptions from his diary and from the synthetic weather diary, calculated for  
325 each location. The first day („fine weather“) indeed was a nice day also in the reconstructions, with no rainfall and  
326 high temperatures. Agreement is also found on the other days, both in terms of rainfall and temperature, except  
327 perhaps for 25 September, when Byron notes "the weather has been tolerable all day" (the meaning of which,  
328 however, is unclear). On this day, the reconstruction shows spatially extensive (though not extremely intense)  
329 rainfall. Also the two stations Aarau and St. Gall report rainfall.

#### 330 **5 Discussion**

331 The analyses show that synthetic diaries can provide local, daily weather information in a format that is comparable  
332 to non-instrumental observations and weather descriptions in diaries. The comparison with independent  
333 observations shows some agreement, although the quality both of the daily reconstruction as well as of the  
334 translation needs further improvement.

335 The comparison of monthly summaries also showed a good agreement and points to the usefulness of vegetation  
336 indices (such as GDD). The monthly summary also points to the effect of combinations of factors (e.g., cold with  
337 little snow) and the importance of pests and insects for agriculture. Experts might be able to make use of the  
338 numerical reconstructions or the synthetic weather data also for analysing insect infestations. In his summaries,  
339 Pictet appears as a rather reserved observer, who largely excludes the societal effects in his descriptions. Other  
340 weather diaries from this time (e.g., the Hoffmann diary, quoted in Bodenmann et al., 2011) have a more  
341 pessimistic or even desperate tone, list in detail the prices, and point to the miserable situation, to beggars etc.

342 The comparison with the travel diary of Lord Byron yields a general agreement. This shows that synthetic weather  
343 diaries might be useful as an additional information source to better analyse the journey.



344 For all analyses, we should note that rainfall is much more difficult to reconstruct by the analog method than  
345 temperature due to its very high spatial variability (Pfister et al., 2020). Moreover there is a large representativity  
346 error and arguably also a large observation error. For instance, rain may fall unnoticed during the night. Moreover,  
347 instrumental precipitation (which is the basis for the analog method) is defined as 6 local time to 6 local time,  
348 making comparison at times more difficult; a one-day shift is possible. Note also that the 2x2 km<sup>2</sup> grid does not  
349 represent the resolution of the observing network, which has a typical inter-station difference of 15-20 km  
350 (MeteoSwiss, 2019). In any case, precipitation can only be taken as a rough indication. Temperature, conversely,  
351 is well reconstructed, but less often in the focus of observers. Eventually, wind would be an important variable for  
352 any reconstruction, which should be considered in future approaches.

353 While the agreement as measured in correlation is at times low, currently limiting the application of synthetic  
354 diaries, it should be noted that future reconstructions will likely be much improved and resolve further detail. Once  
355 this stage is reached, the potential of this tool is immense. Weather information can be generated for military  
356 operations or other weather-sensitive activities. Weather diaries can also be produced for travels and expeditions.  
357 The translation into text as well as the comparison with reference periods allows a more direct comparison, and  
358 the calculated indices may be useful for some applications. In particular, impacts on agriculture or on other areas  
359 of life can be assessed more easily. In short, the weather diaries could be used in a variety of ways by historians  
360 to constrain, cross-date, compare or complement other information.

361 The approach is however also important for sciences. If the translation from numeric weather data to a synthetic  
362 diary that resembles historical sources succeeds, inversion methods can be used to do the opposite: Reconstruct  
363 weather numerically from descriptive data. Data assimilation techniques use such „forward models“, however, for  
364 a formal data assimilation approach the variables need to be on a metric scale. For other approaches such as analog  
365 selections, the variables must at least allow to express similarities (or ordinal distances). Systematically compiled  
366 categorial information, however, as is produced in our approach, could be used for instance by machine learning  
367 approaches. This requires that historical weather diaries can be categorized (or are already categorized) in a prior  
368 step. If this is the case, machine learning approaches could then be trained on synthetic weather diaries generated  
369 in the most recent few decades to provide weather types, or even entire weather fields. Once successfully trained,  
370 such approaches can then applied to past weather diaries.

## 371 **6 Summary and Conclusions**

372 Recent efforts in climatology have resulted in daily weather reconstructions for the globe covering the last 200  
373 years. Daily weather reconstructions are also generated for specific regions at high resolution and might soon reach  
374 250 years back. These data sets could be important for history and sciences. In this paper I explore this by  
375 translating a high-resolution, prototype weather reconstruction for Switzerland, 1816, into synthetic weather  
376 diaries for selected locations. These synthetic weather diaries provide not only the reconstructed values, but  
377 translate them into a categorial form that makes them comparable to weather descriptions. Reconstructed values  
378 are referenced to a contemporary reference period, and a calibrated language (e.g., „very cold“) is used to translate  
379 numbers to categories. Furthermore, monthly summaries are provided, using the monthly statistics of the daily  
380 reconstruction (translated to descriptive categories) as well as indices for plant growth, freezing, and drought (also  
381 translated to descriptive categories).



382 Results from our prototype reconstructions for Switzerland, 1816, show a good agreement with independent non-  
383 instrumental daily weather observations from Aarau and St. Gall, and with monthly weather summaries from  
384 Geneva. Also, qualitative agreement with the travel diary of Lord Byron on his journey through Switzerland in  
385 September 1816 is found. The quality of this pilot reconstruction is arguably not accurate enough for many  
386 applications. However, future products are expected to be of sufficient quality to yield useful information, although  
387 there will always be substantial uncertainty for rainfall and particularly for sky conditions.

388 Synthetic weather diaries are also relevant for science. Combined with machine learning approaches, they could  
389 be used to reconstruct weather numerically from descriptive data. This opens an immense potential for the use of  
390 existing data bases of historical weather data such as EURO-CLIMHIST (Pfister et al., 2017), Tambora.org  
391 (Riemann et al., 2015), and TEMPEST (Veale et al., 2017) but requires intense collaboration between historians  
392 and scientists.

393

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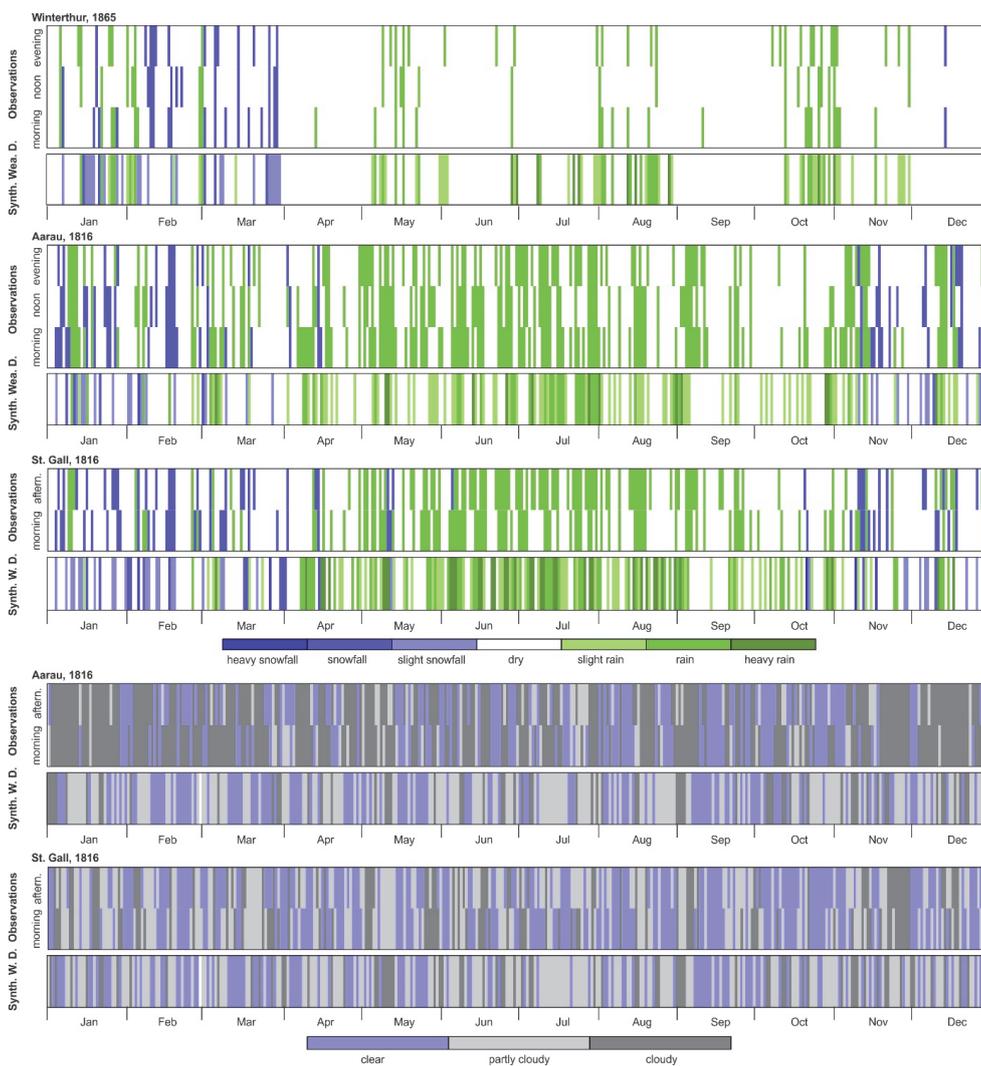


im Aargau, Juli 1816.

Wochentage.	Wochenszeiten.	Barometer.		Thermometer.			Barometer.		Schnee oder Regen.			W i n d e .		Eis oder Reif.	N e b e l .	Himmelsbeschaffenheit.		
		Bei Einnahme gang.	Bei Einnahme gang.	Bei Einnahme gang.	Nachmittags 2 Uhr.	Bei Einnahme gang.	Rein Mittags.	Nachmittags.	Nacht.	Vormittags.	Nachmittags.	Nachmittags.	Nachmittags.			Nachmittags.	Nachmittags.	Nachmittags.
1	Erst. St.	26.10.4	26.9.6	+	10	+	17	+	13	24	22	—	—	—	—	—	—	—
2		26.10.5	26.11.4	+	7	+	9	+	8	39	32	Regen	Regen	Regen	W.	W.	—	—
3		26.11.5	27.0.1	+	8	+	10	+	11	36	12	Regen	Regen	Regen	W.	W.	—	—
4		27.0.3	27.0.5	+	8	+	15	+	13	30	11	Regen	Regen	Regen	W.	W.	—	—
5		27.0.0	27.0.1	+	8	+	12	+	8	26	29	—	—	—	W.	W.	—	—
6		27.0.6	27.0.4	+	8	+	16	+	12	30	11	—	—	—	W.	W.	—	—
7		27.0.4	26.10.6	+	9	+	15	+	14	20	8	—	—	—	W.	W.	—	—
8		26.10.9	26.10.8	+	12	+	18	+	14	28	12	Regen	Regen	Regen	W.	W.	—	—
9	Wolm.	26.10.9	26.10.7	+	12	+	23	+	8	22	16	—	—	—	W.	W.	—	—
10		26.10.0	26.10.8	+	13	+	13	+	12	22	25	—	—	—	W.	W.	—	—
11		26.10.8	26.10.8	+	10	+	12	+	12	26	11	Regen	Regen	Regen	W.	W.	—	—
12		26.10.7	26.10.7	+	9	+	11	+	10	31	34	Regen	Regen	Regen	W.	W.	—	—
13		26.11.7	27.0.3	+	8	+	15	+	12	37	12	Regen	Regen	Regen	W.	W.	—	—
14		27.0.3	27.0.0	+	10	+	16	+	11	26	6	Regen	Regen	Regen	W.	W.	—	—
15		26.11.0	26.10.4	+	9	+	15	+	12	22	22	—	—	—	W.	W.	—	—
16		26.10.9	26.10.9	+	9	+	20	+	9	30	41	—	—	—	W.	W.	—	—
17	Sept. St.	26.11.2	26.11.4	+	8	+	12	+	17	36	26	Regen	Regen	Regen	W.	W.	—	—
18		26.11.4	26.11.3	+	8	+	17	+	12	36	10	Regen	Regen	Regen	W.	W.	—	—
19		26.11.7	26.11.6	+	9	+	20	+	13	23	6	Regen	Regen	Regen	W.	W.	—	—
20		27.0.3	27.0.5	+	11	+	21	+	11	25	9	—	—	—	W.	W.	—	—
21		26.11.0	27.0.1	+	11	+	21	+	16	21	10	—	—	—	W.	W.	—	—
22		27.0.6	27.0.5	+	12	+	18	+	15	10	5	Regen	Regen	Regen	W.	W.	—	—
23		26.11.8	26.10.6	+	10	+	21	+	15	15	6	—	—	—	W.	W.	—	—
24		26.10.6	26.10.6	+	12	+	15	+	16	17	13	Regen	Regen	Regen	W.	W.	—	—
25	Neum.	26.11.1	26.11.6	+	10	+	17	+	12	25	10	Regen	Regen	Regen	W.	W.	—	—
26		27.0.3	27.0.8	+	10	+	15	+	14	22	8	—	—	—	W.	W.	—	—
27		27.0.9	27.0.9	+	10	+	16	+	15	17	6	Regen	Regen	Regen	W.	W.	—	—
28		27.0.3	26.10.0	+	8	+	19	+	14	20	10	—	—	—	W.	W.	—	—
29		26.8.4	26.7.8	+	13	+	16	+	14	24	25	Regen	Regen	Regen	W.	W.	—	—
30		26.7.2	26.9.4	+	7	+	10	+	9	48	29	Regen	Regen	Regen	W.	W.	—	—
31	Erst. St.	26.8.8	26.7.9	+	7	+	10	+	9	29	24	Regen	Regen	Regen	W.	W.	—	—

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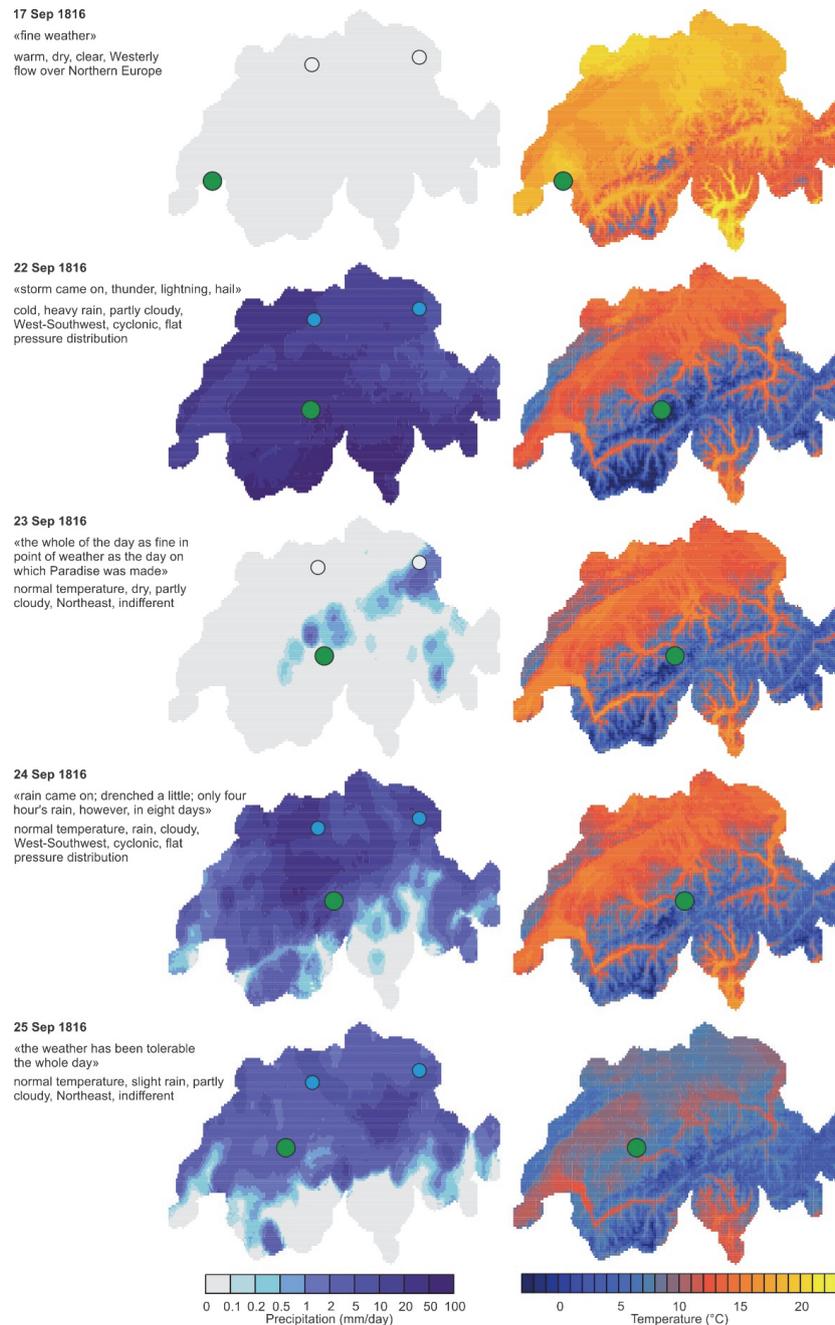
524 Figure 1. Weather observations by Zschokke, Aarau, for July 1816 (Zschokke, 1817).



525

526 Figure 2. Comparison of observations (2-3 times daily) and synthetic weather diaries (daily) for Winterthur (1865) as well as  
527 Aarau and St. Gall (1816).

528



529

530 Figure 3. The weather during Lord Byron's travel from Lake Geneva to the Bernese Oberland in September 1816.  
 531 The figure shows his diary entries (in quotation marks) as well as the synthetic weather diary for five days. Also  
 532 shown are precipitation and daily mean temperature from the reconstructions. The green dot marks the position of  
 533 Lord Byron. The small dots indicate whether the observers at Aarau and St. Gall noted precipitation (blue) or not  
 534 (grey).

535



536 Table 1. Description of CAP7 weather types, corresponding CAP9 types, and frequencies in the cold and warm  
 537 season in the period 1961-1990

CAP7	Description	CAP9	$f_{\text{Apr-Sep}}$	$f_{\text{Oct-Mar}}$
1	Northeast, indifferent	1	0.28	0.08
2	West-southwest, cyclonic, flat pressure	2	0.18	0.11
3	Westerly flow over Northern Europe	3	0.12	0.13
4	East, indifferent	4	0.15	0.12
5	High pressure over Europe	5+8	0.03	0.30
6	North, cyclonic	6	0.15	0.09
7	Westerly flow over Southern Europe, cyclonic	7+9	0.09	0.16

538

539 Table 2. Taxonomy used in the observations from Zschokke and Mayer as well as in the synthetic weather diary,  
 540 together with the definition (Def.;  $T$  = daily mean temperature in °C,  $T'$  = standardized daily mean temperature  
 541 anomaly,  $R$  = precipitation in mm per day,  $I$  = Irradiance relative to possible irradiance).

Temperature		Precipitation				Sky conditions			
Synthetic	Def.	Zschokke	Mayer	Synthetic	Def.	Zschokke	Mayer	Synthetic	Def.
extremely cold	$T_{\text{mean}} \leq -2.5$	(empty), Staubregen	(empty)	dry	$R < 1$	heiter	schön, heiter, neb. schön	clear	$I < 0.33$
very cold	$-2.5 < T_{\text{mean}} \leq -1.5$	Regen	Regen	slight rain	$1 < R < 5$ $T > 2$	halbheiter	vermischt, neb. vermischt	partly cloudy	$RR > 0$ or $0.33 < I < 0.66$
cold	$-1.5 < T_{\text{mean}} \leq -0.5$			rain	$5 < R < 15$ $T > 2$	bewölkt	trüb, neb. trüb	cloudy	$0.66 < I$
average	$-0.5 < T_{\text{mean}} \leq -0.5$			heavy rain	$15 < R$ $T > 2$				
warm	$0.5 < T_{\text{mean}} \leq 1.5$	Schnee, Schneeregen	Schnee	slight snowfall	$1 < R < 5$ $T \leq 2$				
very warm	$1.5 < T_{\text{mean}} \leq 2.5$			snowfall	$5 < R < 15$ $T \leq 2$				
extremely warm	$-2.5 < T_{\text{mean}}'$			heavy snowfall	$15 < R$ $T \leq 2$				

542



543 Table 3. Seven-point scale for indexing standardized anomalies (std. dev.), description ( $x$  denotes a property and  $-x$  its reverse,  
 544 e.g., “warm” and “cold”, “wet” and “dry”, or “late” and “early”) and corresponding probabilities (Prob.) and cumulative  
 545 probabilities (Cum. prob.) for (left part of table) this study and (right) (Pfister et al. 2018). Italics: Thresholds and descriptions  
 546 that are part of the definition; other columns are implied by assuming a normal distribution.

This study				Pfister et al. 2018			
Std. Dev.	Description	Prob. (%)	Cum. prob. (%)	Std. Dev.	Description	Prob. (%)	Cum. prob. (%)
< -2.5	<i>extremely [-x]</i>	0.6	0.6	< -1.38	<i>extremely [-x]</i>	8.3	8.3
-2.5 to -1.5	<i>very [-x]</i>	6.1	6.7	-1.38 to -0.67	<i>[-x]</i>	16.7	25
-1.5 to -0.5	<i>[-x]</i>	24.2	30.9	-0.67 to -0.2	<i>rather [-x]</i>	17	42
-0.5 to 0.5	<i>normal/average</i>	38.3	69.1	-0.2 to 0.2	<i>normal/average</i>	16	58
0.5 to 1.5	<i>[x]</i>	24.2	93.3	0.2 to 0.67	<i>rather [x]</i>	17	75
1.5 to 2.5	<i>very [x]</i>	6.1	99.4	0.67 to 1.38	<i>[x]</i>	16.7	91.7
> 2.5	<i>extremely [x]</i>	0.6	100	> 1.38	<i>extremely [x]</i>	8.3	100

547

548



549 Table 4. Synthetic weather diary for Aarau, July 1816 (columns: Year, month, day,  $T_{\text{mean}}$ , anomaly of  $T_{\text{mean}}$ , standardized anomaly of  $T_{\text{mean}}$ ,  
 550 precipitation, temperature description, precipitation description, cloud cover description, weather type, description of weather type.

YR	M	D	$T[^\circ\text{C}]$	$dT[^\circ\text{C}]$	$T[\text{sd}]$	$R[\text{mm/d}]$	$T[\text{text}]$	$R[\text{text}]$	Sky[ $\text{text}$ ]	WT	WT[ $\text{text}$ ]
1816	7	1	16.40	-2.25	-0.69	9.69	cold	rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	2	11.75	-7.23	-2.23	0.72	very cold	dry	clear	6	North, cyclonic
1816	7	3	12.65	-6.13	-1.89	0.18	very cold	dry	cloudy	6	North, cyclonic
1816	7	4	14.34	-4.24	-1.31	0	cold	dry	clear	6	North, cyclonic
1816	7	5	13.31	-4.52	-1.40	0.72	cold	dry	clear	2	West-Southwest, cyclonic, flat pressure distribution
1816	7	6	13.89	-4.25	-1.32	10.72	cold	rain	cloudy	2	West-Southwest, cyclonic, flat pressure distribution
1816	7	7	16.92	-0.50	-0.15	5.43	normal	rain	cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	8	18.45	0.41	0.13	19.37	normal	heavy rain	partly cloudy	6	North, cyclonic
1816	7	9	19.55	1.39	0.43	0	normal	dry	clear	7	Westerly flow over Southern Europe, cyclonic
1816	7	10	19.85	1.43	0.45	2.57	normal	slight rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	11	17.10	-1.70	-0.53	3.8	cold	slight rain	partly cloudy	6	North, cyclonic
1816	7	12	15.82	-1.91	-0.60	3.8	cold	slight rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	13	15.10	-2.99	-0.94	9.46	cold	rain	partly cloudy	6	North, cyclonic
1816	7	14	11.80	-5.41	-1.71	2.71	very cold	slight rain	partly cloudy	2	West-Southwest, cyclonic, flat pressure distribution
1816	7	15	15.38	-2.52	-0.80	10.07	cold	rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	16	12.14	-4.94	-1.57	9.69	very cold	rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	17	10.09	-6.62	-2.11	3.8	very cold	slight rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	18	15.18	-1.44	-0.46	5.89	normal	rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	19	16.92	-0.60	-0.19	7.32	normal	rain	partly cloudy	2	West-Southwest, cyclonic, flat pressure distribution
1816	7	20	16.25	-1.18	-0.38	11.59	normal	rain	partly cloudy	2	West-Southwest, cyclonic, flat pressure distribution
1816	7	21	20.49	2.69	0.87	0.91	warm	dry	clear	7	Westerly flow over Southern Europe, cyclonic
1816	7	22	17.28	-0.35	-0.11	0	normal	dry	clear	6	North, cyclonic
1816	7	23	15.57	-2.07	-0.67	0	cold	dry	clear	7	Westerly flow over Southern Europe, cyclonic
1816	7	24	16.35	-0.98	-0.32	7.06	normal	rain	cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	25	13.19	-4.66	-1.53	9.19	very cold	rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	26	12.82	-4.81	-1.58	9.46	very cold	rain	partly cloudy	6	North, cyclonic
1816	7	27	14.31	-4.77	-1.57	10.19	very cold	rain	partly cloudy	1	Northeast, indifferent
1816	7	28	17.91	-0.97	-0.32	7.32	normal	rain	partly cloudy	2	West-Southwest, cyclonic, flat pressure distribution
1816	7	29	18.68	-0.17	-0.06	2.01	normal	slight rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	30	12.41	-6.67	-2.23	38.48	very cold	heavy rain	cloudy	7	Westerly flow over Southern Europe, cyclonic
1816	7	31	15.40	-4.75	-1.59	12.13	very cold	rain	partly cloudy	7	Westerly flow over Southern Europe, cyclonic

551

552



553 Table 5. Comparison of monthly summaries of weather and state of vegetation by Pictet in Geneva, 1816 (translated), and in our synthetic  
 554 weather diary (excerpt giving monthly mean temperature, number of frost days (if any), max<sub>10</sub>FDD, GDD, delay, monthly mean rainfall,  
 555 percentage of normal rainfall, number of rain and snowfall days, P-E with qualifier, overview of frequent (>150%) and infrequent (<50%  
 556 relative to expected frequency from reference period) weather types, with number and percentage compared to reference period). Highlighted  
 557 in italics are text excerpts (left) that can qualitatively be compared with the synthetic diary (right).

Mon	Pictet	Synthetic
Mar	The <i>harsh temperature</i> , and the <i>lack of snow</i> on the wheats, makes one fear that they will not recover from the winter's hardship. Clovers and alfalfa are uprooted in the cold and wet soils. Field work has been little interrupted.	T = 3.67 °C ( <i>cold</i> ), 3 frost days, max <sub>10</sub> FDD = 1 °C, GDD = 35 °C (late, 5 d), R = 1.17 mm/d (56%), 7 raindays, 3 snowfall days, P-E = 21 mm (normal moisture), frequent „Northeast, indifferent“ (8 days, 252%), „Westerly flow over Southern Europe, cyclonic“ (9 days, 169%), infrequent „High pressure over Europe“ (1 day, 16%)
Apr	The season is uniquely <i>delayed</i> . The vine has not yet grown at all. The vegetation is very weak. The rains seem to have replenished the meadows that the frosts have lightened; but the wheat is very meager; some have been lost. Spring sowing has been done with ease.	T = 7.86 °C ( <i>cold</i> ), max <sub>10</sub> FDD = 1 °C, GDD = 158 °C ( <i>very late</i> , 21 d), R = 1.77 mm/d (72%), 9 raindays, P-E = 13 mm (normal moisture), frequent „Westerly flow over Southern Europe, cyclonic“ (12 days, 202%), infrequent „Westerly flow over Northern Europe“ (2 days, 41%) and „West-southwest, cyclonic, flat pressure“ (1 day, 36%), no „East, indifferent“ and „High pressure over Europe“
May	The scourge of cockchafers has been felt with great violence this year. The stone fruit trees are almost completely leafless: plum and cherry trees in particular. Pear trees suffer just as much from caterpillars. The season is <i>about one month later than last year</i> . Wheat that has not been destroyed or damaged by the winter has gained a lot. A rather large number of grapes have appeared, but the <i>unfavourable temperature</i> cost part of the whites: the red grapes resist better. The meadows look good.	T = 12.29 °C ( <i>cold</i> ), GDD = 415 °C ( <i>very late</i> , 15 d), R = 2.61 mm/d (104%), 12 raindays, P-E = 6 mm (normal moisture), frequent „North, cyclonic“ (16 days, 337%), „Westerly flow over Southern Europe, cyclonic“ (7 days, 223%), no „West-southwest, cyclonic, flat pressure“, „Westerly flow over Northern Europe“, „East, indifferent“, and „High pressure over Europe“
Jun	Trees are still very susceptible to attacks by cockchafers and caterpillars. The oaks have not yet had a single leaf as of June 30. There are pear trees that also lack them, and whose fruit has fallen off. The wheat has flourished, the barley and oats are beautiful. <i>The grapes are not yet flowering</i> . The natural and artificial meadows give a lot of fodder.	T = 12.73 °C ( <i>very cold</i> ), GDD = 676 °C ( <i>very late</i> , 17 d), R = 5.51 mm/d (192%), 15 raindays, P-E = 86 mm ( <i>very wet</i> ), frequent „North, cyclonic“ (16 days, 301%), „Westerly flow over Southern Europe, cyclonic“ (6 days, 285%), infrequent „Northeast, indifferent“ (4 days, 47%), no „Westerly flow over Northern Europe“, „East, indifferent“, and „High pressure over Europe“
Jul	The <i>cold, rainy weather</i> delayed the harvest so much that only little rye and little winter barley was harvested. Grapes are <i>very late</i> and the branches have a lot of aborted berries, and are also in small quantities. The late-ripening meadows, which are only cut once, yield very little, and the annual clovers look good. Potatoes are in danger of <i>rotting in places where there is no drainage</i> .	T = 15.1 °C ( <i>very cold</i> ), GDD = 1020 °C ( <i>extremely late</i> , 22 d), R = 6.23 mm/d (254%), 19 raindays, P-E = 96 mm ( <i>extremely wet</i> ), frequent „Westerly flow over Southern Europe, cyclonic“ (16 days, 1385%), „North, cyclonic“ (8 days, 162%), infrequent „Northeast, indifferent“ (1 day, 9%), no „Westerly flow over Northern Europe“, „East, indifferent“, and „High pressure over Europe“
Aug	The harvests, at first thwarted by the <i>rains</i> , were then carried out in very favourable weather. The clovers of the second cut are beautiful, as well as the second-growth hay, and the annual clovers. Potatoes are abundant where they have not <i>rotted in the ground, which has happened everywhere where water has stayed</i> . Wheats have little grain and are afflicted with rust. Barley yields a lot. Grapes have grown, but it is doubtful that they can ripen.	T = 16.46 °C ( <i>very cold</i> ), R = 3.19 mm/d (119%), 12 raindays, P-E = 1 mm ( <i>wet</i> ), frequent „Westerly flow over Southern Europe, cyclonic“ (4 days, 329%), infrequent „Westerly flow over Northern Europe“ (1 day, 26%), no „High pressure over Europe“
Sep	The weather was beautiful and the <i>temperature was quite mild</i> throughout the month to advance the ripening of the oats and barley from the mountains: we now have hopes that they will ripen, but the grapes are still almost unchanged, and benefit little. The second-growth hay has been reliable. Sowing is difficult in the clay fields. The first wheat sown	T = 15.04 °C ( <i>average</i> ), R = 2.35 mm/d (78%), 7 raindays, P-E = -5 mm (normal moisture), frequent „Northeast, indifferent“ (9 days, 152%), no „High pressure over Europe“ and „North, cyclonic“



	has risen well. The potatoes planted by the plough are largely rotten, those planted by the spade are less affected.	
Oct	The month of October was of a <i>remarkable beauty</i> ; the buckwheat sown after the wheat has prospered a lot; the harvest of the mountains is coming, the white grapes got lighter, when the frosts of the 22nd and 23rd spoiled everything, except for the grapes of some vineyards located near the lake. All the red grapes were frozen, because they were just beginning to change. A reliable white harvest was made, and some owners put sugar in it to make sure that the juice would ferment. The wood of the vine is not ripe.	T = 9.23 °C ( <i>cold</i> ), R = 2.59 mm/d (83%), 8 raindays, P-E = 41 mm (normal moisture), frequent „Northeast, indifferent“ (6 days, 230%), „North, cyclonic“ (5 days, 269%)

558