



The 1857–1858 drought in Alsace: from water shortage to a socio-political extreme event

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Abstract

Few studies address past droughts by combining different geographical and temporal scales, and a contextualization of social and environmental conditions. This paper proposes a study of the 1857–1858 dry spell in eastern France (Alsace), its natural (climatological and hydrological) as well as socio-political consequences. This episode is one of the major droughts that affected the north of France in the nineteenth century, as much by its duration as by its intensity. Here, we do not only consider the drought as a natural hazard producing physical damage (lack of water, weakening of river discharge) or social tensions (competition for the water, conflicts), but we place it in the particular context of the basins it affects, in order to better evaluate its natural and social intensity. First, we highlight the importance of the 1857–1858 drought from the regional to the Alsatian scale, by unravelling the spatial and temporal distribution of precipitations, based on available instrumental measurements. Depending on the stations, the rainfall deficit established between 10 and 40% of the average rainfall amount in 1857 or 1858. Suitable narrative sources from municipal, departmental and national archives allow us to specify the position of water stakeholders and to analyse the discourses as well as their social and political reactions. Comparing natural and social data, it appears that rivalries for water resource did not necessarily match the meteorological rhythm of the dry spell. The severity of the drought varies depending on economic needs. Three periods seem very demanding for water consumers: August–September 1857, February 1858, and August–October 1858. The structural responses appear to be linked to the economic context, both at a local and national scale. Finally, our approach shows that drought partly is a socially constructed phenomenon, and one to consider carefully, when it comes to both contemporary and past events. Hence, to better understand drought episodes, we need to disentangle the socio-natural interactions at the local level.

Keywords Drought · Water scarcity · Rainfalls · Climate variability · Territory · Alsace

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Introduction: reconstructing past droughts and analyses of water scarcity crises

Numerous authors consider drought as a complex phenomenon (Charre 1977; Goerig 1979; Wilhite et Glantz 1985; Brodu 1990; Stahl 2001; Dubreuil 2005; Rivière-Honegger and Bravard 2005, 2006; Lang Delus 2012; Lloyd-Hughes 2014; Lange et al. 2017; Metzger and Meschinet de Richemond 2019). Unlike brutal, physical damages resulting of hazards occurring over short periods of time (floods, earthquakes, tsunamis, hurricanes...), drought-related damages are much more difficult to identify. They develop over the long term, and do not necessarily correspond to the least rainy period of a dry sequence.

Drought is caused by a deficit of precipitation whenever climatic conditions unfavourable to rain persist abnormally in time (Stahl 2001; Vicente-Serrano and Cuadrat 2007). Moreover, the geological context and the availability of groundwater are also important, as they can explain an unequal sensitivity to dry events from a catchment to another (Soubeyroux et al. 2011). In addition, “human activities can directly trigger a drought unlike other natural hazards, with exacerbating factors such as overfarming, excessive irrigation, deforestation, over-exploiting available water, and erosion, adversely impacting the ability of the land to capture and hold water” (Mishra and Singh 2010), what highlights the eminently complex nature of the phenomenon.

Among the effects of dry sequences, water scarcity is the hardest, and also the one that best raises the problem of defining the drought phenomenon. Water scarcity may occur independently of dry weather conditions. This leads some authors to clearly distinguish between the two phenomena, defining the first as an “overexploitation of water resources when demand for water is higher than water availability” (Van Loon and van Lanen 2013, p. 1484). But with the perception of the drought, the sensitivity to shortage can be deeply influenced by the conditions of water management (Jacob-Rousseau 2015). Thus, following Sheffield and Wood (2011), it seems preferable to consider that drought is defined by both natural and human conditions. In this paper, we consider droughts as moments of hydrological and social crises that have to be spatialized (Marchand 2005; Dubreuil 2005).

If droughts have already been the subject of many studies in climate history, as well as in varied fields such as historical climatology, historical hydrology or even economic and social history (Barriendos 1997; Ingold 2001; Piervitali and Colacino 2001; Pichard and Roucaute 2014; Grau-Satorras et al. 2016; Brázdil et al. 2018; Metzger et al. 2020), few analyses of particular events, their progress and consequences at precise spatio-temporal scales have been made up to this day (Brázdil et al. 2019; Pfister et al. 2015). In particular, numerous studies have focused on the identification of past droughts, and have attempted to develop ways to compare dry sequences of the pre-instrumental period (Wetter and Pfister 2013) in order to determine whether extreme events of the past could give us possible scenarios of future droughts (Wetter et al. 2014).

This leads us to address the two perspectives that guide the present study. On the one hand, to avoid a separative approach to drought and water scarcity, we postulate that drought (*l.s.*) is a more systemic crisis, involving meteorological factors and anthropogenic control variables. On the other hand, we seek to show that a high-resolution, spatio-temporal approach, in the manner of microhistory, can allow to finely decipher the crisis by reconstructing its socio-economic or spatial context, and not only by replacing the natural event into a climatic trend.

In this regard, this paper is strongly influenced by *microstoria*, a historiographical movement that emerged in Italy in the 1970s, and had a great influence on social history in other countries from the 1980s onwards, particularly in France (Ginzburg and Poni 1981, Revel 1996). Microhistory provides access to the lived experience of the individual, to the singular experiences of individuals composing a social group. It helps to illuminate tensions or conflicts, whether on a global or daily scale, while integrating the concrete dimension of space where the facts occur. Until now, it has mainly been applied to social, political or cultural issues (Le Coq 2011), whereas it would also be relevant in issues of environmental history. Microhistory can and should be another facet of historical climatology, and of research about the climate-society relationship, an approach to which Pfister (2010) already invited us by suggesting to focus on the vulnerability of past societies. This micro-scale approach is also an interesting counterpoint to the temptation of determinism, a sensitive point in the historical analysis of the influence of climate on societies.

In the East of France, despite several mentions, the 1857–1858 drought is not well known although Pfister et al. (2006) consider that this (hydrological) winter drought was one of the worst in the Upper-Rhine basin. In spite of very rich documentary sources, to be later addressed (Dostal 2004, Garnier 2010, Dostal and Bürger 2010), this social, hydrological and climatological event has not been studied with great attention.

Therefore, we aim to attempt a comprehensive analysis of this dry sequence, using a body of varied documents (meteorological records and narrative sources), in order to better understand the course of this drought, its consequences and associated responses at a local scale proposed by microhistory. It further leads to take a new look on the documentary sources usually exploited in historical climatology. As Brázdil et al. (2018, p. 1923) have underlined, “the extraction of drought information from documentary sources requires a source-critical approach generally applied to scientific work in historical climatology”. From a historical perspective, we conversely need to accept “social bias”, and to investigate what it reveals about the event, considering that climatic (natural) factors are not always the main causes of a “perceived” drought.

Study area

Case study in Alsace

Our study focuses on some valleys of the Haut-Rhin and Bas-Rhin departments, in Alsace (Fig. 1). The upper part of these basins is located in the middle mountains of the Vosges massif, and the lower part in the Rhine Graben, with an altitude ranging from 160 to 1424 m a.s.l. The eastern slope of the Vosges massif is principally characterized by a strong gradient

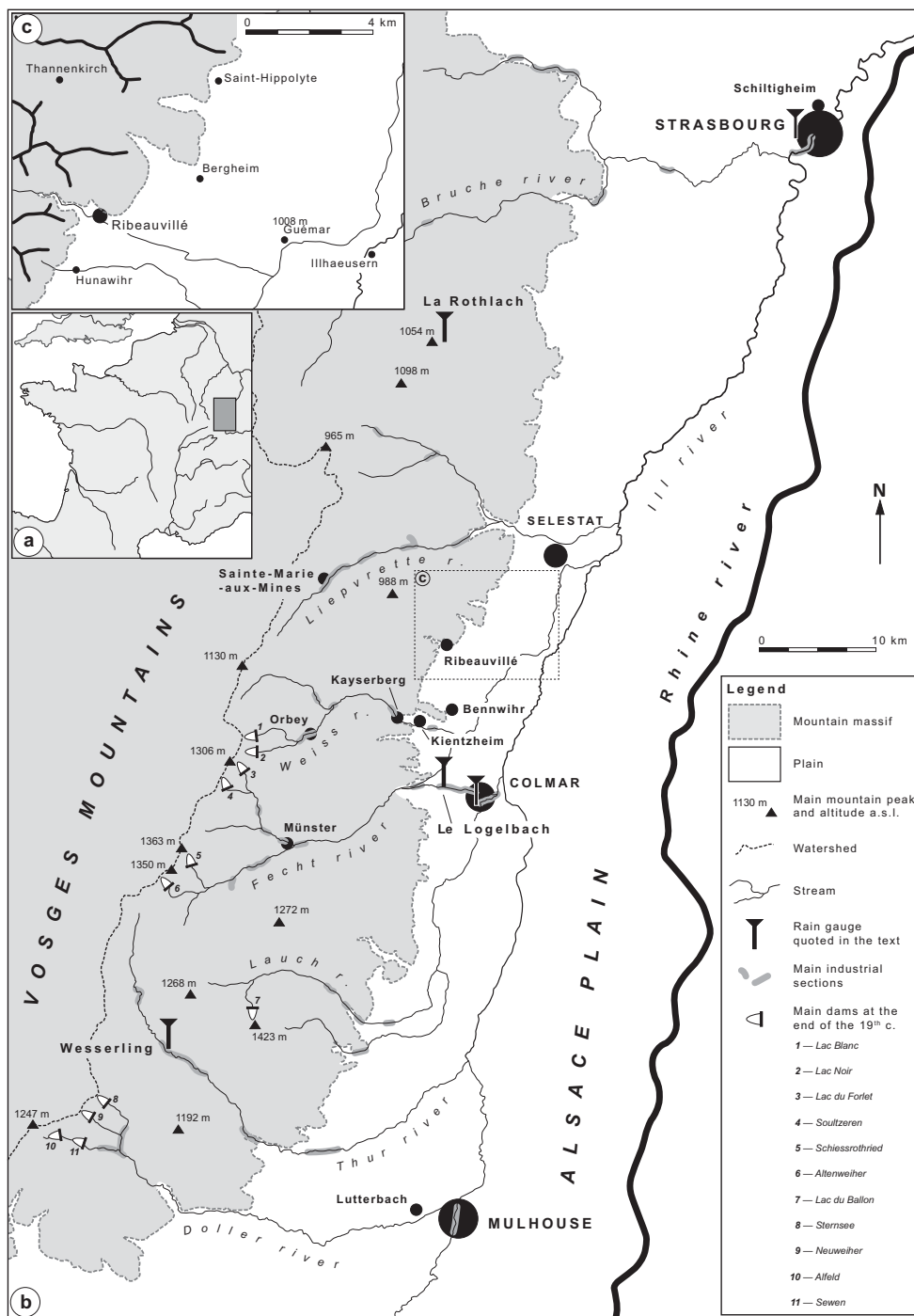


Fig. 1 Location of the study area indicating the main places and stations mentioned in the text. Sources: French topographic maps of Cassini

(1761–1770), *État-major* (1818–1835) and the *Institut Géographique National* (2018)

of precipitation between the Vosges summits and the Rhine plain (2300 mm at the Grand Ballon, and 600 mm only in Colmar), occurring over a short distance: only 21 km separate Colmar from the Vosges ridge. The foehn effect, consecutive

to the downwind position of the plain, is partly responsible for this climatic framework (Chappaz 1975). While the Vosges are characterized by an oceanic climate (with a maximum of precipitation in winter), the Alsace plain enjoys a continental

climate (with a maximum of precipitation in summer, due to convective mechanisms).

The socio-economic context

The 1857–1858 drought occurred in the context of strong economic development that marked France during the Second Empire, both in its industry and agriculture. If the use of water for irrigation and mills is very ancient, the sustained population growth throughout the Industrial Revolution has considerably increased water requirements. The extension of watered surfaces and the proliferation of factories using water (weavings, forges, mills, fullers, sawmills, tannery, paper mill, dyeing ...) testify to such an increase in water supply. During the Industrial Revolution, and even until the beginning of the twentieth century, water remains the main source of energy for all industrial sites located in rural areas.

This sustained industrial development resulted in significant pressure on water resources. In the Haut-Rhin department, statistic censuses enumerated 841 factories in 1860 (AN F14 6036). In the Bas-Rhin, there were 700 factories in 1859 (AN F14 6037-6049). In the beginning of the second half of the nineteenth century, factories using water reached their maximum number in Alsace. Moreover, during the 1850s, a process of industrial concentration took place (Service régional, Alsace 2008), which led to an increase in the size of production units, thus in energetic needs as well.

Devoted to pasture or to scything, meadows were principally located in the alluvial bottoms of valleys but too on mountains slopes where water was derived from springs or small streams. Irrigation enabled to increase the productivity and to obtain a second, or even a third cut during very favourable years. Thereby, water was at the time a highly coveted resource.

To the multiplicity of uses was added the entanglement of water rights. A great number of industrial sites claimed very ancient rights dating back to the late Middle Ages, and sometimes before the twelfth century, as in many other parts of Europe (Lespez 2012). In addition, in case of competition over water resources, and to warrant vital productions such as flour, the mills were ensured to obtain priority over others. In Colmar, they had held this privilege since 1478 and 1594. In the eighteenth and nineteenth centuries, the industrialists continued to rely on these ancient rights to manage their conflicts.

The farmers practiced irrigation under the old customs, formalized by the civil code after the French Revolution. In the case of rivers neither navigable nor floatable, the civil code allowed any riparian owner to divert the water to irrigate his fields (section 644). Hence, collective institutions or practices did not necessarily exist; agreements for sharing water resources were generally private. Such cases of “non-regulated hydraulic system” (Jacob-Rousseau 2015), which in fact

characterized most of the French countryside in the nineteenth century, resulted in many tensions and conflicts over the use of water resources. These conflicts almost invariably matched situations of natural shortage (low waters or prolonged droughts), aggravated by unfettered exploitation practices.

Materials and methods

Meteorological data

Several long series of weather records allowed us to study the evolution of precipitations during the nineteenth century. We used the Global Historical Climatology Network (GHCN) database, available on the National Climatic Data Center’s website: <http://www.ncdc.noaa.gov/ol/climate/research/ghcn/ghcn.html> (Vose et al. 1992). Rainfall records are available at a monthly resolution.

Besides the Alsatian rainfall series of Strasbourg and Colmar, we selected 18 other stations covering the period 1850–1890, and located in a geographical area surrounding Alsace, so as to be able to put the 1857–1858 dry sequence back in its climatic and geographical context, at a regional scale. The characteristics of each station are summarized in Supporting Online Table 1.

Besides, we were fortunate to find three other stations located in Alsace (see Fig. 1), in a compilation of French meteorological observations (Raulin 1881). The series of La Rothlach, Le Logelbach and Wesserling have the advantage of being continuous, and sufficiently long to be exploited (Supporting Online Table 2). Added to Colmar and Strasbourg, these series provide an even more accurate knowledge of the dry sequence in Alsace. Even though five rainfall series were available to us, thus giving us correct, spatial density of information, they did not exactly stand for all the nuances of the Alsatian climate. Only one station, La Rothlach, is situated in the mountains.

Given the limited number of rainfall stations, and the predominantly qualitative aims of our study, we opted for simple treatments, allowing stations to be compared with one another. For each station from the GHCN database, we calculated the annual average of rainfall, over the period 1861–1890. For the three other series taken from Raulin (1881), all being shorter because ending in 1869 or 1870, we calculated the annual average on the entire duration of available observations. In particular, it enabled us to avoid expressing the values in millimetres, when the measurement conditions from one site to another were not exactly known.

For the five Alsatian stations (Strasbourg, La Rothlach, Colmar, Le Logelbach and Wesserling), all studied at the intra-annual scale, we compared the gross rainfall values for

each month with the average monthly rainfall, in order to analyse the seasonal course of the drought from 1857 to 1859. To perceive its delayed effects (the drying up of springs, the low-level of the aquifers, the low water of rivers), of which one does not find in the archives any measurement for this period of time, we expressed for each month the cumulative deficit of rainfall over the 12 and 6 previous months, while always comparing the deficit either to the annual average or to the average over 6 months (cf. Cole and Marsh 2006).

The narrative documentary sources

On the other hand, we collected precise, historical information describing the course of the drought and its consequences. Archive documents are useful to understand the social and economic consequences of droughts, and to appreciate the way in which they were perceived by populations (cf. Brázdil et al. 2018). Yet, in the case of droughts, a difficult point is that “the duration defined by the historian does not correspond to a total absence of rain but rather to its chronological perception by societies” (Garnier et al. 2015, p. 5). Thus, it requires a constant, dialectical reading of descriptive sources and meteorological data.

Archives containing drought- or shortage-related information are varied and numerous as water issues have economic importance, and deal with a wide range of activities. The specific contributions from each type of source are presented in Supporting Online Table 3. Narrative sources in the National archives (AN), departmental archives (AD), and municipal archives (AM) of French administrative archives are the basis of our study. They consist of letters written by municipal stakeholders, farmers, industrialists, engineers etc. Some reports, written by engineers or individuals focusing on dam projects and/or irrigation issues, also proved helpful. We also found departmental decrees and statistical reports about harvests disrupted by the drought. These sources all attest to the political and social reactions during the drought.

The 1857–1858 drought in Alsace: from climatological and hydrological observations to social troubles

The 1857–1858 drought in France and in Europe

The rainfall analysis of the 20 selected stations shows that, between 1850 and 1890, either dry years or dry sequences affected the area on both sides of the Rhine Graben (Fig. 2). In general, the period between 1857 and 1872 is characterized by a lower rainfall amount than the average rainfall over the whole period. The dry sequences of 1857–1858, 1864–1865, 1870–1871 and 1884 are well identifiable. The first two

sequences are the strongest, showing a deficit of more than 20% compared with average of the 20 selected stations (1857 and 1864), and the 1857–1858 event appears as one of the most severe of the nineteenth century. For some stations, the deficit is reached or exceeded 40% of average. Although this sequence did not necessarily reach exceptional records in every station during the second half of the nineteenth century, it was characterized by a marked drop in rainfall in all the stations studied. Moreover, it had a geographical extension the 1870–1871 sequence did not reach. Though the latter sequence sometimes exhibited pronounced rainfall deficits, they were limited to a smaller area (Colmar and Burgundy), while precipitations remained close to, or above the average in many stations in western Germany.

Besides, the cartographic approach of the 1857–1858 sequence enables us to specify its geographical characteristics (Fig. 3). In 1857, a general gradient was perceptible between the western part (Burgundy) and the eastern part of the studied area, around 12–20% to 30–40% below the average value. In 1858, the gradient was rather oriented from the south-west to the north-east, with a smallest deficit in southern Burgundy and Jura, and the highest around the Rhine Graben. The deficit is particularly strong in the south and east of the Rhine valley, just as around the Jura massif, whereas it is less sensitive in the other parts of France. Its geographical extension is comparable with that of the 1834 drought (particularly hot and dry in the Germanic countries) or, more recently, to that of the 2018 drought.

Nevertheless, large discrepancies may appear between the values recorded in geographically close stations, like Colmar and Strasbourg in 1857 (with respective deficits of 6% and 32%). We cannot exclude uncertainties due to the questionable quality of the old records, as well as to the relatively simple treatment we carried out. Yet, it might also reveal local conditions, such as the influence of topography and meteorological phenomena of small extent, as we will now examine through a comparison of the two dry years. In most stations, 1857 is drier than 1858. This is particularly the case in the N-E part of our study area, and in the Jura massif. As a matter of fact, the rainfall analysis is interesting, as 1858 was considered especially dry by its contemporaries, as we will see later.

At a European scale, the currently available studies tend to confirm the scheme we suggest. In England, 1854–1860 was a major, long duration drought. Cole and Marsh (2006, p. 33) mention a “sequence of dry winters in both the English Lowlands (seven in succession in Oxford) and northern England”. In 1858, the so-called Great Stink, stemming from the polluted River Thames, caused thousands to flee the city. In Belgium, the rainfall measures in Bruxelles-Uccle showed the total amount of rainfall in a 12-month period, reached its minimum between July 1857 and June 1858 with 454 mm of precipitation, only a little more than half of the normal value.

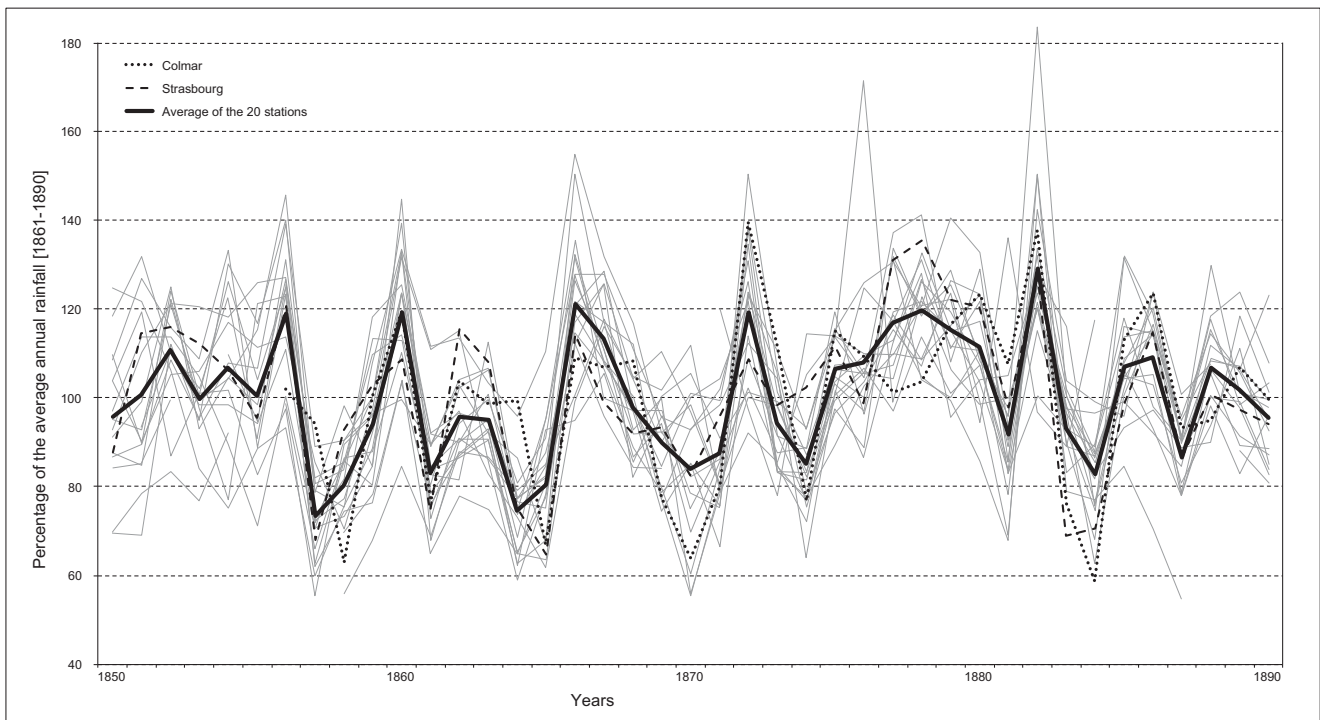


Fig. 2 The evolution of rainfall between 1850 and 1890 in the 20 stations selected from the Global Historical Climatology Network database; the average annual rainfall is calculated over the 1861–1890 period

In Maastricht, the year 1857 showed an important rainfall deficit, with only 356 mm of precipitation. On August 20, 1857, the *Algemeen Handelsblad* in Arnhem (the Netherlands) reported an extremely long drought, as springs and streams were dry. One year later, on August 19, 1858, the drought seemed even more severe, with very low waters in the Véluwe. In Bern (Switzerland), the summer of 1857 was the driest recorded from 1760 to 2003, with a precipitation total of 97 mm (Gimmi et al. 2007). In France, Emmanuel Le Roy Ladurie evokes three, consecutive springs and summers, relatively hot and dry—1857, 1858, 1859 (2006)—but he does not give any further details. We should underline that in the south of France, the total amount of rainfall was higher than the average.

The climatological drought at fine timescales

Conducted from 1857 to 1859 in the five Alsatian stations, our study intended to better perceive the temporal structure of the phenomenon, by expressing the deficit or surplus, compared with the monthly average (Fig. 4). Given our sample had internal heterogeneity, we had to be careful with the obtained values. In fact, for the three stations reported in Raulin (1881), the averages were calculated over a shorter period that did not match exactly the reference period for the 20 stations taken from the GHCN database (see Supporting online tables 1 and

2). Nevertheless, the comparison between the two series of Le Logelbach and of Colmar (3.5 km away, in the same topographic situation) showed they are very close to each other, both in terms of rainfall variations, as in terms of the deficit or surplus values compared with the monthly averages. Considering this station has the shortest observation time of our entire sample (Supporting online table 2), the two other stations of Wesserling and La Rothlach show enough reliability for an interpretation of the dry sequence.

The graphs show the deficit started as early as January 1857, and even in December 1856, when the monthly precipitation was below average. The deficit went on until the beginning of 1859, although being discontinuous and unequal according to the stations. In particular, it was very strong at La Rothlach and Wesserling.

At the same time, we noted the fast fall of cumulative precipitation values, over 6 or 12 rolling months. From the 1857 spring, the values were below average for nearly two years. For the cumulation over 6 months, the values were always lower than the average, suggesting there was in fact almost no remission during the dry episode. 1857 was apparently not as dry in Le Logelbach and Colmar (see also Fig. 3), as both stations showed a very wet month of August, as well as a little rain at the beginning of autumn. We also found such positive fluctuations in Wesserling, Strasbourg and La Rothlach, although they were very weak, especially in the

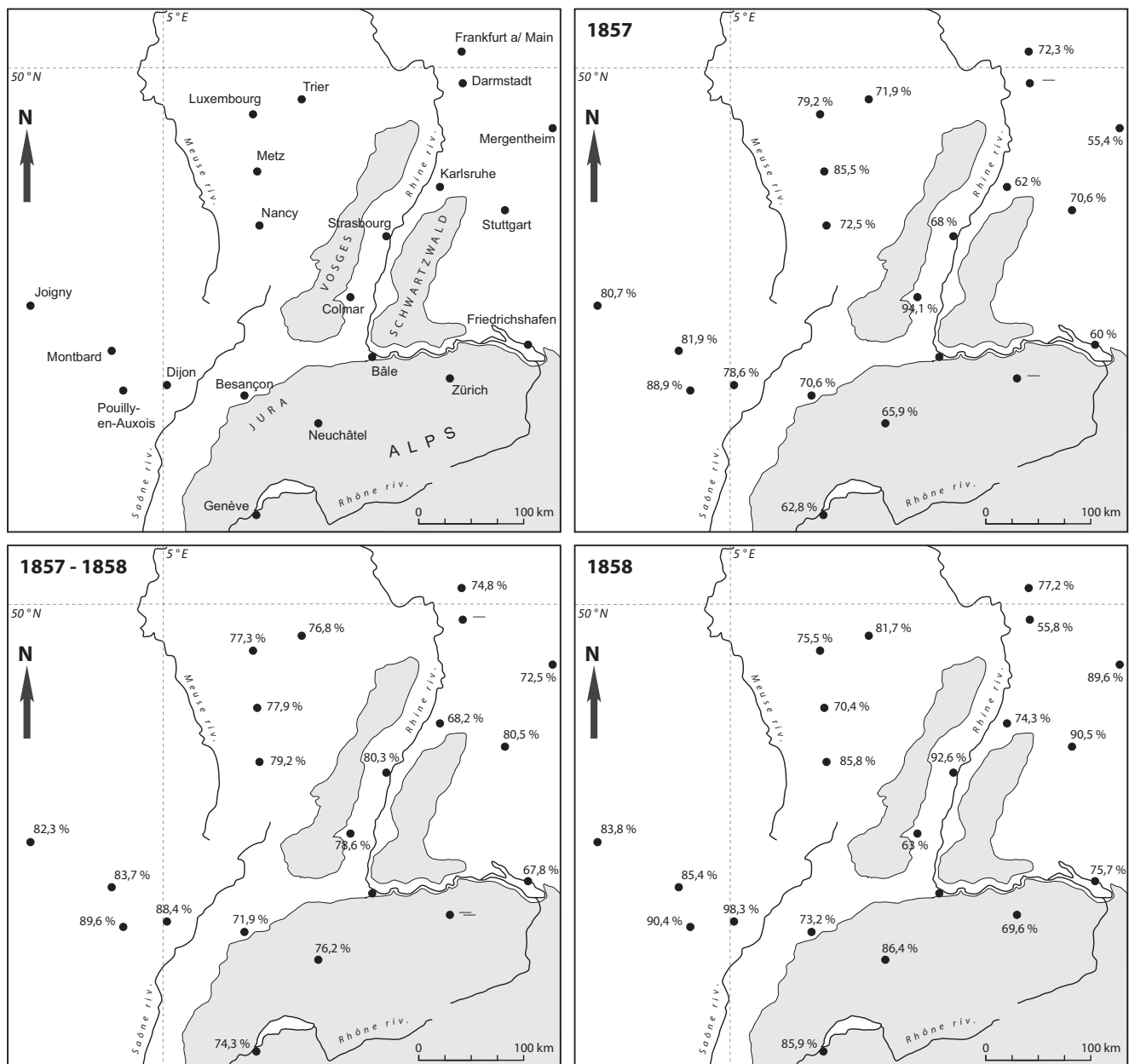


Fig. 3 Location of the studied rainfall stations, and cartography of the rainfall deficits in 1857, 1858 and of the average deficit over the 1857–

1858 sequence (the reference period for the annual rainfall average is 1861–1890)

latter station. This suggests these rainfalls were thunderstorms produced by convective clouds localized over the plain of Alsace, a typical feature of this area during summer. This hypothesis is furthermore supported by the absence of heavy rainfall in the only mountain station of our sample (La Rothlach), as well as in Wesserling, located within the Vosges mountains (Fig. 1).

The monthly analysis confirms and specifies the approach at annual and regional scales: 1857 appeared drier

than 1858. Even though it is not as clear in Colmar, if we set apart the summer contributions which were probably stormy and concentrated in time, we would find the same general trend.

In terms of precipitation trends, the most critical moment occurred at the end of 1857 and at the beginning of 1858, when cumulative totals over 6 and 12 months reached their lowest level. However, in Colmar and Le Logelbach, cumulative totals over 6 months were already

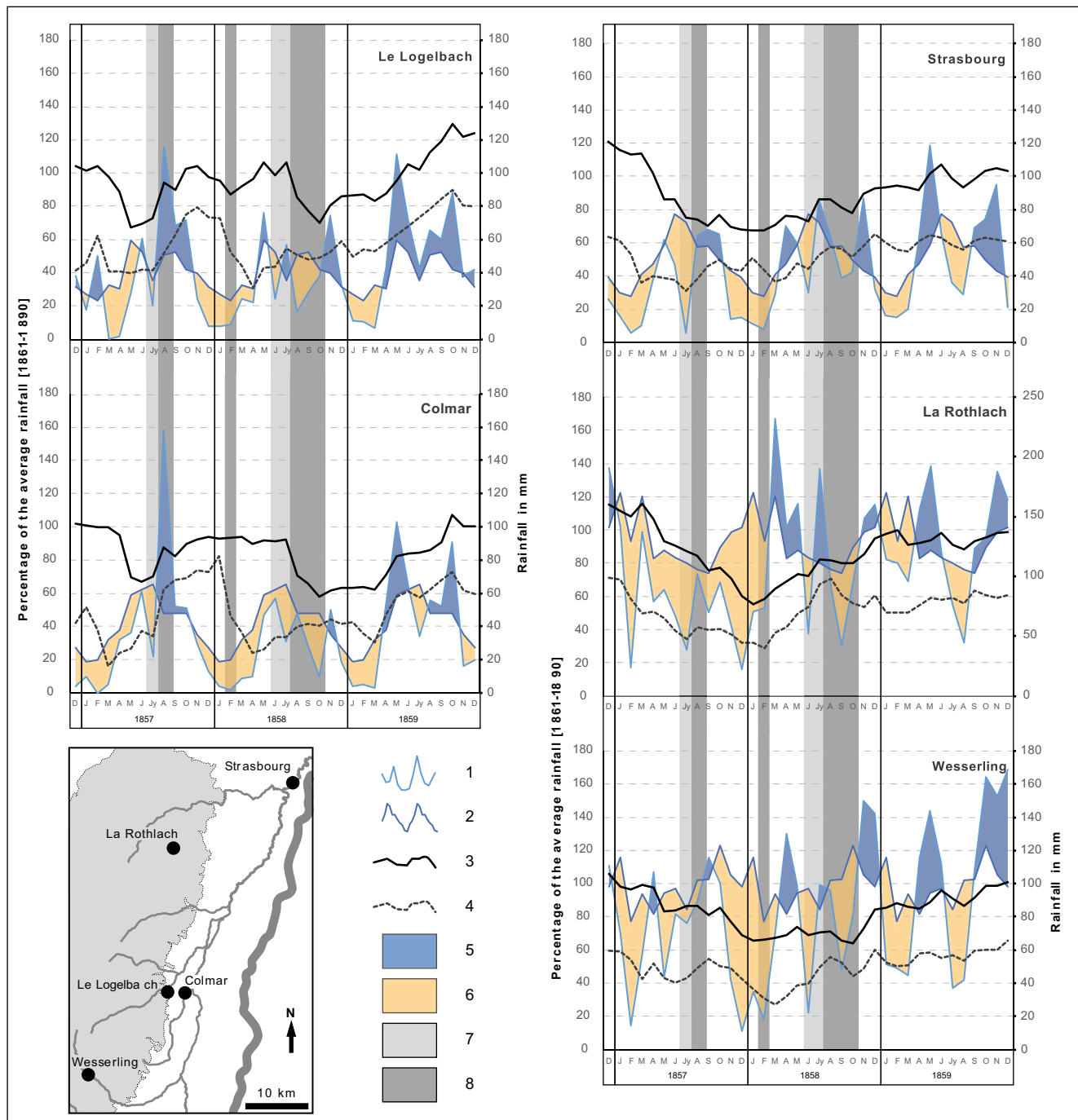


Fig. 4 Monthly rainfall and evolution of rainfall deficits between December 1856 and December 1859 in the five studied stations; characterization of the drought severity according to documentary mentions. (1) Annual rainfall (12/1856–12/1859); (2) average annual rainfall [1861–1890]; (3) cumulated rainfall over 12 months (percentage of average annual rainfall [1861–1890]); (4) cumulated rainfall over 6 months (percentage of average rainfall over the previous 6 months

[1861–1890]); (5) rainfall surplus compared with the annual average [1861–1890]; (6) rainfall deficit compared with the annual average [1861–1890]; (7) period with documentary mentions of drought; (8) period with documentary mentions of intense drought. Sources: Global Historical Climatology Network database, Raulin (1881) and documentary archives (see details in the text). Note that the rainfall deficit remains sensitive until the first half of 1859

very low at the beginning of 1857. This critical period also corresponds to a strong precipitation deficit that took place in the autumn of 1857, a common feature in all stations. In this respect, La Rothlach was very instructive,

as we observed very clearly the low rainfall in the autumn (following a downward trend since March). Between November 1857 and February 1858, the cumulative totals of the 6 previous months only reached about 30% of the

average rainfall, for the same period of the year. Such a fact inevitably reduced the amount of water stored in the mountains in the form of snow, thus reducing the water supply to rivers in spring. In these conditions, it makes no doubt water scarcity was strongly felt by the cultivators. Yet, this did not happen in the fall of 1858, which probably led to an increase of river discharges in 1859.

The hydrological drought

Numerous testimonies mentioned a very low flow of rivers in Alsace and it was particularly the case during the 1857–1858 winter (Pfister et al. 2006, p. 967). Yet, the most interesting testimony in the archives was given on February 28, 1858, in the *Journal de Sainte-Marie-aux-Mines* (Bas-Rhin), quoting the *Journal de Belfort*: “for 160 years, we have not seen the waters of the Rhine as low as they are. In Beuggen, people jump between the two sides with a pole. Between this city and Saecingen, a rock appears in the middle of the river, where one can walk with his feet dry. On January 6th, a mark with the current date has been incised in the previously mentioned rock”.

The aforementioned stone seems to remain unknown up to this day, even though there are other (rare) indicators. Garnier et al. (2015) mention the stone of “Laufenstein”, which served as early-stage indicator for the local populations for centuries. Yet, this rock situated in Laufenbourg, 40 km east of Basel, disappeared. Fortunately, it was described in 1901 by an engineer (Supporting Online Figure 1): The extreme events of 1541, 1750, 1823, 1858 and 1891 are reflected.

The archives also reported that the effects of the winter drought were still vivid during the summer. During the haymaking season in August 1858, a letter of the mayor of Guémar mentioned: “The making of hay has not been satisfactory. Because of the drought in June, and the absence of an overflowing of the Ill river past winter, our fields were not garnished, and the harvest can be evaluated at more or less

half of an ordinary year”. In 1859, the Conseil général of the Bas-Rhin department spoke about an “extraordinary drought” occurring in 1858. The canal between the Marne and the Rhin was not navigable, as there was not enough water available to refill it.

The economic and social consequences

Winners and losers: the testimony of agricultural statistics

The archives contain many reports of poor harvests caused by the drought. Relying on agricultural statistics (Table 1), we focused on wheat, *meslin* (mixed wheat and rye) and rye crops in the township of Ribeauvillé.

In general, the year 1857 was favourable to cereals, as yields were 30% higher than the average harvest. Yet, there were disparities: in Ribeauvillé, the harvest was 40% above the average value, but only corresponded to the average value in Thannenkirch. Microclimatic nuances may have played a role, depending on the topographic position and altitude. Indeed, the greater part of Thannenkirch is located at more than 500 m of altitude. We may thus attempt to establish a parallel with the rainfall series of La Rothlach, which exhibited only a small deficit at the end of the 1857 winter. Conversely, in the municipalities of Bergheim, Saint-Hippolyte and Guémar, the wheat fields were located in the same topographical situation as in Colmar and Le Logelbach, where dry weather occurred earlier in the year. However, the available documentary sources should not make us forget the other productions. Thus, in Guémar, where cereal crops are 25% above average, the 1857 drought was nevertheless considered harmful to agriculture. This suggests that depending on the importance of the various crops (cereals, fodder, orchards, potatoes...) in the overall agricultural production, the economic impact could greatly vary from one municipality to another.

In addition, Table 1 shows a strong difference between the two years. In Ribeauvillé, a document dated from October 24, 1858, mentioned that the drought had had a “detrimental influence on the quantity and quality of products”. At the scale of the canton, the harvest is quantitatively lower than 20–25%, compared with the average value. There is also a spatial contrast between the municipalities of the Rhine Graben and the others: in Illhausern, the proximity to the Ill river in the alluvial terrains was probably an advantage for cereal crops in 1858. In Saint-Hippolyte, closer to the Vosges, and perhaps more affected by the foehn effect, the harvest was very bad. The small rivers coming from the massif were probably dry in the summer, because of very low rainfall (and probably a thin snow cover) during the previous winter, as shown in Fig. 4. Unfortunately, the absence of data for the other municipalities did not allow us to have a more complete view of the year 1858.

Table 1 Grain harvest in the canton of Ribeauvillé in 1857 and 1858, according to the municipal, agricultural surveys. Sources: AM Ribeauvillé F52

	1857			1858		
	Wheat	Rye	Meslin	Wheat	Rye	Meslin
Bergheim	30	30	30	−20	−20	−20
Guémar	28	25	25	−18	−18	0
Hunawhir	30	0	30	—	—	—
Illhausern	20	0	0	−5	10	10
Ribeauvillé	43	43	43	—	—	—
Thannenkirch	0	0	0	—	—	—
Saint-Hippolyte	34	34	34	−25	−30	−30
Ribeauvillé (C ^b)	31	29	31	−21	−24	−24

The perceived drought: discrepancies and time variability

It is relevant to compare the rainfall situation with the frequency of drought record in the archive documents (letters, reports from engineers, complaints or petitions). These fairly precise statements allowed us to determine two types of period: (1) the phases in which drought is simply mentioned by the scarcity of water; (2) the phases in which it is described as exceptional (the “great drought”, the “extraordinary drought”), and sometimes associated with very severe impacts such as fires, or with conflicts between right-holders.

Figure 4 shows there is no exact coincidence between rainfall patterns and their social perception. While the beginning of 1857 was marked by the start of deficits, they did not give way to any particular mention. This can probably be explained by the relatively well-watered autumn of 1856, as well as by sufficient flows in the spring to satisfy the agricultural (meadows irrigation) and industrial needs. On the other hand, there is no mention of agricultural drought in December 1857–January 1858, although the rainfall deficit (cumulative values) reached a peak in the studied period. Logically, this is due to the fact these months correspond to the agricultural off-season. Only two documents mentioned a drought at this time of the year, and were written by industrialists, whose factories either operated all year round (AN F14 6380, AD68 7S314).

Interestingly, many testimonies mentioned a serious drought in August 1857, when the amount of precipitation was much higher than the monthly average in Colmar and Le Logelbach, yet close to the average in Strasbourg. In the two remaining stations, the deficit was relatively small compared with the other months. This suggests these precipitations did not make up for the deficit trend that had started several months earlier. It also reinforces the hypothesis according to which these rains were short-lived, stormy events (see above). In this case, the rainfall amount could be abundant over a short period, and the drought could reappear soon after the rainy episodes. We may add that during the vegetative period and in the summer, rain interception by vegetation can reach 30% of the total in the temperate milieu, which further reduce the contribution to soils and flows. Undoubtedly, the summer of 1857 remained dry even in Colmar and its surroundings, the documentary sources of which enable to specify the data provided by pluviometric records. Fires are mentioned in the archives, and they may confirm the situation of summer drought. This happened in Schiltigheim in July 1857 (67 AD 3M122). In August of the same year, because of the drought, the municipality of Sainte-Marie-aux-Mines reminded its inhabitants of the absolute prohibition to divert water and to irrigate, in accordance with the Regulation No. 50 of the municipal police. Besides, to prevent fires, the inhabitants had to place a basin of 50 l of water at the front of their house (AM Sainte-Marie-aux-Mines).

Social troubles and conflicts

Water scarcity led to numerous tensions and conflicts between water users, farmers and industrialists. Agricultural withdrawals resulted in a weakening of flows in streams, where water level was already low due to the drought. On irrigated surfaces, part of the water was consumed by plants and evaporated. On the other hand, industrial canals diverted a significant part of the river discharge (sometimes several hundred litres per second) between the water intake, and the discharge channel, located downstream of the plant. In such short-circuited sections of rivers, which could reach several hundreds of metres long, the flows were sometimes insufficient for riparian farmers.

On August 14, 1858, numerous irrigants from Kientzheim claimed the right to take water from the canal, between Saturdays at 6 p.m. and Sundays at 6 p.m., despite the canal being completely dry. Located downstream from the Kaysersberg industries, the petitioners made the industrialists responsible for the shortage, and argued that water was sufficient to irrigate their grasslands before factories were built (AD68 7S314).

The petitioners then became vindictive, especially since the industrialists had “the remarkable idea” to ask for their help in building a dam upstream, because of the repeated droughts. The dam was intended to stock water reserves in winter, in order to reduce shortages during drought periods. Yet, to the question asking whether the canal was dry because of natural droughts, or increased water withdrawals from industrialists, farmers unambiguously chose the latter. They further added: “If the imperative need to accumulate wealth encourages them to build a hundred new plants, [industrialists] would say having water for 10 leagues round (“dix lieues à la ronde” in French) is essential to operate their factories.” This controversy took place during a particularly tough period of the 1857–1858 drought. Indeed, Fig. 4 shows that, except in April 1858, precipitation in Alsace had been very low since autumn 1857.

Here, we are faced with a blatant example of social tensions occurring between two economic worlds, each having their own logic and means. The farmers used the dam project as a mere pretext to express deep rejection, both of industrialists and of industry. Relying on water rights granted to flour mills sometimes in a distant past, industrialists had indeed made irrigation practices more difficult, especially as the conversion of mills into factories had increased the pressure on water, and the volumes were redirected between water intakes and factories.

On June 15, 1856, the industrialists suggested to appoint water guards who could themselves irrigate the farmers’ fields. Undoubtedly, such a suggestion stood as an attempt for overall management, in a situation characterized by

multiple conflicts, and by the absence of any coherent, water-sharing rules. However, numerous municipalities opposed the project. As the conflict was still ongoing at the end of 1858, the Ponts-et-Chaussées engineers following the affair decided to close the case on May 10, 1859. This suggests the situation was tense even after the dry sequence of 1857 and 1858.

On such watercourses, neither navigable nor floatable, the right to exploit the water resource was attached to the riverine property. Therefore, concerted management initiatives were extremely rare and could even be misunderstood, insofar as it was feared they would establish, *de facto*, ways of managing which would restrict the ordinary old rights, and which could then set a precedent.

The political and technical answers

The position of the authorities and the rules of water use: the case of Colmar and the Fecht river

In the nineteenth century, in the Fecht river basin, to let the water flow to Colmar without being diverted in periods of low water was a challenge. The valley and the city were home to many factories, and flour mills continued to play a vital role in feeding the urban population. The records suggest that in 1857 and 1858, and probably during most of the nineteenth century, the prefectural authorities (based in Colmar) were completely “hand-in-hand” with the owners of industries (Supporting online table 4), thus guaranteeing the volumes of water needed for their activity. At the same time, the authorities may also have feared discontent from the urban population, if ever the unemployment in the mills had produced a shortage of flour.

Consequently, the farmers had to adapt to the industrial, water needs. In a letter from February 24, 1858, the ordinary engineer of Haut-Rhin claimed the water could be used [by the factories!] all year long, as long as the water level remained above the marks placed in the bed of the river, near the factories. Other sources confirm this observation. Two letters dated from July 18, 1857, were sent to the mayors of the Fecht Valley. The author, the prefect in Colmar, required the municipalities to publish once again the old edict from the Alsace Intendant, dated June 18, 1779. The order formally prohibited to divert the waters of the Fecht river, and of the Le Logelbach canal, during “periods of drought”. A letter addressed directly to the mayor of Munster, located higher up in the valley, recalled the 1779 edict while being even more detailed: complaints were made because of inappropriate irrigations, using the waters from the Le Logelbach canal. These waters were considered necessary to the factories, and to the healthiness of Colmar (AM Munster O III 229 B). The 1779 edict was also mentioned repeatedly during the summer of 1858.

In our case, the domination exerted by the industry—supported by the state authorities—on agriculture—supported by some municipal authorities—seems quite clear. A few

years after the 1857–1858 drought, during the summer of 1870, also marked by significant rainfall deficits, guards escorted by police officers destroyed the dams built by the meadows’ owners, in the month of July. However, at the end of July, the ordinary engineer handling the case, suggested to conduct a public inquiry in order to grasp the possible advantages and disadvantages of organizing irrigation every evening from 19 to 4 h in the morning. It is the first time an engineer had established such type of rules, with potential benefits for irrigators fighting against nineteenth century regulations and official decrees. Following this investigation, the prefect sent a brief letter to the French minister, indicating the suggestion seemed appropriate (AN F14 6381). A few days later, the engineer-in-chief wrote in his control report: “Given this situation, we would like to ask whether we should not seek to make significant changes to the regulations in the Haut-Rhin” (AN F14 6049). Just before the Franco-Prussian war, such important changes would drastically modify the drought thresholds, and precipitation deficits would not be experienced in the same way anymore. The archive testimonies would also change, which implied a reinforced, critical approach of the sources in a comparative study.

The technical answer

As mentioned above, some water users facing scarcity suggested to build dams to increase the flows during the summer. In 1857, the Kayersberg industrialists had decided to build one on the small, glacial lake release (Lac Noir), as they intended to use the latter as a reservoir the following year. However, they were totally at odds, and the dam was not built. Unlike them, farmers did not have the economic capital necessary to such an enterprise although it could have been beneficial to them (AN F14 6381).

Similar dam projects appeared in many valleys of the Vosges (Supporting online Table 5 and see Fig. 1) and, during the drought of 1857–1858, or soon after, 4 dams were built. Although the technical and political context was very favourable to these undertaking at that time, repeated references to projects of the kind suggest the drought may have encouraged the establishment of such “technofixes”. On August 31, 1846, on a very hot and dry day, the millers and industrialists of Orbey sent a letter to the prefect (AD68 7S314). They argued that during the drought, the working class was in a very difficult situation, because of reduced work and rising food prices—a consequence of the drought that was not observed in 1857–1858. The solution they found was to build two dams on the Lac Blanc and Lac noir, to support the summer flows of the stream.

These dams possibly played a role in weakening social tensions, as higher volumes of water were available during periods of scarcity. There were also changes in the design of

methods for water management. In the late 1860s, the idea of building dams “in the public interest” appeared (AN F10 / 3569). At this point, industrialists and farmers seemed to be treated in the same way, in the various reports we found. In February 1869, the General Council of Ponts-et-Chaussées wrote that dams could be of public interest: “if they improved both the agriculture and industry, and not exclusively the industry”. Gradually, the engineers of the department adopted a nuanced speech: “the old rules had to be changed in the department of Haut-Rhin” (7S288).

Discussion

The archives show the sensitivity to droughts is highly dependent on the social and economic context, at the local scale. As Taylor et al. (2009) emphasized in their study of past droughts in England and Wales, droughts are not only natural events but also shaped by the framework of institutional management. In this sense, rainfall deficit must be understood as a “pistolero”, in the words of Le Roy Ladurie (2013).

Is the 1857–1858 drought a crisis?

The study of the 1857–1858 drought, in its natural and social components, should allow us not only to analyse an environmental crisis (Beck et al. 2006) but also to discuss the notion of crisis. The drought is a crisis insofar as the testimonies left in the archives allow us to understand and grasp the opposing forces, and the ordinary conditions of resource management (here the water). Such is the original meaning of the word “crisis”, the moment it becomes possible to make a diagnosis (Portal, 2009). Crises are not lived in the same way by each person, and from such a point of view, the multifactorial approach on a fine scale is an opportunity to better analyse crises.

The strong pressure on resources characterizing this era seems to have played an important role in exacerbating conflicts. Water withdrawals increased in the whole Fecht basin during the previous decades, and they lowered the resistance threshold, thus allowing the 1857–1858 dry sequence to have a strong impact. In numerous catchments, all available water was consumed or used, either by farmers or by industrialists; consequently, there was no available margin in case of dry spells. Such a situation is comparable with what happened in many other French regions at that time (Berger 1998, Jacob-Rousseau 2015, Jacob-Rousseau et al. 2016). However, the local-scale approach reveals different power relations, from one case to another. In the eastern part of the Massif Central, the pressure exerted by industry (silk factories and paper mills) was undoubtedly more intense than that of agriculture,

because the industrial canals were watertight, up to the point of entry into the factory, whereas agricultural canals allowed part of the water to rapidly seep into the ground (Jacob-Rousseau 2015). In Burgundy, where the hydraulic industry was mainly represented by wheat mills, it seems, on the contrary, that agriculture exerted a strong pressure on industrial needs, to the point it sometimes required the intervention of authorities. Thus, in 1858, water withdrawals from farmers resulted in the drying of river reaches (Jacob-Rousseau et al. 2016). Such an example shows the water resource was heavily exploited, and sometimes overexploited, in the middle of the nineteenth century.

On the other hand, the 1857–1858 episode does not make a crisis in the recent sense of the word (Portal 2009), defined as a moment of general confusion, during which nobody knows which conduct to adopt. Nowhere in the archives was a questioning of ordinary practices found, nor of the legal bases from which competition for water developed.

The crossroads of water rationalities

The construction of dams, upstream of the valleys, appears to be a fairly innovative response to the water shortage of the 1857–1858 drought. However, we should not interpret it as a binary mechanism, associating a process (drought/shortage) with a response (hydraulic equipment policy). Such a turning point, which seemed to occur during the 1860s in the studied sector, has to be placed in a broader context.

The previous decades were marked by a sharp increase in pressuring the water resources and the consecutive increase of conflicts. Moreover, we witnessed during this period the rise of the Ponts-et-Chaussées Engineers Corp and the assertion of their technical expertise (Ingold 2011). The 1857–1858 drought occurred at a time when the concept of watershed was perfectly formalized, and provided the framework within which engineers could propose the water resource management. Besides, this period also corresponds to the development of the interventionist state and to the formalizing of projects considered “of public interest”. In France, during the Second Empire, and after the great floods of 1856, environmental interventions were implemented: reforestation, torrential corrections and dam projects to prevent floods (Picon et al. 2006). Such an integrative design totally differed from the most prevalent modalities of water management at the time, based on riparian property, personal and transmissible water rights, and on water exploitation at a river reach level. Two very different rationalities were at work there, and we should not be surprised that dam construction projects, in other regions of France also, led to tensions between the different groups of water users.

The implications of our findings: the need for a fine spatio-temporal resolution

The analysis of the 1857–1858 episode at a fine, spatio-temporal resolution, reveals a complexity that does not appear in a global approach, at the annual or interannual scale. In the case we studied, we noted that the economic impacts (in particular on agriculture), and the perception of the severity of the phenomenon and of its consequences, can vary over short distances (about ten kilometres), and over short durations (a few weeks to a few months). The location of the sites from which the documentary evidence, or the nature of the agricultural productions originate, can explain the heterogeneity. On the other hand, two successively dry years that appear as fairly comparable at the interannual scale (Figs. 2 and 3) are in fact rather different at the intra-annual scale. From this point of view, it is remarkable that the mentions of very intense drought are more numerous for the year 1858, during which the rain deficit was not greater than in 1857. The cumulative impacts of low rainfall on agricultural production over several successive years were also shown for various episodes of the past (Jacob-Rousseau and Astrade 2010). This underlines the fact every drought has its own characteristics, and that it seems difficult to model the variety of events. It also probably points to limits to the comparison of episodes on the basis of the only rainfall values.

From a methodological point of view, the microhistory approach of past droughts is not only possible but it also makes an interesting contribution to the analysis of events. It further leads to an environmental history of water management. It allows us to open the black box of society, in the words of Pfister (2010), and to question the relations between climate and societies, from a point of view other than that of determinism. On the other hand, in seeking to interpret the facts from a variety of angles and at different spatio-temporal scales, *microstoria* may reduce the incompatibility between the macro and micro-level approaches (Pfister 2010) in narratives about climate change (Adamason et al. 2018). It shows the meteorological episode certainly fits in a climatic trend, but also in a socio-economic trend, and in a mode of development of which the meteorological episode reveals the fragilities.

The limits of documentary data and cross interpretations

We inevitably faced certain documentary limits. Such a “documentary puzzle”, to use the words of E. Garnier (2010), is on the one hand incomplete, and on the other hand heterogeneous, as it consists of direct and indirect data (or proxies), whose respective scope must be correctly evaluated. Every narrative is more or less influenced by the social, cultural

and political dimensions of an individual, or by private interests related to water (e.g. Aguilera-Kink et al. 2000). We took into account the fact that tellings can hide, knowingly or not, structural aspects of water shortage, such as inequalities in water distribution, or pressures exerted by stakeholders (Jacob-Rousseau 2009). For example, such narrative sources show a seasonal variability of drought (spring and summer), as they often focus on agricultural issues. As Petit notes (2017), “the spatial and temporal interdependence around water imply a collective planning and arbitration with different interests”. Such interests must be decoded as much as possible, in order to better understand the causes of the “crisis”.

Furthermore, such an approach may be limited either by the heterogeneity or the absence of certain sources. In our field, most of the information comes from the elites and individuals having a dominant position in society (public servants, industrialists, main landowners). Cultivators and farmers left fewer writings and testimonies than industrialists and engineers, due to their lower political influence, and to a certain extent, to the marginalization of their interests and points of view by industrialists and engineers. Such a fact is an ordinary phenomenon in France, during the entire nineteenth century. The individual strategies of farmers are much more difficult to perceive.

Such an analysis should also be relevant when applied to the individuals and scientists who reported the weather observations at the time. For example, we curiously note that a large number of rainfall series in eastern France (Lorraine, Jura, Burgundy) began in 1858 or 1859. The foundation of the first meteorological network by Le Verrier, in November 1857, may have played a determining role. However, one should also question the possible influence of the 1857–1858 dry sequence, and the anxiety it may have produced among contemporaries about water resources, and even about climate “stability”. At the end of the nineteenth century, Roche (1899), a meteorologist from Montpellier, evoked the great 1837–1839 drought in Languedoc. In his study on meteorology and meteorologists, he noted that, at the time, the event “(had) made many people scream at climate change”, although it was only a short fluctuation in rainfall amounts. An investigation of diaries, if they exist and have been preserved, or in notarial archives, might provide a more accurate view of this part of society.

Conclusion

As we have illustrated, a study of the socio-economic structure of water management is essential to understand all the determinants entering a drought situation. At the scale of the territory, it seems essential to systematize the analysis of every component making a potential source of environmental crisis, such as droughts. Even today, one could easily

show, case-by-case and for each territory, which component of the socio-natural system makes a drought more prejudicial. As we have shown, particularly in mountainous regions, droughts are experimented in different ways depending on the people, their professional connections to water and on the location of sites in the various valleys and in each valley (upstream or downstream). This approach is grounded in a territorialized analysis of risks: every (spatialized) socio-cultural discourse is important in order to understand the process of risk production.

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Archival sources with mentions of droughts in Alsace Archives nationales: F146380

Archives départementales du Haut-Rhin: 7S288, 7S314
Archives départementales du Bas-Rhin: 3M122, 3M123
Archives municipales de Colmar: 302
Archives municipales de Munster: OIII229b
Archives municipales de Ribeauvillé: F52
Archives municipales de Sainte-Marie-aux-Mines
Archives municipales d'Erstein: OIII03b

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