LARGE FIRES AND CLIMATIC VARIABILITY IN URBAN EUROPE, 1500–1800

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ABSTRACT: Several hundred large urban fires occurred in Europe during the early modern period, but they did not take place randomly. This article charts their incidence and reveals a peak in the seventeenth century, coinciding with some of the coolest periods of the Little Ice Age. This apparent paradox can best be explained by climatic variability, since overall cooling was accompanied by numerous warm, dry anomalies. While the cause of fires was usually human activity, and small fires happened frequently, this paper shows that many of the largest conflagrations of the early modern period took place in years of such hot and/or dry climatic anomalies, and closer analysis of individual fires confirms that these meteorological conditions facilitated their spread. This strongly suggests that climatic variability associated with the Little Ice Age was a major determinant of the timing of large fires in Europe. Over the same broad period, climatic disasters linked to cooler and damper conditions contributed to social and political instability, and there is evidence that this in turn undermined fire prevention and control and thus further increased the likelihood of small fires becoming large ones.

KEYWORDS: History of fire; Little Ice Age; early modern Europe; urban history; climatic variability

The history of large fires in early modern European towns offers a striking paradox. Charting their incidence across a long period reveals that the greatest number, and many of the most disastrous ones, occurred during the coldest periods of the Little Ice Age. Five of the eight largest fires to strike European towns in peacetime, during the entire early modern period (1500–1800), took place in the thirty years between 1656 and 1686, and the seventeenth century as a whole witnessed a disproportionate number of major conflagrations. These included the Great Fire of London of 1666, the most devastating urban fire in Europe since Ancient times, and the second-largest early modern urban fire, the 1656 conflagration in Aachen that destroyed around 4,600 houses. This article argues that climatic factors provide much of the explanation for this apparent paradox, and that they do so in two ways. Firstly, a great number of large fires, right across the early modern period but particularly in the seventeenth century, coincided with anomalous hot, dry seasons. Secondly, the climatic disasters of the Little Ice Age contributed to political, economic and social instability that undermined the capacity of urban governments and populations to prevent and manage large fires.

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Until recently, neither urban historians nor environmental historians have paid much attention to climatic factors in accounting for disastrous fires.[1] Although large parts of individual European towns and cities burned at intervals, destructive fires have largely been taken as a given, accidents waiting to happen. Since flame was used for many day-to-day purposes, there was an ever-present risk of wildfire in towns built primarily of wood, with narrow streets and densely-packed housing. Only across the nineteenth century did urban fires that burned hundreds or even thousands of houses disappear from Europe, a change generally attributed to the introduction of less flammable building materials and to suburbanisation.[2] Environmental history has not shown great interest in early modern urban fire, despite Stephen Pyne's observation that, as long as towns were predominantly built of materials taken from the lands that surrounded them, primarily wood and thatch, urban fires behaved in the same ways as wildfires elsewhere. He too sees the nineteenth century as the major turning point in urban fire regimes, as industrialisation brought new forms of building and new ways of controlling and using fire (Pyne 2001: 101–18).

Only in the last few years have historians begun to recognise that accidental urban fires did not occur randomly in the preindustrial period. In 2012, the editors of an important collective volume, covering many parts of the world, argued that fire regimes have shifted significantly, particularly since the expansion of global trade in the seventeenth century, which drove the creation of new forms of wealth and social control. They suggested that in cities dominated by imperial and mercantile interests, by autocratic rulers, or by colonial elites, new political regimes combined with local environmental conditions to change the way fires took place and were managed (Bankoff et al. 2012: Introduction; Garrioch 2019a).

The influence of climatic factors, however, has only begun to be explored. The most important work to date is Cornel Zwierlein's monumental study of fires in German-speaking Central European towns during the past millennium (2021). It identifies 1666, unusually warm and dry, as one of the worst peacetime fire years in the continent's history, second only to 1540, which climate historians have shown to be one of the hottest and driest of the last 500 years. Zwierlein also points out that the two decades of the 1650s and 1660s not only witnessed a wave of fires in parts of Europe, but also huge blazes in Edo (Tokyo) and Constantinople (Istanbul). He concludes that anomalies linked

1. Exceptions are Mauelshagen 2010 and Zwierlein 2021: 90–99.
2. The key study is Frost and Jones 1989. There has been debate about the chronology proposed by Frost and Jones, and Shane Ewen has argued that the concept of the 'fire gap' is methodologically flawed. See particularly Pearson 2004: 33–38; Zwierlein 2021: 69; Ewen 2006.

to the long period of cooling were major factors in the conflagrations both of 1540 and 1666 (Zwierlein 2021: 90–99).[3] Drawing on this work, Geoffrey Parker (2013: 62–63) also connects drought with exceptionally large fires in the mid-seventeenth century, pointing to several examples from around the world, and suggests that climate was the ‘true culprit’ in the fires of 1666. The present article builds on these insights, examining the record of large urban fires across most of Europe from 1500 to 1800, and drawing on the work of climate historians to examine the role of meteorological conditions and broader climatic factors in the outbreak and spread of such fires.

The sources for early modern fires are incomplete and often imprecise, and this must particularly be borne in mind in any comparative study. Early chronicles, compiled in religious houses or by local scholars, were often more concerned to demonstrate God’s purpose than to construct an accurate chronology. They frequently tell us only that a large fire took place, rarely give the precise date, and are sometimes vague even about the year. We know, for example, that Venice experienced two bad fires in 1505/6, and that one burned ‘the entire district of Casselaria’, while the second destroyed ‘the whole island of Rialto’ (Gallicciolli 1795: Vol. 2, 237). Many descriptions of fires, even at later dates, were based on hearsay, rather than eyewitness information, and where first-hand accounts exist, they are often impressionistic, referring to a ‘great’, ‘dreadful’ or ‘impetuous’ fire. Many accounts, in pamphlets or local histories, simply assert that half, a third, or even the whole of a town burned. Even where more detail is given, the information needs to be treated with caution, as different sources often offer conflicting accounts. Estimates of the destruction in the French town of Issoudun in 1651, for example, range from 600 to 1200 houses destroyed (Pérémé 1847: 205). Many accounts of damage, as in this example, offer suspiciously rounded figures. Wherever possible, we must compare different sources. Municipal records sometimes mention payments to firefighters and court rulings awarding compensation to victims, or plans drawn up for reconstruction, often indicate that earlier reports of the scale of a fire were greatly exaggerated. Archaeological or architectural records sometimes help to evaluate the accuracy of the original accounts. Where the sources offer different estimates, the minimum estimate of damage has been adopted here.

We rarely possess much information on fire behaviour, unfortunately, since that might also indicate the role of meteorological conditions. Only occasionally, as in the London fire of 1666, did witnesses record spotting, changes of fire direction and sudden increases in intensity, or details such as shifts in wind direction, strength and gusting. This is very useful information. But there was no agreement on terminology, and neither the scientific knowledge nor the

3. For corroborating evidence on the 1666 anomaly, see Mauelshagen 2010: 128.

instruments of the time allowed the collection of information on the intensity of flames, or even accurate observations of wind speed and direction.

The most common statistical indication of fire damage is the number of houses destroyed, which is commonly used by historians of urban fire for comparative purposes. Figures are very frequently provided in diaries, municipal requests for assistance and newspaper reports, and these estimates offer some sense of scale. Admittedly, this method of evaluating the size of a fire has its drawbacks. Public rumour and claims for compensation often inflated the losses. Contemporary accounts do not always distinguish between dwellings, warehouses and other buildings. In some places, local measures were used, as in Scandinavia, where fire damage was often expressed as the number of *gårdar* that burned: literally 'yards', the buildings around a central courtyard. And even where estimates seem fairly accurate, the dimensions of a 'house' varied considerably from one place to another. Small towns typically contained single- or two-storey houses, whereas the larger cities had many multi-storey buildings. The most extreme example is eighteenth-century Edinburgh, which was built on a confined site and where some residential buildings reached ten or even fifteen storeys. In London or Vienna, most of the buildings were no more than four storeys but, as in most European towns of any size, there was a significant difference between the centre and the suburbs. Even within individual neighbourhoods the size of houses might vary greatly, with large houses inhabited by noble families sitting alongside far humbler dwellings. There were also major changes over time. Even the largest sixteenth-century towns had a very low skyline, with few residential buildings more than two storeys tall, but by 1800 they contained many apartment buildings that were not only higher but had a much greater surface area.

Nevertheless, the number of houses destroyed is the best measure we have, and this study uses the threshold of 100 houses, for what I will simply call 'large' fires. This is much higher than the benchmark adopted by Eric Jones and his collaborators, who took the loss of ten houses as the minimum threshold for a 'major' fire, one that Cornel Zwierlein also broadly adopted in his survey of fires in German-speaking Central European towns (Jones et al. 1984; Zwierlein 2021: 74). My reason for using a higher figure is pragmatic. The nature and quality of the sources vary considerably from place to place. The primary ones used by Zwierlein, the extraordinary *Städtebücher*, were originally a product of the Nazi regime's desire to document the history of the German Volk, and do not exist for other parts of Europe (Zwierlein 2021: 65–69). Elsewhere, gathering equivalent data would require visits to the surviving archives in hundreds of towns, and would even then be seriously incomplete. Even the admirable *Gazetteer* compiled by Jones, Porter and Turner, which attempted to cover only England, where newspapers and local histories are abundant, has been shown to have omitted a great many fires (Pearson 2004: 33). Blazes that destroyed over 100 houses, on the other hand, are far more likely to be traceable in the historical record, to be reported in the international press as well as in local sources, and to be recalled in local histories. It is important to note, however, that this threshold is arbitrary and has no absolute value. It serves simply to identify the greatest conflagrations, which exceeded all hope of control with the resources available to early modern urban populations, destroyed significant parts of a city or town, and caused serious social and economic dislocation.

I have followed Jan de Vries's study of *European Urbanization* in excluding the eastern parts of Europe (Russia, the Baltic states, the eastern half of Poland, Hungary, Slovakia, Ukraine and the Balkans), areas which in any case had fewer towns than many other parts of Europe. This enables a comparison with his estimates of population growth during the early modern period (de Vries 1984). I have, however, adopted a minimal definition of 'urban' that includes places with a population of at least 2,000, although in the absence of reliable censuses it is often difficult to be sure. The database also excludes fires that we know were deliberately lit as weapons of war, since their chronology, as Zwierlein has shown, primarily reflects shifts in military strategies. In the seventeenth century, armies routinely burned towns, either as a siege tactic or to punish the inhabitants, but in the eighteenth century this practice was largely abandoned (Zwierlein 2021: 87–88).

Between 1500 and 1800, in the regions covered by this survey, I have used a wide range of primary and secondary sources, including many archival ones, to identify 574 peacetime fires that burned 100 or more houses.[4] They took place in 417 towns in different parts of Europe. Their approximate size is given in Table 1.

The largest, by far, was the Great Fire of London of 1666, which destroyed some 13,200 houses and 87 churches. Next in size was the 1656 Aachen fire, which devastated seven-eighths of the town's buildings: some 4,425 houses and twenty churches (Porter 1998; Kraus 2007: 35, 48). A blaze of 1684 burned over 1,700 houses in Hamburg, then a city of 60,000 people. Stockholm too experienced many large fires, including one that burned around 1,800 buildings, mostly small, single-storey dwellings. A fire of similar size burned nearly a third of Copenhagen in 1728. Devastating fires also completed the almost total destruction of Lisbon, a city of around 180,000 people, in the aftermath of the earthquake of 1755 (Zwierlein 2021: 200; Stockholm City Archives [henceforth SSA], John Swensk Collection, BI–4; Gamrath 1999; Molesky 2012).

4. This includes, for German-speaking Central Europe, considerable relevant material generously provided by Cornel Zwierlein. Comprehensive data on Poland are now available in Karpińsky 2021.

Table 1. Number of fires, 1500–1800, by scale of destruction.

Number of houses destroyed	Number of fires
>1000	12
500–999	24
300–499	82
100–299	456
Total	574

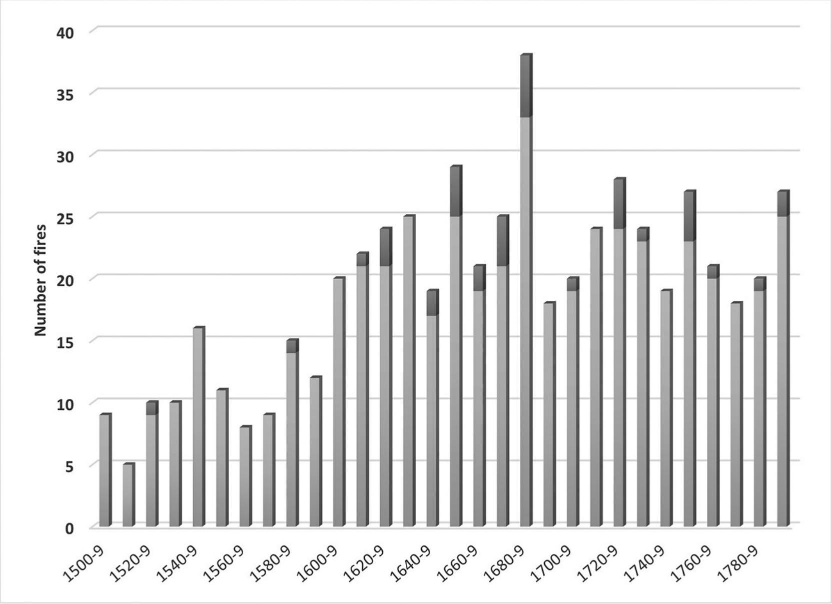

Figure 1. Peacetime fires that burned 100–499 houses (light) and >500 houses (dark), 1500–1800.

The chronology of reported large fires, by decade, is given in Figure 1. Their incidence fluctuated across the sixteenth century, with peaks in the 1540s and the 1580s. The beginning of the seventeenth century then saw a sudden jump in their frequency, rising to peaks in the 1650s and especially the 1680s. Not only were the overall numbers of these fires higher in those years, but there were many more very large conflagrations (over 500 houses burned). After a relative lull in the 1690s, the number of large fires recorded then rose steadily to another peak in the 1720s. For the rest of the eighteenth century, it remained at levels broadly similar to, but often below, those of the 1600s. Very large fires continued to occur, with the 1720s and the 1750s worse than most decades of the preceding century. The nineteenth century is not included in this study, but blazes of the kind discussed here continued to occur until the 1840s, although the general trend was for major fires to be confined to large single buildings and industrial complexes rather than destroying wide residential areas (Ewen 2010). In terms of the simple numbers of dwellings burned, what we might call the early modern era of great urban fires lasted from the early seventeenth century to the early nineteenth.

Yet, within this period, the seventeenth century stands out. In the years 1600–1699 we know of 241 large peacetime fires, compared with 105 for the sixteenth century, an increase of just under 230 per cent. Even allowing for a possible under-recording of large fires in the earlier period, this was a dramatic change. There were also slightly more large fires recorded for the seventeenth century than for the eighteenth, when 228 are identifiable. That was despite the growth in the numbers and size of towns and cities in the 1700s, which meant there were many more buildings that could have burned.

The exceptional character of the 1600s is also apparent if we consider the incidence of very large fires (those that burned >500 houses – see Figure 1). Only two (if we accept a suspiciously rounded figure of 500 houses lost in Łowicz in 1529) occurred between 1500 and 1599, but 21 were recorded between 1600 and 1699. In 1700 to 1799, despite there being more large cities, fourteen such fires took place. As already noted, the second half of the seventeenth century also witnessed the most devastating fires: the Great Fire of London of 1666 and that of Aachen in 1656. Only the 1842 fire in Hamburg, which burned 4,200 houses, came close to these in size.

Within the seventeenth century, the decade of the 1680s was the worst. It was unusual in witnessing one or more large fires recorded every year, and these included some very extensive ones: around 700 houses burned in Turku in 1681, more than 1,000 buildings in the London suburb of Wapping in 1682, over 1,700 houses in Hamburg in 1684, some 1,300 in Stockholm in 1686, and 568 in Mühlhausen in 1689. Further fires in Passau, Dresden, Bergen, Gera, Elberfeld and Sagan destroyed over 300 houses each.

The graphs reveal, therefore, that both the numbers of large fires, and their scale, were greatest during some of the coldest periods of the Little Ice Age, which is generally dated from around 1300 to roughly 1850 (White et al. 2018: 338–44). It was one of the coolest eras of the last two millennia, although the decline in average temperatures was not constant: in Europe, Alpine glaciers advanced rapidly in the fourteenth century, again from the 1580s to around 1660, and in the nineteenth century. The first half of the sixteenth century was mild, but it was followed by markedly colder, wetter conditions that persisted until the early seventeenth century. There was then a brief respite before cooling resumed. The middle decades of the century, from the 1640s to the 1670s, punctuated by some very large volcanic eruptions, brought many exceptionally cold, wet years across much of the northern hemisphere. European winter temperatures were again low during what is termed the late Maunder Minimum (1684–1715), associated with reduced solar activity, and the 1690s were very cold and wet, leading to famines in some parts of Europe. Warmer conditions gradually returned in the first half of the eighteenth century but, after 1740, average winter temperatures were again cooler in much of the continent, other seasons more favourable (Pfister et al 2018; Parker 2013: 3–8, 15).

This broad pattern is now well known, but finding out what was happening in a particular year, in a specific region, is more difficult. No meteorological measurements were taken before the mid-seventeenth century, and thereafter only in a few places. Even after they began, the instruments used were often not accurate and the recording was not always systematic. Before the eighteenth century, too, the records kept by different observers rarely cover the same periods, making us reliant on often idiosyncratic methods of measurement. Fortunately, many early modern chroniclers and diarists commented on extreme weather events, albeit in very subjective terms, and this has enabled the reconstruction of certain weather and climate patterns. In addition, paleoclimatologists have come up with a wide range of proxy measures, such as tree ring data, the dates of harvests, evidence of advances and retreats of glaciers, river and lake depths and archaeological material.[5] Most attention, understandably, has been devoted to the overall cooling trend and to its consequences for European society, and only recently have droughts begun to attract attention (Garnier 2019; Pribyl 2020; Przybylak et al. 2020; Leijonhufvud and Retsö 2021). Unfortunately, the nature and quality of the sources varies considerably from place to place, and more research has been done in some regions than in others. There was much variation in local conditions across the continent, and these are often very difficult to establish when looking at fires in individual towns. Such gaps make it impossible to establish statistically valid correlations between meteorological conditions and large fires.

It is nevertheless clear that the largest conflagrations occurred overwhelmingly in hot, dry and windy weather, particularly during summer and autumn. The summer of 1666 was unusually warm, and there was no rain in London in the six weeks before the Great Fire began on 2 September (Clark 1891–1900: vol. 2, 82; Evelyn 1955: vol. 3, 451; Macadam 2012: 237; Manley 1974: 393). This ‘great Drought’, wrote John Strype in 1720, ‘had so dryed the Timber, that it was never more apt to take Fire’. He added that ‘an Easterly Wind, (which is the dryest of all others) had blown for several Days together before;

5. For a survey of the sources, the methods used to analyse them, and the reconstructions they make possible, see White, Pfister and Mauelshagen 2018: 27–148.

and at that Time very strongly' (Strype 1720: vol. 1, 227). Eyewitness reports tell of the wind carrying embers several hundred metres ahead of the fire front, allowing the flames to jump firebreaks. This may indicate the formation of convection currents, also suggested by the observation of ash falling many kilometres away from the city and the smell of smoke 100 miles distant (Bell 1920: 68, 98–9).

Similar weather conditions prevailed at the time of other great fires. The one in Aachen in May 1656 followed a long period of warm, dry weather and, on the day of the fire, a strong westerly wind blew embers across the town from the suburb where the fire started, producing secondary fires (Kraus 2007: 42-7). The year 1728 also had an unseasonably warm summer, and in October that year some 1,670 houses burned in Copenhagen. Such weather dried out the buildings and sometimes reduced the availability of water with which to fight fires: both in Copenhagen in 1728 and in London in 1666, there were some difficulties getting enough water, especially in the crucial early stages of the fire (Gamrath 1999: 297–98).

The years when the greatest numbers of large fires were recorded were also, in the majority of cases, exceptionally hot and dry. During the three centuries covered by this study, the worst individual years were 1684, 1723 and 1794, each of which saw seven large fires. The summer of 1684 was hot and dry, and there were fires in towns across northern Germany and Estonia, including one in Hamburg that burned 1,714 houses (Zwierlein 2021: 200; Glaser 2001: 168). In 1723, the spring was unusually warm across much of Europe, and in May, a big fire on the south shore of Stockholm burned some 400 houses. Driven by strong winds, it even leapt the harbour, a distance of nearly a kilometre (Pfister et al. 2018: 280. SSA, John Swensk Collection, BI–4). In June, one of the largest urban fires in France during the early modern period took place in Châteaudun on a hot and dry Sunday, burning around 1,000 houses. It too was hastened by strong and changeable winds, and only stopped when it reached the barrier of the town walls (Robreau 2009: vol. 2, 180). In 1794, the spring was unusually warm and the summer was hot. Four of the five fires whose dates are known took place in those months (Pfister et al. 2018: 281; Glaser 2001: 176).

Table 2. worst years for large fires recorded 1500–1800, and known weather conditions in the areas affected.

Year	No. fires	Season where known (no. of fires)	Conditions
1540	6	Summer (5)	'Megadrought', very hot in most of Europe all year
1590	5	Spring (1), summer (2)	Drought year
1616	6	Summer (1), autumn (1)	Very hot summer across Europe
1624	6	Autumn/winter (2)	Unexceptional in most regions
1628	5	Spring (1)	Cold and wet in regions where fires occurred
1634	5	Autumn (1)	Drought in some regions
1652	5	Spring (1), summer (2), autumn (1)	Very hot summer, drought across Europe
1664	5	Spring (2), summer (1)	Unexceptional year
1682	5	Summer (1), autumn (1)	Unexceptional year
1684	7	Summer (4)	Hot, dry summer
1686	5	Spring (2), summer (1), autumn (1)	Very dry spring/summer in much of Central Europe
1719	6	Spring (1), summer (4), autumn (1)	Warm summer, extreme drought and heat in France
1723	7	Late winter (1), spring (4), summer (1)	Unusually warm, dry spring. Strong winds
1725	5	Spring (3), summer (1)	Mostly wet year
1731	6	Spring (1), summer (4)	Dry in some regions affected
1794	7	Winter (1), spring (1), summer (3)	Warm spring, very hot dry summer
1795	5	Late spring (2), summer (3)	Unexceptional year

As Table 2 shows, there were a further five years when six large fires occurred: 1540, 1616, 1624, 1719 and 1731. While we do not know the precise dates of all of these blazes, in four of the five years there appears to be a clear link to climatic conditions: only in 1624 is there no evidence of particularly hot or dry conditions. The summer of 1540, the hottest and driest of the entire early modern period, has already been mentioned. That of 1616 was very hot, and two of the fires were very significant: 440 houses burned in Oschatz in July, 375 in Paderborn in September.[6] 1719 had one of the few warm summers in the entire eighteenth century, and in France and central Germany was a year of extreme drought and heat, 1.8 to 2ºC higher than the average for 1900–1960 (see Figure 2a) (Garnier 2019: 58–59; Pfister et al. 2018: 280–81). In August,

6. Gai, Mahytka and Otte 2019: 213; F.L. Siegel, 'Historische und statistische Notizen über die Wichtigsten der abgebrannten Gebäuden ... und einer Schilderung des grossen Brandes derselben im Jahr 1616': http://www.oschatz-damals.de/siegel_07.html (accessed 27 Jan. 2023).

some 365 houses were destroyed in the north-eastern French town of Sainte Menehould, where the fire jumped wide streets, as well as the river that ran through the town. The dry conditions extended to Switzerland and to the western parts of Germany, where 400 houses burned in Frankfurt-am-Main in June, and there was insufficient water to fight the flames. The same year, two large fires took place in Stockholm, in July and September, burning some 200 and 300 houses respectively (Grasset 1988; Pfister 1988: 129; Herden 2005: 69; SSA, John Swensk Collection, BI–4; Forsbom 1950: 9). In 1731, once again, the summer and autumn were unusually dry and quite warm, both in England and in the Paris region. Early in June, a big fire in Blandford, in the west of England, burned 337 houses, and a day later one in Tiverton, not far away, destroyed 298. Both fires were driven by strong winds.[7]

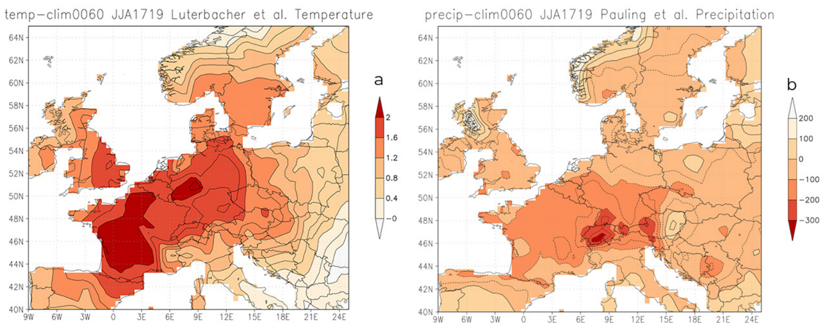

Figure 2. the summer of 1719 (JJA), compared to the average over the reference period of 1900–1960. Map 2a shows the anomalies of mean temperature in ºC. Map 2b shows the anomalies of precipitation, in millimetres. Sources: created using the KNMI Climate Explorer (https://climexp.knmi.nl), historical reconstructions. Temperature data from Luterbacher et al. 2004 and Xoplaki et al. 2005; precipitation data from Pauling et al. 2006.

Some of the years when there were five large fires were also unusually warm and/or dry. In 1590, large fires occurred in Wolverhampton and in Poznan, as severe drought affected England and Western Poland (Brázdil et al. 2016: 108; Pribyl 2020: 1031; Przybylak et al. 2020: 648) Most of Europe again had an exceptionally hot, dry summer in 1652, which in Sweden was called 'the Great Drought Year'. It saw five large fires that we know of, including some exceptional ones: 500 houses burned in Glasgow in July, at least 600 in two separate fires in Stockholm in March and September, and 433 in the German town of

7. Snell 1892: 72; https://www.dorsetlife.co.uk/2009/03/when-blandford-burnt/ (accessed 5 Aug. 2023); Garnier 2019: 59.

Luckau (Pribyl 2020: 1034; Pfister 1988: 140; Rácz 2013: 131; Leijonhufvud and Retsö 2021: 2018; SSA, John Swensk Collection, BI–4; Cleland 1820: 4).

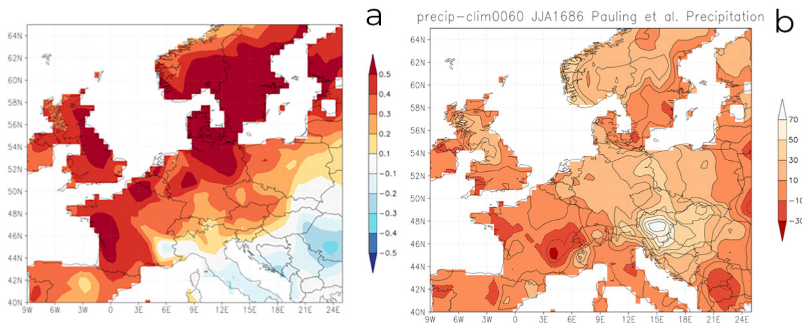

Figure 3. The summer of 1686 (JJA), compared to the average over the reference period 1900–1960. Map 3a shows the anomalies of mean temperature in ºC. Map 3b shows the anomalies of precipitation, in millimetres. In greyscale image, the darker the colour, the higher the temperature. Sources: as for Figure 2.

The spring of 1686 was the driest in 500 years and, in late March, a large fire destroyed 358 houses in the substantial German town of Gera. The summer was also hot and dry across much of Europe (see Figure 3). In June, a huge blaze burned 1,300 houses in Stockholm while, in September, another large fire took place in Bergen, in Norway, reportedly burning 231 blocks (Pauling et al. 2006: 393. Glaser 2001: 169; Hahn 1855: vol. 1, 659; SSA, John Swensk Collection, BI–3; Nielsen 1877: 372). 1634 was also very dry in England, Finland, and some of the Czech lands, although it is not singled out in climate histories of the German-speaking areas where large fires took place (Pribyl 2020: 1031; Garnier 2019: 51; Vesajoki and Tornberg 1994: 52; Brázdil et al. 2016: 108).

Although climate data are missing for some years and for some regions, therefore, it is clear that a great many large fires, including a majority of the most disastrous ones, occurred in hot and dry seasons that conspicuously departed from the general climatic trend. Climate historians have established that the Little Ice Age, like the Anthropocene, was characterised by considerable seasonal variability and by extreme weather events. While most years were cool and damp, by comparison with earlier periods and with the later nineteenth and twentieth centuries, some winters were very cold and a few summers exceptionally hot. The summer of 1540 rivalled the heat wave of 2003 in Europe, and at intervals across the early modern era there were periods of drought that sometimes lasted for several years (Pfister 2018; Garnier 2019; Pribyl 2020). Studies of the late Maunder Minimum and of the eighteenth and nineteenth centuries suggest that these anomalous seasons were related to atmospheric circulation in the Atlantic, which determined wind direction over much of Europe, and influenced both temperature and precipitation. These anomalies also appear to be linked to abnormal wind strength, as well as direction, which are both crucial factors in the incidence of large fires (Frich and Frydendahl 1994; Mellado-Cano et al. 2018; Mellado-Cano et al. 2020; Pfister 1994: 311). They continued into the eighteenth century but became less frequent after about 1750, although with variations across the continent (Pfister et al. 2018: 273–83; Frenzel, Pfister and Gläser (eds) 1994). It seems clear that they played a significant role in the incidence of large urban fires.

Yet we must also note the exceptions to this general pattern. There were a few unusually warm and dry summers, such as that of 1747, when very few large fires seem to have occurred (Pfister et al. 2018: 280. Le Roy Ladurie 2004–06: vol. 2, p. 24). Nor were heat and drought a necessary precondition for large fires. In 1628, for example, five such conflagrations took place in different Central European towns, making it one of the dozen worst years between 1500 and 1800. Yet across most of that region the year was cold and wet (Pfister et al. 2018: 280). In 1651, too, Issoudun lost over 600 houses to fire, but conditions do not seem to have been either hot or dry. Similarly, a huge fire in the London docks – admittedly driven by a very strong wind – destroyed over a thousand buildings in 1682, even though the year was very wet (Pérémé 1847: 205; Blackstone 1957: 56). A great many towns, constructed of wood and subject to the same weather conditions, never experienced a large fire, even at times when others in the same region burned. But of course we do not expect all forests to burn simultaneously, even when the fire risk is high. Hot, dry weather and high winds greatly increased the likelihood that a small fire would spread and become unstoppable, but did not make huge conflagrations inevitable. In any case, aside from lightning strikes, meteorological conditions were not in themselves a cause of urban fires, which were overwhelmingly produced by human activity. It is worth asking, therefore, in what circumstances climatic variability was important in the incidence of large urban fires.

One obvious factor was the nature of the buildings in any given location, since they provided the primary fuel for urban wildfires. In Mediterranean Western Europe, where early deforestation made timber scarce and expensive and where stone was often plentiful and suitable for construction, there were very few large fires. By the sixteenth century, most Italian, Spanish and southern French towns were built of stone and had tiled roofs. In the Low Countries, too, brick became the usual building material quite early and, there too, few large fires occurred. Elsewhere in Europe, the replacement of wood and straw with brick, stone, tiles or slates was often required by building regulations, but these were very unevenly observed. The construction of firewalls, in stone or brick, was obligatory in some places, and appears to have been effective, particularly where they projected above the roofline. In Paris and some other places, the widespread use of plaster – an effective fire retardant – was an important factor in preventing small fires from spreading (Keene 1999: 196–98; Garrioch 2019b). Historians have documented a trend towards the use of less flammable materials, especially in the eighteenth century (Frost and Jones 1989; Borsay 1989: 18).

Many historians have suggested that rapid population increases – at least as a proxy for urban growth – were a major factor in the occurrence of major fires. However, the data do not bear this out. Across the areas included in this study, Jan de Vries has estimated that the number of town dwellers grew by roughly 51 per cent between 1500 and 1599, by just over 24 per cent from 1600 to 1699, and by a little more than 44 per cent from 1700 to 1799. It was to accelerate dramatically after 1800. Yet, as we have seen (Figure 1), the number of large fires actually fell in the second half of the sixteenth century, rose strongly during the seventeenth-century period of slower urban growth, then levelled off in the eighteenth century, even though the urban population was then increasing more rapidly. Overall, the statistical correlation between population increase and the number of large fires was relatively low.[8]

In individual places, too, population growth did not necessarily accompany frequent large fires. Paris grew far more rapidly than most European cities between 1600 and 1700, but experienced only one fire that burned around 100 houses. Amsterdam also grew very fast in the first half of that century but appears to have had no fires of this size. By contrast, some of the most disastrous early modern fires took place in towns that had very low, even negative, rates of growth. Aachen, where the second-largest European fire of the period occurred in 1656, had a lower population in 1650 than in 1500. In Rennes, the population had stagnated for thirty years before the fire of 1720. Eighteenth-century Stockholm, whose economy and population grew slowly, if at all, nevertheless continued to experience large fires, notably in 1719, 1723 and 1759.[9]

This does not mean that population growth was irrelevant. It resulted in high demand for housing, which in turn encouraged poor-quality timber construction, if there were no well-enforced building regulations. That was certainly true for early modern London, especially in the port districts that housed a large labouring population, and probably contributed to the gravity

8. de Vries 1984: 50. Linear regression analysis, using de Vries's figures, indicates only a moderate association ($R^2 = 0.64$). I am grateful to Kathleen Neal for this calculation.

9. de Vries 1984: 272; Aubert 2010: 96; Ericson 2001: 100. Zwierlein 2021 (102) makes similar points for Hamburg.

of the numerous large fires in those areas (Power 1972). The same was almost certainly true in seventeenth-century Stockholm, where very large fires in 1625, 1640, 1652 and 1686 all coincided with a rapid increase in population and the extension of suburbs that contained mainly timber buildings, sometimes with thatched roofs (Ericson 2001: 98–100). Population pressure could also deplete groundwater supplies, making the task of firefighters even harder. There is evidence that the London water table fell in the early modern period, due to overuse (van Lieshout 2016: 790).

It is often forgotten, however, that buildings were not the only source of fuel for urban fires. London is, again, a conspicuous example. The frequency of very large fires there resulted partly from its functions as a port and a manufacturing centre. The Great Fire of 1666, according to witness reports, only became disastrous after it reached old wooden warehouses along the river, because they contained 'the most combustible matter of Tarr, Pitch, Hemp, Rosen, and Flax which was all layd up thereabouts so that in six houres it became a huge stream of fire at least a mile long and could not possibly be approach'd or quencht' (Nicolson and Hutton (eds) 1992: 276). The 1682 Wapping fire engulfed not only houses but also many warehouses and shipyards along the river, which contained similarly flammable substances (*Sad and Lamentable News from Wapping*). Between 1666 and 1800, of sixteen fires in London that burned more than 100 houses, all but three took place in port areas. This reflects the wider growth of world trade, and particularly that of the Atlantic. Hamburg had a similar port economy and experienced a very large fire in 1684. There too, many smaller but still dangerous fires destroyed factories and warehouses containing sugar, rum, and other flammable products linked to European and Atlantic trade (Garrioch 2016; Zwierlein 2021: 99–108). Yet, once again, preventative measures helped determine whether the presence of such potential fuels contributed to large fires. From the late seventeenth century, the authorities in Paris and Vienna regulated dangerous industries reasonably effectively, removing them from densely-packed residential areas to the urban outskirts (Le Roux 2011: 46–68; Weigl 2001–2006: vol. 2, 157). Wide avenues were created in many cities, especially in the late seventeenth and eighteenth centuries. Even when the motive was to demonstrate the power of the ruler or to improve traffic flow, the open spaces prevented fires from spreading.

Once a fire did break out, the efficacy of firefighting was crucial in determining whether it was extinguished or developed into a large conflagration. Controlling a dangerous fire depended particularly on early detection and rapid action. In many places, the introduction of night watch services, or of fire-spotters installed on church towers, enabled fires to be caught before they spread. Such arrangements assisted Vienna to avoid large fires after a terrible conflagration in 1627 (Pils 1999: 183). They were not failsafe, though, since similar measures did not prevent huge fires in Stockholm, for example – although it is possible that without them there might have been even more blazes.

Most accidental fires were put out quickly, even though very few towns engaged paid firefighters before 1800. The inhabitants were well aware of the danger, and some groups – notably building workers and sometimes other occupational categories – developed a lot of expertise in fighting fires. The tools were quite simple: buckets, fire-axes, hooks, ladders and, by the late seventeenth century, hand-operated fire pumps. Thus equipped, people doused the flames and dampened nearby sources of fuel. They watched for flying embers and quickly extinguished them. Knowing that fires usually spread from roof to roof, they removed or dampened wooden slats and shingles. If a fire continued to grow, they demolished buildings to create firebreaks. Such measures often enabled even multi-house blazes to be controlled and put out. One in the French town of Rennes in 1661, for example, destroyed around fifteen houses in a densely built block, but was prevented from spreading further. Another in Paris, in 1718, destroyed about twenty houses before being brought under control (Fillaut 1999: 32; Bibliothèque nationale, Paris, France. Collection Joly de Fleury, MS 1324, fol. 127).

Many disastrous fires, by contrast, began late at night, when there were few people in the streets. This happened in Aachen in 1656, in London in 1666, in the London borough of Southwark in 1676, in Rennes in 1720, and in Copenhagen in 1728. Fires that broke out on holidays, when many volunteer firefighters were absent, were also more likely to spread. The great fire in Rennes in 1720 started on a Sunday night just before Christmas and, when the alarm was given, few people arrived to fight the flames before they took hold (Aubert and Provost (eds) 2020: 28–29).

Even so, such accidents were less likely where preventative measures were enforced, and where firefighting services were well organised and funded. In Amsterdam, the fire service seems to have been particularly effective. Many potentially serious fires broke out there, and a few consumed multiple buildings, but well-trained firefighters generally arrived promptly, armed with the best equipment available, before the flames could spread further. This was also true of Venice, where squads from the city Arsenal were employed as firefighters, becoming experienced in reaching fires and extinguishing them quickly (van der Heyden 1996; Svalduz 2006: 62). In these two cities, of course, the widespread use of brick for building made their task easier, and canals provided ready access to abundant water. Elsewhere, firefighters depended on public fountains and conduits, which were reliable only if the city government built and maintained them. That was done in Vienna and Paris, but in London firefighters sometimes had difficulty obtaining water (Pearson 2004: 83–84). Effective prevention and firefighting required considerable foresight on the part of town authorities, both in providing equipment and training and in ensuring adequate supplies of water. In most towns, where there were no permanent firefighters, the experience and capacity of local officials was also crucial. Amid the confusion and smoke of large fires, they directed operations and decided when and where to create firebreaks.

Drought, heat and unfavourable meteorological conditions were therefore far from being the only factors that helped determine when and where small fires grew into large ones. Yet some of these other variables, notably the preparedness of city governments in the face of the fire risk, were indirectly influenced by the unfavourable climatic conditions of the Little Ice Age. These had a hugely disruptive impact on European society. Harvest failures produced by untimely cold, excessive rain, or even drought, led to population decline and economic crisis. High prices for basic necessities were disastrous at a time when much of the European population lived permanently on the edge of poverty. One result was very high mortality: it has been estimated that between 1691 and 1701 a million people died in France of climate-related famine and disease, in an overall population of around 20 million. Some 600,000 more were to die because of the harsh winter of 1709 (Parker 2013: 589). Undernourishment made them more vulnerable to diseases that flourished in very cold and wet conditions. But drought was also a killer. In early modern Britain, many very dry years were accompanied by outbreaks of plague, fevers and smallpox, and the great drought of 1719 in France saw high mortality from dysentery, spread by polluted water (Pribyl 2020:1035; Garnier 2019: 59).

Food shortages, death and disease in turn produced serious social disruption and political instability. The seventeenth century was marked by huge numbers of local revolts. These have been closely studied in France, where the very harsh winter of 1662 was followed by near famine in many towns, producing a record number of riots. This pattern recurred at the end of the century, from 1692 to 1710, when harvests failed repeatedly. The same years witnessed a huge spike in revolts against tax collectors (Nicolas 2008: 87, 346–67). It is arguable, too, that the number and extreme brutality of the civil conflicts and wars of the seventeenth century were also in part a product of harsh economic conditions linked to climatic variability.

Certainly, the economic consequences of these crises made it more difficult for urban authorities to invest in fire prevention and control. Even though firefighting was mostly done by volunteers, they required buckets, fire pumps and other tools. These were expensive, but tax revenues fell as populations and production declined, and municipalities had difficulty finding funds. In Rennes, when the great fire of 1720 began, there were no buckets or other firefighting equipment in the municipal store (Aubert and Provost (eds) 2020: 82). This was not a direct result of climatic factors, but these contributed to the pressures on local government. In many other towns, parishes and trade guilds were responsible for providing firefighting equipment, and these same institutions were generally the primary providers of poor relief. Demands on their resources grew at precisely the moment when they had less to spare.

Social and political crises may also have undermined the local leadership and social cohesion that were crucial in the event of a large fire. In London in 1666, the failure of the mayor to take decisive action has often been identified as a major factor in preventing the fire from being controlled in its early stages, and some of the local aldermen also appear to have opposed the destruction of houses to create firebreaks (Bell 1920: 29–30, 346). This might have been partly a product of inexperience. The political disruption of the years before the Great Fire – Civil War, followed by republican government until 1660, then the return of the monarchy – had left the city in the hands of less experienced administrators. The situation was exacerbated by a major plague epidemic, in 1665, that killed many people and drove others from the city. The mayor himself was relatively young, had come into office largely thanks to royal patronage, and had far less experience than most previous occupants of the position (Harding 2019; Porter 1998: 58). The case of London was exceptional, but economic and social dislocation and political instability were particularly widespread in the second half of the seventeenth century. This did not automatically lead to poor fire preparedness or management, but the failure of local officials to provide equipment, and to act effectively when fire disasters took place, is well documented.

This article has offered evidence of a causal link between large peacetime fires in early modern European towns and climatic variability linked to the Little Ice Age. The seventeenth century emerges as the worst period for such fires, both in the number that occurred and in their extent. It includes many of the most devastating ones, notably those of 1656 in Aachen and 1666 in London. This is at first surprising, given that climatic conditions were in general colder and wetter than in the Middle Ages or in the nineteenth and twentieth centuries. Yet the individual years and seasons when large fires were most numerous were, with a few exceptions, hot and dry, and analysis of individual large and very large fires reveals that drought, heat, and high winds contributed directly to their gravity. These weather conditions were anomalies, which appear to be a feature of periods of climatic variability. While not directly causing the fires, such anomalies greatly contributed to their spread and intensity.

They were not the only relevant variable. The impact of climatic conditions on wildfire, as we know from recent experience, is not independent of human activity. Just as increased housing on the fringes of cities has contributed to losses in recent years, so in early modern times the forms of building, zoning, and other preventative measures – or their absence – significantly influenced the scale of urban fires. Towns where extensive use was made of non-flammable building materials, and where dangerous activities were removed from residential areas, were far less affected by large fires. Those where firefighting was well funded and well organised were also often able to avoid large fires, even when meteorological conditions were unfavourable. These were crucial factors in reducing the overall number of large fires during the eighteenth century, despite quite rapid urban growth.

For precisely this reason, the social and economic disruptions brought by climatic conditions during the Little Ice Age, and the political dislocation that accompanied them, had an impact on the ability of some urban communities to deal with wildfire. Even towns where, in normal times, fires were usually controlled quickly now had fewer resources available to invest in less flammable building materials, in prevention, and in training and equipping firefighters. There is circumstantial evidence that in some places these disruptions to local government contributed to reduced enforcement of preventive measures and to poor handling of dangerous fires.

The early modern European experience offers a sobering warning of the potential impact of climatic variability on urban wildfire. Today's global warming is producing forest fires of unprecedented intensity, which in Australia, the United States and parts of southern Europe have converged on urban peripheries. But the risk is greater in areas of overcrowded housing where building materials are more vulnerable to fire. For example, the *favelas* around São Paolo, in Brazil, experienced massive fires in 2009, 2012, 2014 and 2016. Similarly huge blazes destroyed slums and shantytowns in New Delhi and in Freetown, Sierra Leone, in 2018 and, in 2021, a similar one hit Dhaka, in Bangladesh. Equally vulnerable urban zones exist in many large cities, notably in tropical and subtropical areas. The reporting of these blazes has focused on the ramshackle nature of the buildings, the absence of fire safety measures, and often on the likelihood that arson was involved, but climatic factors have received less attention. In addition to the direct effects of heat and drought, the early modern example of social and political disruption that was directly or indirectly produced by climatic factors is worth considering in the twenty-first century context. Urban planning, building regulation, fire prevention and firefighting are, in most parts of the world, publicly funded and run, and risk dislocation if budgets are cut and enforcement disregarded. Some of this was already clear in the Grenfell Tower fire of 2017 in London. It seems, alas, that the age of great urban fires is far from over.

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