





**Figure S1.** Locations of regions (a) and places (b) cited in the text: A (Austria): 1 – Retz, 2 – Steyr, 3 – Vienna; CH (Switzerland): 4 – Fischingen; CZ (Czech Republic): 5 – Česká Lípa, 6 – Dačice, 7 – Doksany, 8 – Drahotuše, 9 – Hodonín, 10 – Hranice, 11 – Jankov, 12 – Klučenice, 13 – Krupka, 14 – Louny, 15 – Nové Město nad Metují, 16 – Nový Jičín, 17 – Orlík, 18 – Pacov, 19 – Plzeň, 20 – Podivín, 21 – Prague, 22 – Radenín, 23 – Rakovnick, 24 – Rumburk, 25 – Slaný, 26 – Stará Břeclav, 27 – Teplice, 28 – Velké Meziříčí, 29 – Žatec; D (Germany): 30 – Augsburg, 31 – Bad Belzig, 32 – Braunschweig, 33 – Bremen, 34 – Cologne, 35 – Döbeln, 36 – Dresden, 37 – Eilenburg, 38 – Esslingen, 39 – Freiberg, 40 – Gera, 41 – Glückstadt, 42 – Hamburg, 43 – Kahla, 44 – Kassel, 45 – Leipzig, 46 – Meißen, 47 – Naumburg, 48 – Nuremberg, 49 – Rotenburg an der Fulda, 50 – Würzburg; HU (Hungary): 51 – Sopron, 52 – Szécsény; PL (Poland): 53 – Gdansk, 54 – Kłodzko; SK (Slovakia): 55 – Bratislava, 56 – Brodské, 57 – Levoča, 58 – Pavlovce nad Uhom, 59 – Spišské Podhradie, 60 – Stará Lesná, 61 – Trenčín, 62 – Trnava; Tr (Transylvania): 63 – Cluj, 64 – Făgăraș, 65 – Fântânele, 66 – Mediaș, 67 – Oradea, 68 – Sibiu, 69 – Sighișoara.



**Figure S2.** Fluctuations in seasonal numbers of days with frost (frost, persistent frost), hot weather (hot, very hot) and precipitation (snow, mixed – snow and rain, rain) days and dates of the latest and earliest occurrences of frost and snowfall in Kassel/Rotenburg an der Fulda (Germany) in the 1621–1648 period based on daily observations by Landgraf Hermann IV from Hesse (data in Lenke, 1960): (a) winter, (b) spring, (c) summer, (d) autumn. Smoothed by Gaussian filter for 5-years. Corresponding means for 1621–1648 are indicated as horizontal lines.

## **S1: Weather and climatic extremes in Central Europe during 1618–1648**

### **1618**

After cold January with thick ice on the rivers in Bohemia, a sudden thaw starting on 6 February caused breaking of ice and its leaving, but without a large damage (archival source AS11; AS18). Ice drifts in February occurred also on the Rhine, Pegnitz and Danube Rivers (Happel, 1690). Also the frozen Neisse River in Silesia in this winter was mentioned (Schmidt-Reder, 1882). After frequent rainy spells, floods on the Ohře River in north-west Bohemia occurred on 20 June and 3 August. The last one was the largest of four floods that appeared during three weeks (AS11; AS18). In June floods affected Gera in Thuringia and Naumburg in Saxony-Anhalt (AS9; Zopf, 1692). Heavy floods in June and July were reported from Transylvania as well (Réthly, 1962). A fertile year with enough wine of average quality was reported for Austrian Retz (Lauscher, 1985). But during a cold spell in late November grapes froze in the vineyards in German Esslingen (Ginschopff, 1631). Mild and rainy weather prevailed in Bohemia during December (AS11). In Silesia, it snowed in December and thawed by Christmas, when was “*as warm as in the middle of summer*” (Militzer, 1998).

### **1619**

In Bohemia, the Louny chronicler Pavel Mikšovic reported deep frosts and much snow with impassable roads in March (AS11). Frosts on 15–17 May with ice on the water did a great damage to vegetation (AS10; AS11). Frost on those dates damaged vine, grain, and garden trees in several regions of Germany, which led to an increase in prices (AS7; Roch, 1687). Frost on 18 May destroyed almost the grapevines around Sopron in Hungary. What remained was killed off by repeated hailstorms in the last week of August (Réthly, 1962). In the Württemberg region in south Germany, cold weather began around 4 July and continued intermittently until the end of the month, while from mid-July to October was also rainy and stormy with damage to grapes (Ginschopff, 1631). Flood on the Ohře River was reported on 29–30 July and 4 December (AS11). Memorial book of Rumburk (AS10) mentioned failure of fruits and cabbage in Bohemia. Less amount of good wine was harvested in Retz (Lauscher, 1985). In Silesia, snow fell on 1 December and continued until 22 March 1620 (Militzer, 1998).

### **1620**

Frosts on 16 and 19–20 May were reported for Louny (AS11). During a wetter summer (Panáček, 2016), a flood on 19 August occurred on the Bečva River in Moravia (Mráček, 1912) and on 20–21 August on the Váh River in Slovakia (Réthly 1962). Frequently reported were thunderstorms with hail and fires caused by lightning in Bohemia (Panáček, 2016). The similar reports come from Sibiu in Transylvania (Trausch, 1847). In Lesser Poland, the summer was rather average based on harvest dates (Czaplinski, 2004). Miserable weather and hailstorms in the summer contributed to not much wine in Retz, but still good in quality (Lauscher, 1985). After frosts in mid-October, new severe frosts with snow and frozen people were mentioned after 11 November in Bohemia (AS11).

### **1621**

For description see main text, Section 5.3.

### **1622**

The Vistula River in Poland was frozen in the winter (Zernecke, 1711, 1727). Cold and windy weather in northwest Germany, when many water bodies froze, continued from the year beginning until May (Müller, 1823). Lauscher (1985) reported extraordinary colds with much

snow for Retz, followed by floods from snow melting. After large rains on 11 and 17 May in Brandenburg and Saxony (Mörbitz, 1726; Bekmann, 1751) and on 15 May in northwest Bohemia (AS11) floods were reported. Landgraf Hermann IV from Hesse recorded 53 spring precipitation days for Kassel, Germany (Figure S2b). Rainy weather from 22 June caused floods on 24 June at Louny continuing until 5 July (AS11) and after 9 July in Moravia (Rybička, 1892) with a high water level lasting until mid-July. Several Czech sources cited bad harvest and expensiveness, which was confirmed by the highest rye prices (nearly double of rye price in 1621) in incomplete price series (1610–1651) in Sopron (Dányi and Zimányi, 1989). Very high grain prices were also reported from the Spiš region in Slovakia (Wagner, 1774). Price increases for grain, wood, and wine were also reported in Saxony (MISA, 1771). Not much of sour wine was reported for Retz (Lauscher, 1985). Various regions of former Hungary suffered from famines, plague outbreaks and epizootics (Réthly, 1962). Bad weather in the summer caused crop failure also in Poland (Ratajczak, 1991), where also many floods and rain spells were reported.

### **1623**

The extremely cold weather lasted until April in Meißen, Saxony (AS7). It confirms 23 frost days in March recorded by Hermann IV in Kassel (Lenke, 1960). Thunderstorms and hailstorms damaged grapes and injured people during May and June in the Württemberg region (Ginschopff, 1631). These two months experienced even 46 precipitation days in Kassel (Lenke, 1960). Failure of grains and dearth due to drought were reported in the Czech Lands (e.g., AS11; AS18; Mráček, 1912) that grain export and its buying by foreigners have been permitted there (Hrubý 1934). On 21 October was commanded draining of water from ponds to the Morava River in Moravia, suffering by low water, to prevent enemy invasion from former Hungary (Hrubý, 1934). Reports from Retz mentioned a wetter summer with hailstorms, little sour wine and further movement of ice with flood without closer specification (Lauscher, 1985).

### **1624**

Extremely severe weather was in January–February in the Czech Lands, with much snow (as was not seen from 1606), frozen people or water mills out of operation (AS18; Fišer, 1931). Very cold weather between 17 December 1623 and 22 March 1624 was reported in Naumburg (AS9). In Sopron, it snowed every day all through winter, resulting in unseen amounts of snow (Heimler, 1942). The severe winter 1623/24 is confirmed by 66 days with frost/persistent frost recorded for Kassel (Figure S2a). The Lake Biel, which is a smaller lake in Switzerland, was ice-covered (Chaillet, 1845). Deep frosts in Bohemia continued also in March, where as far as on 24–25 March the movement of ice on the Ohře began (AS11). More snow fell after 7 April in Silesia (Militzer, 1998). Between 24 April and 17 June no rain occurred in south Moravia (Fišer, 1931). Drought caused failure of grain in Bohemia, but the harvest of fruit was good and vine grapes average (AS11). In Saxony, spring and summer were very warm, while no rainfall occurred in May and June (Simon, 1696). Many sources reported expensiveness of grain and generally dearth (e.g. Roch, 1687). Warm summer and not much good wine was mentioned for Retz (Lauscher, 1985). Persistent warm weather from May to the end of August on the Swiss Plateau caused drought damages to vines, but wine was extremely strong (AS8). Frequent thunderstorms in the mountains were reported in June for Swiss Fischingen (AS15). Mild autumn and following winter (e.g., cows on the fields) were reported by a source for Thuringia (Zopf, 1692).

## 1625

Very mild weather was in January–February in Bohemia (ploughing, growing grass, some plants in blossom) (Menčík, 1897). Mild January, but great colds in February, were reported in Austria (Lauscher, 1985). Intense rain between 13–19 April in Bohemia caused a flood of the Vltava River in Prague (Svobodová, 1990). Snow fell on 24 May in Kahla in Thuringia (Militzer, 1998). On 28 May a late frost damaged vineyards around Louny, but bad harvest was mentioned also for grain, hops and fruits (AS11). Damage to vineyards by frosts in May was also reported from Cluj in Transylvania (Jakab, 1862). The latest spring frost in Kassel occurred on 26 May (Figure S2b). Source from Retz reported cold and very wet May and June and very warm July (Lauscher, 1985). In the Ore Mountains (along the Czech-German border) hard frost occurred on 8 September and one day later it snowed (Lehmann, 1747), while in Kassel the earliest frost appeared on 10 September (Figure S2d). Enough wine of average quality despite September frost was cited for Retz (Lauscher, 1985).

## 1626

The late frosts on 30 April–1 May with damage to vineyards in Bohemia were followed by others on 10–11 May and then between 26 and 30 May with further damage to grain and hops (AS11; Menčík, 1897). Frost with large damage on 20 May was cited for Retz (Lauscher, 1985). Due to colds people had to dress fur coats; also it snowed (AS16). In Eilenburg (Saxony) it snowed on 26 May and people had to heat their homes due to cold weather (Simon, 1696; Militzer, 1998). At Kassel the last spring frost occurred on 28 May (Figure S2b). In East and West Prussia, strong northerly winds persisted for the first half of the year until 24 June and it rained almost continuously for 13 weeks between July and September (Bock, 1782). Wetter summer was reported for Austria (Lauscher, 1985). Kassel in Germany had 49 precipitation days in the summer (Figure S2c). Very dry weather, lack of water and troubles with milling were reported in the letter from 3 November in Moravia (Hrubý, 1937) which is confirmed by only 17 precipitation days in September–October in Kassel (Lenke, 1960) and dry autumn with little sour wine in Austria (Lauscher, 1985). Only two rainy days were mentioned by Brunschwiler from the end of August to 6 November in north-eastern Switzerland (AS15). Mikšovic (AS11) mentioned for Louny rain on 23 October and then onset of frosts with severe colds in December (see also Fišer, 1920).

## 1627

For description see main text, Section 5.3.

## 1628

For description see main text, Section 5.3.

## 1629

As reported for the Württemberg region, the year 1629 started as very mild and such weather lasted until 12 February, when trees were seen to grow (Ginschopff, 1631). In Bohemia very mild weather continued until 15 January and then frosts followed (AS11). Extreme colds and rains occurred on 21–23 April in Levoča (Slovakia) and in Sopron, in addition to knee-deep snow in the local mountains (Bal et al., 1910; Heimler, 1942). Reports from Krupka in north-west Bohemia speak of warm summer and autumn and a good harvest, but a little of wine, although very good (AS13). After favourable summer much fruits, early vintage and much of very good wine were mentioned at Retz (Lauscher, 1985). Floods were reported at the end of July and in September in Silesia (Weikinn, 1961), for the Vltava and Elbe in Bohemia on 10–11 October (AS19; Fejtová, 1998) and in Dresden (Saxony) on 12 October (Weck, 1679).

### 1630

The snow cover in Silesia lasted until 31 March (Militzer, 1998). Stüeler mentioned in his Krupka records dry summer and autumn, when all brooks and springs went dry (AS13). Drought should have been greater than those in the extreme summer of 1590 (cf. Brázdil et al., 2019). Daily weather observations from Kassel confirm, that summer in Germany was not only very dry, but also hot (Figure S2c), while in the north of Poland frequent rains in summer were reported (AS2). Despite dry weather, a good harvest of winter grains, an average harvest of spring grains, excess of wine, sufficient fruits, nuts and further crops were in Bohemia (AS13). Also further sources from the Czech Lands confirm plenty of good wine (e.g., AS11; AS17). Much fruits and very much of good wine was reported in Retz (Lauscher, 1985). Unlike Stüeler, Pavel Mikšovic stated the average harvest of winter grains and a small harvest of field crops (AS11). Moreover, the early frosts on 9–10 and on 16 September in Bohemia damaged grapes, cucumbers and melons (AS13). The first frost on 9 September (AS13) agrees with records by Hermann IV in Kassel (Figure S2d). The dry year and rather bad harvest of grains are confirmed by reports about dearth and hunger from further places in the Czech Lands (e.g., AS12; Schram, 1906; Dostál, 1962). In December, a large flood occurred on the Tisza River (Kraus, 1862).

### 1631

On 2 February in Transylvania, an ice-jam broke in Cluj and the river Someş damaged many buildings and bridges (Jakab, 1862). On 7 February, so much snow fell in Levoča as was not seen for 19 years (Bal et al., 1910). Mikšovic reported at Louny the great drought and hot weather before 29 June, when brooks and wells became dry, water mills could not operate and wood fires were frequent (AS11). Dry patterns in Bohemia were reflected in bad harvest (particularly spring grain) and dry grassland, followed by a subsequent shortage of fodder (AS13). Unusually dry weather was reported from Sopron (Réthly, 1962) and Cluj (Jakab, 1862) as well. In Thuringia and Saxony wells and creeks dried up and forest fires appeared (AS7; Dreyhaupt, 1749). Water mills in Saxony were out of operation, that caused a shortage of flour. The drought led also to more shortages of food and fodder (Abel, 1732; Mörbitz, 1726; Militzer, 1998). Warm and variable weather was experienced from April to late July in north-eastern Switzerland (AS15). Warm summer, a lot of fruit and other crops, early vintage, very much wine of very good quality, reflected in shortage of wine barrels and very low prices of wine, were reported in Retz (Lauscher, 1985). Stories of people freezing outside in the second half of December were reported for eastern Germany (Moller, 1653; Lehmann, 1747).

### 1632

Changeable winter in January with many rainy days occurred in the north-eastern Poland (Radziwiłł, 1980a). In Saxony, Thuringia, and Brandenburg, the winter was hard with deep snow. Snow and frost for Gera were reported for 12 days in the second half of April (Zopf, 1692) and again on 27 May, but intermittent cold winds lasted until the end of June (AS7; Bekmann, 1751). On 26–27 April at Krupka, snow fell up to knees, like at Christmas, and a hard frost damaged fruit trees, vineyards and grains (AS13). The Czech exile Václav Nosidlo of Geblice (Lisa, 2014) reported frost damage (after the preceding warm weather), when even dead birds were found. Severe frost damage to vineyards on 28 April was reported from Sopron, which resulted in grape harvest as late as the end of November. According to the chronicler Payr, such frosts happened in many places in former Hungary (Heimler, 1942). Poor harvest of fruits and grapes, in places also field crops, resulted from frost damage. In Saxony and Brandenburg, the cold weather took a warm turn on 4 July, leading to pleasant weather in July and August. It contributed to a generally good fruit harvest, while grapes did

not recover from spring frosts (AS7; Bekmann, 1751). The wetter summer, frost in autumn, little sour wine, expensiveness and plague were reported in Austria (Lauscher, 1985). The first frosts at the end of November occurred in the south-eastern Poland (Radziwiłł, 1980a).

### 1633

January was rainy in Masovia, in Lesser Poland and in Silesia (Radziwiłł, 1980a). Frosts in the week before 15 May and then on 20–21 May (with snow) damaged cereals, vineyards and fruit trees in Bohemia (AS18; Koldinská and Maťa, 1997). Around 20 May snowfall and frost were mentioned in Silesia (Militzer, 1998). Similarly, extreme colds in many places in Transylvania occurred on 21–22 May (Jakab, 1862). Repeated frosts and snow damaged vineyards in the second half of May also in Sopron (Heimler, 1942). Very warm June was mentioned in north-eastern Poland (Radziwiłł, 1980a). Source of Retz cited cold spring and autumn, no fruits and little sour wine (Lauscher, 1985). No frost was indicated for the autumn in Kassel, because the first such day appeared as far as on 2 December (Figure S2d).

### 1634

In Sibiu (Transylvania), a major hailstorm occurred on 22 May, and, because of the cold weather, ice up to one's knees remained on the streets for eight days. On 13 July, the whole of Transylvania was hit by a huge windstorm (Kraus, 1862). Only 31 summer precipitation days in Kassel (Figure S2c) indicates dry patterns. Stüeler characterised this year in north-west Bohemia as dry, but with sufficient grain and good wine (AS13). A year with a good harvest was reported also in Moravia (AS14). Much fruits, crops and good wine was in Austria “*yet the war has laid waste to everything*” (Lauscher, 1985). September was very warm and dry in Saxony and East Prussia (Bock, 1782; Militzer, 1998). Very cold end of year was reported in Austria (Lauscher, 1985).

### 1635

Very severe winter with frozen rivers and the Gdansk Bay was reported in Polish sources (Radziwiłł, 1980a). It was possible to walk over the frozen Baltic Sea from the Danish island of Bornholm to Schonen on the Swedish mainland (Berghaus, 1837/1838). The River Elbe near Glückstadt (Schleswig-Holstein) was frozen until March (Müller, 1823). In very cold winter frozen people and animals in Austria (Lauscher, 1985). Very cold winter is confirmed by 63 frost days recorded in Kassel (Figure S2a). Frozen waters in Saxony complicated operation of water mills, similarly as in summer due to a lack of water (AS6; AS9; Abel, 1732). Dry April, cold May and rainy weather for mid-June and August were reported for Poland (Czaplewski, 1917; Radziwiłł, 1980a). In Saxony, “*the weather in May was frosty like autumn*” and damaged fruit trees (Lehmann, 1747; Militzer, 1998). Repeated frosts in May destroyed grapevines in many parts of Transylvania (Réthly, 1962). Nosidlo characterised summer in Bohemia as cold (Lisa, 2014), which is confirmed by small number of hot days recorded during this summer in Kassel (Figure S2c). As for Bohemia, the economic official at Pacov, Martin Škvorecký, reported poor harvest of wheat and greatly damaged buckwheat and hops by frost (Teplý, 1928). Stüeler described this year as dry, with little grain and fruit, but good wine (AS13). Poor harvest of grains and its bad quality was reported also in Nové Město nad Metují (Šůla, 1998). It agrees with dry summer and autumn mentioned for Slovakia (Réthly, 1962). Little bad wine, expensiveness and great plague were cited for Austria (Lauscher, 1985). Frost in Poland set in from the beginning of December, but from c. 13 December it was rainy (Radziwiłł, 1980a).



## 1636

In January and February, several thunderstorms caused much damage in Transylvanian towns, for example in Cluj, Oradea and Sighișoara (Réthly, 1962). Based on the author of the Jesuit diary from Trnava (Slovakia), György Dobronoki, very mild weather prevailed in January when people were even ploughing and sowing everywhere. After mild weather on the first third of February, frosts set in on 11 February and on 24 February ice was already on the Danube in Bratislava (Réthly, 1962). It coincided with Poland where frosts lasted from mid-February until 4 March. While rainy beginning of June was followed there by sunny weather (Radziwiłł, 1980a), in Trnava a beseeching procession for rain was kept on 8 June after six weeks of drought when wells, springs and rivers dried up (also winter was dry) (Réthly, 1962). In northwestern Germany, there was no rain from January to June and the summer months were also dry (Müller, 1823). In Leipzig (Saxony), a drought starting in May continued for six weeks and brought mills to a standstill for lack of water (Vogeln, 1714). A disastrous thunderstorm on 13 July caused great damage to many places in north-west Bohemia when hail knocked down grains and damaged vineyards; in some places hail remained lying until the third day (e.g., AS13; AS16; Lisa, 2014). In August, a hailstorm hit the town of Mediaș in Transylvania, killing animals (Jakab, 1862). A sufficient good wine was reported for Krupka, while the whole year was described there as mildly dry (AS13). Frequent thunderstorms and hailstorms, enough of good wine, famine and great plague were mentioned for Austria (Lauscher, 1985). A great drought from early April until 28 July was recorded in western Switzerland (Chaillet, 1845). Drought in Transylvania resulted in an exceptional dearth of hay (Benkő, 1862). The second half of September was rainy in Slovakia (Réthly, 1962). Hermann IV recorded six frost days during October in Kassel (Lenke, 1960). November was remembered as a month with many great floods in Hungary and Transylvania (Kraus, 1862).

## 1637

In northwestern Germany, hard frost began on 21 November 1636 and lasted until early March 1637, but it froze again two weeks later (Müller, 1823). In Gdansk (Poland), the ice vanished from the Baltic Sea around 15 March, only to return one day later, almost crushing some ships (Bock, 1782). On 3 April, snow fell in Germany and it was possible for the nobility to travel in sledges (Weck, 1679). Severe and long-lasting colds from October 1636 in Slovakia finished after Dobronoki by warming on 9 April (not remembered so severe and long winter; Réthly, 1962). It agrees with Polish sources reporting severe winter (frost and snow from January until the first half of March) when Gdansk Bay was covered by ice still in the beginning of April (AS2; Czaplewski, 1917; Radziwiłł, 1980b). In spring it did not rain for three months in Bohemia (AS3; dry spring was reported also in central Poland – Radziwiłł, 1980b), so that winter and spring grains perished due to drought. Hot weather and drought was reported in Slovakia from 12 May to June when on 22 and 27 June beseeching processions for rain were kept. It resulted in very bad harvest, particularly of spring grain (Réthly, 1962). Very hot June was reported also in Saxony (Militzer, 1998). In Bohemia, Stüeler denoted the whole year as very dry. Although vineyards suffered by frost in the night from 7 to 8 May, a crop of vine grapes was considered as good (AS13). Spring and summer were also very dry and warm around Sighișoara (Kraus, 1862). In Bohemia, a bad harvest of barley and oats was reported in Nové Město nad Metují (Šůla, 1998) and a dry year by the provost of the Doksany friary, Norbert Amoen (Straka, 1926). Also Moravian sources mentioned very dry summer, poor harvest, problems with milling in water mills, lack of fodder for cattle and dearth (e.g., AS4; Dostál, 1962). Due to long lasting drought Kobylské Lake near Hodonín became dry (Beck, 1883). A very strong wind on 29–31 July damaged trees and thrown down fruits in Bohemia (AS13). The Austrian source mentioned much good

wine, but terrible famine (Lauscher, 1985). Snowstorms, a quantity of snow and impassable roads were reported on 12–14 November in Bohemia (AS13). István Keresztes in Trnava Jesuit diary reported snow on 13 November as unusual phenomena for this part of the year (Réthly, 1962). After rainy October in Poland, frost and snow continued there from 16 November until early December (AS2; Radziwiłł, 1980b). On 6 December, a sudden flood destroyed a boat-bridge in Bratislava (Réthly, 1962) and this month also ice drift and flooding occurred along the Rhine River (Happel, 1690).

### **1638**

Rather short winter with frosts was reported for Poland (AS2), when ice on the Neisse River in Silesia melted in mid-February (Weikinn, 1961). A windstorm on 3 February caused a great damage to buildings and trees in Bohemia and Moravia (e.g., AS3; AS13). Very dry weather in April and May were documented by many sources in Bohemia (e.g., AS1; Teplý 1928; Šůla, 1998), during May in Ung county in Slovakia (Szopori Nagy, 1881), in spring in Făgăraș, Transylvania (Benkő, 1862) and in summer in Moravia (e.g., Dostál, 1962; Fialová, 1967). Cucumbers, cabbages, flax and buckwheat froze on 6–7 June and on 30 June it snowed in the Ore Mountains. (AS13). In Gera, snow and frost also affected the summer seeds, but did not affect the grains and fruit trees (Zopf, 1692). Warm and dry summer with a good harvest was in northwestern Germany (Müller, 1823). Due to droughts, grains and grass dried in many places in Bohemia, being followed by a poor harvest and the lack of fodder for cattle (AS13). But there was plenty of good wine, despite it was attacked by blight in July (AS13; AS16). In Austria, very good wine, but in small amount and very expensive, and continuing famine were reported (Lauscher, 1985). From 11 September until 12 October it rained in Thuringia and snow inundation followed (Koch, 1914). Already on 10 October heavy frost came in north-western Bohemia and for the following three days it was snowing (with much snow in the Ore Mountains) (AS13).

### **1639**

On 17 April a flooding of the Elbe in Bohemia was reported (Straka, 1926). In May, several rivers flooded in Transylvania, causing the death of many people and animals (Kraus, 1862). Frequent rain spells in the Czech Lands occurred in summer (Dvorský, 1886), that wheat and barley were high, but poor on grain (Teplý, 1928). Wet summer is confirmed by 61 precipitation days recorded by Hermann IV in Kassel (Figure S2c). Mostly rainfall with cold wind from late May to 17 August together with a delayed and wet haymaking and grain harvest were reported in north-east Switzerland (AS15). Grapes could not be harvested at all because of the cold rains at Fântânele in Transylvania (Benkő, 1862). The Austrian source mentioned wet summer, much of very sour wine and frost in early autumn (Lauscher, 1985). Several reports in the Czech Lands cited a fertile year (e.g., Straka, 1926), while some from Moravia spoke about expensiveness, but not so large as in 1629–1630 (e.g., Schram, 1906). A good harvest in Saxony eased somewhat the price increase in autumn (Vogeln, 1714), which was very mild with blossoming bushes, roses and spring flowers (AS7). Very mild autumn was reflected in only 3 frost days (5 hot days) in records of Hermann IV in Kassel (Figure S2d). Rainy weather at the end of December was in Masovia (Radziwiłł, 1980b).

### **1640**

Frosty Easter (5–9 April) with a snowfall on 9 April in north-west Bohemia (AS13) were followed immediately by high water on the Ohře River (Straka, 1926). Continuous rain was reported in April in Masovia (Radziwiłł, 1980b). Wet spring with 58 precipitation days was recorded in Kassel (Figure S2b). On 2 June, there was a storm in Levoča followed by a flood larger than anything in living memory, in which four people died (Bal et al., 1910). In eastern

Germany it rained continuously from around 22 to 29 June, which damaged the hay and grains (AS9; Vogeln, 1714; Abel, 1732). In Bohemia, the year brought a lot of fruits and nuts, but little grain and wine (AS13). After cold winter, “*delayed spring*” and frost in early autumn, much sour wine was in Austria (Lauscher, 1985). Different diseases were frequent in stormy September in Poland, but only rarely they were deadly (Radziwiłł, 1980b). The first snowfall in the night 24/25 October and a snowfall on 1 November “*like on the feast of Three Kings [6 January]*” were accompanied by onsets of frosts in Bohemia (AS13; Teplý, 1928). In Sopron, there was heavy snowfall on 26–28 October, which resulted in the death of two people during grape harvest (Réthly, 1962). The “*nice [weather] as it is sometimes in the spring*” was in September and early October in East and West Prussia, but at the end of October snow and frost arrived. December was very cold (Bock, 1782) as confirmed by 23 frosts days in Kassel (Lenke, 1960).

### 1641

On 17–18 April it snowed at Krupka (frost on 18 April), but towards the end of the month cherry trees were in blossom. After further snowfalls on 9, 12 and 14 May (a knee deep snow in the Ore Mountains), trees, vineyards and hop-gardens froze on 15–16 May (AS13; AS18). May was very cold and brought heavy snow, which lay until June in Silesia (Militzer, 1998). After episodic frosts in summer (25/26 July at Pacov – Teplý, 1928; 10 August at Krupka – cucumbers and cabbages froze), early frosts on 2–3, 24 September and 10–12 October caused freezing of ripe grapes in Bohemia (AS13). Very cold weather on 21 July in East Prussia and in Pomerania (Bock, 1782) was followed in Saxony by sharp colds on the “*dog days*”, usually the hottest days of the year. Moreover, rains during the harvest time negatively affected yields (AS7). In the Spiš region (Slovakia), a protracted period of cold weather appeared in August, during which 150 horses and two herders died froze to death on an alpine pasture (Réthly, 1962). In Rotenburg an der Fulda (Hesse) was the first autumn frost recorded as far as on 22 September (Figure S2d). In Sighișoara, when grape harvests were about to begin on 20 October, all the grapes froze. Bonfires had to be made so that the grapes melt (Réthly, 1962). In Austria, after “*delayed spring*”, wet summer and frost in early autumn resulted in a little of sour wine (Lauscher, 1985). As for the Czech Lands, the year was rich in grain (other sources in Moravia speak of average harvest – e.g., Schram, 1906; Indra and Turek, 1946), but with no fruits. After the first snow at Krupka on 29 November, when snow remained lying, came heavy snowstorms on 10 December during great colds (AS13). Also Moravian sources from Nový Jičín (Schram, 1906) or Drahotuše (Indra and Turek, 1946) reported a lot of snow in December, which is in coincidence with 12 days with snowfall in observations by Hermann IV in Hesse (Lenke, 1960). Very strong frosts at the end of December were reported in Poland (Radziwiłł, 1980b).

### 1642

A flood of the Ohře River on 2 February destroyed a bridge in Louny (Lůžek 1970). Stüeler mentioned in February four times damaging strong winds and snowing and very cold weather on the beginning of March for northwest Bohemia (AS13). Wet in January and February was in Polish Masovia and strong frost came there on 25 February (Radziwiłł, 1980b). Snowfall in Bohemia on 5–6 and 14–15 May and hard frosts on 6–7 May damaged vineyards on slopes and nuts (AS13; in Slaný, frosts were on 26–28 May – Lacina 1885). In Levoča, winter grains frozen on 26 May, which doubled the prize of grain (Bal et al., 1910). Frosts appeared again in the night 11/12 June and on 18 June in Bohemia (at Pacov before 23 June – Teplý, 1928). Similarly frosts in May and June damaged vine and grain in the Saale region, Franconia, Alsace, Austria, and Hungary (Dreyhaupt, 1749). Then on 23 June around Levoča and Spišské Podhradie there was a great hailstorm, which reportedly resulted in a one-metre thick

layer of ice (Réthly, 1962). During the summer no rain appeared for seven weeks in Leipzig, while dry weather continued until November. It resulted in lack of water, troubles with operation of water mills and bad fruit harvest in Saxony (Weck, 1679; Vogeln, 1714). In the summary information Stüeler (AS13) stated a good grain harvest, average vintage, little fruit and no nuts for Bohemia (a hop perished at Žatec – AS18). But frosts on 17 September and again on 25 September caused freezing of grapes (AS13). In Rotenburg an der Fulda, the first frost was reported for 26 September (Figure S2c). Much snow followed by a devastating flood in September occurred in the region of the Orava River in Slovakia (Rakovszky, 1889). After a frosty spring, little wine of good quality was produced in Austria (Lauscher, 1985).

### 1643

Stüeler (AS13) mentioned in Krupka rather mild weather in January–February, followed by much snow on 7–8, 10–11 and 29 April and very cold weather from 7 to 15 April (April frosts and snowfalls affected also Saxony – Knauth, 1721). Further frosts on 1, 16–17 (again with snow), 19 (“*the frozen soil could carry a horse and a wagon*”) and 29 May caused great damage to vineyards (AS13). A great cold and frosts from March until 4 April, causing much damage to crops, were reported in Sighișoara (Kraus, 1862). Major snowfall occurred in Pavlovce nad Uhom (Slovakia) on 23 April (Szopori Nagy, 1881). Polish sources reported frost and snow in April in Masovia and the same for spring in Pomerania (Zernecke, 1711; Radziwiłł, 1980b). In East and West Prussia, the colds continued from winter until early May, when many birds perished and animals could not find enough food on the fields (Bock, 1782). Great colds and long lying snow in Moravia allowed sowing of summer crops and barley only in June (AS5). Stüeler (AS13) stated a little wine, the same as fruits and grain (but much wheat), and no nuts (in Nové Město nad Metují, the harvest was conspicuously lower than in 1642 – Šůla, 1998). A little wine of average quality, after mild winter, frosts in spring and autumn, was harvested in Retz (Lauscher, 1985). On 8 to 10 September, thunderstorms with heavy rain in Saxony and Thuringia led to damaging floods (Zopf, 1692; Knauth, 1721). A heavy snowfall with “*much snow like in winter*” on 28 October followed by frosts complicating vintage in north-west Bohemia (AS13) was reported also in Moravia (AS4; AS14), where snow cover lay until 11 November (Fialová, 1967). Much snow fell also around Pavlovce nad Uhom on 28 October (Szopori Nagy, 1881). Snow and frost came on 31 October in Saxony, when grapes had to be thawed before harvest, nevertheless, the vintage turned out good (Weck, 1679). At the beginning of November appeared already the ice on the Oder River in Silesia (Radziwiłł, 1980b).

### 1644

Late March winter in Germany was indicated by 22 frost days and 13 days with snow or snow with rain recorded in Rotenburg an der Fulda (Lenke, 1960). After a nice preceding weather with blossoming trees, late April and early May in Bohemia experienced several frost and snow episodes: 23 April, 2–3 May, 5–6 May (a snowstorm like in winter) and 7–8 May (again a lot of snow, similar as on 7 May in Saxony and Thuringia – Mörbitz, 1726; Koch, 1914). Trees were broken under the weight of snow and hard frosts damaged the vine, cherry trees, nut trees, cabbages and spring grains significantly in many places (AS13). Frost on 23 April was reported also from Szécsény in Hungary (Benkő, 1862). In May, bugs, rats, and caterpillars fed off the grapes, damaged trees, and ruined the grains in Saxony and Thuringia (Vogeln, 1714; Koch, 1914). Very dry spring was mentioned for Masovia (Radziwiłł, 1980b). On 17/18 July, a terrible thunderstorm with a lot of rain, led to flooding along rivers in Saxony and Saxony-Anhalt (Vogeln, 1714; Dreyhaupt, 1749). After cold winter and spring, a little of very good wine was harvested in Retz (Lauscher, 1985). The broken trees and a lot of

damage in Bohemia appeared after a disastrous storm on 19 September, when a rapid wind arose “*as [an] earthquake*”. A lot of snow fell there on 15 October (AS13).

### 1645

In Transylvania, the winter was exceptionally cold, there was almost two metres of ice on the Olt and Mureş Rivers, and many lakes froze over completely (Kraus, 1862). Very cold winter was reported also for northwestern Germany, when people froze to death in Bremen. Groceries remained very expensive there until imports from Gdansk arrived in 1649 (Müller, 1823). Winter colds on the beginning of March reported by Stüeler (AS13) were indicated also by further Czech reports connected with the war operations that mentioned the frozen Vltava near Orlík (27 February) and Klučenice (2 March) and frozen fields near Jankov (6 March), accompanied by deep snowdrifts and sharp gusty wind (Brázdil et al., 2004). On 18 May it snowed, in the mountains there were strong wind, great snowdrifts and knee-deep snow. The vineyards around Krupka were heavily damaged. On 12 July water froze in the meadows around Teplice (AS13). While in Rotenburg an der Fulda Landgraf Hermann IV recorded 55 summer precipitation days (Figure S2c), a warm and dry summer with damage to crops and low water levels was cited in Switzerland (AS20). Drought in spring and summer was reported from Sopron as well (Heimler, 1942). Much of good wine was harvested in Austria (Lauscher, 1985).

### 1646

In the Saale River region in Germany, heavy frost and snow from 20 December 1645 continued until 8 February 1646 (Dreyhaupt, 1749). In Masovia, frost set in on 21 December after preceding rains in this month; from frosty January snow remained until March. February frosts were reported in Pomerania (Radziwiłł, 1980b) as well as in Masuria (Girguś, 2022). In Saxonian Döbeln, a cold winter with a lot of snow was reported (Mörbitz, 1726). Hermann IV recorded 22 snowfall days in Rotenburg an der Fulda (Figure S2a). Stüeler (AS13) reported two damaging thunderstorms with hail on 3 and 23 July not only in Bohemia, but also in Germany (e.g., at Freiberg (Saxony) 15 houses caught fire from lightning). On 13 July, there was a major hailstorm in Sopron, followed by two days of good weather and then eight days of continuous rains. The water level of Neusiedl (Fertő) Lake between Austria and Hungary increased to such a degree that it almost reached the neighbouring villages (Réthly, 1962). Good was the harvest of grains, average harvest of nuts and fruits, while wine was little and sour in Bohemia (AS13). The Austrian source cited a little of good wine, reporting also cold winter and dry summer (Lauscher, 1985). The autumn was characterised as cold and wet in Bohemia (frost on 10 September, first snowfall on 27 October) (AS13), which is in agreement with 57 autumn precipitation days recorded in Rotenburg an der Fulda (Figure S2d). In the Ore Mountains, flowers grew, cattle grazed at meadows, and people worked at fields during mild November and December (Lehmann, 1747).

### 1647

Polish records reported a very frosty February for Pomerania and a cold, frosty and snowy March (Radziwiłł, 1980c). Stüeler’s Bohemian records mentioned blossoms on cherry and pear trees on 17 April, a heavy frost on 3 May (on 7–11 May at Rakovnick), hoar-frost in meadows on 30 June and a snowfall like in winter on 9 July (AS13). In July, there were heavy floods in Transylvania and also around Sopron, destroying buildings and the harvest (Réthly, 1962). Wet summer patterns in Germany were indicated by 60 precipitation days recorded in Rotenburg an der Fulda (Figure S2c). Kłodzko in Silesia experienced a damaging flood on 27 August (Roch, 1687). Due to spring frosts was little wine, fruits and nuts, but a good harvest of grain in Bohemia (AS13). Much of good wine was cited in Retz (Lauscher, 1985). The

autumn in north-western Bohemia was characterised as nice and very mild, with the first snowfall on 27 October (AS13).

## 1648

For East and West Prussia, reports cited a mild winter with almost no frosts (Bock, 1782), which does not fully correspond to 35 winter frost days recorded in Rotenburg an der Fulda (Figure S2a). On 16 January, a sudden flood damaged many houses and killed several animals in Sopron (Heimler, 1942). Variable weather in winter was reported in Masuria (Radziwiłł, 1980c). Thaw in late February was followed by a flood on the Ohře River in north-west Bohemia (Straka, 1928). A changeable winter weather in January was reported for central Poland, while severe frost and snow appeared in mid-March in Pomerania (Radziwiłł, 1980c). Stüeler evaluated summer and autumn of 1648 as cold, with enough grain, some fruits, but no wine (AS13). But in the Plzeň region in western Bohemia, less grain was harvested than had been sown during autumn in some places (Menčík, 1897). The cold summer was confirmed by only 13 hot days, but 64 rainy days in Rotenburg an der Fulda (Figure S2c), following after wet spring with 54 precipitation days (Figure S2b). The Neisse River flooded on 11 June in Silesia and the Lausitz region (Müller, 1806). A little of sour wine was in Austria (Lauscher, 1985). The first snow in Krupka fell on 23 October (AS13). In Polish Masovia, winds and snow were reported in the second half of November (Radziwiłł, 1980c).

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