DOCUMENTARY EVIDENCE OF DROUGHTS IN SWEDEN BETWEEN THE MIDDLE AGES AND c1800

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Abstract

This article explores documentary evidence of droughts in Sweden in the pre-instrumental period (1400-1800). The database has been developed using contemporary sources such as private and official correspondence letters, diaries, almanac notes, manorial accounts, and weather data compilations. The primary purpose is to utilize hitherto unused documentary data as an input for an index that can be useful for comparisons on a larger European scale.

The survey shows that eight sub-periods can be considered as particularly struck by summer droughts with concomitant harvest failures and great social impacts in Sweden. That is the case with 1634-1641, 1652-1657, 1665-1670, 1677-1684, 1746-1750, 1757-1767, 1771-1776 and 1780-1783 and 1641-1646. Among these, 1652 and 1657 stand out as particularly troublesome. A number of data for dry summers are also found for the middle decades of the 15th century and the 1550s.

Introduction

Drought is not the most typical meteorological anomaly in a country like Sweden. Stretching from 69º N to 55º N it is characterized by arctic climate in the extreme north and temperate climate in the south. Located between the Baltic Sea and the Scandian mountain range it is normally affected by wet weather from the Atlantic. The length of the winter and the length of the growing period have the most distinct effect on agricultural production and society in general. Still, the early modern history of Sweden gives evidence of repeated periods of severe droughts.

In general, drought at the latitude of Sweden is caused by deficient precipitation and only occasionally by excessive temperature and evapotranspiration. But sometimes several meteorological and hydrological factors do combine to produce severe drought with serious socioeconomic consequences. For example, apart from deficiency in precipitation (meteorological drought) seasonal lack of streaming water can also be the result of late spring or low summer temperatures in the Scandian mountain range when snow fail to melt at a normal pace resulting in insufficient discharge into the rivers which produces streamflow (hydrological) droughts and/or low flows (Hisdal and Tallaksen, 2000). Insufficient spring floods also partly lies behind failed harvests of hay grown in wet meadows and in historical times concomitant raised cattle mortality. Conversely, low water levels in streams due to dry autumn/summer weather facilitates quick freezing in the early winter and implies further obstacles to running watermills. Therefore, in the long run droughts do affect agriculture but strike more directly at industrial activities depending on water power. Socioeconomically this has had serious consequences for Sweden, to a large degree dependent on mining and exports of iron and copper especially from the 17th century.

In this article, the annual indices from documentary data have been based on the stated intensity of the drought event and its spatial extension. It has only been possible to construct reliable indices for the 16th, 17th and 18th centuries since no continuous time series

REFERENCE

Hisdal and Tallaksen, 2000
can be reconstructed before that due to insufficient amounts of documentary records. Nevertheless, an overview of documentary data from the 15th century will be given.

For some years, the documentary data are too contradictory to enable any definite conclusions. In some cases, it derives from regional variations. One example is from 1554, when there was “severe drought” in the province of Uppland and at the same time good harvest in the Kronoberg province further to the south (Forssell 1884, bil A p 161). But even when data are relatively plentiful they can be contradictory. One such example is the year 1733. Some data from that year speak of an “unusual” drought in the provinces of Västergötland in the west, and Hälsingland and Dalarna further to the north in May (Broman, 1911-1949; Olofsson and Liedgren, 1974: 261; Svanberg, 1987: 209f). In a period of 18 weeks between early March and the end of June only three short showers of rain is said to have fallen in Västergötland, a province with typical humid weather conditions, and the water level of Lake Vänern was quite low (Bergstrand, 1934: 196; Wallén, 1910: 13). At the same time the harvests were good in general in Sweden and there are no reports of harvest failures (Utterström, 1957, II: 429). In Västergötland itself the harvest was even said to have been plentiful (Olander, 1951: 119). The explanation for this discrepancy can be different timings of sowing of different crops, where e.g. early-maturing crops like barley and wheat (which was only cultivated in Sweden to a small degree before the 19th century) (Söderberg and Myrdal, 2002) suffered most and crops with a long growing season, like rye and buckwheat, could survive. In no case there are evidence of droughts covering the entire growing season, which means that no generalized nutritional catastrophe has been registered. A mitigating factor was that periodically local demand for foodstuffs was reduced through the absence abroad of a large part of the male population in the numerous wars Sweden fought in Europe between 1630 and 1718.

Method

The most important part of establishing climatic variations in the past is the construction of an index that represents notions of drought and wet periods along a 7-point scale ranging from -3 (extremely wet) to +3 (extremely dry). This has been done here for the period 1500-1816. This consists of reading notes from different sources and interpret how these notes may be transformed into the index. For this study, we already had index of wet years (Retsö 2015) and complimented it with indexed notices concerning droughts.

As can been seen in Fig 1, there are many more notices which we have labelled “dry”, especially in the 18th century, than there are notices on “wet” conditions. The word “rain” occurs 3,361 times in the database (of a total of 20,896 entries), while the word “sun” only occurs 1,224 times. However, varieties of “heat”, “dry”, “warm” occur 1,726 times compared to the two words describing “wet” in Swedish, which only occur 292 times. Many notices regarding rain is of the kind “A beautiful rain fell”. Generally, wet conditions are defining for agriculture in Scandinavia, but many fields are located such that they have a natural drainage (Leijonhufvud, 2001: 130). These findings suggest that although notices of rain are more frequent than notices describing fine weather, consequences of “fine” weather were more troublesome.

Figure 1 depicts the precipitation index that has been constructed. Positive signs indicate years that were dryer than normal, while negative values indicate years that were wetter than normal.

Fig. 1. Precipitation index for Sweden 1500–1816
In this study we have used homogenized historical instrumental data from the observatory (Observatorielunden) in Stockholm. The temperature record begins in 1756 and the precipitation data in 1859. The datasets are freely available and were downloaded from Bolin centre [https://bolin.su.se/data/stockholm-historical-temps-monthly](https://bolin.su.se/data/stockholm-historical-temps-monthly) on 7th December 2019 and from the Swedish Meteorological and Hydrological Institute (Sveriges meteorologiska och hydrologiska institut, SMHI): [https://www.smhi.se/data/meteorologi/ladda-ner-meteorologiska-observationer/#param=precipitation24HourSum,stations=all,stationid=98210](https://www.smhi.se/data/meteorologi/ladda-ner-meteorologiska-observationer/#param=precipitation24HourSum,stations=all,stationid=98210) on 22nd January 2020. E-mail contact with SMHI confirmed that precipitation data from 1863 are missing.

Correlation between proper instrumental data of temperature and precipitation, from the same observational site of Observatorielunden in central Stockholm showed, rather surprisingly, a slightly negative correlation between summer temperatures and precipitation of -0.35 (Table 1). This result is also in accordance to personal experience: a rainy summer in Stockholm is usually also a rather chilly one.

Table 1: Correlation between temperature (°C) and precipitation (mm) at Stockholm (Observatorielunden) 1859-2011. Instrumental records

<table>
<thead>
<tr>
<th>Precip.Temp</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>JJA</th>
<th>MIJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pmay</td>
<td>-0.238</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pjun</td>
<td>-0.301</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PJul</td>
<td>0.020</td>
<td>-0.385</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paug</td>
<td>0.039</td>
<td>0.010</td>
<td>-0.334</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PJJJA</td>
<td>-0.077</td>
<td>-0.320</td>
<td>-0.375</td>
<td>-0.349</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMJJ</td>
<td>0.027</td>
<td>-0.187</td>
<td>-0.358</td>
<td>-0.246</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 2 depicts a scatter plot of June, July, August (JJA) precipitation over JJA temperatures.  
The warmer the summer, the less it rains.

Fig. 2: Scatter plot of JJA precipitation and temperature JJA 1859-2011

Figure 2: Scatter plot of JJA precipitation and temperature JJA 1859-2011

Turning our attention to the index, we get a similar result, although the highest correlation is 
received using MJJ-temperatures (hence the inclusion of this parameter in Tab. 1).  
However, since correlation for instrumental data between precipitation and temperature in 
May was very weak (non-existing), we argue that the standard season of summer months 
(June, July, August) will be more adequate in our exploration of droughts.

Another difference is that the index hardly has any correlation with August 
temperatures, while instrumental data renders a (slight) correlation between temperature and 
precipitation in August. We believe the main reason for this might be that the database may be 
more stringent when it comes to weather related events occurring during the first half of the 
year. It is also possible that a cool May, may be experienced as “wet”, and therefore described 
as such in the sources forming the foundation of the index.

Since there are no precipitation data before 1860, we have tested the 
precipitation index against Stockholm temperature series from 1756.

Correlation between the index and average monthly temperature for the period 1756-1816 
turned out significantly for the months May, June and July (Table 2).

Table 2: Correlation between average monthly temperatures against the drought index 1756- 
1816 and precipitation of Stockholm for the period 1859-2011

<table>
<thead>
<tr>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>MJJ</th>
<th>JJA</th>
<th>C-Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
<td>0.2552</td>
<td>0.3048</td>
<td>0.5150</td>
<td>0.3853</td>
<td>0.1288</td>
<td>0.5060</td>
<td>0.4708</td>
</tr>
<tr>
<td>Precip</td>
<td>-0.148</td>
<td>-0.238</td>
<td>-0.301</td>
<td>-0.385</td>
<td>-0.334</td>
<td>-0.246</td>
<td>-0.349</td>
</tr>
</tbody>
</table>

Precipitation data were downloaded from https://www.smhi.se/data/meteorologi/ladda
observationer/#param=precipitation24HourSum,stations=all,stationid=98210 on 22nd January 2020

Documentary data on droughts for the 15th and 16th centuries
For the 15th and 16th centuries documentary data are scarce, uneven and spread out in a number of different source categories. Indeed, there is a number of evidences for harvest failures, although the reasons are rarely stated. But in a region like Scandinavia it can be assumed that most of them has to do with drought rather than hydrological extremes like excessive rains, at least in the east. Furthermore, most data in accounts and letters tell about the date for sowing and reaping. Although these activities can be assumed to have varied within the framework of normal spring and autumn temperatures their variability should depend on hydrological conditions.

Information on grain prices in medieval Sweden are found in several sources, most often in municipal, Church, and other institutional accounts. Combined, they form a fairly complete annual series from the early 15th century onwards (Figure 3) and can be used as a proxy. Most of the price information stems from the province of Uppland, where Stockholm is located (Söderberg, 2007).

Fig. 3: Grain price per hectolitre in Sweden, harvest years 1291-1500

Since demand for foodstuffs in medieval society can be assumed to have been very stable, unusually high grain prices, as in the first decade of the 1400s and in the 1470s, can be attributed to fluctuations on the supply side, i.e. weather impact on harvests. For example, in 1403 there was famine on the island of Gotland (Joachim, 1896: 295; Ziesemer, 1921: 539; Eimer, 1966: 218) and in 1405 harvests were reported in nearly contemporary annals to have failed in Denmark and Sweden. A mild winter this year was followed by a dry spring and summer until the end of July, when a long rainy period began (Paulsson, 1974: 399. See also Weikinn, 1958: 286-8; Ogilvie, 1992: 242).

Apart from grain prices, it is likely that prices of certain other goods contain climatological information, in particular wax (in medieval society used primarily for the making of candles for religious ceremonies) and honey, both highly dependent on weather conditions in the summer. During the last three decades of the 16th century, production of bee wax was much reduced in Sweden, probably due to the transition to a cooler and wetter climate which was damaging to the bees (Husberg, 1994). Further research may be able to
clarify if short-run price changes in the price of wax during the medieval epoch could have a similar explanation.

Data on agricultural activities in the province of Östergötland are found for a few years in the first and last decades of the 15th century. Harvesting dates for 1402, 1407 and 1410 suggest close to normal summer temperature and precipitation (Lundén, 1958: 141, 161, 133; Retsö, Normality and anomaly, in preparation) while available data on dates for sowing of barley and other grains and fodder for the swine indicate somewhat late or cold spring in 1491, and early or warm spring in 1489, 1490 and 1492 (Alvered, 1999: 104, 145, 192, 245).

Food crises are frequently mentioned in the 15th century, in particular the four decades between 1430 and 1460s. It is assumed here that the mentioning of a food crisis in a particular year reflects a harvest failure the preceding year. As for the 1430s, we know that a period of crisis years began in 1435 and although we have no Swedish evidence of dearth for the first years of the decade, it can be noted that Danish and German sources mention hard times and high corn prices in 1433 that could be connected to cold springs (compare Camenisch et al., 2016: 2110). It is also conspicuous that a major peasant uprising occurred in Sweden in 1434 and it can be suspected that it had something to do with a food crisis in combination with unusually high taxes. In the spring of 1437 there was a lack of food grains in Finland and famine and dearth in Sweden are mentioned in early 1438 (Hausen, 1921 no. 2220; Tunberg, 1937: 214). The monetary valuations of the barley tithes in Funbo parish in Uppland in 1438 and 1439 more than doubled compared to the preceding years (Andræ, 1965). These years are well-known in continental Europe as a time of food crises with concomitant social and economic impacts. The harvests of 1437 and 1438 were the worst in England during the 15th century, and the price of grain rose to an exceptionally high level in 1439. The famines of the mid-1400s occurred in a context of repeated plague epidemics also hitting Sweden (Myrdal, 2003: 249). They also fall within a subperiod of colder summers related to a Spörer minimum of solar activity within a longer period (1400-1550) of slightly warmer summers as compared to the 20th century, at least in northern Fennoscandia, according to tree-ring data; the eruption of Mount Fuji in Japan in 1435/1436 may have contributed to cold winters and late and cool summers in north-western Europe during these years (Moberg et al., 2006: 24, 26ff; Campbell, 2009: 30; Camenisch et al., 2016: 2110).

The 1440s were also troubled by harvest failures. In 1442 the rye and hops harvest failed in Finland (Hausen, 1921 nos. 2512 and 2517; Bunge and Hildebrand, 1889 no. 955. See also Hausen, 1921 nos. 2521, 2528, 2529, 2535) and just a few years later the Vadstena abbey had been forced to sell some of its valuable chalices and shrines in order to buy food, due to the harvest failures in 1445 and 1446 (RA Medieval codex A21 fol. 89r-v). From 1446 there is information on famine in Sweden (Hadorph, 1674: 370ff) and 1448 was described as a year of dearth in Stockholm due to a dry spring and much rain from late May onwards (Klemming, 1866: 255).

The Vadstena annals describe the years 1454-1457 as struck by famine, which in the first of these years was combined with an outbreak of plague (Gejrot, 1996: 286f, 292f; Styyfe, 1870: 85. See also Christensen, 1895: 297 n. 2; Fant, 1818: 173, 175; Codex dipl. lub. 1:9, no. 328; Ropp, 1883 nos. 516, 520) and in 1470 there was famine in Finland (Hausen, 1924 no 3142). This, as well as the harvest failure of 1460, may have had something to do with a volcanic eruption in the Pacific in 1453, marking the onset of a 15-year cool period (Esper et al., 2017).

Also the early 1470s display evidence of a period of hot and dry weather, seemingly a general European pattern (Camenisch et al., 2020). In August 1474 the council of the Swedish realm issued a statute regulating the use of watermills due to repeated droughts, i.e. presumably causing lack of water (Hadorph, 1676 no. 9). Furthermore, food crisis is indicated in a letter from Åbo (Turku), Finland, from May 1471 (Hausen, 1890 no. 625), in Sweden
nominal grain prices display an unprecedented peak in the early 1470s, (Franzén and Söderberg, 2006) and the Danish Roskilde annals speak of a “severely hot and burning summer” in Denmark in 1473 (Rordam, 1873).

Summarizing, the years in the 15th century with harvest failures and/or unusually early onsets of the growing season are the following: 1402, 1405, 1436-1437, 1439, 1442, 1445-1446, 1448, 1453-1456, 1460, 1469-1470, 1473-1474, 1489, 1490 and 1492.

From the first decade of the 16th century there are a number of reports of harvest failures and famine. In Västergötland, Småland and the Stockholm area they speak of unnown fields, starving peasantry forced to eat bark, and expensive corn that point to a harvest failure in 1503 (RA Sturearkivet nos. 255, 637; Styffe, 1875 no 232). Shortage and poverty among the peasants are reported for the following year (Wegener, 1866-1870: 319-20). In southwestern Finland the harvest of 1507 had been consumed already in June 1511 and the peasantry suffered famine and ate “more bark than ever” (Hausen, 1930 nos. 5324, 5329). Similar reports are found for the same year from mid-Sweden and the Stockholm area (RA Sturearkivet nos. 573, 597). 1508 seems to have been even worse. Again, prices on rye were high in March 1509, but already by harvest time in 1508 prices were rising in Finland and the misery was said to be the worst in ten years; by the end of the year the country was ravaged by both great poverty and plague, enabling the peasantry to pay their taxes (Sjödin, 1937: 336; Hausen, 1930 nos. 5341, 5347, 5354, 5368). The same was reported from Sweden; in March 1509 the peasants northeast of Stockholm starved and ate bark (Styffe, 1875 no. 229; Sjödin, 1937: 322, 344; RA Sturearkivet no. 1053; Styffe 1875 no. 229). Widespread poverty was also reported as a result of a bad harvest in 1509, already in December in central Sweden, and in the spring and summer of 1510 (Sjödin, 1937: 350; Styffe, 1875 nos. 302, 304; RA Sturearkivet no. 1467).

In both Finland and southeastern Sweden there was severe drought in late spring and summer of 1551 (Almquist, 1905: 115 ff., 123 ff., 212 f., 430 ff.). Also in the autumn there was a severe drought in the Bergslagen mining area (Almquist, 1905: 430 ff., Johansson, 1882: 1590). In June 1559 the harvest of both rye and barley in Östergötland and southeastern Småland were in danger already in its blooming time due to both night frost and drought (Almquist, 1916: 190, 202, 651). The same was reported from Finland in September (Almquist, 1916: 287). Apart from 1551 and 1559 there are also reports from other years of the 16th century but they are sporadic and it is uncertain as to how extensive the droughts were. In 1599, there are evidence from southeastern Småland of severe heat and forest fires (Edman, 1985: 74; see also Utterström, 1955: 29, Hallendorff, 1902: 79) and the production of honey was reduced drastically (Husberg, 1994: 275). Other single years seem to have been dry on an all-European scale, like 1540 (Wetter et al., 2014). Although some of the dry periods recorded in Sweden coincide with similar drought episodes in other areas of Europe (see e.g. Brázdil et al., 2016), negative spatial correlations are to be expected between northern and southern Europe.

Documentary data on droughts for the 17th and 18th centuries

For the 17th and 18th centuries sources are far more abundant and continuous, among other things thanks to a number of private diaries. Eight periods stand out as particularly critical in terms of drought in the 17th and 18th centuries (for references for the particular years, see Table 4 below).

1) 1634-1641. There are reports of drought from the north as well as the south every year in this period. Weather conditions are characterized in the relatively detailed sources as generally dry with a typical pattern of dry and cold springs, hot and warm summers and rather wet fall seasons. The result was disaster for the harvest of hay but rather good harvests of rye. The hardships could even have begun earlier than 1634; in June 1635 Gabriel Gustafsson
Oxenstierna wrote to his brother that poverty was widespread in the whole country after the last 288 years (in plural) of dearth (Sondén, 1890: 363).

2) 1652-1657. 1652 was called the Great Drought Year already in contemporary sources. Several reports from virtually all regions of the country tell about dry weather caused by lack of rain and excessive heat. According to one source no rain fell between early May and late September, except for some thunder rains in Karlstad and at Letstigen in the province of Närke in June. Grain and hay harvests suffered severely except for rye and particularly in Finland, which fared slightly better. Great bushfires were rampant, destroying forests and rye in the fields. Watermills stood still due to dried out rivers. The heat caused epidemics killing many people, including members of the Royal Council. Also from 1657 there are reports covering all of Sweden about severe drought. Already in April the gardens were “longing for rain”. In Johan Rosenhane’s diary from Östergötland every day is noted to have been hot or very hot weather from early May to late August. Both the month of August and the entire year is said to have been so dry and hot that wells and streams dry up in Småland and Östergötland and that no one could remember such a drought. In the spring, eleven out of 65 iron mills in the Bergslagen region were unable to operate due to lack of water, especially those located by smaller rivers, and most of them had to limit their operations considerably during the whole year. The lack of water in the rivers running into Lake Mälaren is also shown by the fact that the water level of the lake was so low that sandbanks were visible. Even in the northern province of Norrbotten the summer drought caused forest fires and much damage to the harvest.

3) 1665-1670. The last years of the 1660s was a new period of dry years. 1666 seems to have been the worst; already in July harvests were forecasted to fail and at least in the west there was a lack of rain between late June and late September. But also in all of the following four years harvest failures are reported and water levels in lakes and streams were extremely low.

4) 1677-1684. The same pattern was repeated in the end of the 1670s and early 1680s. In particular, 1681 and 1684 stand out; in the former year Stockholm had no rain at all in April and May and hay harvests were weak, and in 1684 there was a food crisis, the peasants requiring to pay their church tithes in cash rather than in grains.

5) 1746-1750. A new prolonged drought period occurred in the mid-1700s. Beginning in 1746, there are repeated reports on spring drought, and in the following years also a summer drought from Hälsingland in the north to Västergötland in the west. Streams dried up and harvests failed and bark beetles, favoured by the hot weather, destroyed timber wood.

6) 1757-1767. Most of the growing seasons of this period were affected by dry weather with harvest failures and dried up wells and marshes. Spring was particularly late in 1758; in the Stockholm harbor ice was said to be one meter thick in late April and there was still ice in inlet and small lakes in early May. The following summer was hot and dry, as were the summers of 1759, 1762 and 1764. According to one source, the dry period extended from 1749 to 1767 at least in the north and with annually varying degrees of intensity.

7) 1771-1776. According to sources covering most of the southern half of the country these years were all characterized by cold springs and hot and dry summers. Hay harvests failed due to dried up wet meadows and even rye failed to mature in due time. In particular 1775 stand out as a critical year. Barley, peas and hay suffered severely and lake water levels reached record lows. In the Stockholm region famine threatened in 1771.

8) 1780-1783. From Västerbotten in the north to Blekinge in the south there are reports on cold springs and dry summers, dried-up wells and streams, bushfires, and in Västergötland marshes were even so dry that they caught fire. In 1782, sowing was delayed until the first week of May in the Stockholm region due to persisting ground frost. In Västerbotten in the north it only rained twice from summer to October in 1780 and roots and cabbage failed, while the rye harvests were quite good as was the hay harvest, probably due to
cultivation on wet meadows watered by meltwater from the mountains. On the other hand, in all regions in the south the hay harvest seems to have failed and the price of rye rose with more than a third over the year. The same pattern was repeated in 1781 and 1783.

Since we have temperature measurements for the latter half of the 18th century, it is possible to quantify points 6, 7 and 8 above. In Table 3, average monthly temperature for June, July and August, as well as the summer season JJA, are compared to average monthly temperature for the entire period 1756-1816, i.e. until the year when the index ends. None of the dry sub-periods differ significantly from average monthly temperature for any of the summer months, or of the summer season. The period of 1771-1776 has the highest difference compared to average monthly temperature for the whole period 1756-1816, being c. 1 degree warmer.

Table 3 Dry periods in Sweden in the second half of the 18th century reflected in instrumental measurements. Average monthly temperature for 3 sub-periods

<table>
<thead>
<tr>
<th>Period</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>JJA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1756-1816</td>
<td>14.88</td>
<td>17.81</td>
<td>16.47</td>
<td>16.39</td>
</tr>
<tr>
<td>(Index period)</td>
<td>(1.62)</td>
<td>(1.61)</td>
<td>(1.51)</td>
<td>(1.17)</td>
</tr>
<tr>
<td>1757-1767</td>
<td>15.69</td>
<td>17.99</td>
<td>16.19</td>
<td>16.62</td>
</tr>
<tr>
<td></td>
<td>(1.44)</td>
<td>(1.59)</td>
<td>(1.18)</td>
<td>(0.63)</td>
</tr>
<tr>
<td>1771-1776</td>
<td>16.50</td>
<td>18.95</td>
<td>17.13</td>
<td>17.53</td>
</tr>
<tr>
<td></td>
<td>(1.44)</td>
<td>(1.16)</td>
<td>(1.68)</td>
<td>(1.13)</td>
</tr>
<tr>
<td>1780-1783</td>
<td>15.63</td>
<td>18.58</td>
<td>17.53</td>
<td>17.24</td>
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<tr>
<td></td>
<td>(1.58)</td>
<td>(2.25)</td>
<td>(2.02)</td>
<td>(1.56)</td>
</tr>
</tbody>
</table>

Discussion and conclusions

The main problem with the precipitation index is that we have no precipitation data overlapping the index. There is some correlation between the precipitation index and summer temperatures in Stockholm, just like there is some correlation between precipitation and summer temperatures. Correlation between the precipitation index and summer temperatures are higher than between summer temperatures and precipitation, so it is possible that the precipitation index is rather a “good-summer-weather-index”. We think that the ideal would be to extend the documentary database until – at least – early 20th century.

Despite the shortcomings of the index, we still think that some conclusions may be drawn from it. The height of the Little Ice Age, between c. 1570-1630, is, rather surprisingly, characterized by very high variations with some years extremely wet, and some years extremely warm. After c1660, wet years become increasingly uncommon, and most years are either dry or very dry, especially from the mid-1700s onwards. Although previous estimates of Stockholm summer temperatures after 1756 have been shown to be positively biased, this seems to correspond to trends in tree-ring widths and density in at least northern Fennoscandia (Moberg et al., 2003; Grud, 2008).

Since the index is made of discrete variables, we thought it less meaningful to try out a regression analysis and model (which would only render 7 different “temperatures”), especially since we have been concentrating on precipitation and not temperature.

The drought chronology presented here is likely to be related to the climatic variability in northern Europe caused by atmospheric circulation patterns over the North Atlantic area (the North Atlantic Oscillation, NAO). Although there seems to be no determinant influence by NAO on local summer conditions, especially in the inter-annually and seasonally very variable Baltic Sea area, the evidence does suggest a connection between dry periods and...
positive NAO values. Further research into documentary data from Sweden and the Baltic region on wind conditions and storms, especially for the Middle Ages, may further illuminate the issue.

Archival sources

( RA:) Riksarkivet (National Archives of Sweden), Stockholm

Medieval codex A21 Sturearkivet

Riksrägisteret


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### Table 4: Drought periods in Sweden 1600-1800

<table>
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<th>Period</th>
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<td>1634-1641</td>
<td>Falkengren, 1781; Bergh, 1886: 194; Bergh, 1888: 155; Sondén, 1890: 363; Edén, 1905: 216; Norberg, 1956: 23; Låf, 1942: 151</td>
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