UNUSUAL CLIMATE IN NORTHWEST EUROPE DURING THE PERIOD 1730 TO 1745 BASED ON INSTRUMENTAL AND DOCUMENTARY DATA

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Abstract. This study focuses on one of the most interesting times of the early instrumental period in northwest Europe (from 1730–1745) attempting to place the extremely cold year of 1740 and the unusual warmth of the 1730s decade in a longer context. The similarity of the features in the few long (and independent) instrumental records together with extensive documentary evidence clearly indicates that remarkable climatic changes occurred rapidly in this period. We use unpublished subjective circulation charts developed by the late Hubert Lamb, to assist in understanding the course of events, particularly during the extreme year of 1740 and the four subsequent years. We also compare these subjective charts with others recently developed using more objective modern reconstruction techniques. Apart from evidence of a reduction in the number of explosive volcanic eruptions following the 1690s, it is difficult to explain the changes in terms of our knowledge of the possible factors that have influenced this region during the 19th and 20th centuries. The study, therefore, highlights how estimates of natural climatic variability in this region based on more recent data may not fully encompass the possible known range.

1. Introduction

The barometer and the first reliable thermometers were developed in the seventeenth century. Hence, for much of the period from about 1650 to 1800, information about European climate comes first from a mix of documentary sources and then progressively with an increasing contribution from instrumental sources. Written information becomes scarce during the nineteenth century as the reliance on objective meteorological measurements took hold. The period with which we are concerned in this paper, the 1730s and the early 1740s, lies at a time of early transition. A few instrumental records exist, but also many and diverse documentary sources.

In this paper we draw this information together, concentrating on the instrumental sources that will enable the climate in the period 1730–1745 to be viewed in a longer-term context. The principal purpose of the paper is to study the period, especially the extremely cold year of 1740 in the few very long northwest European instrumental records. This calendar year and especially the 1739/1740 winter were exceptionally cold. The impacts of the extreme cold in Ireland are discussed by Dickson (1997), the most remarkable of which is that the River Shannon froze over

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during the winter. Dickson (1997) refers to the period as the ‘Forgotten Famine’ in Ireland, when it is believed that as many people emigrated as in the later mid-1840s ‘Potato Famine’.

Tentative, monthly-mean pressure maps for Januarys and Julys for part of the period (1739–1744) were previously drawn by the late Hubert Lamb, The original, unpublished copies are held in the Climatic Research Unit archives. We use these charts to consider the circulation features that led to some of the undoubtedly extreme events that occurred in this period. The subjective charts are compared with those recently developed on a monthly basis for the period from 1659 by Luterbacher et al. (2002b), henceforth L02B. What appears most remarkable about the exceptional cold year of 1740 is that there does not appear to have been any simple cause for the event, such as a single or a series of large volcanic eruptions: no major events are listed in the Smithsonian Archive (Simkin and Siebert, 1994).

We begin by reviewing the early instrumental evidence and then introduce documentary evidence from Britain and continental regions of northwest Europe. The emphasis of the paper is Britain, but reference is also made to other parts of northwest Europe. The atmospheric circulation maps (together with the comparison with the L02B modern objective charts) are then used to determine the likely extent of the event, followed by some discussion and conclusions.

2. Long-Duration Instrumental Series

The British Isles is endowed with the longest continuous temperature and precipitation records available anywhere in the world. In this section, we place the period (especially the early 1740s) in the joint contexts of the earlier 1730s and the period since using the few long records Britain and northwest continental Europe continuously available from this time.

2.1. TEMPERATURE

Perhaps the world’s best known long series of instrumental data was published by the late Gordon Manley (1974). This series is referred to as the Central England Temperature (CET) record and it contains monthly values for each year back to 1659. It was updated and made available on a daily basis back to 1772 by Parker et al. (1992). The record has been comprehensively analysed in Jones and Hulme (1997). On century timescales, it has been shown to agree well with the trends derived from borehole reconstructions (from 26 sites across the country) of the average air temperature since 1500 (Jones, 1999).

Figure 1 shows annual average temperatures year-by-year from the beginning of the CET record, plotted alongside the other continuous continental series that extend back to the 1730s. The two coldest years in the entire CET record are 1740 (6.8 °C) and 1879 (7.4 °C), with the warmest years occurring more recently

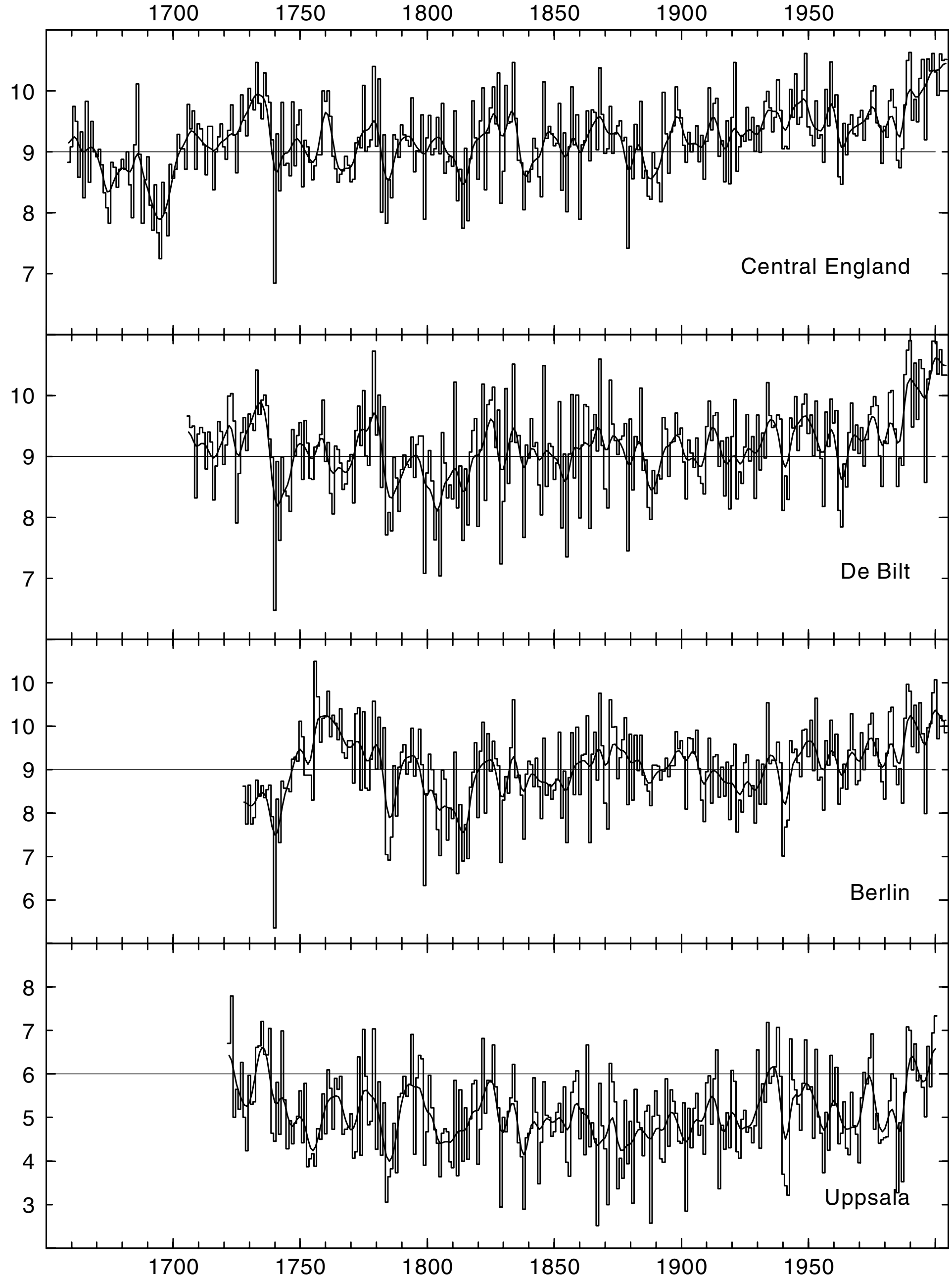


Figure 1. Annual mean temperature (°C) for Central England, De Bilt, Berlin and Uppsala. For sources of the data see text. The smooth line highlights variations on the decadal timescale. The length of the records is 1659–2003 for CET, 1706–2003 for De Bilt, 1729–2003 for Berlin and 1722–2003 for Uppsala.

(1990 and 1999 are tied as the warmest) with annual temperature averages of 10.6 °C. These extremes compare with a 1961–1990 average of 9.5 °C and a standard deviation over this period of 0.5 °C. The range between the warmest and coldest years is only 3.8 °C, much smaller than in more continental areas, due to the strong maritime influence on this region. The average for the year 1740 is clearly the most anomalous year of the entire record with all months except September being colder than their 1961–1990 average. Both May and October are recorded as the coldest such months in the entire record. No other year was so different from those immediately preceding or following, being over 2.4 °C colder than either 1739 or 1741. The cold of 1740 must have come as a great surprise to the people living then, given that it followed an exceptionally warm period between the years 1729 and 1738. The warmth of the autumns (September to November) during this time was equal to that recorded during 1991 to 2000. Both 10-year periods have a mean of 10.5 °C (the warmest recorded) compared to 10.2 °C for the 1961–1990 average. On an annual basis, mean temperatures for the period 1729–1738 are only 0.3 °C below the average for the last ten years (1995–2004, see Figure 1, top panel). The last ten complete years are the warmest 10-year period in the CET series. CET correlates highly with other sites around the British Isles (even peripheral stations, e.g. 0.78 for Valentia, 0.65 for Stornoway and 0.54 for Lerwick, see Jones and Hulme, 1997) so 1740 would be expected to be the coldest year across all the British Isles, except possibly for the very north of Scotland, as here the variance explained by CET is lower than for the other peripheral locations.

For continental Europe, the only other three long records, that extend continuously back this far, are plotted in Figure 1. These are De Bilt (van Engelen and Nellestijn, 1995), Berlin (Schaak, 1982) and Uppsala (Moberg and Bergström, 1997; see also Bergström and Moberg, 2002). The long-term agreement between CET and De Bilt is excellent. The agreement with Berlin is also high for years back to 1780, but lessens due to an exceptional warm period in the 1760s and 1770s in the Berlin record. In all three records, the exceptionally cold year of 1740 stands out, together with the marked contrast with 1739 and 1741. For CET and De Bilt there is a near 1 °C difference between the mild 1730s and the cooler 1740s and this drop represents the most dramatic cooling in both records. For Berlin, the 1730s were not as exceptionally warm as the two more western sites. The Schaak (1982) record for Berlin indicates a cooler 1730s, but the poorer agreement between this site and CET and De Bilt for the 1760s and 1770s suggests probable problems with the homogeneity of this record compared to those for the other sites, rather than any anomalous influence of the circulation. Berlin is in excellent agreement with the two more western sites after about 1780. The warmth of the years 1729–1738 in northwest Europe is rarely commented upon in proxy climatic reconstructions for the region. Rather most reconstructions tend to refer to a general agreement with the notion of a protracted cold period (the ‘Little Ice Age’) from 1550 until 1850 (see discussions in Lamb, 1977, 1982 and Brázdil et al., 2006).

A similar, but smaller temperature drop occurs in the early 1780s. CET and De Bilt also highlight the rapid warming from the markedly cold decade of the 1690s to the 1730s. Although the De Bilt record only begins in 1706, the last decade of the 17th century and the first six years of the 1700s are exceptionally cool in documentary data (van Engelen et al., 2001). A possible reason for this temperature increase is the dearth of major explosive volcanic eruptions from the early 1700s compared to the previous two decades (see Simkin and Siebert, 1994), but more recent studies would indicate that this change can only explain some of the initial rise during the 1700s (Jones et al., 2003).

At the third continental location, Uppsala, 1740 is only marginally cooler than the 1961–1990 reference period. Moberg and Bergström (1997) were worried by the apparent lack of a very cold 1740 in this record as this might imply some lack of homogeneity in the pre-1741 data. They note that the same pattern of a mild 1730s and cooler 1740s evident in CET and De Bilt is clearly apparent at Uppsala. At all three sites the 1730s is the mildest decade in the record until the 1990s. The only marked difference with the other three European sites occurs in 1740 itself. The 1739–1740 winter was near normal at Tornio (at the head of the Gulf of Bothnia, Vesajoki et al., 1995) and this suggests the development of a persistent, cold blocking high over central Europe, which reached unusually far west. This suggests that cyclonic activity was restricted to the Iceland and Mediterranean regions. Only for a short period in late January and early February was central Scandinavia affected. This assertion is explored later in the context of the atmospheric circulation over Europe at that time.

Information on the freeze and break-up dates from Lake Mälaren in central eastern Sweden has been used to extend the Uppsala temperature record back to 1712 (see Eklund, 1999 and Moberg et al., 2005). Figure 2 shows this reconstruction and compares it with winter temperature series from more distant records at Tallinn and northern Sweden (both of which are combinations of freeze/break-up dates and more recent instrumental records, see Tarand and Nordli, 2001 and Klingbjer and Moberg, 2003, respectively). The year 1740 is one of the extreme winters at Tallinn, but not the most extreme. At the two Swedish sites, 1740 is only slightly colder than normal for late winter/early spring, confirming the earlier work of Vesajoki et al. (1995) and Moberg and Bergström (1997).

Reconstructions of seasonal gridded temperature anomalies for Europe have recently been developed (see e.g. Luterbacher et al., 2004) using an orthogonal spatial regression technique with a range of instrumental and documentary sources reaching back to 1500. Whilst exceedingly useful we prefer, however, to consider only the original series of immediate spatial relevance to our study area. As an aside, we note one important point about these types of reconstructions (e.g. Luterbacher et al., 2004) which may not be widely appreciated. For years before the availability of widespread pressure data in Europe (∼1780), such temperature reconstructions cannot be used to assess the strength of circulation influences from reconstructions of circulation maps also produced by L02B, nor reconstructions of the North

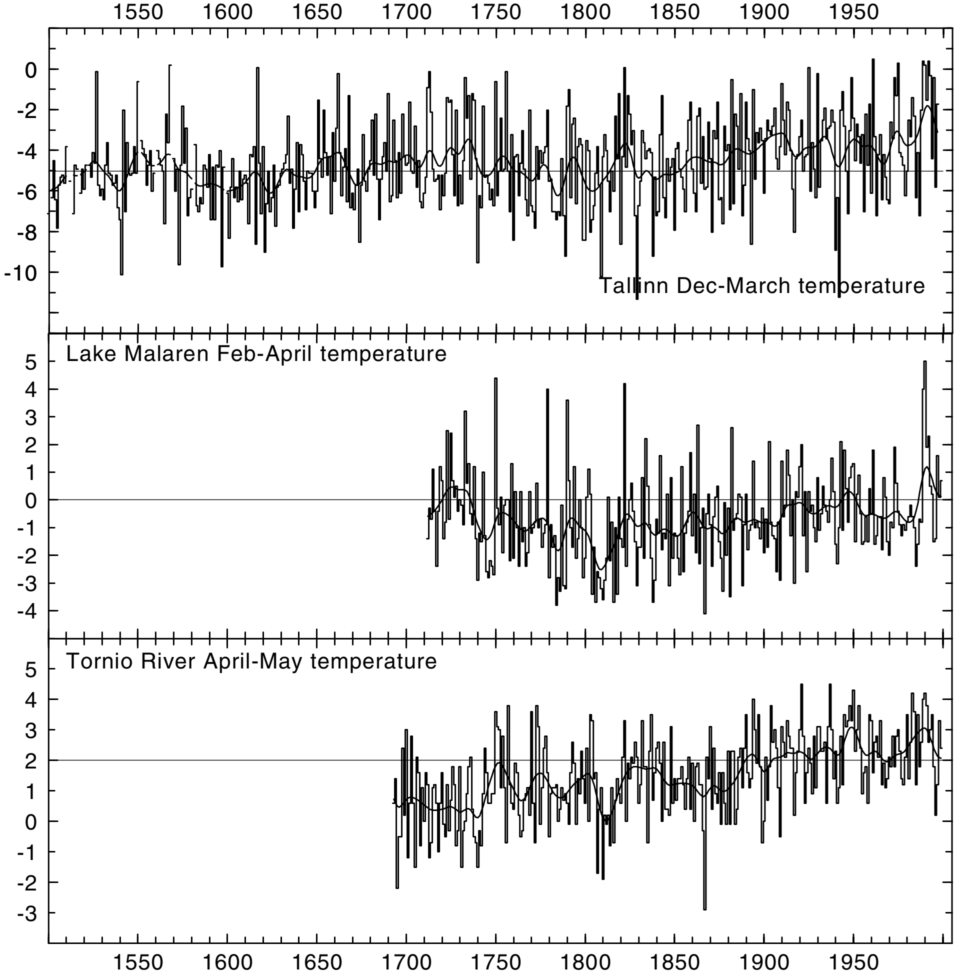


Figure 2. Combined series of reconstructed (from freeze/break-up dates) and instrumental winter temperature records (°C) for Tallinn (Tarand and Nordli, 2001), Uppsala (using Lake Mälaren, Eklund et al., 1999 and Moberg et al., 2005) and northern Sweden (Klingbjer and Moberg, 2003 and Moberg et al., 2005).

Atlantic Oscillation (NAO) by Luterbacher et al. (2002a) as all these reconstructions use much the same sort of predictor information (station-based sources of temperature, precipitation and pressure and documentary series). This point is made by Luetrbacher et al. (2002a,b), but this clear circularity in the various reconstructions seems to have been ignored by Robinson (2005). He considers the influence of the NAO on winter temperatures, back to 1500, using temperature reconstructions for the Low Countries developed by van Engelen et al. (2001), a series used by Luterbacher et al. (2002a,b, 2004) in their reconstruction of the NAO.

2.2. PRECIPITATION

The first conventional rain gauge was developed by Richard Towneley in Burnley, Lancashire in 1677. Since the early 1700s, at least three gauges have operated somewhere in the British Isles every year. Changes in gauge design and necessary relocation of gauges at many sites mean that it is more difficult to maintain, or construct long homogeneous rainfall series in a similar manner to that achieved for temperature. Rainfall is also much more influenced by local environmental changes adjacent to gauge locations, such as the growth of trees and the construction of nearby buildings. The development of long, composite rainfall series therefore requires considerable care (see, e.g., Craddock, 1976). The much greater spatial variability of precipitation, compared to temperature, means that individual sites will tend not to be very representative of larger spatial scales. Also regional average precipitation will be very dependent on the number of constituent series. Errors of estimation in the regional averages will be considerably greater from series developed with a few gauges than with the much greater numbers of gauges available from the 1840s (see the extensive discussion, particularly on the assessment of errors in Wigley et al., 1984).

Nicholas and Glasspoole (1931) made the first serious attempt to construct a large-regional average record with the development of the England and Wales rainfall (EWR) series. This extends back to 1727 on a monthly basis. The choice of title is somewhat odd as there were no gauges in Wales until the late eighteenth century and only a few in upland areas of England and Wales until about 1840. The choice seems to have been influenced by the publication of a wheat price series for the same region (Beveridge, 1922) and a desire to know how much variation in this price index might be explained by the variability of precipitation.

The Nicholas and Glasspoole (1931) series was known to have homogeneity problems because of changes in the method of construction through time, and for this reason a new England and Wales precipitation (EWP) series was developed extending back to 1766 (see Wigley et al., 1984; Wigley and Jones, 1987; Gregory et al., 1991 and Jones and Conway, 1997). Woodley (1996) compared the two series and provides a tentative correction to adjust EWR using EWP. Given our focus on the early 1740s here, we use these revised totals for 1728–1765 to consider our period in a longer-term context. Prior to 1752, however, the calendar change of 11 days has not been corrected for, unlike the Manley (1974) temperature series (see discussion in Thomson, 1995), because the requisite daily totals are not all available at all sites. However, given the lack of any major seasonal cycle in precipitation over the region, this should not cause much concern. Figure 3a shows annual precipitation totals from 1728. The period from 1740 to 1743 is the driest four year sequence in the entire record. Again, we stress that the relative dryness of the record before 1766 must still be in some doubt, but if the data for the period are at least internally consistent, the annual total for the four year sequence could still be adjusted to be about 100mm wetter and it would still be the driest period. Figure 3b shows the

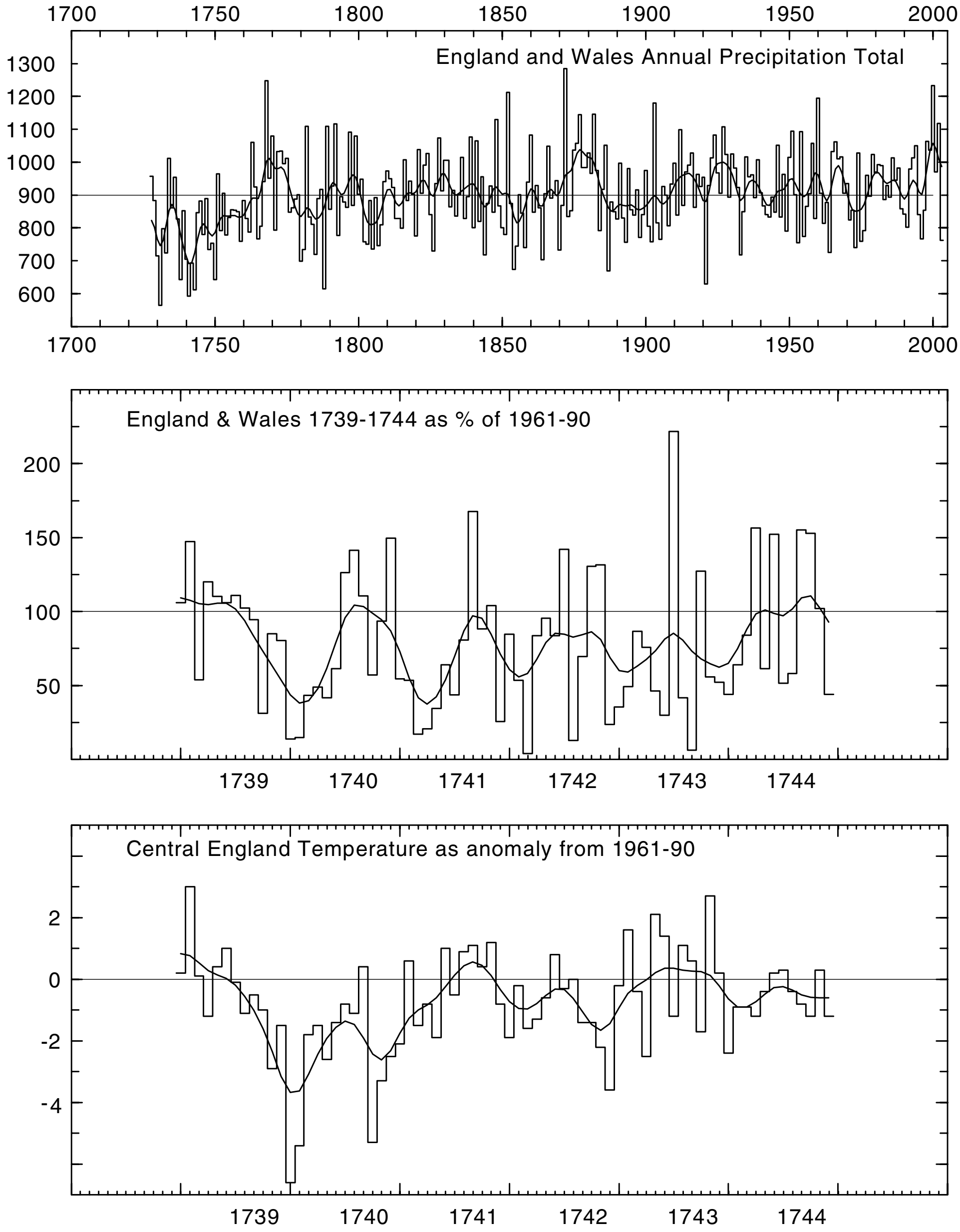


Figure 3. (a) Annual precipitation totals (mm) over England and Wales, 1728–1997, (b) monthly precipitation 1739–1744 as a percentage of the 1961–1990 average and (c) monthly Central England temperatures as °C anomalies from the 1961–1990 average. In (a), the smooth line highlights variations on the decadal timescale while in (b) and (c) it highlights variations on the annual timescale.

individual months from 1739 to 1744 as a percent of the 1961–90 average. The most important dry spells were from January-June 1740, January-June 1741, December 1741 to March 1742, December 1742-February 1743, and August and September 1743. Apart from the 1740/41 winter, little winter recharge of groundwater would have occurred during 1739/40, 1741/2 and 1742/3. The simple conclusion to be drawn from the above data for Britain is that this period, and 1740 in particular, was the driest and coldest in the last 280 years.

3. Documentary Evidence

Brazdil et al. (2006) have reviewed documentary sources from western Europe, indicating how they can be used for understanding past climate over the continent. The type of evidence provided by most documentary sources is particularly suitable, because it often records unusual weather, for the study of extreme events. The sources also provide information, often specific to individual months and seasons, from a range of written historical records. Evidence though from the autumn season concerning past temperatures is considerably poorer than for the other three seasons (Pfister, 1992).

Manley (1958) reviews the 1740 winter with a focus on Britain. Temperatures were below freezing in London from about January 8 until February 20, with the Thames frozen for seven weeks. The coldest temperature recorded in the London area was at Stoke Newington ($-18\,^{\circ}$C). Lake Windermere, in the Lake District (northwest England), was completely froze over so that cattle could be taken across. The River Eden in Carlisle was frozen to a thickness of 50cm and horse races were held on the River Tees at Barnard Castle. Further south, trees were split by the frost at Enfield and killed by the cold at Penzance. On the River Tyne, the ice had to be cut away to allow coal to be transported to London.

Over much of Britain there was little snow during the winter which meant that the hard frost penetrated very deeply into the ground. In Suffolk the frost started on January 6 and was still evident in the ground in June. Norwich Cathedral was covered by snow on May 26. Further north in southern Scotland peat could not be dug because of the intense frost on May 31, while in northeast Scotland, the sowing of grain could not begin until June.

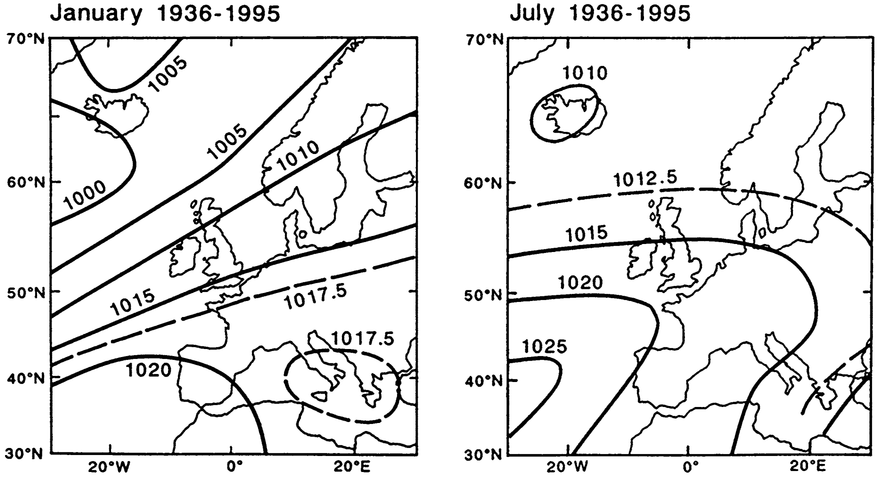
The effects of the winter in Ireland are extensively discussed by Dickson (1997). Evidence from the Netherlands is discussed in many of the sources referred to by van Engelen et al. (2001), see also Shabalova and van Engelen (2003). In Fennoscandia, the 1739/40 winter was very severe. Sea ice was extensive across the Baltic [see Seinä and Palosuo (1996) for the Finnish coast and Koslowski and Glaser (1999) for the Danish and German coasts] and the break-up of ice in the port of Riga (Jevrejeva, 2001) was exceptionally late in the spring. Further south, the winter was also extremely cold in central Europe (Switzerland, Germany, Czech Republic, Poland and Hungary, see Pfister, 1999; Glaser, 2001; Brazdil et al., 2006; Przybylak et al., 2005 and Rácz, 1999, respectively). The winter was also exceptionally cold in Portugal (Taborda et al., 2004).

4. Atmospheric Circulation

During the 50 years up until his death in 1997, Hubert Lamb collected numerous pieces of instrumental and documentary evidence about the weather and climate of various parts of the world during historic times. He entered this information on to a series of separate January and July maps that extended over the period since 1200. In 1966, a series of monthly mean surface pressure maps for each of the Januarys and Julys from 1750 to 1962 was published, based on the interpretation of this information (Lamb and Johnson, 1966). His collection (housed today in the Climatic Research Unit Archives) includes global maps for each January and July since 1200. Between 1650 and 1749 the majority of maps contain tentative circulation charts for the Atlantic/European sector. Prior to 1650, some extreme months have tentative charts, but most have some descriptions of the weather of the winter and summer seasons. Several of the circulation charts for the most extreme seasons (principally in the 16th and 17th century) have been published earlier (see, e.g., Lamb, 1977, 1982). More recently Jacobeit et al. (1999) also produced hand-drawn charts, in much the same way as Lamb, for extreme European months during the 16th century.

Here for the first time, we show Lamb's unpublished working charts for the six years 1739–1744 for both January and July. For each of the six years there are three pressure observations for London, as well as a location in the Netherlands and for Uppsala. These barometric observations provided Lamb with firm points of reference, allowing him to draw isobars (plotted at 5 hPa intervals) with some confidence over these areas. Away from these three locations the isobars are based on his considerable meteorological experience of interpreting surface meteorological data in terms of large-scale circulation patterns. Lamb intended that these charts be interpreted as indicative of average 'seasonal' conditions rather than being seen simply as representing the particular single month. In the context of the earlier discussion of Luterbacher et al. (2002a,b) and Robinson (2005) it is important to guard against potential circularity in interpreting the circulation influence on surface temperature and precipitation discussed earlier. Lamb would have been careful to consider these issues in arriving at his circulation maps, but their quality will diminish towards the periphery of the grid as has been shown by L02B (see also later discussion).

Before discussing the charts, we qualitatively compare them with those produced by L02B. In many respects, L02B can be considered as the modern equivalent to Lamb's charts, using multivariate statistical (and hence reproducible) techniques not available to climatologists in the late 1950s and early 1960s, largely because of computational constraints. L02B have been able to develop



(a) (b)

Figure 4. Average atmospheric circulation charts, based on the 1936–1995 period, for (a) January and (b) July. Contours at 5hPa intervals.

monthly charts for the whole period back to 1659 (with seasonal ones even further back to 1500). L02B have also used some additional information for the period, not available to Lamb. All the charts developed by L02B are available (http://www.ncdc.noaa.gov/paleo/pubs/luterbacher2002/luterbacher2002.html) and there is a rudimentary plotting tool as well. Here we plot charts for average pressure for January and July (Figure 4) for 1739–1744 (Figure 5).

First, we briefly discuss the quality of the charts developed by L02B. The authors state that they are more reliable for winter compared to summer months. The fact that the circulation can be more widely and easily reconstructed from a few locations in winter has been demonstrated previously (see e.g. references in Jones et al., 1999) and would have been well known to Lamb. It should come as no surprise then that all six Julys for 1739–1744 developed by L02B are very similar and close to the average pressure pattern. Circulation in July will generally be closer to the average than in January, but the similarity is mostly due to the reduction in explained variance for this season in their multivariate regression. The best regions in terms of variance explained are in the central areas of the grid, near to the locations of the sites with pressure measurements. In our comparisons, therefore, we assume that the January maps will be more reliable than those for July, and for both sets of reconstructions, they will be better over the central parts of the grid as opposed to the periphery (see also Jones et al., 1999).

For the Januarys, the agreement between L02B and Lamb's charts is good if comparison is restricted to the central to northern parts of the maps (i.e. 45–70°N by 15°W–20°E). Beyond these regions to the south and to the western and eastern edges of the maps, agreement is poorer. In particular, the small low pressure features

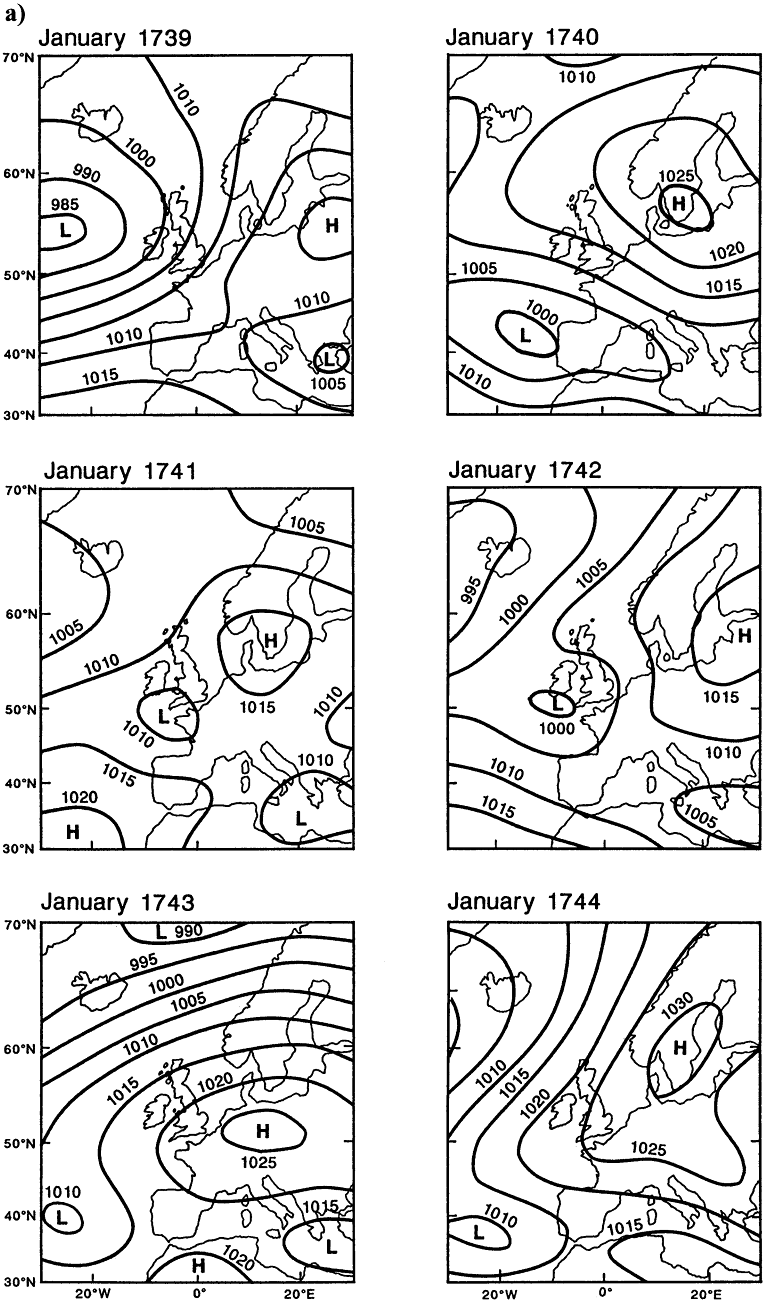
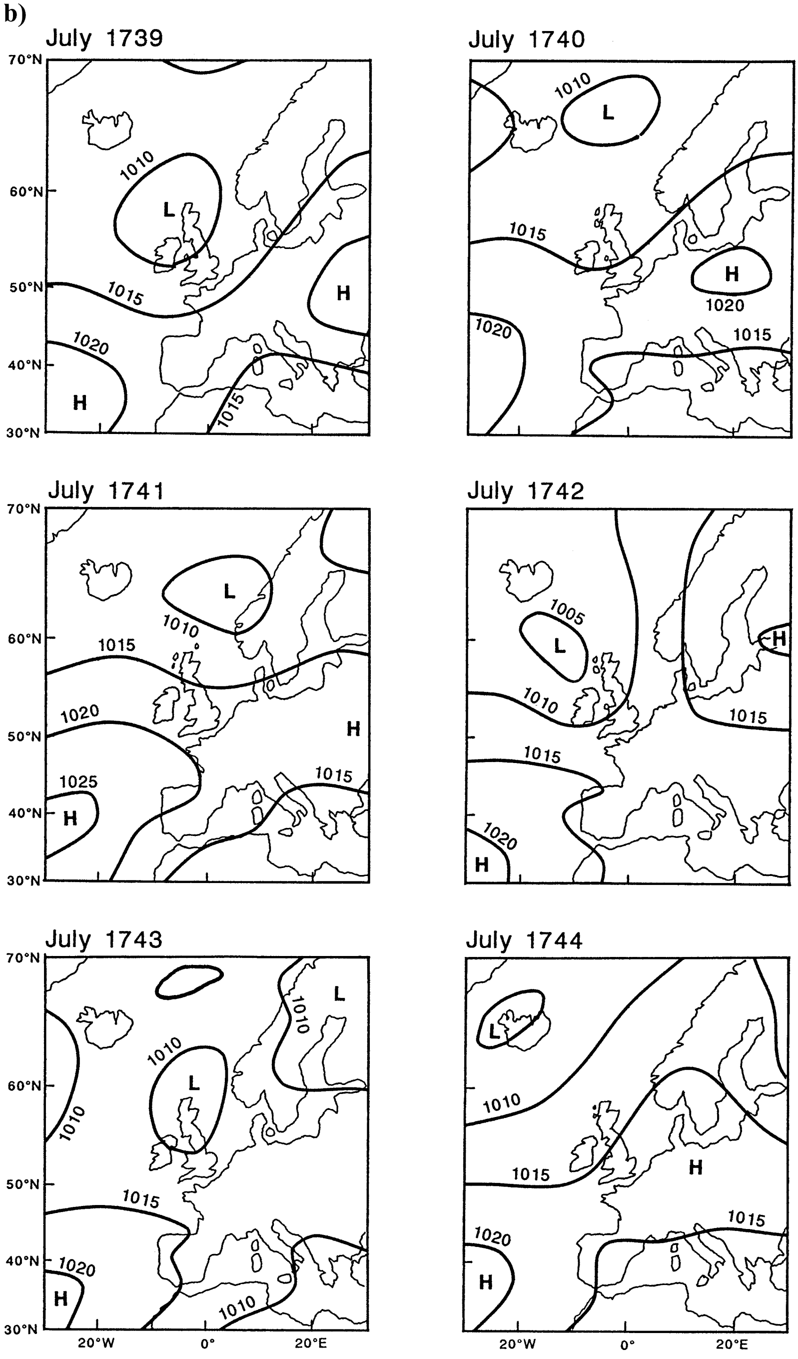


Figure 5. Atmospheric circulation charts for the six Januarys (a) and Julys (b) in the period 1739–1744. All maps are tentative reconstructions produced by Hubert Lamb, from a few instrumental measurements and much documentary data. Comparisons with L02B indicate that the charts are useful for the region (45–70°N by 15°W–20°E) and likely contain more information in January than July. Contours at 5hPa intervals.



b)

July 1739

July 1740

July 1741

July 1742

July 1743

July 1744

Figure 5. (*Continued*)

evident in Lamb's charts in the extreme southwest and southeast, in all Januarys, are not present in L02B. Studies such as L02B and Jones et al. (1999) have shown that it not possible to reliably extrapolate to these areas from more northern parts of Europe, even in winter months. The following discussion takes these points into account. So, if a circulation feature is commented upon its position is either within or extends into this 'central' region and is also close to the location given by L02B (within 5° of latitude and 10° of longitude).

The 'normal' patterns of the atmospheric circulation over the North Atlantic and western European regions in January and July can be shown by averaging the maps over a number of years. In Figure 4 we show this average calculated for the 1936–1995 average. This period was chosen to be the same as Jones et al. (1999). Usually, in January (Figure 4a), a low pressure centre is located just southwest of Iceland (~997hPa) with a high pressure belt in the subtropical Atlantic extending from the southeastern United States through Bermuda and the Azores to the Iberian Peninsula. Pressure is generally highest in the Azores region (~1024hPa). These two features act to bring moist southwesterly airstreams over the British Isles and into central and northern Europe. The strength of the westerlies across the British Isles is directly related to the pressure difference between the Azores and Iceland, an important index of the atmospheric circulation (the NAO, see earlier discussion and Hurrell, 1995, 1996; Jones et al., 1997; Luterbacher et al., 2002a; Xoplaki et al., 2005).

The normal circulation pattern is not evident in any of the reconstructed maps for the Januarys of 1739–1744 (Figure 5a). In January 1739, the Iceland Low is situated west of Ireland and the Azores High is far to the south. The 1738/9 winter over the British Isles would have been mild and wet. In January 1740, both the Iceland Low and Azores High are unrecognisable and the chart is dominated by a high pressure system centred over the southern Baltic Sea (L02B has this feature more to the west over the British Isles). This would cause very cold and dry southeasterly air to affect central Europe and the British Isles. This circulation chart agrees well with Moberg and Bergström's (1997) explanation of why Uppsala was less cold in the 1739/40 winter than is suggested by data for northwest continental European and British Isles stations (cf. Figure 1). The chart suggests that the tracks of depressions crossing the North Atlantic would have been diverted either to the north into northern Scandinavia or, more likely, to the south into the Mediterranean and over the Iberian Peninsula.

The chart for January 1741 is a less intense version of January 1740. The month would have been less cold and slightly wetter (but still drier than average) because the air pressure was lower. The low pressure centre over northwestern France is not evident as a distinct feature in L02B. The chart for January 1742 is similar to the previous year, again suggestive of colder than normal temperatures and below normal precipitation. Again the low pressure feature south of Ireland is not a distinct feature in L02B. In January 1743, the continental High is located just south of its position in January 1740. This location would bring mild maritime air and possibly wetter weather over western parts of the British Isles. The final January we show, that for 1744, exhibits another Scandinavian High, and considering its more northerly location, this would bring cool and relatively dry air over the British Isles. As noted earlier, none of the low pressure features over the southeast (in the Januarys of 1739 and 1742) and southwest (in the Januarys of 1740, 1743 and 1744) corners of the grid area are evident in L02B, but as noted by L02B and others these areas are the least reliable in terms of explained variance in the reconstruction.

The pattern of 'normal' circulation in July is similar to that in January (see Figure 4a), but with the intensity of the Iceland Low reduced by about 10 hPa. Correspondingly, air flow from the Atlantic is weaker, with a more westerly, as opposed to southwesterly direction of flow.

The July charts for the 1739–1744 period (Figure 5b) show features that are much more in accord with the 'expected' positions than was shown for the Januarys. We concentrate our discussion for July on the British Isles. In July 1739, the proximity of the low pressure centre over northern Scotland would bring wetter than normal weather. The July map for 1740, exhibits a relatively strong pressure gradient over the British Isles indicative of cool and wetter conditions. The chart for July 1741 is very similar to July 1740, while that for July 1742, shows a circulation similar to July 1739, consistent with wetter than normal weather over the British Isles. July 1743 exhibits a slight variant with a more northwesterly component to the atmospheric flow, but still implying somewhat above normal precipitation. The final map, for July 1744, shows a circulation with some similarities to the 1961–1990 average. This month should have had near normal temperatures and precipitation. The low pressure features on five of the July maps (the exception being 1744) situated over the north, or just to the north, of the British Isles are evident in L02B (but only as very weak features) in all five Julys, except for 1741 and 1742. In L02B in July 1741, the low pressure is shown in its normal position near to Iceland, whereas in 1742 the low pressure is centred to the northeast of the British Isles (over Scandinavia) rather than between Scotland and Iceland.

In all respects the six January maps show marked differences from the 'normal' (1936–1995) features. The Iceland Low and Azores High are both weak features and each winter was affected by a high pressure centre, situated either over Scandinavia or Central Europe. The precise position of the centre and its strength are crucial in determining the surface weather over the British Isles (cf. the slight differences in 1740 and 1743 and the dramatic differences in impacts). The average for the six Januarys contrasts markedly with the 1730s average chart (see Lamb, 1977, his Figure 18.10, p491). Lamb reconstructs the 1730s with enhanced westerlies (and hence milder winters) across the British Isles. The July charts appear much like the 'normal' July circulation. Although similar to the 1730s chart (Lamb, 1977, also p491), they imply that the British Isles would have experienced slightly wetter conditions because of the proximity of the low pressure centre to northern Scotland in many of the summers.

5. Conclusions

The period 1740–1743 has been shown to be the driest period of the last 280 years, with the year 1740 the coldest recorded over the British Isles since comparable records began in 1659. The winter atmospheric circulation over the period 1739–1744 was very unusual. The major features of the ‘normal’ pressure maps, i.e. the Iceland Low and the Azores High, were much weaker. The dominant feature was a continental or Scandinavian High. Its exact position determined the relative coldness of each winter and led to a sequence of dry winters. The circulation was less anomalous during the Julys of the period with most having near normal temperatures and rainfall totals.

The year 1740 is all the more remarkable given the anomalous warmth of the 1730s. This decade was the warmest in three of the long temperature series (CET, De Bilt and Uppsala) until the 1990s occurred. The mildness of the decade is confirmed by the early ice break-up dates for Lake Mälaren and Tallinn Harbour. The rapid warming in the CET record from the 1690s to the 1730s and then the extreme cold year of 1740 are examples of the magnitude of natural changes which can potentially be recorded in long series. Consideration of variability in these records from the early 19th century, therefore, may underestimate the range that is possible.

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