Hydrological Sciences–Journal–des Sciences Hydrologiques, **51**(5) October 2006
Special issue: *Historical Hydrology*

The catastrophic floods of February 1784 in and around Belgium – a Little Ice Age event of frost, snow, river ice … and floods

GASTON R. DEMARÉE
Royal Meteorological Institute of Belgium, Ringlaan 3, B-1180 Brussels, Belgium
gaston.demaree@oma.be

Abstract The winter of 1783/84 is known to have been severe and long-lasting in a number of European countries. Two very cold spells occurred: at the end of December 1783 and in January 1784. Furthermore, it snowed heavily in the months of December 1783, January and February 1784. On 21 February 1784, a warm southerly wind led to a thaw which resulted in fast breaking-up of the ice on the frozen rivers and to catastrophic floods. This large-scale and long-lasting event took place in the present-day Belgium, The Netherlands, Luxemburg, northern France, Germany, Austria, and the Czech and Slovak Republics. The above-mentioned event is studied for Belgium and for adjacent areas of its hydrological river basins. Emphasis is given to the hydrological phenomena, but these are, of course, strongly linked to the weather of that particular winter. Therefore, instrumental and non-instrumental climatological observations are presented and their relation to the floods is given. The main narrative data consist of two meteorological manuscripts of the Library of the Royal Observatory of Belgium that have never been used heretofore. The instrumental meteorological observations of the *Mannheim Ephemerides* series at Brussels, the Godart series at Verviers and Baron de Poederlé's observations at Brussels are used. These narrative and instrumental meteorological data are further documented by quotations from a large number of contemporaneous authors and newspapers.

Key words Belgium; floods; Little Ice Age; River Meuse; River Scheldt; narrative sources

Les inondations catastrophiques de février 1784 en Belgique et alentour – un phénomène du petit âge glaciaire, de froid, de neige, de la glace … et d'inondations

Résumé L'hiver des années 1783/84 est connu dans grand nombre de pays européens pour sa sévérité et sa longueur. Deux périodes de grand froid se sont produites à la fin du mois de décembre 1783 et la fin du mois de janvier 1784. Il avait d'ailleurs abondamment neigé durant les mois de décembre 1783, janvier et février 1784. Le 21 février 1784, un vent chaud du sud engendrait un dégel provoquant la débâcle rapide des rivières et, consécutivement, des inondations catastrophiques. Cet événement à grande échelle et de longue durée a sévi en Belgique, aux Pays-Bas, dans le Luxembourg, le nord de la France, l'Allemagne, l'Autriche et les Républiques Tchèque et Slovaque d'aujourd'hui. Le phénomène mentionné ci-haut a été étudié pour la Belgique et pour les régions voisines de ses bassins hydrologiques. L'accent est mis sur les phénomènes hydrologiques lesquels sont évidemment directement liés au temps de cet hiver mémorable. Dans cette optique des observations climatologiques instrumentales ou non instrumentales sont présentées de même que leurs interactions avec les inondations sont étudiées. Les principales sources narratives consistent en deux manuscrits de la Bibliothèque de l'Observatoire Royal de Belgique jamais utilisés auparavant. Les observations météorologiques instrumentales des Ephémérides de Mannheim à Bruxelles, la série temporelle de Godart à Verviers et les observations du Baron de Poederlé à Bruxelles ont été utilisées. Les sources narratives et les observations instrumentales ont également été complétées par des citations d'auteurs et de journaux contemporains.

Mot clefs Belgique; inondations; le petit âge de glace; Rivière Meuse; Rivière Escaut; sources narratives

"*Le temps est un grand maître,*
il règle bien des choses"
Corneille, Sertorius (1662), Acte II, v. 717.

INTRODUCTION

The Little Ice Age (LIA) is a collective term originally coined by glaciologists for the period of glacial advances in the course of the last millennium (Grove, 1988).

Uncertainties about its time of initiation and termination still exist, but it is generally accepted that, for Europe, the LIA may have started about 1500 and lasted until the end of the 19th century or earlier (Brázdil *et al*., 2005b). Therefore, the harsh and long-lasting winter of 1783/84 was considered by the author as a typical LIA event. However, it is now accepted that the LIA does not stand for a worldwide synchronous and prolonged cold period (Jones & Briffa, 2001).

However, it remains necessary to set the winter of 1783/84 in the context of the weather and climate of the 1780s. John Kington (1980, 1988) used the instrumental meteorological observations carried out under the influence and directives of the Societas Meteorologica Palatina at Mannheim and of the Société royale de Médecine at Paris, as well as other individual stations, to draw daily synoptic charts of the early 1780s. Kington (1980) noted that high climatic variability on the month-to-month scale and the year-to-year variations were much more marked than in the 20th century. Several summers were drier and several winters colder in the 1780s than at present. Furthermore, a pronounced maximum of blocked weather systems occurred during the early winter period, indicating an early start to cold season continental conditions, a characteristic of the LIA period.

The harsh and long-lasting winter of 1783/84 followed the "*Annus mirabilis*" 1783 that was characterized by the "Great Dry Fog" and the fiery thunderstorms of the summer of 1783. The "Great Dry Fog" phenomenon was actually due to the Icelandic Lakagígar volcanic eruption and was the dominating factor of that year (Grattan & Brayshay, 1995; Stothers, 1996; Demarée & Ogilvie, 2001). How did the contemporary people explain such a harsh winter? What were the explanations offered by the scientific community at the time? Benjamin Franklin (1785) advanced the thesis of the correlation between the volcanic eruption of summer 1783 and the ensuing cold winter 1783/84 in December 1784 in a lecture at the Manchester Literary and Philosophical Society. During the 1783/84 winter, several newspapers already quoted the hypothesized link: "*Some natural scientists pretend that the extraordinary vapour, that covered nearly the whole globe last summer, has some relation to the increasing coldness that we endure. However, it is believed that one must be more advanced in the season in order to verify if the earthquakes that were felt in different regions have indeed cooled the central fire of our globe and that we will need to take into account more rigorous winters than before*." (*Supplément à la Gazette de Cologne*, 2 mars 1784). The fact that the journalist blamed the earthquakes instead of the volcanic eruption, the real source of the fog, fitted the still dominant scientific theory of Aristotle on "meteoric" occurrences, where all sub-lunar manifestations were considered as meteors (Demarée & Nordli, 2006).

It is therefore not surprising that several observers and journalists referred to these summer fogs when heavy fog was noticed in December 1783 and January 1784. "*Last year and the beginning of this year have been remarkable by the excessive heat and the dry fog that were felt so generally, and by the harsh winter that we endure, and that is not less widespread*." (*Journal politique de Bruxelles*, février 1784, p. 180) The text is followed in that newspaper by a description of the fogs in Sicily in December 1783 and January 1784, as well as at Amsterdam on 15 December 1783.

Also, parts of Germany experienced very thick fogs in part of December (Cotte, 1784, p. 464). "*Munich, 10 January 1784: The excessive cold of the last days was accompanied in the morning and in the evening by a black fog like the thickest smoke*

that hardly let one distinguish objects at a few steps away. The smell of the fog was fetid and suffocating. Yesterday, the 9th" […] "*the fog less impenetrable, dissipates in the morning and reappears in the evening*" (*Journal politique ou Gazette des Gazettes*, février 1784, *Seconde Quinzaine*, p. 26). It is quite natural that scientists, and hence also journalists, did ask whether these fogs, just like the dry fogs of the summer of 1783, were related to the Lakagígar volcanic eruption in Iceland that was still active at that very moment.

The disastrous floods concern large parts of Western and Central Europe, among them the Seine, Somme, Loire, Scheldt, Meuse, Rhine, Mosel, Saar, Main, Neckar, Danube, Weser, Elbe [Labe], Vltava [Moldau], Ohře, and Oder River basins (Glaser, HISKLID; Militzer, CLIMDAT®; Weikinn, 2000; Brázdil *et al.*, 2005a). Hennig (1904) describes the winter of 1783/84 as being very cold from 23 December 1783 to 24 February 1784 in the whole of Europe, with an uncommon, deep low pressure area on 18 January, and, from 28 February to 2 March, floods in Germany and Bohemia of an extent previously unknown. In London, in February 1784, the Thames was frozen and traffic crossed on the ice (Kington, 1980), while navigation was affected for much longer periods. In York, the River Ouse was frozen for eight weeks and chestnuts were roasted upon the river (Currie, 1996). In Thüringen, Germany, "*February 1784: extreme damage and casualties on the Saale, White Elster and Werra – including their tributaries*" (Deutsch & Pörtge, 2003, p. 20). According to the observations by Antonín Strnad at the Klementinum in Prague, the winter of 1783/84 was very severe and snowy. A sudden thaw associated with a warm southern wind and precipitation on 24 February made the snow melt, broke up the ice on the rivers, and caused the hitherto largest winter flood on the Vltava [Moldau] River in Prague on 27–29 February 1784 (Brázdil *et al.*, 2003, 2004, 2005). On the Labe [Elbe] River and its tributaries, the ice broke up and caused floods in Bohemia, the Czech Republic and in Saxony, Germany (Elleder & Munzar, 2004; Munzar *et al.*, 2005). Glaser and Hagedorn studied in detail the weather conditions and the catastrophic floods in the Main River valley, Germany. Severe damage was noted to bridges, mills, ... but also the people living in the flooded areas suffered serious damage through loss of property and goods (Glaser & Hagedorn, 1990; Glaser, 2001).

This paper deals with the hydrological phenomenon as described above in its European scope, but concentrates on Belgium and its river basins, all of them rising in France. Records of instrumental meteorological observations, as well as narrative descriptions from manuscript sources from that area (some of them hitherto unused material) are presented. A presentation of documentary data about floods is given in Brázdil *et al.* (2006).

THE INSTRUMENTAL METEOROLOGICAL OBSERVATIONS

At the end of the 18th century, at least two long-term meteorological series are available for the present-day territory of Belgium. At Brussels, the Imperial and Royal Academy of Sciences carried out thrice-a-day meteorological observations in the framework of the Societas Meteorologica Palatina. At Verviers (330 m a.m.s.l.), the physician Guillaume Lambert Godart (1721–1794) carried out observations from January 1767 to February 1794 (Demarée *et al.*, 2002). At Brussels, Baron Eugène-

Joseph de Poederlé (1742–1813), one of the earliest meteorological observers in the Austrian Netherlands, carried out meteorological observations and wrote on the weather in newspapers. He corresponded with Father Louis Cotte, one of the leading meteorologists of his time, responsible for the observations of the Société royale de Médecine in Paris (de Poederlé, 1784a,b,c,d,e, 1785).

Figure 1 shows temperature records at Verviers and Brussels and atmospheric pressure at Brussels for December 1783–March 1784. The record at Verviers (Godart, ms.) shows low temperatures on 30 December (–24.4°C), 31 January (–16.3°C) and still on 21 March (–13.8°C), while at Brussels the following minima were recorded: 31 December: –16.3°C; 30 January: –11.6°C; 13 February: –10°C; and 21 March: –5°C.

Baron de Poederlé describes the end of December 1783 as follows: "*On the 28th, the cold became more severe by a violent and biting ENE to northeasterly wind. On the 29th the thermometers were at –14.1°C, on the 30th at –16.3°C and on the 31st at –17.5°C. The day of the 30th was excessively cold, because at half past one in the afternoon, the thermometers were at only –13.4°C. The cold started to diminish on the 31st at about 7 o'clock in the evening and, around midnight, rain started to fall with a violent, variable southeasterly wind. Also on 1 January, the temperature was warm, as there was a difference of 21 degrees with the day before. Snow has been abundant in several districts of our provinces, mainly in Luxemburg, where from the 28th to the 1st of the New Year several people perished in the snow. One could not travel on foot, nor by horse*." (de Poederlé, 1784d, pp. 348–349). De Poederlé let note that these observations were carried out in the upper part of the town, which explains, for him, the observation of –16.3°C published in the "*Journal historique et politique*, no. 3, janvier 1784" and taken in the lower part of the town. A comparison of observed temperatures on 30 and 31 December 1783 in and around the Austrian Netherlands is given in Table 1.

On 21 February, the wind in Brussels veered from north or northwest in the previous week to south and later on to southwest and a rapid thaw set in (see the *Mannheim Ephemerides*, Year 1784). The abrupt inflow of warm air from the Mediterranean region was caused by a blocking high pressure area over Eastern Europe. The Low north of the British Isles brought several succeeding fronts with rain over Western Europe (Kington, 1988).

Table 1 Observed temperatures (in °C) on 30 and 31 December 1783 in and around the Austrian Netherlands, some of them isolated readings for the exceptional cold spell.

Observer	Location	Date	Reading	Published
de Witry	Tournai	31st	–16.3°C	Mémoires, Acad., Tome V
Mann	Brussels	31st	–16.3°C	Mémoires, Acad., Tome V
Mann	Brussels	31st	–16.3°C	Ephemerides, 1784
Godart	Verviers	30th	–24.4°C	Godart (ms.)
de Feller (?)	Liège	30th	–22.5°C	*Journal hist. & pol.*; *Journal hist. & litt.*
de Limbourg (?)	Theux	30th	–23.8°C	*Journal hist. & pol.; Journal hist. & litt.*
de Poederlé	Brussels	31st	–17.5°C	*Journal hist. & pol.*
?	Antwerp	31st	–13.8°C	*Gazette van Antwerpen*
?	Lille (F)	31st	–12.5°C	Cotte (1784)
?	Dunkirk (F)	31st	–14.4°C	Cotte (1784)

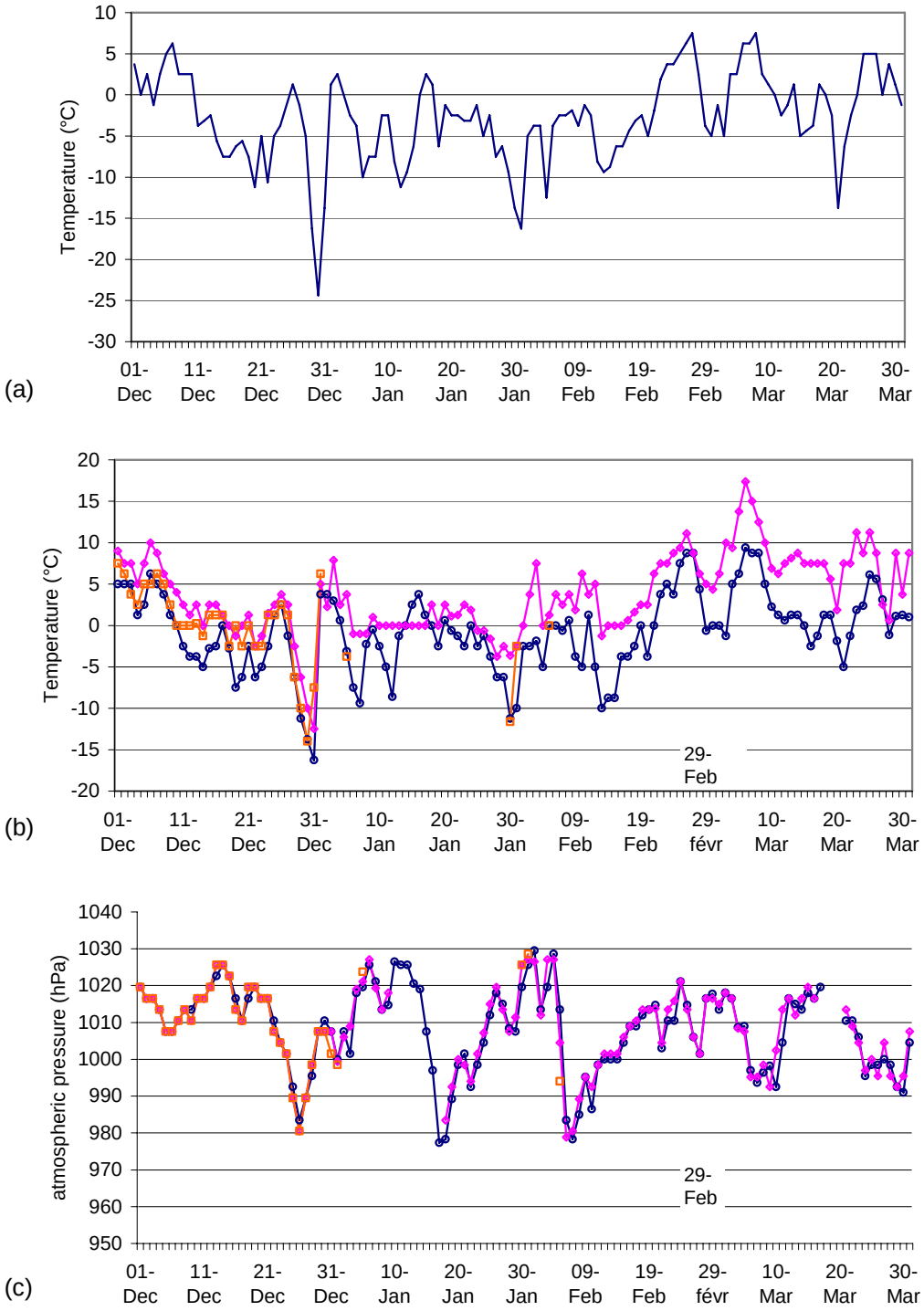

Fig. 1 Temperature records (°C): (a) morning at Verviers, December 1784–March 1784 (Godart, ms.) and (b) morning (o), afternoon (◊) and evening (□) observations at Brussels, December 1783–March 1784 (published in the Ephemerides Meteorologica Palatina for 1784). The original data expressed in °R have been converted into °C. (c) Atmospheric pressure record: morning (o), afternoon (◊) and evening (□) observations at Brussels, December 1783–March 1784. The original data in Paris units have been converted into hPa (see Lamb, 1986) from the published record in the Ephemerides Meteorologica Palatina for 1784.

NARRATIVE DESCRIPTIONS OF FROSTS AND SNOW IN THE WINTER OF 1783/84

Jacques-Joseph Ansiaux (1736–1810), edge-tool maker at Ciney and successor of his father as burgomaster of Ciney, kept a detailed meteorological diary for the period 1779–1810 (Vincent, 1901; Florkin, 1954, p. 205). The weather of the winter of 1783/84 is described there as follows:

December 1783: "*The east wind gave us quite strong frosts in the night and most pleasant weather and quite mild during the day. The same weather continued until the 22nd when the sky became overcast and seemed to announce snow, and indeed it snowed a little on the 24th, but on the 25th it started already to thaw. On the 26th, snow and rain; the 27th frost but the sky is overcast which gave us on the 28th a lot of snow, violently blown by a strong easterly wind. On 29, 30 and 31 December, came a very severe frost*".

January 1784: "*On 1 January 1784 thaw, the 2nd very rainy, on the 3rd a little bit of rain in the day, but in the evening the weather cleared and the frost returned with strength and continuity that the ice was widespread. On the 8th the sky became covered with clouds, the barometer fell and, as the wind was coming on, one believed that it would thaw, but the following night, a little snow fell. On the 9th the wind turned back to the east and the frost came again. On the 13th and 14th: fog that gave us plenty of hoar frost. On the 15th the fog became more moist and in the afternoon it rained. On the 16th heavy rain, on the 17th snow and frost, on the 18th frost with the sky overcast and, although the barometer remained at storm since the day before, in the morning neither rain nor snow fell, but in the afternoon it snowed quite a lot. On the 19th, overcast and a little bit of snow and on the 20th snow the whole day; the next days were constantly overcast and with fine snow; the same overcast sky continued until the 28th without it being very cold; all the more so because the wind stayed always near the west and even, from time to time, near the south, but on the 28th in the evening a very strong east wind started to blow and the severe cold returned; on the 30th, the sky cleared up and the frost was very severe the following night. On the 31st, the wind turned, the sky was still overcast; a little snow fell in the morning and the cold diminished.*"

February 1784: "*On 1 February 1784, quite mild weather that seemed inclined to thaw. On the 2nd the wind still southerly, a lot of snow; on the 3rd, it having snowed the whole night, the wind turned easterly again; clear sky; the frost returned in the following night. In the morning of the 4th the wind had already turned, the sky became overcast, the weather quite calm the whole day. On the 5th, a southerly wind blows the whole day and makes us long for thaw and for the end of such a long winter, but in the evening, instead of rain, the snow returned in large amounts and continued without stopping until noon on the 7th. The rest of the day was quite calm, but in the evening the snow returned again and today, the morning of the 8th, snow still falls. Then the weather remained calm until the 11th, quite a lot of snow fell in the night and day. Afterwards the wind, which varied all the time, became more constantly easterly. Fortunately, the sky was more often overcast than clear, which made the cold less sharp and this was maintained until the 20th when the wind started to change approaching south. On the 21st mild thaw without rain; one wonders if it will continue. It thawed steadily until the 28th on which day the wind again turned east, the sky cleared up next day and the frost was quite strong today the 29th*".

March 1784: "*…and continued until 3 March when the wind again turned south and from the 4th to the 8th it was quite nice weather with a light wind. On the 8th, the weather became somewhat colder; even some little sleet fell. The next days were worse, particularly the 10th due to half-melting snow that fell in large quantities, but it froze nevertheless the next days*" (Ansiaux, ms.).

An anonymous manuscript at Tongre-Notre-Dame, near Ath in the province of Hainault, provides brief daily weather descriptions for the period 1777–1787. The author is probably connected to the local church, a place of pilgrimage to Our Lady. According to the manuscript, the first frosts were already noticed in the beginning of November 1783. On 24 and 27 November: "*fog in the morning, later on nice weather*". From 15 December: "*heavy fog*"; from the 23rd onward: "*snow*". On the 29th: "*quite strong frost*", on the 30th: "*heavy frost*", on the 31st: "*heavy frost and a little bit of snow in the afternoon*". On 1 January 1784: "*half thaw and strong glazed frost*"; 2 January: "*thaw and fog*".

On 29 and 30 January: "*strong frost*". On 9 January it mentions: "*the ground did not thaw at all since 11 December*" and on Sunday 18 January the information is repeated: "*the deep soil remains frozen*". On 2 February: "*snow on the frozen ground*". On 21 and 22 February: "*thaw*" and on the 23rd: "*floods*". Throughout March 1784 alternation of "*little frost, frost, thaw and snow*" (Anonymous, ms.).

Both narrative sources are telling approximately the same LIA scenario of cold, frost, snow, wind and high waters. None of the observers lived near to a major river and, therefore, did not directly witness floods and inundations in their home towns.

GENERAL DESCRIPTIONS OF THE WINTER 1783/84

Buisman (1984) describes the winter of 1783/84 as a very severe winter, a rigorous snowy winter ending with floods. In the following, quotations are given dealing with this and the floods; the texts speak largely for themselves. Theodore Augustin Mann (1735–1809) wrote in his treatise on cold winters: "*The winter of 1783/84 was really extraordinary by its duration and by its intensity of coldness: nearly the whole of Europe felt its effects. The frost started on 10 December 1783 and ended only on next February 21st, more than 10 weeks in all, with very few interruptions. The months of March and April 1784 were equally very cold: the coldest day of March was the 21st with 4.7°C below zero; the coldest day of April was the 2nd with 6.9°C below zero*" (Mann, 1792, p. 83).

Joseph van Walleghem (1757–1801) describes in the unpublished part of his manuscript what happened in the town of Bruges: "*On 1 January 1784 it looked to everybody like another world and that because of the weather over the last three days of the year. This morning, it was as if all houses of the town had turned completely white, and particularly those of blue stone, which were as white as marble. This was by no means surprising, because, over three days, it froze so much and it was so cold that none of the old people could remember a more severe cold and frost, so that compared to the records of the years 1740, 1763 or other years, it has frozen several degrees more.*

"*On 2 January, there was such a thick fog here that one could hardly see where one was going. The frost started again on the Day of Epiphany and the cold continued with much snowfall (and some short periods of thaw) until 21 February.*

"*On 8 February 1784, early in the morning in the town of Bruges, attempts were made to open the frozen waterway from the Coupure Bridge to the merchant inner harbour – a major effort, but completely futile. Even the icebreaker got stuck fast in the ice and could not be freed.*

"*On Saturday 21 February, the frost, after 1 foot* [1 Paris foot = 32.48 cm] *of snowfall last night, started to change into a firm thaw.*" […] "*In many places, there were two feet of frozen snow. On 25 February, Ash Wednesday, the fruitless labour of the 8th was resumed and the icebreaker at the Coupure Bridge was towed to the inner harbour without much difficulty by six horses*" (van Walleghem, ms. – courtesy Jan D'hondt, City Archive of Bruges).

Sexton Pieter-Lodewijk Cuvelier (1739–1822) wrote in his chronicle a short description of the winter at Reningelst, near Ypres: "*This winter, a severe cold prevailed and the frost lasted eight weeks and there was much snow, particularly on Saint Sebastian's day* [20 January]. *It snowed so much that one could not see through it and in these regions it lay 15 to 16 inches* [1 Paris inch = approx 2.70 cm] *thick until 21 February, when it thawed*" (De Smet, 1970, p. 96).

From Lille in French Flanders: "*Lille, Friday 13 February 1784. The cold remains very rigorous here. It has frozen nearly continuously for six weeks. The snow and ice, ground up by pedestrians and carriages in the streets, looks like sand. If the sun shines during the day, it is a sea of mud, but in the evening it starts to freeze again. Our countryside is covered with one foot or more of snow. Wildlife has nowhere to hide and cannot find food anymore*" (Feuilles de Flandres, III Année, Lille, p. 249).

At Dendermonde "*it started to freeze on 8 December 1783 and continued until 21 February 1784. The greatest and heaviest cold was on the 29, 30 and 31 December. On the first day of the year, it thawed, but the same night, it started to freeze again. The River Scheldt was frozen over from 18 December and opened up again in the night of 25 February without damaging the bridge, as everybody had feared. That the thaw ended so quickly was due to the mass of snow that fell in the above-mentioned period. So much water came from the River Dender that it overspilled the lock.*" […] "*There were freezing temperatures for the whole month of March and consequently the spring was very late*" (Blomme, 1892, p. 246).

Extracts from a register by J. Fr. Nicolas, prosecutor at Orp-le-Grand, a small town on the Little Gete River, mention: "*In the year 1783, it started to freeze on 1 December, which continued until 1 and 2 January 1784. The thaw started on the 2nd making the river rise so much that it flowed in front of the house of Widow Chenoux at Orp-le-Grand. This thaw was preceded by a heavy frost and snow that continued until 22 February, on which day it started to thaw without rain, but the large amounts of snow made the river swell so much that, at 11 o'clock in the evening, the stage was two feet higher than on 2 January 1784 and continued so for two days*" (Vincent, 1904, p. 352).

Jean-Nicolas Comhaire (1778–1837), describing briefly the meteorological observations carried out at Liège in the 18th and early 19th centuries, states: "*The greatest cold was also felt in 1783, namely from 29 to 30 December. The thermometer showed –24.4°C. The winter of 1783/84 is one of the longest and most rigorous ever experienced. On 21 March 1784, the thermometer dropped to –12.5°C. The River Meuse stayed frozen over its whole width from 20 December 1783 until 22 February 1784 and the ice at some places was one ell* [about one metre] *and more thick*" (Comhaire, 1828, p. 125; Courtois, 1828).

In Flanders, a system of canals connecting Dunkirk (France), Furnes, Nieuport, Ostends, Bruges and Ghent, served for transport of passengers and goods. The list of receipts for duties paid for the use of the canals or locks provides dates of freezing-up and of the re-use of the canals. These dates are given in Table 2.

Table 2 Dates of freezing-up and of first re-use of the canals for different location in Flanders.

Location	Date of freezing-up	Date of first re-use
Not identified location	21 December 1783	27 February 1784
Dampoort at Bruges	20 December 1783	1 March 1784
Slykens at Bredene	24 December 1783	27 February 1784
Provincial lock at Nieuport	10 December 1783	1 March 1784
Not identified location	21 December 1783	27 February 1784

From Table 2, it can be seen that most canals froze up shortly after 20 December 1783 and remained frozen until 21 February, when the thaw set in. After the breaking-up of the canals and the clearing of ice in the next days, navigation was re-established between 27 February and 1 March, depending on the location. The Slykens locks at Bredene are an exception, because a few ships did pass or re-pass the locks in January and February 1784 (*Archief van de Staten van Vlaanderen*, no. 6311; Nuyttens, 1986). It is hypothesized that seawater may have entered the sluice system, as this sluice connected the sea-harbour of Ostends with the inland canal system.

At Sainte Menehould, in the Champagne-Ardenne region of northern France, it was noted that "*the winter 1783/84 was renowned for the extraordinary amount of snow that covered the land for more than six weeks. During the thaw, accompanied by rainfall lasting several days, there were considerable and disastrous inundations that caused great damage to houses, gardens and the surrounding countryside*" (Buirette, 1837, p. 487).

… FOLLOWED BY FLOODS

River Scheldt and its tributaries

The River Scheldt (see Fig. 2) rises near the French town of Saint Amand (95 m a.m.s.l.) and is 350 km long, and its basin covers an area of 22 100 km^2. It traverses France, the Walloon Region and the Flemish Region in Belgium, and, finally, The Netherlands. It is presently canalized over a large stretch and, as such, connected with neighbouring catchments. Its main tributaries are the Lys, Dender, Durme, Nete, Senne, Dijle, Demer and Gete. A map representing the River Scheldt catchment and the international hydrographical district (DHI) of the Scheldt is given in Fig. 3 (see also the section on northern France).

"*Fortunately, the River Senne* [at Brussels] *has only overflowed and produced floods outside the town, between the gates of Halle and the canal. The level of the water has been at least 5 inches, it was higher on 17 January 1772, and on the 10th of the same month in 1774*" (de Poederlé, 1784e).

At Louvain, on the Dijle River: "*After a severe frost, and the onset of thaw on the first day of this year, together with the amount of snow that has fallen in the Walloon*

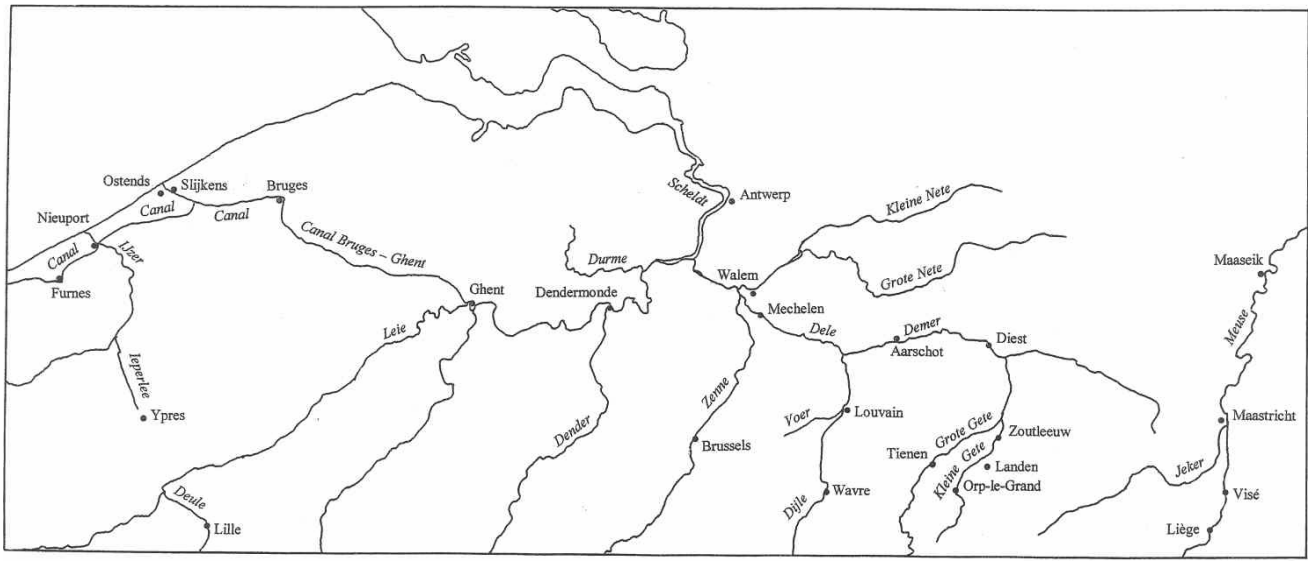

Fig. 2 Sketch map of the rivers, canals and places in and around Flanders.

Brabant, and just now melted, our rivers swelled so much on Sunday 4 January 1784 that they have overflowed their banks. Most houses, and particularly the adjoining cellars, were flooded, which caused much damage. Many streets were inaccessible. The monastery of the Dominican Friars became an island; most of the Grand Beguinage was also flooded; all the fields behind the Temple Garden, together with those in the Louvain Marsh around the White House as far as the eye could see, are like a sea. Since the frost started again, these are frequented by ice-skaters, although after three days the high stage of the water lowered remarkably. One cannot remember such high waters around Louvain for 20 or more years" (*Lovens-Nieuws*, no. 2, Sondag 11 Januarii 1784, p. 17).

"*In an unprecedented long and harsh winter, where the frost on several days at the end of December 1783 and the end of January 1784, was more severe than in the remarkable winters of 1709 and 1740, the navigation canal was blocked on 7 December 1740, and is still not navigable, since more than 12 weeks. Due to abundant snow that had fallen in and around the Walloon Brabant, when the thaw set in on the 21st, the water and snow could not soak away, making our rivers swollen beyond description, and flooding nearly the whole town. It started around midnight of the 23rd to the 24th of this month, while everybody was fast asleep; shouting and yelling to one another, everybody in danger of his life tried to save himself to the second floor and attic of his house. It was horrible; at 10 o'clock in the morning of the 24th, what a level the waters have reached.*" […] "*Outside and within the Canal Gate, as far as the eye could see: nothing other than water. Like the River Dijle, which seriously overflowed its banks on all sides, the River Voer did the same. In short, the whole Lower Town was flooded; there was no street there that was not like a stream*" (*Lovens-Nieuws*, no. 9, Sondag 29 Februarii 1784, pp. 130–131).

"*On 24 February 1784, there was such a flood in Louvain that the people nearly drowned in their houses. The water stood up to the house named The Golden Comb in Brusselsstreet and up to the back door of the White Ladies' monastery*" (Hous, 1964).

"*On 3 January, the Gete River flooded so that Mulk* [a quarter of the town of Tienen] *was totally inundated.*" […] "*It started to freeze on 10 December until*

Fig. 3 The present-day international hydrographical district (DHI) of the Scheldt. The area comprises the River Scheldt basin, the River Somme basin, the River Aa basin, and coastal basins in France, the Flemish Region and The Netherlands (courtesy: the Scaldit Project).

21 February 1784. This frost was continuous, except that it rained heavily on 3 January, as a result of which it flooded, but it started to freeze again immediately. Between 31 December and 1 January it was only half a degree less cold than in 1709 and four degrees more than in the year 1740, which was followed by large masses of snow. On 23 February it flooded again so that whole Mulk and Avendoren were inundated. The water stood up to the Prisoners Gate and, in the infirmary, the water stood up to the bell-door" (Goetschalckx, 1902, p. 46).

"*Under these conditions of flooding, the distressed people have been awake the whole night and the day of Tuesday 24 February. It is heartbreaking to contemplate the conditions of these pitiful households, the moaning and the lamentations of fathers, mothers and children, sitting on the attics and roofs of their houses, without fire, food or drink, waiting for their imminent doom by drowning or by other deadly peril. For the sake of humanity, one tried by means of barges to save the most exposed people*

through windows in the attics of their houses, or by making holes in walls or roofs, and in all possible ways" (*Lovens-Nieuws*, no. 9, Sondag 29 Februarii 1784, p. 133).

Louvain, 7 March 1784: "*When the high waters receded, a stable in Noah's Ark had collapsed in the night of 27 February. As a horse was drowned on that occasion, the inhabitants of other poor dwellings, along the bank of the River Dijle, became so scared that several of them have left their old crumbling houses or dwellings. One really fears that here and there accidents will occur. The losses of all the inhabitants, whose houses, cellars, rooms, stables, etc. were flooded, being one thousand, is unspeakable, more than one had imagined in the beginning. Among them, there are some that have lost 7 to 8 thousand guilders and, although one would estimate the loss per house at 200 guilders, it still would amount to at least 200 thousand guilders*" (*Lovens-Nieuws*, no. 10, Sondag 7 Meert 1784, p. 149).

"*Nothing other than floods and losses, from all sides, since the onset of the thaw, with the ice blocks and large amounts of snow all over Brabant, particularly in the upper region; at Tienen, Zoutleeuw, Diest, Waver, Mechelen and around, also Aarschot and further to Walem, the inundations of the Gete, Dijle, Demer and other rivers have, one way or another, caused damage and accidents that are inestimable*" (*Lovens-Nieuws*, no. 10, Sondag 7 Meert 1784, p. 150).

Diest, 2 March 1784: "*The headwaters have caused unusual floods along the Demer River since 26 to 27 February 1784. Today, it is still a pitiful state of affairs: the city is so hindered by the abundant waters that it is only accessible by horse, high carriages and boats. Although the level of the water is diminishing, one still fears for danger and damage, even in the countryside where new cobbled roads have suffered much.*" […] Aarschot, 3 March 1784: "*It was on 25 February 1784 at 10 o'clock in the morning that the River Demer started to overflow here. One hears that upstream the situation is very wretched; particularly Zoutleeuw was heavily flooded between the River Gete and the waters flowing from Landen, Neerlanden and Tienen. The number of drown horned animals is estimated at eighty at Zoutleeuw. Around Diest it looked like a sea*" (*Lovens-Nieuws*, no. 11, Sondag 14 Meert 1784, pp. 170–171).

Mechelen, 29 February 1784: "*Since yesterday the River Dele* [Dijle], *flowing from the confluence of the rivers Dijle and Demer, started to flood the lower town, in particular around the Great Beguinage and the military barracks. The broad daylight and Providence have cooperated to prevent calamities. The headwaters make one fear for an inundation. Last night, the cobbled road between this city and Walem was flooded so much that today in the morning one could hardly pass there on a horse or with a carriage*" (*Gazet van Antwerpen*, 2 Meert 1784).

Mechelen, 1 March 1784: "*Since yesterday, the floods of our rivers, brooks and water courses have inundated the cellars, houses and low-lying areas so much that people had to be evacuated from the Great Beguinage with carriages. In order to ease the public distress, the Lords of the City Council have dispatched wagons or carts with ladders to take down people through the windows from the upper floors of the flooded houses. Yesterday 700 loaves of bread were distributed to the poor people. Until now the Great Nete River remained in its river bed and the Walem bridge remained passable.*" (*Gazet van Antwerpen*, 2 Meert 1784).

Mechelen, 3 March 1784: "*Since yesterday, the water level has diminished and one hopes that this evening it will have lowered completely. The floods outside the Antwerp Gate will stop.*" Mechelen, 4 March 1784: "*Since yesterday, the city has been delivered*

from the inundations. One has not heard of bridges or houses being destroyed or of human causalities" (*Gazette van Antwerpen*, 5 Meert 1784).

No problems occurred at Antwerp, neither with the ice nor with floods, as is learned from the newspapers: Antwerp, 3 March 1784: "*Our town is not affected at all by the inundations by which one is distressed elsewhere, thanks to the ebb and flow of the River Scheldt which made us get rid of these floods*" (*L'Esprit des Gazettes*, 6 Mars 1784, p. 372).

River Meuse

The River Meuse is 935 km long. It rises from the Langres plateau 200 km northeast of Dijon, at about 400 m. a.m.s.l. After passing through France and Belgium, it enters The Netherlands south of Maastricht and afterwards joins the delta. The river is mainly fed by rainfall and, at present, canalization has rendered the Meuse navigable (Middelkoop & van Haselen, 1998). A map representing the present-day Meuse catchment is given in Fig. 4.

In 1784, the River Meuse flooded at Dinant, Namur and Liège, while at Huy, the water flooded the Market Square. At Dinant, a flood mark in the Church of Our Lady reads (H.G., 1844, p. 370):

VLt**IM**â febr**V**ar**II**, h**VC V**sq**V**e as**C**en**DI**t aq**V**a

This Latin chronogram says "*On the last of February* [1784] *the water stood until here*". "*The day of Laetare Sunday 1784, 21 March, a large part of Namur was flooded by a furious overflow of the waters from the Meuse and the Sambre. The water had not been seen to rise to such a level since the flood that occurred in 1740*" (Galliot, 1790, p. 157).

At Maastricht "*On 1 December 1783 it started to freeze and on the 29th the River Meuse started to freeze over and we experienced 20½ degrees R* [25.6°C] *of cold. In the decrease of the frost in the middle of March, the ice caused much damage to the bridge. The Meuse broke its banks between Liège and Maastricht. The ice piled up against the bridge because a larger ship was lying across the bridge. The water with the ice went through Heugem, Limmel and Borgharen and took its old course at Itteren*" (van Gulpen, 1889).

Liege, 2 March 1784: "*Our city has probably never experienced so markedly the help of Providence than in the alarming circumstances of this rigorous winter that, happily, is near to its end. The tremendous mass of ice blocks, and the overflowing of the River Meuse as a natural consequence of the breaking-up, threatened a large part of the town and its surroundings with total ruin.*" […] "*Thank heavens that danger has disappeared without any calamity, which seemed unavoidable. The River Meuse broke up one league upstream of Liege and the ice blocks came loose, but with a miraculous tranquillity. An enormous mass departed quietly, downstream as well as upstream of the town*" (*Journal politique ou Gazette des Gazettes*, 15 Mars 1784, pp. 450–451).

Extract of a letter from Visé downstream from Liège, dated 23 January 1784: "*The whole river area between here and Maastricht is flooded. The inhabitants of the flooded areas, having abandoned their dwelling places, came here and to the surroundings in crowds to search for a refuge. The cannon is constantly being fired at the ice near the Wiek Bridge in Maastricht but it is said that it would be better to pull the bridge down*

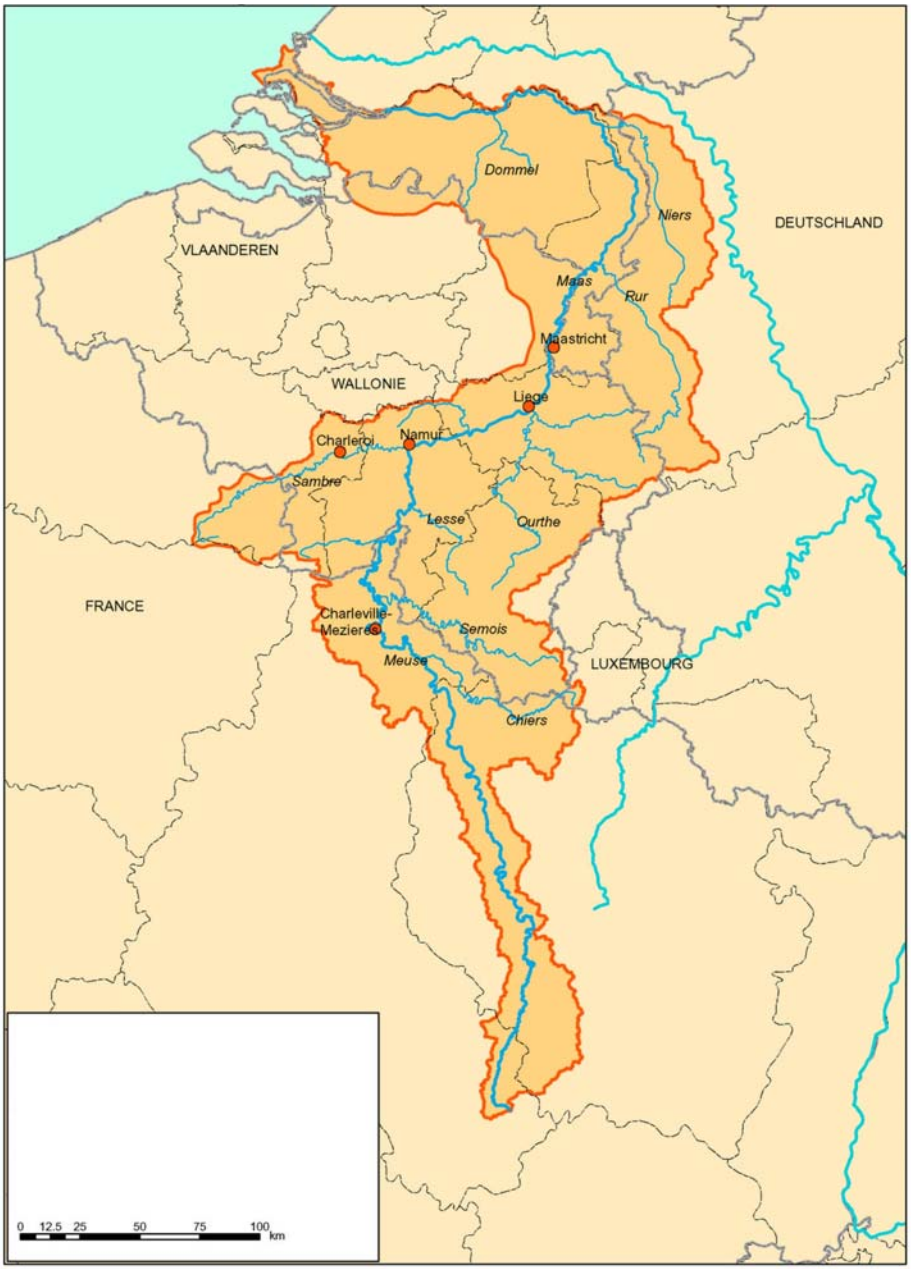

Fig. 4 The present-day Meuse catchment in France, Belgium, Luxemburg and The Netherlands (courtesy *http://nl.wikipedia.org/wiki/Stroomgebied_van_de_Maas*).

to put an end to the calamities caused by the obstruction of the water and the blocks of ice. The height of these exceeds the roofs of the neighbouring houses. The River Meuse has not been seen so swollen in living memory. Here and there, it looks as if there are enormous rocks: the blocks of ice are piled up so high. Five times the river has frozen up and broken up: the level was seen to rise three feet in half an hour" (*Journal politique ou Gazette des Gazettes*, Février 1784, pp. 80–84).

The *Caris* chronicle at Maaseik, in the province of Belgium Limburg, describes the winter of 1783/84: "*On 13 December 1783, it started to freeze so that the River Meuse froze up and so it was on 17 December. It broke up for a day or two under high waters;*

however, the cold continued, so that the Meuse River froze again. On the 27th followed high waters, but the Meuse remained frozen over; the waters flowed above and below the ice, and the river remained closed. On 21 February, it started to thaw. On the 25th, at about half past 7 in the morning, the ice on the River Meuse broke up and dammed up so that the stage of the water was 12 inches higher than in the year 1740. On the 27th, the water level lowered or the water flowed away, and four holes were found in the paved road outside the Bosch Gate. The new bridge of the Bosch Brook near the mill was swept away; also the Bleumer Dike was washed out in four places. The Bleumer Gate suffered large holes. Between 28 and 29 February 1784, the River Meuse rose again and again flooded half of the town, which was the fourth flood in the same year. The damage caused by the water cannot be described" (Janssen, 1986, p. 19).

Van Postel, a parish priest at Venlo, a city on the Meuse River in the province of Limbourg, The Netherlands, wrote in his diary: "*On 29 December 1783, the River Meuse became ice-bound. On 5 January 1784, the River Meuse broke up damaging severely the ships in the harbour as well as on the beach, particularly near Blerick.*

"*In the evening of the 6th, the River Meuse froze up again and remained frozen, so that, on the 29th, along the Staai, many carriages that came with wood and peat paid half of the ferry fare for the work carried out by the bridge men in clearing a passage them. On 30 January 1784, it was the coldest night. On 21 February at noon, the weather changed. The River Meuse started to swell* [an ice dam had been formed downstream of Velden] *and on the 24th in the evening the water came just for a moment into the town. On 25 February, the level of the water was 38 feet and 3 inches* [3 inches lower than in 1740], *nearly the whole town was flooded. On 2 March, the stage of the water started to reduce; on the 4th the water was out of the town. The drift of the ice and the water did not cause great damage. Near to the Le Roi bastion, the ice piled up about 20 feet high. At the Parade, the vault of the brook collapsed in four places, as did five or six vaults of private cellars*" (Uyttenbroeck, 1912, pp. 14–16).

Northern France (Somme, Seine and Oise Rivers)

In his overview on inundations in France, Maurice Champion wrote the following about the Somme River basin and the flooding of the town of Amiens: "*One will remember the inundation of 1784 for a long time. On 20 February 1784, after a continuous frost of 70 days, and 24 days of snow, the thaw started. It was accelerated on the 22nd by a fine and gentle rain. On the 24th, the waters came down from the valley of Conty in such a mass so that the Hautoie and the road from Hem were flooded. All the floating gardens above Amiens were laid waste; the loss was evaluated at 100 000 francs.*" […] "*The botanical garden and the water tower were flooded. The waters ran with great speed through the town and the water level increased by 12 feet. There had been more than three feet of snow*." (Champion, 1858/65, V, pp. 167–168).

In northern France, the River Oise was frozen for 69 days and the temperature fell to –19°R [–23.8°C] (Rottée, 1858, p. 147). At Paris, 23 February 1784: "*On 20 February, the ice broke up above the general hospital without accident, and a southeasterly wind still blows. As the thaw is very mild, the streets that were swept with care, are passable today, the pedestrians are only afraid of the carriages that splash and the sliding of the snow from the roofs of the houses*" (*L'Esprit des Gazettes*, 6 Mars 1784, p. 366).

HUMAN IMPACTS

The poorer people suffered severely from this long-lasting cold, frost and snowfall, as they could not continue to work and, consequently, there was no income to sustain their families. Several private and more public initiatives tried to cope with these difficulties.

Paris, 30 January 1784: "*Since a month the cold has been very severe in this capital and in its surroundings. There is no single day without snowfall and the frost does not allow one to clear the streets. As there is one foot of snow in Paris, it suggests there are three feet in the countryside and on the roads; everywhere was blocked. The price of hay and straw went up. Vegetables and other foods are also of a horrible high price. However, the well-to-do and the rich people do not suffer from the scarcity; they manage by paying a little bit more. But the poor people, such as the workman whose work is suspended by the rigour of the season, deprived of his bread, heating and other things needed in life, require the most urgent help*" (*Gazette de Leyde*, Supplément, 6 février 1784).

In Antwerp City, by a notice acted in the Assembly and dated 15 February 1784, "*the Lords Commissioners are requested, noting the severe continuous cold and the needs of the poor people for relief, to remain being helpful with a generosity that the needs of the poor require in this continuous and long-lasting coldness*" (Anonymous, Berigt, 1784b).

On 21 February, "*at the request of the bishop of Bruges, a special day of prayer was held to beg the Almighty to please him to change this uncommon frost weather … since yesterday the thaw weather continued with a westerly wind and rain*" (van Walleghem, ms.).

In Dendermonde "*there has been a day of prayer so that the sweet Lord will ease the rough and harsh weather and the long-lasting frost*" (Blomme, 1892).

At Ostends "*the poverty was more pronounced in other towns than in Ostends: because the canals were frozen, all ships had to unload onto wagons, so many workers could earn their daily wages*" (Bowens, 1792, II, p. 221).

At Venlo "*on 13 February 1784, a stove was put at the entry of the church of the Weide where all the poor people could warm themselves; they were also given soup. On 15 February, General Weinhuysen donated 10 pounds of meat and a basket of potatoes and carrots. On the 17th, the monastery of the Friars Minor gave a full mid-day meal to all the poor people*" (Uyttenbroeck, 1912, pp. 14–16).

Liège, 2 March 1784: "*In order to thank Providence to have saved the town of Liège by such a distinguished favour, a solemn mass has been sung in all churches as thanksgiving*" (*Journal historique et littéraire*, 15 mars 1784, p. 451).

"*The high prices of food supplies and mainly fish, caused by the rigour of this long-lasting winter has obliged the* [Belgian] *bishops to depart from the severity of the fast during the Lent of 1784*" (*Journal historique et littéraire*, 15 mars 1784, p. 452).

Jacques Renéaume de la Tache, editor of the *Journal politique ou Gazette des Gazettes* at Bouillon (Ardennes), presents his excuses to the subscribers of his bi-monthly journal as follows: "*If, during six weeks, Messieurs, the subscribers of this journal did not receive it with the usual punctuality, the fault has only been the extreme rigour of the season and the state of the roads having become nearly impassable, delaying the mail, carriages and public transport. As these inconveniences have*

diminished considerably in several countries and totally stopped in others, there is good reason to hope one will not complain any more of a delay, in which we had no part at all" (*Journal politique ou Gazette des Gazettes*, mars 1784, p. 95).

Antoine Cadet de Vaux (1743–1828), a French pharmacist and philanthropist, wrote a short treatise on the way to reduce the noxious conditions in the houses that were flooded. Besides the more common suggestions, Cadet de Vaux advises also to wash the walls that were flooded with pure water so that the fungi that might grow on such an exposed wall will be washed away (Anonymous, 1784a).

In Vienna, under the supervision of Count Buquoi and with Imperial and Royal permission, a collection organized by the Institute for the Poor raised 4220 Florins and 30½ Kreuzer. L.A. Hoffmann praised the noble-minded inhabitants of Vienna, many of them having a modest living, who contributed freely to this philanthropic goal. Nevertheless, he regretted that the amount was so low and blamed the many rich capitalists in Vienna whose names did not appear in the list of contributors (Hoffmann, 1784). In The Netherlands, and this for the first time, a well-organized and centralized assistance to the victims of the inundations took place (Driessen, 1994).

DISCUSSION

The records of instrumental meteorological observations, the Brussels Ephemerides series and the Godart series at Verviers present a very similar picture, showing similar characteristics of the temperature in Brussels and Verviers. Of course, the temperature in Verviers was lower due to both a slightly more continental climate and its higher elevation. Extreme cold temperatures by the end of December 1783, the end of January 1784, on 13 February and on 20 March 1784 were recorded by both series.

A little improvement in the temperature immediately after the cold spell of the end of December 1783, accompanied by rain, was responsible for the first series of floods. It may be assumed that the melting ice was not very thick yet. This, together with the snowmelt, caused rivers in the Dijle and Demer catchments of the Scheldt basin to flood (see Fig. 2 for the location of towns and rivers). This was the case for the Little Gete River at Orp-le-Grand on 2 January 1784, followed by the Gete River at Tienen on 3 January. The Dijle River flooded at Louvain on 4 January. At Venlo, the Meuse River broke up on 5 January to freeze again the next day.

Most of the narrative sources in the larger area of Belgium give the date of 21 February for the beginning of the thaw. This date is advanced by one single day by the more southerly locations of Amiens and Paris. The date the thaw started may depend on the observer, the phenomenon that he observes, the geographical location and the incoming direction of the warm winds and rain, etc. The date of 21 February is corroborated by the instrumental observations. At Brussels, the morning temperature started to rise above 0°C on 21 February, while this happened at the more continental location of Verviers only on 22 February.

Breaking-up of the rivers occurred within the next days after the thaw set in. At Dendermonde, the Scheldt River broke up on 25 February. The River Dijle flooded at Leuven in the night of 23–24 February. Downstream, the town of Mechelen was flooded on 28 February and subsequent days. In the Demer catchment, floods of the Little Gete River in Orp-le-Grand were mentioned in the night of 22–23 February,

while, downstream at Tienen, the Gete River flooded the town on 23 February, Aarschot in the morning of 25 February and the Demer River flooded Diest from 26 to 27 February. Fortunately, there were no floods of the Scheldt River at Antwerp (see Fig. 2).

For the Meuse River, the pattern is slightly different. Floods did occur at the end of January 1784 between Visé and Maastricht; at the end of February and beginning of March 1784 at Dinant, Namur and downstream of Maastricht, and again on 21 March at Namur (see Figs 2 and 4).

The situation became really catastrophic in the area of the Rhine and Meuse river system in The Netherlands. The thaw started abruptly on 21 February and was accompanied by a sharp rise in temperature, warm southerly winds and a lot of rainfall in the catchment area of the Rhine in Germany and the Meuse in France and Belgium. The ice melted partially and the ice blocks started to move downstream. The river system had to evacuate the meltwater and rainwater together with the drifting ice blocks. Downstream the rivers were still frozen so that the flow of large amounts of water and ice was blocked in certain areas. At several places, ice dams or ice jams were formed, blocking the flow even more. The water level of the rivers increased very rapidly and soon dikes burst, one after the other. The first dike bursts occurred on 29 February along the Rhine River near Nijmegen with the consequence that land flooded between the IJssel, Rhine and Meuse. Downstream of Nijmegen, the dikes burst in many places resulting in flooding of the Upper Betuwe, Lower Betuwe, Thielerwaard, Land van Maas en Waal, and partly the Bommelerwaard. The waters were stopped by the *Diefdike* on 3 March 1784 (Driessen, 1994; van de Ven & Driessen, 1995).

It is clear that the catastrophic floods following a long-lasting and harsh winter were a terrible ordeal for the people, and particularly for the poorest. However, being aware of such a recurrent LIA scenario, the population was well aware of the dangers of a rapid breaking-up of the river ice and took appropriate measures. Among them was the firing of cannons at the ice in order to prevent the formation of an ice dam. The population living in the low-lying areas were warned and asked to evacuate their houses. In The Netherlands, this resulted in a low death toll in the flooded areas. A slightly larger number of casualties occurred along the River Rhine near Köln and Deutz, where houses collapsed due to the inundations.

CONCLUSIONS

The catastrophe of February and early March 1784 followed a typical LIA scenario, mainly caused by the breaking-up of river ice after the rapid and marked increase in temperature giving rise to a thaw on 21 February 1784. Much rain accompanied this thaw so that the ice partially melted and started to move downstream where ice jams were formed at specific obstacles. Ice jams blocked the ice and water, producing high water levels, followed by floods and dike bursts.

It can be said that ice jams were the major cause of flooding in the Rhine and Meuse area in The Netherlands over the last 300 years. In this area, the dikes burst repeatedly and in the period 1750–1820 all except two were due to ice jams (Driessen, 1994, p. 28). In The Netherlands, similar cases to the 1783/84 event did occur in the 19th century, for example 1819/20 and 1860/61, but only a few cases occurred in the

20th century. Large floods due to long-lasting rains occurred in 1926 (combined with snowmelt), in December 1993 and in January 1995. Changes in the climate system towards a warming climate and changes due to anthropogenic impacts on the river systems (for the Main River see: Glaser, 2001, pp. 49–50) make such a Little Ice Age scenario less probable today.

Acknowledgements The author gratefully thanks Jan D'hondt, City Archive Bruges; Ludo Vandamme, City Library Bruges; Eric Huys, Rijksarchief at Kortrijk; Michel Nuyttens, Rijksarchief at Bruges; Paul Kempeneers, Tienen; Monique Devorst, Royal Meteorological Institute of Belgium; and the Rijksarchief at Ghent for their precious help. He acknowledges the input of Erik Thoen, Pieter-Jan Lachaert and Tania Verhoeve in the framework of the European research project IMPROVE and thanks the reviewers for their helpful and critical comments on the manuscript.

REFERENCES

Manuscript sources

Anonymous: Observations météorologiques à Tongre-Notre-Dame [1777–1786]. Manuscript, Library Royal Observatory of Belgium, Brussels, Belgium.

Ansiaux, Jacques-Joseph: Description de l'hiver de 1778 a 1779 et du tems qui l'a precedé comme celui qui l'a suivi. [Ciney, 1779–1810]. Manuscript, Library Royal Observatory of Belgium, Brussels, Belgium.

Archief van de Staten van Vlaanderen. Staten van ontvangsten van de jaarlijkse pachtsommen voor: bootdiensten, tolrechten, koetsdiensten, brug- en sluisrechten, "vaete ghelt", grasrechten, visrechten, cynzen, en een oliewatermolen te Brugge, 1 mei 1783–30 april 1784, 1 band. No. 6311, Rijksarchief Gent, Ghent, Belgium.

Godart, Guillaume-Lambert: Registre des observations météorologiques et des visites médicales. 1er Janvier 1767–31 Décembre 1790, 1er Janvier 1791–8 Février 1794, 2 tomes, Manuscript, Abbé Hubert de Their, Brussels, Belgium.

van Walleghem, Joseph: Merckenweerdigste voorvallen en Daegelijcksche gevallen. Manuscript, City Archives of Bruges, Bruges, Belgium.

Published works

Anonymous (1784a) Mittel gegen die übeln Folgen der heurigen großen Ueberschwemmungen in Rücksicht auf Gesundheit. Rezension. *Der Teutsche Merkur*, 2. Viertelj., 94–96.

Anonymous (1784b) Berigt. Alhoewel men overtuygt is, dat by deeze zwaere aenhoudende koude de Heeren Commissarissen, ..., Antwerpen.

Blomme, A. (1892) Les manuscrits des cinq chroniques de Termonde. Oudheidskundige Kring der stad & des voormaligen lands van Dendermonde. Gedenkschriften - Tweede Reeks, D IV. Dendermonde.

Bowens, J. (1792) Nauwkeurige beschryving der oude en beroemde zee-stad Oostende, gelegen in Oostenryksch Vlaanderen: van haeren oorsprong […]. 2 vols, De Busscher, Brugge.

Brázdil, R., Valášek H. & Macková J. (2003) Climate in the Czech Lands during the 1780s in light of the daily weather records of parson Karel Bernard Hein of Hodonice (southwestern Moravia): Comparison of documentary and instrumental data. *Climatic Change* **60**, 297–327.

Brázdil, R., Dobrovolný, P. & Kotyza, O. (2004) Floods in the Czech Republic during the past millennium. *La Houille Blanche* **5**, 50–55.

Brázdil, R., Dobrovolný, P., Elleder, L., Kakos, V., Kotyza, O., Květoň, V., Macková, J., Müller, M., Štekl, J., Tolasz, R. & Valášek, H. (2005a) *Historical and Recent Floods in the Czech Republic*. Masaryk University and Czech Hydrometeorological Institute, Brno, Prague, Czech Republic.

Brázdil, R., Pfister, C., Wanner, H. von Storch, H. & Luterbacher, J. (2005b) Historical climatology in Europe – the state of the art. *Climatic Change* **70**, 363–430.

Brázdil, R., Kundzewicz, Z. W. & Benito, G. (2006) Historical hydrology for studying flood risk in Europe. *Hydrol. Sci. J.* **51**(5), 739–764 (*this issue*).

Buirette, C. (1837) Histoire de la ville de Sainte-Ménehould et de ses environs. Poignée-Darnould, Sainte-Ménehould.

Buisman, J. (1984) Bar en boos. Zeven eeuwen winterweer in de Lage Landen. Bosch & Keuning, Baarn.

Champion, M. (1858/1865) *Les inondations en France depuis le VIe siècle jusqu'à nos jours.* Tome I–VI, Paris.

Comhaire, J. N. (1828) Résumé des observations météorologiques faites à Liége, de 1736 à 1783, et de 1806 à 1826; par MM. Fallise, Thomassin et Comhaire, professeur à l'université de Liége. L'Observateur médical, Journal de Médecine, Chirurgie, Accouchements et Pharmacie. Liége, Collardin, Ière Année-Tome II, 124–128.

Cotte (1784) Mémoire sur l'hiver rigoureux de 1783 à 1784. Observations sur la physique, sur l'histoire naturelle et sur les arts par M. l'Abbé Rozier, **XXV**, 445–466.

Courtois, R. (1828) Recherches sur la statistique physique, agricole et médicale de la province de Liége. Tome premier, Verviers. Chez M.-R. Beaufays, 232–248.

Currie, I. (1996) *Frosts, Freezes and Fairs*. Chronicles of the frozen Thames and harsh Winters in Britain since 1000 AD. Frosted Earth, Coulsdon, UK.

de Poederlé, E.-J. (1784a) Lettre aux auteurs du *Journal Politique*: A Bruxelles, le 25 janvier 1784. Précis des observations faites à Bruxelles, dans le haut de la ville, sur le froid rigoureux de la fin du mois de décembre 1783. *Journal historique et politique des principaux évenements du temps présent.* **I**(4), Janvier 1784, 174–176.

de Poederlé, E.-J. (1784b) Suite des observations météorologiques, Depuis le premier de l'an 1784, sur les baromètres et thermomètres, selon reaumur, jusqu'au 31 Janvier, qui ont été faites dans la basse-ville de Bruxelles. No. X. *Supplément à la Gazette des Pays-Bas*. Lundi 2 Février 1784.

de Poederlé, E.-J. (1784c) Précis des observations faites sur le grand froid rigoureux de la fin de décembre 1783, à Bruxelles. Degrés de froid de 1763 à 1783 inclus. *L'Esprit des Journaux françois et étrangers* **II**(février 1784), 346–348.

de Poederlé, E.-J. (1784d) Précis des observations météorologiques faites à Bruxelles pendant l'année 1783. *L'Esprit des Journaux, françois et étrangers* **V**(mai, 1784), 326–349. A Paris, Chez Valade, Imprimeur-Libraire.

de Poederlé, E.-J. (1784e) Suite du précis des observations faites à Bruxelles sur le grand froid rigoureux & long du 11 décembre 1783, au 21 février 1784 inclusivement. *L'Esprit des Journaux françois et étrangers* **VI**(juin 1784), 352–359.

de Poederlé (1785) Précis des observations météorologiques faites à Bruxelles pendant l'année 1784; Mois de Mars–Mois de Décembre. *L'Esprit des Journaux françois et étrangers* **III**(mars 1785), 346–363.

De Smet, J. (1970) Zuid-Westvlaamse Tijdskroniek uit de Oostenrijkse en Franse Tijd 1761–1814. Het "*Memoriael van Reninghelst door koster Pieter-Lodewijk Cuvelier"*. Westvlaams Verbond van Kringen voor Heemkunde, Assebroek, vols I & II.

Demarée, G. R. & Ogilvie, A. (2001) Bons baisers d'Islande: climatic, environmental and human dimensions impacts of the Lakigígar eruption (1783–1784) in Iceland. In: *History and Climate: Memories of the Future* (ed. by P. D. Jones, A. E. J. Ogilvie, T. D. Davies & K. R. Briffa), 219–246. Kluwer Academic/Plenum Publishers, New York, USA.

Demarée, G. R., Lachaert, P.-J., Verhoeve, T. & Thoen, E. (2002) The long-term daily Central Belgium Temperature (CBT) time-series (1767–1998) and early instrumental meteorological Observations in Belgium. *Climatic Change* **53**, 269–293.

Demarée, G. R. & Nordli, Ø. (2006) The Lisbon earthquake of 1755 *vs* volcano eruptions and dry fogs – are its "*meteoric"* descriptions related to the Katla eruption of mid October 1755? **In:** *Proceedings Colóquio Internacional O Terramoto de 1755: Impactos Históricos, Lisboa (ISCTE)* (3–5 November 2005) (submitted).

Deutsch, M. & Pörtge, K.-H. (2003) *Hochwasserereignisse in Thüringen*. Schriftenreihe der Thüringer Landesanstalt für Umwelt und Geologie no. 63.

Driessen, A. M. A. J. (1994) Watersnood tussen Maas en Waal: Overstromingsrampen in het rivierengebied tussen 1780 en 1810. Walburg Pers, Zutphen.

Elleder, L. & Munzar, J. (2004) Extrémní povodeň na Vltavě a Labi v únoru 1784 jako následek mimořádných hydrometeorologických podmínek. *Meteorologické Zprávy* **57**(5), 125–135 (in Czech with English abstract).

Florkin, M. (1954) *Médecine et Médecins au Pays de Liège*, Tome I. Imprimerie H. Vaillant-Carmanne, Liège, Belgium.

Franklin, B. (1785) *Meteorological Imaginations and Conjectures*. By Benjamin Franklin, LL.DFRS and Acad. Reg. Scient. Paris. Soc. &c. Communicated by Dr Percival. Read, 22 December 1784. *Memoirs of the Manchester Literary and Philosophical Society* ii, 373–377.

Galliot, M. (1790) *Histoire générale ecclésiastique et civile de la ville et province de Namur*. Tome V. Liège, Belgium.

Glaser, R. (2001) *Klimageschichte Mitteleuropas: 1000 Jahre Wetter, Klima, Katastrophen*. Wissenschaftliche Buchgesellschaft, Darmstadt, Germany.

Glaser, R. & Hagedorn, H. (1990) Die Überschwemmungskatastrophe vom 1784 im Maintal. Eine Chronologie ihrer witterungsklimatischen Voraussetzungen und Auswirkungen. *Die Erde* **121**, 1–14.

Glaser, R. & Stangl, H. (2004) Climate and Floods in Germany since AD 1000. Data, methods, results and consequences. *Surv. Geophys.* **25**(5/6), 485–510.

Glaser, R. HISKLID – Historische Klimadatenbank http://www.hisklid.de/de.

Goetschalckx, P. J. (1902) Thienen, Memorie of nota's aangaande vorst, wind en overstroming te Thienen, in de XVIIIe eeuw. Bijdragen tot de Geschiedenis bijzonderlijk van het aloude Hertogdom Brabant. Hoogstraten, 45–46.

Grattan, J. & Brayshay, M. (1995) An amazing and portentous summer: environmental and social responses in Britain to the 1783 eruption of an Iceland volcano. *The Geographical Journal* **161**(2), 125–134.

Grove, J. (1988) *The Little Ice Age*. Methuen, London, UK.

H.G. (1844) Navigation fluviale. Détermination de l'étiage de la Meuse. Crues extraordinaires et débacles – variations diurnes des eaux. *Annales des Travaux Publics de Belgique* **II**, 361–390.

Hennig, R. (1904) *Katalog bemerkenswerter Witterungsereignisse von den ältesten Zeiten bis zum Jahre 1800.* Abhandlungen des Königlich Preussischen Meteorologischen Instituts, Bd. II, No. 4.

Hoffmann, L. A. (1784) Denkmal des Edelmuths der Bürger Wiens bey der Ueberschwemmung im Monat März 1784. In dem Archiv der Menschheit niedergelegt von L.A.H., Wien, Schmid. Rezension. Allgemeine deutsche Bibliothek, Nr. 59, Bd 2, 546–547.

Hous, J.-B. (1964) *Leuvense Kroniek (1780–1829)*. Gepubliceerd door J. De Kempeneer, Abdij van Park. Heverlee.

Janssen, R. (1986) De Maaseiker kroniek Caris (1783–1847). Uitgegeven door Roger Janssen. Hasselt: Culturele Aangelegenheden, Provinciebestuur, Limburg.

Jones, P. D. & Briffa, K. R. (2001) The "Little Ice Age": local and global perspectives. In: *The Iceberg in the Mist: Northern Research in Pursuit of a "Little Ice Age"* (Guest ed. by A. Ogilvie & T. Jónsson). *Climate Change* Special Issue **48**(1), 5–8.

Kington, J. (1980) Daily weather mapping from 1781: a detailed synoptic examination of weather and climate during the decade leading up to the French Revolution. *Climatic Change* **3**, 7–36.

Kington, J. (1988) *The Weather of the 1780s over Europe.* Cambridge University Press, Cambridge, UK.

Lamb, H. H. (1986) Ancient units used by the pioneers of meteorological measurements. *Weather* **41**, 230–233.

Mann, T. A. (1792) Mémoires sur les grandes gelées et leurs effets. Où l'on essaie de déterminer ce qu'il faut croire de leurs retours périodiques, et de la gradation en plus ou moins du Froid de notre Globe. Gand.

Middelkoop, H. & van Haselen, C. O. G. (eds) (1998) *Twice a River, Rhine and Meuse in the Netherlands.* Ministry of Transport, Public Works and Water Management, RIZA Report 99.003, Arnhem, The Netherlands.

Militzer, S. *CLIMDAT®: Klima – Umwelt – Mensch (1500–1800).* http://mitglied.lycos.de/mili04/index.html.

Munzar, J., Elleder, L. & Deutsch, M. (2005) The catastrophic flood in February/March 1784 – a natural disaster of European scope. *Moravian Geographical Reports* **13**(1/2005), 8–24.

Nuyttens, M. (1986) Inventaris van het archief van de Staten van Vlaanderen. Brussel, Algemeen Rijksarchief.

Rottée, E. (1858) Météorologie du département de l'Oise. *Annuaire de la Société météorologique de France* **VI(**Deuxième Partie), 136–192. Paris, France.

Stothers, R. B. (1996) The great dry fog of 1783. *Climatic Change* **32**, 79–89.

Uyttenbroeck, H. H. H. (1912) Het Dagboek of De Kroniek door Pastoor J. C. van Postel. *Bijdragen tot de Geschiedenis van Venlo* **III**. Venlo.

van de Ven, G. P. & Driessen, A. M. A. J. (1995) Niets is bestendig … : de geschiedenis van de rivieroverstromingen in Nederland. Matrijs, Utrecht, The Netherlands.

van Gulpen, Ph. (1889) Kroniek der stad Maastricht van haren oorsprong af tot in Juni van het jaar 1862. (Medegedeeld door Jos. Eversen). *De Maasgouw* 11de Jaargang, 127–128.

van Walleghem, J. (1982/1996) Merckenweerdigste voorvallen en Daegelijcksche gevallen. Manuscript at the City Archives of Bruges & Edited 1787/1796 by Yvan Vanden Berghe. Brugse Geschiedbronnen, Brugge.

Vincent, J. (1901) Deux vieux journaux météorologiques. Le Journal de Ciney [1779–1810] Le Journal de Hauregard [1807–1830]. *Annuaire Météorologique pour 1901*, 287–327. Observatoire Royal de Belgique. Hayez, Bruxelles.

Vincent, J. (1904) Evénements météorologiques anciens. *Annuaire Météorologique pour 1904*, 347–358. Observatoire Royal de Belgique. Publié par les soins de A. Lancaster, Hayez, Bruxelles.

Weikinn, C. (2000) *Quellentexte zur Witterungsgeschichte Europas von der Zeitwende bis zum Jahr 1850 – Hydrographie* Band 1, Teil 5 (1751–1800). (ed. by M. Börngen & G. Tetzlaff). Gebrüder Borntraeger, Berlin, Germany.

de Witry, L.-H. (1788) Observations sur le degre de froid des 30 et 31 Décembre 1783, faites à Tournay par Mr l'Abbé de Witry. *Mémoires de l'Académie impériale et royale des Sciences et Belles-Lettres de Bruxelles*, Tome V, 435–436. Imprimerie Académique, Bruxelles.

Received 10 April 2006 ; accepted 22 June 2006