Great Historical Events That Were Significantly Affected by the Weather: 6, Inundations and the Mild Winter 1672–73 Help Protect Amsterdam from French Conquest

Abstract
In the 17th century, the small Dutch Republic, the union of seven provinces of the northern part of the Low Countries, was the most important country in the world in matters of finance, commerce, and shipping (as well as in the arts, especially painting). Within the Republic, Amsterdam wielded most of the economic power. In the 1670s, King of France, whose rule was characterized by expansionist tendencies, began a war against the Republic in June 1672 (war actually was declared in April of that year). France and her allies, eastern neighbors of the Republic, sent an invading army of about 150,000, as against a hastily collected and poorly trained defense force of 50,000–60,000 Dutch led by Prince William of Orange, who became William III of Holland in July 1672 and King William III of England in 1689. The spring of 1672 was dry and, as a result, the water level in the rivers was low, a fact that facilitated the crossing of water courses by the hostile forces. Within less than a month, most of the eastern sector of the Republic was captured by the invaders. In order to prevent the penetration of the French into the province of Holland, in which Amsterdam was situated, the Dutch resorted to inundating much of their low-lying lands, creating a kind of moat, roughly 20 km wide, about Amsterdam. The French, who were not equipped for crossing wide water areas, decided to wait until the winter when, so they hoped, the cold would freeze the flooded areas and make it possible for them to reach Amsterdam. However, the winter of 1672–73 turned out to be mild on the whole. On 13 December, a frost set in that does not appear to have been excessive. On 27 December, the French began their advance across the ice, but on the 28th the winds turned from east to west and the milder air and rains caused the ice to thaw. The French returned to their former positions, but with difficulty, losing many men in the process. January was mild altogether. As a result of the mild winter, Amsterdam was saved from French conquest.

Our estimates of air temperatures for the two critical months are: December 1672, 3.3°C; and January 1673, 3.4°C. The observed averages for 1735–1834 at Utrecht–DeBilt, however, were 2.4°C and 0.5°C, respectively. Thus, both of the two months of concern appear to have been relatively warm, especially January.

1. Introduction
The effects of cold winters on wars or battles were considered in some previous papers (Neumann, 1978, 1981; Stolfi, 1980; Lindgrén and Neumann, 1982). The winters of concern either made some military operations possible that would not have been feasible in mild winters (e.g., the crossing of firmly ice-bound sea surfaces), or influenced the conduct of wars and/or battles in a decisive manner. In the present paper, we study a case in which a winter was comparatively mild and the mildness played an important role in the shaping of historical events. The winter of concern here is that of 1672–73 and the country involved was the Dutch Republic or, as it was called then, the United Provinces (of the Netherlands), i.e., the northern region of the Low Countries whose area coincides approximately with the Netherlands of our days.

2. The Dutch Republic
In the 16th century, the Low Countries were part of the Spanish Empire. From about the 1560s on, the Low Countries were in a state of intense social, economic, religious, and political ferment (see, e.g., Geyl, 1964; and Parker, 1977). These tumults led to repeated revolts against the Spanish rule, which Spain tried to quell in a ruthless manner. In 1579, the seven northern provinces of the Low Countries founded the Union of Utrecht, which was to bring these provinces and some additional areas that did not enjoy the status of provinces into a kind of confederacy in which the individual provinces had a not insubstantial measure of autonomy. By far the most important of the seven was the Province of Holland, which subsequently gave its name as the alternate name for the Netherlands. The capital of that province was The Hague, but the most important and richest city of the province was Amsterdam.

From the point of view of trade and commerce, Amsterdam was the most important city and port of the world in the 17th century. Much of the grain and other agricultural produce

1 In some phases of this period of ferment, a contributory cause was the weather—see, e.g., Neumann (1981, especially pp. 11–16).
3. France

France was the most populous country of Europe in the 17th century, with a population of about 20,000,000. At the same time, the Dutch Republic had only about 2,000,000 inhabitants (McEvedy and Jones, 1978, pp. 59 and 64). Additionally, France was the strongest military power on land. In the period of Louis XIV's reign (1643–1715), France waged several wars to increase the country's economic and political influence. The ideology of French expansionism expressed itself in the economic theory and practice subsequently called "mercantilism," which aspired to enhance the (French) government's authority over the nation's economy in order to augment the power of the state. As a corollary, French mercantilism placed the interests of France above the interests of other states.

Colbert (1619–83) was Louis's great Minister of Finance and the protagonist of French mercantilism. Louis and Colbert wanted France to take over the Dutch Republic's role in the European economy. In 1668, Colbert introduced tariff regulations in France that severely hit the interests of the Republic. These steps led to countermeasures by the Dutch (Geyl, 1964, pp. 100–103). In 1671, Louis had the effrontery to complain that the Republic imposed hurtful duties on French goods (Blok, 1970, p. 362), although these duties were just countermeasures to the original French tariffs.

4. France prepares for war

From the outset of the tariff war, Louis and his Minister of War, Marquis de Louvois (1639–91), a young genius (Baxter, 1966, p. 67) and a ruthlessly efficient administrator, undertook diplomatic action with the aim of isolating the Republic. In May 1670, a secret treaty directed against the Republic was signed at Dover between France and England, whose king at the time was Charles II. Additional action was taken to obtain the support of powers to the east and north of the Republic. Diplomacy and bribes won over the Archbishop of Cologne and the Bishop of Münster (Geyl, 1964, p. 102), secular rulers to the east of the Republic. Both hoped to get their share of the spoils, and the pretext of beating down a leading Protestant state suited their purposes.

It was not until 1671 that Pieter de Groot, the United Provinces' Ambassador in Paris, was able to obtain details of the secret treaty of Dover. In his report to Jan de Witt, the Council Grand Pensionary (a type of Chief Magistrate) of the Republic, de Groot wrote (Geyl, 1964, p. 104): "The intention is said to be...to sap the strength (of our State) to its very foundation...and to ruin, in the interest common to both England and France the commerce of a State [the Dutch Republic]."

France's military preparations were conducted by Minister of War Louvois. An army of about 120,000 was built up, including 8,000 elite troops. The invasion army was to be headed by the King in person, but most of the time the actual command was in the hands of Louis's able and experienced generals—de Turenne (1611–73), one of the prominent military leaders in the Thirty Years' War; Prince de Condé (1621–86); and the Duc de Luxembourg (1628–95). The Cologne and Münster Prelates-Rulers were to add 30,000 men (Blok, 1970, p. 361) to the invading forces.

5. The Dutch Republic's preparations

On the Dutch side, there was hardly any land army to speak of. Although the Dutch navy was strong and had outstanding commanders (de Ruyter, Tromp) in the second half of the 17th century, the land army was neglected. By neglecting the latter, the Council Pensionary de Witt hoped that it would be possible to prevent the return to power of the House of Orange, which supplied military leaders and heads of state from the beginning of the Dutch Revolt in the last third of the 16th century. However, the multiplying signs of an imminent war forced de Witt to give in to popular demand, and in February 1672, the young Prince William of Orange (1650–1702, and from 1689, also King of England jointly with Mary) was appointed, after much bickering, Captain-General of the Union. While France was ruled by an absolute monarch, the Dutch Republic was a union of not too harmoniously cooperating provinces, which made the making of urgent decisions difficult. In fact, Louis counted upon the dissension among...
FIG. 1. The Dutch Republic (United Provinces of the Netherlands), 1672. The map shows the seven "Provinces" (Friesland, Gelderland, Groningen, Holland, Overijssel, Utrecht, and Zeeland), as well as "The Generality" (Lands) and Drente, which, though not having the status of a province, formed parts of the Republic. Note the River IJssel in the more eastern parts of the Republic, which formed the "IJssel Water Line" and that was intended to be the first line of defense of the Republic, but was abandoned about mid-June 1672. For the "Holland Water Line," i.e., the edge of the inundated area, see Fig. 2.

the provinces and the dissatisfaction of the Catholic sector of the population in this sternly Protestant country (Blok, 1970, p. 372).

Despite the jealousies and obstacles, an army of between 50,000 and 60,000 was set up by the time of the war's outbreak in April 1672. Some of these troops were in the pay of city authorities and thus were subject to the often narrow-minded policies of town and province oligarchies, others were conscripted farmers, still others mercenaries. Most of this force lacked training in comparison with the French. Additionally, more than half of the Dutch army was detailed to defend towns and/or forts, so that the real field army counted but about 15,000 (Geyl, 1964, p. 122). Spain, once a determined enemy of the Republic, sent a small contingent of men in aid, out of the common enmity to France.

In this situation, the determination and perseverance of the young Prince of Orange (his powers were extended considerably with time) and his supporters would not have been enough to prevent the French from taking Holland and the Republic's most important city, Amsterdam. The Dutch were aided greatly by the application of a move that was not expected by Louis, Louvois, or their generals, despite the fact that similar defense measures were brought into operation by the Dutch on several occasions during the period 1568-1648, albeit on a much smaller scale (see Section 9).

Although the element of surprise has played a decisive role in the winning of wars and/or battles throughout history, not even the unexpected measure by the Dutch would have saved the Republic for longer than about six months. To prevent the advance of the French to Holland, the Dutch resorted to
TABLE 1. Estimates of the average air temperatures (°C) for each of the months of May, June, and December 1672 and January 1673 at Utrecht-De Bilt, the Netherlands, based on the correlation between the monthly averages for Central England and Utrecht-De Bilt during the one hundred years from 1735 to 1834. \( T \) and \( a \) = the average and standard deviation, respectively, of monthly temperatures for the hundred-year-long series; subscripts \( E \) and \( H \) = Central England and Utrecht-De Bilt; \( R \) = the correlation coefficient between the data of the two series; \( \bar{T}_E \) = the air temperature in Central England in 1672 (Manley, 1974); \( \bar{T}_H \) = the air temperature in Utrecht-De Bilt in 1672 based on the regression equation, \( \bar{T}_H = a + b \bar{T}_E, \) \( a \) and \( b \) being the constants of the regression equation; and \( \sigma_{HE} \) = the standard error of the estimate of the temperature at Utrecht-De Bilt.

<table>
<thead>
<tr>
<th>Source</th>
<th>January</th>
<th>May</th>
<th>June</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manley, 1974</td>
<td>2.66</td>
<td>11.38</td>
<td>14.43</td>
<td>3.82</td>
</tr>
<tr>
<td>Labrijn, 1945</td>
<td>2.06</td>
<td>1.28</td>
<td>1.14</td>
<td>1.66</td>
</tr>
<tr>
<td>Labrijn, 1945</td>
<td>0.54</td>
<td>12.11</td>
<td>14.94</td>
<td>2.42</td>
</tr>
<tr>
<td>Manley, 1974</td>
<td>2.83</td>
<td>1.48</td>
<td>1.29</td>
<td>2.50</td>
</tr>
<tr>
<td>Manley, 1974</td>
<td>0.87</td>
<td>0.78</td>
<td>0.68</td>
<td>0.82</td>
</tr>
<tr>
<td>Manley, 1974</td>
<td>-2.64</td>
<td>1.87</td>
<td>3.87</td>
<td>-2.28</td>
</tr>
<tr>
<td>Manley, 1974</td>
<td>1.20</td>
<td>0.90</td>
<td>0.77</td>
<td>1.23</td>
</tr>
<tr>
<td>Manley, 1974</td>
<td>5.00</td>
<td>0.94</td>
<td>0.95</td>
<td>1.45</td>
</tr>
<tr>
<td>Manley, 1974</td>
<td>3.40</td>
<td>12.7</td>
<td>16.2</td>
<td>3.30</td>
</tr>
<tr>
<td>Manley, 1974</td>
<td>1.40</td>
<td>0.94</td>
<td>0.95</td>
<td>1.45</td>
</tr>
</tbody>
</table>

6. The Weather of May 1672 Through January 1673

During the nine months in question, the weather of the first three months played but a minor role in the war, and the weather of most of the summer and early autumn appears to have had virtually no impact on the war. In contrast, the character of the winter of 1672–73 turned out to be decisive: it saved Holland and Amsterdam.

With regard to air temperature and weather observations, it is well known that the only series of more-or-less reliable air-temperature measurements made during the 17th century was that for Central England, the data of which were studied critically and presented by Manley (1974). The series begins with 1659, but Manley warns us (p. 393) that the figures for 1659–1720 are less trustworthy than those for the period since then. As far as descriptive types of weather observations are concerned, either for the Low Countries or for the neighboring areas, they are few in number, perhaps because, except for a drought in the spring of 1672, the weather did not produce extremes.

First, the spring of 1672. The Dutch historian Jan Wagenaar (1709–73), who wrote a multivolumed treatise on the history of the Netherlands and who was the official historian of the city of Amsterdam, wrote (1764, p. 158) that the summer (we think that it would have been more appropriate to use the term "spring") of 1672 was dry, and that therefore there was not much water in the rivers. The relevance of this is that the Netherlands is a river country, and a low water level in the rivers would make it easier for the enemy to cross them; moreover, much of the transportation in the Dutch Republic was effected by means of canals and streams, and it was feared that "a continued dry spell could mean disaster" (Baxter, 1966, pp. 66–66, quoting sources). Baxter further quotes sources who note that by the beginning of June there were perhaps a hundred places along the River IJssel where cavalry could cross. The short-lived significance of this fact was that the IJssel formed the first-line defense of the Republic (see Fig. 1). But the French could and did execute flanking movements, so that in June the Dutch already had given up the so-called IJssel Water Line.

Labrijn's (1945, pp. 89–93) series of monthly averages of air temperature for Utrecht-De Bilt begins in 1735. This series and the parallel set of air-temperature data for Central England (Manley, 1974, pp. 393–398) make it possible to estimate the monthly averages in Utrecht-De Bilt in 1672–73. Table 1 shows the statistical characteristics of the two sets, including the correlation coefficients (which are highly significant, as would be expected) and the constants of the regression equation of the Dutch on the English data, based on data from the one hundred years from 1735 to 1834. In the regression equation

\[
\bar{T}_H = a + b \bar{T}_E. \tag{1}
\]

\( \bar{T}_H \) is the estimate of the monthly average of Utrecht-De Bilt, \( \bar{T}_E \) is the "observed" value in Central England, and \( a \) and \( b \) are constants of the regression equation. The resulting estimates for spring 1672 are: May, 12.7°C; and June, 16.2°C; whereas the averages for 1735–1834 are 12.1°C and 14.9°C, respectively. Thus, the period May–June 1672 appears to have been warmer than the long-term average. Unfortunately, no corresponding rainfall data are available, but the descriptive type of observations mentioned in the next paragraph make it clear that the weather was dry.

Vanderlinden (1924, pp. 161–162) quotes contemporary sources for Mons, Belgium, to the effect that there was a great drought ("... trop grande sécheresse ...") in summer. Similarly, Douxchamps-Lefèvre and Dufour (1976, p. 28) cite records for Namur, a city that is even closer to the Republic, which state that the harvest of 1672 was almost nil because of a great drought.

It seems that the drought broke in July. At the beginning of July, after his victorious entry into Utrecht (see Section 7), Louis decided to return to Paris with part of his force. On his way back, about mid-July, he put 's Hertogenbosch, in the
southern part of the Republic, under siege. But soon afterwards, rains turned the area around the fort into a marsh and the King felt forced to give up the siege (Trevelyan, 1930, p. 209).

As was pointed out earlier, the period whose weather was of decisive importance, and whose effect on the war is the principal topic of this study, was that of the winter of 1672–73, which, on the whole, was mild. There was a spell of frost in December, which, however, was not excessive; January appears to have been particularly mild, with winds from the west, storms, and rain.

Our statement that the cold of December was not excessive seems to be contradicted by a report by William, addressed to the States-General, dated 20 December (Baxter, 1966, p. 97, quoting manuscript sources). At the time, the Prince was beleaguering Maastricht in the southeast in an effort to draw French forces away from Holland’s border. His report speaks of an intense cold on 16 December, with the ground frozen to a depth of 45 cm, making the digging of trenches impossible. We find that with the onset of frost on 13 or 14 December (as indicated by historians), it would have required a wave of improbably great cold to bring the temperature in the ground at a depth of 45 cm down to 0°C in a matter of two to three days. Certainly, the reports on the state of ice in the inundated areas do not bear out a very great cold. The following paragraph intends to show on a somewhat more quantitative basis that the cold could not have been inordinate.

Taking a homogeneous soil with a thermal diffusivity $\kappa$ that is constant in time, the ratio of temperature amplitudes $\delta_1, \delta_2$ at two depths, $z_1$ and $z_2$, with $z_2 > z_1$, is

$$\frac{\delta_2}{\delta_1} = \exp\left[-(z_2 - z_1) (\omega/2\kappa)^{1/2}\right]$$

(e.g., Sellers, 1965, p. 136), where $\omega$ (the angular frequency of oscillation of the temperature) is equal to $2\pi/T$. $P$ is the period of the wave, and the quantity $(2\pi/\omega)^{1/2}$ is called “damping depth” by van Wijk and de Vries (1963, p. 109). For the purpose of a rough estimate we shall take $P = 3$ days or, in round figures, $2.5 \times 10^3$ s, or $\omega^{1/2} = 5 \times 10^2$, approximately. Sellers (p. 136) points out that the thermal diffusivity for most soils lies between $10^{-3}$ and $1.2 \times 10^{-2}$ cm$^2$ s$^{-1}$. With the aforementioned values, the damping depth works out as about 0.8 and 10 cm, respectively. The parallel values of $(\omega/2\kappa)^{1/2}$ are about 1.1 and 0.3 cm$^{-1}$. These, multiplied by $z_2 - z_1 = 45$ cm, result in such a high negative value of the power of the exponential in Eq. (2) that the ratio $\delta_2/\delta_1 = 0$ for all practical purposes. The meaning of this is that $\delta_2$ would be very closely equal to zero, i.e., the soil at a depth of 45 cm, which is said to have been at 0°C on 16 December, was too warm due to the drought, as was pointed out earlier, and the hostile cavalry could easily wade them. Moreover, it was possible for the invaders to carry out flanking movements so that the Dutch force that was deployed on the west bank of the IJssel was in danger of encirclement. Under these circum-

4 Charles II was the uncle of the Prince of Orange, who was the Republic’s Captain-General at the time of the declaration of war by his uncle. This fact led the contemporary Dutch historian Abraham de Wicquefort (1598–1682) to remark that “Kings have no relatives” (Baxter, 1966, p. 69). We must point out that at the time of the Revolution of 1688 in England, the same Prince sailed with a force from Holland, invaded England, and sent James II, King of England (ruled 1685–88), into exile in France (Louis was again involved—he supported James). The unfortunate James, Charles II’s brother, was not only the uncle, but also the father-in-law of the Prince, who from 1689 on ruled England jointly with his wife Mary (James’s daughter) under the name William III. (The Prince was not only Captain-General, but also Stadholder of the Provinces of Holland and Zeeland, and Captain-Admiral-General of the Union beginning in July 1672.)
FIG. 2. Map of inundations in Holland, 1672. Map was prepared on the basis of maps in van Sypesteyn and de Bordes (1850), copies of which were kindly provided by H. W. van Asten (see Acknowledgments), and a map in Trevelyan (1930). Fig. IV in Gottschalk (1977) shows some changes introduced in the maps of van Sypesteyn and de Bordes by other investigators.

stances, the Prince and the field deputies of the States-General (roughly comparable to Parliament) of the Republic decided to retreat and concentrate on flooding some of the low-lying lands in order to defend the province of Holland.

As is well known, a substantial part of the Netherlands west of a line running roughly from north to south via Utrecht lies somewhat below certain tide levels of the North Sea and its inlet, the Zuider Zee. These lowlands are kept free of water by artificial means, and by reversing the process, one can inundate them. This technique had already been used to save Leiden from the onslaught of Spanish troops in 1574. At this time, the area mainly to the south of the city was flooded. Realizing the difficulty of reaching their objective, the Spaniards withdrew after a time (Wagenaar, 1758, pp. 218–219). Other small-scale inundations were applied against the Spanish in the province of Zeeland during the period 1568–1648 (see Plate 7 in Gottschalk (1977), based on a map prepared by N. Visscher about 1650).

In 1672, the idea was to inundate the major part of the northern section of the province of Holland and thus create a kind of moat about Amsterdam (see map of inundations in Fig. 2). However, these operations were somewhat slow at the beginning. In April 1672, the states of Holland set up a Committee of Inquiry to report on the possibilities of inundation, but the report did not become available until the end of May or beginning of June. The states’ Deputies then went on an inspection tour, but it did not begin until 11 June, i.e., a day before the main body of the French army crossed the Rhine (van Sypesteyn and de Bordes, 1850, pp. 26–39). Even as late as 11 June, the great city of Amsterdam refused to comply with the States-General’s requests to inundate its approaches (van Sypesteyn and de Bordes, 1850, p. 90). In their reply, the Burgomaster and Council of Amsterdam said that “The demand is premature. The Burgomaster and Council . . . would find themselves obliged to prevent and obstruct the flooding actions.” However, when news of the French crossing of the Rhine on 12 June reached Amsterdam, the city fathers changed their minds. By 23 June, the water level over the lowlands was deemed sufficiently high to hinder the advance of the French. Fortunately for the Dutch, the French advance was made in slow stages, and it thus failed to take advantage of the delays on the part of the Dutch.

Amsterdam was not the only city to resist flooding at first. The worst resistance was put up, however, by peasants, who did not mind the loss of the crops of the season and the cattle as much as the ruination of the soil, which, in some cases, had to be flooded partially with sea water. In many instances, the peasants stopped the holes pierced into dikes or manipulated sluices, and even tried to use the very weapons they were issued for use against the invaders to prevent the Republic’s forces and officials from effecting the inundations. Eventually, William, the Prince of Orange, had to issue warnings that
anyone who interfered with the flooding actions would be punished by death.

Units of the Republic’s small army were stationed in defense at or along five points or routes whereby the French could have reached Amsterdam, e.g., along high river banks. Some of these military posts are marked in Figs. 1 and 2.

With the IJssel Line abandoned, the French continued with their conquest, and on 3 July Louis entered the important city of Utrecht amidst great pomp. Amsterdam was only an aerial distance of about 35 km from Utrecht, but a “moat” roughly 20 km wide protected the city.

While the invasion went on, there was a panic among Holland’s population. Sources describe how people wept in the streets, and those who could manage tried to hide or ship away their valuables and flee. The Prince and some of the other leaders displayed composure, but not even they could oppose attempts at peace negotiations. The representatives of Amsterdam showed intransigence in these negotiations, and representatives of some of the other provinces insinuated that it was easy for Amsterdam and Holland to reject the terms of the French when Amsterdam was a safe “island” protected by the water surrounding it (Baxter, 1966, pp. 73–74).

In the peace negotiations, the French demanded that: 1) all areas of the Republic outside the provinces and part of the province of Gelderland become part of their empire; 2) the Dutch return to the low tariffs of 1662 on French goods, while they, the French, would retain their present high rates imposed on Dutch commodities; 3) France receive “most-favored nation” status and other privileges; 4) the Republic pay a huge indemnity; and 5) complete freedom be granted to the Catholic faith. When the Republic rejected these terms (a minority would have been ready to accede to them), Louis declared “... to stay until winter when dykes would freeze and then he would leave not one stone of Amsterdam standing on another” (quoted in Baxter, 1966, p. 74).

Thus the French pinned their hopes on the winter, when the cold, which they confidently expected, would freeze the “moat.” With the deferment of the final assault, some of the French forces were taken away from the Holland front. Louvois is quoted (Trevelyan, 1930, p. 207) as having written his father on 9 July: “The King, having realized that all the approaches to Holland are at present inundated, and that until the frost sets in, it is not possible to penetrate them, has ordered the advance guards to be withdrawn.” The King, taking with him some of his best troops, returned early to Paris in July, and on his way back he placed ’s Hertogenbosch (see Fig. 1) under siege, as was mentioned previously (see Section 6). Somewhat later, additional troops were moved from the Holland theater eastward to the Rhine Valley to meet a threat by armies of Leopold I, the Hapsburg Emperor, and Frederick William, the “great” Elector of Brandenburg, who were anxious to keep the expansionist actions of Louis in check. The French forces left behind at the Holland frontier were under the command of the Duc de Luxembourg.

A detailed account of progress of the war will be found in the Dutch text by van Syptestein and de Bordes (1850). A somewhat shorter, but more recent, Dutch tract on the subject is by Fruin (1972). Some interesting details concerning how the French tried to use flooding operations against the Dutch, are given in a recent book by Gottschalk (1977).

8. A frost in December is followed by a lengthy mild period

Wagenaar (1764, p. 220) quotes manuscript sources to the effect that during the first part of November 1672 the Dutch were already considering plans as to how to counteract the effects of the anticipated cold. These plans included the breaking up of the ice surfaces by hand tools and the suggestion by the Water Board of Rhineland that certain sluices be kept open so as to cause a constant flow of water in the inundated areas and thus reduce the chances of freezing. We note with interest that the Water Board was aware of this fluid dynamical effect of flow.

The first period of frost set in about 13 December. Fortunately for the Dutch, Luxembourg could not begin his march immediately. First of all, the ice was not yet firm enough to bear the cavalry, and secondly, his forces close to the Holland border were not strong enough and he had to collect troops from the provinces of Utrecht and Gelderland. By 17 December the frost was severe, and in some sectors the ice was thick enough to carry the weight of horses and men (Wagenaar, 1764, p. 222; van Syptestein and de Bordes, 1850, pp. 167–169; Baxter, 1966, p. 97). On 27 December, Luxembourg began the march across the ice with 9000 foot soldiers and 2000 cavalry (van Syptestein and de Bordes, 1850, p. 176, footnote 1). On the 28th, however, a change in the air circulation set in, the wind swung from east to west (Wagenaar, 1764, p. 223), and rain fell. It appears from all this that an anticyclonic circulation changed into a cyclonic one and a “great thaw” developed, which prevented the penetration of Luxembourg’s forces into Holland (Wagenaar, 1764). The position of the French forces became uncomfortable, and it now became a problem to get the troops back to their base at Utrecht. In the process of returning, many troops drowned in canals and dikes and others died from exposure (Baxter, 1966, p. 99).

The historical sources indicate that in January the weather continued to be frost-free. The few weather observations recorded in sources not connected with the war also indicate that the circulation remained essentially westerly, with some cases of heavy rain (see Section 6). It appears that in February there was a brief frost, but by that time the French had already given up the plan of taking Amsterdam. Wagenaar (1764, p. 239) reports that in January Count von Tott, Sweden’s Ambassador in Paris, called on Louis to limit his conquests. Louis promised to desist from further attacks on the Republic after Maastricht’s capture. In the 17th century, Sweden was a great power whose pressure could not be left unheeded, even by Louis. Moreover, the Emperor Leopold and the Elector of Brandenburg continued to actively oppose Louis’s policies.

9. Concluding comments

Several modern historians (e.g., Trevelyan, 1930, pp. 206–208; Baxter, 1966, p. 88) take the view that the French could have reached Amsterdam in June before the Dutch managed to complete their inundation operations had they, the French, not taken the time to capture city after city and fort after fort in the eastern part of the Republic. It is not our concern
quote speculations on the causes of this failure. What does concern us is the fact that their relative slowness was such that the French did not reach Holland before the flooding was accomplished, and that therefore their only hope of taking Amsterdam was that the winter would be cold enough to freeze the waters to a sufficient depth to support the cavalry and make an invasion over the ice possible.

It was pointed out previously that the French did not anticipate that the Dutch would resort to flooding their low-lying lands despite the precedents set in 1574 and by a number of other previous cases of (small-scale) flooding by the military that were mentioned earlier. This lack of anticipation by the French is illustrated clearly by their failure to gather information in advance on the location of sluices of critical importance, the capture of which would have enabled them to drain areas that blocked their progress. This absence of intelligence-gathering is shown by the following incident, which, following a famous dictum of Talleyrand, was a blunder (see Fig. 2). From there they continued northwestward and drained areas that blocked their progress. This absence of intelligence-gathering is shown by the following incident, which, following a famous dictum of Talleyrand, was a blunder ("in diplomacy to commit a crime is a blunder, but to commit a blunder is a crime"). (For a reference on the incident, see van Sypesteyn and de Bordes (1850, p. 136, footnote 2)).

After the abandonment of the IJssel Water Line by the Dutch about mid-June, a French cavalry force under the command of the Duc de Rochefort took a number of cities in the eastern part of the Republic, among them, Wageningen (see Fig. 2). From there they continued northwestward and Rochefort entered the small city of Naarden, on the coast of the Zuider Zee, a distance of about 20 km from Amsterdam. There was no combat, for Naarden's magistrates disarmed their garrison and sent the men away in order to prevent bloodshed. Approximately 6–8 km west of Naarden, Rochefort could have drained the sluices on the river Vecht, thereby eliminating a vital section of the inundations blocking the way to the coveted city. But neither Rochefort nor the French Command knew about these sluices at the time.

As to the significance of the mildness of the winter on the conduct of the war, Wagenaar (1764, p. 220) points out that had the weather favored the enemy, the consequences would have been fatal for Holland. In Section 8 we quoted the complementary statement of this historian to the effect that the thaw that set in on 28 December prevented the penetration of Luxembourg's forces into Holland. In his book on Amsterdam's history, Wagenaar (1760, p. 650) repeats that statement.

Adriaan van der Goes (1619–86), a prominent "advocaat" (jurist) of the court of Holland, wrote (Gonnet, 1909, p. 449) in his letter of 12 January 1673 to his brother Willem (1613–88) in exile: "The thaw that saved us and that infuriated the French, is an indication that God has not forsaken us."

The significance of Louis XIV's failed attempt to capture Amsterdam is that had France succeeded in taking Amsterdam, and with it Holland, a major upheaval would have taken place in Europe's economic order: France would have added economic dominance to its already prevailing military superiority on land, and this dominance would have included an increasing share in the overseas trade with colonies at a time in history when the possession of colonies was of growing importance. Very probably, France would have seized at least part of the Dutch Navy and thus enhanced its own naval power, which was weak compared with the navies of either England or the Dutch Republic. French success also would have led to an intensified resistance by other European powers against Louis's ambitions. The mildness of the winter of 1672–73 and the abrupt change in atmospheric circulation from an easterly to a westerly circulation toward the end of December 1672, just about the time that the French launched what they hoped would be their final assault on Amsterdam, were important factors in bringing about France's failure.

Acknowledgment. The writers wish to express their warm thanks to H. W. van Asten, Librarian of the Historisch Seminarium, University of Amsterdam, for his kind assistance with literature and information.

References

Neumann, J., 1978: Great historical events that were significantly affected by the weather: 3, the cold winter of 1657–58, the Swedish army crosses Denmark's frozen sea areas. Bull. Amer. Meteor. Soc., 59, 1432–1437.
——, 1981: Crossing of ice-bound sea areas in history and historical climate of Belgium in the later half of the 16th century. Contribution 24, Institut d'Astronomie et de Géophysique, Université Catholique de Louvain, Louvain-la-Neuve, Belgique, 20 pp.
Stolfi, R. H. S., 1980: Chance in history: The Russian winter of
grant to obtain samples, but proposals for grant support of such studies will be considered by NSF’s United States Antarctica Research program.

For detailed core description catalogs and more information, contact Dennis Cassidy, Curator, Antarctic Marine Geology Research Facility and Core Library, Department of Geology, Florida State University, Tallahassee, Fla. 32306 (tel.: 904-664-2407).

**Dropwindsonde data available from Hurricane Debby**

Post-processing of Omega dropwindsonde data from Hurricane Debby (1982) has been completed and tapes of the post-processed data are now available. The tape consists of 78 soundings of pressure, temperature, humidity, and wind from the storm environment (100–850 km from the storm center). The data were collected from 1900 GMT 14 September to 0300 GMT 16 September 1982. Included on the tape are flight-level data from the National Oceanic and Atmospheric Administration (NOAA) P-3 aircraft involved in the dropsonde missions. Photocopies of commercial aircraft observations, Air Force vortex messages and reconnaissance reports, P-3 flight tracks, and the official storm track complete the data package, which is available from James Franklin, Hurricane Research Division, Atlantic Oceanographic and Meteorological Laboratory, 4301 Rickenbacker Causeway, Miami, Fla. 33149 (tel.: 305-361-4403).

**NACOA river and flood forecasting report**

The National Advisory Committee on Oceans and Atmosphere (NACOA) recently reported to Congress and the President that improvements must be made in the nation’s flood forecast and warning services in order to prevent the $2 billion average annual loss to floods. Local flood warning systems in more than 650 communities have proved highly successful and NACOA urged the expansion of these programs, funded and operated by the communities which benefit from the customized flood warnings. The expansion, NACOA noted, should include augmentation of rain gauge networks, which consist largely of volunteers, by recruiting more observers, and by installing automated rain gauges in sparsely populated areas.

The report, *The Nation’s River and Flood Forecasting and Warning Service*, emphasizes the dependence of the National Weather Service (NWS) flood forecasters on the river and rainfall information gathered by agencies, such as the U.S. Geological Survey (USGS), U.S. Army Corps of Engineers, and the Soil Conservation Service as part of their missions. The report recommends the formation of a high-level coordinating mechanism to ensure that any changes to the data gathering system arising from non-flood related needs do not reduce the effectiveness of the flood forecasting and warning services.

The report also noted that there is no relationship between the National Flood Insurance Program, which provides homeowners, businesses, and others with federally subsidized insurance at affordable costs, and the presence or absence of flood forecasting and warning service in an area. NACOA suggested that the premium rates, federal insurance subsidies, and other related costs might be reduced with increasingly effective flood warning systems and community preparedness programs. Citing this possibility as a business proposition that cannot be ignored, NACOA recommended that the Federal Emergency Management Agency and the National Oceanic and Atmospheric Administration study the relationships involved.

Copies of *The Nation’s River and Flood Forecasting and Warning Service* are available from NACOA, Page Building 1, 3300 Whitehave St., NW, Washington, D.C. 20235.

(continued on page 799)