Sustainability or Collapse?

An Integrated History and Future of People on Earth

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 Revolutionary Weather

The Climatic and Economic Crisis of 1788–1795 and the Discovery of El Niño

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ABSTRACT

Archival evidence and historical analyses strongly suggest that the 1788–1795 El Niño event was remarkable for its intensity and prolonged global impact. This event may have been among the most severe in the available written record. Climate anomalies associated with the event played a role in key historical events. Severe, prolonged drought starting in 1788 accompanied the European settlement of New South Wales, Australia and challenged the agricultural strategies of the new settlers. The event was manifest as a failure of the Indian monsoon, starting about 1780 and resulting in the famine and associated high mortality throughout most of India. Unusual harvest failures were reported in the Caribbean. In Africa, the event is associated with record low levels of the Nile from 1790 to 1797. Highly abnormal weather patterns in western Europe starting in 1787 led to severe crop failures, which, in turn, exacerbated social pressures that culminated in the French Revolution and the Catalan Revolt. In North America, during this period unusually hot weather and mild winters were associated with disease outbreaks. The global scope of this severe El Niño event sheds light on the interactions of globally scaled climate events and regional historical events.

INTRODUCTION

Australia has above all other places a claim on the epithet, “the El Niño continent.” It is regularly beset by this phenomenon, which links climate anomalies across the globe. During an ENSO event, a spatial pattern of climate fluctuations develops: heavy rains fall on the Pacific coast of South America, while the lands to the west of the Pacific Ocean—from Australia and Indonesia through to southern and northeast Africa, and including South Asia—suffer severe droughts. The distinct feature about the phenomenon is that fluctuations appear
in many locations almost simultaneously. Climatologists call the relations between fluctuations "teleconnections" (Nicholls 1992; Grove 1997).

The remarkable correlations and connections between the strength of the El Niño current and Southern Oscillation (ENSO) have been a particular focus in climatology and oceanography since about 1982, but research into historical records can extend data backward to approximately A.D. 1500 with some reliability. From this long data series garnered from the scrutiny of the archival record, some ENSO events stand out as particularly severe. None is worse that the 1788–1795 crisis, which coincided with the first European settlement of New South Wales in Botany Bay, right at the heart of what we now know to be the part of Australia most affected by ENSO. The main perennial drinking water supply, the Tank Stream, dried up. The same event produced very prolonged droughts in South Asia. The severity of the situation warranted comment in contemporary sources in these and other places. Thus some of the earliest documentation of this global climate phenomenon was achieved.

Despite the regularity of claims that the "latest" El Niño (whichever it may be) "is the worst in history" (e.g., by U.S. Vice-President Al Gore in 1997–1998) and the concomitant fears that such events may be linked to global climate change, the historical as well as the prehistoric record suggests that worse events have occurred in earlier eras (Grove 1998). Documentary evidence suggests that, even in the last thousand years, very much stronger and longer El Niño events than those experienced since 1982 have been experienced globally. The strongest of them took place during the Little Ice Age between about 1250 and 1900, and especially in the closing years of the 18th century, when an El Niño event of exceptional strength and length appears to have affected the entire global environment. This last event is of particular interest in understanding the economic and social history of its time. It also suggests the intrinsic value of reconstructing the characteristics and impact of pre-instrumental El Niño events.

EL NIÑO, AUSTRALIA, AND THE REST OF THE WORLD

The extent to which Australia's history has been significantly shaped by El Niño events has been underexplored. This chapter considers the severe environmental events that shaped the world at the time of the first seven years of European settlement in New South Wales. Conditions were remarkably contrary to supporting the imperial agricultural vision for the newly annexed land.

On November 5, 1791, Governor Arthur Phillip reported that the normally perennial "Tank Stream" flowing into Sydney Harbor had been dry for "some months" (Governor Phillip's diary in McCormick 1987). It did not flow again until 1794. The drought had begun, Phillip records, in July 1790 and no rain had fallen at all by August 1791. In a letter to W. W. Grenville on March 4, 1791, he noted that "from June (1790) until the present time so little rain has fallen that most of the runs of water in the different parts of the harbour have been dried up for several months, and the run which still supplies this settlement is greatly reduced, but still sufficient for all culinary purposes...I do not think it probable that so dry a season often occurs. Our crops of corn have suffered greatly from the dry weather" (Nicholls 1988, pp. 4–7).

The settlement of New South Wales was a struggle because of environmental conditions, yet the knowledge base and networks supporting the agricultural venture were growing. As early as 1791, Phillip was chancing a comparison: such a dry a season was rare. There are many problems involved in reconstructing the conditions and severity of El Niño events that took place before about 1870, when the period of modern instrumental observation began. However, Phillip's intuitive hunch (perhaps informed by Aboriginal insights) that this drought was exceptional can, in fact, be confirmed with hindsight.

Corroborating evidence for the severity of the 1788–1795 El Niño event comes from contemporaneous reports of drought in southern Africa, South Asia, the Atlantic, the Caribbean, and Mexico, where severe famines were reported in some regions. From the early 18th century, and even more so after about 1780, the richness of the available historical record, especially in the South Asian tropics, allows us to reconstruct the global footprint of a major El Niño event with very reasonable accuracy and resolution. This is due partly to the growing contemporary detail of Indian weather and population data gathered by the British East India Company. Useful contemporary global weather data from voyages and new settlements at the time are also available, particularly from the Southern Hemisphere, not least from parts of Australia and Oceania from which weather data prior to the 1780s is largely nonexistent.

The drought years of 1788–1794 in India were first recognized as having had a global impact by Alexander Beatson, Governor of St. Helena. Beatson suggested in 1816 that drought events of 1791, which occurred simultaneously in different parts of the world (he referred particularly to India, St. Helena, and Montserrat), had been part of the same connected phenomenon (Beatson 1816, p. 10). Beatson witnessed drought-stricken parts of South India before arriving in St. Helena and also experienced the effects of the 1791 drought in Mysore.

INDIA AND THE DROUGHTS OF 1788–1795

The El Niño episode of 1788–1795 was actually the culmination of a succession of unusual weather episodes that had begun in about 1780, and which were characterized by extreme events in both temperate and tropical latitudes in Europe and Asia (Kington 1988). These years were especially serious throughout South Asia (though of course there is no formal data for Australia before 1788). One

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1 See statement by U.S. Vice-President Al Gore and NOAA scientists, The White House, June 8, 1998, claiming the 1997–1998 El Niño to be the most significant climatic event of the century and suggesting (without any evidence being produced), that this implied an acceleration of global warming. Other examples include Trenterth and Hear (1996, pp. 57–60).
year, 1783, which brought famine to almost all India, was memorialized in popular culture throughout India under the name of the *chalis*. The word itself, which emphatically associates the Hindi number “forty” with a particular variety of famine, may suggest a characteristic return interval of 40–50 years for severe droughts, an interval which is, very roughly, borne out in reality during the Little Ice Age. The social disruption caused by this particular event was long term, since nearly 4% of all villages in the Tanjore district of the Madras Presidency were entirely depopulated in the early 1780s and over 17% in the Sirkali region (see Census of Tanjore). Up to eleven million people may have died in South Asia as a direct result of the passage of this event.

The earliest indications of the event are contained in the manuscript records of meteorological observations made for the East India Company by William Roxburgh, a Company surgeon, at Samulecottah in the northern Circars of the Madras Presidency (modern day Samalkot) (Roxburgh 1793a). Roxburgh accumulated a fourteen-year set of temperature and pressure data from the early 1770s and was thus able to recognize the exceptional nature of the droughts that began about 1789 (Roxburgh 1778). These droughts had previously been approached in intensity, he reported to the Company, only by those of a century earlier, in 1685–1687 (Roxburgh 1793b). These latter years are also now believed to have been characterized by “very severe” El Niño conditions in the eastern Pacific, but a year later, in 1687–1688. Roxburgh’s rainfall figures record the consecutive failure of the South Asian monsoon between 1789 and 1792, with the most severe failure being experienced in 1790 (see Table 10.1).

Of particular note is the indication that the first major rainfall deficit associated with the event was experienced in 1789 in southern India, more than a year before similar deficits were experienced, toward the end of 1790, in Australia, Mexico, the Atlantic islands, and southern Africa. The possibility that the Indian monsoon is an active rather than a passive feature of tropical circulation and that monsoon failure may be efficient in *foreshadowing* El Niño (rather than being predicted by it) has been suggested (Krishnamurthy and Goswami 2000). It should be noted that some El Niño events, such as that of 1997, appear to correlate only with a failure of the Southeast Asian monsoon rather than with a South Asian failure. In the case of the 1789–1793 El Niño event (and the 1685–1688 El Niño event), a failure of the monsoon in both regions appears to have occurred. By November 1792, over 600,000 deaths were being attributed directly to the prolonged droughts in the 167 districts of the northern Circars of the Madras Presidency alone; up to half the population there died in 1792 (Table 10.2).²

The long drought periods were interspersed by very short periods of intense and highly destructive rainfall. In three days at Madras, in late October 1791, 25.5 inches of rain fell, “more than has been known within the memory of man” (Madras Courier 1791). Throughout India, the famines of 1788–1794 resulted in very high mortality. In limited areas, such as the Northern Circars, East India Company officials attempted to estimate total mortality statistics. In other regions a much rougher but still useful guide is provided by the figures for deserted village sites. In the Ghorakhpur district of Bihar, for example, the 19,600 villages extant in 1760 had fallen to 6,700 by 1801, with a mere third of the district falling under cultivation. Not all of these desertions can be attributed to famine mortality, but a high proportion of them probably were (figures quoted in Commander 1989, p. 50). A similar pattern of mortality obtained in southern India during the period, where a pronounced pattern of village desertion can be established, and up to 30% of villages were deserted, for example, in some parts of the


<table>
<thead>
<tr>
<th>Table 10.1</th>
<th>Monthly rainfall at Samulecottah, Andhra Pradesh, India May–November 1788–1792 (in inches and twelfths of an inch) as measured by Roxburgh (1794).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1788</td>
</tr>
<tr>
<td>May</td>
<td>15.4</td>
</tr>
<tr>
<td>June</td>
<td>7.2</td>
</tr>
<tr>
<td>July</td>
<td>22.3</td>
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<tr>
<td>August</td>
<td>12.2</td>
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<tr>
<td>September</td>
<td>8.9</td>
</tr>
<tr>
<td>October</td>
<td>5.9</td>
</tr>
<tr>
<td>November</td>
<td>6.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>77.5</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 10.2</th>
<th>Deaths from famine in the Madras Presidency in 1792.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muggalore</td>
<td>141,682</td>
</tr>
<tr>
<td>Havelly 1</td>
<td>53,956</td>
</tr>
<tr>
<td>Havelly 2</td>
<td>4,874</td>
</tr>
<tr>
<td>Peddapore</td>
<td>184,923</td>
</tr>
<tr>
<td>Pittapore</td>
<td>82,937</td>
</tr>
<tr>
<td>Nandegannah</td>
<td>11,376</td>
</tr>
<tr>
<td>Sullapelly</td>
<td>9,018</td>
</tr>
<tr>
<td>Poolavam</td>
<td>16,204</td>
</tr>
<tr>
<td>Goulatah</td>
<td>12,639</td>
</tr>
<tr>
<td>Cottupilly</td>
<td>4,851</td>
</tr>
<tr>
<td>Corcudah</td>
<td>9,035</td>
</tr>
<tr>
<td>Ramachandrapuram</td>
<td>7,430</td>
</tr>
<tr>
<td>Cottah</td>
<td>7,800</td>
</tr>
<tr>
<td>Sonapah villages</td>
<td>2,306</td>
</tr>
<tr>
<td>Noozeed</td>
<td>96,210</td>
</tr>
<tr>
<td>Char Mahar</td>
<td>16,245</td>
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</tbody>
</table>
Salem district (for an overview, see Murton 1984; see also Lardinois 1989). Extrapolating from these kinds of figures we may attribute a total famine mortality during 1788–1794 of perhaps eleven million to the extended El Niño conditions of the period. However, although the human cost of the episode was particularly high in the subcontinent, severe consequences were also felt elsewhere, especially further east.

EL NIÑO PATTERNS EAST OF AUSTRALIA TO THE CARIBBEAN

The rainfall deficiency of South Asia spread toward the East, with unseasonably severe droughts being experienced in Java (Quinn et al. 1975). In the Pacific region, temperatures were unusually low. There is some limited evidence of cold and severe drought in the western Pacific from the journals of D’Entrecasteaux, who visited New Caledonia in 1793 (Thierry Corrège, Orstom, Noumea, New Caledonia, pers. comm.). Another source of data from the late 1780s is the logbook of HMS Bounty. Temperature readings were made every four hours while at sea, and the lowest and highest temperatures were read while in port. In the December 6, 1788, entry of his logbook, Bligh wrote while his ship sheltered at Matavai Bay, Tahiti, that:

I experienced a scene of today of Wind and Weather which I never supposed could have been met with in this place. The wind varied from ESE to the NW and the Therm. stood between 78 and 81 5 degrees. By sunset a very high breaking sea ran across Dolphin Bank, and before seven o’clock it made such a way into the Bay that we rode with much difficulty and hazard. midnight it increased still more and we rode until eight in the morning in the midst of a heavy broken sea which frequently came over us. The Wind at times dying away was a great evil to us for the Ship from the tremendous Sea that broke over the reefs to the eastward of Point Venus, producing such an outset thwarting us against the surge.

Bligh’s observations of atypical weather conditions for the time of year suggest that by December 1788, the El Niño episode was already well under way. A few months later the El Niño might have actually saved the life of Bligh and the men who were cast adrift by the mutineers. Instead of the very hot conditions that would normally have confronted the 23-foot open boat between Tofoa in the South Pacific and Timor during the period of April 29 to June 14, Bligh and his men encountered cool conditions throughout the voyage. Furthermore, instead of a dry heat that would probably have been deadly, the rainfall they experienced was so cold that Bligh instructed his men to soak their clothes in warm seawater and then wear the wet clothes to keep warm! The next month, Bligh again recorded on June 18, 1789, heavy rain, “which enables us to keep our stock of water up.” The crew all complained of rheumatic pains and cold. Furthermore, the supply of rainwater allowed Bligh to avoid making landings on hostile Pacific islands for water, as they would have in a normal year. So the El Niño that began in 1788 probably meant that the history of Captain Bligh and the Mutiny returned to Britain, instead of an uncertain note about the “mysterious disappearance of both the Bounty and Captain Bligh.”

In Mexico the prolonged aridity that developed during 1791 was recorded in the steady fall in the level of Lake Patzcuaro between 1791 and 1793, giving rise to disputes over the ownership of the new land that unexpectedly emerged (Endfield and O’Hara 1997). As in Europe, these events were preceded by summer crop failures. On August 27, 1785, a hard night frost and the ensuing crop failure precipitated the great famine of 1785–1786 (Owencen 1996, p. 92). In the 1790s in Mexico, not one annual maize crop yielded an abundant harvest. This was entirely due to droughts every year, primarily in June and July. The severest droughts of the 1788–1795 El Niño event did not strike Mexico until 1793, so that the onset of full El Niño conditions did not affect rainfall for more than two years after the same event had caused monsoon failure in India. But wholesale failures of the wheat and maize crops took place in 1793 and 1797 (Owencen 1996, pp. 75–91). In 1794 the maize crop was again very poor due to almost complete drought. In 1795 the crop returned to near normal, although one might note that drought conditions persisted in that year in many Caribbean islands.3

Along the Peruvian coast, the great strength of the El Niño current itself during 1791, with its resulting degradational effects on agriculture and fisheries, was also documented by contemporary observers. Flooding of normally arid areas was especially widespread during that year. The first indications of the onset of unusual drought in the Caribbean were felt in the most drought-prone islands of the eastern Antilles, especially on Antigua and Barbuda. Antigua had already suffered from a long drought in 1779 and 1780 in an earlier El Niño episode. In 1789 the drought occurred again, but with “redoubled severity.” Even as late as 1837 this year was still referred to by Antiguans as “the year of the drought.” As a chronicler notes: “What miseries the Antiguans then suffered I am of course from experience unable to say, but if they exceeded those endured in that eventful year 1837 [a later severe El Niño] they must have been terrible indeed” (Oliver 1844, pp. 189–191).

By August 1791 the desiccating effects on the islands of the Antilles were already the severest recorded since the late 17th century. On the islands of St. Vincent and Montserrat no measurable rainfall had been recorded by the middle of the month, according to the colonial archival documentation. Landowners made formal requests for tax relief due to harvest failure.4 The drought continued on

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3 Further ENSO-caused crop failures also took place in the summers of 1808–1811, bringing about a wholesale restructuring of the economy of Central Mexico.

4 Petition dated Aug. 13, 1791 by William McKeal on behalf of the Council of Montserrat, Leeward Islands, British West Indies; Montserrat Legislative Assembly Proceedings, Government Archives, Plymouth, Colony of Montserrat.
Montserrat until at least November 1792. The timing varied slightly from place to place. For example, the extended and abnormal periods of drought (1791–1794) on St. Helena in the South Atlantic were later than those in the Caribbean. On St. Vincent and on St. Helena the droughts drove calls by government naturalists for the formal gazetting of forest reservations to encourage rainfall. The great El Niño event continued longest for the eastern Caribbean and Atlantic, with the Times Index indicating that in 1795 there was still an unrelied drought in Antigua (Michael Chenoweth, pers. comm. [1998], who referred to the Times Index of 1796).

**AFRICAN DROUGHTS AND EL NIÑO**

The recorded incidence of the El Niño current, as documented by Quinn and Neal (1987), may not be, by itself, an adequate guide to the true dimensions, impact, and longevity of the 1788–1795 event. Turning to Africa, record low levels of the Nile from 1790 to 1797 suggest its extraordinary reach and true severity, in much reducing monsoonal rainfall on the Ethiopian highlands. In Egypt three successive years of exceptionally low floods led to famine and soaring wheat prices. This was followed in 1789 by the plague (called Ta‘oun Ismail Bey), which lasted for five months. In 1791 and again in 1792, a slight drop below the long-term mean and only two cubits or about one meter from the optimal level led to a severe famine. According to Antoine Zakry (1926), people were forced to eat dead horses and donkeys and even children. Another series of low floods in 1794, 1795, and 1796 led to a peasant revolt. This experience was comparable only with that of 1877, when the flood was two meters below average, leaving 62% of Qena Province and 75% of Girga Province unirrigated (Willocks and Craig 1913).

Evidence from much of the rest of Africa is scanty. However, prolonged droughts in Natal and Zululand between 1789 and 1799 resulted in the Makhathule famine (Webb and Wright 1976). This was the most severe drought known in the written record to have affected southern Africa prior to an El Niño event of 1862. The low rainfall shows up very clearly in dendrochronological records (Hall 1976, p. 702). This ten-year drought began with an extraordinary record of cold sea conditions off the Cape. On December 24, 1788, while carrying vital supplies to New South Wales, the Guardian foundered on an iceberg right up near the Cape of Good Hope.

**THE “GREAT EL NIÑO” AND THE FRENCH REVOLUTION**

In the normally temperate regions of western Europe, highly abnormal weather patterns were making themselves felt as early as 1787. There was an unusually cold winter in western Europe in 1787–1788, followed by a late and wet spring, and then a summer drought, which resulted in severe crop failures that helped to stimulate the critically exploitative social pressures that culminated in the French Revolution (Neumann 1977; Neumann and Dettwiller 1980).

The extreme summer droughts and hailstorms of 1788 were decisive in their effects, as recorded by a peasant winemaker from near Meaux (Desbordes 1961):

In the year 1788, there was no winter, the spring was not favorable to crops, it was cold in the spring, the rye was not good, the wheat was quite good but the too great heat shrivelled the kernels so that the grain harvest was so small, hardly a sheaf or a peck, so that it was put off, but the wine harvest was very good and very good wines, gathered at the end of September, the wine was worth 25 livres after the harvest and the wheat 24 livres at the harvest, on July 13 there was a cloud of hail which began the other side of Paris and crossed all of France as far as Picardy, it did great damage, the hail weighed 8 livres, it cut down wheat and trees in its path, its course was two leagues wide by fifty long, some horses were killed (Le Roy Ladurie 1972, p. 75).

This hailstorm burst over a great part of central France from Rouen in Normandy as far as Toulouse in the south. Thomas Blaikie, who witnessed it, wrote of stones so monstrous that they killed hares and partridge and ripped branches from elm trees. The hailstorm wiped out budding vines in Alsace, Burgundy, and the Loire, and laid waste to wheat fields in much of central France. Ripening fruit was damaged on the trees in the Midi and the Calvados regions. In the western province of the Beauce, cereal crops that had already survived one hailstorm on May 29 succumbed to the second blow in July. Farmers south of Paris reported that, after July, the countryside had been reduced to an arid desert. These kinds of conditions led in late summer 1788 to serious rural unrest. Small-scale rural revolts took place in the areas worst affected by the summer droughts: Provence, Hainault, Cambresis, Picardy, the area to the south of Paris, eastward in Franche-Comté, around Lyon and Languedoc, and westwards in Poitou andBrittany (Lefebvre 1932, pp. 47–53).

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5 As stated in letter of March 6, 1792, from the Commissioner of the Council of Trade and Plantations to the Council of Montserrat, Government Archives, Plymouth, Montserrat.

6 Letter from the Directors of the East India Company to the Governor of St. Helena, dated March 7, 1794, St. Helena Records, Government Archives, St. Helena, South Atlantic, reproduced in Junisch (1908); see also article by Grove (1992).

7 The 1862 event caused the worst droughts in southern Africa in the 19th century. Dendrochronological records point to the early 1860s and the 1790s as long dry spells.

8 The Australian, Dec. 24, 1998. (Note that similar unusually heavy ice conditions caused the wreck of Shackleton's ship Endurance in Oct. 1914.)
To make matters worse, the prolonged drought was followed by the severest winter since 1709. Rivers froze throughout the country and wolves were said to descend from the Alps down into Languedoc. In the Tarn and the Ardeche, men were reduced to boiling tree bark to make gruel. Birds froze on the perches or fell from the sky. Watermills froze in their rivers and thus prevented the grinding of wheat for desperately needed flour. Snow lay on the ground as far as Toulouse until late April. In January, Mirabeau visited Provence and wrote:

Every scourgé has been unloosed. Everywhere I have found men dead of cold and hunger, and that in the midst of wheat for lack of flour, all the mills being frozen (Monahan 1993).

Occasional thaws made the situation worse: the Loire burst its banks and flooded onto the streets of Blois and Tours.

All of these winter disasters came on top of food shortages brought on by the droughts of the 1787 summer and the appalling harvests of summer 1788. Warm, dry spring summers are usually favorable to grain in northern France and northwestern Europe, but at certain times, they can be disastrous. For example, a spell of dry heat during the growth period, when the grain is still soft and moist and not yet hardened, can wither all hope of harvests in a few days. This is what happened in 1788, which had a good summer, early wine harvests, and bad grain harvests. The wheat shivered, thus paving the way for the food crisis, the “great fear,” and the unrest of the hungry, when the time of the soudard or bridging of the gap between harvest came in the spring of 1789. No one expressed this fear better than the poor woman with whom Arthur Young walked up a hill in Champagne on a July day in 1789:

Her husband had a morsel of land, one cow, and a poor little horse, yet they had 42 lbs. of wheat and three chickens to pay as a quit-rent to one seigneur, and 168 lbs. of oats, one chicken and one sou, to pay another, besides very heavy taillés and other taxes. She had 7 children, and the cow’s milk helped to make the soup. It was said at present that something was to be done by some great folks for such poor ones, but she did not know who or how, but God send us better, car les taillés et les droits nous écrasent.”

The price of bread doubled between 1787 and October 1788. By midwinter 1788-1789, clergy estimated that one-fifth of the population of Paris had become dependent on charitable relief of some sort. In the countryside landless laborers were especially badly affected. Exploitation of the dearth by grain traders and hoarders made the situation steadily worse. It was in this context that the French King requested communities throughout France to draw up cahiers of complaints and grievances to be presented in Paris. During February to April 1789 over 25,000 cahiers were written. From these we can assess not only the accumulation of long-term grievances but some idea of the intense dislocation of normal economic life that the extreme weather conditions had brought.

The excessive cold and food shortages of early 1789 drove increased poaching and stealing. There were regular attacks on grain transports both on road and river. Bakers and granaries were also robbed. Rabbits, deer, and other game were slaughtered, irrespective of ownership or regulation. Gamekeepers and other symbols of authority who opposed such actions were killed. The populace became accustomed to a level of resistance that soon developed into broader reaction and violent protest. Anger at the price of grain and bread in Paris soon found suitable targets for rioting and violence, particularly where the large population of quayside laborers were out of work because the Seine was still frozen in April. A number of pamphlets printed at this time proclaimed that the supply of bread should be the first object of the planned Estates-General: the very first duty of all true citizens was to “rear from the jaws of death your co-citizens who groan at the very doors of your assemblies” (quoted in Schama 1989, p. 331).

In the summer of 1789 much of France rose in revolt; in cities, urban crowds rioted. How far the resulting course of revolution had its roots in the anomalous climatic situation of the period is open to debate. What is certain is that the part played by extreme weather events in bringing about social disturbance during the French Revolution simply cannot be neglected. It may be, as de Tocqueville put it, that had these responses to anomalous climatic events not occurred, “the old social edifice would have none the less fallen everywhere, at one place sooner, at another later; only it would have fallen piece by piece, instead of collapsing in a single crash” (de Tocqueville 1952, p. 96).

THE CATALONIAN REVOLT AND THE REST OF EUROPE

Connections between an accumulation of unusual and extreme weather events and popular rebellion were by no means confined to France. In northern Mediterranean Spain, the cold winter of 1788–1789 was even more unusual than in France. Here, too, persistent summer droughts were followed by a winter of intense cold and heavy snowfall (Barriendos et al. 2000). One observer wrote:

Autumn this year was colder than normal...and no one alive has ever experienced the weather so cold in El Prat. It was extraordinary, both what was observed and the effects it caused...on the 30th and 31st December the wash of the waves on the beach froze which has also never been seen or heard of before. Likewise it was observed that the water froze in the washbasins in the cells where the nuns slept at the Religious Order of Compassion...the river channels froze and the carriages passed over the ice without breaking it (Salva 1788).

Between August 1788 and February 1789, cereal prices in Barcelona rose by 50% (Fontana 1988, quoted in Barriendos et al. 2000).
March, 1789, there was a revolt in the city of Rebomboris de Pa, when the population set fire to the municipal stores and ovens. The authorities attempted to pacify the angry crowds by handing out provisions and offering supplies at reasonable prices. The privileged classes also provided money and contributions in kind to pacify the underprivileged, while the military and police authorities stepped back to allow events to run their course. The authorities then took refuge in the two fortresses that controlled the city and put up powerful defenses in case events got out of control. Despite these measures, chaotic riots ensued and in the aftermath six people were executed (Mercader 1986; Riera i Teyols 1985; Torras i Ribe 1978, all quoted in Barriéndos et al. 2000). Similar riots took place on other parts of Catalonia when the poor outlook for the 1789 harvest became clear and profiteers and hoarders made their appearance. Revolts and emergency actions by municipal authorities took place both in the coast and inland with documentary reports being made in cities such as Vic, Mataro, and Tortosa (Barriéndos et al. 2000). The fact that these social responses to cold and crop failure did not lead to the same degree of social turmoil and rebellion as in France should not disguise the fact that they were highly unusual.

Even where there were no revolutions, extraordinary weather patterns were reported. In the English winter of 1790, for example, Parson Woodforde’s diary tells of unusually high temperatures and summer-like weather in January and February of 1790 (Woodforde 1855).\(^{11}\)

One of the advantages in trying to understand European history in terms of the succession of prior climatic stresses is that it provides an environmental context for events of the major revolutions, rather than analyzing them as purely social phenomena. As de Tocqueville commented: “The French Revolution will only be the darkness of night to those who see it in isolation; only the winds which preceded it will give the light to illuminate it” (de Tocqueville 1952, p. 249).\(^{12}\)

The whole social edifice of Ancien Régime France collapsed at a single blow, and the fact that this was in the midst of one of the worst El Niño episodes of the millennium is something that should be taken into account when examining this history.

**THE GREAT EL NIÑO IN NORTH AMERICA**

High winter temperatures were also experienced in North America in the early 1790s. Contemporary observers commented that horse herds expanded greatly in numbers. This facilitated expansion and migrations by the Cree, Assiniboine, Blackfoot, and Gros Ventre in parts of Washington, Montana, and Wyoming. The first three years of the 1790s were very warm and dry on the northern Great Plains. Fur traders in the region repeatedly remarked about how warm and snowless those winters were. High temperatures were accompanied by high rainfall events. On January 13, 1791, the first of a series of very heavy thunderstorms in the region was recorded in Saskatchewan. This produced hardships for bison hunters, but horse herds multiplied. Hostilities among native groups were rare in those years. That warm episode ended abruptly in 1793–1794. At the end of the El Niño event, the return of cold winters provoked wars between the Indian tribes as conditions deteriorated for them and their horses. Horse herds were decimated, and warfare reached a climax in the next year.\(^{13}\)

Further south, conditions also gave rise to heavy rainfall and high temperatures in the United States, which brought an inexorable rise in the mosquito population. As a result, by 1793 conditions were ideal for the spread of mosquito-borne diseases. On August 19, 1793, Dr. Benjamin Rush, a doctor in the relatively northerly city of Philadelphia, noted his first cases of yellow fever (Foster et al. 1998). This is a disease normally spread in tropical America by Aedes aegypti, a mosquito with a pronounced tropical range. By October 1793 the epidemic had killed over 5000 people in Philadelphia alone, and the epidemic was only ended by a severe frost in November, which killed the mosquitoes. It seems that the epidemic had spread from the French colony of Saint Domingue (now Haiti), where a slave rebellion had been aggravated by prolonged bad weather and crop failure in Europe. Refugees from the rebellion carried the yellow fever with them to the East Coast ports of the U.S., where the aberrantly high mosquito population allowed the disease to flourish. The political consequences of this disease event were far-reaching and resulted, not least, in the French losing Haiti and relinquishing most of their American colonies.

Other diseases also flourished in North America during the period of the Great El Niño. This was particularly the case with influenza, a disease whose epidemics had previously rarely affected the North American mainland. An epidemic spread from Georgia in the southern U.S. to Nova Scotia, Canada, between September and December 1789, and again in spring 1790. Its most famous victim was George Washington. Dr. Warren recorded that “at New York, as far as I can learn, its appearance was somewhat later than here, and our beloved President Washington is but now on the recovery from a very severe and dangerous attack of it in that city” (Pettingrew, quoted in Thompson 1852, p. 234). Thomas Pettigrew observed that “the summer preceding the fall disease, was remarkably hot...the last winter was uncommonly mild and rainy. The diseases of that season numerous, [including] both synocha and typhus” (Pettigrew, quoted in Thompson 1852, pp. 199–202). Certainly the very hot summers and mild winters which characterize El Niño conditions in much of

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11 Temperatures were comparable to the high temperatures of January, 1998.

12 For a more developed discussion of the agrarian background to the French Revolution, see Davies (1964).

13 I am indebted for archival details of the weather in the Great Plains in 1790–1793 to Ted Binema. See also Binema (2001).
North America appear to have encouraged the spread of epidemics in several different diseases, and not least in 1788–1794.

CONCLUSIONS

Although further archival research is needed to characterize the 1788–1795 event more fully, the evidence of an intense and prolonged global impact already suggests that it may have been among the most severe in the available written record. The data from this well-documented period can throw light on exceptional global weather patterns. The correlation between a weak phase in the North Atlantic Oscillation (NAO) and an extreme El Niño episode elsewhere suggests a pattern tying NAO and ENSO together via the South Asian monsoon. There were already well-established strong correlations between interannual variability in the NAO and Indian summer monsoon rainfall, specifically between summer monsoon rainfall and the NAO of the preceding year in January.

The early stages of the great El Niño event were observable in southern India more than a year before the warm current was recorded along the Peruvian coast, the usual key indicator of an El Niño phenomenon. This was also the case for the major El Niño event of the 17th century in 1685–1688. Moreover, it appears that in both episodes, a presumed weak phase of the NAO led to a very cold winter, high pressure over Europe, a cold wet spring and a summer drought preceding later monsoonal blocking and drought in South and Southeast Asia.

We are only now realizing that this sequence of events and phasing of activity seems to form a global pattern. The mechanisms of the NAO, the Asian monsoon, and the Pacific ENSO appear to be closely articulated in the case of the severest El Niño episodes.

The connection (“teleconnection”) between the failure of Indian monsoons and Australian droughts was noted in Australia by Charles Todd as early as 1888 (Grove 1998). In 1896, the New South Wales Government Observer, H. C. Russell, carefully documented the coincidences between India and Australia over the period from 1789 to 1886 and showed the correlations to be strongest in the case of the worst episodes (Table 10.3).

The developmental sequence of the 1788–1795 El Niño may provide a model by which we can compare other subsequent, very severe El Niño events that have occurred since that time: 1895–1902, 1982–1983, and 1997–1998. It may also serve as a template for understanding much earlier events in the historical record, where data are sketchier. Such an understanding would give retrospective comfort to the observant Arthur Phillip, that his hunch was right. The events do not directly correlate, but rather form a pattern that may take several years to work sequentially through the global weather and ocean system (Grove 1998).

Table 10.3 Coincidence of Australian and Indian droughts (after Russell’s account; see Grove 1997).

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