# Climatic Eextremes, Recurrent Crises and Witch Hunts: Strategies of European Societies in Coping with Exogenous Shocks in the Late Sixteenth and Early Seventeenth Centuries

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*In the late sixteenth and early seventeenth centuries, continental Europe north of the Alps was afflicted by a 13-year cycle of frequent cold and rainy summers which was the result of a series of volcanic explosions in the tropics. The inclement weather led to recurrent subsistence crises and to multiple floods in the Alps following from extensive glacier advances. This article discusses the relationship between 'climate' and 'history' from the example of this unique period. The vulnerability of food production in Europe to climatic hazard is assessed from an impact model. The result shows that the period 1560 to 1630 is most prominently marked by a high level of climatic stress. Likewise, this study demonstrates how authorities in Val Aosta (Italy) responded to annually recurrent floods in the 1590s*

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*triggered by the advancing Ruitor glacier. Finally, by confirming the thesis advanced by Wolfgang Behringer relating extensive witch hunts during that period to climatic change and recurrent subsistence crises, this article makes a plea for bridging the gap separating studies of climate from those of culture.*

## The Narrow and the Broad Understanding of 'Disaster'

Environmental history is usually understood as being an account of man transforming his natural surroundings. This article looks at the other side of the coin and asks about nature's role as an agent in history. In order to investigate interactions between the history of human societies and the dynamics of their quasi-natural environment, we have to bear in mind that processes in these two spheres usually follow their internal drive and are independent of each other. Among the most obvious examples which need to be taken into account within the human realm are population growth, economic development, the construction of Large Technical Systems, such as networks of transportation and communication,[1] globalization,[2] changes in institutional structures, as well as the rise or decline of empires. In the sphere of the natural environment, changes to which humans contribute—such as soil salinity, deforestation and drops in groundwater levels—should be distinguished from exogenous factors, such as fluctuations in solar activity, orbital changes of the earth and changes in sea-surface temperature, which often take place on different temporal and spatial scales.[3]

Severe climate anomalies and disasters are processes in which physical, biological and socio-cultural systems interact. The breakdown of natural resources and the destructive working of natural hazards lead to material losses, death and physical and psychological stress for the affected communities. At the same time, such events offer an insight into people's perception of and relationship to environmental forces and so

[1] Hughes, *The Development of Large Technical Systems*. Mayntz, *The Development of Large Technical Systems;* Summerton, *Changing Large Technical Systems.*

[2] See for example: Gills, *Globalisation and Global History;* Osterhammel, *Globalisation.*

[3] A recent convincing long-term integration of human history and environmental history is provided by Costanza, *Integrated History and Future of People on Earth.*

present an opportunity to investigate such responses, explicitly addressed as they are in discourses.

In both the natural and social sciences, a narrow understanding of natural disasters focuses on sudden, rapid, and destructive effects on society wrought by natural forces, such as floods, hurricanes, volcanic eruptions and earthquakes. A broad understanding of the term also includes slow-moving disasters, as Carl Böhret termed them,[4] such as droughts, the collapse of ecosystems,[5] subsistence crises and epidemics.

Historians during the nineteenth and early twentieth century had ruled out investigating natural phenomena altogether, regarding them as purely accidental facts unrelated to human history.[6] Sudden disasters, climatic anomalies and strategies of coping with these in the early modern period were not investigated until the recent years, in response to the latest debates on anthropogenic greenhouse warming and the related public interest in climatic change, especially following the occurrence of severe disasters.[7] Much work on sudden disasters deals with towns. It was initiated by a project of the international commission on urban history in the 1990s.[8] Among sudden disasters, earthquakes cause most damage because their impact is felt over an extensive area.[9] In most cases, particularly vulnerable

[4] Böhret, *Folgen.*

[5] Diamond, *Collapse*; Tainter, *The Collapse of Complex Societies.*

[6] Kempe, 'Introduction': 123.

[7] Borst, 'Das Erdbeben von 1348; Fouquet', 'Das Erdbeben in Basel 1356' Groh, *Naturkatastrophen.* See also: Jakubowski-Tiessen, *Um Himmels Willen*; Kempe, *Coping with the Unexpected*; Lübken, 'Zwischen Alltag und Ausnahmezustand'; Pelling, *Natural Disasters and Development in a Globalising World*; Pfister, *Am Tag danach.* (See also the French translation: *Le Jour d'après. Surmonter les catastrophes naturelles: le cas de la Suisse entre 1500 et 2000.* Traduit par Véronique Mange, Bern.) Pfister, *Katastrophen und ihre Bewältigung*; Lübken, Rohr, 'Mensch und Naturkatastrophe'; Massard-Guilbaud, *Cities and Catastrophes*: Some case studies are contained within two volumes of essays.

[8] Körner, 1999–2000. *Stadtzerstörung und Wiederaufbau.* Ranft, *Städte aus Trümmern*; See also: Schott, 'Forschungsbericht'.

[9] For Greece: Papazachos, *The Earthquakes of Greece.* For Italy: Guidoboni, *Quand la terre tremblait.* For France: Quenet, *Les tremblements de terre aux XVIIe et XVIIIe siècles.* For Austria: Rohr, 'Naturerfahrung zwischen Alltag und Katastrophe'. Aspects of perception, interpretation and coping: Borst, 'Das Erdbeben von 1348'; Fouquet, 'Das Erdbeben in Basel 1356'; Gisler, *Göttliche Natur?*

areas and regions were affected—such as the North Sea coast,[10] the valleys of large European rivers[11] and avalanche-ridden mountain areas.[12]

Slow-moving disasters such as epidemics and subsistence crises are usually better documented for the early modern period[13] and the Middle Ages than sudden and rapid hazards.[14] Subsistence crises recurred frequently during these centuries and were likely to profoundly affect the entire social fabric, triggering off widespread popular unrest and the search for scapegoats. At the same time, they presented the affected actors and groups with opportunities for 'learning' as well as for renegotiating relationships of power. The severity of subsistence crises was contained by the efficiency of buffers, by the supportive capacity of the social network and by the timing and efficacy of relief measures undertaken by ruling elites.[15] The culture of risk in Western and Central Europe was mainly focussed on minimising the risk of harvest failure and epidemics, whereas in disaster-ridden parts of the world such as the Philippines, risk minimisation strategies were mainly developed against floods, earthquakes, volcanoes and hurricanes, as we have learnt from Greg Bankoff.[16] However, it needs to be investigated whether there were sequences of weather

[10] Jakubowski-Tiessen, *Sturmflut 1717.* Other case case studies are chapters in recently published books: Jakubowski-Tiessen, *Um Himmels Willen;* Massard-Guilbaud, *Cities and Catastrophes.* See also: Brázdil, *Historical and Recent Floods in the Czech Republic;* Kraker, Adriaan M. J. de. 2006. 'Flood Events in the Southwestern Netherlands and Coastal Belgium'.

[11] Barriendos, 'Flood Data Reconstruction in Historical Times'; Glaser, 'Climate and Floods in Germany'; Munzar, 'The Catastrophic Flood in February/March 1784'; Pfister, *Wetternachhersage.* Poliwoda, *Aus Katastrophen lernen.*

[12] Schoeneich, 'Spaltkeil und Ebenhöch'. See also articles within: Favier, *Récits et représentations des catastrophes depuis l'Antiquité ;* Favier, *Histoire et mémoire des risques naturels;* Favier, *Les pouvoirs publics face aux risques naturels dans l'histoire;* Grünig, 'Aus der Katastrophe gelernt'.

[13] Behringer, 'Die Krise von 1570'; Brázdil, 'Hungerjahre 1770–1772 in den Böhmischen Ländern'; Jütte, 'Klimabedingte Teuerungen und Hungersnöte'; Lachiver, *Les années de misère;* Outhwaite, *Dearth, Public Policy and Social Disturbance in England;* Pfister, 'Social Vulnerability to Climate'; Post, 'Nutritional Status and Mortality in Eighteenth-century Europe';

[14] Jankrift, *Brände, Stürme, Hungersnöte*: XX–XX; Rohr, 'Mensch und Naturkatastrophe'; Jordan, *The Great Famine;* Le Roy Ladurie, *Histoire humaine et comparée du climat.*

[15] Behringer, *Kulturelle Konsequenzen der "Kleinen Eiszeit";* Pfister, 'Social Vulnerability to Climate'.

[16] Bankoff, *Cultures of Disaster.*

spells likely to paralyse the known strategies of risk avoidance thus making harvest failures quasi unavoidable. Can we even identify prolonged cycles of 'catastrophic weather' in time and space?

The issue of cycles and multiple events is significant because there is agreement on the fact that people's perception and interpretation of crises and disasters, both sudden and slow-moving, and the response to such events depends on their frequency and severity.[17] Whereas single disasters and crises were accepted as being a part of life, multiple events had a disruptive effect both in terms of how to interpret them as well as how to create material buffers against them, as such events were perceived as being beyond the pale of current world views and likely to jeopardize the very basis of survival.

This article addresses four issues. It first outlines a model of climatic impact leading to subsistence crises, which allows one to assess the biophysical vulnerability of food production—grain, viniculture and dairy products—over time. Secondly, it identifies periods of high and low climatic effects. It then examines how authorities in Val Aosta (Italy) responded to annually recurrent floods triggered by the advancing Ruitor glacier in the 1590s. Finally, it investigates the relevance of climatic change and ensuing subsistence crises with 'super-hunts'[18] for witches, which was a particular way in which communities responded to subsistence crises between 1560 and 1630.

## Approaches to 'Climate and History'

Two extreme positions mark the approach to studying the impact of climate on history. On the one hand, 'climate determinists' such as Ellsworth Huntington and Kenneth Hsü[19] need to be mentioned. Those representing the opposite position may be termed 'market determinists' or 'distributionists'.[20] Nobel laureate Robert Fogel is undoubtedly the most prominent among these. Fogel tried to disprove the existence of any relationship

[17] See for example Poliwoda, *Aus Katastrophen lernen.*

[18] Monter, 'Witch Trials in Continental Europe': 22.

[19] A classic is: Huntington, *The Pulse of Asia. Huntington, Mainsprings of Civilisation,* New York. The book of the geologist Kenneth Jinghwa Hsü is an extreme example of a crude, ahistoric and deliberately unscientific climate determinism: Hsü, *Klima macht Geschichte.*

[20] These terms were coined by Mauelshagen, 'Interactive Comment on Social vulnerability to Climate in the "Little Ice Age"': 79.

between climatic anomalies and famines, i.e. between agriculture and climate. He argued in a sophisticated way, though his methods appear problematic: on the basis of yield data from late nineteenth- and early twentieth-century England, Fogel seeks to demonstrate the resilience of agrarian societies to climatic shocks as a universally valid proposition.[21] Such a gimmick led many historians of medieval and early modern times to discount any influence that weather and climate might have had upon societies, which is an odd position in the present world. Michel Jarraud, Secretary General of the World Meteorological Organization (WMO), claims, 'Climate variability affects all economic sectors, but agriculture and forestry sectors are perhaps the most vulnerable and sensitive activities to such fluctuations.'[22] Between the extreme positions of 'climate determinists' and 'market determinists' there is a third group, that of historical climatologists, which attempts to empirically reconstruct past climates in detail and with sufficient rigour as to be accepted by natural scientists.[23]

Most historians became acquainted with the history of climate through the path-breaking work of Emmanuel Le Roy Ladurie.[24] Having been a student of Fernand Braudel, Le Roy Ladurie wrote his *History of Climate* according to the Braudelian scheme of historical temporalities which considers changes in climate as an element of the *longue durée*. Indeed, Le Roy Ladurie's classical historiographic concept of the Little Ice Age mirrors the Braudelian scheme of long duration. His approach, in tune with the macro-history of climate prevalent at the time he wrote, involved providing impressive overviews of annual average temperature on centurial or even on millennial scales.[25] Consequently, Le Roy Ladurie sought to uncover the impact of long-term changes in temperature and precipitation on human societies. He argued that 'in the long term [emphasis added by C.P.] the human consequences of climate seem to be slight, perhaps negligible, and certainly difficult to detect.'[26]

Le Roy Ladurie however did not argue on the appropriate level of temporalities. People may adapt their way of living to a changing climate

[21] Landsteiner, 'Wenig Brot und saurer Wein'.
[22] Jarraud, 'Foreword'.
[23] Brázdil, *Historical and Recent Floods in the Czech Republic.*
[24] Le Roy Ladurie, *Times of Feast, Times of Famine.*
[25] *Ibid.*: 237.
[26] *Ibid.*: 119.

in the long term. Innovations that are better suited to a new situation will come to be accepted, while older outdated practices may tacitly disappear.[27] Actually, a human history of climate should address extreme events in the short term and highlight changes in the frequency of those climate patterns which are known to have affected everyday life, i.e. considerable departures, positive and negative, from average conditions of temperature and precipitation, which tend to disrupt daily routines.[28] In the language of the sources, climatic events are often restricted to anomalies whose duration ranges from hours to seasons. It is not simply by chance that Le Roy Ladurie has in his recent book shifted the focus from the long term to the short, thereby providing, almost, a history of subsistence crises in France and neighbouring countries.[29]

Despite the fact that the physical history of climate in Western and Central Europe is presently known in considerable detail,[30] climatic change is rarely integrated in grand historical syntheses or theoretical writings. Even the renowned historian Joachim Radkau resisted from integrating climatic change in his recent environmental history. ‘Climate is the most awkward unknown factor for many environmental historians [...]’, he noted. ‘Historical climatology has become a highly specialised branch of science. For an outsider it is difficult to determine how reliable its results are and how far they may be generalized’.[31] Radkau’s reluctance to read and rely on peer-reviewed articles on historical climatology may be due to his discomfort with quantitative arguments. In the end he wrote a global environmental history without climatic change. A human history of climate should highlight those extreme climate anomalies which are known to have affected everyday life and disrupted daily routines.[32] In particular this relates to those systems on which humans depend for their basic needs and well-being.

According this model (see Figure 1) climate variability is determined by the frequency, the severity and the level of accumulation of impacts

[27] This issue is discussed in: Wigley, ‘Historical Climate Impact Assessments’.

[28] Pfister, ‘Weeping in the Snow’.

[29] Le Roy Ladurie, *Histoire humaine et comparée du climat.*

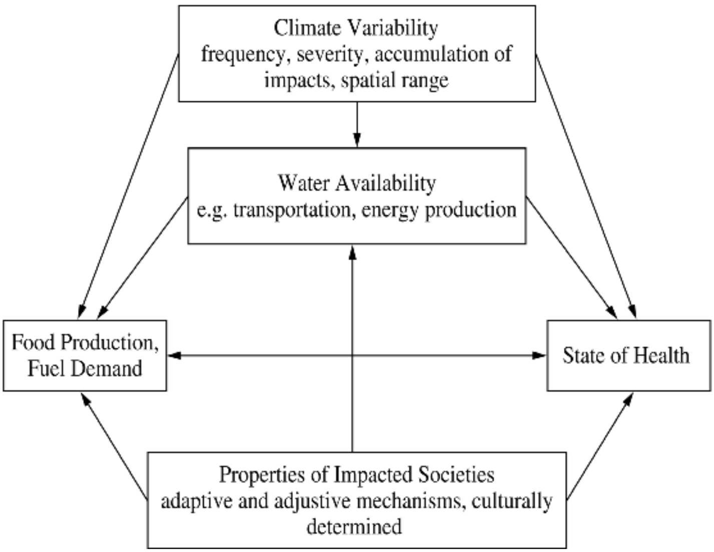
[30] Luterbacher, ‘Reconstruction of Sea Level Pressure Fields’; Luterbacher, ‘Atmospheric Circulation Variability’; Luterbacher, ‘Five Hundred Years of Gridded High-resolution Precipitation Reconstructions’.

[31] Radkau, *Natur und Macht*: 48. (Translated by C. Pfister.)

[32] Pfister, ‘Weeping in the Snow’: 38.

as well as by their spatial range. It affects among other things the availability of water—which then has an immediate effect, for instance on power generation and river navigation. Climate also directly affects food production and fuel demand as well as the health system, as many epidemics—for example dysentery—are bound to certain thresholds of temperature. Obviously, there are many indirect effects induced by the variables that are not being addressed here in detail.

**Figure 1**
***Impacts of Extreme Climate Events on Societies***



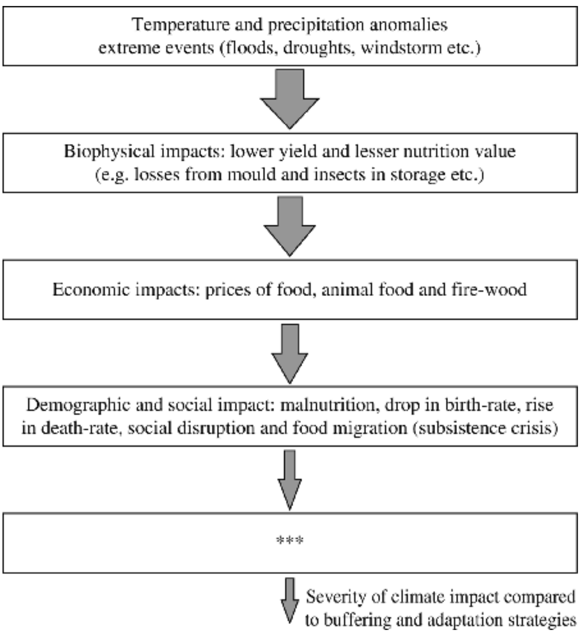

The vulnerability[33] of societies to climatic hazards largely depends on certain factors, such as their cultural representation of the natural environment, their technological level, social system, their governance and the degree of their preparedness to overcome exogenous shocks. Subsequently, this issue is highlighted from the analysis of the food system (Figure 1). Food-security was a matter of perpetual concern in agrarian societies. This accounts for the subject being well documented.

[33] Social (or internal) vulnerability is a state of a system: encompasses all structural factors that make the system vulnerable to external hazard, that determine the outcome of an event of a given nature and severity (Brooks, *Vulnerability, Risk and Adaptation*: 4–5).

Figure 2 provides an idea of how causal links between the physical and the human world might be plotted by distinguishing between several impact levels. Their sequence and the size of the intermediate arrows indicate how closely these effects are related to climatic impact. The one directional top-down arrays are, of course, extreme oversimplifications. In particular, they omit the many positive and negative feedback loops contained in Bob Kates' seminal article, from which the figure is derived.[35]

The quantity and quality of harvested crops situated on the first level are most immediately related to the weather. However, strategies of risk minimisation already come into play. Dieter Groh has convincingly argued in an important article that for most members of early modern

**Figure 2**
***A Basic Model of Climatic Impacts on Society (Modified after Kates 1985) (Pfister and Brazdil 2006: 18)***[34]




[34] Pfister, 'Social Vulnerability to Climate': 118.
[35] Kates, *Climate Impact Assessment*.

societies, risk avoidance was the fundamental strategy to cope with risk.[36] The key measure involved spreading out risk, such as through the cultivation of mixed grains as a strategy against an excess or a lack of rainfall, or through the dispersal of cultivation on many plots situated at different altitudes and subject to varied exposure.[37] In fact, even though dearth was not always present in reality, it was more or less constantly present in people's minds. The avoidance of the worst-case was a lasting concern that somehow impinged on most of the individual and social decisions which had to be taken.

Fluctuations in food prices are among the most obvious of consequences of a second order. A graphic integration of the wide array of regional studies into a spatial survey was attempted by the German economic historian Wilhelm Abel in his classic work of 1978.[38] Climatic effects were in a sense masked by the working of other factors—supra-regional trade, public grain stocking, hoarding and speculation. The impact of a third order made itself felt mainly through demographic effects, such as a slump in the birth-rate and excess mortality. Malnutrition is known to be contingent on distributional systems, in turn dependent on power relations, factors of class and gender, and the supportive capacity of social networks. Relationships between demography and climate are intertwined with epidemiological and public health contexts in ways that are inextricable and at the same time highly controversial.[39] To summarise, Figure 2 points to the following conclusion: the farther we move away from the effects of a first order, the broader are the options open to individual or collective actors. Further, the web of factors masking the climatic effect gets to be all the more complex, and it becomes proportionately more difficult to document all variables on the basis of reliable sources.

Two different approaches need to be adopted to deal with this issue: links of a first order between climate and crop production concern the biophysical world and should be analysed using statistic modelling. The human consequences of the harvest cycle (i.e. links of a second and third order) need to be understood in terms of an interplay of economic, social,

[36] Groh, 'Die verschwörungstheoretische Versuchung oder'.

[37] Pfister, *Das Klima der Schweiz von 1525–1860*; Groh 'Strategien, Zeit und Ressourcen'.

[38] Wilhelm, *Agrarkrisen und Agrarkonjunktur.*

[39] See, for example, Dupâquier, 'Demographic Crises and Subsistence Crises'; Matossian, *Poisons of the Past*; Rotberg, *Hunger and History.*

political, cultural and epidemiological factors. As a theoretical framework, an agent-based approach is appropriate.

The concept of social or internal vulnerability is particularly suited to investigate processes at the interface of 'nature' and 'culture'. It was introduced by sociologists in the 1990s and quickly picked up by geographers, sociologists, anthropologists and, finally, historians.[40] The concept includes the level of socio-economic development (taking into account the degree of social stratification), demographic growth and the available varieties of technical equipment and institutional supports in situations of emergency. Among the many definitions of the term, that proffered by Nick Books is particularly illustrative and straightforward. According to his understanding, vulnerability describes a group's ability to anticipate, cope with, resist and recover from crises and disaster. It depends on a variety of social, economic, political and environmental processes on a much larger scale. The magnitude of biophysical vulnerability is measured on one hand in terms of human losses through forces of nature, epidemics and malnutrition, and on the other in terms of impoverishment and material losses.[41]

## Temporal and Spatial Dimensions of Cold Anomalies

In this section the social vulnerability of food and animal-feed production is addressed. It has been argued that societies during early modern times had developed strategies of risk minimisation in order to reduce the danger of overall crop failure. However, the question must be raised as to whether there were sequences of weather spells which were likely to paralyse such sophisticated systems of risk avoidance. Can we identify climatic patterns which are likely to affect most or even all resources at the same time?

An analysis of the effects of a first and second order is being presented here for the Swiss Plateau, the geographical zone between the Jura mountain chain in the north and the Alps in the south. In a first step, the vulnerability of the main produce—grain, animal husbandry and viticulture—needs to be investigated separately for each source of food. Such analyses are done by combining present-day knowledge of agricultural sciences with results obtained from the study of historical sources. This approach yielded the following results (Table 1).

[40] Brooks, '*Vulnerability*' Risk and Adaptation: 8; Oliver-Smith, 'Introduction'.

[41] Brooks, *Vulnerability, Risk and Adaptation.*

**Table 1**
***Climatic Conditions Affecting the Quantity and Quality of Crops (Conditions Affecting the Quality of Crops, i.e. their Content in Nutrients e.g. Starch, Raw Proteins or Sugar)***

| | *Agricultural produce* | | |
|---|---|---|---|
| *Critical months* | *Grain* | *Dairy products* | *Vine* |
| **September–October** | Wet | cold | **cold** |
| **March–April** | Cold | cold | (late frost) |
| **July–August** | **Wet** | **wet** | wet |

According to Table 1 the following weather patterns were critical for several or all sources of agricultural produce: cold periods in March and April lowered the volume of the grain harvest and the produce of animal husbandry, rainy summers affected all kinds of agricultural produce whereas wet spells in autumn held up the timely ploughing of the fields, lowered the sugar content of grapes and forced the peasants to take their animals earlier into the stables, at the augmented expense of winter feed. Most importantly, climate-yield relationships are non-linear and the simultaneous occurrence of rainy autumns combined with cold springs and wet summers in subsequent years had a cumulative impact on agricultural production. In short, a lack of warmth plus an excess of water. Such packages of adverse factors leading to overall crop failures were named Little Ice Age-Type Impacts (LIATIMP).[42]

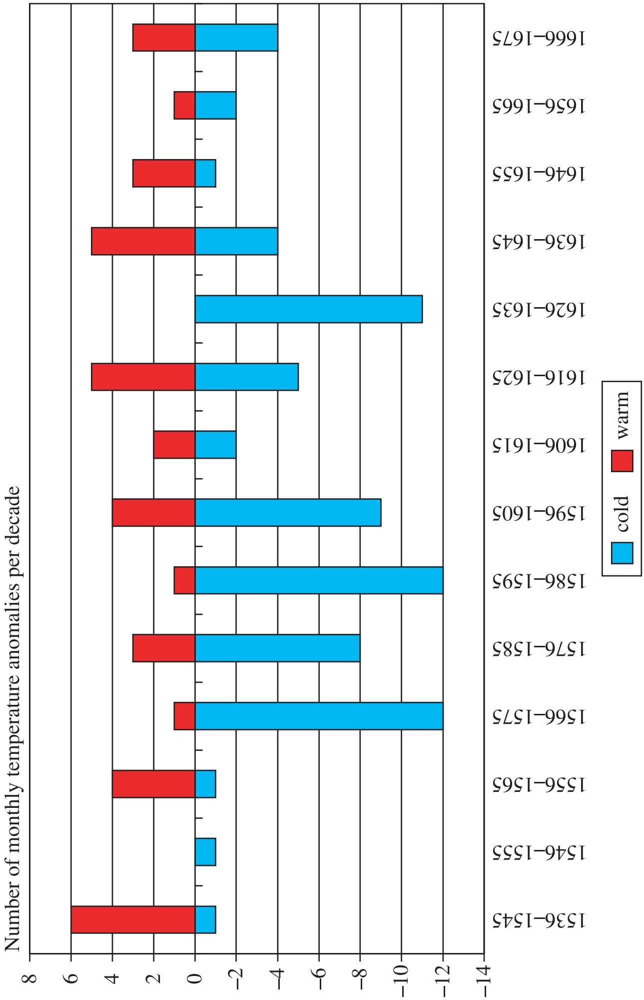
In a subsequent step, the frequency and severity of such situations was investigated from a multifarious body of data arranged according to monthly units. Useful values from documentary evidence are obtained by transforming the basic data into simple and weighted temperature and precipitation indices on an ordinal scale. Weighted monthly indices are based on a seven-term classification for temperature (3 extremely warm, 2 very warm, 1 warm, 0 normal, –1 cold, –2 very cold, –3 extremely cold) and correspondingly for precipitation.[43]

Figure 3 displays the number of extremely warm and cold monthly anomalies (index +3 or –3) per decade from 1536 through 1675 for the months April to September. These months are the most critical for agricultural production (see Table 1). According to the Figure 3, cold

[42] Pfister, 'Weeping in the Snow': 67–74.
[43] Brázdil, 'Historical Climatology in Europe'.

**Figure 3**

***Decennial Sum of Extremely Cold and Warm Anomalies During the Summers (April to September) from 1536 to 1675 in Switzerland, North of the Alps***[44]




[44] Data basis: Pfister, *Raum-zeitliche Rekonstruktion*: 106–16.

anomalies were remarkably frequent from 1566 to 1605 and again from 1626 to 1635.[45] It may be argued that this result merely represents the climatic situation in a harsh alpine climate. What was the spatial dimension of extremely cold anomalies in the summer months?

The latest and perhaps most spectacular step in climate reconstruction has been achieved by Jürg Luterbacher and his colleagues at the NCCR[46] Climate (University of Bern) in recent years. Luterbacher discovered that a few spatially well-distributed data series based on instrumental measurements of air pressure are sufficient for assessing the air pressure field at sea-level over Europe and the adjacent North Atlantic, thereby enabling the positioning of centres of low and high pressure.[47] His group succeeded in drawing up weather charts on a statistical basis of monthly (back to 1659) and seasonal (back to 1500) air pressure and surface temperature from early instrumental observations and series of temperature and precipitation indices for the whole of Europe.[48]

The most famous cold anomaly in the summer of 1816 was mainly a consequence of the explosion of the volcano Tambora (Indonesia) in April of 1815.[49] During that 'year without a summer' it snowed in the Alps all the way down into the valleys, every fortnight, and sledges had to be used until mid-July.[50] The weather in the Geneva region was so oppressive that the 19-year old Mary Shelley (1797–1851) was inspired to write the story of *Frankenstein*.[51]

The chart (Figure 4) is based mostly upon temperature measurement. It shows that the cold and wet air mass primarily affected south-western Scandinavia, western Germany, France and Switzerland. In regions east of the river Elbe, temperatures were at or even above the twentieth century mean—as for instance in the St. Petersburg area. From this result it may be inferred that harvest yields in eastern Central Europe were average or even abundant.

[45] Pfister, 'Weeping in the Snow': 56.
[46] NCCR stands for National Center for Competence in Research.
[47] Luterbacher, 'Reconstruction of Sea-Level Pressure Fields'.
[48] Luterbacher, 'European Seasonal and Annual Temperature Variability'.
[49] Rampino, 'Eyewitness Account'.
[50] Numerous articles in: Harington, *The Year Without a Summer?*
[51] Britton, 'The Summer of 1816'. http://www.kimwoodbridge.com/maryshel/summer.shtml (last modified: 26 June 2001).

**Figure 4**
***Temperature Distribution in Europe in the 'Year without a Summer' (1816)***[52]

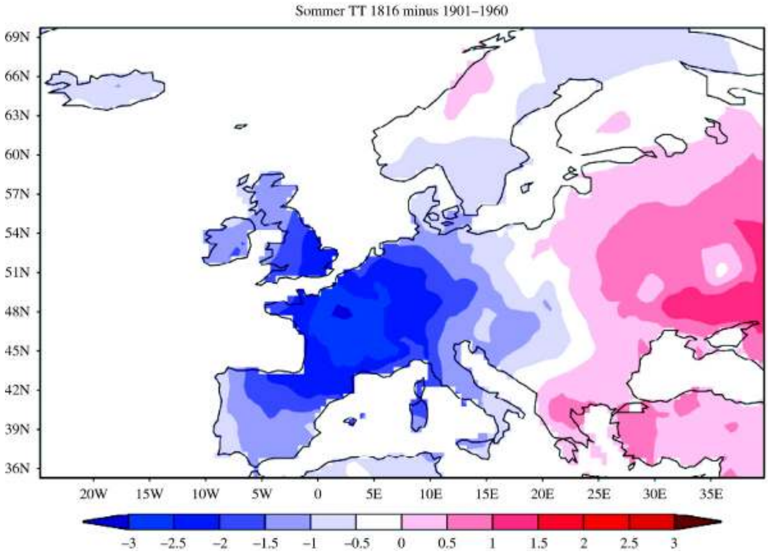
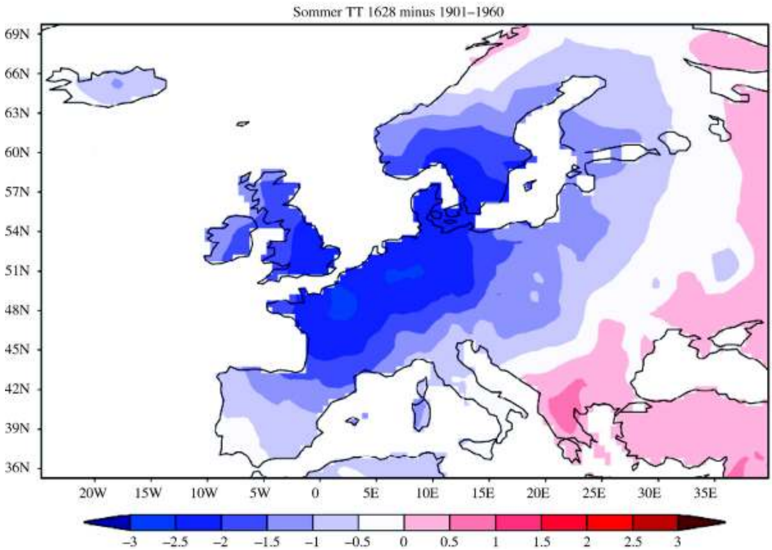



Figure 5 is entirely based upon series of temperature indices from several European regions as well as from the evidence of tree rings. The year 1628 was another 'year without a summer'. Like 1816, the anomaly was the result of a depression centred over southern Scandinavia in conjunction with a weak Azores anticyclone. To some extent, the structure of the cold trough looks similar, but it was located more to the east so that eastern Central Europe also suffered from its effects. In Switzerland, snow fell in the village of Frutigen (Bernese Oberland, 770 m) during every month of the entire year. On 1 July, it also snowed in the town of St. Gallen (670 m). On the Engstligen-Alp (Bernese Oberland, 2,000 m), it snowed no less than 23 times between 10 July and 23 August. The fresh snow was so deep on three separate occasions that the cows nearly starved and had to be driven downhill. Likewise, a deep layer of fresh snow covered the Swabian mountains (about 1,000 m) in

[52] Chart kindly provided by Jürg Luterbacher, NCCR Climate, University of Bern.

**Figure 5**
***Temperature Distribution in Europe in the 'Year without a Summer' (1628)***[53]



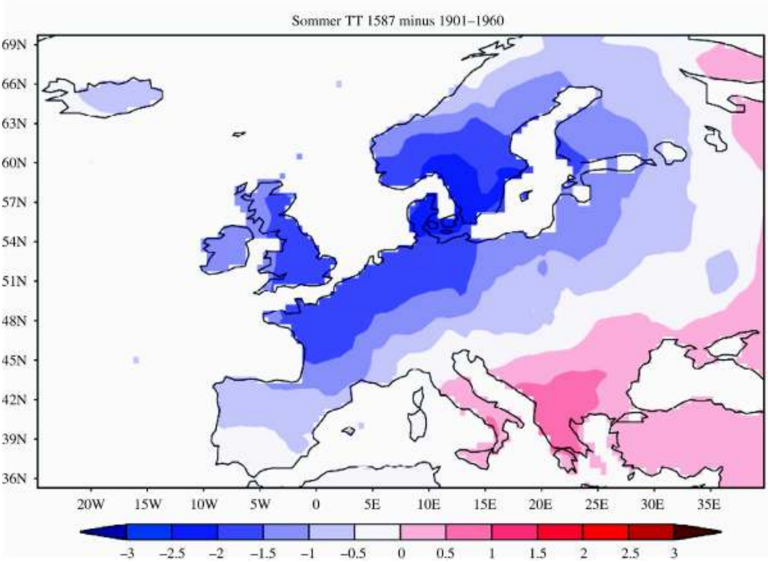

Germany three times during July. Grapevines in the valleys took five weeks to flower.[54] Rooms in Stuttgart had to be heated. For the month of July, Landgrave Hermann IV of Hesse (1607–58) recorded 21 rainy days in his diary.[55] August was somewhat better. Nevertheless, oats and grapes did not ripen completely.[56]

Figure 6 is equally based upon a series of temperature indices from several European regions and information from tree rings. The year 1587 was another year without a summer—and there have been several more within the last millennium. Compared to normal summer conditions, the sea-level pressure was higher over the eastern Atlantic, between Iceland and the Azores Islands. On the other hand, the pressure was below normal

[53] *Ibid*.
[54] Militzer, *Klima – Umwelt – Mensch (1500–1800): 196.*
[55] Glaser, *Klimageschichte Mitteleuropas:* 141.
[56] Glaser, 'Seasonal Temperature and Precipitation Fluctuations': 196.

**Figure 6**

***Temperature Distribution in Europe in the 'Year without a summer' (1587)***[57]




over Scandinavia. Between these two pressure systems, frequent incursions of (sub-) polar air were advected to Central Europe. Snow fell in the Swiss lowlands (450 m) in June and July, and again in September, whereas August was warm and dry.[58]

Undoubtedly, 'years without a summer' had a lasting effect upon people's mentality in the Little Ice Age. The impact of such summers on mentalities is well known from the detailed accounts available for 1816. There was a full-grown disaster affecting every crop, which led to despair, and those regions—where the authorities did not take effective countermeasures in time—were hit by famine.[59]

[57] Chart kindly provided by Jürg Luterbacher, NCCR Climate, University of Bern.

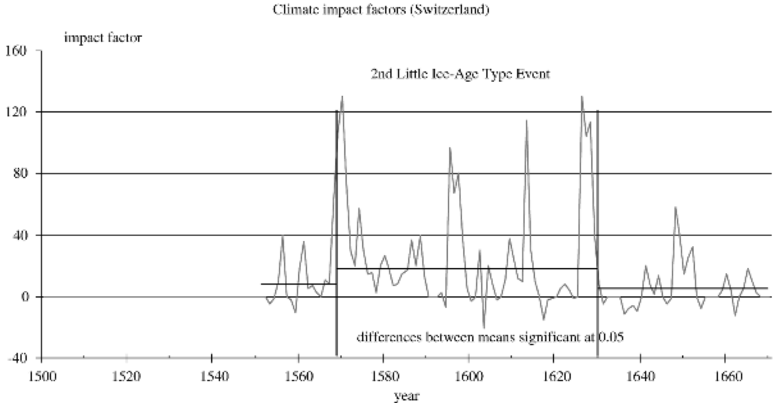
[58] Glaser, 'Seasonal Temperature and Precipitation Fluctuations'; Glaser, *Klimageschichte Mitteleuropas:* 143.

[59] See for example: Post, *The Last Great Subsistence Crisis;* Specker, *Die grosse Heimsuchung*; Vasold, 'Das Jahr des grossen Hungers'.

## Modelling Climatic Impact

In order to explore the sequence and severity of climatic impact, and based on temperature and precipitation indices for the period from 1530 to 1670, models of climatic impact factors (LIATIMP) were created.[60]

**Figure 7**
***Little Ice Age-Type Impacts (LIATIMP) in Southern Central Europe from 1560 to 1670***[61]



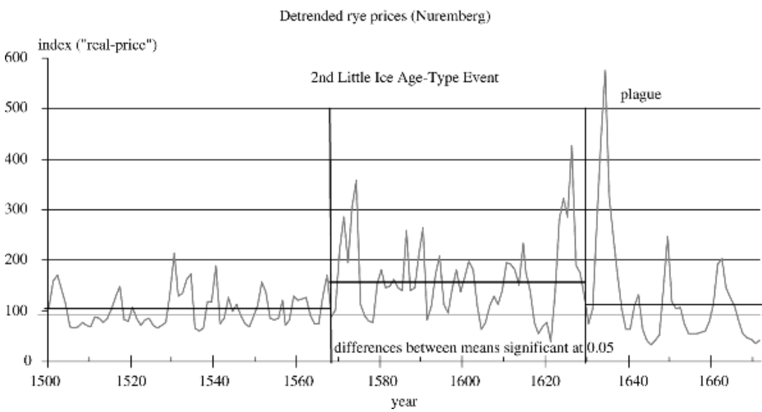

**Source:** Pfister 1988.

The level of the impact factors (Figure 7) is interpreted as an approximate value for the intensity of climatic stress. Impact levels were low in the final phase of a period of relatively favourable climate up to 1567. The transition to Little Ice Age-climate in 1569–73 took the form of a major peak of climatic stress during the time of severe famine. Somewhat minor peaks emerge in the late 1590s and again in 1614. A secondary pronounced peak stands out between 1626 and 1629. After 1630 the level of climatic stress drops substantially. On a whole, impact levels from 1568 to 1630 were significantly above the long-term mean, which suggests that these six decades were a period of enhanced climatic stress. This result contrasts with the general idea that climatic stress was a short-term feature with random distribution. Rather, it seems that periods of low and high climatic impact levels need to be distinguished.

[60] Pfister, 'Little Ice Age-type Impacts': 203–12.
[61] Pfister, 'Weeping in the Snow': 68.

This result is confirmed and chronologically supported by grain-price data counting among impacts of the second order (Figure 8). In addition to climate hazards, intervening variables, such as the invention of supply inventories, trade and markets, need to be considered in the interpretation of grain prices. As there is no long series of grain prices available for Switzerland yet, a deflated rye-price series from Nuremberg was investigated. The severe European crisis of the early 1570s protrudes from the series, marked by a sharp peak. During the preceding decades, severe crises were absent, which may have led to an increase of vulnerability stemming from rapid population growth and the cultivation of marginal and risk-prone areas. Moreover, we must assume that the degree of public and private preparedness to cope with crises was declining. The subsistence crisis of the early 1570s was thus a bolt of thunder after a long

**Figure 8**
***Detrended Rye Prices in Nuremberg 1500 to 1670***[62]




**Source:** Bauernfeind 1993: 507–10.

[62] Data: Bauernfeind, *Materielle Grundstrukturen im Spätmittelalter.* It is a matter of monthly prices paid in Gulden at the Nuremberg grain market (Table A12, p. 433–37). In a first step Bauernfeind computed prices for the harvest year. At the same time, he allowed for the debasement of coin by converting harvest year prices according to their equivalence in grams of gold (Table A13, p. 438–41). In a second step he indexed the debased prices at 1500–1550 = 100 (Table A23, p. 465–70). In the last step, he eliminated the remaining long-term trend (Table A33, p. 503–10). The figure draws on Table A33.

period of economic sunshine. Its many facets have recently been described by Wolfgang Behringer.[63] The years 1626 to 1629 are another peak. These years of distress have been cited thus far as being a secondary effect of the Thirty Years' War. However, from the results of impact modelling, it seems plausible that the disruptions related to the war were superimposed on a substantial amount of climate stress. On a whole, the level of deflated grain prices was significantly higher from 1568 to 1630 than in the preceding decades. Results for the subsequent period are not conclusive, because they are affected by the enormous price peak around 1635 related to the plague.

## The Climatic Downturn at the End of the Sixteenth Century

The years around 1570 were the onset of a period of climatic deterioration which came to a climax during the 1590s and early 1600s. In order to highlight the outstanding character of this period, the average air pressure at sea-level was reconstructed by Jürg Luterbacher for the period 1585 to 1597.[64]

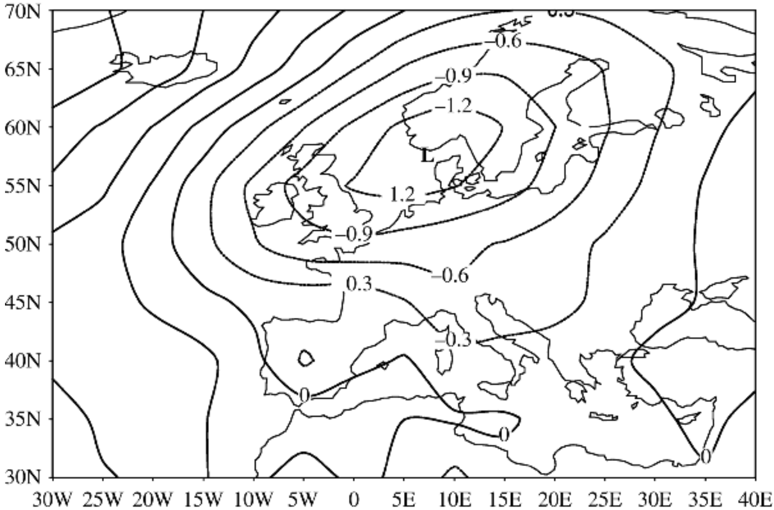
Figure 9 is most revealing: Average weather during these 13 summers was dominated by subnormal pressure over large parts of Central Europe and by a weak and remote Azores anticyclone. Such synoptic situations lead to cool and rainy weather in relationship to the passage of frontal systems from the West and North-west. The somewhat higher pressure over Iceland points to occasional northerly flows, which may have moved polar air through the eastern Atlantic towards Central Europe. At present, such situations usually last for a week, in severe cases up to a month. In the late sixteenth century, summers were predominantly cool and rainy for no less than 13 years. This pattern affected continental Europe north of the Alps from the Massif Central to Poland. The likely causes of this climatic disturbance are related to enhanced volcanic activity.

Five large volcanic explosions in low latitudes are known to have occurred between 1580 and 1600: Billy Mitchell (Bougainville, Melanesia),

[63] Behringer, 'Die Krise von 1570'.

[64] Privatdozent Dr. Jürg Luterbacher from the National Center for Climate Research (NCCR) in Bern is acknowledged for setting up this reconstruction from his data-base.

**Figure 9**
*Average Air Pressure in Europe During the Summer, 1585 to 1597*[65]




erupted in 1580,[66] Kelut (Java) in 1586, Raung (Java) in 1593, Ruiz (Colombia) in 1595, and Huaynaputina (Peru) in 1600. This short sequence of explosions is unique within the last millennium.[67] The recurrent volcanic impacts brought about more than two decades of quasi-continuous cooling, of which the global effects have yet to be investigated.

The longer-term deterioration of climate had profound consequences for the physical, biological and cultural world. These changes did not escape alert observers, among whom the statesman and pharmacist Renward Cysat (1545–1614), the son of Italian immigrants, was perhaps the most outstanding. Near his home in Lucerne he created a well-known botanical garden, thereby laying the foundation for his scientific reputation. Furthermore, he became one of the most influential Swiss politicians working in favour of the Counter-Reformation. Cysat was accustomed to climbing the mountains near Lucerne—Rigi and Pilatus—during the

[65] Source: Jürg Luterbacher, NCCR Climate, University of Bern.
[66] Or 1579, concluding from the disastrous summer of that year.
[67] Palmer, 'High-precision Dating of Volcanic Events'.

summer months. On his hikes he used to talk with local herdsmen, who had a good knowledge of their environment. At that time, such an attitude was quite unusual for a man of his status. In this manner Cysat came to learn about the astonishing changes of mountain climate and incorporated this acquired knowledge in his accounts. Mountain areas are known to be particularly sensitive to climate changes. The effects of cooling during summer months became manifest through delayed melting of snow and, consequently, in the forced postponement of cattle movements to alpine meadows in the summer. Moreover, long cold spells during the period of alpine grazing lead to frequent snowfalls on the meadows. When such situations persisted for more than a day or two, the cows had less than enough fodder to satisfy their hunger and had to be driven downhill.[68]

Cysat's weather observations, made over the period from 1570 to 1612, are included in his large collection of miscellaneous information known as the *Collectanea.*[69] In about 1600, Cysat took a retrospective view of the recent past in the foreword to his *Collectanea*, and maintained that

> ... during recent years the weather and other things have taken such a peculiar and astounding course and undergone such extraordinary alterations ...[that we had to record it]... as a warning to future generations. Unfortunately because of our sins, for already some time now the years have shown themselves to be more rigorous and severe than in the earlier past, and deterioration amongst creatures, not only among mankind and the world of animals but also of the earth's crops and produce, have been noticed, in addition to extraordinary alterations of the elements, stars and winds.[70]

Considering the climatic context in which Cysat made his observations, there is no doubt that the Swiss chronicler described a change in climate without, of course, having a clear concept of climatic change. He stressed the enduring nature of the alteration and the repetitive sequence of anomalies, as opposed to familiar short-term deviations from the 'normal'. In attempting an explanation, he pointed out changes in the wind system, meteorological causes, as well as considered the stars as possible influencing forces in which point he clearly follows astro-meteorological patterns.

[68] Pfister, 'Weeping in the Snow': 79.

[69] Schmid, *Renward Cysat.* The data scattered throughout this publication were compiled by: Pfister, *Das Klima der Schweiz von 1525–1860* (vol. 2): 34–35.

[70] Schmid, *Renward Cysat*: 907.

Finally, he addressed the impact on vegetation, agricultural production, wild and domestic animals, and even population in ways which may denote apocalyptic beliefs in signs of an imminent end of the world.[71] It would appear that many contemporary thinkers shared Cysat's prospects. William Bouwsma identifies a growing concern with personal identity, shifts in the interests of major thinkers, a decline in confidence about the future, and a heightening of anxiety at this time.[72]

In many parts of Europe, the 1590s were a period of crisis and turmoil. In 1985 Peter Clark published a book of essays on this period, which did not receive the attention it deserved.[73] Observers in France, England, Italy and Spain referred to the 1590s as a time of great upheaval.[74] From the mid-1580s to the late 1590s, France suffered from harvest failures, epidemics and religious warfare. Likewise, England and Scotland saw a disastrous sequence of harvest failures (1593–197) with economic depression, widespread poverty and high mortality from plague and starvation. In Austria there were large-scale peasant uprisings between 1594 and 1597 precipitated by higher food prices. Turning to Scandinavia we hear of crop failures in Sweden (1596–1603) with great scarcity and starvation in the West and South. Sicily and Naples were shaken by a subsistence crisis in 1590–92. Likewise, parts of Spain suffered from harvest failures in the 1590s.[75]

Clark emphasises that diagnosis is difficult, because the rhythms of suffering were not synchronous in all countries. In his analysis he first refers to climatic factors. As a second factor Clark mentions wars: the Dutch Revolt, the French Religious Wars, the Anglo-Spanish conflict. Both military conflict and famines may have contributed to the international incidents of epidemics, plague and other diseases of which the relationship to malnutrition is disputed.[76] Most of these impacts are to be located on the third or fourth level within our model (see Figure 2). Clark sums up: 'The most visible, immediate results of the crisis were fourfold: high

[71] Pfister, 'Weeping in the Snow'.
[72] Bouwsma, *The Waning of the Renaissance*.
[73] Clark, *The European Crisis*.
[74] Clark, 'Introduction': 7.
[75] *Ibid*.: 4.
[76] *Ibid*.: 7.

mortality, extensive social distress, popular disorder, and severe strains on government.' [77]

The cultural impact of climatic change should not be imagined in the form of clear causal chains of effects as would appear to have been presented above, because the perception and the interpretation of the consequences by the victims would thus disappear from the reader's sight. The issue of cultural context matters, because it was therein that people's response was embedded. This subject was the focus of a first conference on the Cultural Consequences of the Little Ice Age, the fruits of which were published in a handsome volume.[78] Before concluding this essay, two issues of a cultural nature will be addressed. First, the response of Catholic elites to the hazard of recurrent flood disasters resulting from far reaching glacier advances around 1600 will be investigated. Second, the relevance of climatic change for the 'super-hunts'[79] of witches between 1560 and 1630 will be discussed—also to highlight the degree to which leading historians of witchcraft have accepted the arguments about the relationship between climate and witch hunts in early modern Europe. The discussion of both these issues should be understood as providing impulses to the respective debates in this field.

## Multiple Flood Disasters

The history of glaciers and the history of subsistence crises have much in common. The simultaneous occurrence of rainy autumns with cold springs and wet summers in subsequent years had a cumulative impact on agricultural production. At the same time, 'years without a summer' were the most crucial motors underlying Little Ice Age-Type Events (LIATE),[80] i.e. far-reaching glacier advances.[81]

Three phases of advanced glacier positions in the Alps within the last millennium are known collectively as the Little Ice Age.[82] The first one

[77] *Ibid*.: 7.

[78] Behringer, *Kulturelle Konsequenzen*.

[79] Monter, 'Witch Trials': 22.

[80] Wanner, 'Vom Ende der letzten Eiszeit zum mittelalterlichen Klimaoptimum'.

[81] Pfister, 'Weeping in the Snow': 45, 66; Zumbühl, 'Alpengletscher in der Kleinen Eiszeit'.

[82] Grove, 'The Initiation of the "Little Ice Age"'.

culminated in the late fourteenth century. The second far-reaching advancement, originating about 1570, had its maximum expansive thrust during the 1590s. Throughout the subsequent three centuries most glacier snouts remained in advanced positions, with minor phases of melting back and growth (for example, after 1628, 1675, 1770 and 1816). The advances during the 1590s were particularly disastrous for people because in the preceding two centuries the ice streams had remained outside the cultivated areas for about two centuries, their inherent risks thereby being nearly forgotten. From the perspective of disaster history it would be worthwhile to compare strategies of coping, which developed variously in different valleys. However, these histories are not yet known in sufficient detail. Some ice streams—such as the two Grindelwald glaciers—penetrated into the cultivated areas, covering forests, meadows, barns and sometimes even houses with ice.[83]

In other areas, such as Val de Bagnes (Switzerland), Oetztal (Austria), as well as in the Italian Alps south of Mont Blanc, the human consequences of advancing glaciers were more drastic. In 1595, at Val de Bagnes, the advancing Giétroz glacier dammed the river Drance, thereby creating a lake. When the dam of ice broke on 4 June, a devastating flood-wave rushed down the valley and destroyed some 500 buildings, killing 140 people.[84] Likewise, in the uppermost part of Oetztal, the tongue of the Vernagt glacier rapidly expanded in 1599 and 1600, and dammed a lake of about 11 million $m^3$. The breaking of the dam on 20 July 1600 had catastrophic consequences for Oetztal and the Inn valley below. The flood-wave caused damage amounting to some 20,000 Gulden. The flood directed people's attention to the dangerous situation which the advancing glacier in the remote area presented.[85] During the subsequent year, the lake filled up again. The news alerted the Tyrolian authorities at Innsbruck. They dispatched specialists to the lake who initially drafted a breathtaking coloured plan of the lake filled with floating icebergs,[86] and then tried to make an outflow. In addition, the authorities had the riverbeds cleared from dangerous logs and stationed guards who were to warn

[83] Haeberli, 'Schwankungen der Alpengletscher im Wandel von Klima und Perzeption'; Pfister, 'Neue Ergebnisse'.

[84] Forquet, *Martigny, chronique, site et histoire:* 111–15 ; Gard, *16 juin 1818.*

[85] Richter, 'Urkunden über die Ausbrüche': 357.

[86] Nicolussi, Kurt. 1990. 'Bilddokumente zur Geschichte': 99.

the population in time. The Church too became an actor in the process of 'prevention' by organising processions. However, in the end, the water ran off gradually and the lake was almost completely emptied.[87]

In the case of the Ruitor glacier, the advance of the ice led to recurrent flood disasters every year for almost a decade. This glacier is situated in Italy, some 15 km south of the southern entrance of the Mont Blanc tunnel above the locality of La Thuile.[88] Its significant human history is only known from a lengthy article by Martino Baretti published in the Bulletin of the Italian Alpine Club in 1880.[89] The imminence of the advancing glacier was first noticed in 1594, when a wall of water from the glacial area destroyed houses, barns, forests and meadows on its way down to La Thuile. There it triggered off a second flood wave in the main river in the Duchy of Aosta, the Dora Baltea, which washed away everything in its course. A disaster of similar magnitude occurred in midsummer of the subsequent year. The recurrence of the disaster upset the political authorities of the Duchy—the Estates, the Council, and the Duke of Savoy. Duke Charles Emmanuel (1562–1630) had the situation inspected by his 'engineer', Giacomo Soldati. Soldati reported from his journey to the remote area that the advancing ice had blocked the outflow of the of Lake Ruitor, thus causing the lake to rise excessively in spring and early summer when melting snow and precipitation were abundant, until the ice dam would break. Therefore, the resulting floods would continue to recur annually. This alarming diagnosis called for preventive interventions on the part of the authorities. They subsequently promised to pay the enormous sum of 10,000 gold ducats at the expense of the taxpayers to any specialist who would provide a technical solution to the problem. Soldati proposed to build a wooden dam in the area below the lake that should withhold the flood waters from the lake (today estimated at 4–5 million $m^3$). An engineer by the name of Simon Tübinger proposed to build a 400 m-long tunnel through the mountain that would have

[87] Richter, 'Urkunden über die Ausbrüche': 362–63.

[88] Today, the surface of the Ruitor glacier is 9.54 $km^2$, it has a lenght of 4.78 km over a catchment area situated between 2,504 m and 3,460 m a.s.l. The history of this glacier is well known for the last 150 years over which its length was continuously monitored: Glaciorisk European Project. http://www.nimbus.it/glaciorisk/Glacier_view.asp?IdGlacier=1455&Vista=rischio&Paese=&IdTipoRischio=8#GLACIER

[89] Baretti, 'Il Lago del Rutor'.

drained water from the bottom of the lake. In the end, neither of the men was successful, as the corresponding reports mention, for which the high costs were not the only reason.[90] It is assumed that adequate technologies were not yet available at that time. The catastrophic outflows of Lake Ruitor continued annually until 1598, perhaps even 1606, which nearly ruined the villages and localities in the valley.[91] In 1603, the idea of preventing the floods through technical measures was abandoned. Instead, people pressed for a procession to the lake led by the Bishop of Aosta with a relic, which—seemingly—did no harm in this extremely dry summer. As a consequence, the idea of building a chapel near the lake in order to contain further outbreaks was born. A hunter claimed that the spirit of a deceased colleague had advised him to have a chapel built, and that would provide the needed miracle. In 1606, the chapel, still existing, was dedicated to Santa Margherita and an annual procession to the lake was scheduled for 20 July.[92] Indeed, after this year the recurring flood disasters held off for nearly two decades. This calm suggests that the Ruitor glacier had somewhat melted back behind its foremost position. Not incidentally, the floods resumed for some years after the 'ice age summer' of 1628, which indeed may have caused the glacier to advance again.[93]

Two observations may be drawn from this example. First, it confirms the theoretically and empirically well-founded conclusion established by historical disaster research that multiple catastrophes are far more likely to mentally and economically destabilize societies and to act as catalysers for novel solutions. It points, secondly, to the prioritising of a 'scientific' approach by the authorities through their determination to take preventive measures and the ensuing search for adaptive technological solutions. This procedure was at odds with the dominant belief in religious causation, which took for granted that floods were the work of God's wrath. Accordingly, processions were arranged as the most suitable mitigation strategy once it became evident that technical solutions had failed. The religious model of causation was thus subordinate to natural causation and to the search for technical solutions. Whether religious practices

[90] *Ibid.*: 52–63.
[91] *Ibid.*: 76.
[92] *Ibid.*: 46–76.
[93] *Ibid.*

were resorted to only as an *ersatz* when the application of technical measures by the authorities did not go a long way, needs to be discussed. In any case, such a setting of priorities during this high phase of the Counter Reformation is remarkable. The emphasis on preventive measures is likewise evident in the Austrian case. The response of authorities to disasters in contemporary Spain under King Philip II was, once more, different: they resorted to a variety of steps such as providing tax reduction and some subsidies to rebuild the infrastructure, but with no conception of prevention.[94]

## Climate and Culture—The Case of Witch Hunts

In a seminal article published in 1995, Wolfgang Behringer initiated a major revision of the prevailing interpretations of the major witch hunts in Central Europe, the core area of persecution, from the period of 1560 to 1630.[95] He observed a supra-regional chronological pattern in terms of waves and conjunctures. 'If we imagine the waves statistically', he wrote, 'the largest ones structure a general pattern along a time line: the gravest persecutions of witches in France, Germany, Scotland and Switzerland occurred in the same rhythm'.[96] He asserted that the long-, medium- and short-term conditions for these waves of persecutions were related to subsistence crises, which, in turn, were an outflow of extreme climate. Indeed, peaks of persecution coincided with critical points of climatic deterioration. One frequent ground for persecutions appears to have been accusations of indulging in weather magic that was responsible for 'unnatural weather'. This is a term which appears in protocols to designate climate anomalies deviating from long-experienced norms.[97] Many historians fail to take contemporary pronouncements to that effect seriously.[98] However, modern Historical Climatology concludes that contemporaries' observations were usually quite accurate.[99] Witches were

[94] Barriendos, 'Climate and Culture in Spain': 358.

[95] Behringer, 'Weather, Hunger and Fear'. Behringer further elaborates the issue in: Behringer, 'Climatic Change and Witch-Hunting'. As well as in his recent synthesis: Behringer, *Witches and Witch-Hunts.*

[96] Behringer, 'Weather, Hunger and Fear': 3.

[97] Behringer, 'Climatic Change and Witch-Hunting': 335, 339.

[98] Behringer, 'Weather, Hunger and Fear': 7.

[99] Pfister, 'Climatic Variability in Sixteenth Century Europe'.

blamed for destroying the wine crop, making the harvest go to rot and driving up grain prices, despite the official teaching of theologians who rejected popular beliefs in weather magic. That is to say, climate anomalies and the ensuing subsistence crises were attributed to the deeds of so-called ‘evil persons’, transformed and personified as enemies in accordance with popular beliefs in the occult.[100] This was the most important charge against suspected witches. Whereas accusations of witchcraft for all kinds of personal bad luck were often a matter among individuals, whole peasant communities demanded persecution in cases of ‘unnatural weather’ and collective damage. ‘In comparison to individual accusations which tended to lead to trials of individual suspects, collective demands for persecution—when accepted by the authorities’—regularly resulted in large scale witch hunts.[101] Charges of crop destruction by climatic anomalies were directed against a fictive collective because it seemed inconceivable that a single person could wield power over larger-scale weather patterns. The persecution of an occult sect allowed torturing the victims until they revealed the names of other members of the sect.[102] The persecuting impulse was fostered almost completely ‘from below’, from communities and their representatives.[103] A key statement is contained in the *Gesta Treverorum* written by Hans Linden:

> Hardly any of the [prince-]archbishops governed their diocese with such hardship, such sorrows and such extreme difficulties as Johannes [Prince-Archbishop Johannes VII von Schönenberg, reigned 1581-99]. During the whole period he had to endure a continuous lack of grain, the rigours of climate and crop failure with his subjects. Only two of the nineteen years [from 1581 to 1599] were fertile, the years 1584 and 1590 [...]. Since everybody thought that the continuous crop failure [emphasis by C.P.] was caused by witches of devilish hate, the whole country stood up for their eradication.[104]

Again, we have to stress the fact that Linden’s diagnosis of the climatic situation and its consequences is appropriate. Climate between 1585 and

[100] Behringer, ‘Weather, Hunger and Fear’: 10–18.

[101] Behringer, ‘Climatic Change and Witch Hunting’: 339–40.

[102] *Ibid.*: 338.

[103] Rummel, *Bauern, Herren und Hexen: 317–21.* Quoted by: Behringer, ‘Weather, Hunger and Fear’: 6.

[104] Emil Zenz (ed.), *Die Taten der Trierer. Gesta Treverorum*, Vol 7, Trier 1964: 13 quoted by Behringer, *Hexen und Hexenprozesse*: 195.

1597 was indeed an experience without parallel, probably within the entire last millennium. It resulted in a more or less continuous crop failure, which is demonstrated at least for the grape crop north of the Alps from Switzerland to western Hungary,[105] so that the deep-rooted *angst* of the populace—described in many sources—becomes plausible.[106]

The last of the major witch hunts took place in the lands of Catholic prelates in the Rhine basin (the three western archbishoprics of Mainz, Cologne and Trier) between 1626 and 1631.[107] The mania was triggered off by an extreme event which remains unique in the weather history of the last 500 years. On 24 May 1626, astronomer Friedrich Rüttel reported a hailstorm in the Stuttgart area which brought hailstones the size of walnuts and that allegedly accumulated to a depth of 7ft. On the afternoon of 26 May, he observed a sharp icy wind. The subsequent night was so bitterly cold that on the morning of 27 May, ice was found on the water in several places.[108] Overnight, grapevines, rye and barley were completely destroyed. The leaves on trees turned black. These devastating events together with subsequent crop failures, cattle diseases, price-rises and epidemics shaped the persecutions of the following years.[109] It was only from the early 1630s that the prosecution and execution of witches entered a new phase marked by a general decline in the number of trials.[110]

In general, Behringer does not mention indirect effects of climatic anomalies such as the death of cattle and the running dry of cows. Bovine animals had a key role in human survival as they provided both driving power and dung for grain cultivation as well as milk for human consumption. The running dry of cows or their death from cattle plague was thus likely to destabilise any small property. It follows that manifold popular beliefs had developed around the animals, including the fear of destructive forces and witchcraft.[111] In the Vaudois region of western Switzerland, no fewer than 971 persons were executed between 1580 and 1620.[112]

[105] Landsteiner, 'Wenig Brot und saurer Wein': 135–42.
[106] Behringer, 'Weather, Hunger and Fear': 19.
[107] Behringer, *Hexen: 53–46*; Monter, 'Witch Trials': 24–25.
[108] Pfister, 'Weeping in the Snow': 33.
[109] Behringer, *Witches and Witch-Hunts*: 113–14.
[110] Levack, *The Witch Hunt*: 209.
[111] Löfgren, 'Natur, Tiere und Moral': 142.
[112] Kamber, Peter. 1982. 'La chasse au sorciers et aux sorcières dans le Pays de Vaud'.

The hunts did not take place in the region of the vineyards, as might be supposed, given the biophysical vulnerability of vines to climatic hazards, but in the grain-growing regions in the hinterland of Lake Geneva. This region witnessed a deep structural crisis between 1580 and 1620. A memorandum drafted in 1591 points to the fact that large parts of the land were laid fallow in the wake of an acute shortage of cattle. Indeed, tithes paid in grain from this region declined sharply from the mid-1580s.[113] This picture points to a dramatic loss of cattle, perhaps as a consequence of a cattle plague, which might be related to the witch hunts. Noteworthy is the fact that the German-speaking region of the Republic of Bern, in which the Vaudoise was located, experienced neither substantial cattle losses nor large-scale witch hunts.

Of course, as Behringer has pointed out, the synchrony of subsistence crises and witch hunts ought not to be read in terms of a deterministic relationship. As a second important factor shaping the dynamics of witch hunts he points to a radical transformation of mentality, after 1560, towards a gloomy depressive world view shared by elites, which explains the sudden decision of ruling elites in some areas to give in to popular demands for persecutions. The traditional rejection of popular belief in weather magic was temporarily rolled back.[114] Behringer was the first scholar to calculate, on the basis of available literature on witch hunts, the total number of victims for each period of persecution.[115]

The dynamics of witch hunting (Figure 10) appear to comprise two distinct components: a long-term trend of persecution amounting to roughly a hundred cases per year provides the basis. It is thought that this trend represents charges against individuals which were not related to communal hunts and to climate. Superposed on the long-term trend is the effect of mass persecutions of witches. The latter trend rises substantially from 1580 to 1600, then it levels off for about 15 years. A second rise starts in 1618 and culminates in the late 1620s. From the early 1630s, the number of executions falls back to the long-term level of individual persecutions.

This pattern agrees well with the number of cold anomalies in the summer months allowing for a time lag between the 'crime', the trial

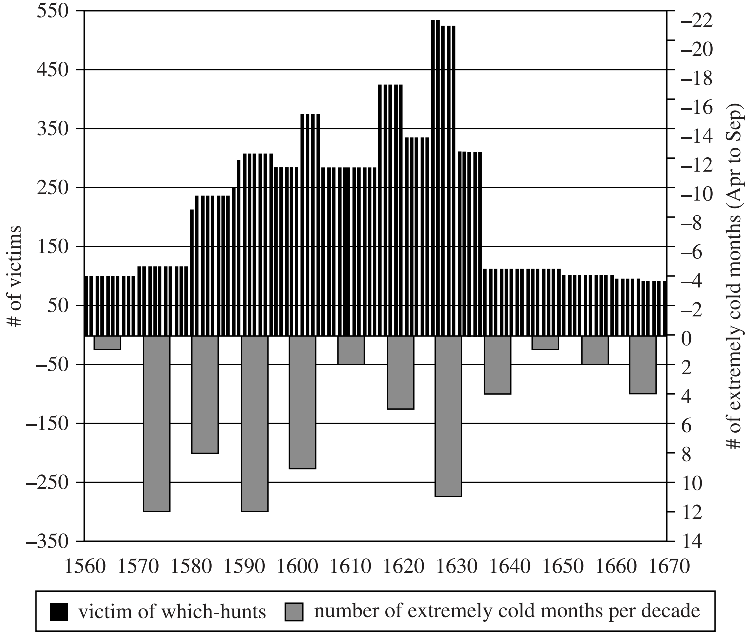
[113] Pfister, *Das Klima der Schweiz von 1525–1860* (vol. 2): 99.

[114] Behringer, 'Weather, Hunger and Fear': 20.

[115] Behringer, *Hexen*: 61.

**Figure 10**

***Average Number of Burnt Witches and Number of Cold Anomalies per Decade in the Summer Half Year (April to September) in Central Europe, 1560–1670***




and the execution. For example, as late as 1630 the suspects still had to confess that they had been responsible for the extreme frost in May of 1626. 'According to the confessions, the Franconian witches had discovered how to make the frost. They prepared an unguent from children's fat, flew through the air on the night of 27 May 1626 and dropped the poison on the crops and everything was frozen.'[116] The first rise in executions up to 1600 coincides with the massive increase of cold anomalies after 1565. From about 1603 to 1617 the anomalies dropped back to their pre-crisis level which obviously coincides with a decrease in the number of executions. From 1618 to 1630 there is a second wave of extreme months which was followed by the most pronounced rise in executions.

[116] Gehm, *Die Hexenverfolgung im Hochstift Bamberg und das Eingreifen des Reichshofrates zu ihrer Beendigung*: 118. Quoted by: Behringer, *Witches and Witch-Hunts*: 114.

This first visualisation of the dynamics of climate in conjunction with large-scale witch hunts strongly supports Behringer's findings.

Needless to say, Figure 10 is not to suggest a mono-causality between persecution and extraordinary climate. Instead of exposing myself to the charge of climatic determinism, which would be misplaced, I hope that the graphic presentation of the issue would provide an impulse to bring climate anomalies and climatic change back into the debate. In this context it needs to be stressed that Behringer's thesis has not been addressed in recent syntheses of the subject, rather it has been dropped altogether from the debate.

William Monter, who is an old hand at the history of witchcraft, provides a seminal summary of witchcraft trials in continental Europe for the century between 1560 and 1660. He explains convincingly why the bulk of the executions was restricted to a handful of territories, referring to confessionalism, appellate justice, a loose institutional structure as well as laxity of the government, and the zeal of individual rulers against their subjects.[117] On the other hand, he hardly addresses the dynamics of witch-hunting, i.e. the dimension of time, which, for a historian, is rather odd. Socio-economic arguments are given in the form of two or three examples within a short paragraph, either accompanied by sparse comments along the way or not noticed at all. In the end, Monter does not mention Behringer's climate thesis, nor does he quote the relevant essays of his colleague even though he must know them.[118]

Like William Monter, Brian P. Levack focuses on the geography of witch-hunting in his important synthesis. The overwhelming majority of witchcraft persecutions occurred in Germany, France, Switzerland and the Low Countries. More than half of this zone lay within the Holy Roman Empire. The empire provided very little legal unity and exercised little judicial control over the activities of the various tribunals which heard witchcraft cases. Likewise, the Swiss cantons were jurisdictionally autonomous, a situation that also made large witch hunts possible.[119] Yet the dynamics of witch hunts are only briefly addressed in this account. In the relevant section, Levack refers to 'unprecedented inflation, a series

[117] Monter, 'Witch Trials', 6–9.

[118] Behringer, 'Weather, Hunger and Fear': 1–27; Behringer, 'Climatic Change and Witch-Hunting': 335–51.

[119] Levack, *Witch Hunt*: 213–14.

of harsh climatic changes, periodic famines [ī], depressions in trade and a more general crisis in production'.[120] Behringer's arguments are not mentioned, nor are his relevant books and articles quoted, perhaps because Levack did not update the third edition of his book. Finally, William Burn's *Encyclopedia of Witch Hunts in Europe and America* does not consider the socio-economic background of witch-hunting and, of course, the issue of climatic change.[121]

The three syntheses are all examples of a 'history from above', focussing on intellectual and legal arguments without sufficiently taking into account popular perceptions and responses. Their reluctance to discuss the issue of climatic change may be rooted in the deep-seated prejudice that events in the natural environment are not relevant to human history. An open-minded synthesis of witch-hunting which tries to provide a balanced picture of all relevant approaches including climatic change is still to be accomplished.

## Conclusions

Climate history and cultural history have been written separately for a long time, even though they actually share a common object, which is mankind. Humans are part of two different dimensions of existence and spheres of causation, the natural and the cultural. With their bodies, humans are part of the material sphere of nature. With their minds, they are part of the symbolic sphere of culture.[122] Weather, more than climate, had a prominent place in both spheres. Prior to the age of Large Technical Systems, it was not only a significant component of man's biological life, via the food-system and the risk of climate-related epidemics. The weather also held a prominent place in people's minds, because it was a fundamental experience of daily life, particularly for rural populations. Weather is an overarching component in peasant memory books.[123] Paul Münch raised the question as to why climate, which had been an important historiographical issue through the eighteenth century, was hardly considered any more as of the nineteenth century. First, weather gradually

[120] *Ibid*.: 208.
[121] Burns, *Witch Hunts in Europe and America*.
[122] Sieferle, 'Kulturelle Evolution des Gesellschafts-Natur-Verhältnisses'.
[123] Münch. *Lebensformen*.

lost its significance for the living conditions of broad strata of society, particularly for city dwellers. Secondly, the broad historiographical approach of the Enlightenment, which had paid considerable attention to climate, was split into special histories, many of which, during the nineteenth century, focussed on the rise of the nation state. Finally, an expanding industrial society dismissed agricultural elements from its preferred interpretations of the world.[124] Nascent global society today seems to have finally understood that the issue of future climatic change may be the ordeal by fire to ensure its survival. As a consequence, weather is not only back in people's minds, it is also becoming an important 'new' issue in historiography.

This article has attempted to bring the two spheres of mankind's existence together by highlighting relationships from the global to the local and, between climatic effects, people's needs, their despair and their collective fears. Of course, this approach suffers from many shortcomings, most of which are related to the well-known 'interdisciplinarity within an individual's mind' (Jürgen Mittelstrass).[125] In order to be more successful, a human history of climate should rather become an interdisciplinary project in which climate historians and cultural historians cooperate. Evidently such a project would require a readiness on both sides to learn from each other in order to prepare common anthologies and jointly authored papers. Such cooperation would yield a more balanced picture of man's relation with climate and with his natural environment, which is appropriate to the needs of the twenty-first century.

## References

Abel, Wilhelm. 1978. *Agrarkrisen und Agrarkonjunktur. Eine Geschichte der Land-und Ernährungswirtschaft Mitteleuropas seit dem hohen Mittelalter*, Hamburg.

Bankoff, Greg. 2003. *Cultures of Disaster. Society and Natural Hazard in the Philippines*, London.

Baretti, Martino. 1880. 'Il Lago del Rutor (Alpi Graje Settentrionali)', *Bollettino del Club Alpino italiano*, vol. 14(41): 43–95.

Barriendos, Mariano. 2004. 'Flood Data Reconstruction in Historical Times from Non-instrumental Sources in Spain and France', in Gerardo Benito and Varyl R. Thorndycraft

[124] *Ibid.*: 153–54.

[125] Mittelstrass, 'Die Stunde der Interdisziplinarität': 151.

(eds), *Systematic, Palaeoflood and Historical Data for the Improvement of Flood Risk Estimation. Methodological Guidelines*, Madrid: 29–42.
———. 2005. 'Climate and Culture in Spain. Religious Responses to Extreme Climatic Events in the Hispanic Kingdoms (16th–19th Centuries)', in Wolfgang Behringer (ed.), *Kulturelle Konsequenzen der 'Kleinen Eiszeit'*, Göttingen: 379–414.
Bauernfeind, Walter. 1993. *Materielle Grundstrukturen im Spätmittelalter und der Frühen Neuzeit. Preisentwicklung und Agrarkonjunktur am Nürnberger Getreidemarkt von 1339–1670*, Nuremberg.
Behringer Wolfgang (ed.). 1988. *Hexen und Hexenprozesse*, Munich.
———. 1995. 'Weather, Hunger and Fear: Origins of the European Witch-Hunts in Climate, Society and Mentality', *German History*, vol. 13(1): 1–27.
———. 1998. *Hexen—Glaube, Verfolgung, Vermarktung*, Munich.
———. 1999. 'Climatic Change and Witch-Hunting. The Impact of the Little Ice Age on Mentalities', *Climatic Change*, vol. 43(1): 335–51.
———. 2003. 'Die Krise von 1570. Ein Beitrag zur Krisengeschichte der Neuzeit', in Manfred Jakubowski-Tiessen (ed.), *Um Himmels Willen. Religion in Krisenzeiten*, Göttingen: 53–156.
———. 2004. *Witches and Witch-Hunts. A Global History*, Cambridge.
———. 2005. *Kulturelle Konsequenzen der 'Kleinen Eiszeit'*, Göttingen.
Böhret, Carl. 1990. *Folgen—Entwurf für eine aktive Politik gegen schleichende Katastrophen*, Opladen.
Borst, Arno. 1981. 'Das Erdbeben von 1348. Ein historischer Beitrag zur Katastrophenforschung', *Historische Zeitschrift*, vol. 233: 529–69.
Bouwsma, William James. 2001. *The Waning of the Renaissance, 1550–1640*, New Haven.
Brázdil, Rudolf. 2001. 'Hungerjahre 1770–1772 in den Böhmischen Ländern. Verlauf, Meteorologische Ursachen und Auswirkungen', *Österreichische Zeitschrift für Geschichtswissenschaften*, vol. 12(2): 44–78.
———. 2005a. *Historical and Recent Floods in the Czech Republic*, Brno.
———. 2005b. 'Historical Climatology in Europe—The State of the Art', *Climatic Change*, vol. 70(3): 363–430.
Britton, Kim W. 1996–2003. The Summer of 1816. http://www.kimwoodbridge.com/maryshel/summer.shtml (last modified: 26 June 2001).
Brooks, Nick. 2003. *Vulnerability, Risk and Adaptation. A Conceptual Framework*, Tyndall Center for Climate Change Research Working Paper No. 38, Norwich.
Burns, William, E. 2003. *Witch Hunts in Europe and America. An Encyclopedia*, London.
Clark, Peter. 1985. 'Introduction', in Peter Clark (ed.), *The European Crisis of the 1590's. Essays in Comparative History*, London: 3–22.
———. (ed.). 1985. *The European Crisis of the 1590's. Essays in Comparative History*, London.
Costanza, Robert (ed.). 2006. *Integrated History and Future of People on Earth (IHOPE). Dahlem Workshop Report 96*, Cambridge.
Diamond, Jared, M. 2006. *Collapse. How Societies Choose to Fail or Succeed*, London.
Dupâquier, Jacques. 1989. 'Demographic Crises and Subsistence Crises in France, 1650–1725', in John Walter and Roger Schofield (eds), *Famine, Disease and the Social Order in Early Modern Society*, Cambridge: 189–200.

Favier, René (ed.). 2000. *Histoire et mémoire des risques naturels. Actes du séminaire international 'Histoire et Mémoire des risques naturels en région de montagne' 25–26 November 1999*, Grenoble.

———. (ed.). 2002. *Les pouvoirs publics face aux risques naturels dans l'histoire*, Grenoble.

———. (ed.). 2005. *Récits et représentations des catastrophes depuis l'Antiquité*, Grenoble.

Forquet, P. 1953. *Martigny, chronique, site et histoire*, Martigny.

Fouquet, Gerhard. 2003. 'Das Erdbeben in Basel 1356. Für eine Kulturgeschichte der Katastrophen', *Basler Zeitschrift für Geschichte und Altertumskunde*, vol. 103: 31–49.

Gard, Jean-Michel (ed.). 1988. *16 juin 1818, débâcle du Giétro. Exposition thèmatique sur la géographie, la géologie et la glaciologie de la vallée de Bagnes. Musée de Bagnes, Le Châble, Valais, 16 juillet–9 octobre 1988*, Le Châble.

Gehm, Britta. 2000. *Die Hexenverfolgung im Hochstift Bamberg und das Eingreifen des Reichshofrates zu ihrer Beendigung*, Hildesheim.

Gills, Barry, K. (ed.). 2006. *Globalisation and Global History*, London.

Gisler, Monika. 2007. *Göttliche Natur? Formationen im Erdbebendiskurs der Schweiz des 18. Jahrhunderts*, Zurich.

Glaser, Rüdiger. 1999. 'Seasonal Temperature and Precipitation Fluctuations in Selected Parts of Europe During the Sixteenth Century', in Christian Pfister (ed.), *Climatic Variability in Sixteenth-century Europe and Its Social Dimension*, Dordrecht: 169–200.

———. 2001. *Klimageschichte Mitteleuropas. 1000 Jahre Wetter, Klima, Katastrophen*, Darmstadt.

———. 2004. 'Climate and Floods in Germany since AD 1000: Data, Methods, Results and Consequences', *Surveys in Geophysics*, vol. 25(5–6): 485–510.

Groh, Dieter. 1986. 'Strategien, Zeit und Ressourcen. Risikominimierung, Unterproduktivität und Mussepräferenz-die zentralen Kategorien von Subsistenzökonomien', *Schweiz. Gesellschaft für Wirtschafts-und Sozialgeschichte*, vol. 5(5): 1–47.

———. 1992. 'Die verschwörungstheoretische Versuchung oder: Why Do Bad Things Happen to Good People?', in Dieter Groh (ed.), *Anthropologische Dimensionen der Geschichte*, Frankfurt: 267–304.

———. (ed.). 2003. *Naturkatastrophen. Beiträge zu ihrer Deutung, Wahrnehmung und Darstellung in Text und Bild von der Antike bis ins 20. Jahrhundert*, Tübingen.

Grove, Jean M. 2001. 'The Initiation of the "Little Ice Age" in Regions Round the North Atlantic', *Climatic Change*, vol. 48(1): 53–82.

Grünig, Martin. 2003. 'Aus der Katastrophe gelernt. Die Bedeutung des Lawinenwinters 1950/51 für die Entwicklung des Lawinenschutzes in der Schweiz', unpublished MA Thesis, Institute of History, University of Bern, Bern.

Guidoboni, Emanuela. 2004. *Quand la terre tremblait*, Paris.

Haeberli, W. 2003. 'Schwankungen der Alpengletscher im Wandel von Klima und Perzeption', in François Jeanneret (ed.), *Welt der Alpen—Welt der Gebirge. Ressourcen, Akteure, Perspektiven*, Bern: 77–92.

Harington, Charles Richard (ed.). 1992. *The Year Without a Summer? World Climate in 1816*, Ottawa.

Hsü, Kenneth Jinghwa. 2000. *Klima macht Geschichte. Menschheitsgeschichte als Abbild der Klimaentwicklung*, Zurich.

Hughes, Thomas, P. 2006. *The Development of Large Technical Systems*, E-Book Project.
Huntington, Ellsworth. 1907. *The Pulse of Asia. A Journey in Central Asia Illustrating the Geographic Basis of History*, Boston/New York.
———. 1995. Main springs of civilisation, New York.
Jakubowski-Tiessen, Manfred. 1992. *Sturmflut 1717. Die Bewältigung einer Naturkatastrophe in der Frühen Neuzeit*, Munich.
———. (ed.). 2003. *Um Himmels Willen. Religion in Katastrophenzeiten*, Göttingen.
Jankrift, Kay Peter. 2003. *Brände, Stürme, Hungersnöte. Katastrophen in der mittelalterlichen Lebenswelt*, Ostfildern.
Jarraud, Michel. 2005. 'Foreword', *Climatic Change*, vol. 70(1–2): 5–7.
Jordan, William Chester. 1996. *The Great Famine. Northern Europe in the Early Fourteenth Century*, Princeton.
Jütte, Robert. 2005. 'Klimabedingte Teuerungen und Hungersnöte. Bettelverbote und Armenfürsorge als Krisenmanagement', in Wolfgang Behringer (ed.), *Kulturelle Konsequenzen der 'Kleinen Eiszeit'*, Göttingen: 225–37.
Kamber, Peter. 1982. 'La chasse au sorciers et aux sorcières dans le Pays de Vaud. Aspects quantitatifs (1581–1620)', *Revue historique vaudoise*, vol. 90: 21–33.
Kates, Robert W. (ed.). 1985. *Climate Impact Assessment. Studies of the Interaction of Climate and Society*, Chichester.
Kempe, Michael. 2003. 'Introduction', in Michael Kempe (ed.), *Coping with the Unexpected—Natural Disasters and their Perception*, Isle of Harris: 123–26.
———. (ed.). 2003. *Coping with the Unexpected—Natural Disasters and their Perception*, Isle of Harris. (Special Issue of Environment and History.)
Körner, Martin (ed.). 1999 (1). 2000 (2, 3). *Stadtzerstörung und Wiederaufbau / Destruction and Reconstruction of Towns/Destruction et reconstruction des villes*, 3 vols. Bern.
Kraker, Adriaan, M.J. de. 2006. 'Flood Events in the Southwestern Netherlands and Coastal Belgium, 1400–1953', *Hydrological Sciences–Journal*, vol. 51(5): 913–29.
Lachiver, Marcel. 1991. *Les années de misère. La famine au temps du Grand Roi 1680–1720*, Paris.
Landsteiner, Erich. 2005. 'Wenig Brot und saurer Wein. Kontinuität und Wandel in der zentraleuropäischen Ernährungskultur im letzten Drittel des 16. Jahrhunderts', in Wolfgang Behringer (ed.), *Kulturelle Konsequenzen der 'Kleinen Eiszeit'*, Göttingen: 87–147.
Le Roy Ladurie, Emmanuel. 1972. *Times of Feast, Times of Famine. A History of Climate since the Year 1000*, translated by Barbara Bray, London.
———. 2004. *Histoire humaine et comparée du climat. Canicules et glaciers (XIIIe–XVIIIe siècles)*, Paris.
Levack, Brian, P. 2006. *The Witch Hunt in Early Modern Europe*, 3rd ed., Harlow.
Löfgren, Orvar. 1986. 'Natur, Tiere und Moral', in Utz Jeggle (ed.), *Volkskultur in der Moderne. Probleme und Perspektiven empirischer Kulturforschung. Zur Entwicklung der bürgerlichen Naturauffassung*, Reinbek bei Hamburg: 122–44.
Lübken, Uwe. 2004. 'Zwischen Alltag und Ausnahmezustand. Ein Überblick über die historiographische Auseinandersetzung mit Naturkatastrophen', *WerkstattGeschichte*, vol. 38: 91–100.

Luterbacher, Jürg. 2002. 'Reconstruction of Sea Level Pressure Fields over the Eastern North Atlantic and Europe Back to 1500', *Climate Dynamics,* vol. 18(7): 545–61.

———. 2003. 'Atmospheric Circulation Variability in the North-Atlantic-European Area Since the Mid-seventeenth Century', *Climate Dynamics*, vol. 20(4): 341–52.

———. 2004. 'European Seasonal and Annual Temperature Variability, Trends, and Extremes Since 1500', *Science*, vol. 303(5663): 1499–1503.

———. 2006. 'Five Hundred Years of Gridded High-resolution Precipitation Reconstructions over Europe and the Connection to Large-scale Circulation', *Climate Dynamics*, vol. 26(4): 387–405.

Massard-Guilbaud, Geneviève (ed.). 2002. *Cities and Catastrophes: Coping with Emergency in European History*, Frankfurt.

Matossian, Mary Allerton Kilbourne. 1989. *Poisons of the Past. Molds, Epidemics, and History*, New Haven.

Mauelshagen, Franz. 2006. 'Interactive comment on Social Vulnerability to climate in the "Little Ice Age": An example fro central Europe in the Early 1770s' by C. Pfister and R. Brázdil', *Climates of past*, Discussions, Vol. 2: 79–87.

Mayntz, Renate (ed.). 1988. *The Development of Large Technical Systems*, Frankfurt.

Militzer, Stefan. 1998. *Klima–Umwelt–Mensch (1500–1800). Studien und Quellen (ClimDat) zur Bedeutung von Klima und Witterung in der vorindustriellen Gesellschaft. Abschlussbericht zum DFG Projekt MI-493*, Leipzig.

Mittelstrass, Jürgen. 1987. 'Die Stunde der Interdisziplinarität', in Jürgen Kocka (ed.), *Interdisziplinarität: Praxis, Herausforderung, Ideologie*, Frankfurt: 146–157.

Monter, William. 2002. 'Witch Trials in Continental Europe 1560–1660', in Bengt Ankarloo (ed.), *The Period of the Witch Trials. Witchcraft and Magic in Europe*, London: 1–52.

Münch, Paul. 1992. *Lebensformen in der Frühen Neuzeit*, Frankfurt.

Munzar, Jan. 2005. 'The Catastrophic Flood in February/March 1784. A Natural Disaster of European Scope', *Moravian Geographical Reports*, vol. 13(1): 8–24.

Nicolussi, Kurt. 1990. 'Bilddokumente zur Geschichte des Vernagtferners im 17. Jahrhundert', *Zeitschrift für Gletscherkunde und Glazialgeologie*, vol. 26(2): 97–119.

Oliver-Smith, Anthony. 2002. 'Introduction: Why Anthropologists Should Study Disasters', in Susanna M. Hoffman and Anthony Oliver-Smith (eds), *Catastrophe & Culture. The Anthropology of Disaster*, Santa Fe: 3–22.

Osterhammel, Jürgen. 2005. *Globalisation: A Short History*, translated by Dona Geyer, Princeton.

Outhwaite, R.B. 1991. *Dearth, Public Policy and Social Disturbance in England, 1550–1800*, Basingstoke.

Palmer, Anne S. 2001. 'High-precision Dating of Volcanic Events (A.D. 1301–1995) Using Ice Cores from Law Dome, Antarctica', *Journal of Geophysical Research,* vol. 106(D22): 28,089–096.

Papazachos, Basil. 1997. *The Earthquakes of Greece*, Salonika.

Pelling, Mark. 2003. *Natural Disasters and Development in a Globalising World*, London.

Pfister, Christian. 1984. *Das Klima der Schweiz von 1525–1860 und seine Bedeutung in der Geschichte von Bevölkerung und Landwirtschaft*, 2 vols (Academia Helvetica, vol. 6), Bern.

Pfister, Christian. 1994. 'Neue Ergebnisse zur Vorstossdynamik der Grindelwaldgletscher vom 14. bis zum 16. Jahrhundert', *Mitteilungen der Naturforschenden Gesellschaft Bern*, vol. 51: 55–79.

———. 1998. *Raum-zeitliche Rekonstruktion von Witterungsanomalien und Naturkatastrophen 1496–1995*, in collaboration with Daniel Brändli, Zurich.

———. 1999a. 'Climatic Variability in Sixteenth Century Europe and its Social Dimension. A Synthesis', in Christian Pfister (ed.), *Climatic Variability in Sixteenth-century Europe and its Social Dimension*, Dordrecht: 5–53.

———. 1999b. *Wetternachhersage. 500 Jahre Klimavariationen und Naturkatastrophen 1496–1995*, Bern.

———. (ed.). 2002. *Am Tag danach. Zur Bewältigung von Naturkatastrophen in der Schweiz 1500–2000*, Bern.

———. (ed.). 2004. *Katastrophen und ihre Bewältigung. Perspektiven und Positionen*, Bern.

———. 2005. 'Weeping in the Snow. The Second Period of Little Ice Age-type Impacts, 1570–1630', in Wolfgang Behringer (ed.), *Kulturelle Konsequenzen der 'Kleinen Eiszeit',* Göttingen: 31–86.

———. 2006a. 'Little Ice Age-type Impacts and the Mitigation of Social Vulnerability to Climate in the Swiss Canton of Bern Prior to 1800', in Robert Costanza (ed.), *Integrated History and Future Of People on Earth (IHOPE). Dahlem Workshop Report 96*, Cambridge: 197–212.

———. 2006b. 'Social Vulnerability to Climate in the "Little Ice Age". An Example from Central Europe in the Early 1770s', *Climate of the Past*, vol. 2(2):115–29.

Pfister, Christian and Rudolf Brázdil. 2006. 'Social Vulnerability to Climate in the "Little Ice Age": An Example from Central Europe in the Early 1770s', *Climate of the Past*, vol. 2: 1–15.

Poliwoda, Guido. 2007. *Aus Katastrophen lernen. Sachsen im Kampf gegen die Fluten der Elbe*, Cologne.

Post, John, D. 1977. *The Last Great Subsistence Crisis in the Western World*, London.

———. 1990. 'Nutritional Status and Mortality in Eighteenth-century Europe', in Lucile F. Newman (ed.), *Hunger in History. Food Shortage, Poverty and Deprivation*, Oxford: 241–80.

Quenet, Grégory. 2005. *Les tremblements de terre aux XVIIe et XVIIIe siècles. La naissance d'un risque*, Seyssel (Ain).

Radkau, Joachim. 2000. *Natur und Macht. Eine Weltgeschichte der Umwelt*, Munich.

Rampino, Michael, R. 1992. 'Eyewitness Account of the Distant Effects of the Tambora Eruption of April 1815', in Charles Richard Harington (ed.), *The Year Without a Summer? World Climate in 1816*, Ottawa: 12–15.

Ranft, Andreas (ed.). 2004. *Städte aus Trümmern. Katastrophenbewältigung zwischen Antike und Moderne*, Göttingen.

Richter, Eduard. 1892. 'Urkunden über die Ausbrüche des Vernagt-und Gurglergletschers im 17. und 18. Jahrhundert', *Forschungen zur deutschen Landes-und Volkskunde,* vol.VI: 345–440.

Rohr, Christian. 2001. 'Mensch und Naturkatastrophe. Tendenzen und Probleme einer mentalitätsbezogenen Umweltgeschichte des Mittelalters', in Sylvia Hahn and Reinhold Reith (eds), *Umwelt-Geschichte. Arbeitsfelder, Forschungsansätze, Perspektiven*, Vienna: 13–32.

———. 2006. 'Naturerfahrung zwischen Alltag und Katastrophe. Studien zur Wahrnehmung, Deutung und Bewältigung von extremen Naturereignissen im Ostalpenraum (13–16 Jahrhundert)', unpublished Professorial Dissertation, Interdisciplinary Center for Medieval Studies, University of Salzburg, Salzburg.

Rotberg, Robert, I. 1983. *Hunger and History. The Impact of Changing Food Production and Consumption Patterns on Society*, Cambridge.

Rummel, Walter. 1991. *Bauern, Herren und Hexen. Studien zur Sozialgeschichte sponheimischer und kurtrierischer Hexenprozesse, 1574–1604*, Göttingen.

Schmid, Josef (ed.). 1969. *Renward Cysat. Collectanea Chronica und denkwürdige Sachen pro Chronica Lucernensi et Helvetiae. Stationes annorum. Witterung, Missjahre, Teuerung*, Lucerne.

Schott, Dieter. 2003. 'Forschungsbericht: Die Rolle von Katastrophen in der (Stadt-) Geschichte', *Informationen zur Modernen Stadtgeschichte*, vol. 3(1): 39–50.

Sieferle, Rolf Peter. 1997. 'Kulturelle Evolution des Gesellschafts-Natur-Verhältnisses', in Marina Fischer-Kowalski (ed.), *Gesellschaftlicher Stoffwechsel und Kolonisierung von Natur. Ein Versuch in sozialer Ökologie*, Amsterdam: 37–53.

Specker, Louis. 1993–1995. *Die grosse Heimsuchung. Das Hungerjahr 1816/17 in der Ostschweiz*, 2 vols, St. Gallen.

Summerton, Jane (ed.). 1994. *Changing Large Technical Systems*, Boulder.

Tainter, Joseph, A. 2004. *The Collapse of Complex Societies*, Cambridge.

Vasold, Manfred. 2001. 'Das Jahr des grossen Hungers. Die Agrarkrise von 1816/17 im Nürnberger Raum', *Zeitschrift für bayerische Landesgeschichte*, vol. 64(3): 745–82.

Wanner, Heinz. 2000. 'Vom Ende der letzten Eiszeit zum mittelalterlichen Klimaoptimum', in Heinz Wanner (ed.), *Klimawandel im Schweizer Alpenraum*, Zurich: 73–79

Wigley, Tom, M.L. 1985. 'Historical Climate Impact Assessments', in Robert W. Kates (ed.), *Climate Impact Assessment. Studies of the Interaction of Climate and Society*, Chichester: 529–64.

Zumbühl, Heinz. 1988. 'Alpengletscher in der Kleinen Eiszeit', *Die Alpen*, vol. 64(3): 129–322.